**This document was too large to scan as a single document. It has been divided into smaller sections.**

**Section 1 of 2**

| Document Information | | | |
|---|---|---|---|
| **Document #** | **RPP-6485** | **Revision** | **0** |
| **Title** | TECHNICAL INFORMATION TO SUPPORT DST EMERGENCY ANNULUS PUMPING | | |
| **Date** | **09/14/2000** | | |
| **Originator** | **REBERGER DW** | **Originator Co.** | **CHG** |
| **Recipient** | | **Recipient Co.** | |
| **References** | | | |
| **Keywords** | | | |
| **Projects** | | | |
| **Other Information** | | | |

S

SEP 14 2000
STA# 4

# (4) ENGINEERING DATA TRANSMITTAL



1. EDT 619712

| | | |
|---|---|---|
| 2. To: (Receiving Organization) Distribution | 3. From: (Originating Organization) DST Engineering | 4. Related EDT No.: NA |
| 5. Proj./Prog./Dept./Div.: DST Annulus Pumping | 6. Design Authority/Design Agent/Cog. Engr.: Dan Reberger | 7. Purchase Order No.: NA |
| 8. Originator Remarks: This EDT transmits for distribution the supporting document, "Technical Information to Support DST Emergency Annulus Pumping". | | 9. Equip./Component No.: NA |
| | | 10. System/Bldg./Facility: DST Annulus |
| | | 12. Major Assm. Dwg. No.: NA |
| 11. Receiver Remarks: | 11A. Design Baseline Document? ☐ Yes ☒ No | 13. Permit/Permit Application No.: NA |
| | | 14. Required Response Date: 8/2/00 |

15. DATA TRANSMITTED

| (A) Item No. | (B) Document/Drawing No. | (C) Sheet No. | (D) Rev. No. | (E) Title or Description of Data Transmitted | (F) Approval Designator | (G) Reason for Transmittal | (H) Originator Disposition | (I) Receiver Disposition |
|---|---|---|---|---|---|---|---|---|
| 1 | RPP-6485 | | 0 | Technical Information | NA | 1 | 1 | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

16. KEY

| Approval Designator (F) | Reason for Transmittal (G) | Disposition (H) & (I) |
|---|---|---|
| E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7) | 1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required) | 1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged |

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)

| (G) Reason | (H) Disp. | (J) Name | (K) Signature | (L) Date | (M) MSIN | (G) Reason | (H) Disp. | (J) Name | (K) Signature | (L) Date | (M) MSIN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Design Authority | | | | | | | | | |
| | | Design Agent | | | | | | | | | |
| 1 | 1 | Cog. Eng. DW Reberger | [signature] | 8/2/00 | 55-13 | | | | | | |
| 1 | 1 | Cog. Mgr. | [signature] | 8/3/00 | 55-13 | | | | | | |
| | | QA | | | | | | | | | |
| | | Safety | | | | | | | | | |
| | | Env. | | | | | | | | | |

| 18. | 19. | 20. | 21. DOE APPROVAL (if required) |
|---|---|---|---|
| [signature] 8/2/00 Signature of EDT Originator Date | Authorized Representative for Receiving Organization Date | [signature] 8/3/00 Design Authority/ Cognizant Manager Date | Ctrl No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments |

September 8, 2000

Mr. G. S. Gustafson, President
Instrumentation Northwest, Inc.
14902 N. E. 31st Circle
Redmond, WA 98052

Dear Mr. Gustafson:

**REQUEST FOR PERMISSION TO INCLUDE PROPRIETARY DRAWINGS INTO RPP-6485, "TECHNICAL INFORMATION TO SUPPORT DST EMERGENCY ANNULUS APUMPING"**

CH2MHill Hanford Group, Inc. would like to include the following proprietary drawings in the "Publicly" release document RPP-6485, "Technical Document to Support DST Emergency Annulus Pumping":

| | |
|---|---|
| Drawing No. 2A0001 | Title: HS8001 Series Hydrostar Sampling Pumps |
| Drawing No. 2A0084 | Title: Air Motor Assy. 2.00" x 12" |
| Drawing No. 2A0020 | Title: Well Completion Assy. PVC/AL/PVC 2" |
| Drawing No. 2D0025 | Title: Rod Assembly 1/4" 1', 2', 3', 5', 10' |

The equipment identified in these drawings was procured to support pumping of the annulus tank of a double shell tank if the primary tank were to leak. This equipment has been satisfactory tested will b3e stored until needed. The technical document referred to above will be included with the equipment to provide reference information if it is needed. CH2MHill Hanford Group, Inc. would like to obtain permission to include the aforementioned proprietary drawings into document RPP-6485.

If you have any questions or further assistance, please contact me at (509) 376-9886. The signatory below has provided their approval to include the above noted proprietary drawings into document RPP-6485.

Lisa Domnoske-Rauch

Lisa Domnoske-Rauch, Cognizant Engineer
Double Shell Tank Cognizant Engineering

APPROVAL:

G. S. Gustafson, President
Instrumentation Northwest, Inc.

9/8/00
Date

blm

# DISTRIBUTION SHEET

| To | From | Page 1 of 1 |
|---|---|---|
| DISTRIBUTION | DST ENGINEERING | Date 8/3/00 |
| Project Title/Work Order | | EDT No. 619712 |
| RPP-6485, "Technical Information to Support DST Emergency Annulus Pumping" | | ECN No. N/A |

| Name | MSIN | Text With All Attach. | Text Only | Attach./ Appendix Only | EDT/ECN Only |
|---|---|---|---|---|---|
| DG Baide | S5-05 | X | | | |
| MH Brown | T4-07 | X | | | |
| RG Harwood | H6-60 | X | | | |
| CE Shipler | S2-25 | X | | | |
| RE Larson | T4-07 | X | | | |
| PC Miller | R1-51 | X | | | |
| LA Domnoske-Rauch | S5-13 | X | | | |
| DW Reberger (3) | S5-13 | X | | | |
| RW Reed | T4-07 | X | | | |
| MJ Sutey | S5-07 | X | | | |
| FM Hauck | A3-04 | X | | | |
| PM Dorsh | A3-04 | X | | | |
| GA Leshikar | S0-08 | X | | | |

# Technical Information to Support DST Emergency Annulus Pumping

**DW Reberger**
CH2MHill Hanford Group Inc.
Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-~~96RL13200~~ 99RL-14047

EDT/ECN: 619712 UC: 2020
Org Code: 74120 Charge Code: 111273
B&R Code: EW3130010 Total Pages: 448

Key Words: Double Shell Tank, Annulus Emergency Pumping, Tank Farm Emergency, Pumping, Secondary Containment, Annulus

Abstract: This document serves as a summarization of information relative to DST annulus emergency pumping.

*Flygt is a registared trademark of ITT Flygt Aktiebolog
*Hydrostar is a registered trademark of Kayaba Kogyo Kabushiki Kaisha

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

SEP 14 2000
DATE
STA 4
4
ID:

9/13/00
Release Approval Date Release Stamp

**Approved For Public Release**

# Technical Information to Support DST Emergency Annulus Pumping

Supporting Document prepared by: DW Reberger, DST Engineering
CH2MHill Hanford Group Inc.

# TABLE OF CONTENTS

Objective.....1

## APPENDICES

APPENDIX A DST ANNULUS PUMPING PROCEDURE LIST.....6
APPENDIX B FLYGT BS-2060 PUMP PERFORMANCE CURVE & ELECTRICAL DIAGRAM.....9
APPENDIX C FLAMMABLE GAS ISSUES.....11
APPENDIX D PROCUREMENT DOCUMENTATION .....62
APPENDIX E DRAWINGS.....137
APPENDIX F SPARE PARTS.....143
APPENDIX G JUMPERS.....148
APPENDIX H CALCULATIONS.....152
APPENDIX I ANNULUS PUMP CRITERIA LETTERS.....417
APPENDIX J SKETCHES FOR PUMP TEST TANK.....428
APPENDIX K FABRICATION.....436

## Objective

This document provides the design calculations for the DST Annulus Emergency Pumping Project. This document also contains essential information relative to DST annulus emergency pumping that may not be found in other documents. This information consists of the following:

- Index drawing for annulus pumping
- References to the Acceptance Test Report, DST Emergency Pumping Guide, Time Deployment study, etc.
- Statements of work
- Reference CEIS and RMIS numbers

A Vendor Information document, VI-50121, is not included in this document, but a copy can be obtained by contacting Document Control Services. This document contains various information regarding the Hydrostar pumps, such as the air motor, cylinder size, pump installation and operation manual. It also contains information regarding the Flygt BS2060 submersible pump, such as parts list, pump handling, preventative maintenance, overhaul and repair. In addition, this document also has information on 3-way PM ball valves, electrical skid components and the alternate Gorman-Rupp stainless steel submersible pump.

Information in this document is organized into appendices, with a short discussion appearing below relative to each appendix. This document serves as a summarization of information.

**APPENDIX A** DST ANNULUS PUMPING PROCEDURE LIST

Provides listing of procedural document number and title for documents related to DST annulus pumping. This listing includes the Operational Test Procedure, OTP-001-001, which discusses the mandatory impeller rotation of the pump to prevent the seals from sticking if the pump is stored for more than a 6 month period.

**APPENDIX B** FLYGT BS-2060 PUMP PERFORMANCE CURVE & ELECTRICAL DIAGRAM

Manufacturers pump performance data for the BS-2060 pump and electrical diagram.

**APPENDIX C** FLAMMABLE GAS ISSUES

Flammable gas Report, FGEAB-00-002 Revision 1, approved Hydrostar and Flygt pumps. The electrical cable feed to the junction chamber was required, by the report, to be evaluated to meet Ignition Source Control Set 1 (ISC1) requirements (NEC Class 1, Division 1, Group B). Several cc-mails address this issue.

The Hydrostar pump was determined to provide equivalent safety to Ignition Source Control Set 1.

The Gorman-Rupp was also presented to the Flammable Gas Equipment Advisory Board (FGEAB), but was unacceptable because it did not have sufficient barriers to the electrical components. In general for pumps, the Flammable Gas Equipment Advisory Board required a double mechanical sealing barrier between potential flammable gas region and electrical components. A single metal housing provided an adequate barrier, but seals on shafts needed double isolation. All electrical components are required to be normally non-sparking or a modification to non-incendive or intrinsically safe.

## **APPENDIX D** PROCUREMENT DOCUMENTATION

Statement of work, #39121, Statement of Work for Annulus Pumping Time Deployment Study
Statement of work, #39142, Statement of Work for Annulus Pumping
Statement of work, #39151, Statement of Work for Annulus Pumping

Interoffice memo 74100-00-029, upgraded the existing spare Flygt pumps from Quality Level 0 to 3. The catch tank pumps are spared under #6111-5514-5670 catalog ID# 552920. Bill of material (BOM)

Procurement Specification, 4975-59-P1 Rev. 0, Annulus Submersible Transfer Pump, provides the minimum requirements for a submersible transfer pump and any special handling equipment required for pump shipping and installation.

Procurement Specification 4975-59-P2 Rev. 0, Annulus Heel Pump, provides the minimum requirements for an air driven heel pump and any special handling equipment required for pump shipping and installation.

A significant number of pumps (>20) were investigated. Twelve vendors were checked more thoroughly. Refer to the listing for reasons why each was eliminated from consideration.

The Flygt BS-2060 has been used on-site since the early 1980's for catch tank pumping (i.e.241-A-302A, 241-ER-311, etc.). The "B" in the model number stands for Multi-vane, open or semi-shrouded impellers for dirty water containing abrasive particles. The "S" stands for Slim Design.

## APPENDIX E DRAWINGS

Drawings included are:

- H-14-104118, Drawing List for Annulus Pumping
- 2A0001, HS-8001-1 Series Hydrostar Sampling Pump
- 2A0004, Air Motor Assembly
- 2A0020, Well Completion Assembly
- 2A0025, Rod Assembly

## APPENDIX F SPARE PARTS

Itemized listing of parts needed to support central pump pit jumper fabrication for annulus pumping. The remaining loose parts stored in the trailer for the pump assembly and annulus jumper have parts lists on the appropriate drawing. Seven Flygt BS-2060 pumps are stored in spare parts under Stock Number 6111-5514-5670 and a modified spare pump in convenient storage under 9900-4865-8002.

## APPENDIX G JUMPERS

To expedite the deployment, pre-fabricated jumpers were considered. The best case assumed a flex could be incorporated into the design near the connector to overcome minor as-built dimensional differences in similar pits. Jumper and pump assemblies are similar for AY and AZ tank farms and AN, AP, AW and SY tank farms.

## APPENDIX H CALCULATIONS

Calculation, DSTAP-P-001 Rev 0, DST Annulus Pump Line Losses provided by Fluor Federal Services Inc.

The objective of this calculation was to determine the line losses of a piping route that transfers waste from the annulus in tank AN-106 to tank AP-104, via existing lines. The line losses are used to select an annulus pump that will satisfy the pressure requirements of the route.

Design Criteria*/Input:

| | |
|---|---|
| Flow rate | 40 gpm minimum |
| Dynamic Viscosity | 30 cp maximum |
| Specific Gravity | 1.47 maximum |
| Temperature | 140 °F maximum |

Safety Class General Service

* Found in Appendix I: Annulus Pump Criteria Letters, 74100-00-005):

It was concluded that the total line loss, at a fluid discharge of 40 gpm, was 175 ft. A pump should be selected that will satisfy this operating condition. Multiple pumps operating in tandem are acceptable, if necessary, to achieve the appropriate discharge head required based on the transfer route distance.

The Flygt pump was the only pump that met the size, flow, and flammable gas criteria.

Calculation, DSTAP-P-002 Rev 0, DST Annulus Jumper Orifice Design provided by Fluor Federal Services Inc.

The purpose of the calculation is to size an orifice, which will be used to reduce the flow rate in the annulus pump pit transfer piping. The transfer line connecting the annulus pump pit to the central pump pit in the AY-101, AY-102 and AZ-102 tanks are direct buried pipe. A flow restriction of 50 gpm is placed on these lines based on the following.
Administrative Control (AC) 5.12 states, "Perform ground level radiation surveys of any single-walled, direct buried/bermed lines that are part of the WASTE transfer route... every 30 minutes during submersible pumping (maximum of 50 gpm)."

It was concluded that a centrally located orifice with a diameter of 0.9 inches should be used in an annulus jumper which required a 50 gpm flow restriction. This number assumes that only one submersible pump is used (as opposed to a tandem arrangement)

Calculation, DSTAP-P-003 Rev 0, DST Annulus Pump Transfer Line Pressure provided by Fluor Federal Services Inc.

The objective of this calculation was to determine if the Hydrostar air pump could pressurize a transfer line above its design pressure

Calculation DSTAP-P-004 Rev 0, Annulus Jumper Piping Stress Analysis provided by Fluor Federal Services Inc.
The objective of this calculation was to perform static and seismic analysis for jumper piping. It was determined that the piping stresses meets acceptance criteria Code B31.3a.

Calculation DSTAP-P-005 Rev 0, DST Annulus Pump Test Piping Line Loss provided by Fluor Federal Services Inc.

Calculation Misc rev 0, DST Annulus Pump Miscellaneous Calculations provided by Fluor Federal Services Inc.

This includes calculations for air compressor sizing, desiccant filler replacement, Test Tank modification analysis, Test Tank sizing, radiation resistance of the Flygt submersible pump elastomers, weep hole sizing and annulus pump assembly

Calculation, DST-C-001 Rev 0, Portable DST Tank Skid provided by Fluor Federal Services Inc.

The objective of this calculation was to check the portable skid structure.

Calculation, DST-C-002 Rev 0, Fused Disconnect Skid provided by Fluor Federal Services Inc.

The objective of this calculation was to check the fused disconnect skid structure.

**APPENDIX I** ANNULUS PUMP CRITERIA LETTERS

This appendix includes letter 74100-00-005, Annulus Pump Design Criteria which discusses the criteria required to support the design of a new style of Annulus Pumps for the DST system and CO-00-RPP-237, Contract No. 4975, release No. 59, DST Annulus Pumping (L-02), which discusses the design of the Hydrostar and Flygt pumps..

**APPENDIX J** SKETCHES FOR PUMP TEST TANK

Sketches in this appendix include:

- Drawings of the Test Skid for the submersible pump arrangement
- Air pump in tank test arrangement
- Mock annulus riser and lower pump arrangement
- Air driven pump adapter arrangements and assembly
- Jumper assembly

**APPENDIX K** FABRICATION

The following Fabrication Requests are located in this appendix. Copies of the work packages can be found in the Annulus Pumping Trailer.

| | |
|---|---|
| 2H-0004706/F | 2H-0004768/F |
| 2H-0004769/F | 2H-0004777/F |
| 2H-0004824/F | |

# APPENDIX A
# DST ANNULUS PUMPING PROCEDURE LIST

# DST ANNULUS PUMPING PROJECT

## WEEKLY PROCEDURE STATUS: 7/6/00 5:16 PM

| DOCUMENT NUMBER | TYPE | DESCRIPTION | DRAFT START | DRAFT COMPLETE | TO 1ST COG REVIEW | TO V & V | 2ND COG REVIEW | APPROVAL CYCLE | APPROVED | WRITER | PRIORITY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ATP-001-001 | ATP | DST ANNULUS PUMPING ATP & PRE-INSTALLATION OTP | COMPLETE | COMPLETE | C-5/31/00 | 6/8/2000 | COMPLETE | COMPLETE | 6/20/2000 | WHITE | W-3 |
| OTP-001-001 | OTP | PRE-INSTALLATION RUN-IN PROCEDURE | COMPLETE | COMPLETE | COMPLETE | COMPLETE | IN PROCES | 6/22/2000 | PENDING | DRAPER | DR-1 |
| TO-001-281 | TO | AN FARM EMERGENCY PUMPING | COMPLETE | COMPLETE | COMPLETE | 5/19/2000 | COMPLETE | COMPLETE | 6/15/2000 | COLEMAN | C-2 |
| TO-001-282 | TO | AP FARM EMERGENCY PUMPING | COMPLETE | COMPLETE | COMPLETE | COMPLETE | COMPLETE | COMPLETE | 6/5/2000 | COLEMAN | C-1 |
| TO-001-283 | TO | AW FARM EMERGENCY PUMPING | 5/23/2000 | 6/1/2000 | 6/1/2000 | 6/8/2000 | COMPLETE | COMPLETE | 6/15/2000 | COLEMAN | C-4 |
| TO-001-284 | TO | SY FARM EMERGENCY PUMPING | 5/1/2000 | 5/15/2000 | 5/15/2000 | 5/31/2000 | COMPLETE | COMPLETE | 6/20/2000 | WHITE | W-1 |
| TO-001-288 | TO | AY FARM EMERGENCY PUMPING | COMPLETE | COMPLETE | 5/23/2000 | 5/31/2000 | COMPLETE | COMPLETE | 6/15/2000 | COLEMAN | C-3 |
| TO-281-289 | TO | AZ FARM EMERGENCY PUMPING | 5/18/2000 | 5/28/2000 | 5/30/2000 | 6/8/2000 | COMPLETE | COMPLETE | 6/19/2000 | WHITE | W-2 |
| ET-07459 | PM | ROTATE UPPER PUMP-2 | COMPLETE | 6/1/2000 | | | | | 6/7/2000 | LAPOINT | LA-6 |
| ET-07460 | PM | ROTATE LOWER PUMP-1 | COMPLETE | 6/1/2000 | | | | | 6/7/2000 | LAPOINT | LA-1 |
| ET-07462 | PM | FLOW INDICATING TRANSMITTER | COMPLETE | 6/1/2000 | | | | | 6/7/2000 | LAPOINT | LA-2 |
| ET-07461 | PM | PRESSURE INDICATOR-101 | COMPLETE | 6/1/2000 | | | | | 6/7/2000 | LAPOINT | LA-3 |
| ET-07464 | PM | PRESSURE INDICATOR-102 | COMPLETE | COMPLETE | | | | | 7/6/2000 | LAPOINT | LA-4 |
| 6-FCD-454 | CAL | CALIBRATE FLOWMETER | | | COMPLETE | | | | 6/13/2000 | LAPOINT | LA-4 |
| 6-PCD-509 | CAL | CALIBRATE PRESSURE INDICATOR | **REPLACES 6-TF-509.** | | | | | | | LAPOINT | LA-5 |

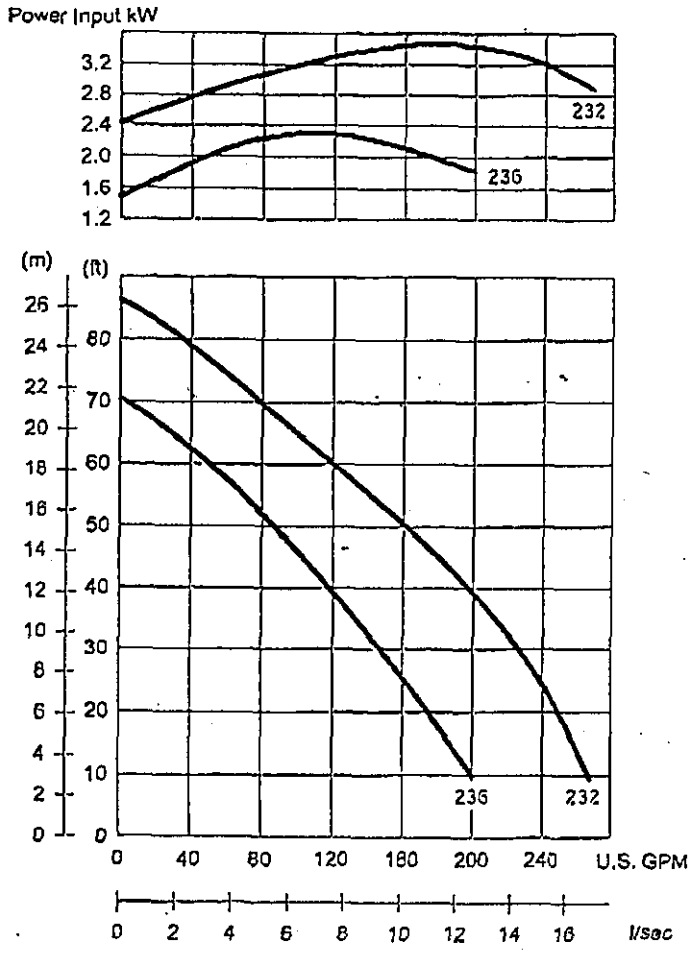
RPP-6985 Rev. 0

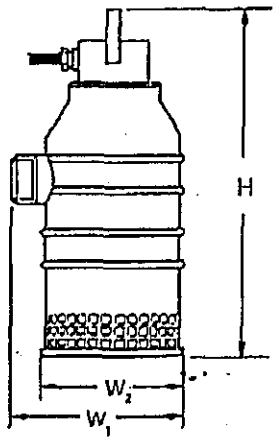
# APPENDIX B
# FLYGT BS-2060 PUMP PERFORMANCE CURVE & ELECTRICAL DIAGRAM

RPP 6485 Rev D

# BS-2060.390

## Performance Data




### Dimensions

| Discharge conn. | $W_1$ inches | $W_1$ mm | $W_2$ inches | $W_2$ mm | H inches | H mm | Weight lbs. | Weight kg | Tandem conn.* |
|---|---|---|---|---|---|---|---|---|---|
| 2 1/2" Hose or 3"- 8 NPSM (male thread) | 11 1/4 | 282 | 8 3/4 | 220 | 22 | 560 | 71 | 32 | 3" Hose conn. 3"- 8 NPSM |

*Optional

| VERSION | IMP. CODE | HP | PHASE | VOLTS | FLA | LRA | CABLE SIZE AWG | MAX. CABLE LENGTH (FT.) |
|---|---|---|---|---|---|---|---|---|
| Standard MT | 236 | 2.5 | 1 | 230 | 11 | 38 | 12/7 | 150 |
| | 232 | 3.6 | 3 | 208 | 10.8 | 60 | 12/7 | 170 |
| | | | | 230 | 9.4 | 52 | | 225 |
| | | | | 460 | 4.7 | 26 | | 900 |
| | | | | 575 | 3.8 | 21 | | 1,350 |

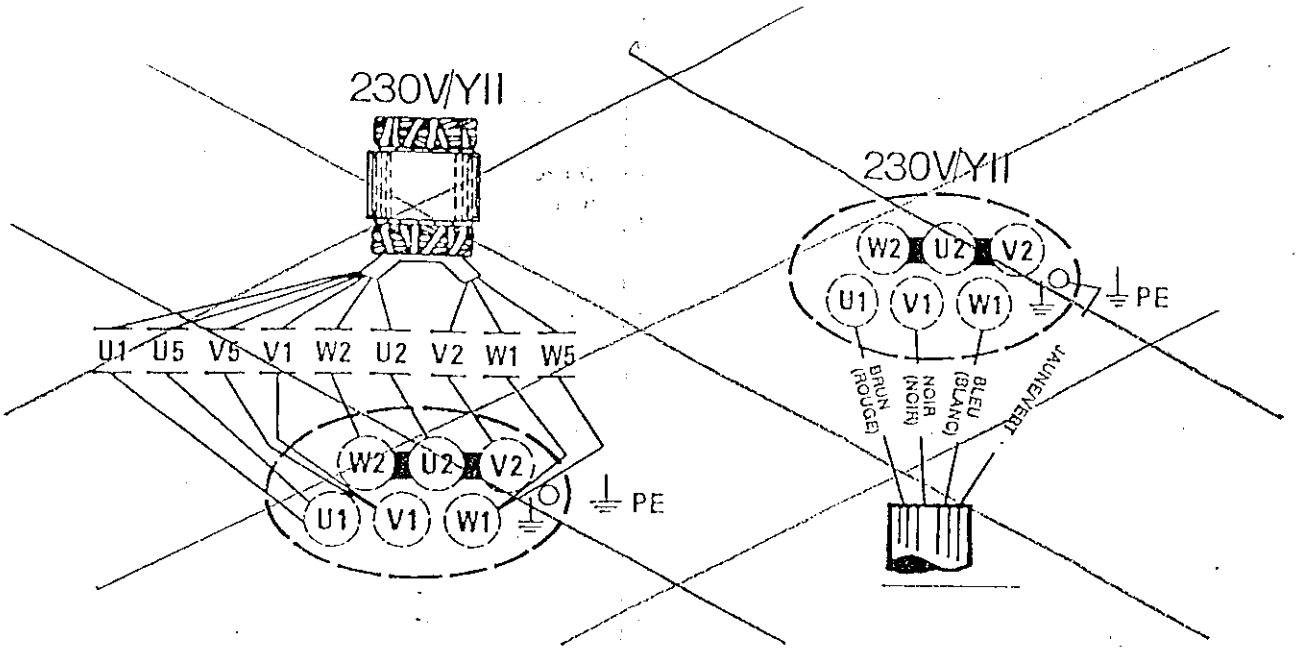
ITT Flygt Corporation reserves the right to modify performance, specifications or design without notice.

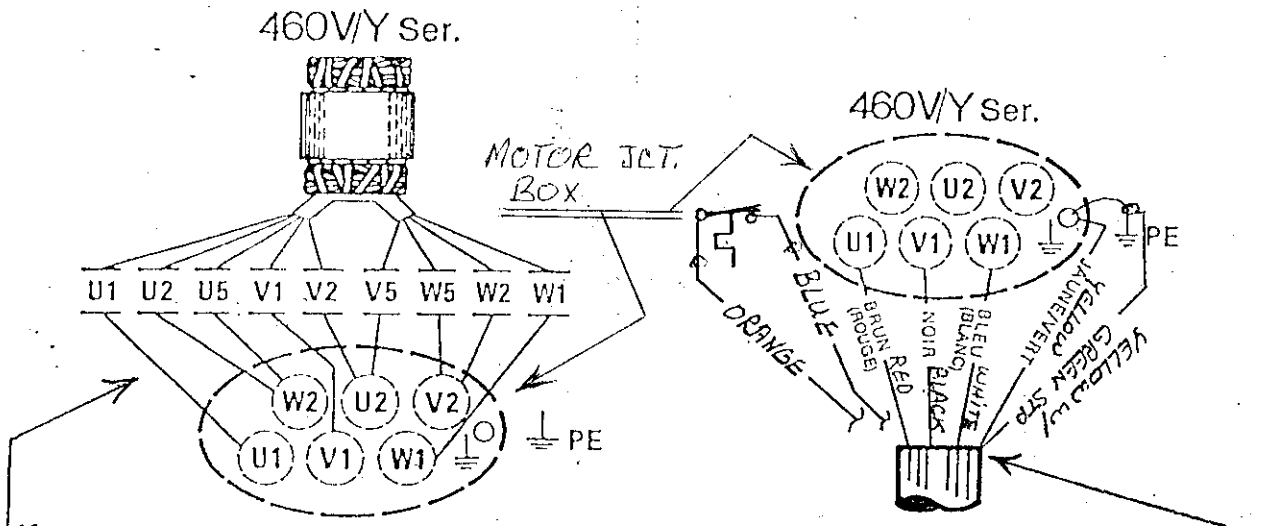
FLYGT
An ITT Industries company
ITT FLYGT CORPORATION, 35 Nutmeg Dr., P.O. Box 1004, Trumbull, CT 06611-0943, Tel. (203) 380-4700 Telefax (203) 380-4700
ITT Flygt Canada, 300 Labrosse Ave., Pointe Claire (Montreal) P.Q. H 9R-4V5. (514) 695-0100

BS-2060.390 FLYGT is a registered trademark of ITT Flygt Corporation, Trumbull, CT Copyright © 1998 by ITT Flygt Corporation, Trumbull, CT Printed in U.S.A.

RPP-6485 Rev. 0

## 9-lead stator



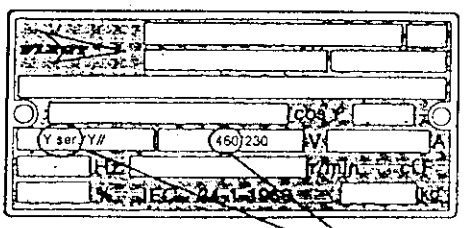




MOTOR INTERNAL LEADS

U1 - RED
U2 - GREEN
U5 - RED

V1 - (TAN) BROWN
V2 - BLUE
V5 - (TAN) BROWN

W1 - YELLOW
W2 - BLACK
W5 - YELLOW




* NOTE! When connecting pumps which have 1 9-lead stator for 460V Y Ser. 60 Hz, no closing links should be used. For correct connection, see inside of junction box cover.

POWER CABLE

U1 - RED
V1 - BLACK
W1 - WHITE

GND - YELLOW
— YELLOW/GREEN STRIPE

THERMAL SWITCH —
— ORANGE
— BLUE
7 - #12 WIRES

REM 6/9/00

# APPENDIX C
# FLAMMABLE GAS ISSUES

## Reberger, Dan W

**From:** Merriman, Raymond E
**Sent:** Wednesday, March 22, 2000 12:50 PM
**To:** Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck)
**Cc:** Merriman, Raymond E; Reberger, Dan W; Rarig, Bradley K
**Subject:** Flygt Pump - Power Cable

All:

I Faxed the cable specification for the Flygt Pump to all of you, except Chuck, yesterday. I made an incorrect notation on the bottom of the front page that the cable was "Not Class 1, Div.1, Gp B". It has been pointed out to me that the cable does meet the requirement of NEC 501-11 and as such it does meet the above requirements for Class 1, Div. 1, Gp B.

I have also checked out the cable specification with the chairperson and secretary the Hanford Electrical Contractor Safety Board, and they agree that the cable meets the requirements of NEC 501-11.

As such, the cable is acceptable to be used in a Class 1, Div, 1, Gp B situation such as the DSTs.

Please review this information and let me know if you concur or if I have overlooked something.

Thank You

Ray

Post-It™ brand fax transmittal memo 7671 | # of pages ▸ 3

| To DAN REBERGER | From PAUL DORSH |
|---|---|
| Co. | Co. |
| Dept. | Phone # |
| Fax # 376-1634 | Fax # |

# Cross Reference Chart

| AWG | mm² | AWG | | | |
|---|---|---|---|---|---|
| 16 | 1.5 | 6 | | | |
| 14 | 2.5 | 4 | 25 | 3/0 | 95 |
| 12 | 4 | 2 | 35 | 4/0 | 120 |
| 10 | 6 | 1 | 50 | 300MCM | 150 |
| 8 | 10 | 1/0 | 70 | 350MCM | 185 |

Metric wire sizes are expressed as millimeters squared. This is the cross-sectional area of the copper conductor.

# SUBCAB-AWG Sales Specification

***SUBCAB-AWG are those SUBCAB cables that are designed specifically to the U.S. and Canadian standards in the size range # 14 AWG through # 1 AWG.***

The power cable shall be designed specifically for use with submersible pumps and shall be type SUBCAB (SUBmersible CABle). The cable shall be rated and applied in accordance with the National Electrical Code (NEC), and constructed according to the standards of the Insulated Cable Engineers Association (ICEA). The outer jacket shall be oil resistant chloroprene rubber, and the tinned copper conductors shall be insulated with ethylene-propylene rubber (EPR). The filler and conductor separator materials shall be of non-wicking vulcanized rubber. One of the conductors shall include marking on its insulation so that the cable may be identified in the event the external marking becomes unreadable. The outer jacket of the cable shall be marked "Water Resistant". The cable shall be rated for 600 volts and 90° C with a 40° C ambient temperature and shall be approved by Factory Mutual (FM) and the Mining Safety and Health Administration (MSHA). The cable length shall be adequate to reach the junction box without the need for splices".

# SUBCAB-Metric Sales Specification

***SUBCAB-IEC are those SUBCAB cables that are designed to the international electrical standard IEC. They are usually used on large pump drive units as power and pilot cables.***

The power cable shall be designed specifically for use with submersible pumps and shall be type SUBCAB (SUBmersible CABle). The cable shall be rated and applied in accordance with the National Electrical Code (NEC). The outer jacket shall be oil resistant chloroprene rubber, and the copper conductors shall be insulated with ethylene-propylene rubber (EPR). The filler and conductor separator materials shall be of

~~non-wicking~~ vulcanized rubber. All jacket and insulation materials shall be lead free. ~~The cable outer~~ jacket shall be marked "~~Water Resistant~~". The cable shall ~~be rated for 750~~ volts and 90° C with a 40° C ambient temperature and shall ~~be approved~~ by Factory Mutual ~~(FM). The cable length~~ shall be adequate to ~~reach the junction~~ box without the need for splices".

# SUBCAB-AWG Technical Data

| CABLE | PART NUMBER | PWR (3) (AWG) | GND (1) (AWG) | CNTL (2) (AWG) | GC (1) (AWG) | DIAMETER INCHES (MM) | WEIGHT LBS/FT | RATING AMPS* (@ 30°C) |
|---|---|---|---|---|---|---|---|---|
| #14/4 | 94 21 01 | 15 | 14 | N/A | N/A | 0.56 - 0.6 (14.2 -15.2) | 0.22 | 25 |
| #14/7 | 94 21 02 | 14 | 14 | 14 | 14 | 0.71 - 0.79 (18.0 - 20.0) | 0.34 | 25 |
| #12/4 | 94 21 03 | 12 | 12 | N/A | N/A | 0.67 - 0.71 (17.0 - 18.0) | 0.32 | 30 |
| #12/7 | 94 21 04 | 12 | 12 | 12 | 12 | 0.79 - 0.87 (20.0 - 22.0) | 0.46 | 30 |
| #10/4 | 94 21 05 | 10 | 10 | N/A | N/A | 0.71 - 0.77 (18.0 - 19.7) | 0.4 | 40 |
| #10/3-2-1-GC | 94 21 06 | 10 | 10 | 12 | 12 | 0.80 - 0.88 (20.3 - 22.3) | 0.54 | 40 |
| #8/4 | 94 21 07 | 8 | 8 | N/A | N/A | 0.94 - 1.02 (24.0 - 26.0) | 0.67 | 65 |
| #8/3-2-1-GC | 94 21 08 | 8 | 8 | 10 | 10 | 1.07 - 1.15 (27.2 - 29.2) | 0.87 | 65 |
| #6/3-2-1-GC | 94 21 09 | 6 | 8 | 10 | 10 | 1.18 - 1.26 (30.0 - 32.0) | 1.00 | 87 |
| #4/3-2-1-GC | 94 21 10 | 4 | 6 | 10 | 10 | 1.29 - 1.37 (32.8 - 34.8) | 1.3 | 114 |
| #1/3-2-1-GC | 94 21 11 | 1 | 4 | 10 | 8 | 1.60 - 1.68 (40.7 - 42.7) | 2.4 | 177 |

*For ampacity @ 70°C, multiply 30° ampacity by 0.58

**GENERAL**

SUBCAB is manufactured to ITT Flygt specifications and in accordance with the following standards:

- Insulated Cable Engineers Association (ICEA No. S-68-516).
- National Electrical Manufacturers Association (NEMA No. WC 8).
- Canadian Standards Association (CSA C 22.2, No. 49).

## RATINGS

- Voltage - 600 Volts;
- Current - Determined by size of conductors;
- Temperature - 90° C total, based on a 40° C ambient.

## CODING

- Power conductors - Black, White, Red;
- Ground Conductors - Green/Yellow or Green;
- Control Conductors* - Blue and Orange;
- Ground check* - Yellow.

*7-conductor cables only.

## MATERIALS

- Jacket - Chloroprene rubber
- Conductor insulation - Ethylene Propylene Rubber (EPR)

## APPROVALS

- Factory Mutual;
- Mine Safety and Health Administration (MSHA);
- Canadian Standards Association (CSA).

# SUBCAB-Metric Technical Data

| CABLE | PART NUMBER | DIAMETER INCHES (MM) | WEIGHT LBS/FT | RATING AMPS* (@30°C) | AWG EQUIV. |
|---|---|---|---|---|---|
| 7X1.5 | 94 19 22 | 0.59 - 0.67 (15 - 17) | 0.26 | 20 | #16 |
| 12X1.5 | 94 19 20 | 0.72 - 0.83 (18.2 - 21.2) | 0.36 | 20 | #16 |
| 24X1.5 | 94 19 21 | 0.98 - 1.14 (24.9 - 28.9) | 0.65 | 20 | #16 |
| 7G1.5 | 94 20 53 | 0.59 - 0.67 (15 - 17) | 0.26 | 20 | #16 |
| 4G10 | 94 20 45 | 0.93 - 1.0 (23.5 - 25.5) | 0.65 | 74 | #8 |
| 4G16 | 94 20 46 | 1.02 - 1.1 (26.0 - 28.0) | 0.84 | 99 | #6 |
| 4G25 | 94 20 47 | 1.28 - 1.36 (32.5 - 34.5) | 1.28 | 131 | #4 |
| 4G50 | 94 20 66 | 1.61 - 1.77 (41 - 45) | 2.29 | 192 | #1 |
| 4G70 | 94 20 67 | 1.77 - 1.93 (45 - 49) | 3.02 | 237 | #1/0 |
| 4G95 | 94 20 68 | 2.13 - 2.28 (54 - 58) | 3.9 | 286 | #3/0 |
| [illegible] | [illegible] | 2.20 - 2.36 | [illegible] | [illegible] | [illegible] |

# Double-Shell Tank Annulus Transfer Pump
# Gorman-Rupp Model SM2E Electric Submersible Pump
# Submitted For FGEAB Evaluation

Preparations are underway to be ready to pump the annulus of any Double-Shell Tank in the event of a primary tank waste leak. The method for pumping an annulus is to have a submersible pump staged in a mobile trailer ready to deploy when a leak is identified. The DST's are either a Facility Group 1 or 2 and the pump column is considered Waste Intruding Equipment and must meet ISC Set 1 per Table 5.10-1 of the TSR.

The candidate pump (Gorman-Rupp Model SM2E) is an electric, submersible, centrifugal type pump. It will be part of a rigid supported column assembly that will be installed through the annulus pump pit 12" riser and extend down to a depth of approximately 50-feet.

Key information regarding the Gorman-Rupp SM2E Submersible pump is summarized below:

• The pump is approved by the Mine Safety and Health Administration (MSHA), and has an explosion-proof motor.

• The pump has an air-filled motor isolated from the waste by upper and lower (2) mechanical shaft seals, which are, operate in oil, as shown

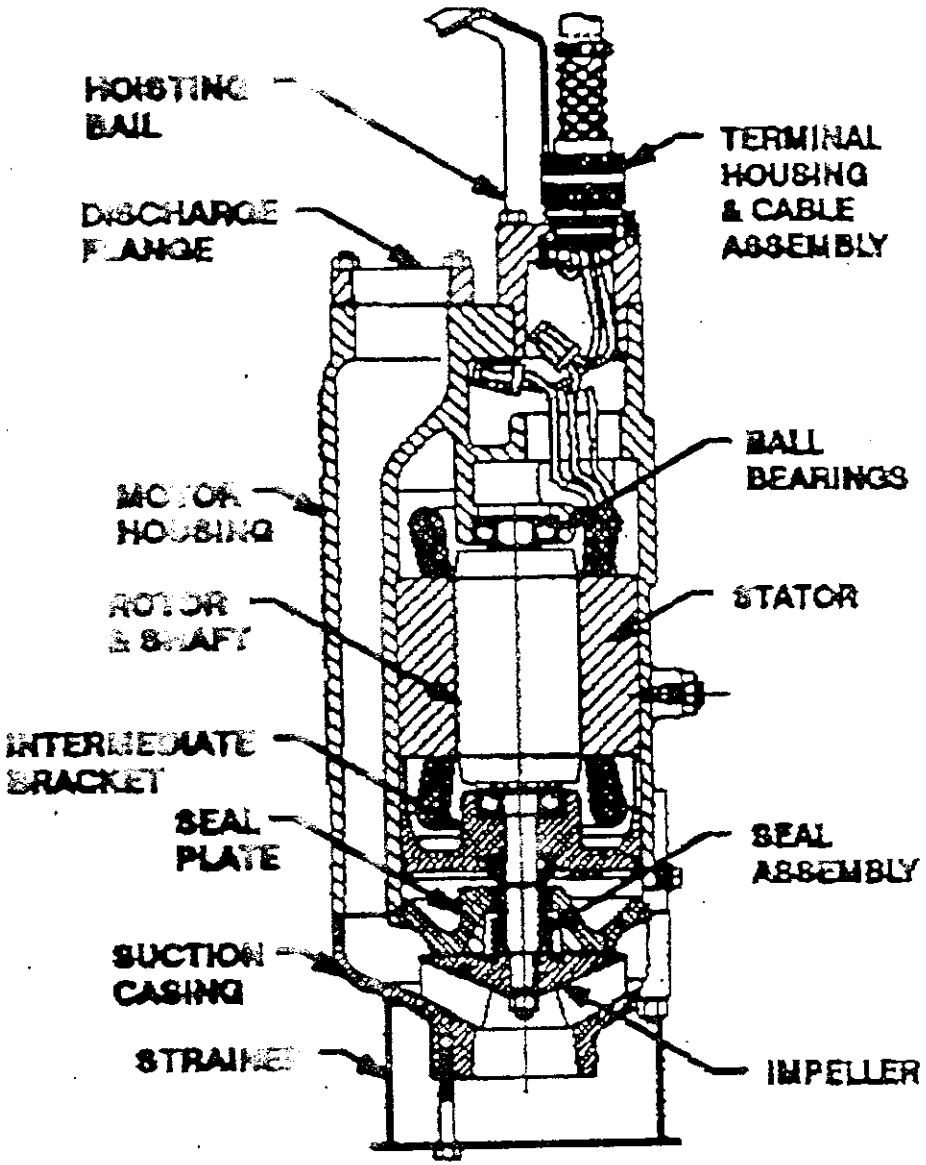
• Motor temperatures are monitored by two thermal switches, embedded in the end coils of the stator windings. The switches have normally closed contacts, activation of either switch will shutdown the pump motor. In order to minimize arcing they are of the snap-action type. The thermal switch opens at a temperature of 145°C (293°F) and closes at 90°C (194°F). The electrical signal from the thermal switches will be modified to intrinsically safe or disconnected. Any thermal protection will be provided in the pump start/stop station located adjacent to the pit.

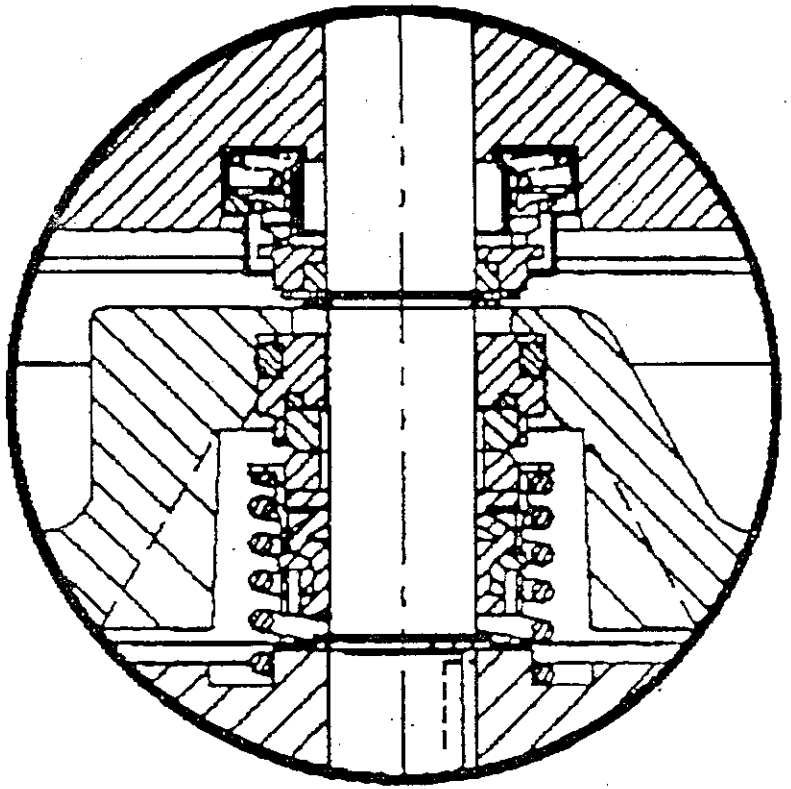
The following documentation is attached:

- Gorman-Rupp SM2E two page cutsheet (includes basic specifications, figures and performance data)
- Figure cutaway of pump internals and sketch of a representative tandem seal
- Descriptive Pages from a Gorman-Rupp Brochure
- Pages from the Gorman-Rupp Technical Manual
- Chemical resistance data on hypalon cable

03/14/00

This page intentionally left blank



Seal - Two. Operate in Oil

Upper - Type 22. Rotating Face is Cast Iron; Stationary Face is Carbon; Elastomers are Buna-N.

Lower - Type 2. Rotating and Stationary Faces are Silicon Carbide; Elastomers are Viton.

RPP-6485 REV. 0

RPP-6485 REV.D

# A complete line of American-made, MSHA approved submersible mine pumps.

Gorman-Rupp manufactures a complete line of submersible pumps designed for safe operation in gassy mines and tunnels.

Twenty-two different models are available in four basic discharge sizes: 2-inch, 3-inch, 4-inch and 6-inch. They are available from 1 to 60 horsepower, with capacities to 2175 gpm, heads to 380 feet.

These pumps are specifically designed for efficient mine dewatering operations. From the compact slimline design, which aids in portability and installation in the mine, to the superior hydraulic design, which reduces operating costs by delivering more gpm at less horsepower, the Gorman-Rupp submersible pump is the most efficient, dependable mine pump you can buy.

## American-Made.

Standard parts. Easy Service.

Gorman-Rupp submersibles are manufactured in the U.S. with standard parts. No waiting for days or weeks for special cables or parts to arrive.

And if service is required, it can be completed quickly and easily with common hand tools. The easy-to-service design permits removal of impeller and suction head without loss of oil in the seal cavity.

## MSHA Approved.

Gorman-Rupp submersibles are approved by the Mine Safety and Health Administration (MSHA) for use in gassy mines or tunnels. The approval is given for complete assemblies which include pump, control and cable. The components that make up this design cannot be changed or substituted without obtaining a new approval. All components must be restored to original condition after service.

These MSHA approved pumps should not be considered for use in hazardous environments other than mining without approval.

Most Gorman-Rupp pump models are also approved by the Commonwealth of Pennsylvania.

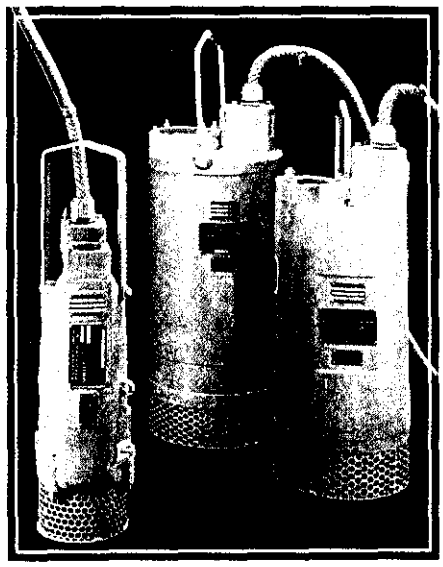
## Special metal construction for corrosive/abrasive applications

Gorman-Rupp submersibles are designed for continuous, unattended operation in the most hostile mine environments.

The rotor shaft and all internal nuts and bolts coming in contact with the liquid are made of stainless steel to resist corrosion and pitting and extend the operational life of the pump.

In addition, stainless steel fitted pump models are available for corrosive applications. The suction head, impeller, and diffuser are constructed of CD4MCu.

For severely corrosive/abrasive applications, pump models constructed entirely of CD4MCu and 316 SST are available.



## 'Round-the-clock unattended operation.

Gorman-Rupp submersibles are electric motor driven, so they operate unattended for long periods of time with no need for service personnel or fuel checks.

They operate totally or partially submerged, so there's no need to move the pump as the water level changes. The pumps are non-overloading, so they'll run even in the worst conditions. And the pumps are designed to run dry for reasonable periods of time without seal damage.

## Compact, slimline design for easy installation and handling.

The slimline design of Gorman-Rupp submersibles allows them to operate in hard-to-reach places where other pumps can't go. And they're light in weight for easy portability in the mine. For instance, the SM2F1 2" pump will deliver up to 110 gpm, yet weighs only 44 lbs. The easy-carry handles make handling and installation simple, even on the larger two-man units.

## Tandem, in-line design.

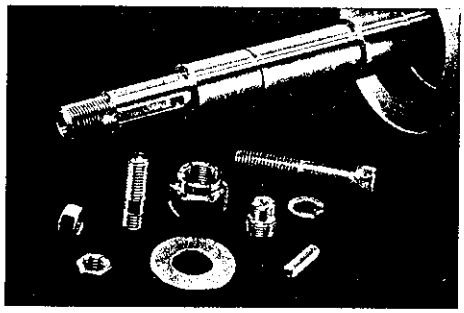
The discharge of one pump can be connected through hose and couplings to the suction of another for in-line series operation which effectively doubles the head at a given flow, eliminating the need for a variety of different size pumps. The narrow slimline design doesn't take up space, so the pumps stay clear of machinery and conveyors.

## Reduced operating costs.

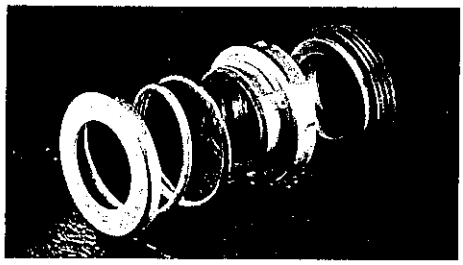
Gorman-Rupp submersibles are designed to provide maximum output with minimal power consumption. The improved hydraulic design allows them to deliver more gpm at less horsepower than other submersible mine pumps.

# Proven dependability is built into every Gorman-Rupp mine pump.

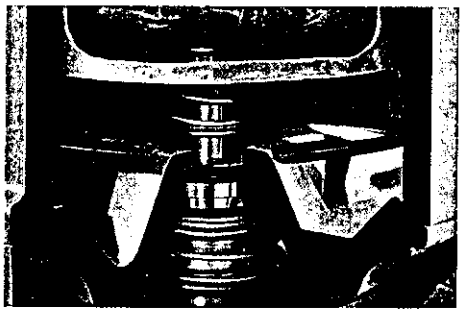
The Submersible Pump is so simple — only one moving part and three wearing surfaces. Behind this simplicity of design is Gorman-Rupp's innovative engineering and manufacturing quality control that assure rugged durability and extended pump life without costly maintenance.



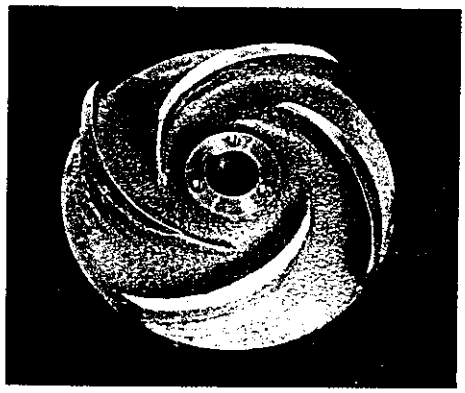
**Corrosion-reisistant stainless steel shaft and hardware.**
Rotor shaft and all internal nuts and bolts coming in contact with the liquid are made of stainless steel to resist corrosion and pitting and extend the operational life of the pump. For severely corrosive applications, stainless steel fitted and all-stainless pump models are available.



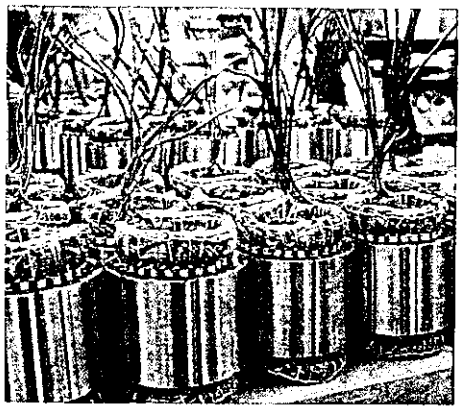
**Dual seals. Double protection.**
Primary seal keeps dirty water in the pump end and prevents contamination of the oil cavity. A second "fail safe" seal provides extra protection against the possibility of damage to the motor. Positive oil lubrication enables the pump to run dry without seal damage.



**Motor cavity keeps motor cool.**
When Gorman-Rupp submersibles start pumping, a flow of water is established between the inner and outer walls of the motor housing which cools the motor and prevents overheating.



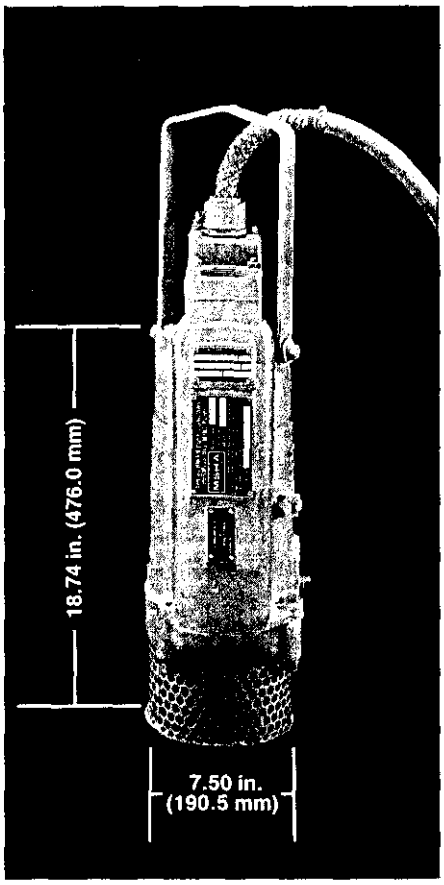
**Rugged impeller handles tough abrasives.**
Abrasion-resistant impellers stand up to coal fines, slurries, and other abrasive mining materials. The fully-shrouded impeller back reduces seal pressure and helps prevent foreign materials from entering the seal cavity. Seal life is extended and operational life of the pump is increased.



**Gorman-Rupp explosion-proof motors**
Three phase 460- or 575-volt explosion-proof motors specifically designed for vertical submersible pumps, and meet all MSHA requirements for use in hazardous mine locations (30 CFR, Part 18).

Pictured above are several motor stators which will undergo rigorous quality control checks before becoming part of a Gorman-Rupp explosion-proof motor.

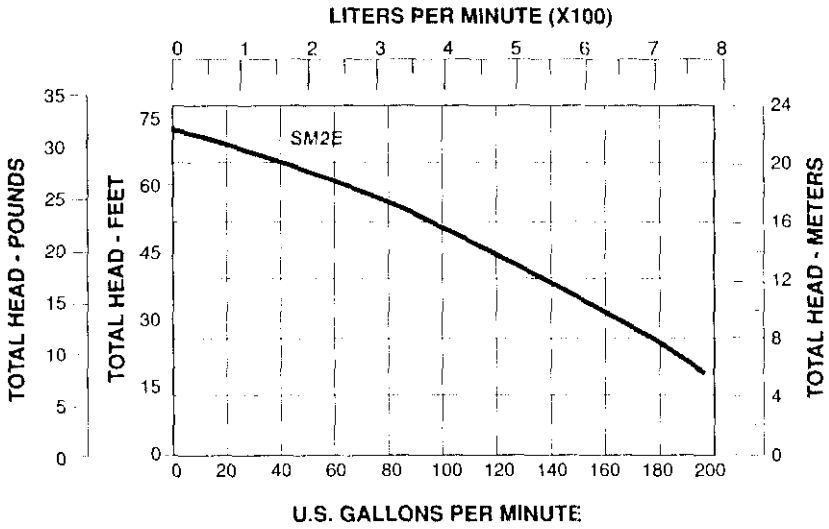
Manufacturing of pumps and controls at Gorman-Rupp provides single source responsibility and ensures fast parts service when necessary.

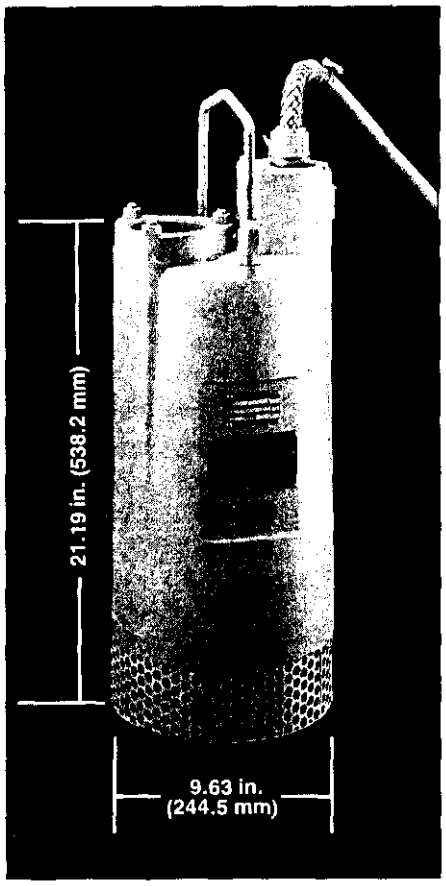



## Model SM2E

MSHA Approval No. 2G-3015A-2
Commonwealth of Pennsylvania No. BFE-637-77

| | |
|---|---|
| Discharge | 2-inch |
| Solids Handled | 5/16-inch |
| Horsepower | 3.5 |
| Hertz | 60 |
| RPM | 3450 |
| Voltage | 460 or 575 volt, 3 phase, 6.8 Kw |
| Cable | # 14 gauge, 50′ length |
| Weight | 57 lbs. |

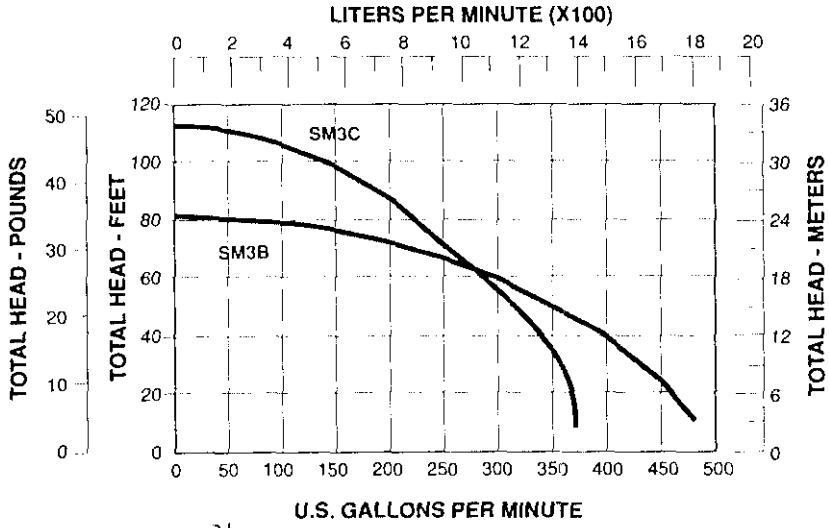



## Model SM3B and SM3C

MSHA Approval No. 2G-3481A-0
Commonwealth of Pennsylvania No. BFE-637-77

| | |
|---|---|
| Discharge | 3-inch |
| Solids Handled | 3/8-inch |
| Horsepower | 6 |
| Hertz | 60 |
| RPM | 3450 |
| Voltage | 460 or 575 volt, 3 phase, 6.8 Kw |
| Cable | # 10 gauge, 50′ length |
| Weight | 106 lbs. |



## SECTION DRAWING

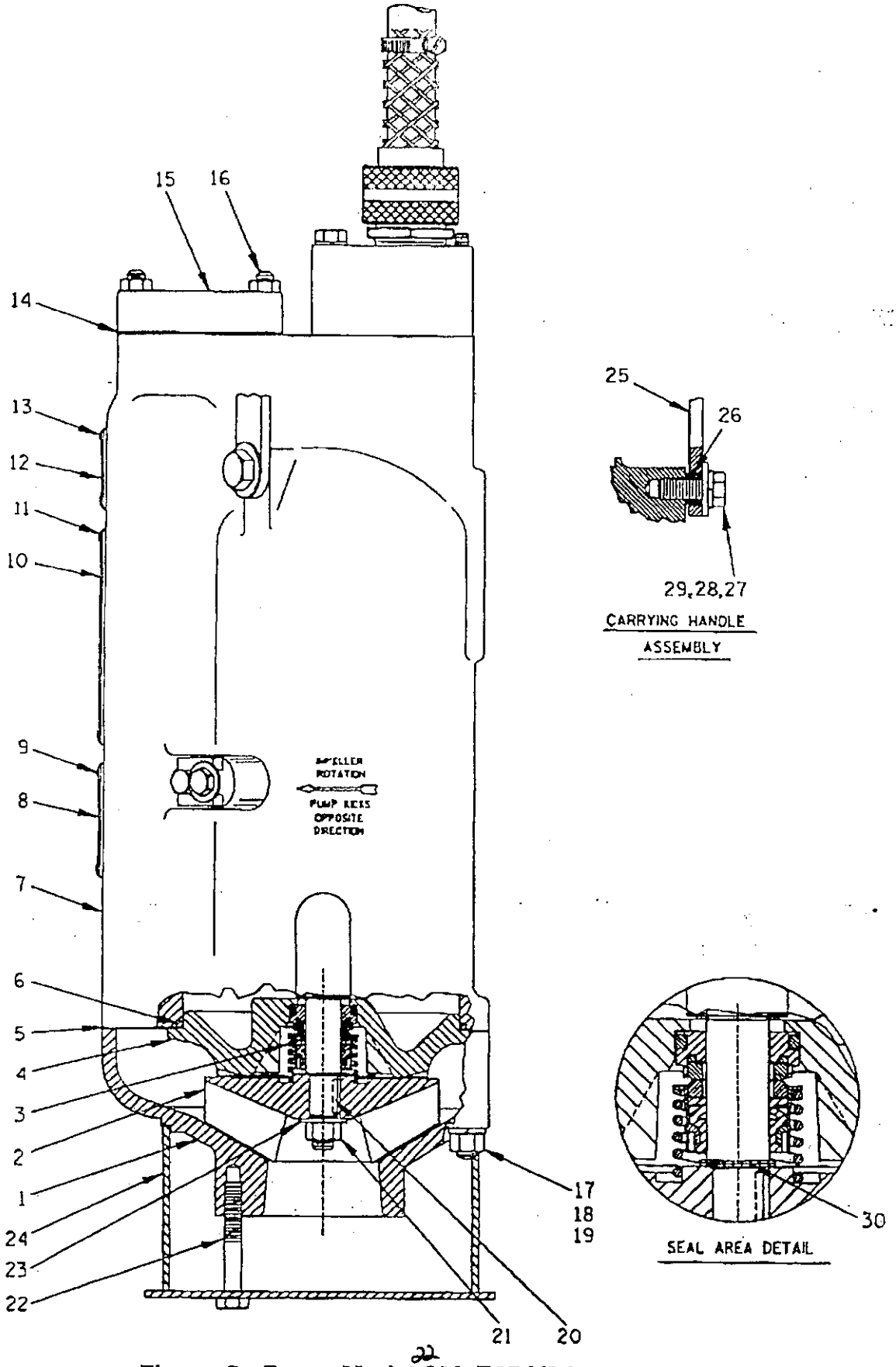



**Figure 3. Pump Model SM2E65-X3.5 460/3 & 575/3**

# PARTS LIST

## Pump Model SM2E65-X3.5 460/3 & 575/3

(From S/N 915775 up)

If your pump serial number is followed by an "N", your pump is NOT a standard production model. Contact the Gorman-Rupp Company to verify part numbers.

| ITEM NO. | | PART NAME | PART NUMBER | MAT'L CODE | QTY |
|---|---|---|---|---|---|
| 1 | | SUCTION CASING | 38222-430 | 1718H | 1 |
| 2 | * | IMPELLER | 38614-710 | 1718H | 1 |
| 3 | * | SEAL ASSEMBLY | 46512-069 | ----- | 1 |
| 4 | | SEAL PLATE | 38272-830 | 1718H | 1 |
| 5 | * | CASING GASKET | 38674-807 | 19370 | 1 |
| 6 | * | SEAL PLATE O-RING | 25154-250 | ----- | 1 |
| 7 | | MOTOR ASSY (460V) | 47111-068 | ----- | 1 |
| | | MOTOR ASSY (575V) | 47111-069 | ----- | 1 |
| 8 | | PENN DOER APPL PLT | 2613-FL | 17040 | 1 |
| 9 | | DRIVE SCREW | BM#04-03 | 17090 | 4 |
| 10 | | MSHA PLATE | 2613-ES | 17040 | 1 |
| 11 | | DRIVE SCREW | BM#04-03 | 17090 | 4 |
| 12 | | NAME PLATE | 2613-DD | 17040 | 1 |
| 13 | | DRIVE SCREW | BM#04-03 | 17090 | 4 |
| 14 | * | FLANGE GASKET | 10195-G | 19370 | 1 |
| 15 | | DISCHARGE FLANGE | 10195 | 17070 | 1 |
| 16 | | HEX NUT | D05 | 17090 | 4 |
| 17 | | STUD | C0611 | 17090 | 4 |
| 18 | | LOCKWASHER | J06 | 17090 | 4 |
| 19 | | HEX NUT | D06 | 17090 | 4 |
| 20 | * | IMPELLER KEY | N0202 1/2 | 17090 | 1 |
| 21 | * | IMPELLER NUT | D06 | 17090 | 1 |
| 22 | | NYLOCK CAPSCREW | BT0508 | 17090 | 4 |
| 23 | | FLAT WASHER | 21161-828 | ----- | 1 |
| 24 | | STRAINER ASSY | 46611-009 | 24170 | 1 |
| 25 | | HANDLE | 10185-A | 17050 | 1 |
| 26 | | BUSHING | 10194 | 17090 | 2 |
| 27 | | HEX HD CAPSCREW | B0604 | 17090 | 2 |
| 28 | | LOCKWASHER | J06 | 17090 | 2 |
| 29 | | FLAT WASHER | KB06 | 17090 | 2 |
| 30 | * | IMP ADJ SHIM SET | 669 | 17090 | 1 |
| NOT SHOWN: | | | | | |
| | | QUART SUBMERSIBLE PUMP OIL | 9568 | ----- | 1 |
| | | VOLTAGE TAG (430V) | 6588-BL | ----- | 1 |
| | | VOLTAGE TAG (575V) | 6588-BM | ----- | 1 |
| | | CONTROL BOX (460V) | 47631-146 | ----- | 1 |
| | | CONTROL BOX (575V) | 47631-147 | ----- | 1 |

* INDICATES PARTS RECOMMENDED FOR STOCK

Above Serial Numbers Do Not Apply To Pumps Made In Canada.

CANADIAN SERIAL NO. .....23..... AND UP

## SECTION DRAWING

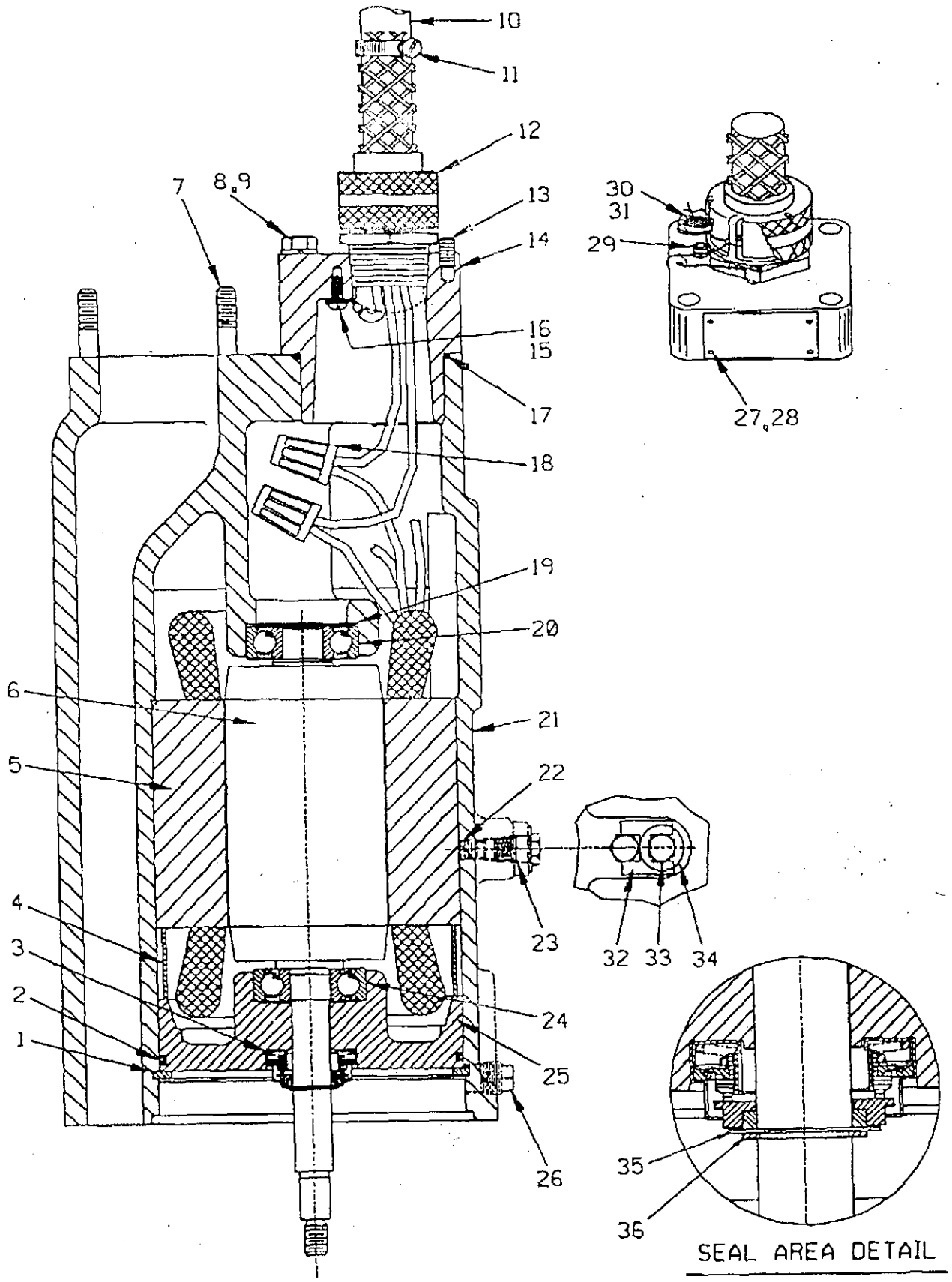





Figure 6. Pump Motor (SM2E65-X3.5 460/3 & 575/3)

# PARTS LIST

## Pump Motor 47111-068 (SM2E65-X3.5 460/3)
## and
## Pump Motor 47111-069 (SM2E65-X3.5 575/3)

| ITEM NO. | | PART NAME | PART NUMBER | MAT'L CODE | QTY |
|---|---|---|---|---|---|
| 1 | | RETAINING RING | 24121-077 | ----- | 1 |
| 2 | * | INTERMEDIATE O-RING | 25152-248 | ----- | 1 |
| 3 | * | MECH SEAL ASSY | 25276-011 | ----- | 1 |
| 4 | | MOTOR BUSHING | 31134-060 | 23010 | 1 |
| 5 | | STATOR (460V) | 47113-805 | ----- | 1 |
| | | STATOR (575V) | 47113-806 | ----- | 1 |
| 6 | | ROTOR & SHAFT ASSY | 47112-802 | ----- | 1 |
| 7 | | STUD | C0506 | 17090 | 4 |
| 8 | | HEX HD CAPSCREW | B0509 | 17040 | 4 |
| 9 | | LOCKWASHER | J05 | 17090 | 4 |
| 10 | | CABLE ASSY - 50 FT. | 47351-011 | ----- | 1 |
| 11 | | HOSE CLAMP | 26518-766 | ----- | 1 |
| 12 | | CABLE GRIP ASSY | 27111-816 | ----- | 1 |
| 13 | | ALLEN HEAD SETSCREW | GA0402 | 17090 | 1 |
| 14 | | TERMINAL HOUSING | 38381-205 | 17040 | 1 |
| 15 | | TERMINAL HOUSING O-RING | 25154-141 | ----- | 1 |
| 16 | | RD HD MACH SCREW | X#10-01 1/2 | 14990 | 2 |
| 17 | | T-TYPE LOCKWASHER | AK#10 | 15991 | 2 |
| 18 | | CONNECTOR | S1718 | ----- | 5 |
| 19 | | SPRING WASHER | S1554 | ----- | 1 |
| 20 | * | BALL BEARING | 23282-004 | ----- | 1 |
| 21 | | MOTOR HOUSING | 38311-042 | 17040 | 1 |
| 22 | | ALLEN HEAD SETSCREW | GA0501 1/4 | 15990 | 1 |
| 23 | | PIPE PLUG | 38649-022 | 17090 | 1 |
| 24 | * | BALL BEARING | 23282-004 | ----- | 1 |
| 25 | | INTERMEDIATE | 38261-016 | 13040 | 1 |
| 26 | | SEAL CAVITY FILL PLUG | P04 | 17090 | 1 |
| 27 | | CERTIFICATION PLATE | 2613-GX | 17040 | 1 |
| 28 | | DRIVE SCREW | BM#04-03 | 17090 | 4 |
| 29 | | ALLEN HEAD SETSCREW | GA0401 | 17090 | 1 |
| 30 | | WIRE - 14 IN. | 14964-103 | ----- | 1 |
| 31 | | LEAD SEAL | 21188-002 | ----- | 1 |
| 32 | | LOCK CLIP | 33645-008 | 17040 | 1 |
| 33 | | NYLOCK CAPSCREW | BT0403 | 17040 | 1 |
| 34 | | FLAT WASHER | KB04 | 17040 | 1 |
| 35 | | ADJUSTING SHIM SET | 513-A | 17090 | 1 |
| 36 | | SNAP RING | S868 | ----- | 1 |
| OPTIONAL: | | | | | |
| | | HOT-MELT ADHESIVE (1/2 IN. STICK) | 18661-044 | ----- | 1 |

* INDICATES PARTS RECOMMENDED FOR STOCK

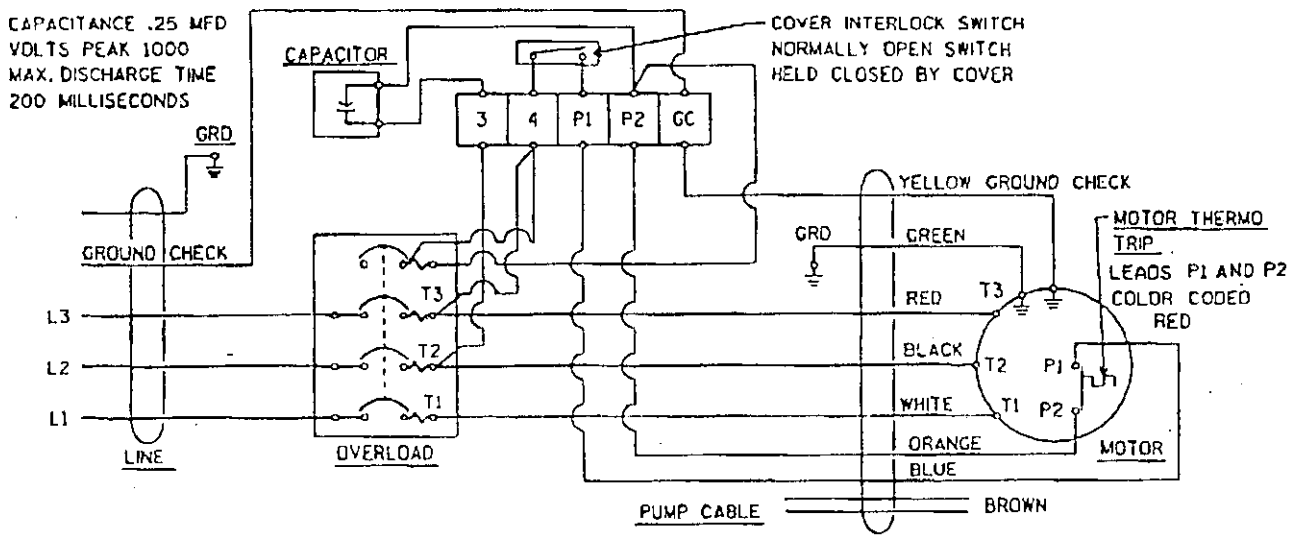



**Figure 7. Pump Power Cable Connection Diagram (All Models)**

## PUMP POWER CABLE CONNECTION INSTRUCTIONS

1. Run the pump cable through the packing gland nuts and washers (the concave side of the washer should toward the packing) at the bottom of the control.

2. Connect the white, black, and red power leads to terminals "T1", "T2", and "T3", respectively.

3. Connect the green ground lead to terminal "GRD".

4. Connect the yellow ground check lead to terminal "GC".

5. Connect the blue control lead to terminal "P1".

6. Connect the orange control lead to terminal "P2".

7. Install the packing in the gland with the washers on each side, and tighten the packing gland nut. With the nuts tight and the packing fully compressed, there must be a minimum space of 1/8 inch between the bottom of the nut and the enclosure.

8. Use the seal wire (P/N 31311-004) and lead seal (P/N 21188-002) to secure the packing gland nut to the enclosure. Use the hole in the hex nut and the hole at the top left of the enclosure to prevent loosening of the nut. See **Terminal Housing And Power Cable Reassembly And Installation** in Section E for details.

Record of Telephone Conversation

To: Bruce Pfieffer of Gorman-Rupp
From: Paul Dorsh
Date: March 07, 2000
Subject: Stainless Steel Submersible Pump Model SM2E65-X3.5

The following bits of information were discussed:

1. The upper and lower single groove ball bearings used in the pump are both SKF Model 6303-2RS. The maximum operating temperature of the seal (taken at the seal housing) is 220° F.

2. The material used for the cable jacket on the MSHA approved pump is Hypalon. This is very similar to Neoprene, which is used on the standard (non-MSHA approved) pump.

3. The air filled motor is not completely surrounded by the pumped fluid. As seen in the Specification Data sheet, only half of the motor is surrounded and cooled by the pumped fluid.

RPP-6485 Rev. 0





# DuPont Products Database Search Results

| **Hypalon(R)** | *Chlorosulfonated Polyethylene* |
|---|---|
| Description:<br>Chlorosulfonated polyethylene, in white chips, used for a wide range of industrial and consumer products that require high performance characteristics. | |
| Uses:<br>o Jacketing and insulation for wire and cable<br>o Automotive components including:<br>- High-temperature timing belts<br>- Power steering pressure hose<br>- Gaskets<br>- Spark plug boots<br>- Hose<br>o Coated fabrics<br>o Sheet roofing<br>o Liners and covers for:<br>- Waste-containment ponds<br>o Variety of protective and decorative coatings<br>o Industrial products such as:<br>- Hose<br>- Rolls<br>- Seals<br>- Gaskets<br>- Diaphragms<br>- Linings for chemical processing equipment | Industries:<br>o Adhesives<br>o Aerospace and Aircraft<br>o Apparel and Footwear<br>o Appliances<br>o Architecture and Design<br>o Automotive<br>o Coatings and Sealants<br>o Communications<br>o Computers and Electronics<br>o Construction<br>o Consumer Goods<br>o Containment<br>o Control Systems<br>o Fluids Management<br>o Industrial Machinery<br>o Marine<br>o Military<br>o Mining<br>o Oil and Gas Extraction<br>o Petroleum Refining and Distribution<br>o Rail Transportation<br>o Sporting Goods<br>o Textiles<br>o Toys and Leisure Products<br>o Waste Disposal |
| http://www.dupont-dow.com/<br><br>Business: DuPont Dow Elastomers<br>Product Contacts | |

## SODIUM HYDROXIDE, 50%

| PLASTICS | 60–460 °F |
|---|---|
| ABS | R |
| ACRYLICS | R |
| ASBESTOS REINF., EPOXY | R — U |
| ASBESTOS REINF., PHENOLIC | U |
| CHLORINATED POLYETHER | R |
| CPVC | R |
| EPOXY | R |
| FLUOROCARBONS FEP | R |
| FLUOROCARBONS TFE | R |
| FURFURYL ALCOHOL | U |
| NORYL | R |
| PHENOLIC | U |
| POLYAMIDES–NYLON | R |
| POLYESTERS | |
| BISPHENOL A-FUMURATE | R |
| HYDROGENATED BISPHENOL-A-BISPHENOL-A | U |
| ISOPHTHALIC | U |
| CHLORINATED POLYESTERS | U |
| POLYSTYRENES | R |
| POLYETHYLENE | R |
| POLYPROPYLENE | R |
| PVC–TYPE 1 | R |
| PVC–TYPE 2 | R |
| POLYVINYLIDENE CHLORIDE | R |
| VINYLIDENE FLUORIDE | R |
| VINYL ESTER | R — U |
| **RUBBERS** | |
| BUTYL GR-1 | R |
| FLUORO ELASTOMERS VITON A | RU |
| FLUORO ELASTOMERS KEL-F 3700 | R |
| HARD RUBBER | R |
| HYPALON | R |
| KOROSEAL | R |
| NATURAL RUBBER (GRS) | R |
| NEOPRENE GR-M (CR) | R |
| NITRILE BUNA N (NBR) | R |
| NORDEL | R |
| POLYBUTADIENE | R |
| SILICONE | R |
| POLYURETHANE | R |

TEMP °F: 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300, 320, 340, 360, 380, 400, 420, 440, 460

# Double-Shell Tank Annulus Auxiliary Transfer Pump
# Hydrostar Air Driven Piston Pump
# Submitted For FGEAB Evaluation

Preparations are underway to be ready to pump the annulus of any Double-Shell Tank in the event of a primary tank waste leak. The method for pumping an annulus is to have a submersible pump staged in a mobile trailer ready to deploy when a leak is identified. The DST's are either a Facility Group 1 or 2 and the pump column is considered Waste Intruding Equipment and must meet ISC Set 1 per Table 5.10-1 of the TSR.

The candidate pump (Hydrostar "Ground Water Sampling Pump") is an air driven, double-check valve, positive displacement piston pump. It will be part of a rigidly supported column assembly, alongside an electric submersible pump, that will be installed through the annulus pump pit 12" riser and extend down to a depth of approximately 50 feet. The Hydrostar pump is adept at removing fluid down to the minimum possible level. It's purpose is to augment the centrifugal type, electric submersible pump which will lose its suction at a level above what the Hydrostar pump can pump down to.

Key information regarding the Hydrostar pump is summarized below:

- The pump has no electrical components. The pump is driven by an air motor cylinder using minimal CFM of compressed air. Air exhaust will be in the annulus pump pit; no air is forced "downhole".

- The pump is less than 2" in diameter. Flow rates are between 3 and 5 gpm. Manual operation through the use of a portable manual handle is possible to a depth of 100' (ie. the force to lift and lower the piston is not great).

- The piston assembly has a teflon seal on each end which seals against the stainless steel pump housing (see attached vendor sheets). This seal provides the vacuum which sucks fluid into the pump during the upstroke cycle. On the downstroke, a spring assembly pulls the piston back towards the stationary lower ball check assembly and fluid exits the pumping chamber. The process fluid provides lubrication between the seal and the pump housing.

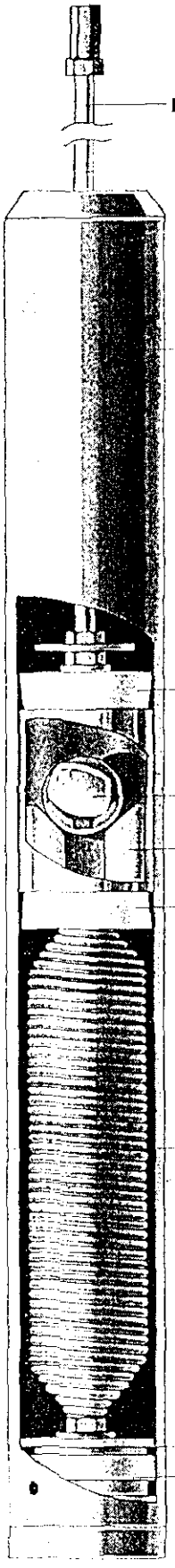
The following documentation is attached:

- Hydrostar vendor data sheets (10), from Instrumentation Northwest Inc.
- Detailed description of Hydrostar pump components and principle of operation

RPP-6485 Rev. 0

# HYDROSTAR™

## GROUND WATER SAMPLING PUMP




**HYDROSTAR PUMP COMPONENTS**

## DEPTH PERFORMANCE UNMATCHED BY ANY OTHER SAMPLING DEVICE

The **HydroStar** is a unique ground water monitoring device for dedicated applications. It is unsurpassed in its ability to deliver high-quality ground water samples from extreme depths in 2" or larger wells. Commonly used ground water sampling pumps, such as bladder pumps and small-diameter electric submersible pumps are limited to depths of 300 feet. The **HydroStar** can pump from depths of 500 feet! This performance is achieved without electricity and without the use of compressed air inside the well.

The **HydroStar** is just 1.62 inches O.D. It can be installed in 2-inch and larger monitoring wells. It can achieve a range of flow rates from 3 to 5 GPM for purge pumping, and adjusts easily to produce low flow rates suitable for sampling.

## ONE PUMP, TWO JOBS

Variable flow rates mean the **HydroStar** can efficiently perform two required operations for ground water monitoring - purge pumping and sampling. Teflon™, 300-series stainless steel and viton components ensure sample quality. The dedicated system design virtually eliminates the possibility of cross-contamination. Sample quality has been analyzed and found to be statistically indistinguishable from that obtained with bladder pumps[1].

[1] Schalla, R. et al. 1988, "The Sensitivity of Four Monitoring Well Sampling Systems to Low Concentrations of Three Volatile Organics", in *Ground Water Monitoring Review*, summer issue.

## PROVEN PERFORMANCE WHERE IT MATTERS - IN THE FIELD

Hundreds of **HydroStar** systems have been installed since 1986. At nuclear facilities, landfills, mining operations and other severe environments, **HydroStar** systems have performed where no other sampling device could do the job.

Instrumentation Northwest, Inc.
**(800) PRO-WELL**

RPP-6485 Rev. 0

# Instrumentation Northwest, Inc.

APPLICATION NOTE:
**Hydrostar System Air Motors**
May 5, 1992

## Introduction

When sizing an air-driven system one must consider the air motor cylinder size being used, the stroke rate desired to produce a certain production rate (GPM) and the air consumption of the air motor.

## Air Cylinder Size

Without going through the formulas, outlined below is a general guideline table for selecting the proper size air motor depending on the installation depth of the HydroStar. For each motor size a range of values is given: the Maximum Full Speed Depth (MFSD) and the Maximum Recommended Depth (MRD). The Maximum Full Speed Depth is the installation depth where some loss in air motor performance will begin to occur. The Maximum Recommended Depth is the deepest installation depth we would recommend using this size air motor.

**Depth Chart (In Feet)**

| Cylinder size (in) | 1.5 | 2.0 | 2.5 | 3.25 | 4 |
|---|---|---|---|---|---|
| MFSD (ft) | 76 | 146 | 240 | 392 | 617 |
| MRD (ft) | 106 | 205 | 337 | 549 | 865 |

## Production Due to Stroke Rate

The HS-8000 and HS-8001 pumps are 1.5" diameter pump cylinders with a stroke rate of 12 inches. If we assume that the pumps operate at 90% efficiency the production factor of the pumps is .082 gallons per stroke. Note: Actual field studies rate the efficiency of the HydroStar pumps better than 90% at their rated operating depth capacity *(see pump curves)*.

Example: If your pump is operating at 40 strokes per minute your production rate would be 40 * .082 = 3.29 gallons per minute.

## Air Consumption *(at 80 PSI operation)*

Air consumption is a factor of the cylinder size you use and the stroke rate of the cylinder. The HydroStar system can operate up to 60 strokes per minute down to less than 1 stroke per minute so naturally the air consumption will vary depending on the desired operating speed.

Below is a table of factors one can use to determine the air consumption of your system in Standard Cubic Feet (SCF). (These factors are just guidelines since a number of additional variables can effect air consumption).

| Cylinder Size (in) | 1.5 | 2.0 | 2.5 | 3.25 | 4 |
|---|---|---|---|---|---|
| Air consumption *(SCF per stroke)* | .10 | .18 | .30 | .49 | .76 |

Example: A HydroStar system operating at 40 strokes per minute using a 1.5 inch cylinder would need .1 * 40 = 4 SCFM of air.

*(cont.)*

RPP-6485 Rev. 0



*(cont.)*

## Freeze-up Considerations

The air cylinders used by INW employ a 4-way valve to switch cylinder direction. Under moist, cold conditions the 4 way valve can be frozen due to air expanding through the valve. The freeze up is due to moisture in the air lines.

The best way to minimize or eliminate freeze up problems is to use dry air. However, air dryers are expensive and not always practical.

What we have found to be the most practical solution is to install a pre-filter, a secondary oil/water removal filter and a lubricator. When installing, they should be put as close to the air cylinder as possible. The lubricator should then be filled with an anti-freeze lubricant such as Kil Frost. However, for sampling applications no lubricant should be used because of potential exhaust contamination.

Comments:
Instrumentation Northwest appreciates any comments you may have regarding this application note. Please call or write to:

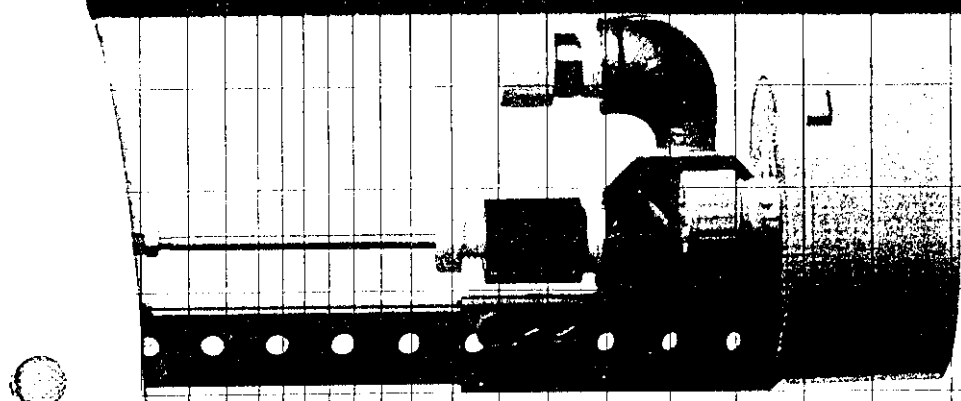
**Instrumentation Northwest, Inc.**
Attn: Engineering Dept. - HYDROSTAR System
14972 NE 31st Circle
Redmond, WA 98052
**(800) 776-9355**

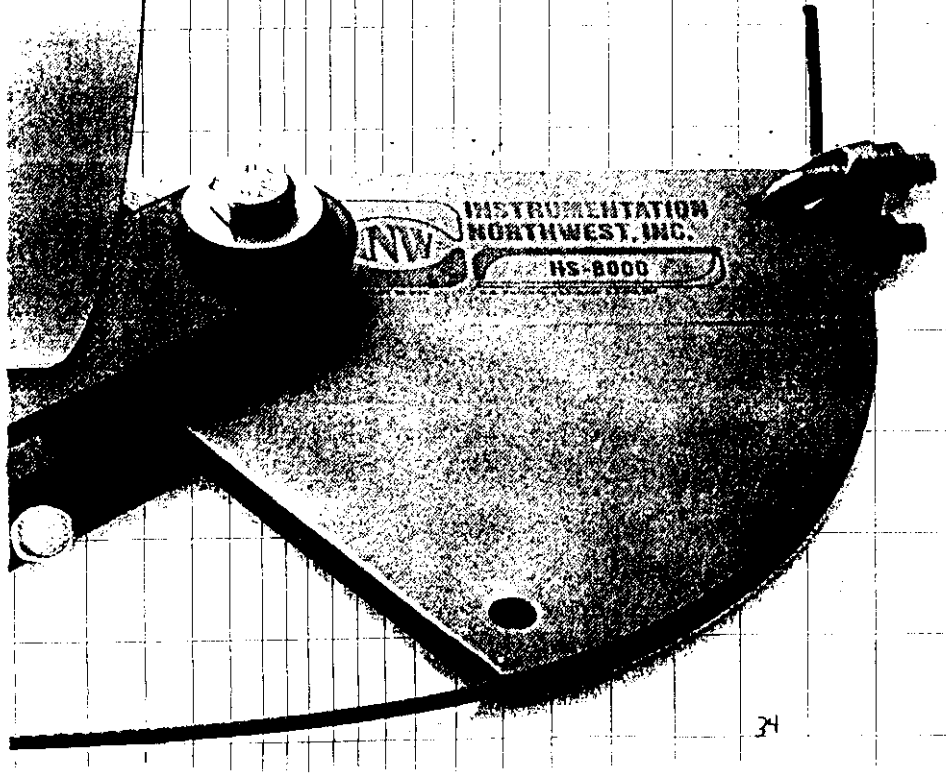
RPP-6485 Rev. 0

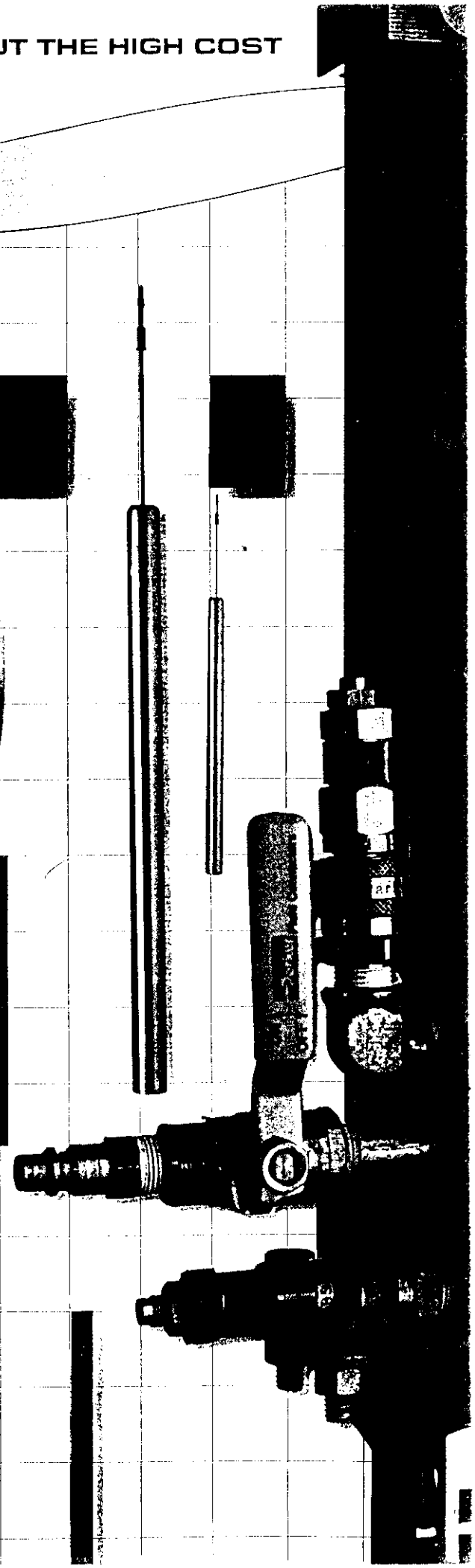
MEETING THE HIGH STANDARDS WITHOUT THE HIGH COST

# HYDROSTAR™

## GROUND WATER SAMPLING SYSTEM





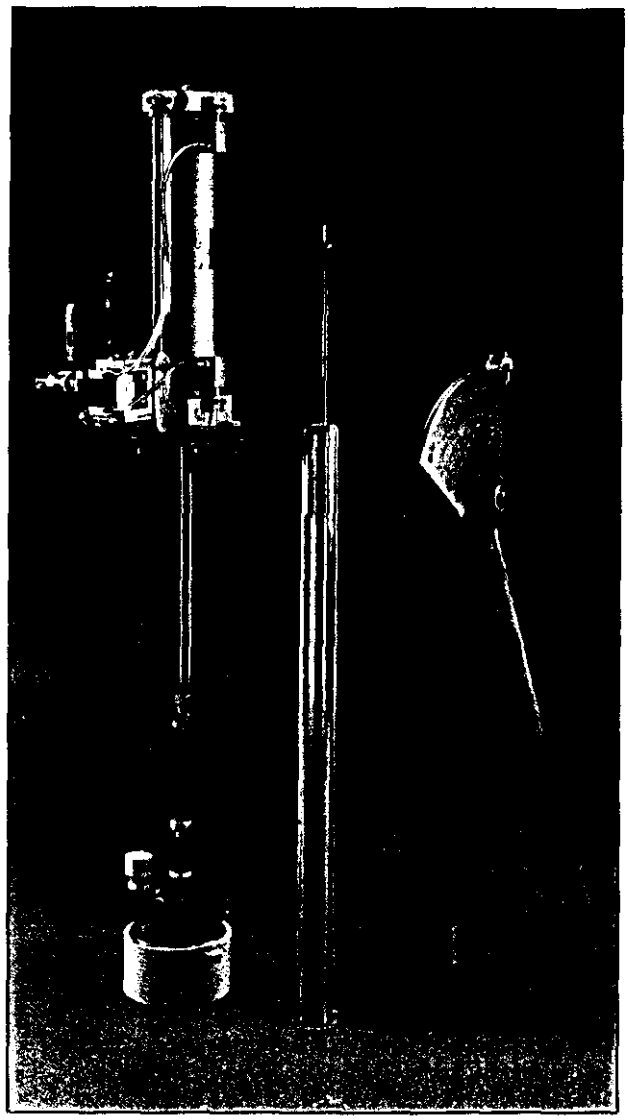
RPP-6455 Rev. 0

# THE HYDROSTAR™ SOLUTION:

## TOP PERFORMANCE, LOW COST, UNCOMPROMISING RESULTS

Ground water monitoring is a high-stakes industry. Whether sampling ground water at industrial sites, landfills, or Superfund sites, you demand equipment that will produce a highly accurate sample. Any compromise could cost you thousands— or millions— of dollars in repeat testing or re-evaluation.

There are a variety of ground water monitoring systems available, and many obtain accurate samples. But now there's a sampling system that meets the high standards **without** the high costs. Instrumentation Northwest, Inc. has developed a system that gives you more than accuracy.



INW's HydroStar™ Ground Water Sampling System produces consistently reliable samples, faster and more economically than conventional methods. You can purge a monitoring well at the high rate of 3 to 5 gallons per minute, then reduce the flow to obtain your sample— with a single dedicated pump and a portable motor.

Because it is a dedicated system, and it is constructed of the most chemically inert materials available, the HydroStar™ ensures virtually no risk of cross-contamination or sample alteration. You can obtain an accurate sample the first time, every time.

And the HydroStar™ is versatile. It can be used in 2-inch or larger monitoring wells, ranging in depth from 5 feet to 500 feet. It can be operated by either manual or automatic motors, allowing you to tailor the HydroStar™ to your specific monitoring needs.

What's more, the HydroStar™ is easy to install and simple to operate. Both training and field time are low, and the chance for operator inconsistency is near zero.

SPEED. ACCURACY. RELIABILITY. INTEGRITY.

The HydroStar™ offers the most cost-effective solution in ground water monitoring today. If you want to meet the high standards without the high costs, turn to the HydroStar™ for your next monitoring program.

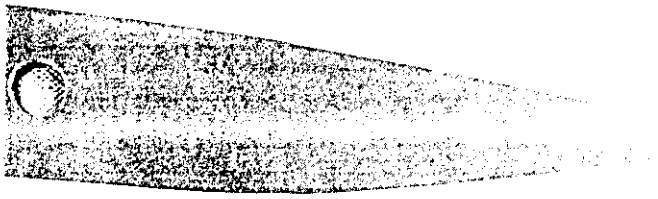
## THE MAJOR BENEFITS ENJOYED BY HYDROSTAR™ USERS.

"Our experience with the HydroStar™ has been very positive. We conducted our own VOA sample integrity study and were pleased to find the sample integrity to be better than that of a bailer. The simplicity, speed and sample purge [illegible] allows us to save a great deal of time in the field."

Warren Perkins
Woodward Clyde Consultants
Seattle, Washington.

"The HydroStar™ has allowed us to purge and sample, with a single pump, from a depth of 690 feet— something that no other sampling system can accomplish. I have recommended the HydroStar to others who are looking for a more cost-effective dedicated sampling system and I will continue to do so in the future."

Glenn AbdunNur
Bermite Division of Whittaker
Saugus, California.



## FEATURES THAT ENSURE TOP PERFORMANCE

QUALITY CONSTRUCTION

Made of stainless steel-virgin Teflon, the two materials combine the greatest chemical resistance and strength.

SMALL-DIAMETER DESIGN

Designed for use in existing and new monitoring wells. With an outside diameter of just 1.625-inches, the HydroStar™ can be installed in wells as small as 1.75-inches in inside diameter.

OPTIMUM SAMPLE INTEGRITY

With a dedicated HydroStar™ Sampling System, there's no risk of cross-contamination between wells. Plus, there's no downhole air that can introduce contaminants to the well. The chemically inert materials used in its construction ensure the most unbiased samples.

HIGH PURGING RATES

By constant cycling of the HydroStar™ in the 40-to-60-stroke per-minute range, purge rates of 3 to 5 gallons per minute may be obtained with minimal submergence.

CONTROLLED SAMPLING RATES

The pumping rate for sampling can be reduced to less than .25 gallons per minute by simply reducing the *stroke rate of the pump.*

FLEXIBLE POWER OPTIONS

Interchangeable manual or automatic motors can be used at multiple-pump installations.

IMPRESSIVE DEPTH CAPACITIES

Consistently high discharge rates of at least 4 gpm can be achieved against pumping heads of 5 to 500 feet.

NO DOWNHOLE MOTORS

Because the motor is at the surface, there's no risk of costly downhole motor failure or leakage.

QUICK INSTALLATION

Installation to 400 feet is accomplished in approximately 20 minutes.

EASY OPERATION

Operators require very little training to master the simple principles of operation.

EXTENDED WARRANTY

Limited two-year warranty on all parts, except seals, is standard.

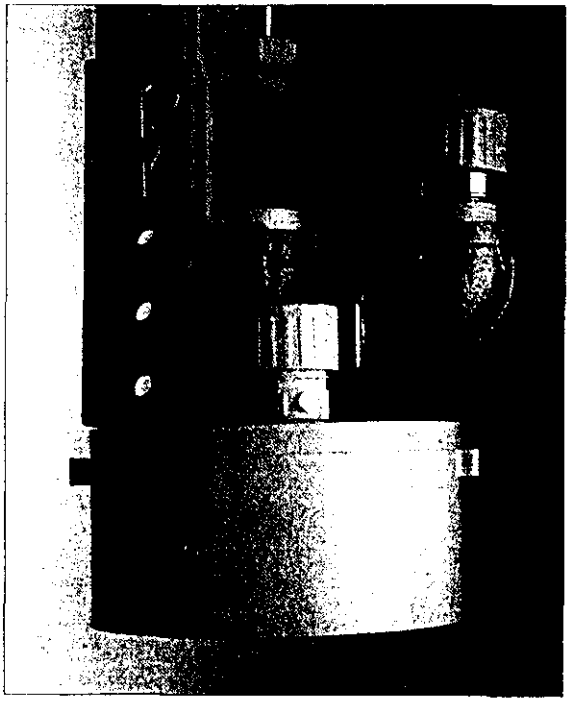
## BENEFITS ONLY A SMALL-DIAMETER PUMP CAN OFFER

The overall cost of a ground water monitoring program includes more than sampling equipment and the associated labor expenses. The cost of drilling the wells and treating or disposing of water purged prior to sampling can effect a dramatic increase in the bottom line.

The HydroStar's™ unique narrow design allows you to work in 2-inch wells, which can reduce your sampling costs in a number of ways. Two-inch wells:

- Can be installed by smaller, less expensive drilling equipment.
- Require less costly well completion materials.
- Can accommodate aquifer characterization *studies such as pump and slug testing* where .25 to 5.0 gpm pump rates are acceptable.
- Contain only one-quarter the casing volume of 4-inch wells.
- Can achieve a 75% reduction in purge water and purge time.

In addition, dewatering and recovery operations may be accomplished in the same less costly 2-inch monitoring well.



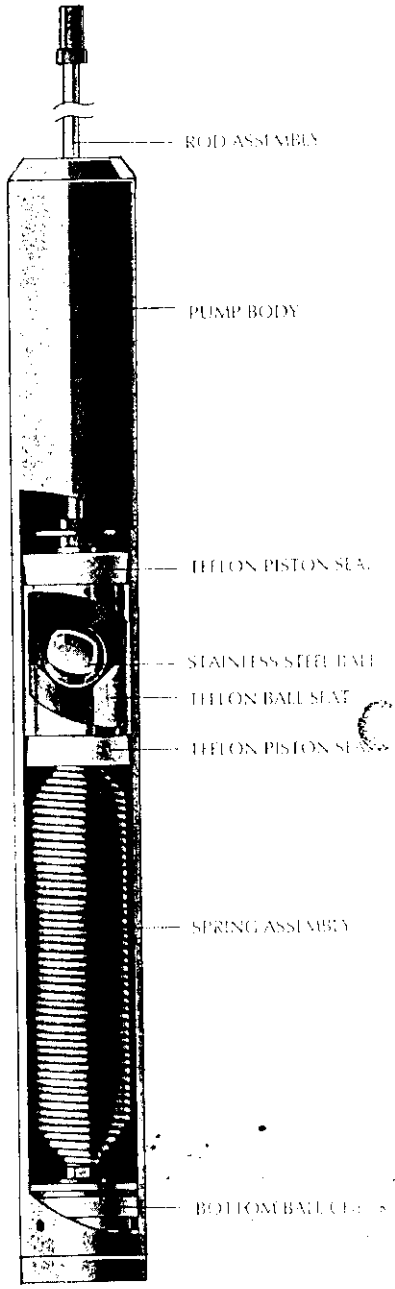
RPP-6485 Rev. 0

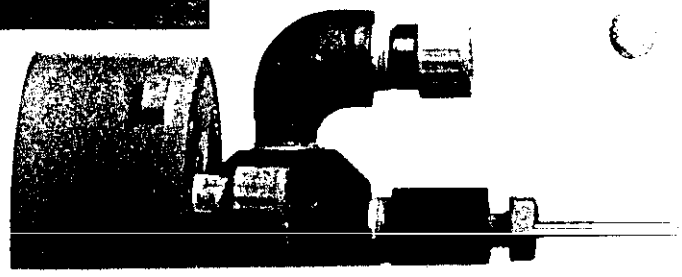
## PRINCIPLES OF OPERATION

The HydroStar™ is a double-check valve, positive displacement piston pump. It employs a simple, single-action design. The upper piston is actuated with a rod from the surface. Patterned after the sucker rod technology used in the oil industry, the pump motor remains at the surface so that only the pump, rod and discharge pipe are downhole in contact with the water.

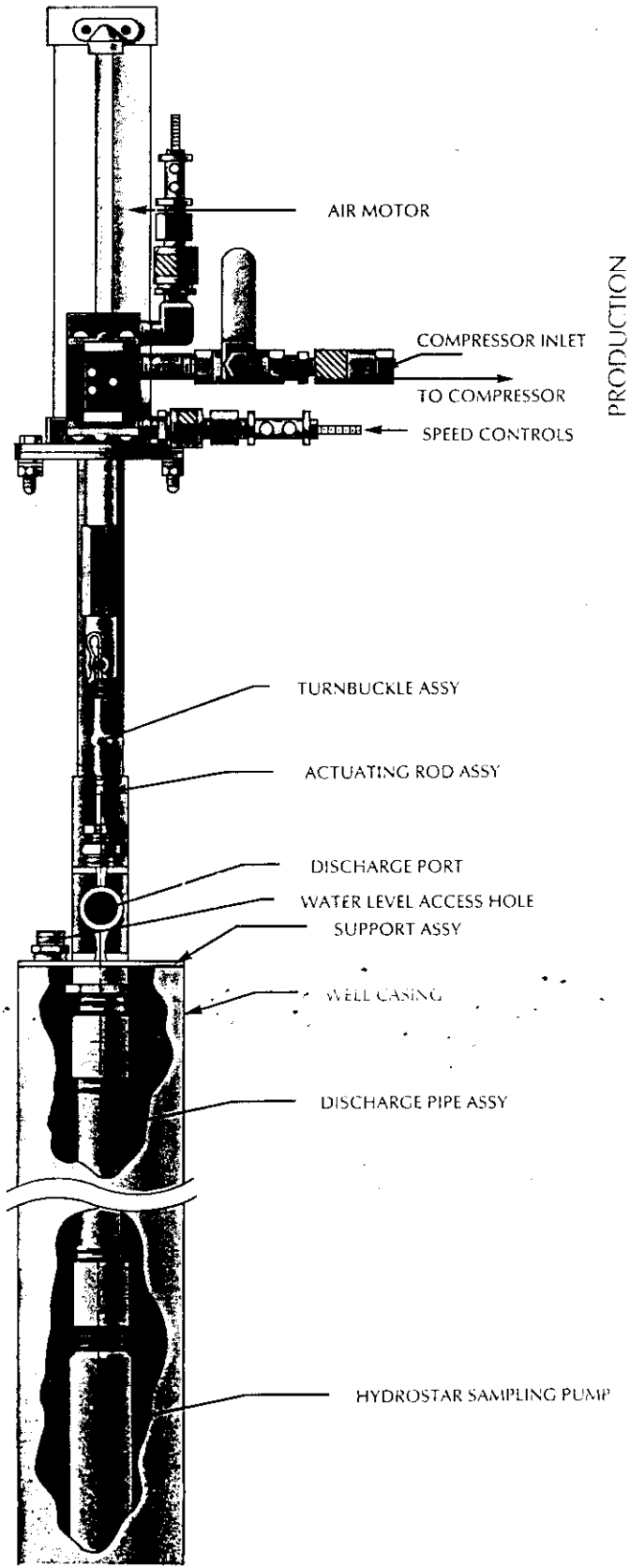
The pump body is divided into an upper and lower chamber by the upper check valve, or piston. This piston is connected to the rod and is actuated from the surface by the motor. When the piston is raised, the check valve closes and moves the water column upward. Simultaneously, the lower check valve is opened due to head pressure in the well. This head pressure fills the lower chamber with water.

When the piston is lowered, the lower check valve closes and the check valve in the piston opens, allowing the water to pass from the lower chamber into the upper chamber. Continuous raising and lowering of the piston pumps the water to the surface.





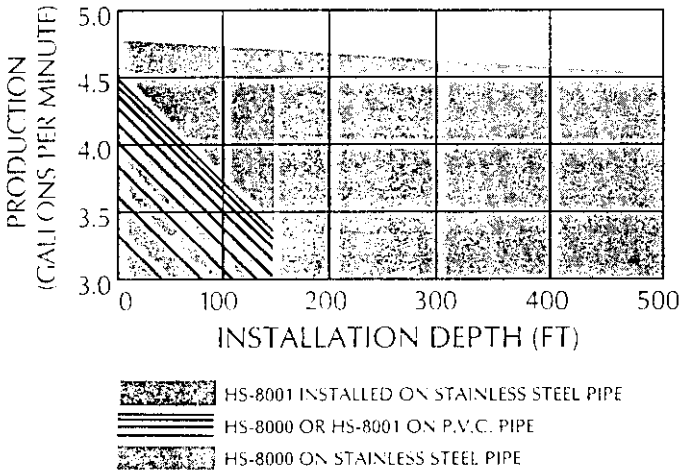
## OPERATING ASSEMBLY




## HYDROSTAR™ SAMPLING PUMPS IN PURGE MODE

The performance curves shown below represent the calculated purge rates when operating the various systems at an optimum rate of 60 strokes per minute with an efficiency factor of 88%.

OPERATING AT 60 STROKES PER MINUTE




## HYDROSTAR SAMPLING MOTORS

The Portable Automatic Motor incorporated in the HydroStar™ Sampling System offers the following features:

### OPERATES ON INDUSTRIAL COMPRESSOR AIR

Since no air is used downhole there is no need for expensive oil-less compressors or inert gasses.

### PORTABLE

Easily moved from well to well to operate an array of HydroStar™ sampling pumps.

### SIMPLE OPERATION

Pump is set up with two clevis pins and operated by connecting an air supply with a quick coupler. Start, stop, and speed are activated by controls mounted on the motor.

Manual operation is possible through the use of the portable manual handle. System operation with manual handle is possible to a depth of 100' and allows shallow wells to be sampled without compressor-driven equipment.

### WARRANTED

One-year unlimited usage warranty.

RPP-6485 Rev. 0

## WELL COMPLETION ASSEMBLIES

| CASING SIZE | STAINLESS STEEL P/N | P.V.C. PART P/N | REQUIRED CLEARANCES BELOW PROTECTOR COVER LID HEIGHT | DIAMETER |
|---|---|---|---|---|
| 2" | QE-20-V001 | QE-20-V0011 | 11" | 6" |
| 4" | QE-40-V001 | QE-40-V0011 | 11" | 6" |
| 6" | QE-60-V001 | QE-60-V0011 | 11" | 6" |

## DISCHARGE COLUMN (WITH ROD)

| MATERIAL | MAXIMUM DEPTH | O.D. | PART NUMBER | LENGTH 10' | 5' | 3' | 2' |
|---|---|---|---|---|---|---|---|
| P.V.C. | 150' | 1.05" | OB-50- | L10 | L05 | L03 | L02 |
| Stainless Steel | 500' | 1.50" | OB-40- | L10 | L05 | L03 | L02 |
| P.V.C. FTJ Adapters | | 1.05" | CM-13-D1 | | | | |

7

## HYDROSTAR PUMPS

| | MAXIMUM DEPTH | O.D. | LENGTH | PART NUMBER | GALLONS PER STROKE |
|---|---|---|---|---|---|
| HS8000-1 | 150' | 1.625 | 26" | QA-10-V001 | .09 |
| HS8001-1 | 500' | 1.625 | 26" | QA-11-V003 | .09 |

## OPERATING MOTORS

| | MAXIMUM DEPTH | STROKE | WEIGHT | PART NUMBER | AIR CONSUMPTION |
|---|---|---|---|---|---|
| 2.5" Air Motor | 300' | 12" | 17 lb. | QD-20-V001 | 15 CFM |
| 3.25" Air Motor | 500' | 12" | 25 lb. | QD-20-V005 | 22 CFM |
| Manual Handle | 100' | 10" | 5 lb. | QD-10-V001 | |

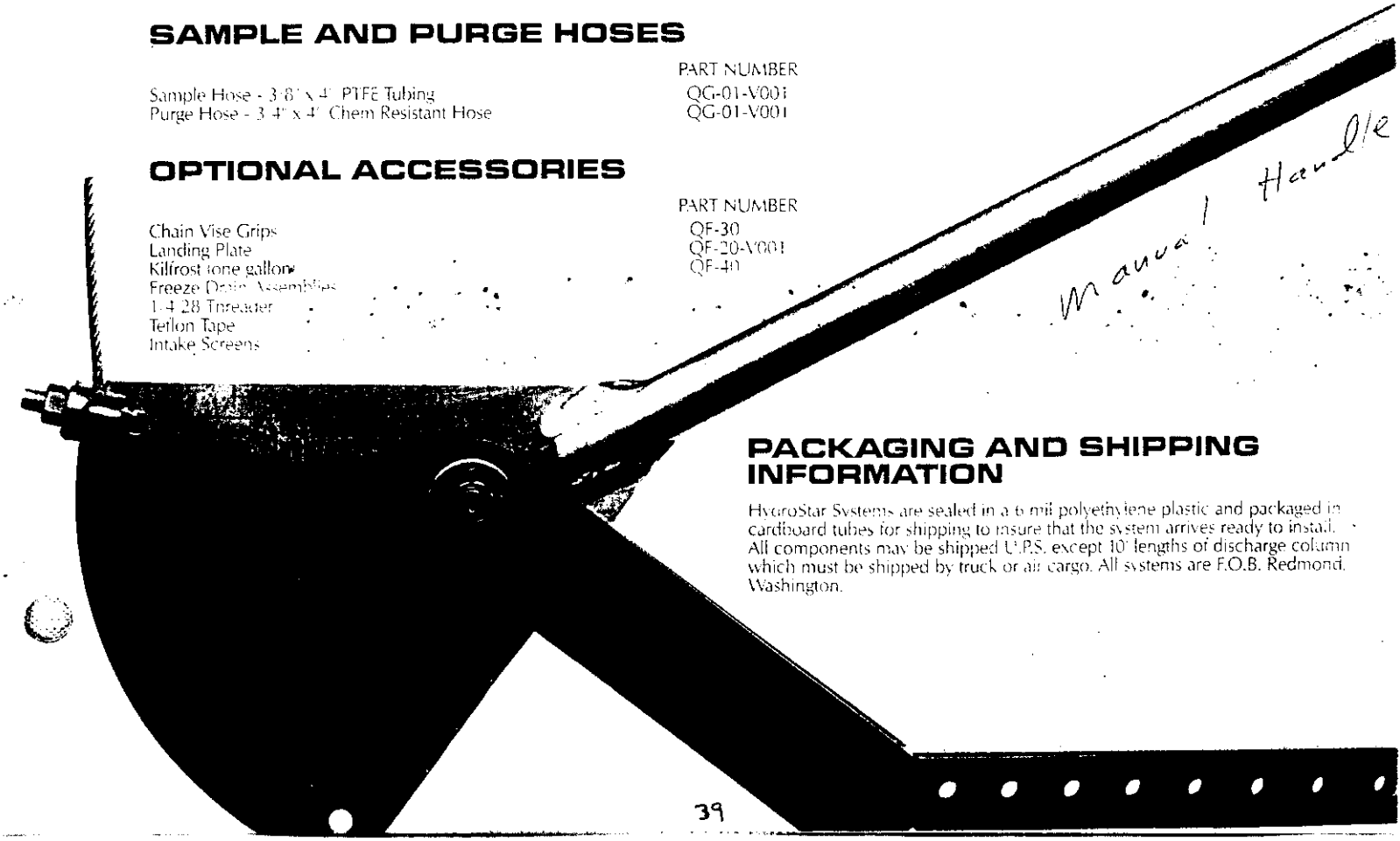
## SAMPLE AND PURGE HOSES

| | PART NUMBER |
|---|---|
| Sample Hose - 3/8" x 4' PTFE Tubing | QG-01-V001 |
| Purge Hose - 3/4" x 4' Chem Resistant Hose | QG-01-V001 |

## OPTIONAL ACCESSORIES

| | PART NUMBER |
|---|---|
| Chain Vise Grips | QF-30 |
| Landing Plate | QF-20-V001 |
| Kilfrost tone gallon | QF-40 |
| Freeze Drain Assemblies | |
| 1-4 28 Threader | |
| Teflon Tape | |
| Intake Screens | |

Manual Handle



## PACKAGING AND SHIPPING INFORMATION

HydroStar Systems are sealed in a 6 mil polyethylene plastic and packaged in cardboard tubes for shipping to insure that the system arrives ready to install. All components may be shipped U.P.S. except 10' lengths of discharge column which must be shipped by truck or air cargo. All systems are F.O.B. Redmond, Washington.

## COMPARE THE COSTS

With faster set-up, purging, and sampling times, the HydroStar™ can cut your sampling costs by **as much as 90%**.

The following table compares equipment and operating costs of the four leading types of sampling systems: a Bailer (B); a Bladder Pump (BP); a Bladder Pump with a Submersible Purge Pump (BP/SP) and the HydroStar™ piston pump (HS).

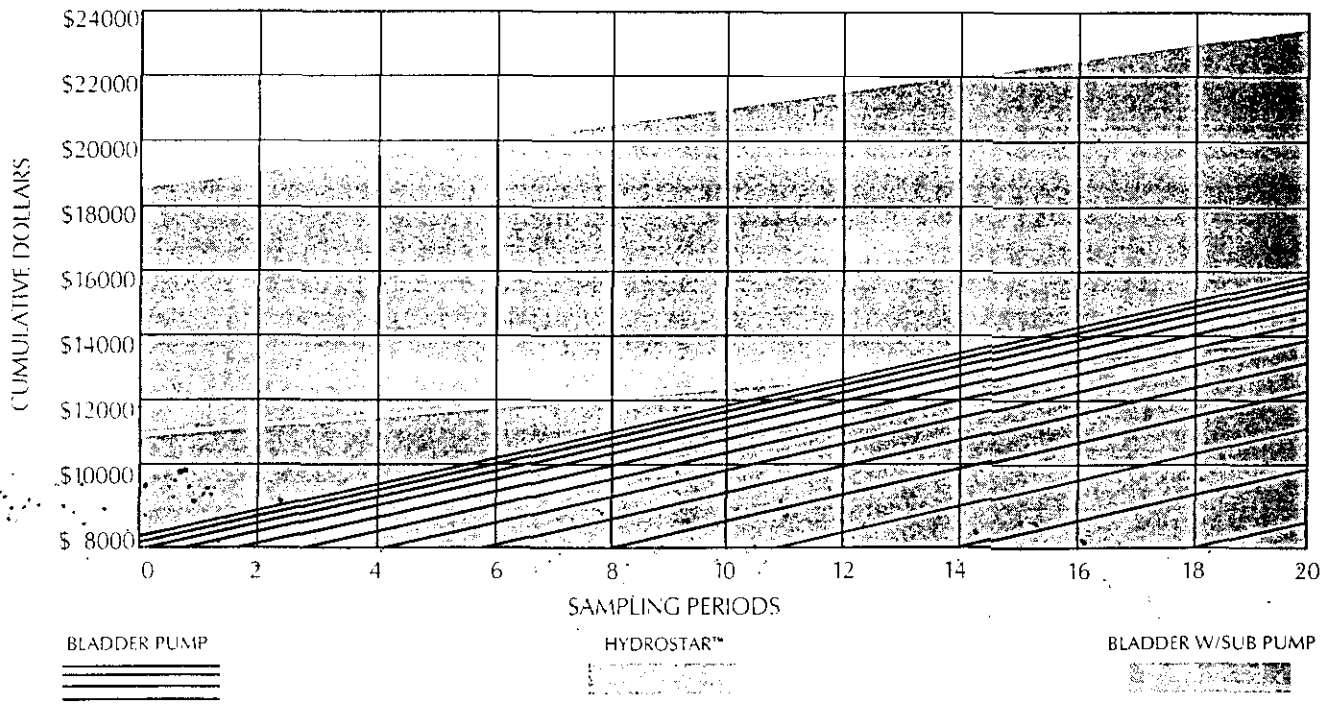
### WELL CHARACTERISTICS

Five monitoring wells, each 150 feet deep with 4-inch Schedule 40 casing. Casing volume for each well is 25 gallons, which requires the purging of *approximately 375 gallons for all 5 wells.*

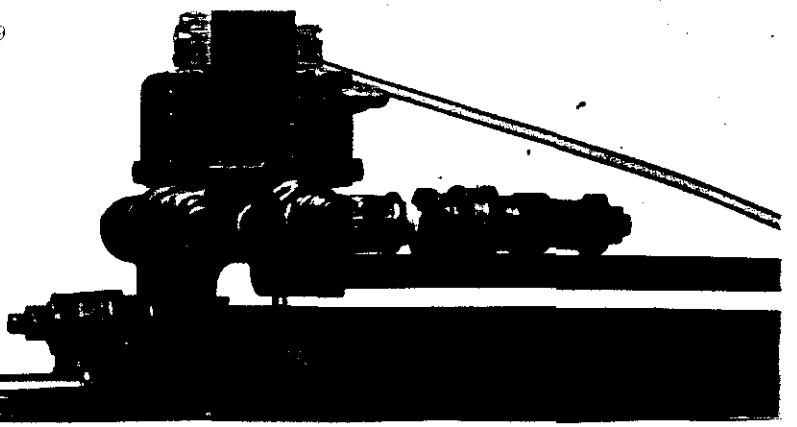
| | B | BP | BP/SP | HS |
|---|---|---|---|---|
| *Initial Equipment Cost | $934 | $8,088 | $18,220 | $12,071 |
| Purge Rate (gpm) | .15 | .5 | 5.0 | 5.0 |
| Purge Time (hrs) | 43.00 | 12.90 | 1.27 | 1.27 |
| Set-up and Sample Time (hours) | 5.8 | 3.3 | 5.03 | 3.33 |
| Total Time Per Sampling Event** (hours) | 48.8 | 16.2 | 6.30 | 4.61 |
| Labor Cost Per Sampling Event ($35/hour) | $1,708 | $567 | $220.50 | $161.35 |

*Based on 1989 costs.

## OPERATING COSTS FOR QUARTERLY MONITORING




1. Based on five-well program described in table above. Includes 1989 equipment and operating costs, but not cost of installation.
2. Bailer sampling is not graphically represented. Sampling costs accumulate at $1708.00 per event to a total of $35,099 at the end of 20 sampling periods.



RPP-6485 Rev. 0

TO: Greg Leshikar
FROM: Paul Dorsh
DATE: 2/25/00
SUBJECT: Hydrostar pump assembly and operation

Components of Pump Assembly

There are 5 main components of the pump operating assembly: The Pump, Discharge Pipe, Actuating Rod, Well Seal/Completion Assembly, and Air Motor.

**Pump** – (Figure 1) The pump housing is made of stainless steel, has an outside diameter of 1 5/8" and a length of 26". The top of the housing contains a ¾" NPT female fitting used for fluid discharge. A piston, which separates the lower and upper chambers in the pump, contains upper and lower Teflon seals and a passage running through it holding a stainless steel ball check. The opening of the ball check allows fluid in the lower area to enter the upper area through the passage in the piston. The top of the piston is mounted to the actuating rod for manipulation. A spring is attached to the bottom of the piston and is anchored at the bottom ball check assembly. The spring provides force for the downstroke of the piston. The bottom ball check assembly is held in a fixed position, via 2 allen head screws located near the bottom of the pump. The bottom ball check is sealed to the pump with a Viton o-ring. The bottom ball check assembly is opened on an upstroke of the piston and allows fluid to enter the lower chamber through the bottom of the pump.

**Discharge Pipe** – (Figure 2 & 4) ¾" stainless steel sch-40 pipe is used. The pipe is connected to the pump via the ¾" NPT female fitting located on the top of the pump housing. The piping generally comes in 10-ft sections (can be varied) and is coupled together to achieve the customers desired length. The top of the discharge piping is attached to the Well Seal/Completion Assembly (Figure 3).

**Actuating Rod** – (Figure 2 & 4) ¼" stainless steel rod is used. The actuating rod is located inside the discharge pipe. The rod runs down through the pump's ¾" NPT female discharge fitting and is attached to the top of the pump's piston (Figure 1). The standard length of the manufacturer's actuating rod is 10 ft. 10-ft rod sections can be coupled together by use of a Coupling Nut to achieve our specified length. On top, the actuating rod runs through the well seal / completion assembly (Figure 3). A turnbuckle

assembly is attached to the top of the rod and is used by an air motor or manual handle for actuation.

**Well Seal / Completion Assembly** – (Figure 3) The well sell / completion assembly is the point of separation for the discharge piping and the actuating rod. The discharge pipe is connected to a discharge tee, which diverts the flow away from the actuating rod. The actuating rod continues up through the discharge tee and through a rod seal assembly, which seals the flow. A turnbuckle is attached to the top of the actuating rod, which will be used as an attachment point for the air motor. The well seal is typically a 2" diameter PVC of stainless steel cap that fits over the top of well casings. It serves the purpose of holding the pump assembly in place. This piece can be modified or removed depending on the design.

**Air Motor** – (Figure 2) The air motor sits on a platform, which is attached to the well seal, and manipulates the actuating rod. More detail on the motor is coming.

Pump Actuation

The air motor is attached to the ¼" actuating rod via the turnbuckle. The actuating rod, running down the discharge pipe, is attached to the piston. As air pressure is applied to the motor, the rod and piston are forced to cycle up and down.

Pump Operation

The pump operation consists of an upstroke cycle and a downstroke cycle (Figure 1).

**Upstroke** – When the control rod is pulled up, the upper ball check assembly restricts liquid flow and positively displaced the fluid in the upper pump chamber. The liquid is then lifted up the discharge pipe, while at the same time, the lower ball check assembly opens, allowing more fluid to enter the lower pump chamber.

**Downstroke** – The downstroke cycle is prompted by the spring attached between the upper and lower ball check assembly. Because the lower ball check assembly is stationary, the spring is in tension. The spring then pulls down on the upper ball check assembly. The upper ball check assembly opens and the lower ball check assembly

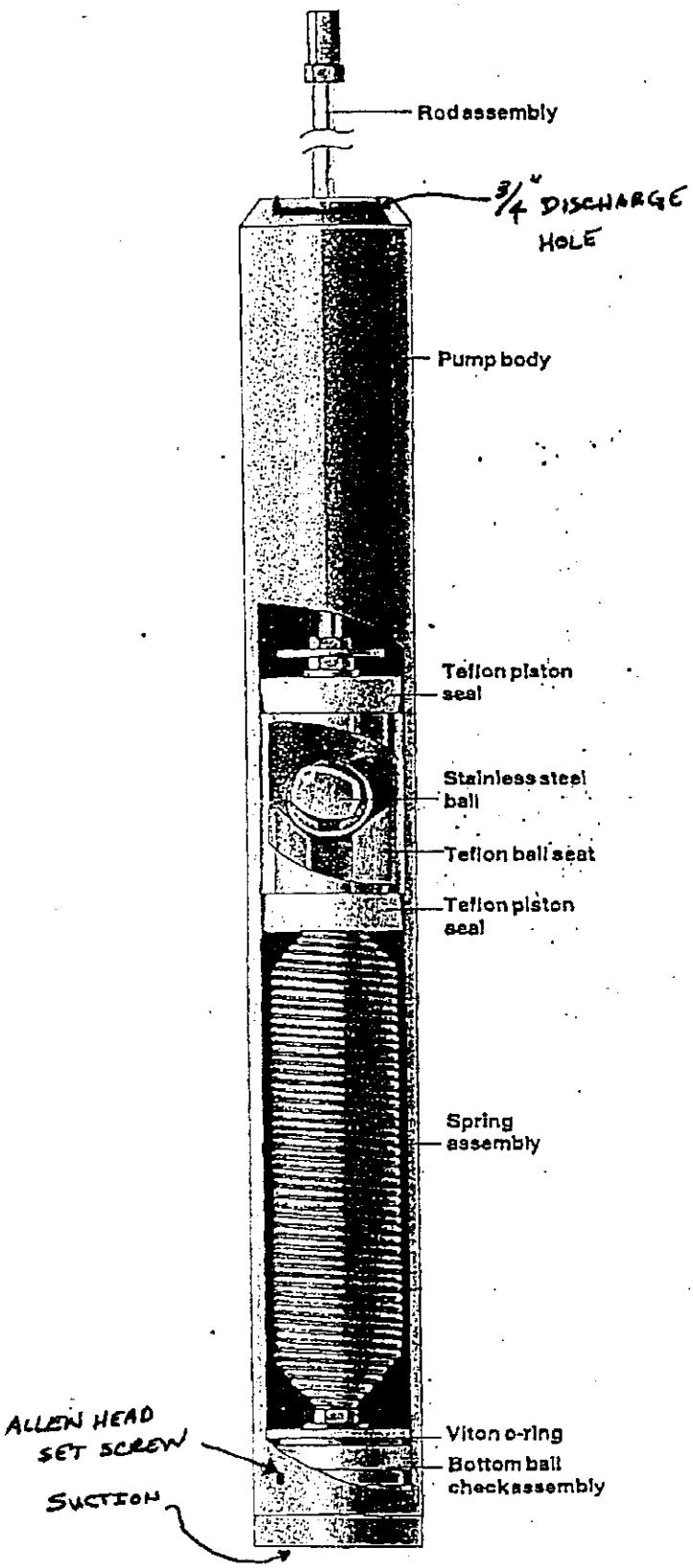
RPP-6485 REV. 0

closes, causing fluid to be forced into the upper pump chamber. The pump cycle is now complete and the pumping cycle begins again with the next stroke.

According to the manufacturer, the bottom of the pump needs to sit 1" to 2" above the bottom of the tank to allow for proper fluid suction.

I hope this clears some things up for you. If you have anymore questions please give me a call (372-0289) and I'll try and help. The demo Hydrostar pump was shipped last night and should be here on Monday.

RPP-6485 REV. 0




HYDROSTAR PUMP COMPONENTS

FIGURE 1

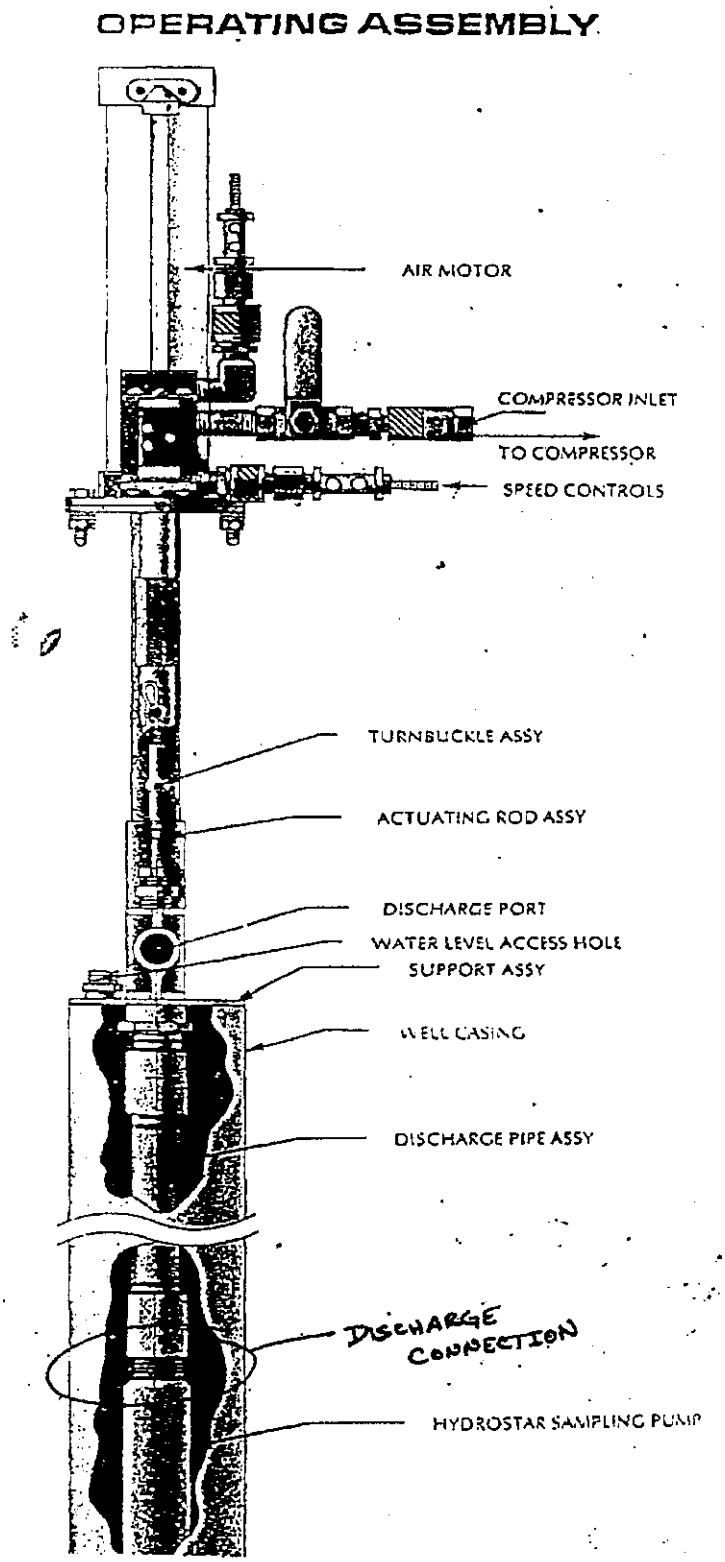



FIGURE 2

RPP-6485 Rev. 0

WELL SEAL / COMPLETION ASSY.

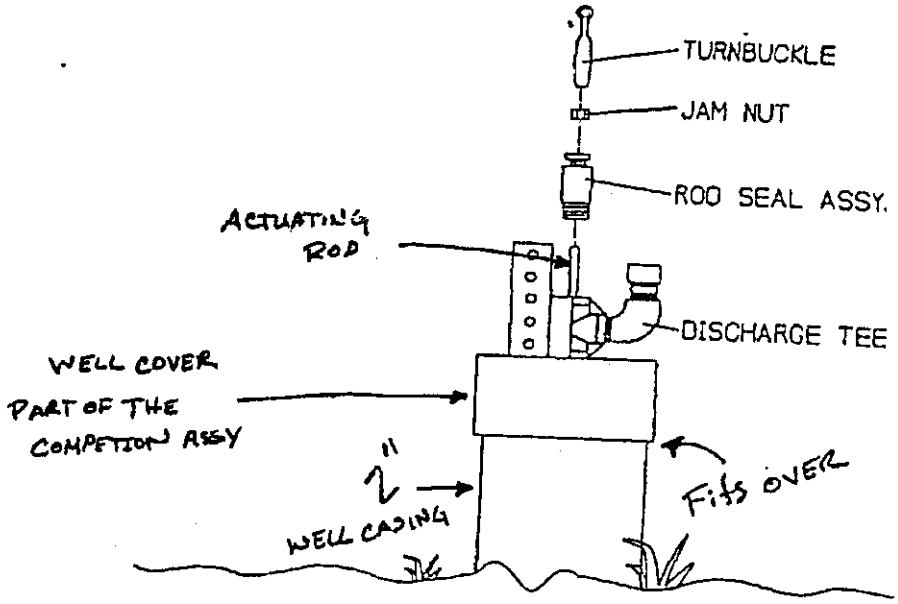



FIGURE 3

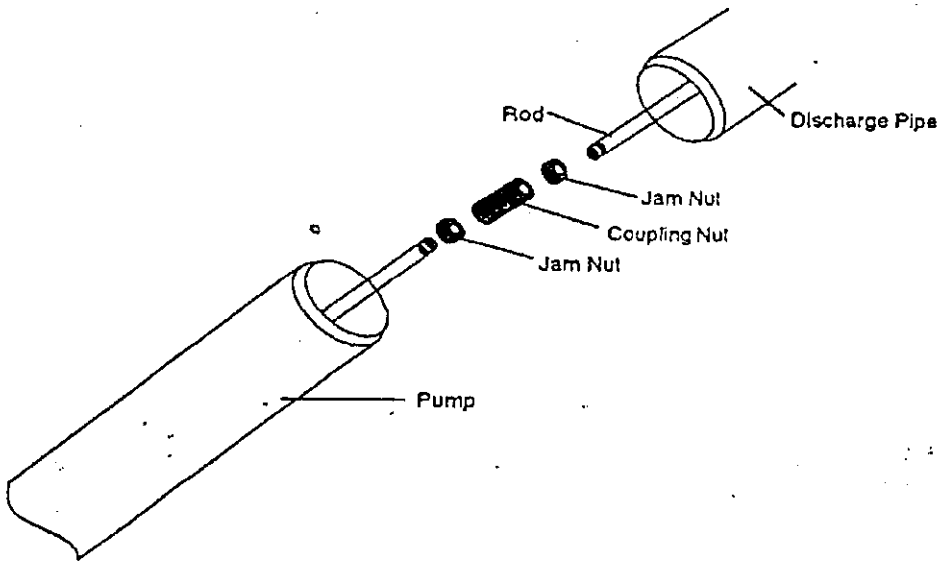



FIGURE 4

## Reberger, Dan W

**From:** Merriman, Raymond E
**Sent:** Monday, February 28, 2000 8:19 AM
**To:** Reberger, Dan W
**Cc:** Rarig, Bradley K; Merriman, Raymond E
**Subject:** DST Annulus Pump - Motor Over Temperature Protection

Dan:

The Flygt Model B-2060 submersible pump technical manual describes over temperature protection for the motor as follows:

Internal Protection Devices-Temperature; Motor temperatures are monitored by two thermal switches, embedded in the end coils of the stator windings. The switches have normally closed contacts and are wired in series. In order to minimize arcing they are of the snap-action type. The thermal switch opens at a temperature of 125°C + 6% (257°F + 11%) and closes at 95°C +15% (203°F +27%).

These snap-action switches are similar to the type in most home resistance electric house heaters, they are a very cheap bimetallic operated switch and they do arc if high enough voltage is impressed on them.

We could either not use the thermal switches or look into getting a signal from them at the intrensically safe level.

Give me a call if this does not answer your questions.

Ray

# FLAMMABLE GAS EQUIPMENT ADVISORY BOARD INTERPRETATION/RECOMMENDATION REPORT

**Date:** March 20, 2000 **Report No:** FGEAB-00-002, Rev. 1

| **Board Members:** | | **Report No.** |
|---|---|---|
| *M. G. Al-Wazani* | *C. C. Scaief III* | FGEAB-00-002 Rev. 1 |
| *R. D. Gustavson* | *R. L. Schlosser* | **Date:** |
| *R. A. Huckfeldt* | *D. B. Smet* | 3/20/00 |

**Requestor/Presenters:**
PM Dorsh, FM Hauck, GA Leshikar, RE Merriman, BK Rariq, DW Reberger

**Problem/Issue Statement:**

**Revision 1 corrects the evaluation of power cable for an electric submersible pump.** The Authorization Basis does not provided flammable gas region definition for the annulus of the double-shell tanks under a condition of primary to secondary leak. The region classification and compliance of equipment to applicable ignition source control requirements needs to be developed for emergency pumping equipment.

**Equipment/Activity Description:**

In order to provide emergency pumping if a primary tank should leak to the annulus, a portable pumping system is required to be located in the DST annulus region. To provide a pump suitable for the service, appropriate flammable gas regions need to be established for the DST annulus and directly connected areas to the annulus. The proposed pumping system consists of a single or multiple Flygt® Model BS-2060 submersible electric pumps. The single stage or first stage will draw suction in the waste. The discharge of the first pump will feed the suction of the second pump in the multiple pump application. All electrical wire is contained in a single feeder cable.

The second pump is an Instrumentation Northwest HydroStar™ ground water sampling pump for removal of waste for small leakage quantities or residual leakage after bulk leakage has been removed. The HydroStar™ pump is an air driven piston pump with air discharge at the pump.

**References:**

Flygt® BS-2060.390 Brochure and BS-2060 Operation and Maintenance Instructions. HydroStar™ Ground Water Sampling Pump descriptive brochure.

**Authorization Basis:** HNF-SD-WM-SAR-067 and HNF-SD-WM-TSR-006, Administrative Control 5.10

**Does equipment/activity comply with the AB ignition control requirements?**
[ ] **Yes** [X] **No** [ ] **Other**

See FGEAB Interpretation/Recommendation for flammable gas region definition.

**If No, does equipment/activity provide equivalent design/measures/controls?**
[X] **Yes** [ ] **No** [ ] **Other**

**Explanation/Justification:**

The Flygt® Model BS-2060 Electric Submersible Pump is fitted with seal barriers and an oil barrier fluid for shaft sealing. The motor is not normally sparking. The electrical cable enters a junction chamber and internal wiring from the junction chamber to the motor through resilient seal barriers. Therefore, a single failure of one of the seals or arcing of the motor winding is accommodated, providing equivalent safety to Ignition Source Control Set 1. The motor has a thermal switch that must meet intrinsic safety requirements if the switch is to be used. **The electrical cable feed to the junction chamber must meet ISC1 requirements (NEC Class 1, Division 1, Group B).** The motor starter and thermal overload (if used) must be located in a nonintrusive region.

The heels pump is an Instrumentation Northwest HydroStar™ air driven piston pump with no electrical components. The pump utilizes Teflon piston seals to allow operation. In the applied condition, the Teflon piston seals are in continuous contact with the conductive piston wall and are wetted. In this applied condition, electrostatic charge build-up and discharge is precluded. Therefore, the HydroStar™ pump provides equivalent safety to Ignition Source Control Set 1.

**If not equivalent, what changes are necessary to comply or provide equivalency?** N/A

# FLAMMABLE GAS EQUIPMENT ADVISORY BOARD INTERPRETATION/RECOMMENDATION REPORT

**Date:** March 20, 2000 **Report No:** FGEAB-00-002, Rev. 1

**FGEAB Interpretation/Recommendation:**

Since the FSAR, HNF-SD-WM-SAR-067, does not address flammable gas conditions for a primary tank leak, the annulus of the DSTs is considered a nonintrusive region. However, under the design conditions following a postulated primary to annulus leak, the annulus is comparable to the primary tank from a flammable gas perspective. The condition has not been analyzed to determine gas retention and release behavior under this condition, therefore, the approach taken is to establish flammable gas regions and ignition source control requirements directly comparable to the Authorization Basis controls established for the primary tanks:

- Leakage collected in the bottom of the annulus is considered waste and the region classified as Waste Intrusive. Equipment extending into the waste is considered Waste Intruding Equipment.
- The vapor space in the annulus is considered comparable to the vapor space of the primary tank and the region classified as Dome Intrusive.
- Pits that drain to the annulus are considered comparable to pits draining to the primary tank and the region classified as Ex-Tank Intrusive.
- Areas around open risers to the lesser of 18 opening diameters or 15 feet are considered Ex-Tank Intrusive.
- Annulus ventilation systems are considered Dome Intrusive to the first mixing point. The ventilation system downstream of the first mixing point is considered Nonintrusive when active ventilation is on and Ex-Tank Intrusive when active ventilation is off.

The application of ignition source controls to the various regions is based on the potential for waste sludge to be included in the material leaked to the annulus. Since the sludge may potentially retain generated flammable gases, the material in the annulus is assumed comparable to wastes currently considered to be in Facility Group 1, 2, or 3 tanks. Therefore, applicable ignition controls are considered to be governed by the controls established in HNF-SD-WM-TSR-006, Administrative Control 5.10, Table 5.10.1 for the tank regions. The Facility Group for each annulus is taken to be the Facility Group for the primary tank in HNF-SD-WM-TSR-006, Administrative Control 5.9, Table 5.9.1.

| Equipment, Materials, & Work Practices | Location | Ignition Control Set | IC Set Met | FGEAB Safety Equivalence Ruling | Approved Exception |
|---|---|---|---|---|---|
| Flygt® Model BS-2060 Electric Submersible Pump | FG 1, 2, 3 Waste Intrusive | ISC1 | No | Yes[1] | |
| HydroStar™ Ground Water Sampling Pump | FG 1, 2, 3 Waste Intrusive | ISC1 | No | Yes | |
| | | | | | |

[1] **The electric cable must be qualified for Class 1, Division 1, Group B service. The thermal switch must be qualified for Class 1, Division 1, Group B** or thermal switch must be de-energized. Motor starter and thermal overload must be located in a nonintrusive region.

**General application of finding, if any:**

Region definitions and Ignition Control Set applications are applicable to any Double-Shell Tank Annulus if a primary to secondary leak occurs.

**FGEAB Representative:** RL Schlosser (signature on file) **Date:** March 20, 2000

**FGEAB Reviewer:** MG Al-Wazani (signature on file) **Date:** March 20, 2000

## Reberger, Dan W

**From:** Merriman, Raymond E
**Sent:** Monday, March 20, 2000 10:27 AM
**To:** Al-Wazani, Mazen G; Reberger, Dan W
**Cc:** Schlosser, Richard L; Huckfeldt, Rick A; Merriman, Raymond E
**Subject:** RE: PUMPS/CABLE

Mazen and All:

The NEC, Article 501-11, allows for the use of Flexible Cords, in Class 1, Div. 1 areas. So this means Flexible cords meet the NEC or equivalent safety requirement below "no single point failure of energized equipment's can result in an arc, spark, or gas burn propagation to the environment external to the source enclosure."?

If this statement is true then we can look for a suitable cable, if it is not true then there is no use looking any further.

Dan tells me Mazen may have a source for a suitable cable, at this time I do not. Mazen can you pass any information on finding a suitable cable on to me when appropriate.

Thanks
Ray

—Original Message—
**From:** Al-Wazani, Mazen G
**Sent:** Monday, March 20, 2000 8:13 AM
**To:** Merriman, Raymond E; Reberger, Dan W
**Cc:** Al-Wazani, Mazen G; Schlosser, Richard L
**Subject:** PUMPS/CABLE

Ray,

All electrical equipment's shall meet IC set #1, this mean electrical equipment's shall be design to meet NFPA 70, Class I, Division 1, group B criteria or provide equivalent safety. As a minimum, this shall be interpreted to mean that no single point failure of energized equipment's can result in an arc, spark, or gas burn propagation to the environment external to the source enclosure.

Thanks,

Mazen

## Reberger, Dan W

**From:** Schlosser, Richard L
**Sent:** Thursday, March 23, 2000 2:59 PM
**To:** Merriman, Raymond E
**Cc:** Reberger, Dan W; AL-WAZANI, MAZEN; GUSTAVSON, ROBERT; HUCKFELDT, RICK; SCAIEF, CHARLES; SCHLOSSER, RICHARD; SMET, DAVID
**Subject:** Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

**Importance:** High

# Ray:

For the FGEAB to accept the Code compliant electrical cable at the pump interface, you need to provide a Professional Engineer evaluation of each of the conditions of NEC Article 501-11 as allowed by the NEC. This will provide a basis for acceptance at the interface with the pump. Since the pump is acceptable to the FGEAB but not a Class 1, Division 1, Group B design, you need to focus your evaluation on equivalence of the design to the cable requirements of the NEC since the FGEAB only addresses equivalence to requirements, not compliance with the requirements.

Thank you,
Rich S

# Double-Shell Tank Annulus Transfer Pump
# Flygt Model BS-2060 Electric Submersible Pump
# Submitted For FGEAB Evaluation

Preparations are underway to be ready to pump the annulus of any Double-Shell Tank in the event of a primary tank waste leak. The method for pumping an annulus is to have a submersible pump staged in a mobile trailer ready to deploy when a leak is identified. The DST's are either a Facility Group 1 or 2 and the pump column is considered Waste Intruding Equipment and must meet ISC Set 1 per Table 5.10-1 of the TSR.

The candidate pump (Flygt Model BS-2060) is an electric, submersible, centrifugal type pump. It will be part of a rigid supported column assembly that will be installed through the annulus pump pit 12" riser and extend down to a depth of approximately 50-feet.

Key information regarding the Flygt BS-2060 is summarized below:

• The pump has an air-filled motor isolated from the waste by upper and lower (2) mechanical shaft seals which are immersed in an oil bath, as shown in Figure 1. The rotating and stationary seal faces (of each seal) form a barrier to waste entry. The other barriers are achieved by o-ring of rotating seal assembly to pump shaft, and o-ring of stationary seal assembly to oil housing. (See attached sketch of tandem seal)

• Motor temperatures are monitored by two thermal switches, embedded in the end coils of the stator windings. The switches have normally closed contacts and are wired in series. In order to minimize arcing they are of the snap-action type. The thermal switch opens at a temperature of 125°C + 6% (257°F + 11%) and closes at 95°C +15% (203°F +27%). The electrical signal from the thermal switches will be modified to intrinsically safe or disconnected. Any thermal protection will be provided in the pump start/stop station located adjacent to the pit.

The following documentation is attached:

- Flygt BS-2060.390 two page cutsheet (includes basic specifications, 3x3 figures, performance data, dimensions)
- Figure 8 1/2 x 11, cutaway of pump internals
- Pages 1 thru 6 of Flygt Technical Manual
- Sketch of a representative tandem seal
- Telecon from SKF regarding bearing temperature

02/29/00

FLYGT

# BS-2060.390

Submersible Pump

## Small Dewatering Pump - Stainless Steel

Capacity up to 260 GPM, Heads up to 85 ft.

### Specifications

A **Cable.** Standard 50 ft. of AWG 12/7 SubCab cable. Other lengths available upon request.

B **Junction Chamber.** Cable entry incorporates a strain relief and grommet controlled compression sealing. Between the junction box and stator housing a rubber gland provides additional seal protection of the motor.

C **Pump Housing.** Stainless steel AISI/ASTM 316. Static seals are leakproof Nitrile rubber O rings in precision machined grooves, with controlled compression.

D **Shaft.** Stainless steel AISI 329.

E **Motor.** Air filled, NEMA design B with class F (155°C) insulation: 2 pole, 3400 rpm. Shrink-fit to the motor housing. Allows at least 10 starts per hour. Built-in thermal sensors for additional motor overload protection.

F **Bearings.** Upper and lower; single row ball bearing.

G **Shaft Seals.** Independent double face seals running in environmentally friendly, FDA approved (Standard #172.878) lubricant. Upper seal: carbon/ ceramic. Lower seal: tungsten carbide/ceramic.
Oil specs: .9 pints (0.5 l).

H **Impeller.** Multivane, open type. Material; stainless steel - AISI 329.

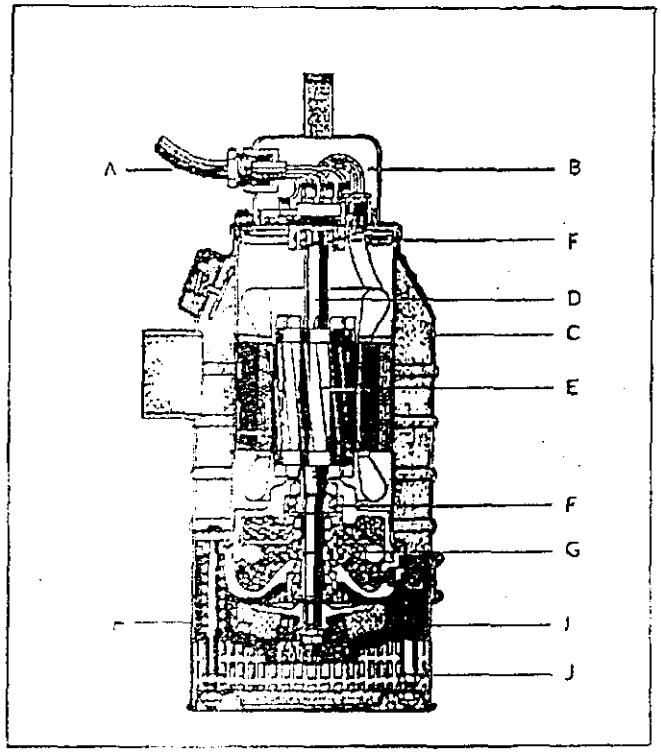
I **Wear Plate.** Protected by Nitrile Rubber liner. Adjustable to maintain pump's hydraulic performance.

J **Strainer.** Stainless steel AISI 316, 156 holes 1/2" dia.

*Fasteners. Stainless steel AISI 304.*

### Applications:

BS-2060 is ideal for pumping water containing corrosive materials in concentration 3-14 pH.




### Approval:

CSA approved to UL Standard #778.

### Controls (not shown).

Manual controls, providing short circuit and overload protection, housed in NEMA 4X (watertight, corrosion resistant) plastic enclosures. Level control Model B.408/4X available for automatic, unattended operation.

### Accessories.

Tandem connection.

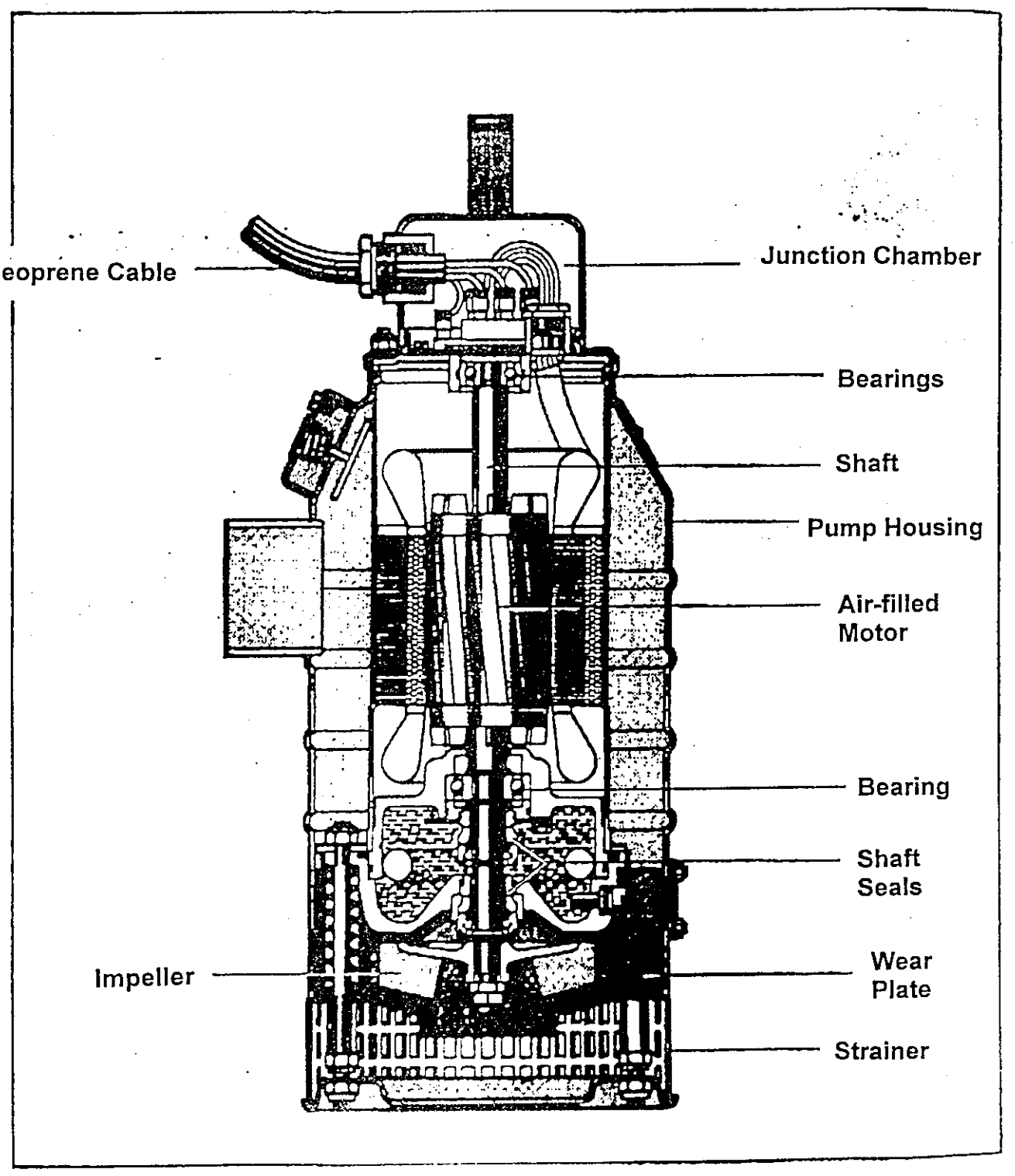
ITT Flygt is a member of the following Associations:

National Mining Association

This page intentionally left blank

## Applications:

BS-2060 is ideal for pumping water containing corrosive materials in concentration 3-14 pH.

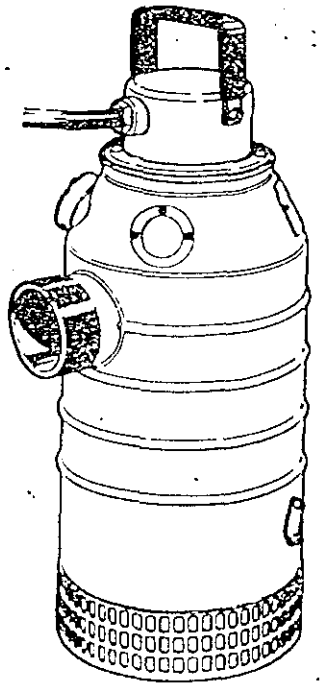


# A. GENERAL INFORMATION

## INTRODUCTION

This Manual refers to Flygt's Electric Submersible Stainless Steel Contracting and Mining Pump. The B2060 is a portable centrifugal pump designed for use in a corrosive liquid environment. The pump is constructed of acid proof SIS 2343 Stainless Steel capable of handling corrosive liquids as outlined on page 3 under "Chemically Acceptable Pumped Media". Where borderline chemical concentrations are encountered, or if in doubt, CONTACT FLYGT CORPORATION BEFORE USING.

Nominal Size: 3", 8 TPI NPSM Threaded Hose Connection



| ITEM NO | | |
|---|---|---|
| 40 | CABLE ENTRY GROMMET | CHLOROPRENE RUBBER |
| 49 | STATOR HOUSING | STAINLESS STEEL |
| 51 | JUNCTION CHAMBER COVER | STAINLESS STEEL |
| 52 | BEARING HOUSING | CAST IRON |
| 53 | STRAINER BOTTOM | STAINLESS STEEL |
| 54 | CARRYING HANDLE | STAINLESS STEEL/RUBBER COATED |
| 60 | LOWER WEAR PLATE | NITRILE RUBBER |
| 63 | SHAFT SEAL LOWER | TUNGSTEN CARBIDE/CERAMIC |
| 72 | SHAFT SEAL UPPER | CARBON/CERAMIC |
| 81 | SHAFT/PART OF ROTOR UNIT | STAINLESS STEEL |
| 84 | IMPELLER | CAST IRON or STAINLESS STEEL |
| 89 | COOLING JACKET | STAINLESS STEEL |
| | ALL SEAL O-RINGS | FLUORINATED RUBBER |
| | ALL PUMP O-RINGS | NITRILE RUBBER |
| | HARDWARE (SCREWS, NUTS, & BOLTS) | STAINLESS STEEL |

MATERIALS FOR B-2060 PUMP

# OPERATIONAL LIMITATIONS



General: Your pump is designed to provide long and dependable service under normal and adverse conditions. Observation of certain rules and limitations will improve performance, reduce maintenance costs and extend useful service life. For more detailed information consult "Preventive Maintenance Schedule", Page 11.

Environmental Temperature Limits: The upper limit for both the pumped liquid and the general surroundings of the pump is 46°C (115°F). Operation at higher temperatures without written approval by Flygt is not covered by Warranty

Volatility: Volatile liquids vaporize readily even at normal (ambient) temperatures and pressures, causing the impeller to become "vapor bound". To prevent vaporizing (flashing) at the suction inlet, either the inlet pressure has to be increased or the temperature reduced. Always check vapor pressure and both Required and Available NPSH. Pumping of volatile liquids which are corrosive or hazardous is not recommended nor covered by Warranty .

Corrosion: The B2060 provides reasonable service in corrosive liquids within an approximate pH range of 3 to 11. Although the pH value will in most cases provide some indication of the nature and extent of corrosive effects, alone it is not conclusive. Excessive aeration or large underwater steel structures nearby can create galvanic action which will accelerate corrosion.

Specific Gravity: The power requirement (kw input) of a centrifugal pump increases proportionally with the Specific Gravity (S.G.) of the liquid. (See Solids Content of the Liquid).

Solids Content of the Liquid: A liquid (usually water) when containing suspended solids in various quantities, becomes a "slurry". There are no definite rules governing the pumping of slurries, some combinations are too stiff or viscous to be pumped at relatively low concentrations (clay, bentonite, & paper stock) while others can be pumped with considerable ease at much higher concentrations (coal, silt, sand, & dusts). In general, always check the S.G. and maintain a minimum flow velocity necessary to keep the solids in suspension (suggested approx. minimum = 5 F.P.S.).

Abrasion: When pumping liquids containing abrasive particles, inspect the pump (seals, wear plate & impeller) frequently. Low capacities (flow velocities) may result in sedimentation and accumulation of particles in the pump, causing abnormal wear or even clogging. On the other hand the higher the flow capacity, the higher the friction wear.

Liquid Flow: If the viscosity of the liquid is higher than that of water, the performance (head & flow output) will be adversely affected. If poor performance is encountered (low GPM and/or low head) have the viscosity checked by a competent analyst.

Submergence: The B2060 will operate with a minimum of submergence (flooded impeller). Deeper submergence will improve external cooling and reduce aeration. Depth limitation is 65 feet. Avoid depths with overconcentration of suspended solids. Check NPSH to avoid cavitation.

Voltage Limitations: Voltages at the pump terminal board must be within the following ranges: 230V Motor, 198V to 252V; 460V Motor, 396V to 506V; 575V Motor, 495 to 633V. Watch for undersized wiring systems or overlong cables which may cause excessive voltage drops. Measurement at the control box under full load is satisfactory if voltage drop in the pump cable is taken into consideration.

Voltage Balance (Three Phase): Proper balance among the three supply-voltage phases applied to the pump motor is vital. A voltage imbalance of only 1% between two phases will result in from 6 to 10% amperage imbalance. This can result in circulating currents internally in the stator, which may not appear as line-current differences but will cause excessive stator temperature rise, substantially shortening motor life, or cause a dry stator burn-out. These high temperatures can affect rotor, bearings and shaft-seals also. Keep voltage imbalance below 1%.

Internal Protection Devices-Temperature: Motor temperatures are monitored by two thermal switches, embedded in the end coils of the stator windings. The switches have normally closed contacts and are wired in series. In order to minimize arcing they are of the snap-action type. The thermal switch opens at a temperature of 125°C + 6% (257°F + 11%) and closes at 95°C + 15% (203°F + 27%).

| CHEMICAL | FORMULA | TEMPERATURE LIMITS (°C) & (°F) | CONCENTRATION PERCENTAGES |
|---|---|---|---|
| Ammonium Hydroxide | $NH_4OH$ | 20 | All% |
| Ammonium Carbonate | $(NH_4)_2CO_3 \cdot H_2O$ | 20 | All% |
| Boric Acid | $H_3BO_3$ | 40 | All% |
| Calcium Hydroxide | $Ca(OH)_2$ | 20 | All% |
| Potassium Carbonate | $K_2CO_3 \cdot 2H_2O$ | 20 | 50% |
| Sodium Carbonate | $Na_2CO_3 \cdot 10H_2O$ | 20 | 30% |
| Sulfuric Acid | $H_2SO_4$ | 20 | 10% |
| Pump use limited to following chemical concentrations because of limited durability of pumps' rubber components. | | | |
| Acetic Acid | $CH_3COOH$ | 40 | 15% |
| Caustic Soda | NaOH | 20 | 78% |
| Hydrofluoric Acid | HF | 20 | 20% |
| Oxalic Acid | $(COOH)_2$ | 20 | 10% |
| Phosphoric Acid | $H_3PO_4$ | 50 | 50% |
| Potassium Hydroxide | KOH | 20 | 15% |
| Stearic Acid | $C_{17}H_{35}COOH$ | 40 | All% |
| Tannic Acid | $C_{14}H_{10}O_9$ | 40 | All% |
| Tartaric Acid | $C_2H_2(OH)_2(COOH)_2$ | 20 | 30% |

Table 1 CHEMICALLY ACCEPTABLE PUMPED MEDIA

## ELECTRICAL CONNECTIONS



Your B2060 pump is delivered connected for the voltage as specified (Fig. 1), and factory tested prior to shipment. CAUTION: Check that the power is off and disconnected before working on pump. The pump power cable, stator leads, and jumperstrips are arranged on the terminal board. Since the stator leads are connected to the terminal studs on top of the terminal board, the junction chamber cover must be removed to rearrange the leads for a different voltage. Be careful not to pinch stator leads or O-ring when re-installing junction chamber cover.

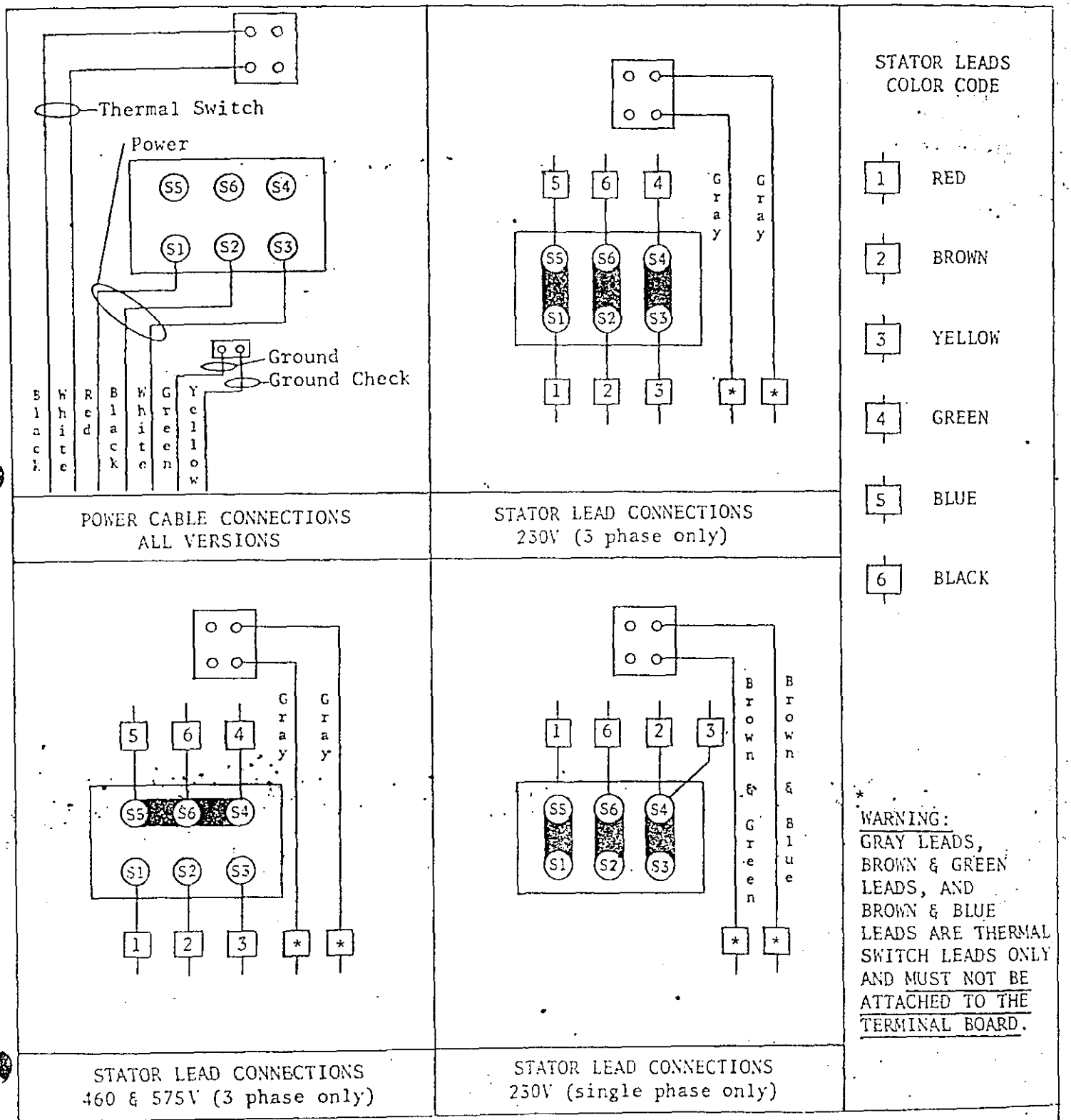



Fig. 1 ELECTRICAL CONNECTIONS

RPP-6485 Rev.0

| VERSION | IMPELLER | | RATED HP | RPM | DESIGN VOLTAGE | KW INPUT MAX | MAX CURRENT (AMPS) |
|---|---|---|---|---|---|---|---|
| | STANDARD | STAINLESS STEEL | | | | | |
| 3 Ø | ITEM 84A | ITEM 84B | 3.7 | 3300 | 230/460<br>575* | 3.5 | 10/5<br>4 |
| 1 Ø | ITEM 84C | ITEM 84D | 2.5 | 3400 | 230 | 2.3 | 10.5 |

*Separate Stator for 575 volt Service.

Power Cable: #12/3-2-1-GC Flygt Special, 7 Conductor; 3 Power, 2 Control, 1 Ground, and 1 Ground Check. Nominal O.D. 21mm = 0.83". Weight: 8 oz. per ft.

Pump Weight: 71 pounds

Table 2 IMPELLER AND ELECTRICAL DATA

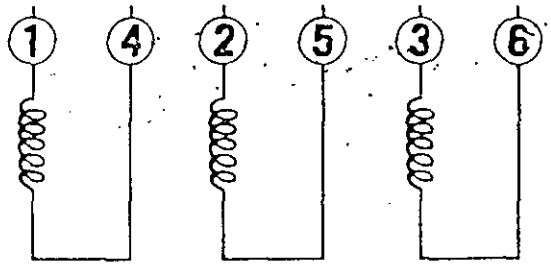
## MOTOR & WINDING RESISTANCES

Motor Design: Dry, shell-type, NEMA design B, squirrel cage induction motor, Class F, insulated, rated 155°C max, or 115°C rise (40°C ambient). Combined service factor of 1.10 (combined effect of voltage, frequency and specific gravity variations not to exceed this value).

| STATOR | RESISTANCE-OHMS |
|---|---|
| 230/460V 3Ø | S1-S4, S2-S5, S3-S6 = 2.6 ± 3% |
| 575V 3Ø | S1-S4, S2-S5, S3-S6 = 5.0 ± 3% |
| 230V 1Ø | S1-S2, S3-S6 = 1.37 ± 3% |

Values taken at 20°C (68°F). Winding resistance varies directly with temperature by approximately .40% per degree C.

230/460V or 575V 3Ø




230V 1Ø

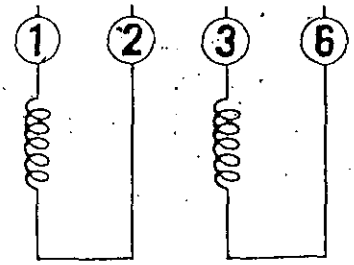



Fig. 2 WINDING RESISTANCES

NOTE: See Instructions for "Testing Stator" on Page 16

Portable Manual Controls (Fig. 3 & 4): The Standard Flygt Control is housed in a NEMA-3 weatherproof enclosure. It must always be mounted vertically and protected from mud, water, and dust. The Portable Manual Control contains one combination circuit breaker/overload disconnect unit/motor temperature sensing coil, with hydraulic/magnetic trip elements sized for pump protection. The disconnect serves a multiple purpose: (1) manual ON-OFF switch, (2) short-circuit breaker protection, (3) closely cablibrated overload protection which is factory pre-set, fast-acting and not affected by temperature changes, and (4) a motor temperature sensing coil which protects the stator windings from damage from excessive heat. If the circuit-breaker trips repeatedly, consult troubleshooting information in the Repair Section of this manual. Never bypass the circuit-breaker under any circumstances. If level regulation is desired, Flygt's Liquid Level Regulating Control System can be supplied as an option (See Pages 23 through 28).

Photograph Available
Next Printing

Fig. 3 SINGLE PHASE PORTABLE MANUAL CONTROL

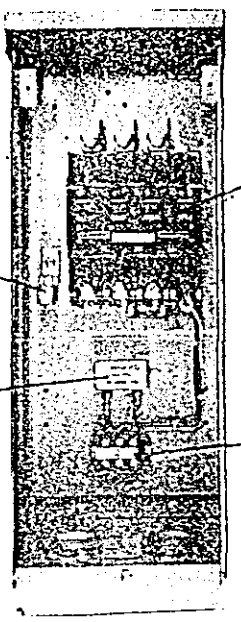



Fig. 4 THREE PHASE PORTABLE MANUAL CONTROL

From: Fluid Sealing Association, Mechanical Seal Handbook

**Jacketed Chamber** FIG. 4
A seal chamber with internal flow passages to heat or cool the chamber fluid. Used with a thick throat bushing to thermally isolate the seal chamber from the process and to contain a minimum volume of fluid to be controlled.

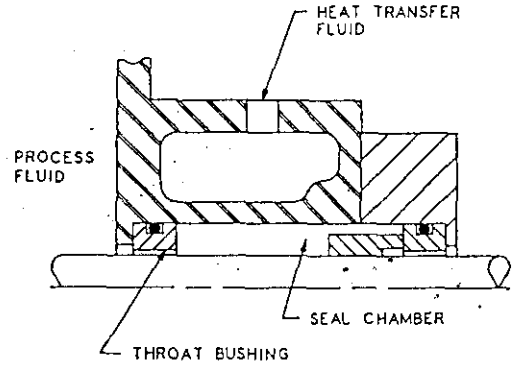



FIGURE 4
TYPICAL JACKETED SEAL CHAMBER

**Large Chamber** FIG. 5
A seal chamber holding a greater fluid volume allows free fluid circulation around the seal. When mechanical seals are retrofitted to packed equipment, as little as .040" gap exists between the rotating seal and the chamber.

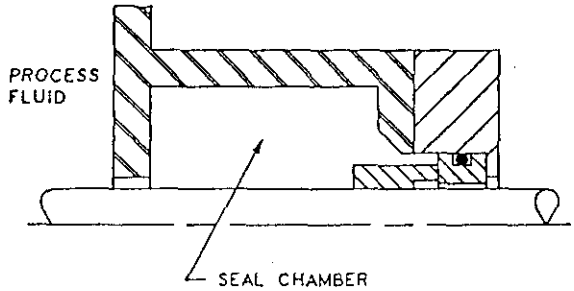



FIGURE 5
TYPICAL LARGE SEAL CHAMBER

**Double Seal** FIG. 6
Two mechanical seals that have a pressurized barrier fluid between them. The double seal can be configured in a back-to-back, tandem or face-to-face arrangement. Most back-to-back seals consist of two back-to-back rotaries running against an inboard (process side) and outboard (atmosphere side) stationary. In this configuration, the inboard stationary may shift or the inboard rotary will pop open when barrier fluid pressure drops significantly below process pressure. Tandem seals are usually two "inside" rotary seals with the barrier fluid pressure less than process pressure; however, double-balanced designs will also seal reliably when the barrier fluid pressure is greater than process pressure. The face-to-face is the most compact arrangement. Face-to-face seals usually consist of an inboard "inside" rotary seal and an outboard "outside" rotary seal. Like tandem seals, they can be double-balanced to seal independently of the barrier fluid pressure.

a.) BACK-TO-BACK

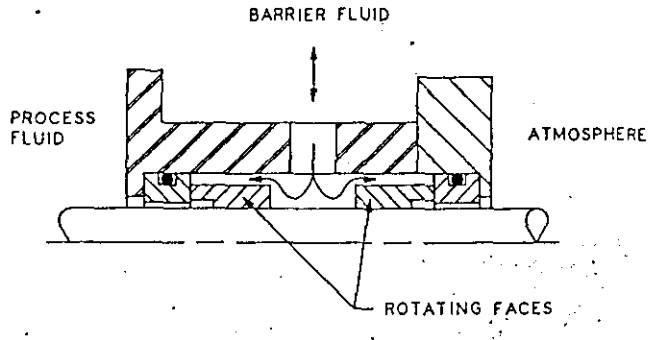



FIGURE 6
TYPICAL DOUBLE SEALS

b.) TANDEM

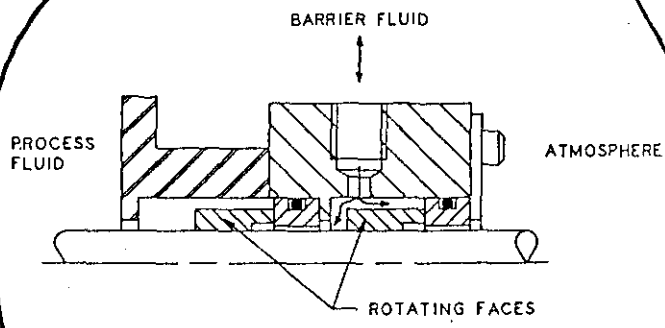



FIGURE 6
TYPICAL DOUBLE SEAL

c.) FACE-TO-FACE

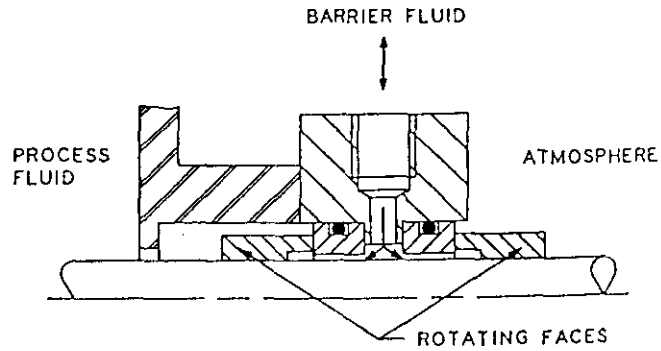



FIGURE 6
TYPICAL DOUBLE SEALS

# APPENDIX D
# PROCUREMENT DOCUMENTATION

RPP-6485 Rev. 0

## Al-Wazani, Mazen G

**From:** Merriman, Raymond E
**Sent:** Tuesday, March 28, 2000 2:32 PM
**To:** Al-Wazani, Mazen G
**Cc:** Merriman, Raymond E
**Subject:** RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

Mazen:

NEC 501-11 sub-items:

Item (3) - Connections at the pump will be by the manufacture, per the specification sheets we provided to the Board earlier. The cable connection at the supply end will be in the control enclosure terminals.

Item (4) - Supports to prevent tension on the terminal connections, will be by two cable connectors (one at the pump housing and one at the motor terminal box) per the manufactures data sheets we provided to the Board earlier.

Item (5) - Seals will be the two cable connectors mentioned above at the Pump. Also per the NEC an explosion proof seal will be installed at changes in the Hazardous Classification designation, such as at the pump tank/flange (Div 1 to Div. 2) and again at the control enclosure (Div. 2 to non-classified).

One other option that Dan Reberger is considering, is to utilize the high temperature switches in the motor. My recommendation to him is to add a separate cable/connectors/supports/seals as described in (3), (4), (5) for this circuit and put Intrinsically Safe Barriers in the control panel for this circuit. One would need to have 2" of separation in the motor junction box between the power and temp. sw. leads and terminations, or a barrier.

This additional circuit would provide some additional protection, but woould complicate the circuitry.

Just to confuse things a little.

Ray

-----Original Message-----
**From:** Al-Wazani, Mazen G
**Sent:** Tuesday, March 28, 2000 11:06 AM
**To:** Merriman, Raymond E
**Cc:** Schlosser, Richard L
**Subject:** RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

RAY,

You have not stated how you meeting 3,4 and 5.

-----Original Message-----
**From:** Merriman, Raymond E
**Sent:** Tuesday, March 28, 2000 10:53 AM
**To:** Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck); Smet, David B
**Cc:** Merriman, Raymond E; McDonald, Gregory P
**Subject:** FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

All:

Addressing the NEC 501-11. Flexible Cords, Class I, Division 1 and 2 article in more detail;

Item #1 - "flexibel cord shall be permitted for connection between ... portable utilization equipment and the fixed portion of their supply circuit." Later in this same article "Electric subermisible pumps .. shall be considered portable utilization equipment."

Based on this statement, I see no problem with using flexible cord in this submersible application.

Item #2 - (1) "Of a type approved for extra-hard usage;"

Based on the cable specification sheets and its extra-hard usage in its mining application, it meets this requirement.

Item #3 - (2) "contain a ground conductor"

Based on the specification the cable contains two #12 ground wires, and is satisfactory.

Item #4 - (3), (4), (5) Conditions of connecting, supporting, and sealing the cable will meet the requirements of the NEC

and this article.

I find the cable and its connections meet the requirements of NEC article 501-11 for application in DST annulus pumping; equivalency is also satisfied since it meets the stated NEC conditions.

Both Greg and I are P.E.s.

If there are any other concerns, please contact us.

Thank You

Ray Merriman, P.E.

-----Original Message-----
**From:** McDonald, Gregory P
**Sent:** Tuesday, March 28, 2000 7:59 AM
**To:** Merriman, Raymond E
**Cc:** Wallace, Debra O; Bresina, William L
**Subject:** RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

Mr. Merriman-

I have reviewed the vendor data you provided, and find the cable specified meets the requirements of NEC 501-11.

Greg McDonald
Chairman, HECB

-----Original Message-----
**From:** Merriman, Raymond E
**Sent:** Thursday, March 23, 2000 3:53 PM
**To:** McDonald, Gregory P
**Cc:** Merriman, Raymond E
**Subject:** FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
**Importance:** High

Greg:

I believe I could provide an answer to meet Mr. Schlossers comments below. However, if the HECB would provide an acceptance of this cable and it's connection at the pump housing and internal at the motor terminal box, I am sure it would carry more weight.

Thanks
Ray

-----Original Message-----
**From:** Schlosser, Richard L
**Sent:** Thursday, March 23, 2000 2:59 PM
**To:** Merriman, Raymond E
**Cc:** Reberger, Dan W; AL-WAZANI, MAZEN; GUSTAVSON, ROBERT; HUCKFELDT, RICK; SCAIEF, CHARLES; SCHLOSSER, RICHARD; SMET, DAVID
**Subject:** Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
**Importance:** High

*Ray:*

For the FGEAB to accept the Code compliant electrical cable at the pump interface, you need to provide a Professional Engineer evaluation of each of the conditions of NEC Article 501-11 as allowed by the NEC. This will provide a basis for acceptance at the interface with the pump. Since the pump is acceptable to the FGEAB but not a Class 1, Division 1, Group B design, you need to focus your evaluation on equivalence of the design to the cable requirements of the NEC since the FGEAB only addresses equivalence to requirements, not compliance with the requirements.

Thank you,
*Rich S*

RPP-6485 Rev. 0

## Al-Wazani, Mazen G

**From:** Huckfeldt, Rick A
**Sent:** Tuesday, March 28, 2000 11:45 AM
**To:** Merriman, Raymond E; Schlosser, Richard L; Al-Wazani, Mazen G; Scaief, C C III (Chuck); Smet, David B
**Cc:** McDonald, Gregory P
**Subject:** RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

This is more than I needed. As long as engineering specifies equipment meeting the NEC for Class I Division 1 locations, it meets the AB ignition control sets. We only need to get involved if it does not.

Rick

-----Original Message-----
**From:** Merriman, Raymond E
**Sent:** Tuesday, March 28, 2000 10:53 AM
**To:** Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck); Smet, David B
**Cc:** Merriman, Raymond E; McDonald, Gregory P
**Subject:** FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

All:

Addressing the NEC 501-11. Flexible Cords, Class I, Division 1 and 2 article in more detail;

Item #1 - "flexibel cord shall be permitted for connection between ... portable utilization equipment and the fixed portion of their supply circuit." Later in this same article "Electric subermisible pumps .. shall be considered portable utilization equipment."

Based on this statement, I see no problem with using flexible cord in this submersible application.

Item #2 - (1) "Of a type approved for extra-hard usage;"

Based on the cable specification sheets and its extra-hard usage in its mining application, it meets this requirement.

Item #3 - (2) "contain a ground conductor"

Based on the specification the cable contains two #12 ground wires, and is satisfactory.

Item #4 - (3), (4), (5) Conditions of connecting, supporting, and sealing the cable will meet the requirements of the NEC and this article.

I find the cable and its connections meet the requirements of NEC article 501-11 for application in DST annulus pumping; equivalency is also satisfied since it meets the stated NEC conditions.

Both Greg and I are P.E.s.

If there are any other concerns, please contact us.

Thank You

Ray Merriman, P.E.

-----Original Message-----
**From:** McDonald, Gregory P
**Sent:** Tuesday, March 28, 2000 7:59 AM
**To:** Merriman, Raymond E
**Cc:** Wallace, Debra O; Bresina, William L
**Subject:** RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

Mr. Merriman-

I have reviewed the vendor data you provided, and find the cable specified meets the requirements of NEC 501-11.

Greg McDonald
Chairman, HECB

-----Original Message-----
**From:** Merriman, Raymond E
**Sent:** Thursday, March 23, 2000 3:53 PM

**To:** McDonald, Gregory P
**Cc:** Merriman, Raymond E
**Subject:** FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
**Importance:** High

Greg:

I believe I could provide an answer to meet Mr. Schlossers comments below. However, if the HECB would provide an acceptance of this cable and it's connection at the pump housing and internal at the motor terminal box, I am sure it would carry more weight.

Thanks
Ray

-----Original Message-----
**From:** Schlosser, Richard L
**Sent:** Thursday, March 23, 2000 2:59 PM
**To:** Merriman, Raymond E
**Cc:** Reberger, Dan W; AL-WAZANI, MAZEN; GUSTAVSON, ROBERT; HUCKFELDT, RICK; SCAIEF, CHARLES; SCHLOSSER, RICHARD; SMET, DAVID
**Subject:** Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
**Importance:** High

*Ray:*

For the FGEAB to accept the Code compliant electrical cable at the pump interface, you need to provide a Professional Engineer evaluation of each of the conditions of NEC Article 501-11 as allowed by the NEC. This will provide a basis for acceptance at the interface with the pump. Since the pump is acceptable to the FGEAB but not a Class 1, Division 1, Group B design, you need to focus your evaluation on equivalence of the design to the cable requirements of the NEC since the FGEAB only addresses equivalence to requirements, not compliance with the requirements.

Thank you,
*Rich S*

## Al-Wazani, Mazen G

**From:** Smet, David B
**Sent:** Tuesday, March 28, 2000 11:12 AM
**To:** Merriman, Raymond E; Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck)
**Cc:** McDonald, Gregory P
**Subject:** RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

Works for me, thanks

Dave

-----Original Message-----
**From:** Merriman, Raymond E
**Sent:** Tuesday, March 28, 2000 10:53 AM
**To:** Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck); Smet, David B
**Cc:** Merriman, Raymond E; McDonald, Gregory P
**Subject:** FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

All:

Addressing the NEC 501-11. Flexible Cords, Class I, Division 1 and 2 article in more detail;

Item #1 - "flexibel cord shall be permitted for connection between ... portable utilization equipment and the fixed portion of their supply circuit." Later in this same article "Electric subermisible pumps .. shall be considered portable utilization equipment."

Based on this statement, I see no problem with using flexible cord in this submersible application.

Item #2 - (1) "Of a type approved for extra-hard usage;"

Based on the cable specification sheets and its extra-hard usage in its mining application, it meets this requirement.

Item #3 - (2) "contain a ground conductor"

Based on the specification the cable contains two #12 ground wires, and is satisfactory.

Item #4 - (3), (4), (5) Conditions of connecting, supporting, and sealing the cable will meet the requirements of the NEC and this article.

I find the cable and its connections meet the requirements of NEC article 501-11 for application in DST annulus pumping; equivalency is also satisfied since it meets the stated NEC conditions.

Both Greg and I are P.E.s.

If there are any other concerns, please contact us.

Thank You

Ray Merriman, P.E.

-----Original Message-----
**From:** McDonald, Gregory P
**Sent:** Tuesday, March 28, 2000 7:59 AM
**To:** Merriman, Raymond E
**Cc:** Wallace, Debra O; Bresina, William L
**Subject:** RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

Mr. Merriman-

I have reviewed the vendor data you provided, and find the cable specified meets the requirements of NEC 501-11.

Greg McDonald
Chairman, HECB

-----Original Message-----
**From:** Merriman, Raymond E
**Sent:** Thursday, March 23, 2000 3:53 PM
**To:** McDonald, Gregory P
**Cc:** Merriman, Raymond E

RPP-6485 Rev. 0

**Subject:** FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
**Importance:** High

Greg:

I believe I could provide an answer to meet Mr. Schlossers comments below. However, if the HECB would provide an acceptance of this cable and it's connection at the pump housing and internal at the motor terminal box, I am sure it would carry more weight.

Thanks
Ray

-----Original Message-----
**From:** Schlosser, Richard L
**Sent:** Thursday, March 23, 2000 2:59 PM
**To:** Merriman, Raymond E
**Cc:** Reberger, Dan W; AL-WAZANI, MAZEN; GUSTAVSON, ROBERT; HUCKFELDT, RICK; SCAIEF, CHARLES; SCHLOSSER, RICHARD; SMET, DAVID
**Subject:** Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
**Importance:** High

*Ray:*

For the FGEAB to accept the Code compliant electrical cable at the pump interface, you need to provide a Professional Engineer evaluation of each of the conditions of NEC Article 501-11 as allowed by the NEC. This will provide a basis for acceptance at the interface with the pump. Since the pump is acceptable to the FGEAB but not a Class 1, Division 1, Group B design, you need to focus your evaluation on equivalence of the design to the cable requirements of the NEC since the FGEAB only addresses equivalence to requirements, not compliance with the requirements.

Thank you,
*Rich S*

## Al-Wazani, Mazen G

**From:** Merriman, Raymond E
**Sent:** Tuesday, March 28, 2000 10:53 AM
**To:** Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck); Smet, David B
**Cc:** Merriman, Raymond E; McDonald, Gregory P
**Subject:** FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

All:

Addressing the NEC 501-11. Flexible Cords, Class I, Division 1 and 2 article in more detail;

Item #1 - "flexibel cord shall be permitted for connection between ... portable utilization equipment and the fixed portion of their supply circuit." Later in this same article "Electric subermisible pumps .. shall be considered portable utilization equipment."

Based on this statement, I see no problem with using flexible cord in this submersible application.

Item #2 - (1) "Of a type approved for extra-hard usage;"

Based on the cable specification sheets and its extra-hard usage in its mining application, it meets this requirement.

Item #3 - (2) "contain a ground conductor"

Based on the specification the cable contains two #12 ground wires, and is satisfactory.

Item #4 - (3), (4), (5) Conditions of connecting, supporting, and sealing the cable will meet the requirements of the NEC and this article.

I find the cable and its connections meet the requirements of NEC article 501-11 for application in DST annulus pumping; equivalency is also satisfied since it meets the stated NEC conditions.

Both Greg and I are P.E.s.

If there are any other concerns, please contact us.

Thank You

Ray Merriman, P.E.

-----Original Message-----
**From:** McDonald, Gregory P
**Sent:** Tuesday, March 28, 2000 7:59 AM
**To:** Merriman, Raymond E
**Cc:** Wallace, Debra O; Bresina, William L
**Subject:** RE: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable

Mr. Merriman-

I have reviewed the vendor data you provided, and find the cable specified meets the requirements of NEC 501-11.

Greg McDonald
Chairman, HECB

-----Original Message-----
**From:** Merriman, Raymond E
**Sent:** Thursday, March 23, 2000 3:53 PM
**To:** McDonald, Gregory P
**Cc:** Merriman, Raymond E
**Subject:** FW: Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
**Importance:** High

Greg:

I believe I could provide an answer to meet Mr. Schlossers comments below. However, if the HECB would provide an acceptance of this cable and it's connection at the pump housing and internal at the motor terminal box, I am sure it would carry more weight.

Thanks

Ray

-----Original Message-----
**From:** Schlosser, Richard L
**Sent:** Thursday, March 23, 2000 2:59 PM
**To:** Merriman, Raymond E
**Cc:** Reberger, Dan W; AL-WAZANI, MAZEN; GUSTAVSON, ROBERT; HUCKFELDT, RICK; SCAIEF, CHARLES; SCHLOSSER, RICHARD; SMET, DAVID
**Subject:** Acceptability of Flygt B-2060 Submersible Pump Electrical Cable
**Importance:** High

*Ray:*

For the FGEAB to accept the Code compliant electrical cable at the pump interface, you need to provide a Professional Engineer evaluation of each of the conditions of NEC Article 501-11 as allowed by the NEC. This will provide a basis for acceptance at the interface with the pump. Since the pump is acceptable to the FGEAB but not a Class 1, Division 1, Group B design, you need to focus your evaluation on equivalence of the design to the cable requirements of the NEC since the FGEAB only addresses equivalence to requirements, not compliance with the requirements.

Thank you,
*Rich S*

RPP-6485 Rev. 0

## Al-Wazani, Mazen G

**From:** Merriman, Raymond E
**Sent:** Wednesday, March 22, 2000 12:50 PM
**To:** Schlosser, Richard L; Al-Wazani, Mazen G; Huckfeldt, Rick A; Scaief, C C III (Chuck)
**Cc:** Merriman, Raymond E; Reberger, Dan W; Rarig, Bradley K
**Subject:** Flygt Pump - Power Cable

All:

I Faxed the cable specification for the Flygt Pump to all of you, except Chuck, yesterday. I made an incorrect notation on the bottom of the front page that the cable was "Not Class 1, Div.1, Gp B". It has been pointed out to me that the cable does meet the requirement of NEC 501-11 and as such it does meet the above requirements for Class 1, Div. 1, Gp B.

I have also checked out the cable specification with the chairperson and secretary the Hanford Electrical Contractor Safety Board, and they agree that the cable meets the requirements of NEC 501-11.

As such, the cable is acceptable to be used in a Class 1, Div, 1, Gp B situation such as the DSTs.

Please review this information and let me know if you concur or if I have overlooked something.

Thank You

Ray

## Reberger, Dan W

**From:** Rarig, Bradley K
**Sent:** Wednesday, May 10, 2000 8:02 AM
**To:** Reberger, Dan W
**Cc:** Hauck, Frank M (Marshall); Leshikar, Gregory A; Shipler, C E (Charlie)
**Subject:** FW: DST Annulus Pump Cable Connections

-----Original Message-----
**From:** McDonald, Gregory P
**Sent:** Wednesday, May 10, 2000 7:51 AM
**To:** Rarig, Bradley K
**Cc:** Merriman, Raymond E; Newhouse, R K (Keith)
**Subject:** FW: DST Annulus Pump Cable Connections

Brad-

I have reviewed the modifications to the pump discharge section where the pump cable connections have been relocated, and find the modification acceptable.

Greg McDonald
Chairman, HECB

-----Original Message-----
**From:** Merriman, Raymond E
**Sent:** Wednesday, May 10, 2000 7:43 AM
**To:** McDonald, Gregory P
**Subject:** DST Annulus Pump Cable Connections

Greg:

Have you had a chance to send Bradley a note on the "acceptance of the Connections for the DST Annulus pump"? Reberger was looking for something in writting.

Thanks
*CHG Equipment Engineering,*
*372-1653, R3-83*

# ELECTRIC SUBMERSIBLE PUMPS

| PUMP MANUFACTURER | VENDOR/ CONTACT/DATE | DOES PUMP MEET THESE REQUIREMENTS? PERFORMANCE* | DIMENSIONAL** | CLASS 1, DIV.1, GROUP B | PROS | CONS | ADDITIONAL INFORMATION |
|---|---|---|---|---|---|---|---|
| ABS / JC models | Pump Industries, Inc. Mark Osterhout Jr. 01/20/00 | YES | YES | NO | • Meets performance and dimensional criteria.<br>• If pump performance requirement is lowered slightly, a 7.25" pump could be used.<br>• Stainless steel hardware.<br>• Top discharge. | • Pump housing is made of aluminum alloy.<br>• No class 1, div. 1, Group B. | Can't use - Aluminum Housing |
| HOMA | F.R. Mahony and Associates 01/20/00 | YES | YES | NO | • Meets performance and dimensional criteria.<br>• Top discharge. | • Pump housings are made of cast iron and aluminum alloy.<br>• No class 1, div.1, Group B. | Can't use - Aluminum Housing |
| Ready Flow 3 | Instrumentation Northwest, Inc. Alvin Smith 01/18/00 | NO | YES | NO | • Meets dimensional criteria. | • Pump does not meet performance requirement.<br>• Aluminum Pump housing.<br>• No class 1, div.1, Group B. | Can't use - Aluminum Housing |
| Flygt / BS 2084 | Whitney Equipment Carrie 01/25/00 | YES | YES | NO | • Meets performance and dimensional criteria.<br>• Stainless steel hardware.<br>• Top discharge. | • Pump housing is made of aluminum alloy.<br>• Pump requires oil for use.<br>• No class 1, div.1, Group B. | Can't use - Aluminum Housing |
| BJM / RX 1500 | Familiam N.W. 01/25/99 | NO | YES | NO | • Meets dimensional requirements.<br>• Stainless steel housing.<br>• Top discharge. | • Pump is well below the performance requirement.<br>• No class 1, div.1, Group B. | • Very low Performance |

# ELECTRIC SUBMERSIBLE PUMPS

| PUMP MANUFACTURER | VENDOR/ CONTACT/DATE | DOES PUMP MEET THESE REQUIREMENTS? PERFORMANCE* | DIMENSIONAL** | CLASS 1, DIV.1, GROUP B | PROS | CONS | ADDITIONAL INFORMATION |
|---|---|---|---|---|---|---|---|
| Mody / G-500 | Mody LLC<br>Sam Mody<br>01/26/00 | YES | YES | NO | • Meets performance and dimensional criteria.<br>• All Stainless steel hardware.<br>• Top discharge. | • Pump is 10.75" in diameter.<br>• No class 1, div.1, Group B. | |
| Flygt BS-2060 | Flygt ITT<br>Grant Stayburg | NO | YES | NO | • Meets dimensional criteria.<br>• All Stainless steel hardware. | • Pump is side discharge<br>• No class 1, div.1, Group B. | • Pump can be used in tandem to achieve performance criteria.<br>• Pump can be converted to top discharge. |
| Gorman Rupp / 2" Stainless Steel | Gorman-Rupp<br>Bruce Pfieffer 03/09/00 | NO | YES | NO | • Meets dimensional criteria.<br>• All Stainless steel hardware.<br>• Pump has MSHA Approval. | • Pump has lower performance. | • Pump can be used in tandem to achieve performance criteria. |
| Griswold / 6" Submersible Turbine Pumps | Griswold Pump Company 02/25/00 | YES | YES | NO | • Meets performance and dimensional criteria.<br>• Small Diameter<br>• Top discharge. | • Pump housing is made of cast iron. • No class 1, div.1, Group B. | Can't use - Cast Iron = sparking |
| Grundfos / Model 60s | Northwest Pump<br>Travis Eschette<br>02/07/00 | YES | YES | NO | • Meets performance and dimensional criteria.<br>• Small Diameter<br>• Top discharge.<br>• Pump all Stainless Steel | • No class 1, div.1, Group B.<br>• Low Flow Rates | Flow Rates are probably to low. |

# ELECTRIC SUBMERSIBLE PUMPS

| PUMP MANUFACTURER | VENDOR/ CONTACT/DATE | DOES PUMP MEET THESE REQUIREMENTS? PERFORMANCE* | DIMENSIONAL** | CLASS 1, DIV.1, GROUP B | PROS | CONS | ADDITIONAL INFORMATION |
|---|---|---|---|---|---|---|---|
| Prosser / 3" Standard Line series 9-50000 | Peninsula Pump Corp - Stephanie 2/24/00 | YES | YES | NO | • Meets dimensional requirements.<br>• Top discharge. | • Pump housing is made of aluminum alloy.<br>• No class 1, div.1, Group B. | Can't use - Aluminum Housing |
| Piranha / PC Series | Equipment Specialties Company 1/26/00 Scott | NO | YES | NO | • Meets dimensional requirements.<br>• Stainless Steel Hardware.<br>• Top discharge. | • In order to meet dimensional requirement, not enough performance.<br>• Aluminum housing.<br>• Top discharge. | Can't use - Aluminum Housing |

* The pump must be capable of producing approximately 160 ft of head at 40 GPM.

** The pump must be able to fit inside a 12" riser.

K1091

# ORIGINAL

B.O.M. Suppl. 01



| CHG - BILL OF MATERIAL | End Use: Test Skid for DST Annulus Pumps | Wk. Pkg. No.: 2E-00-00963 | ECN No.: |
|---|---|---|---|
| Date: 5/30/2000 | Requestor: Charles E. Golden | | Priority: |

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 1 | Nipple, 3/4" SCHED 40 X 6" L, ASTM A 197 | | H0069996359~~4~~ | GS | 0 | NA | | 6/5/00 | |
| | EA. | | | 6/16/00 | | | | | 6/12/00 | 2101HV/ Hickman |
| 02 | 1 | Hose Connector, Male NPT, 3/4 NPT 3/4" ID | 16.60 | ~~H0069996360~~0 | GS | 0 | NA | | 6/6/00 | |
| | EA. | Hose, Swagelok, #SS-12-HC-1-12 RUS 6/8/00 | | 6/13/00 | | | | | 6/13/00 | 2101HV/ Hickman |
| 03 | 1 | Clamp, Hose, Worm drive, for 3/4" ID Hose, | | | GS | 0 | NA | | | Tool Crib |
| | EA. | Commercial Galv. | | | | | | | 6/6/00 | 2101HV/Hickman ~~MC-5C~~ RUS |
| 04 | 10 | Hose, 3/4" ID X 1/8" Wall, Commercial Rubber | | — 3594 | GS | 0 | NA | | 6/5/00 | |
| | FT. | | | 6/16/00 | | | | | | |
| 05 | 1 | Valve, Ball, 3/4", NPT, Whitey, | | — 3594 | GS | 0 | NA | | 6/5/00 | |
| | EA. | Part #S-63TS12 | | 6/16/00 | | | | | | |
| 06 | 1 | Plate, 9 1/2" X 1/2" X 28" L, ASTM A 36 | | | GS | 0 | NA | | | Fab Shop |
| | EA. | | | | | | | | 6/6/00 | 2101HV/ Hickman |

RPP-6495 Rev. 0

Date Required: 06/21/2000

Mandatory ~~Desired~~

Delivery Location: 2704HV/Maintenance Shop

QA Clauses: B34 AND B61

Suggested Vendor:

Special Instructions: Items 11 AND 12 Get A copy of calibration and maintenance MANUALS.

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Karen Stalk — Material Coordinator | 6/5/00 | S5-11 | 2-3909 |
| [illegible] Harty — Cognizant Engineer/DA (if applicable) | 5/31/2000 | S5-13 | 376-4985 |
| [illegible] Harty — Cognizant Manager (if applicable) | 5/31/2000 | S5-13 | 376-4985 |
| Charles E. Golden — Planner | 5/31/00 | S7-90 | 373-5690 |
| W K Adams — Quality Assurance | 5/31/00 | S6-15 | 372-3053 |

Material Released To and Received By: _____ Date _____ 6/7/00 - Driver took items 3, 6, 20-22, 26, 30, 32-36, 112, 117-48 to Hickman

A-6002-729 (02/00)

76

B.O.M. Suppl. 01



# CHG - BILL OF MATERIAL

End Use: Test Skid for DST Annulus Pumps

Wk. Pkg. No.: 2E-00-00963

ECN No.:

Date: 5/30/2000

Requestor: Charles E. Golden

Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 07 | 1 EA. | Valve, Globe, 3/4", FNPT, (McMaster-Carr), Part (#4695K44) | | H0069991635 95 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/13/00 | 2101HV1 Hickman |
| 08 | 1 EA. | 2" Well Head Completion Assembly, Instrumentation NW INC, Part #3E502 | | M/R 37910 / P/O 7237 | GS | 3 ~~0~~ DAR 6/21 | ~~NA~~ Q | | 3/30/00 / 6/15/00 | |
| 09 | DAR 6/21 ~~7~~ 21 ~~8~~ EA. | Actuating Rod (5' Sections W/ Coupling Nut), Instrumentation NW INC, Part #2B095 | | M/R 37910 / P/O 7237 | GS | 3 ~~0~~ DAR 6/21 | Q ~~NA~~ DAR 6/21 | | 3/30/00 / 6/15/00 | |
| 10 | 1 EA. | Air motor, 2', Instrumentation NW INC, Part #38020 | | M/R 37910 / P/O 7237 | GS | DAR 6/21 ~~0~~ 3 | ~~NA~~ Q | | 3/30/00 / 6/15/00 | |
| 11 | 1 EA. | Gauge, Pressure, 0-100# PSI, 4 1/2" Dial 1/4" MPT Bottom Connection, Ashcroft, Type 10095 DAR 6/8/00 | $170 | M/R 42502 | GS | 3 ~~0~~ NA | ~~NA~~ Q | | 6/12/00 | ~~598097-3~~ 597580-3 |
| 12 | 1 EA. | Valve, Relief, Adjustable, ~~5-100~~ 15-75 DAR 6/8/00 PSI Range, 3/4" FNPT Inlet and Outlet, ~~(McMaster-Carr)~~ IMI CASH VALVE INC, Part ~~(#49435K45)~~ K-10 DAR 6/8/00 | $300 | M/R 42502 | GS | 3 ~~0~~ NA | NA Q | | 6/12/00 | 598099-3 |

Date Required: 06/21/2000

◯ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: ____ Date ____

A-6002-729 (02/00)

RPP-6485 Rev. 0

77

# CHG - BILL OF MATERIAL

End Use: Test Skid for DST Annulus Pumps
Wk. Pkg. No.: 2E-00-00963
ECN No.:
Date: 5/30/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 2 / EA. | Hose connector, Male NPT, 3/4" NPT X 3/4" ID<br>Hose, Swagelok, Part #S-12-HC-1-12<br>SS Due 6/8/00 | $76.60 | 3600 / 6/13/00 | GS | 0 | NA | | 6/6/00 / 6/13/00 | 2101HV/ Hickman |
| 14 | 1 / EA. | Coupling, 3/4", 150#, FNPT, ASTM A 197 | | 3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 15 | 10 / FT. | Pipe, 3/4" SCHED 40 | | 3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 16 | 1 / EA. | Bushing, Reducing 3/4" X 1/4", Threaded, ASTM A 197 | | 3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 17 | 1 / EA. | Tee, 3/4', 150#, Threaded, ASTM A 197 | | 3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 18 | 2 / EA. | Clamp, Hose, Worm Drive, 1/2" Band Width, 13/16"-1 1/2 DIA Range, (McMaster-Carr), Part (#5415K15) | | 3595 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/13/00 | 2101HV/ Hickman |

Date Required: 06/21/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

78

RPP-6485 Rev. 0

# CHG - BILL OF MATERIAL

End Use: Test Skid for DST Annulus Pumps
Wk. Pkg. No.: 2E-00-00963
ECN No.:
Date: 5/30/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 10 FT. | Pipe, 2" SCHED 40, Welded, ASTM A 53 Type E GR B | | —3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 20 | 4 EA. | Screw, Hex HD, 5/8"-11UNC-2A X 2 1/2" LG, ANSI B18.2.1 CS | | | GS | 0 | NA | | 6/6/00 | Tool Crib / 2101HV/Hickman ~~MC-5C~~ KS |
| 21 | 4 FT. | Nut, HEX, 5/8"-11UNC-2B, ANSI B18.2.2 CS | | | GS | 0 | NA | | 6/6/00 | Tool Crib / 2101HV/Hickman ~~MC-5C~~ KS |
| 22 | 4 EA. | Washer, Plain, 5/8" Bolt Size, ANSI B18.21.1 CS | | | GS | 0 | NA | | 6/6/00 | Tool Crib / 2101HV/Hickman ~~MC-5C~~ KS |
| 23 | 15 FT. | Hose, Polyester reinforced, 3/4" ID X 1 3/16" OD, 300 PSI Working Pressure, (McMaster-Carr), Part (#5304K44) | | —3595 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/13/00 | 2101HV/ Hickman |
| 24 | 1 EA. | Pail, Storage, 5 Gallon Capacity, (McMaster-Carr), Part (#4211T3) | | —3595 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/13/00 | 2101HV/ Hickman |

Date Required: 06/21/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | | | |
|---|---|---|---|
| Material Coordinator | Date | MSIN | Phone No. |
| Cognizant Engineer/DA (if applicable) | Date | MSIN | Phone No. |
| Cognizant Manager (if applicable) | Date | MSIN | Phone No. |
| Planner | Date | MSIN | Phone No. |
| Quality Assurance | Date | MSIN | Phone No. |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

# CHG - BILL OF MATERIAL

End Use: Test Skid for DST Annulus Pumps
Wk. Pkg. No.: 2E-00-00963
ECN No.:
Date: 5/30/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 1 EA. | Elbow, 90 Deg., 3/4", 150#, FMPT, ASTM A 197 | | —3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 26 | 1 EA. | Screw, Hex, 5/16-18UNC-2A X 1" L, Commercial CS | | | GS | 0 | NA | | 6/6/00 | Tool Crib / 2101HV/Hickman ~~MC-5C~~ |
| 27 | 1 EA. | Channel, 12" L, Unistrut, P1000 | | —3598 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/13/00 | 2101HV/ Hickman |
| 28 | 2 EA. | Pipe Clamp, 3/4" Size, Unistrut, P2558-07 | | —3598 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/13/00 | 2101HV/ Hickman |
| 29 | 1 FT. | Angle Fitting, 90 Deg. (3 1/8" X 1 7/8"), Unistrut, P1538 A | | —3598 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/13/00 | 2101HV/ Hickman |
| 30 | 5 EA. | Channel Nut W/Spring (1/4-20UNC-2B), Unistrut, P1006-1420 | | | GS | 0 | NA | | 6/6/00 | Tool Crib / 2101HV/Hickman ~~MC-5C~~ |

Date Required: 06/21/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: _____ Date _____

RPP-6485 Rev. 0

A-6002-729 (02/00)

# CHG - BILL OF MATERIAL

End Use: Test Skid for DST Annulus Pumps
Wk. Pkg. No.: 2E-00-00963
ECN No.:
Date: 5/30/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 5 / EA. | Screw, Hex Cap (1/4" X 7/16" Size), HHCS025044EG | | — 3598 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/14/00 | 2101HV/ Hickman |
| 32 | 1 / EA. | Plate, 22" SQ X 3/8", ASTM A 36 | | | GS | 0 | NA | | / 6/6/00 | Fab Shop / 2101HV/ Hickman |
| 33 | 1 / EA. | Plate, 24" X 3/8" X 34" L, ASTM A 36 | | | GS | 0 | NA | | / 6/6/00 | Fab Shop / 2101HV/ Hickman |
| 34 | 1 / EA. | Plate, 18" SQ X 3/8", ASTM A 36 | | | GS | 0 | NA | | / 6/6/00 | Fab Shop / 2101HV/ Hickman |
| 35 | 2 / FT. | Plate, 2" X 1/2" X 3 13/16" L, ASTM A 36 | | | GS | 0 | NA | | / 6/6/00 | Fab Shop / 2101HV/ Hickman |
| 36 | 1 / EA. | Bar, 1" X 1/4" X 5' L | | | GS | 0 | NA | | / 6/6/00 | Fab Shop / 2101HV/ Hickman |

Date Required: 06/21/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | | | |
|---|---|---|---|
| Material Coordinator | Date | MSIN | Phone No. |
| Cognizant Engineer/DA (if applicable) | Date | MSIN | Phone No. |
| Cognizant Manager (if applicable) | Date | MSIN | Phone No. |
| Planner | Date | MSIN | Phone No. |
| Quality Assurance | Date | MSIN | Phone No. |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

# CHG - BILL OF MATERIAL

End Use: Test Skid for DST Annulus Pumps | Wk. Pkg. No.: 2E-00-00963 | ECN No.:

Date: 5/30/2000 | Requestor: Charles E. Golden | Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 37 | 1 / EA. | Pipe, 12" SCHED 40 X 72 1/2" L, Welded, ASTM A 53 Type E GR B | | 3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/15/00 | 2101HV/ Hickman |
| 38 | 1 / FT. | Pipe, 3" SCHED 40, Welded, ASTM A 53 Type E GR B | | 3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 39 | 1 / EA. | Pipe, 2" SCHED 40 X 84" L, Welded, ASTM A 53 Type E GR B | | 3594 / 6/16 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 40 | 1 / EA. | Flange, 3", R.F., Screwed, 150#, ASTM A 105 CS | | 3594 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/12/00 | 2101HV/ Hickman |
| 41 | 4 / EA. | Screw, Hex, 5/8"-11UNC-2A X 3 1/4" LG, Commercial CS | 1.00 | H0069963601 / 6/8/00 | GS | 0 | NA | | 6/7/00 / 6/8/00 | Hickman 2101HV |
| 42 | 4 / EA. | Nut, Hex, 5/8" Bolt Size, Commercial CS | | | GS | 0 | NA | | / 6/6/00 | Tool Crib / 2101HV/Hickman ~~MC-56~~ |

Date Required: 06/21/2000

◯ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-64968 Rev. 0

82

# CHG - BILL OF MATERIAL

End Use: Test Skid for DST Annulus Pumps
Wk. Pkg. No.: 2E-00-00963
ECN No.:
Date: 5/30/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 43 | 1 EA. | Gasket, 3" CL 150, R.F., Flange 1/8" THK Compressed Fiber, Garlok, Bluegard Style 3700 | | | GS | 0 | NA | | 6/5/00 | Shop Stock |
| 44 | 2 EA. | Tubing, 8" X 4" X 1/4" Wall X 72" L, ASTM A 500 GR B, square KLS 6/5/00 | | H0089996 3599 6/13/00 | GS | 0 | NA | | 6/6/00 6/14/00 | |
| 45 | 7 EA. | Tubing, 4" X 1/4" Wall X 72" L, ASTM A 500 GR B, square KLS 6/5/00 | | —3599 6/13/00 | GS | 0 | NA | | 6/6/00 6/14/00 | |
| 46 | 2 EA. | Eyebolt, Shoulder, 1/2"-13UNC-2A X 1 1/2" Thread Length, Dia. 1.19" eye, (McMaster-Carr), Part (#3014T491) | | —3595 6/16/00 | GS | 0 | NA | | 6/5/00 6/13/00 | 2101HV/ Hickman |
| 47 | 4 EA. | Nut, Hex, 1/2" Bolt Size, Commercial CS | | | GS | 0 | NA | | 6/6/00 | Tool Crib 2101HV/Hickman ~~MC-5~~ Gas |
| 48 | 4 EA. | Washer, Plain, 1/2" Size, Commercial CS | | | GS | 0 | NA | | 6/6/00 | Tool Crib 2101HV/Hickman ~~MC-5~~ Gas |

Date Required: 06/21/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: ___ Date ___

A-6002-729 (02/00)

RAP-6485 Rev. 0

83

B.O.M. Suppl. 01



# CHG - BILL OF MATERIAL

End Use: Test Skid for DST Annulus Pumps

Wk. Pkg. No.: 2E-00-00963

ECN No.:

Date: 5/30/2000

Requestor: Charles E. Golden

Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 49 | 4 / EA. | Washer, Lock, HLCL Spring, 1/2" NOM, RGLR, Commercial CS | | | GS | 0 | NA | | 6/8/00 | 2101HV/ Hickman |
| 50 | 3 / EA. | U-Bolt, Extended Length, 3" Pipe Size, 1/2-13UNC-2A Threads, W Hex Nuts, (McMaster-Carr), Part (#8880T38) | | 35915 / 6/16/00 | GS | 0 | NA | | 6/5/00 / 6/13/00 | 2101HV/ Hickman |
| 51 | 12 / EA. | Wire-Tie | | | GS | 0 | NA | | 6/5/00 | Tool Crib |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

Date Required: 06/21/2000

○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | | | |
|---|---|---|---|
| Material Coordinator | Date | MSIN | Phone No. |
| Cognizant Engineer/DA (if applicable) | Date | MSIN | Phone No. |
| Cognizant Manager (if applicable) | Date | MSIN | Phone No. |
| Planner | Date | MSIN | Phone No. |
| Quality Assurance | Date | MSIN | Phone No. |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

84

D118

# ORIGINAL

B.O.M. Suppl. 01



## CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.

Wk. Pkg. No.: 2E-00-00955

ECN No.: 658446

Date: 6/09/2000

Requestor: Charles E. Golden

Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 1 / EA. | Enclosure, NEMA Type 4, Left side hinged door, Flange-mounted, 14X12X6, Hoffman, A-1412CHNF | | | GS ~~QL~~ LEG 6/12/00 | 3 | Q | | | |
| 02 | 1 / EA. | Disconnect Switch, Class 9422, with flange-mounted Mechanism and A1 handle, ATCN-301 Non-Fused Lockable, | | | GS ~~QL~~ LEG | 3 | Q | | | |
| | | Square D, ATCN-301 | | | | | | | | |
| 03 | 3 / EA. | Circuit breaker,15A, 480V, 3 PH, Square D, Part #FAL34015 | | PJ7597 | GS ~~QL~~ LEG | 3 | Q | 7/24/00 | 7-24-00 | 2701 HV HICKMAN |
| 04 | 2 / EA. | Push Button, Class 9001, Red, Full Guard, Square D, Type KRIRH13 | | M/R436026 PO 52734 PO 7755 7/18/00 | GS ~~QL~~ LEG | 3 | Q | | 7/3/00 | 598548-3 |
| 05 | 2 / EA. | Conduit Connector, Liquid Tight, 1/2", Metalic, Midwest, LTB-50 | | M/R44160 | GS ~~QL~~ LEG | 3 | Q | | 7/14/00 | 598549-3 |

Date Required: 06/20/2000

Mandatory ~~Desired~~

Delivery Location: 2704HV/Maintenance Shop

QA Clauses: B34-all B76 for items 23, 40, 41, 42, 43, 52

Suggested Vendor:

Special Instructions

RECEIVED

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| D. J. Shultz (Material Coordinator) | 6-13-00 | S6-11 | 3-4249 |
| Carol Black (Cognizant Engineer/DA (if applicable)) | 6/12/00 | S5-13 | 3-3880 |
| Ken Rehberg for DGS (Cognizant Manager (if applicable)) | 6/12/00 | S5-13 | 3-3926 |
| Charles E. Golden (Planner) | 06/12/00 | S7-90 | 373-5690 |
| W L Adams (Quality Assurance) | 06/12/00 | S6-15 | 372-3053 |

Issued To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6495, Rev. 0

85

# CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.
Wk. Pkg. No.: 2E-00-00955
ECN No.: 658446
Date: 6/09/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 06 | 5 / EA. | Nipple Conduit, RGS, 1/2" X 6", ~~Midwest~~, ~~1506~~ DR 7/14/00 | | | GS ~~QL~~ | 3 | Q | | | 598550-3 |
| 07 | 5 / EA. | Cable fitting, 3/4"C - Form C, O.D. .750"-.875", Crouse-Hinds, #CGB297-SG | | M/R 43626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598551-3 |
| 08 | 10 / FT. | Conduit, Liquid Tight Flex, 1/2", Graybar, Type E.F.-J.I.C-Gray | | M/R 43626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598034-3 |
| 09 | 100 / FT. | Pump Cable, 7 Cord #12, 0.83" O.D., FLYGT, (By Owner) | | M/R 44160 | GS ~~QL~~ | 3 | Q | | 7/14/00 | 598499-3 |
| 10 | 1 / EA. | Window Kit, for item 6, SST, Hoffman, A-PWK95NFSS | | M/R 44160 | GS ~~QL~~ | 3 | Q | | 7/14/00 | 598046-3 |
| 11 | 10 / EA. | Fuse, Class 500V, FNQ-5 Amp, Bussman | | M/R 43626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598552-3 |

Date Required: 06/20/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | | | |
|---|---|---|---|
| Material Coordinator | Date | MSIN | Phone No. |
| Cognizant Engineer/DA (if applicable) | Date | MSIN | Phone No. |
| Cognizant Manager (if applicable) | Date | MSIN | Phone No. |
| Planner | Date | MSIN | Phone No. |
| Quality Assurance | Date | MSIN | Phone No. |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

98

# CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.
Wk. Pkg. No.: 2E-00-00955
ECN No.: 658446
Date: 6/09/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 2 / EA. | Panel Meter Analog, 4-1/2", ~~1~~ 0 DR 7/25/00 1-10 Amps, Triplett, ~~7015~~ 430 DR 7/25/00, G Series 153-0044 | | MW 44674 | GS ~~QL~~ CEG | 3 | Q | | 7-25-00 | 598773-3 |
| 13 | 58 / EA. | Terminal Blocks, Class 9080, Square D, Type GM6 | | m/R 43626 6/12/00 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598026-3 |
| 14 | 10 / EA. | Fuse, LPJ-2SP, Bussman | Quantity Tilt | m/R 43626 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598047-3 |
| 15 | 10 / EA. | Fuse, LPJ-15SP, Bussman | | m/R 43626 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598048-3 |
| 16 | 6 / EA. | Thermal Unit, For Air Cmpsr, Square D, B7.70 | | m/R 43626 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598041-3 |
| 17 | 12 / EA. | Thermal Unit, For Pumps 1 & 2, Square D, B8.20 | | m/R 44160 | GS ~~QL~~ CEG | 3 | Q | | 4/14/00 | 598040-3 |

Date Required: 06/20/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | | | |
|---|---|---|---|
| Material Coordinator | Date | MSIN | Phone No. |
| Cognizant Engineer/DA (if applicable) | Date | MSIN | Phone No. |
| Cognizant Manager (if applicable) | Date | MSIN | Phone No. |
| Planner | Date | MSIN | Phone No. |
| Quality Assurance | Date | MSIN | Phone No. |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

L3

# CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.
Wk. Pkg. No.: 2E-00-00955
ECN No.: 658446
Date: 6/09/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 2 / EA. | Ground Rod, Dia. 5/8" X 8'-0" L, Blackburn, BLA6258 | | M/R 44160 | GS ~~QL~~ | 3 | Q | | 7/14/00 | 598066-3 |
| 19 | 4 / EA. | Clamp, Ground Rod, 5/8" Blackburn, JAB58 | | M/R 431626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598065-3 |
| 20 | 100 / FT. | Conductor, Grounding Electrode, #6 AWG, Bare Copper Stranded, Graybar | | M/R 431626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598553-3 |
| 21 | 1 / EA. | Box, 1/2" THD, Cast W/mounting Lugs, Crouse-Hinds, FS019 | | M/R 431626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598068-3 |
| 22 | 2 / EA. | Nipple, Conduit RGS, 3/4" X 3", ~~Midwest~~, ~~1510~~ DJR 7/14/00 | | | GS ~~QL~~ | 3 | Q | | | 598554-3 |
| 23 | 3 / EA. | Pipe Clamp, 2", Unistrut, 032N036 | 7-24-00 | 43193 / 7/24/00 | GS ~~QL~~ | 3 | Q | 7/24/00 | 6-21-00 / 7-24-00 | 598467-3 / 2101 HV HICKMAN |

Date Required: 06/20/2000
◯ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

88

# CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.
Wk. Pkg. No.: 2E-00-00955
ECN No.: 658446
Date: 6/09/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 4 / EA. | Fuseblock, Bussman, JP6 0030-3CR | | | GS ~~QL~~ CEG 6/12/00 | 3 | Q | | | 598049-3 |
| 25 | 12 / EA. | Connector, Ground, Burndy, KPA4CUP | | m/R43626 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598555-3 |
| 26 | 3 / EA. | Legend Plate "ON", Square D (For item 20), JN199 | | m/R43626 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598556-3 |
| 27 | 3 / EA. | Legend Plate "OFF", Square D (For item 21), JN199 | | m/R43626 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598557-3 |
| 28 | 3 / EA. | Legend Plate "START", Square D (For item 22), KN301 | | m/R43626 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598558-3 |
| 29 | 3 / EA. | Legend Plate "STOP", Square D (For item 23), KN302 | | m/R43626 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598559-3 |

Date Required: 06/20/2000
○ Mandatory ◉ Desired
Delivery Location: 2704HV/Maintenance Shop
QA Clauses:

Suggested Vendor:
Emergency Justification:
Special Instructions: check cat id. If ok, order
77C00/111273

| | | | |
|---|---|---|---|
| Material Coordinator | Date | MSIN | Phone No. |
| Cognizant Engineer/DA (if applicable) | Date | MSIN | Phone No. |
| Cognizant Manager (if applicable) | Date | MSIN | Phone No. |
| Planner | Date | MSIN | Phone No. |
| Quality Assurance | Date | MSIN | Phone No. |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

B.O.M. Suppl. 01



# CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.

Wk. Pkg. No.: 2E-00-00955

ECN No.: 658446

Date: 6/09/2000

Requestor: Charles E. Golden

Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 3 / EA. | Wire Mesh Grip (For item 26), Crouse-Hinds, RPE421-119 | | MR43626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598560-3 |
| 31 | 2 / EA. | Cable fitting, 3/4"C - Form C, O.D. .625"-.750", Crouse-Hinds, CGB296-SG | | MR43626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598833-3 |
| 32 | 2 / EA. | Wire Mesh Grip, Crouse-Hinds, RPE417-117 | | MR43626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598861-3 |
| 33 | 1 / EA. | 1/8" Plate, 6" X 6", #6061-T6 ALUM, Ryerson, AMS-4027 (T DAL 6/28/00) | | CR-0-317303-1A | GS ~~QL~~ | 3 | Q | DAW 7-19-00 | 7-24-00 | 2101 HV HICKMAN |
| 34 | 10 / EA. | Locknuts, 3/4" Steel, Midwest, 12 | | MR43626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598562-3 |
| 35 | 10 / EA. | Locknuts, 1/2" Steel, Midwest, 11 | | MR43626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598563-3 |

Date Required: 06/20/2000

○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

96

# CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.
Wk. Pkg. No.: 2E-00-00955
ECN No.: 658446
Date: 6/09/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 36 | 10 / EA. | Locknut Sealing 3/4", Midwest, SL-2 | | M/R 431626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598564-3 |
| 37 | 10 / EA. | Locknut Sealing 1/2", Midwest, SL-1 | | M/R 431626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598565-3 |
| 38 | 10 / EA. | Bushing, Insulated 3/4", Midwest, 932 | | M/R 431626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598566-3 |
| 39 | 10 / EA. | Bushing, Insulated 1/2", Midwest, 931 | | M/R 431626 | GS ~~QL~~ | 3 | Q | | 7/3/00 | 598567-3 |
| 40 | 5 / EA. | Hose Clamp, 3/8", Unistrut, P3409 | | 43193 | GS ~~QL~~ | 3 | Q | 7/24/00 | 6/22/00 7-24-00 | 598476-3 2101 HV Hickman |
| 41 | 3 / EA. | Flex Clamp, 1/2", Unistrut, P3411 | | 43193 | GS ~~QL~~ | 3 | Q | | 6/22/00 | 598477-3 |

Date Required: 06/20/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 Rev. 0

# CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.
Wk. Pkg. No.: 2E-00-00955
ECN No.: 658446
Date: 6/09/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 42 | 10 / EA. | Nut Spring 1/4" -20, Unistrut, P1006-1420 | | 43193 | GS ~~QL~~ CEG 6/12/00 | 3 | Q | 7/24/00 | 6/22/00 / 7-24-00 | 598478-3 / 2101 HV Hickman |
| 43 | 10 / EA. | Hex Head Cap Screws, 1/4" X 3/4", Unistrut, HHCS025075EG | | 43193 | GS ~~QL~~ CEG | 3 | Q | 7/24/00 | 6/22/00 / 7-24-00 | 598479-3 / 2101 HV Hickman |
| 44 | 10 / EA. | 1/4-20UNC2B, Commercial, ASTM A307 CS | | | GS ~~QL~~ CEG | 3 | Q | | | |
| 45 | 10 / EA. | 1/4-Lockwasher, Commercial, ASTM A125 CS | | | GS ~~QL~~ CEG | 3 | Q | | | |
| 46 | 14 / in. | Mounting Track, Standard, Class 9080, Square D, GH114 | | MR436026 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598568-3 |
| 47 | 15 / EA. | Jumper 2 Pole, Square D, GH700 | | MR436026 | GS ~~QL~~ CEG | 3 | Q | | 7/3/00 | 598569-3 |

Date Required: 06/20/2000
○ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: _____ Date _____

A-6002-729 (02/00)

RPP-6485 REV. 0

# CHG - BILL OF MATERIAL

End Use: DST Annulus Pumping Control Sta.
Wk. Pkg. No.: 2E-00-00955
ECN No.: 658446
Date: 6/09/2000
Requestor: Charles E. Golden
Priority:

| Item No. | Quantity / Unit | Material Description | Estimated Cost | Req./Store No. / Exp. Delivery Date | Safety Class | Q Level | Approval Designator | QC Approval | Ordered / Received | Stock No. / Storage Location |
|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 10 / EA. | Jumper 6 Pole, Square D, GH710 | | M/R43626 | GS | 3 | Q | | 7/3/00 | 598570-3 |
| 49 | 10 / EA. | Label, 1-25, Square D, GH220 | | M/R43626 | GS | 3 | Q | | 7/3/00 | 598571-3 |
| 50 | 2 / EA. | Label, Blank, Square D, GH230 | | M/R43626 | GS | 3 | Q | | 7/3/00 | 598572-3 |
| 51 | 1 / EA. | Plug, 60A, 3 Wire, 4 Pole, Crouse-Hinds, APJ6485 | | 689103430 | GS | 0 | NA | | 6-13-00<br>7-25-00 | SENT TO [illegible] 7-25-00 |
| 52 | 3 / EA. | Pipe Clamp, 4-1/2", Unistrut, 072N080 | | M/R44160 | GS | 3 | Q | | 7/14/00 | 598480-3 |
| 53 | 6 / EA. | Truk Trak, 36" X 20" X 2.31", 5-Channel 1.25" X 1.25", Hubbell, HBLTT5 | | 689103430 | GS | 0 | NA | | 6-13-00 | |

Date Required: 06/20/2000
◯ Mandatory ◉ Desired

Delivery Location: 2704HV/Maintenance Shop

QA Clauses:

Suggested Vendor:

Special Instructions

Emergency Justification:

Org. Code/Cost Code: 77C00/111273

| | Date | MSIN | Phone No. |
|---|---|---|---|
| Material Coordinator | | | |
| Cognizant Engineer/DA (if applicable) | | | |
| Cognizant Manager (if applicable) | | | |
| Planner | | | |
| Quality Assurance | | | |

Material Released To and Received By: ____ Date ____

A-6002-729 (02/00)

RPP-6485 REV. 0

93

RPP-6485 Rev. 0

**CH2MHILL**
*Hanford Group, Inc.*

# INTEROFFICE MEMO

From: DST Engineering 74100-00-029
Phone: 373-3926
Date: June 1, 2000
Subject: MODIFICATION OF FLYGT PUMPS FOR ANNULUS PUMPING

To: R. S. Popielarczyk R2-58
J. B. Hebdon S6-15

Copies: D. G. Baide DGB S5-05
G. T. Frater S5-05

The purpose of this memorandum is to document the Chief Engineer and Quality Assurance Manager approval as required by RPP-MD-110, Rev, 1 for the upgrade of a Quality Level 0 item to a Quality level 3 item.

Items to be upgraded are four submersible pumps manufactured by Flygt Corporation Model 2060. The pumps are intended for future use in the annulus pumping of a double shell tank. The pumps will be shop modified from a side to a top discharge for use in an assembly for quick deployment in the event of a waste leak to the annulus.

The four pumps have been in spare parts for 10 years and purchased as Impact Level 4 items (PO# GAP-611-630161, spare part# 6111-5514-5670, serial numbers 8770002, 8880007, 8 & 9). The pumps were refurbished in May 2000 by a certified Flygt distributor to ensure proper operation.

The Flygt Model 2060 pump design, with the modification, was approved for use in annulus pumping operation by the Flammable Gas Equipment Advisory Board (Report FGEAB-00-002, Rev. 1).

The work package for the pump modification to top discharge verifies the proper pump models.

Should you have any questions please contact me on 373-3926.

Approvals:

R S Popielarczyk — 6-2-00
Chief Engineer — Date

J.S. SPARKS
J S Sparks For J.B. HEBDON — 6-2-00
Q. A. Director — Date

Don Reberger
D. W. Reberger
Engineer

blm

| ***PUMPING CONTROL STATION - Electrical Skid [2E-00-00955, supplement 0]*** | | | | |
|---|---|---|---|---|
| BOM Item No. | Material | Status (where is it) | ETA | Responsible Person |
| 2 | Disconnect Switch | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 3 | Circuit Breaker | Rec'd 6/28/00 -- Need QC buyoff | 7/10/00 | Hendrickson |
| 4 | Square D Starter/OL | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 5 | Enclosure | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 6 | Panel | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 7 | AC Timing Relay | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 8 | Transformer | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 9 | Mounting Track | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 10 | Terminal Blocks | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 11 | Terminal Block End Barric | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 12 | Pilot Light Red | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 13 | Pilot Light Green | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 14 | Push Button Green | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 15 | Push Button Black | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 16 | Conduit Connector | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 17 | Cable Fitting | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 18 | Conduit Flex | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 20 | Cable SOW-A | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 21 | Plug | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 22 | Conduit Body | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 24 | Air Regulator | PO 7558 - in AVS for inspection | 7/20/00 | Hendrickson |
| 25 | Air Dryer | PO 7567 - in AVS for inspection | 7/20/00 | Hendrickson |

| | | | | |
|---|---|---|---|---|
| 26 | Pipe Clamp | ***PO 7596 (Factory does not have) Still on order, taking care of on supplement # 1, changed the size*** | ***7/13/00*** | Sandall |
| 27 | Fuse FNQ-7 | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 28 | Fuse FNQ-20 | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 29 | Nut, Hex | Needs Vendor for price quote - should be able to find onsite - NO Concern - QA buy off today 06/28/00 | Toolcrib 06/29/00 | Shults |
| 30 | Beam W-shape | PO 7564 - through AVS - ready to ship | 7/20/00 | Hendrickson |
| 31 | Post Base | PO 7596 - shipped complete - to AVS | ***7/20/00*** | Sandall |
| 32 | Channel Brace | PO 7610 - shipped complete 7/13/00 | 7/20/00 | Sandall |
| 33 | Anular Fitting | PO 7596 - shipped complete - to AVS | ***7/20/00*** | Sandall |
| 34 | Screw Hex HD 1/2" | PO 7596 - shipped complete - to AVS | ***7/20/00*** | Sandall |
| 35 | Framing Channel | PO 7610 - shipped complete 7/13/00 | 7/20/00 | Sandall |
| 36 | Flat Plate Gusset P1356 | PO 7596 - shipped complete - to AVS | ***7/20/00*** | Sandall |
| 37 | Flat Plate Gusset P1334 | PO 7596 - shipped complete - to AVS | 7/20/00 | Sandall |
| 38 | Nut spring | PO 7596 - shipped complete - to AVS | ***7/20/00*** | Sandall |
| 39 | Screw Hex HD Cap | PO 7596 - shipped complete - to AVS | ***7/20/00*** | Sandall |
| 40 | Beam W-shape | PO 7564 - through AVS - ready to ship | 7/20/00 | Hendrickson |
| 41 | Pipe Clamp | ***PO 7596 (Factory does not have) Still on order, taking care of on supplement # 1, item #52 (changed the size)*** | ***7/13/00*** | Sandall |
| 42 | Overload Relay for pump | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 43 | Overload Relay for air | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 44 | Wire #14 | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 45 | Enclosure | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 46 | Panel | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 47 | Panel kit | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 48 | Window kit | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 50 | Framing Channel | PO 7610 - shipped complete 7/13/00 | 7/20/00 | Hendrickson |

| | | | | |
|---|---|---|---|---|
| 51 | Fuse LPJ-2SP | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 52 | Fuse LPJ-15SP | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 53 | Receptacle assembly | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 55 | Receptacle Duplex | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 56 | Ground Rod | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 57 | Clamp Ground Rod | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 59 | Box | PO 7584 - expected delivery date 8/5/00 | 8/11/00 | Hendrickson |
| 60 | Spring Door cover | PO 7584 - in AVS for inspection | 7/20/00 | Hendrickson |
| 64 | Union Oring | PO 7470 - in AVS for inspection | 7/20/00 | Hendrickson |
| | | | | |

| ***PUMPING CONTROL STATION - Electrical Skid [2E-00-00955, supplement 1]*** | | | | |
|---|---|---|---|---|
| BOM Item No. | Material | Status (where is it) | ETA | Responsible Person |
| 4 | Push Button | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 5 | Conduit Connector | Ordered on M/R 44160 | ***7/24/00*** | ***Stark*** |
| 6 | Nipple Conduit | Clarified with Reberger--need to clarify a few things with vendor -- then will change cat id | | ***Stark*** |
| 7 | Cable Fitting | PO 7755 - expected delivery date 8/6/00 | 8/11/00 | Stark |
| 8 | Conduit, Liquid Tight Flex | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 11 | Fuse, 500V, FNQ-5 | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 12 | Panel Meter Analog | **Need more info. from vendor, our Model 7015 is not a good #** | | **Stark** |
| 13 | Terminal Blocks | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 14 | Fuse, LPJ-2SP | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 15 | Fuse, LPJ-15SP | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 16 | Thermal Unit for Air Com | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 19 | Clamp, Ground Rod | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 20 | Conductor | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 21 | Box 1/2 | PO 7755 - expected delivery date 8/6/00 | 8/11/00 | Stark |
| 22 | Nipple, Conduit | Need more info. from vendor, our Model 7015 is not a good # | | Stark |
| 23 | Pipe Clamp 2" | ***Ordered, vendor attempting to provide B-Line to improve ETA*** | ***7/24/00*** | ***Need BOM changed*** |
| 24 | Fuseblock JP6 | Ordered (4) more, Past Due | 6/26/00 | Buyer |
| 25 | Connector | PO 7755 - to AVS for inspection | 7/20/00 | Stark |

| | | | | |
|---|---|---|---|---|
| 26 | Legend Plate "ON" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 27 | Legend Plate "OFF" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 28 | Legend Plate "START" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 29 | Legend Plate "STOP" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 30 | Wire Mesh Grip 119 | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 31 | Cable Fitting 3/4" | PO 7755 - expected delivery date 8/6/00 | 8/11/00 | Stark |
| 32 | Wire Mesh Grip 117 | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 33 | Plate 1/8" | Available through Fab. Shop - they will deliver to me 7/14/00 | ***7/14/00*** | ***Stark*** |
| 34 | Locknuts 3/4" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 35 | Locknuts 1/2" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 36 | Locknut Sealing 3/4" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 37 | Locknut Sealing 1/2" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 38 | Bushing 3/4" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 39 | Bushing 1/2" | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 40 | Hose Clamp 3/8" | ***PO 7674 - expected delivery date 7/21/00*** | ***7/28/00*** | Sandall |
| 41 | Flex Calmp 1/2" | ***PO 7674 - expected delivery date 7/21/00*** | ***7/28/00*** | Sandall |
| 42 | Nut Spring 1/4" | PO 7674 - expected delivery date 7/21/00 | 7/28/00 | Sandall |
| 43 | Hex Head Cap Screws | PO 7674 - expected delivery date 7/21/00 | 7/28/00 | Sandall |
| 44 | 1/4-20unc2b ASTM A307 | Reberger changed bom to reflect UNC-2A. Need to do cat. Id | | ***Stark*** |
| 45 | 1/4 lockwasher A125 | Reberger still working this item | | ***Reberger*** |
| 46 | Mounting Track | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 47 | Jumper 2 pole | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 48 | Jumper 6 pole | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 49 | Label 1-25 | PO 7755 - to AVS for inspection | 7/20/00 | Stark |
| 50 | Label Blank | PO 7755 - to AVS for inspection | 7/20/00 | Stark |

| | | | | |
|---|---|---|---|---|
| 51 | Plug, 60A | Ordered, should be in Richland (Vendor), Shults to verify with Vendor | ETA? | Shults |
| 52 | Pipe Clamp 4-1/2" | ***PO 7674 - expected delivery date 7/21/00*** | ***7/28/00*** | Sandall |
| 53 | Truk Trak | Ordered, should be in Richland (Vendor), Shults to verify with Vendor | ETA? | Shults |
| | | | | |

| ***Test Skid - Pump Riser Stand (test only) [2E-00-00963 supplement 1]*** | | | | |
|---|---|---|---|---|
| BOM Item No. | Material | Status (where is it) | ETA | Responsible Person |
| 12 | Relief Valve | ***Delivered to field*** | ***7/10/00*** | Hickman |
| | | | | |

| ***FUSE DISCONNECT SKID ASSEMBLY [2E-00-001222, supplement 0]*** | | | | |
|---|---|---|---|---|
| BOM Item No. | Material | Status (where is it) | ETA | Responsible Person |
| 1 | Fused Disconnect | Bom changed to H362RB. Ordered on M/R 44146 -- routed for approvals | | ***Stark*** |
| 2 | Fuse 30A | PO 7751 - in AVS | 7/20/00 | Stark |
| 3 | Plug, Pin/Sleeve | PO 7751 - in AVS | 7/20/00 | Stark |
| 4 | Cord, 4 Conductor | Vendor Verification needed | new item | Shults |
| 5 | Fitting, Strain Relief | PO 7751 - in AVS | 7/20/00 | Stark |
| 6 | Receptacle Housing 30A | PO 7751 - in AVS | 7/20/00 | Stark |
| 7 | Beam, W8x28 | Approved, PO7670 generated, Past Due | 6/26/00 | Sandall |
| 8 | Beam, W5x16 | Approved, PO7670 generated, Past Due | 6/26/00 | Sandall |
| 9 | Post Base | Changed cat id and sent for approvals | | ***Stark*** |
| 10 | Channel Brace | Changed cat id and sent for approvals | | ***Stark*** |
| 11 | Flat Plate Gussett P1356 | Changed cat id and sent for approvals | | ***Stark*** |
| 12 | Flat Plate Gussett P1334 | Changed cat id and sent for approvals | | ***Stark*** |
| 13 | Channel, Framing 3-1/4" | Verify part #'s with vendor before changing cat. Ids. | | ***Stark*** |
| 14 | Channel, Framing 1-5/8" | Verify part #'s with vendor before changing cat. Ids. | | ***Stark*** |
| 15 | Screw, Hex 1/2" | Verify part #'s with vendor before changing cat. Ids. | | ***Stark*** |
| 16 | Screw, Cap 1/2" | Verify part #'s with vendor before changing cat. Ids. | | ***Stark*** |
| 17 | Nut, Hex 1/2" | Shults has in possession | 7/3/00 | Shults |
| 18 | Nut, Spring 1/2" | Verify part #'s with vendor before changing cat. Ids. | | ***Stark*** |
| 19 | Fuse Kit | PO 7751 - in AVS | 7/20/00 | Stark |
| 20 | Angular Fitting 45 deg | Should have excess from previous order | not ordering | Shults |
| 21 | Ground Rod 5/8" dia | PO 7751 - in AVS | 7/20/00 | Stark |
| 22 | Clamp, Ground Rod | PO 7751 - in AVS | 7/20/00 | Stark |
| 23 | Conductor, #8AWG | PO 7751 - in AVS | 7/20/00 | Stark |

| *- Pump Assembly Modification (Steve Galloway, DynCorp)* | | | | |
|---|---|---|---|---|
| BOM Item No. | | Status (where is it) | ETA | Responsible Person |
| | | No item list generated yet not ready to do so | | per Denny Hert |

RPP-6485 Rev. 0

Req. # 39121

**Title – Statement of Work for Annulus Pumping Time Deployment Study**
**Contract 4975 – Fluor Daniel Northwest**
**Revision Number - 0**
**Date – December 9, 1999**

**Objective:**
This task order is to authorize Fluor Daniel Northwest to initiate development of a study to determine the time period required to initiate the pumping of a Double-Shell Tank Annulus. The study will evaluate and compare several cases in which equipment is readily available in storage or equipment needs some degree of fabrication. This task order will be supplemented as necessary to allow completion of the task.

**Background/Introduction:**
The Code of Federal Regulations (10CFR40, Vol. 16, Part 265.193(c)(4) and the Washington Administrative Codes (WAC 173-330-640(4)(iv) require "Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system within 24 hours, or in a timely a manner as is possible to prevent harm to human health or the environment…" This requirement is applicable to pumping the annulus of a double-shell tank.
Equipment is being assembled in the 200 areas to allow the timely pumping of a double-shell tank annulus. Depending on the amount of documentation updates (i.e., drawings) and degree of equipment assembly it is desired to determine the amount of time required to complete the documentation, planning, fabrication and installation to allow initiation of the annulus pumping.

**Scope:**
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:
1. Identify all the required activities necessary to initiate annulus pumping
2. Estimate the amount of time required for completion of activities
3. Sequence activities and establish an estimated schedule for deployment
4. Provide a recommendation for removal of the 5 existing annulus pumps next year based on impacts to initiation of pumping. Removing contaminated pumps requires use of the Long Length Contaminated Equipment Retrieval System, which is extremely expensive and time consuming.

The study shall include the following three cases discussed below:

Case 1 – Assume submersible pumps are available and require only flange installation
Assume rigid jumper drawings need ECN updates (Central & Annulus pump pits)
Assume rigid jumpers (Central & Annulus pump pits) will be fabricated from available components in storage

Case 2 – Assume submersible pumps are available and require only flange installation
Assume rigid jumper drawings are up-to-date (Central & Annulus pump pits)
Assume rigid jumpers (Central & Annulus pump pits) will be fabricated from available components in storage

Case 3 – Assume submersible pumps are available and require only flange installation
Assume rigid jumper drawings are up-to-date (Central & Annulus pump pits)
Assume rigid jumpers (Central & Annulus pump pits) are fabricated and available in storage at 2101-M

The activities associated with the pumping shall include, assembly and testing of the pump, assembly of the jumpers and testing, transport of the Emergency Pumping Trailer and jumpers to the site, installation of pumps and jumpers, connection of electrical and pneumatic supplies to the pumps.

**Deliverables:**
A supporting document compiling the information from the deployment study by February 11, 2000. This is the latest date for completion; any delays could result in a monetary fine for LMHC. A copy of the SD computer file will be transferred to the LMHC Technical Contact.

Req. # 39121

**Acceptance Criteria:**
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

**Period of Performance:**
Activities associated with this SOW are expected to be initiated as soon as possible after receipt of the Task Order, with completion on or before February 11, 2000.

**Technical Point of Contact:**
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering
- Administrative Contact: A. B. Johnson, & L. K. Martin, LMHC, Financial Control
- Engineer: S. J. Lepka, LMHC, Operational Configuration Management

**Applicable ES&H requirements:**
Standard ES&H requirements (without ISMS) are warranted for this work.

**Safety Requirements:**
N/A

**Requirements (Including Quality Assurance Requirements):**
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), *Quality Assurance Requirements*, and the enforcement actions under 10 CFR 820, *General Statement of Enforcement Policy.*

**Hold Points:**
N/A

**Configuration Management Requirements:**
N/A

**Work Location/Potential Access Requirements:**
N/A

**Training:**
N/A

**Qualifications:**
Degreed Engineering support as required.

**Special Requirements:**
N/A

**Reporting/Administration:**
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.

RPP-6485 Rev. 0

Req. # 39142

**Title – Statement of Work for Annulus Pumping**
**Contract 4975 – Fluor Daniel Northwest**
**Revision Number - 0**
**Date – December 9, 1999**

**Objective:**
This task order is to authorize Fluor Daniel Northwest to provide engineering support for identifying, supporting procurement, testing, and final design of a pump assembly for waste removal in the Double-Shell Tank Annulus.

**Background/Introduction:**
The objective is to provide a combination of two pumps capable of high flow removal of waste for the DST Annulus, and removal of the heel to the extent possible. The pumping scheme should follow that addressed in an ARES Report Number 9905303-001, March 1999, "Double-Shell Tank Annulus Pumping Alternative Evaluation" unless changed with LMHC concurrence. A spare pumping system will also be procured. These activities support Tasks 19DAPB " Prepare Procurement Specification & Procure Pump" and 19DAPC "Design, Procure, Fabricate, Receive & Store Jumpers & Pump Assemblies" of the schedule attached to correspondence LMHC-9954506R2 October 25, 1999.

**Scope:**
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:

Task 19DAPB

1. Review of piping system and prepare preliminary design (6 DST Farms transferring to 106-AP)
2. Prepare procurement specification for pumps
3. Support procurement activities
4. Evaluate bids, and select vendor
5. Prepare acceptance test procedure
6. Evaluate run-in data for the tested pumps
7. Develop Certified Vendor Information File

Task 19DAPC

8. Final design of pump assemblies and farm specific flanges
9. Fabrication support of pump assemblies
10. Identification of common spare jumper parts
11. Prepare spare parts list

**References:**
Piping pressure drop calculations for the Cross-site transfer route to AP Tank Farm have been documented in Project W-058 files in calculation numbers W058-P-044 and 048. Schematics with transfer line lengths have been developed for most tank farm routings to AP farm and can be found in the Emergency Transfer procedures TO-001-181, 182, 183, 184 and TO-430-500 as excavation schematics.

**Deliverables:**
Design drawings, procurement specification, acceptance test procedure all prepared in accordance with LMHC approved procedures.

**Acceptance Criteria:**
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

**Period of Performance:**
Activities associated with this SOW are expected to be initiated as soon as possible after receipt of the Task Order, with completion on or before April 11, 2000 for Task 19DAPB and June 2, 2000 for Task 19DAPC.

**Technical Point of Contact:**
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering

Req. # 39142

- Administrative Contact: A. B. Johnson, L.K. Martin LMHC, Financial Control
- Project Engineer: S. J. Lepka, LMHC, Operational Configuration Management.

**Applicable ES&H requirements:**
Standard ES&H requirements (without ISMS) are warranted for this work.

**Safety Requirements:**
N/A

**Requirements (Including Quality Assurance Requirements):**
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), *Quality Assurance Requirements*, and the enforcement actions under 10 CFR 820, *General Statement of Enforcement Policy.*

**Hold Points:**
N/A

**Configuration Management Requirements:**
N/A

**Work Location/Potential Access Requirements:**
N/A

**Training:**
N/A

**Qualifications:**
Degreed Engineering support as required.

**Special Requirements:**
N/A

**Reporting/Administration:**
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.

Req. # 39142

# ISMS Clause Flow Down Prescreening Questions

| Does the work involve one or more of the following? | Applicable Yes/Maybe* | Applicable | SME ** |
|---|---|---|---|
| 1. Operation, maintenance, repair or testing of electrical, pneumatic, hydraulic or mechanical systems (e.g., N2 plant operation, elevator repair, substation breaker repair, etc.) | | X | IS/H |
| 2. Construction or excavation | | X | IS/IH/ ENV/Rad |
| 3. Hazardous materials, chemicals or substances (e.g., pest and weed control, chemical inventory, lead or lead-containing materials, asbestos, beryllium, hazardous or radiological waste, etc.) | | X | ENV/IH/ Rad |
| 4. The activity includes deliverables or services where potential radiological harm, radiation, or radioactive material governed by 10 CFR 835 is present. | | X | Rad/IH |
| 5. Exposure to significant occupational hazards (e.g., hoisting, rigging or cranes; confined space; scaffolding or elevated work platforms; compressed gas cylinders; portable hand held tools, powered by electrical or mechanical energy; portable heating equipment; welding or cutting; explosives; heat stress, etc.) | | X | IS/IH |
| 6. Nuclear facilities, or their support systems or their authorization basis. | | X | Nuc Safety |
| 7. Tanks, lines or vessels being breached | | X | IS/IH |
| 8. Structures, systems or components designated as Safety Class, Safety Significant or identified as providing defense-in-depth or worker safety in a Facility Authorization Basis (FAB). | | X | Nuc Safety |
| 9. Work that could impact the health and safety of site personnel. | | X | IS/IH |
| 10. The potential for changes in emission, generating rates, or new discharge of hazards, radiation, petroleum, substances, or other pollutants from a facility or process to the environment (air, water, land). | | X | ENV |
| 11. Maintenance or repair of Fire Protection systems. | | X | Fire Prot |

* If any question is answered YES or MAYBE, then Subject Matter Expert (SME) evaluation is REQUIRED.
** This is not a comprehensive list of SME(s). All appropriate SME(s) shall be involved in the evaluation as needed.

A-6002-699

RPP- 6445 Rev. 0

Req. # 39151

**Title – Statement of Work for Annulus Pumping**
**Contract 4975 – Fluor Daniel Northwest**
**Revision Number - 0**
**Date – December 9, 1999**

**Objective:**
This task order is to authorize Fluor Daniel Northwest to provide engineering design support for modifying the Emergency pumping trailer to support waste removal in the Double-Shell Tank Annulus.

**Background/Introduction:**
The objective is to provide capabilities in the trailer to store the pump assemblies, and provide electrical and pneumatic interfaces with the farms to allow rapid response to annulus pumping operations. These activities support Tasks 19DAPD " Modify Emergency Pumping Trailer" and 19DAPE " Develop Procedures" of the schedule attached to correspondence LMHC-9954506R2 October 25, 1999.

**Scope:**
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:

Task 19DAPD

1. Design trailer racks for equipment storage
2. Support fabrication and installation of racks
3. Design modification to trailer electrical skid to support pumping operations in all 6 DST farms
4. Design modifications to electrical interface for six tank farms
5. Design modifications to trailer air supply to support pump operation

Task 19DAPE

6. Prepare Operational Test Procedure (OTP) for trailer and farm equipment and pumps

Task 19DAPD

7. Support OTP and prepare Operational Test Report (OTR)

**References:**
An electrical skid design for annulus pumping in AP Tank Farm is on Drawing H-2-90470 Sheet 4.
The Drawings for the trailer equipment are – Index H-14-103175 and H-14-103144 through H-14-103150

**Deliverables:**
Design drawings, procurement specification, operational test procedure and report all prepared in accordance with LMHC approved procedures.

**Acceptance Criteria:**
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

**Period of Performance:**
Activities associated with this SOW are expected to be initiated, as soon as possible after receipt of the Task Order, with completion on or before March 15, 2000 for Task 19DAPD and May 1, 2000 for Task 19DAPE.

**Technical Point of Contact:**
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering
- Administrative Contact: A. B. Johnson, L.K. Martin, LMHC, Financial Control
- Project Engineer: S. J. Lepka, LMHC, Operational Configuration Management

**Applicable ES&H requirements:**

Standard ES&H requirements (without ISMS) are warranted for this work.

**Safety Requirements:**
N/A

**Requirements (Including Quality Assurance Requirements):**
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), *Quality Assurance Requirements*, and the enforcement actions under 10 CFR 820, *General Statement of Enforcement Policy.*

**Hold Points:**
N/A

**Configuration Management Requirements:**
N/A

**Work Location/Potential Access Requirements:**
N/A

**Training:**
N/A

**Qualifications:**
Degreed Engineering support as required.

**Special Requirements:**
N/A

**Reporting/Administration:**
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.

Req. # 39151

# ISMS Clause Flow Down Prescreening Questions

| Does the work involve one or more of the following? | Applicable Yes/Maybe* | Applicable | SME ** |
|---|---|---|---|
| 1. Operation, maintenance, repair or testing of electrical, pneumatic, hydraulic or mechanical systems (e.g., N2 plant operation, elevator repair, substation breaker repair, etc.) | | X | **IS/H** |
| 2. Construction or excavation | | X | **IS/IH/ ENV/Rad** |
| 3. Hazardous materials, chemicals or substances (e.g., pest and weed control, chemical inventory, lead or lead-containing materials, asbestos, beryllium, hazardous or radiological waste, etc.) | | X | **ENV/IH/ Rad** |
| 4. The activity includes deliverables or services where potential radiological harm, radiation, or radioactive material governed by 10 CFR 835 is present. | | X | **Rad/IH** |
| 5. Exposure to significant occupational hazards (e.g., hoisting, rigging or cranes; confined space; scaffolding or elevated work platforms; compressed gas cylinders; portable hand held tools, powered by electrical or mechanical energy; portable heating equipment; welding or cutting; explosives; heat stress, etc.) | | X | **IS/IH** |
| 6. Nuclear facilities, or their support systems or their authorization basis. | | X | **Nuc Safety** |
| 7. Tanks, lines or vessels being breached | | X | **IS/IH** |
| 8. Structures, systems or components designated as Safety Class, Safety Significant or identified as providing defense-in-depth or worker safety in a Facility Authorization Basis (FAB). | | X | **Nuc Safety** |
| 9. Work that could impact the health and safety of site personnel. | | X | **IS/IH** |
| 10. The potential for changes in emission, generating rates, or new discharge of hazards, radiation, petroleum, substances, or other pollutants from a facility or process to the environment (air, water, land). | | X | **ENV** |
| 11. Maintenance or repair of Fire Protection systems. | | X | **Fire Prot** |

* If any question is answered YES or MAYBE, then Subject Matter Expert (SME) evaluation is REQUIRED.
** This is not a comprehensive list of SME(s). All appropriate SME(s) shall be involved in the evaluation as needed.

A-6002-699

4975-59-P2

PROCUREMENT SPECIFICATION

**ANNULUS HEEL PUMP**

Prepared for
CH2M Hill Hanford

by
Fluor Federal Services
Contract Number 65100541

APPROVED

Fluor Federal Services (FFS)

| | | | |
|---|---|---|---|
| Author | 2/24/00 Date | Technical Documents | 2/24/00 Date |
| Checker | 2/24/00 Date | Project Management | 2/24/00 Date |
| Quality Engineering | 2/24/00 Date | | |

CH2M Hill Hanford (CHG)

| | |
|---|---|
| Cognizant Engineer | 2/24/00 Date |
| Cognizant Engineering Manager | 2/28/00 Date |

# TABLE OF CONTENTS


| | Page |
|---|---|
| Title and Approval Page | 1 |
| Table of Contents | 2 |
| 1 SCOPE | 3 |
| 2 APPLICABLE DOCUMENTS | 3 |
| 3 REQUIREMENTS | 3 |
| 4 QUALITY ASSURANCE | 7 |
| 5 SUBMITTALS | 9 |
| 6 PREPARATION FOR DELIVERY | 10 |
| SUMMARY OF SUBMITTALS | 11 |
| ATTACHMENT - Figure 1 | 12 |

1 SCOPE

1.1 This Specification provides the minimum requirements for an air driven heel pump, driver and any special handling equipment required for pump shipping and installation.

1.2 Work Included: Design, analysis, fabrication, inspection, testing, documentation, packaging, and shipping.

1.3 Work Not Included: Site services and installation or operation of equipment.

2 APPLICABLE DOCUMENTS

2.1 The following documents form a part of this Specification to the extent designated, except as modified by the requirements specified herein. The latest edition with addenda shall be used unless noted otherwise.

2.1.1 Hydraulic Institute (HI)

| | |
|---|---|
| 6.6 | Reciprocating Pump Tests |

2.1.2 National Fire Protection Association (NFPA)

| | |
|---|---|
| 70 | National Electric Code (NEC) |

3 REQUIREMENTS

3.1 Equipment Description

3.1.1 The pump unit shall be used to transfer the heel of the abrasive radioactive slurry that has leaked into the annulus between the inner and outer tank shell.

3.1.2 The heel pump will be installed into the annulus of double shell underground radioactive waste storage tanks, which are typically 75 to 85 feet in diameter, flat-bottomed with domed tops and approximately 6 feet of soil cover. The liquid capacity of the tanks is typically one million gallons with maximum liquid depths of up to 35 feet.

3.1.3 Pump access is through concrete pump pits located just above the waste tank annulus.

3.1.4 The heel pumps and drivers will be installed in these sealed pump pits and will not be accessible for periods of up to a year. This equipment is expected to operate for up to 2,000 hours over a 2-year period without any maintenance.

3.1.5 These pumps will be stored and installed only in the case of a leak into the tank annulus. During the time in storage it is anticipated that they will be periodically performance tested to ensure the availability of reliable pumps should there be a leak.

3.1.6 The maximum weight of the pump assembly, including motor and water, shall not exceed 1,000 lbs. The Seller shall specify both wet and dry weights of the equipment furnished.

3.1.7 The equipment furnished shall be air driven, positive displacement, and reciprocating cylinder pumps capable of pumping the fluid described herein.

3.2 Environmental Conditions

3.2.1 The heel pump shall be able to withstand the following conditions inside the pump pit and in the annulus area:

| LOCATION | TEMPERATURE | % RELATIVE HUMIDITY | RADIATION EXPOSURE IN RAD | |
|---|---|---|---|---|
| | | | PER HOUR | 2 YEARS ACCUMULATION |
| PUMP PIT | 15 to 150 °F | 0 to 100 | 50 | $8.8 \times 10^5$ |
| TANK VAPOR SPACE | 50 to 140 °F | 0 to 100 | 400 | $6.8 \times 10^6$ |
| ANNULUS LIQUID | 65 to 140 °F | N/A | 500 | $8.8 \times 10^6$ |

3.3 Fluid Pumped

3.3.1 The radioactive sludge settled in the tanks consists mainly of insoluble oxides and/or hydroxides of aluminum, iron, manganese, and zirconium.

3.3.2 Fluid Properties

| | |
|---|---|
| Specific Gravity | 1.47 |
| Absolute Viscosity, Centipoise | 1.0 to 30 cP |
| Solids Content (vol.%) | 0 to 20.0 |
| Particle Size, Micron | 0.5 to 4000* |
| Abrasiveness, Miller Number (ASTM G75-82) | less than 100 |
| Temperature (transfer) | 65 to 140 °F |
| Temperature (flush or dilution) | 35 to 150 °F |
| pH | 7 – 14 |

- Although 50-micron particle size is the nominal design point, the pump must be fully capable of operating with the full range of particle sizes. The number of larger (500 to 4000 micron) particles will be relatively small (less than 1% of the total particles). Particles in the range of 50 to 500 micron will constitute less than 5% of the total particles. Particles ranging in size from 0.5 to 50 micron will constitute approximately 95% of the total particles.

3.4 Performance Requirements

3.4.1 The pump shall be designed to deliver a minimum 2 gpm at 100 feet of head.

3.4.2 Any special design features that improve the pump's ability to pump closer to the bottom of the annulus shall be considered.

3.4.3 The transfer pump shall deliver the rated head and flow at a minimum NPSHA of 19 feet at 140 °F (assumes zero submergence).

3.4.4 The pump shall have a stable head/capacity curve that continuously rises from rated capacity to shut-off.

3.5 Design

3.5.1 Assembly

3.5.1.1 The pump assembly specified herein includes pump parts and driver.

3.5.1.2 The design pressure of the pressure-retaining components shall be the maximum pressure of the pump at shut-off when pumping fluid of the highest specific gravity specified herein.

3.5.1.3 The pump suction will be located as close as possible to the bottom of the tank without obstructing the suction flow.

3.5.2 Pump Installation

3.5.2.1 Installation of the pump will be by a single (preferred), mobile crane operation. The fully assembled pump, driver, and column will be lifted from the horizontal to the vertical position and then lowered through a 12-inch (inside diameter) adapter into the waste storage tank annulus. Prior to installation the Heel Pump will be attached to its companion Transfer Pump (procured under a separate specification) and both will be installed simultaneously.

3.5.2.2 The pump shall be provided with a lifting attachment. The Seller shall detail any special handling requirements in the instruction manual to ensure that the pump assembly can be safely lifted and installed without damage to the pump or tank.

3.5.2.3 The pump assembly will be fully assembled (by the Buyer) prior to installation into the waste tank.

3.5.3 Dimensional Restrictions

3.5.3.1 The pump assembly will consist of the air driven heel pump specified herein and a motor driven transfer pump. Together they shall not exceed 11-1/2 inches in diameter so the pump can pass freely through a 12-inch inside diameter riser into the annulus. (See Figure 1)

3.5.3.2 The pump assembly length shall be determined by the Buyer, based on locating the pump's suction as close as possible to the tank bottom, given the elevations from the existing riser flange to the inside bottom of tank annulus. The column piping and fittings shall be designed and supplied by the Buyer.

3.5.4 Materials

3.5.4.1 Materials shall be selected by the Seller based on acceptable performance when subjected to the chemical and radiation exposures described herein. Wetted parts shall be made of corrosion-resistant materials, suitable for this environment and shall be constructed of non-sparking materials, or shall have been analyzed and evaluated

to be incapable of sparking under the applied conditions. Material selection shall be identified in Seller documents submitted to the Buyer.

3.5.4.2 Brass, bronze, and copper base materials, if used, shall not come in contact with the waste tank fluid or vapor. The use of aluminum and chrome is not acceptable.

3.5.4.3 Materials used shall be clearly identified on the bill of material as to material type and grade; however, Certified Material Test Reports (CMTR's) are not required.

3.5.4.4 Chemical and physical properties of the elastomers shall be suitable for the chemical and radiation environment in which they are used.

3.5.4.5 Lubricants, adhesives, and gaskets shall be constructed of non-sparking materials, or shall have been analyzed and evaluated to be incapable of sparking under the applied conditions.

3.5.4.6 Exposed polymer materials shall be constructed of, as a minimum, the anti-static class of materials.

3.6 Fabrication Processes

3.6.1 Fabrication by welding, as well as any weld repairs to such parts, shall be performed and inspected by operators and procedures qualified in accordance with the Seller's QA Program.

3.7 Marking

3.7.1 The pump shall have a manufacturer's nameplate using the Sellers standard practice. The nameplate shall include the assembly weight (dry and wet) and purchase order number.

3.8 Cleaning/Painting

3.8.1 The pump, including parts, shall be delivered to the Site clean and free of any oils, tape adhesives, weld splatter, dirt, loose debris, and other contaminants.

3.8.2 Solvents and cleaning solutions used on stainless steels shall be chloride-free.

3.8.3 Stainless steel components do not require painting except as needed for identification or for targeting. Paint used on stainless steel shall be epoxy-phenolic.

3.9 Inspection/Examination

3.9.1 Inspection shall be done in accordance with the manufacturers standard practice.

3.10 Testing

3.10.1 General

3.10.1.1 The Buyer reserves the right to witness all tests and shall be given a minimum of 10 working days written notice prior to each test date.

3.10.1.2 The performance tests shall be conducted using only job components.

3.10.1.3 Water used for hydrostatic and performance testing shall be tested for chlorides. The chloride content of the test medium shall not exceed 50 ppm for water temperatures of 149 °F and less. The chloride content for water at elevated testing temperatures of 212 °F shall not exceed 1 ppm.

3.10.2 Hydrostatic Testing

3.10.2.1 The pump shall be hydrostatically tested in accordance with the Sellers standard practice.

3.10.3 Performance Testing

3.10.3.1 Performance testing shall be done to the Sellers standard practice.

3.11 Instruction Manuals

Instruction manuals shall be provided that contain storage, installation, start-up and maintenance instructions for the pump and all associated equipment.

Pump lifting requirements shall be provided in detail along with any special precautions related to either handling or operating the equipment furnished. The use of any special tooling provided shall be explained in detail. All drawings and procedures required for pump installation and operation shall be included in the *manual for quick reference*.

4 QUALITY ASSURANCE

4.1 Quality Assurance Program

The Seller shall have a Quality Assurance Program (QAP) that establishes quality control. The QAP shall identify procedures or workmanship standards. (If the Seller has an established QAP he shall furnish a matrix which cross-references the established program with criteria listed.) The QAP shall include details on the following programmatic functions:

4.1.1 Organization: The organization structure, functional responsibilities, levels of authority, and lines of communication for activities affecting quality shall be documented. Persons or organizations responsible for ensuring that an appropriate QAP has been established and verifying that activities affecting quality have been correctly performed shall have sufficient authority, access to work areas, and organizational freedom to:

a. Identify quality problems.

b. Initiate, recommend, or provide solutions to quality problems through designated channels.

c. Verify implementation of solutions.

d. Ensure that further processing, delivery, installation, or use is controlled until proper disposition of a nonconformance, deficiency, or unsatisfactory condition has occurred.

4.1.2 The documented QAP shall be planned, implemented, and maintained. The program shall provide control over activities affecting quality to an extent consistent with their importance. The program shall be established at the earliest time consistent with the schedule for accomplishing the activities.

The program shall provide for the planning and accomplishment of activities affecting quality under suitably controlled conditions. The program shall provide for any special controls, processes, test equipment, tools, and skills to attain the required quality and for verification of quality.

The program shall provide for indoctrination and training, as necessary, of personnel performing activities affecting quality to ensure that suitable proficiency is achieved and maintained.

The program shall establish responsibility and authority to stop work or to control further operations where conditions adverse to Specification and quality requirements are identified and immediate corrective actions are required.

4.1.3 Design Control: The design shall be defined, controlled, and verified. Applicable design inputs shall be appropriately specified on a timely basis and correctly translated into design documents. Design interfaces shall be identified and controlled. Design adequacy shall be verified by persons other than those who designed the item. Design changes, including field changes, shall be governed by control measures commensurate with those applied to the original design.

4.1.4 Instructions, Procedures, and Drawings: Activities affecting quality shall be prescribed by and performed in accordance with documented instructions, procedures, or drawings of a type appropriate to the circumstances. These documents shall include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished.

4.1.5 Document Control: The preparation, issue, and change of documents that specify quality requirements or prescribe activities affecting quality shall be controlled to ensure that correct documents are being employed. Ensure the latest approved issue of Specifications and Drawings are used for designing, procuring, manufacturing, assembling, inspecting, and testing.

4.1.6 Identification and Control of Items: Controls shall be established to ensure that only correct and accepted items are used or installed. Identification shall be maintained on the items or in documents traceable to the items, or in a manner that ensures identification is established and maintained. Controls for receiving inspection shall include provisions for detection and exclusion of misrepresented products.

4.1.7 Control of Processes: Processes affecting quality or services shall be controlled. Special processes that control or verify quality, such as those used in welding, heat treating, and nondestructive examination, shall be performed by qualified personnel using qualified procedures in accordance with specified requirements.

4.1.8 Inspection: Inspection required to verify conformance of an item or activity to specified requirements shall be planned and executed. Characteristics to be employed shall be specified. Inspection results shall be documented. Inspections shall be performed by persons other than those responsible for the work.

4.1.9 Test Control: Tests required to verify conformance of an item to specified requirements and to demonstrate that items will perform satisfactorily in service shall be planned and executed. Characteristics to be tested and test methods to be employed shall be specified. Test results shall be documented and their conformance with acceptance criteria shall be evaluated.

4.1.10 Control of Measuring and Test Equipment: Tools, gages, instruments, and other measuring and test equipment used for activities affecting quality shall be controlled and, at specified periods, calibrated and adjusted to maintain accuracy within necessary limits.

4.1.11 Nonconformance Reporting: Items that do not conform to specified requirements shall be controlled to prevent inadvertent installation or use. Controls shall provide for identification, documentation, evaluation, segregation when practical, and disposition of nonconforming items, and for notification to affected organizations. In addition, the Seller shall deliver copies of all Seller-initiated nonconformance reports to Buyer at time of initiation and closeout.

4.1.12 Quality Assurance Records: Records that furnish documentary evidence of quality shall be specified, prepared, and maintained. Records shall be legible, identifiable, and retrievable. Records shall be protected against damage, deterioration, or loss.

5 SUBMITTALS - See Summary of Submittals for number of copies, purpose, and when required.

5.1 General

5.1.1 Identify each submittal by this Specification number, item number, PO number, and Seller's identification number.

5.1.2 Data shall be sufficiently clear to allow legible copies to be made on standard reproduction equipment after microfilming.

5.1.3 Allow 21 calendar days for Buyer review and disposition.

5.1.4 Approval by the Buyer does not relieve the Seller of responsibility for accuracy or adequacy of design under this Specification.

5.1.5 Submittals are divided into 2 types: 1) those requiring "approval" (e.g., approval data or prepurchase evaluation data); and 2) those "not requiring approval" (e.g., vendor information data).

5.1.6 Submittals "not requiring approval" will be reviewed to verify completeness and adequacy for their intended purposes. Unacceptable items will be handled as specified below:

5.1.6.1 A submittal requiring approval that is not approved, is identified as: 1) "Not Approved, Revise and Resubmit." The submittal is considered technically deficient, or incomplete, and therefore unacceptable. Resubmittal is required, hence fabrication, procurement, or performance of procedures shall not proceed; or 2) "Approved with Exception." Fabrication, procurement, and performance of procedures may proceed, and resubmittal is required to verify incorporation of the exception.

5.1.6.2 Submittals "not requiring approval" that are determined to be incomplete or inadequate will be returned marked "Resubmit." An explanation of the deficiencies will be included for corrective action by the Seller.

5.2 List

5.2.1 (Item 1) Quality Assurance Program (4.1).

5.2.2 (Item 2) Schedule: Schedule showing shipment of the equipment after receipt of the order.

5.2.3 (Item 3) Drawings

a. General arrangement and outline drawings for the pump assembly and motor, showing overall dimensions and overall weights.

b. Cross-sectional drawings showing the details of the proposed equipment, including bill of materials to reflect the actual equipment and scope proposed.

5.2.4 (Item 4) Catalog bulletins and descriptive data illustrating the pump and motor being offered.

5.2.5 (Item 5) Preliminary performance curve with high- and low-end rating points, including efficiency, water NPSHR, and air consumption expressed as functions of capacity.

5.2.6 (Item 6) Certified pump and driver outline drawings with dimensions and bill of materials.

5.2.7 (Item 7) Instruction Manuals (3.11).

5.2.8 (Item 8) Bill of Materials.

6 PREPARATION FOR DELIVERY

6.1 Preservation: Item shall be protected from dirt, soil, and moisture.

6.2 Packaging: Item shall be boxed or crated in a manner to prevent damage during shipping.

6.3 Marking: Packages shall be suitably marked on the outside to facilitate identification of the purchase order, the procurement specification, the package contents, and any special handling instructions.

6.4 The Seller shall recommend the preferred method of shipping and provide protection of the equipment during transit and storage.

| SUMMARY OF SUBMITTALS | | | | |
|---|---|---|---|---|
| Item | Title | Copies | Purpose | When required |
| 1 | Quality Assurance Program | 2 | Prepurchase Evaluation | With bid |
| 2 | Schedule | 2 | Prepurchase Evaluation | With bid |
| 3 | Drawings | 2 | Prepurchase Evaluation | With bid |
| 4 | Catalog Bulletin/Descriptive Data | 2 | Prepurchase Evaluation | With bid |
| 5 | Preliminary Performance Curve | 2 | Prepurchase Evaluation | With bid |
| 6 | Certified Pump Dimensional Drawings | 2 | Approval | Prior to fabrication |
| 7 | Instruction Manuals | 5 | Vendor Information | With Shipment |
| 8 | Bill of Materials | 2 | Approval | Prior to Fabrication |

RPP-6485 Rev. 0

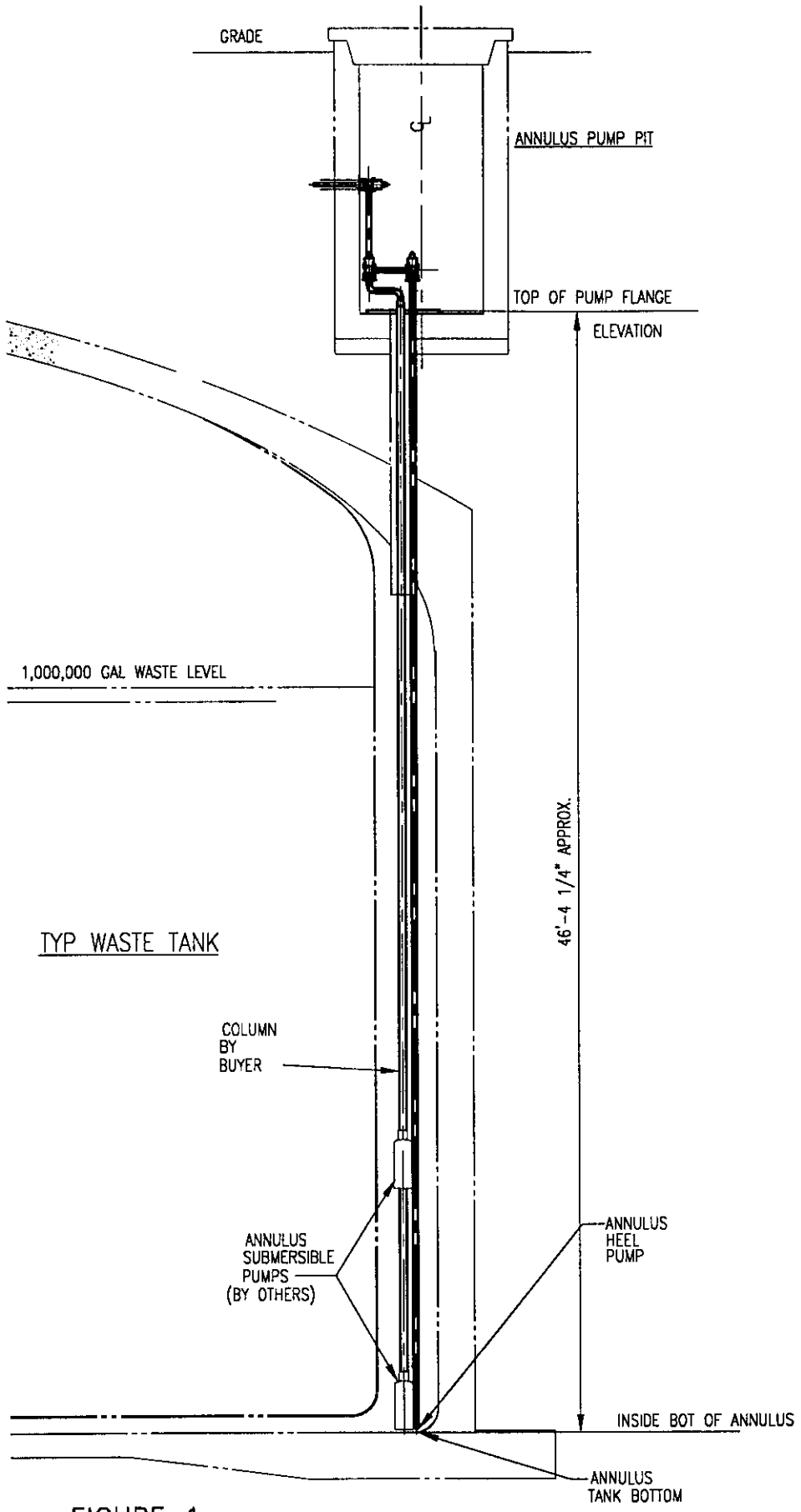



FIGURE 1
SCALE: 1 1/2" =1'-0"

4975-59-P2, REV. 0

RPP-6485 Rev. 0

PROCUREMENT SPECIFICATION

**ANNULUS SUBMERSIBLE TRANSFER PUMP**

Prepared for
CH2M Hill Hanford

by
Fluor Federal Services
Contract Number 65100541

APPROVED

Fluor Federal Services (FFS)

| | | | |
|---|---|---|---|
| Author | 2/17/00 Date | Technical Documents | 2/17/00 Date |
| Checker | 2/17/00 Date | Project Management | 2/17/00 Date |
| Quality Engineering | 2/17/00 Date | | |

CH2M Hill Hanford (CHG)

| | |
|---|---|
| Cognizant Engineer | 2/17/00 Date |
| Cognizant Engineering Manager | 2-17-00 Date |

# TABLE OF CONTENTS


| | | Page |
|---|---|---|
| Title and Approval Page | | 1 |
| Table of Contents | | 2 |
| 1 | SCOPE | 3 |
| 2 | APPLICABLE DOCUMENTS | 3 |
| 3 | REQUIREMENTS | 3 |
| 4 | QUALITY ASSURANCE | 8 |
| 5 | SUBMITTALS | 10 |
| 6 | PREPARATION FOR DELIVERY | 11 |
| SUMMARY OF SUBMITTALS | | 12 |
| ATTACHMENT - Figure 1 | | 13 |

1 SCOPE

1.1 This Specification provides the minimum requirements for a submersible transfer pump and driver, and any special handling equipment required for pump shipping and installation.

1.2 Work Included: Pump design, analysis, fabrication, inspection, testing, documentation, packaging, and shipping.

1.3 Work Not Included: Design and manufacture of pump dilution water system and column piping. Site services and assembly, installation or operation of equipment.

2 APPLICABLE DOCUMENTS

2.1 The following documents form a part of this Specification to the extent designated, except as modified by the requirements specified herein. The latest edition with addenda shall be used unless noted otherwise.

2.1.1 Hydraulic Institute (HI)

| | |
|---|---|
| 1.6 | Centrifugal Pump Tests |

2.1.2 National Electrical Manufacturers Association (NEMA)

| | |
|---|---|
| MG-1 | Motors and Generators |

2.1.3 *National Fire Protection Association (NFPA)*

| | |
|---|---|
| 70 | National Electric Code (NEC) |

2.1.4 Underwriters Laboratories Inc. (UL)

*Hazardous Locations Equipment Directory*

3 REQUIREMENTS

3.1 Equipment Description

3.1.1 The pump unit shall be used to transfer abrasive radioactive slurry that has leaked into the annulus between the inner and outer tank shell.

3.1.2 The transfer pump will be installed into the annulus of double shell underground radioactive waste storage tanks, which are typically 75 to 85 feet in diameter, flat-bottomed with domed tops and approximately 6 feet of soil cover. The liquid capacity of the tanks is typically one million gallons with maximum liquid depths of up to 35 feet.

3.1.3 Pump access is through concrete pump pits located just above the waste tank annulus.

3.1.4 The transfer pumps and drivers will be installed in the annulus and will not be accessible for periods of up to a year. This equipment is expected to operate for up to 2,000 hours over a 2-year period without any maintenance.

3.1.5 These pumps will be stored in a warehouse and installed only in the case of a leak into the tank annulus. During the time in storage it is anticipated that they will be periodically performance tested to ensure the availability of reliable pumps should there be a leak.

3.1.6 The maximum weight of the pump assembly, including motor and water, shall not exceed 1,000 lbs. The Seller shall specify both wet and dry weights of the equipment furnished.

3.2 Environmental Conditions

3.2.1 The transfer pump shall be able to withstand the following conditions inside the pump pit and in the annulus area:

| LOCATION | TEMPERATURE | % RELATIVE HUMIDITY | RADIATION EXPOSURE IN RAD | |
|---|---|---|---|---|
| | | | PER HOUR | 2 YEARS ACCUMULATION |
| PUMP PIT | 15 to 150 °F | 0 to 100 | 50 | $8.8 \times 10^5$ |
| TANK VAPOR SPACE | 50 to 140 °F | 0 to 100 | 400 | $6.8 \times 10^6$ |
| ANNULUS LIQUID | 65 to 140 °F | N/A | 500 | $8.8 \times 10^6$ |

3.3 Fluid Pumped

3.3.1 The radioactive sludge settled in the tanks consists mainly of insoluble oxides and/or hydroxides of aluminum, iron, manganese, and zirconium.

3.3.2 *Fluid Properties*

| | |
|---|---|
| Specific Gravity | 1.47 |
| Absolute Viscosity, Centipoise | 1.0 to 30 cP |
| Solids Content (vol.%) | 0 to 20.0 |
| Particle Size, Micron | 0.5 to 4000* |
| Abrasiveness, Miller Number (ASTM G75-82) | less than 100 |
| Temperature (transfer) | 65 to 140 °F |
| Temperature (flush or dilution) | 35 to 150 °F |
| PH | 7 – 14 |

* Although 50-micron particle size is the nominal design point, the pump must be fully capable of operating with the full range of particle sizes. The number of larger (500 to 4000 micron) particles will be relatively small (less than 1% of the total particles). Particles in the range of 50 to 500 micron will constitute less than 5% of the total particles. Particles ranging in size from 0.5 to 50 micron will constitute approximately 95% of the total particles.

3.4 Performance Requirements

3.4.1 The pump shall be designed to deliver a range of flows from 40 gpm at 160 feet of head to 140 gpm at approximately 100 feet of head. Multiple units in tandem are acceptable.

3.4.2 If multiple units are used, only the lowest pump shall be required to have the pump suction submersed in the pumpage.

3.4.3 Any special design features that improve the pumps ability to pump closer to the bottom of the annulus shall be considered.

3.4.4 The transfer pump shall deliver the rated head and flow at a minimum NPSHA of 19 feet at 140 °F (assumes zero submergence).

3.4.5 The pump shall have a stable head/capacity curve that continuously rises at least 5% from rated capacity to shut-off.

3.4.6 The pump shall be designed to tolerate reverse rotation or be provided with an anti-reverse rotation device if reverse rotation of the pump is unacceptable.

3.5 Design

3.5.1 Assembly

3.5.1.1 The pump assembly specified herein includes pump parts and driver. The pump(s) will be connected to the buyer's discharge column and to the adjacent Heel pump (procured under a separate specification) at the site prior to installation in the Annulus. If the pump(s) are not furnished with a top discharge, it will be field modified to a top discharge configuration.

3.5.1.2 The pump will have a system (by the Buyer) to add 50 gpm of dilution water at 100 psig or less pressure, injected at the suction of the pump in a manner that directs the diluent into the pump.

3.5.1.3 The design pressure of the pressure-retaining components shall be the maximum pressure of the pump at shut-off when pumping fluid of the highest specific gravity specified herein.

3.5.1.4 The rotor assembly shall be sized and supported to minimize vibration and promote maximum bearing life.

3.5.1.5 Impeller design shall be the Seller's choice but shall be free draining.

3.5.1.6 The pump shall be designed such that the first classical running critical speed (wet) is at least 25% above the maximum operating speed.

3.5.1.7 The pump suction will be located as close as possible to the bottom of the tank without obstructing the suction flow.

3.5.1.8 The pump shall have a top discharge (or be convertible to a top discharge) with a 3" NPT male connection.

3.5.2 Pump Installation

3.5.2.1 Installation of the pump will be by a single (preferred), mobile crane operation. The fully assembled pump, motor, and column will be lifted from the horizontal to the vertical position and then lowered through a 12-inch (inside diameter) adapter into the waste storage tank annulus.

3.5.2.2 The pump(s) shall be provided with a lifting attachment. The power cable and motor cable entry point shall be located to prevent being damaged during installation. The Seller shall detail any special handling requirements in the instruction manual to ensure that the pump assembly can be safely lifted and installed without damage to the pump or tank.

3.5.3 Dimensional Restrictions

3.5.3.1 The pump assembly will consist of the pump(s) specified herein and an air driven heel pump. Together they shall not exceed 11-1/2 inches in diameter so the pump can pass freely through a 12-inch inside diameter riser into the annulus. The transfer pump diameter shall not exceed 9.5 " in diameter. (See Figure 1)

3.5.3.2 The pump assembly length will be determined by the Buyer, based on locating the pump's suction as close as possible to the tank bottom, given the elevations from the existing riser flange to the inside bottom of tank annulus. The column piping and fittings will be designed and supplied by the Buyer.

3.5.3.3 The pump suction inlet shall be provided with a screen. The strainer/screen openings shall be determined by the Seller to protect the pump's internal passages from large solids.

3.5.4 Mechanical Shaft Seals

3.5.4.1 If required, the mechanical shaft seals shall be the Seller's choice for this service.

3.5.4.2 The pump mechanical seal materials shall be compatible with the pumped fluid.

3.5.5 Submersible Electric Motors

3.5.5.1 Motor horsepower shall be non-overloading when operating at any point on the pump curve, with the fluid specified in this Specification.

3.5.5.2 The motors shall be induction-type without sparking contacts. Where circuits are located in the tank (e.g., submersible motors), they shall be designed to meet the requirements of NFPA 70 for use in a Class I, Division 1, Group B (hydrogen) atmosphere or equivalent.

3.5.5.3 The pumps shall be provided with a 70-foot pigtail power cable to facilitate power hookup. The motors shall be supplied without a terminal box. The pigtail shall be flexible and be suitable for the Class 1, Division 1, Group B environment.

3.5.5.4 The motor shall be rated 460 V, 3-phase, 60 Hz.

3.5.6 Materials

3.5.6.1 Materials shall be selected by the Seller based on acceptable performance when subjected to the chemical and radiation exposures described herein. Wetted parts shall be made of corrosion-resistant materials, suitable for this environment and shall be constructed of non-sparking materials, or shall have been analyzed and evaluated to

be incapable of sparking under the applied conditions. Material selection shall be identified in Seller documents submitted to the Buyer.

3.5.6.2 Brass, bronze, and copper base materials, if used, shall not come in contact with the waste tank fluid or vapor. The use of aluminum and chrome is not acceptable.

3.5.6.3 Materials used shall be clearly identified on the bill of material as to material type and grade; however, Certified Material Test Reports (CMTR's) are not required.

3.5.6.4 Chemical and physical properties of the elastomers shall be suitable for the chemical and radiation environment in which they are used.

3.5.6.5 Lubricants, adhesives, and gaskets shall be constructed of non-sparking materials, or shall have been analyzed and evaluated to be incapable of sparking under the applied conditions.

3.5.6.6 Exposed polymer materials shall be constructed of, as a minimum, the anti-static class of materials.

3.6 Fabrication Processes

3.6.1 Fabrication by welding, as well as any weld repairs to such parts, shall be performed and inspected by operators and procedures qualified in accordance with the Seller's QA Program.

3.7 Marking

3.7.1 The pump shall have a manufacturer's nameplate using the Sellers standard practice. The nameplate shall include the assembly weight (dry and wet), purchase order number and this specification number.

3.8 Cleaning/Painting

3.8.1 The pump, including parts, shall be delivered to the Site, clean and free of any oils, tape adhesives, weld splatter, dirt, loose debris, and other contaminants.

3.8.2 Solvents and cleaning solutions used on stainless steels shall be chloride-free.

3.8.3 Stainless steel components do not require painting except as needed for identification or for targeting. Paint used on stainless steel shall be epoxy-phenolic.

3.9 Inspection/Examination

3.9.1 Inspection shall be done in accordance with the manufacturer's standard practice.

3.10 Testing

3.10.1 General

3.10.1.1 Performance testing and hydrostatic testing of the pump/motor are required. The Buyer reserves the right to witness all tests and shall be given a minimum of 10 working days written notice prior to each test date.

3.10.1.2 The performance tests shall be conducted using only job components.

3.10.1.3 Water used for hydrostatic and performance testing shall be tested for chlorides. The chloride content of the test medium shall not exceed 50 ppm for water temperatures of 149 °F and less. The chloride content for water at elevated testing temperatures of 212 °F shall not exceed 1 ppm.

3.10.2 Motor Testing

3.10.2.1 The motor shall be given a routine test to demonstrate that it is free from mechanical and electrical defects. The test shall be performed in accordance with the Sellers standard practice.

3.10.3 Hydrostatic Testing

3.10.3.1 The pump shall be hydrostatically tested in accordance with the Sellers standard practice.

3.10.4 Performance Testing

3.10.4.1 Performance testing shall be done to the Sellers standard practice and shall comply with the Hydraulic Institute's requirements for centrifugal pump testing.

3.11 Instruction Manuals

Instruction manuals shall be provided that contain storage, installation, start-up and maintenance instructions for the pump and all associated equipment. Specifically, mechanical seal operating instructions shall be included in addition to the pump instructions.

Pump lifting requirements shall be provided in detail along with any special precautions related to either handling or operating the equipment furnished. The use of any special tooling provided shall be explained in detail. All drawings and procedures required for pump installation and operation shall be included in the manual for quick reference.

4 QUALITY ASSURANCE

4.1 Quality Assurance Program

The Seller shall have a Quality Assurance Program (QAP) that establishes quality control. The QAP shall identify procedures or workmanship standards. (If the Seller has an established QAP he shall furnish a matrix which cross-references the established program with criteria listed.) The QAP shall include details on the following programmatic functions:

4.1.1 Organization: The organization structure, functional responsibilities, levels of authority, and lines of communication for activities affecting quality shall be documented. Persons or organizations responsible for ensuring that an appropriate QAP has been established and verifying that activities affecting quality have been correctly performed shall have sufficient authority, access to work areas, and organizational freedom to:

a. Identify quality problems.

b. Initiate, recommend, or provide solutions to quality problems through designated channels.

c. Verify implementation of solutions.

d. Ensure that further processing, delivery, installation, or use is controlled until proper disposition of a nonconformance, deficiency, or unsatisfactory condition has occurred.

4.1.2 The documented QAP shall be planned, implemented, and maintained. The program shall provide control over activities affecting quality to an extent consistent with their importance. The program shall be established at the earliest time consistent with the schedule for accomplishing the activities.

The program shall provide for the planning and accomplishment of activities affecting quality under suitably controlled conditions. The program shall provide for any special controls, processes, test equipment, tools, and skills to attain the required quality and for verification of quality.

The program shall provide for indoctrination and training, as necessary, of personnel performing activities affecting quality to ensure that suitable proficiency is achieved and maintained.

The program shall establish responsibility and authority to stop work or to control further operations where conditions adverse to Specification and quality requirements are identified and immediate corrective actions are required.

4.1.3 Design Control: The design shall be defined, controlled, and verified. Applicable design inputs shall be appropriately specified on a timely basis and correctly translated into design documents. Design interfaces shall be identified and controlled. Design adequacy shall be verified by persons other than those who designed the item. Design changes, including field changes, shall be governed by control measures commensurate with those applied to the original design.

4.1.4 Instructions, Procedures, and Drawings: Activities affecting quality shall be prescribed by and performed in accordance with documented instructions, procedures, or drawings of a type appropriate to the circumstances. These documents shall include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed activities have been satisfactorily accomplished.

4.1.5 Document Control: The preparation, issue, and change of documents that specify quality requirements or prescribe activities affecting quality shall be controlled to ensure that correct documents are being employed. Ensure the latest approved issue of Specifications and Drawings are used for designing, procuring, manufacturing, assembling, inspecting, and testing.

4.1.6 Identification and Control of Items: Controls shall be established to ensure that only correct and accepted items are used or installed. Identification shall be maintained on the items or in documents traceable to the items, or in a manner that ensures identification is established and maintained. Controls for receiving inspection shall include provisions for detection and exclusion of misrepresented products.

4.1.7 Control of Processes: Processes affecting quality or services shall be controlled. Special processes that control or verify quality, such as those used in welding, heat treating, and nondestructive examination, shall be performed by qualified personnel using qualified procedures in accordance with specified requirements.

4.1.8 Inspection: Inspection required to verify conformance of an item or activity to specified requirements shall be planned and executed. Characteristics to be employed shall be specified. Inspection results shall be documented. Inspections shall be performed by persons other than those responsible for the work.

4.1.9 Test Control: Tests required to verify conformance of an item to specified requirements and to demonstrate that items will perform satisfactorily in service shall be planned and executed. Characteristics to be tested and test methods to be employed shall be specified. Test results shall be documented and their conformance with acceptance criteria shall be evaluated.

4.1.10 Control of Measuring and Test Equipment: Tools, gages, instruments, and other measuring and test equipment used for activities affecting quality shall be controlled and, at specified periods, calibrated and adjusted to maintain accuracy within necessary limits.

4.1.11 Nonconformance Reporting: Items that do not conform to specified requirements shall be controlled to prevent inadvertent installation or use. Controls shall provide for identification, documentation, evaluation, segregation when practical, and disposition of nonconforming items, and for notification to affected organizations. In addition, the Seller shall deliver copies of all Seller-initiated nonconformance reports to Buyer at time of initiation and closeout.

4.1.12 Quality Assurance Records: Records that furnish documentary evidence of quality shall be specified, prepared, and maintained. Records shall be legible, identifiable, and retrievable. Records shall be protected against damage, deterioration, or loss.

5 SUBMITTALS - See Summary of Submittals for number of copies, purpose, and when required.

5.1 General

5.1.1 Identify each submittal by this Specification number, item number, PO number, and Seller's identification number.

5.1.2 Data shall be sufficiently clear to allow legible copies to be made on standard reproduction equipment after microfilming.

5.1.3 Allow 21 calendar days for Buyer review and disposition.

5.1.4 Approval by the Buyer does not relieve the Seller of responsibility for accuracy or adequacy of design under this Specification.

5.1.5 Submittals are divided into 2 types: 1) those requiring "approval" (e.g., approval data or prepurchase evaluation data); and 2) those "not requiring approval" (e.g., vendor information data).

5.1.6 Submittals "not requiring approval" will be reviewed to verify completeness and adequacy for their intended purposes. Unacceptable items will be handled as specified below:

5.1.6.1 A submittal requiring approval that is not approved, is identified as: 1) "Not Approved, Revise and Resubmit." The submittal is considered technically deficient, or incomplete, and therefore unacceptable. Resubmittal is required, hence fabrication, procurement, or performance of procedures shall not proceed; or 2) "Approved with Exception." Fabrication, procurement, and performance of procedures may proceed, and resubmittal is required to verify incorporation of the exception.

5.1.6.2 Submittals "not requiring approval" that are determined to be incomplete or inadequate will be returned marked "Resubmit." An explanation of the deficiencies will be included for corrective action by the Seller.

5.2 List

5.2.1 (Item 1) Quality Assurance Program (4.1).

5.2.2 (Item 2) Schedule: Schedule showing shipment of the equipment after receipt of the order.

5.2.3 (Item 3) Drawings

a. General arrangement and outline drawings for the pump assembly and motor, showing overall dimensions and overall weights.

b. Cross-sectional drawings showing the details of the proposed equipment, including bill of materials to reflect the actual equipment and scope proposed.

5.2.4 (Item 4) Catalog bulletins and descriptive data illustrating the pump and motor being offered.

5.2.5 (Item 5) Mechanical shaft seal drawing showing type, manufacturer, and bill of materials.

5.2.6 (Item 6) Preliminary performance curve with high- and low-end rating points, including efficiency, water NPSHR, and power expressed as functions of capacity. Minimum flow, maximum flow, and any limitations of operation shall be indicated.

5.2.7 (Item 7) Certified pump and driver outline drawings with dimensions and bill of materials.

5.2.8 (Item 8) Certified mechanical shaft seal dimensional drawing(s) and bill of materials.

5.2.9 (Item 9) Instruction manuals. (3.11)

6 PREPARATION FOR DELIVERY

6.1 Preservation: Item shall be protected from dirt, soil, and moisture.

6.2 Packaging: Item shall be boxed or crated in a manner to prevent damage during shipping.

6.3 Marking: Packages shall be suitably marked on the outside to facilitate identification of the purchase order, the procurement specification, the package contents, and any special handling instructions.

6.4 The Seller shall recommend the preferred method of shipping and provide protection of the equipment during transit and storage.

SUMMARY OF SUBMITTALS

| Item | Title | Copies | Purpose | When required |
|---|---|---|---|---|
| 1 | Quality Assurance Program | 2 | Prepurchase Evaluation | With bid |
| 2 | Schedule | 2 | Prepurchase Evaluation | With bid |
| 3 | Drawings | 2 | Prepurchase Evaluation | With bid |
| 4 | Catalog Bulletin/Descriptive Data | 2 | Prepurchase Evaluation | With bid |
| 5 | Mechanical Shaft Seal Drawing/Control Panel Information | 2 | Prepurchase Evaluation | With bid |
| 6 | Preliminary Performance Curve | 2 | Prepurchase Evaluation | With bid |
| 7 | Certified Pump Dimensional Drawings | 2 | Approval | Prior to fabrication |
| 8 | Mechanical Shaft Seal Drawing | 2 | Approval | Prior to fabrication |
| 9 | Instruction Manuals | 5 | Vendor Information | With Shipment |
| 10 | Bill of Materials | 2 | Approval | Prior to fabrication |

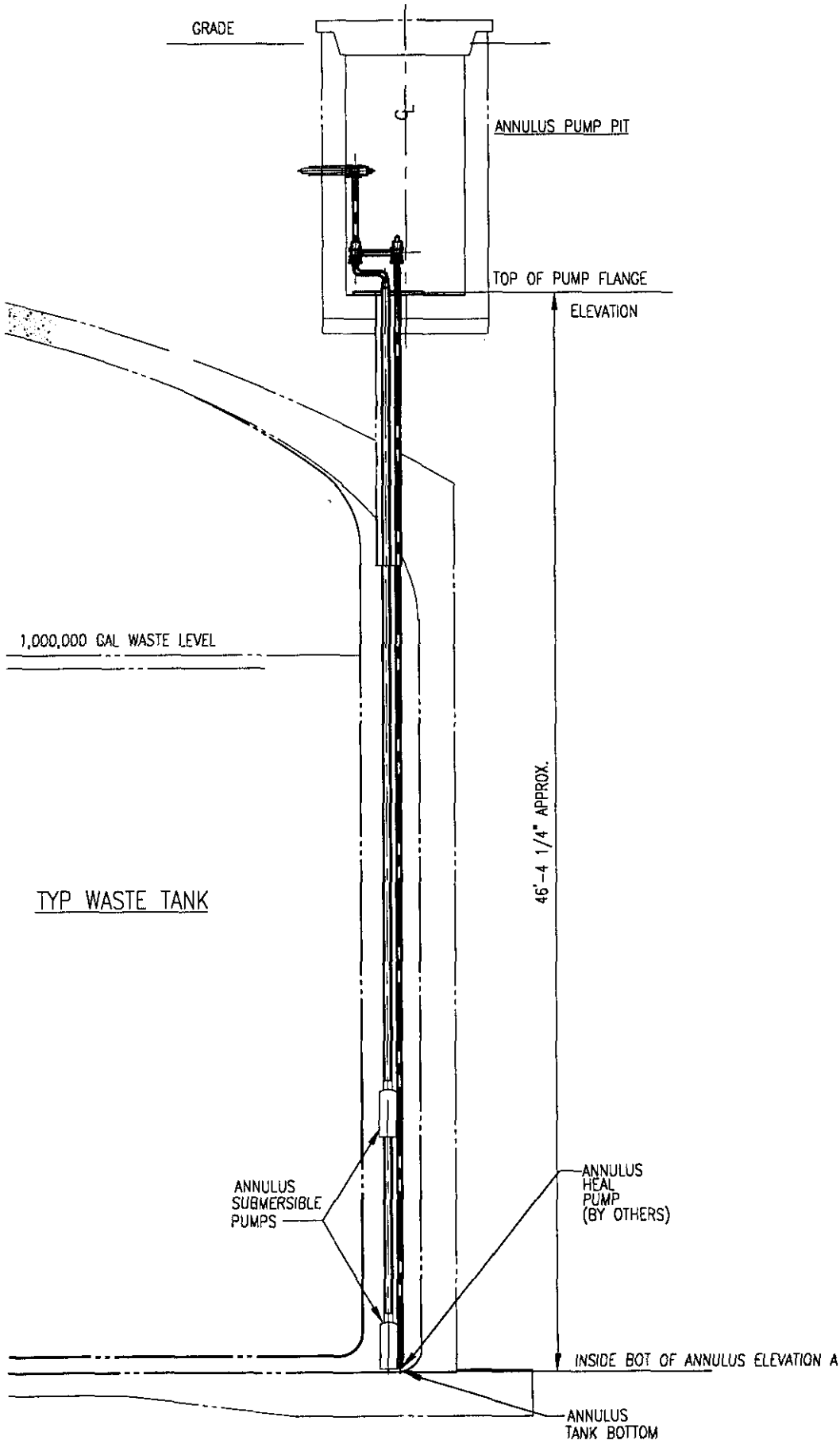



FIGURE 1
SCALE: 1 1/2" =1'-0"

# APPENDIX E
# DRAWINGS

PROJECT TITLE:

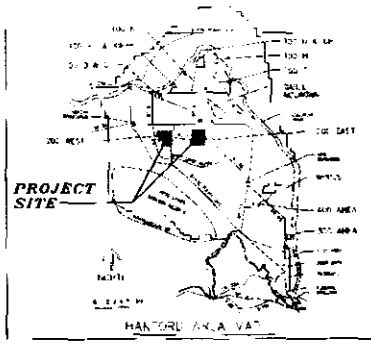
# DST ANNULUS PUMPING CONTRACT 4975 RELEASE 59 AND 60

FOR:

## CH2M Hill Hanford Group

BY:

## FLUOR FEDERAL SERVICES




## DRAWING LIST

### DRAWING LIST

| DRAWING NO. | INDEX NO. | TITLE |
|---|---|---|
| H-14-104118 | 0000, 0100 | DRAWING LIST & AREA MAP |

### PIPING & VESSELS

| DRAWING NO. | INDEX NO. | TITLE |
|---|---|---|
| H-14-104122 | 8404 | JUMPER ARRANGEMENT ANNULUS PUMP PIT 241-AN-01B THRU -07B |
| H-14-104123 SH 1 | 8404 | JUMPER ARRANGEMENT ANNULUS PUMP PIT 241-AP-01B, 03B, 06B & 08B |
| H-14-104123 SH 2 | 8404 | JUMPER ARRANGEMENT ANNULUS PUMP PIT 241-AP-02B, 04B, 05B & 07B |
| H-14-104124 | 8404 | JUMPER ARRANGEMENT ANNULUS PUMP PIT 241-AW-01B THRU -06B |
| H-14-104125 | 8404 | JUMPER ARRANGEMENT ANNULUS PUMP PIT 241-AY-01F & -02F |
| H-14-104126 | 8404 | JUMPER ARRANGEMENT ANNULUS PUMP PIT 241-AZ-01F & -02F |
| H-14-104127 | 8404 | JUMPER ARRANGEMENT ANNULUS PUMP PIT 241-SY-01B, 02B & -03B |
| H-14-104128 SH 1&2 | 8405 | JUMPER ASSEMBLY ANNULUS PUMP PIT 241-AN-01B THRU -07B |
| H-14-104129 SH 1&2 | 8405 | JUMPER ASSEMBLY ANNULUS PUMP PIT 241-AP-01B THRU -06B |
| H-14-104130 SH 1&2 | 8405 | JUMPER ASSEMBLY ANNULUS PUMP PIT 241-AW-01B THRU -06B |
| H-14-104131 SH 1&2 | 8405 | JUMPER ASSEMBLY ANNULUS PUMP PIT 241-AY-01F & -02F |
| H-14-104132 SH 1&2 | 8405 | JUMPER ASSEMBLY ANNULUS PUMP PIT 241-AZ-01F & -02F |
| H-14-104133 SH 1&2 | 8405 | JUMPER ASSEMBLY ANNULUS PUMP PIT 241-SY-01B, -02B & -03B |
| H-14-104134 SH 1&2 | 2600 | PUMP ASSEMBLY ANNULUS PUMP PIT 241-AN-01B THRU -07B |
| H-14-104135 SH 1&2 | 2600 | PUMP ASSEMBLY ANNULUS PUMP PIT 241-AP-01B THRU -08B |
| H-14-104136 SH 1&2 | 2600 | PUMP ASSEMBLY ANNULUS PUMP PIT 241-AW-01B THRU -08B |
| H-14-104137 SH 1&2 | 2600 | PUMP ASSEMBLY ANNULUS PUMP PIT 241-AY-01F & -02F |
| H-14-104138 SH 1&2 | 2600 | PUMP ASSEMBLY ANNULUS PUMP PIT 241-AZ-01F & -02F |
| H-14-104139 SH 1&2 | 2600 | PUMP ASSEMBLY ANNULUS PUMP PIT 241-SY-01B, -02B & -03B |
| H-14-104140 | 2600 | SUBMERSIBLE PUMP ASSEMBLY MODIFICATIONS |

### ELECTRICAL

| DRAWING NO. | INDEX NO. | TITLE |
|---|---|---|
| H-14-104119 | 7502 | DST ANNULUS PUMPING UTILITY WIRING DIAGRAM |
| H-14-104120 | 5907, 7501 | DST ANNULUS PUMP SYSTEM FUSED DISCONNECT SKID ASSY |
| H-14-104141 SH 1 | 5907/7501 | DST ANNULUS PUMP SYSTEM-FIELD RACK ARRANGEMENT |
| H-14-104141 SH 2 | 5907/7501 | DST ANNULUS PUMP SYSTEM-FIELD RACK ARRANGEMENT |
| H-14-104141 SH 3 | 5903 | DST ANNULUS PUMP SYSTEM-FIELD RACK SCHEMATIC |
| H-14-104141 SH 4 | 5903 | DST ANNULUS PUMP SYSTEM-FIELD RACK ASSEMBLY |
| H-14-104142 | 8001, 8510 | DST ANNULUS PUMPING UTILITY ARRANGEMENT 241-AN TANK FARM |
| H-14-104143 | 8001, 8510 | DST ANNULUS PUMPING UTILITY ARRANGEMENT 241-AP TANK FARM |
| H-14-104144 | 8001, 8510 | DST ANNULUS PUMPING UTILITY ARRANGEMENT 241-AW TANK FARM |
| H-14-104145 | 8001, 8510 | DST ANNULUS PUMPING UTILITY ARRANGEMENT 241-AY TANK FARM |
| H-14-104146 | 8001, 8510 | DST ANNULUS PUMPING UTILITY ARRANGEMENT 241-AZ TANK FARM |
| H-14-104147 | 8001, 8510 | DST ANNULUS PUMPING UTILITY ARRANGEMENT 241-SY TANK FARM |

FLUOR FEDERAL SERVICES

U.S. DEPARTMENT OF ENERGY

DRAWING LIST & AREA MAP

H-14-104118 0

DRAWING TRACEABILITY LIST

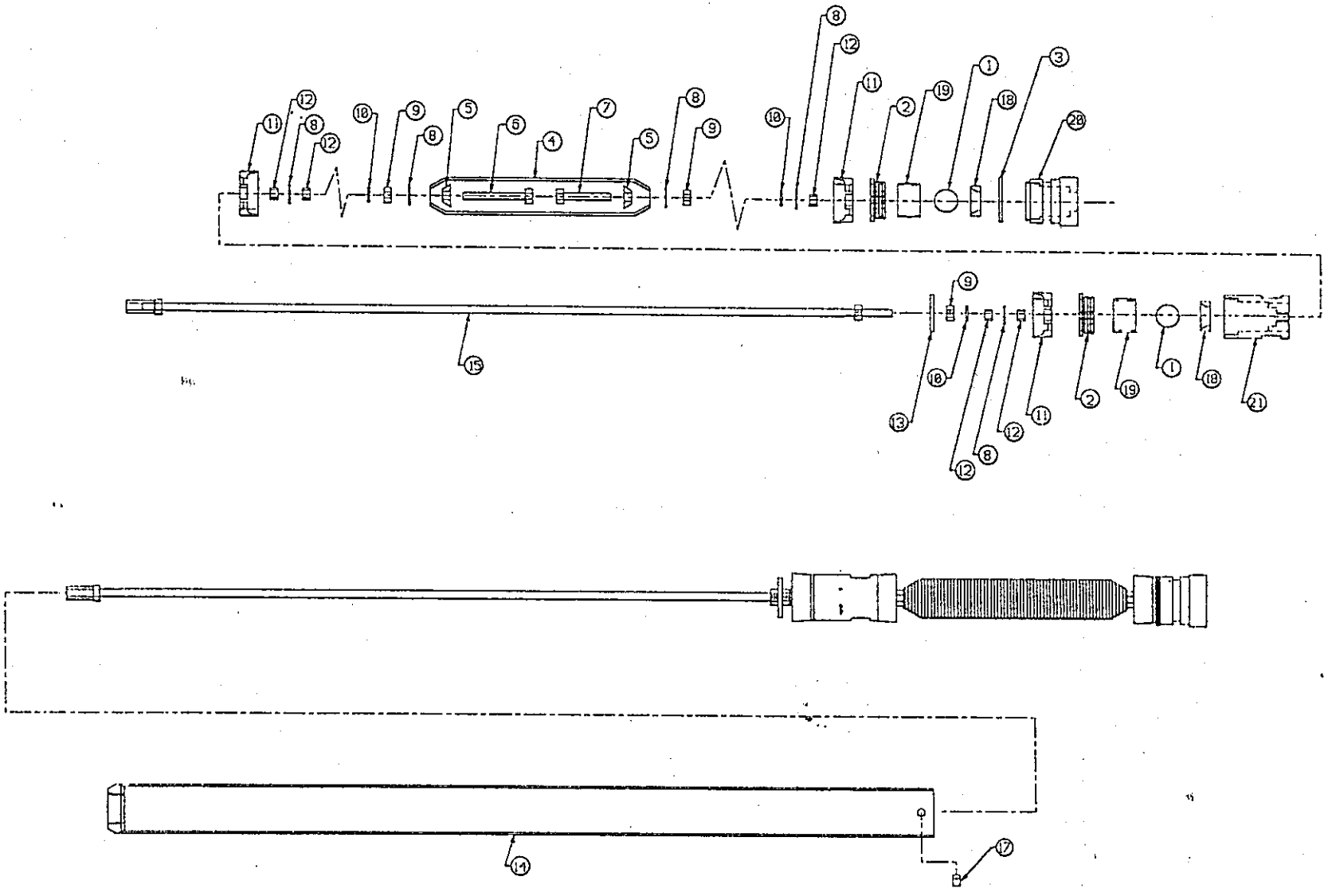
REFERENCES

REVISIONS

138

RPP-6485 Rev. 0

| DESCRIPTION | REV |
|---|---|



# HS-8001-1 w/ Standard Configuration

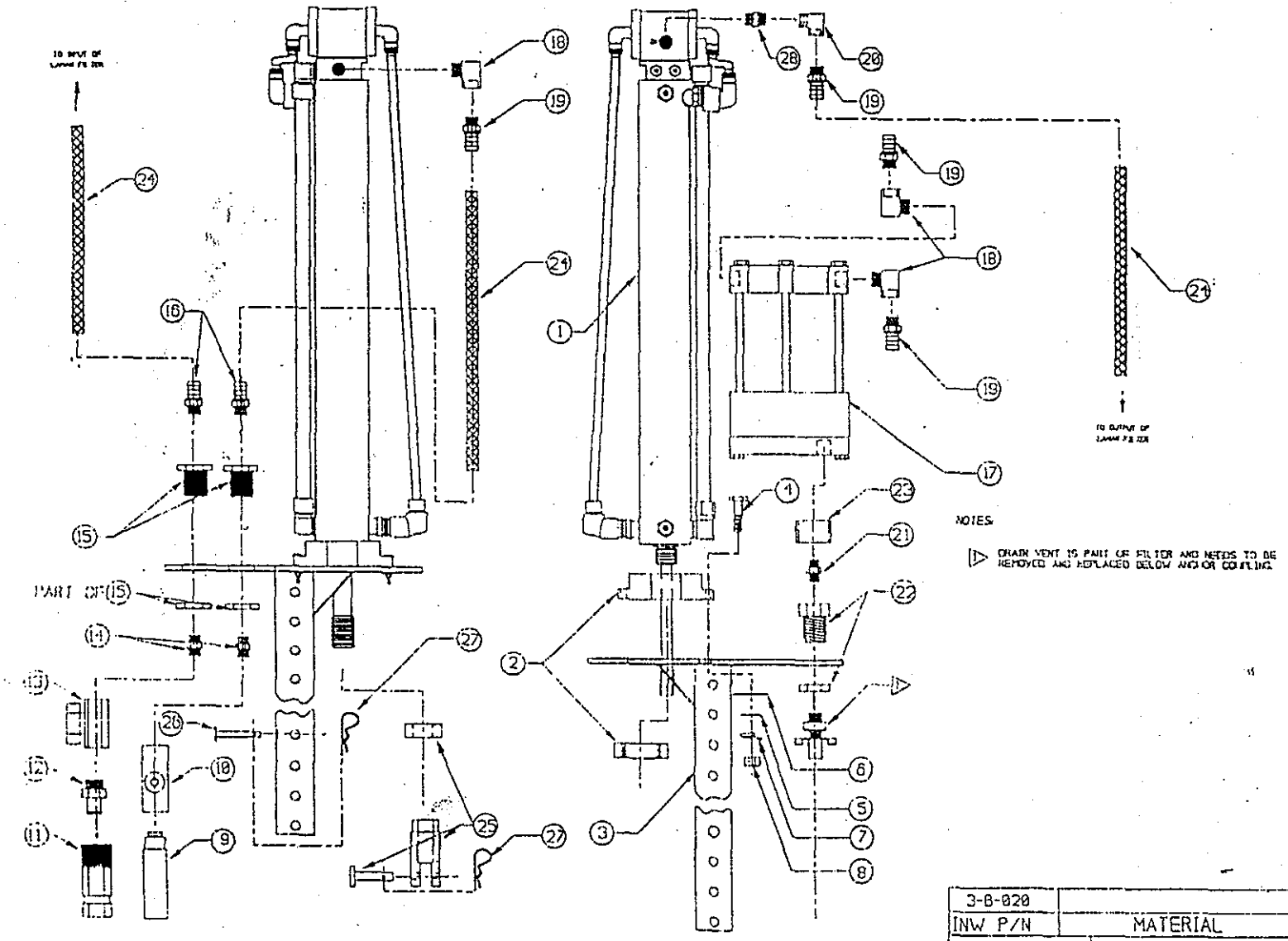
INSTRUMENTATION NORTHWEST, INC.

This drawing is the sole property of INW and is made available to customers and/or suppliers for limited use. The information contained on this drawing is considered confidential and this drawing must be returned after it has served its purpose. No use or disclosure of this drawing is authorized for any purposes beyond that specified when transmitted. Any unauthorized use of this drawing shall be subject to the penalties provided under law.

| | | |
|---|---|---|
| 3A001 | | |
| INW P/N | MATERIAL | FINISH |
| SCALE: NONE | HS8001 SERIES HYDROSTAR SAMPLING PUMPS | DRAWN BY JMK |
| DATE: 3-1-92 | | INSP BY |
| INSTRUMENTATION NORTHWEST 14072 N.E. 31ST CIRCLE REDMOND, WA 98052 (206) 885-3729 © 1992 | TOL | APPROVED BY |
| | ±XX | SHT 2 OF 7 |
| | ±XXX | DRAWING # 2A0001 |
| | ANG | REV C |

RPP-6495 Rev. 0

| DESCRIPTION | REV |
|---|---|




NOTES:

1. DRAIN VENT IS PART OF FILTER AND NEEDS TO BE REMOVED AND REPLACED BELOW ANCHOR COUPLING.

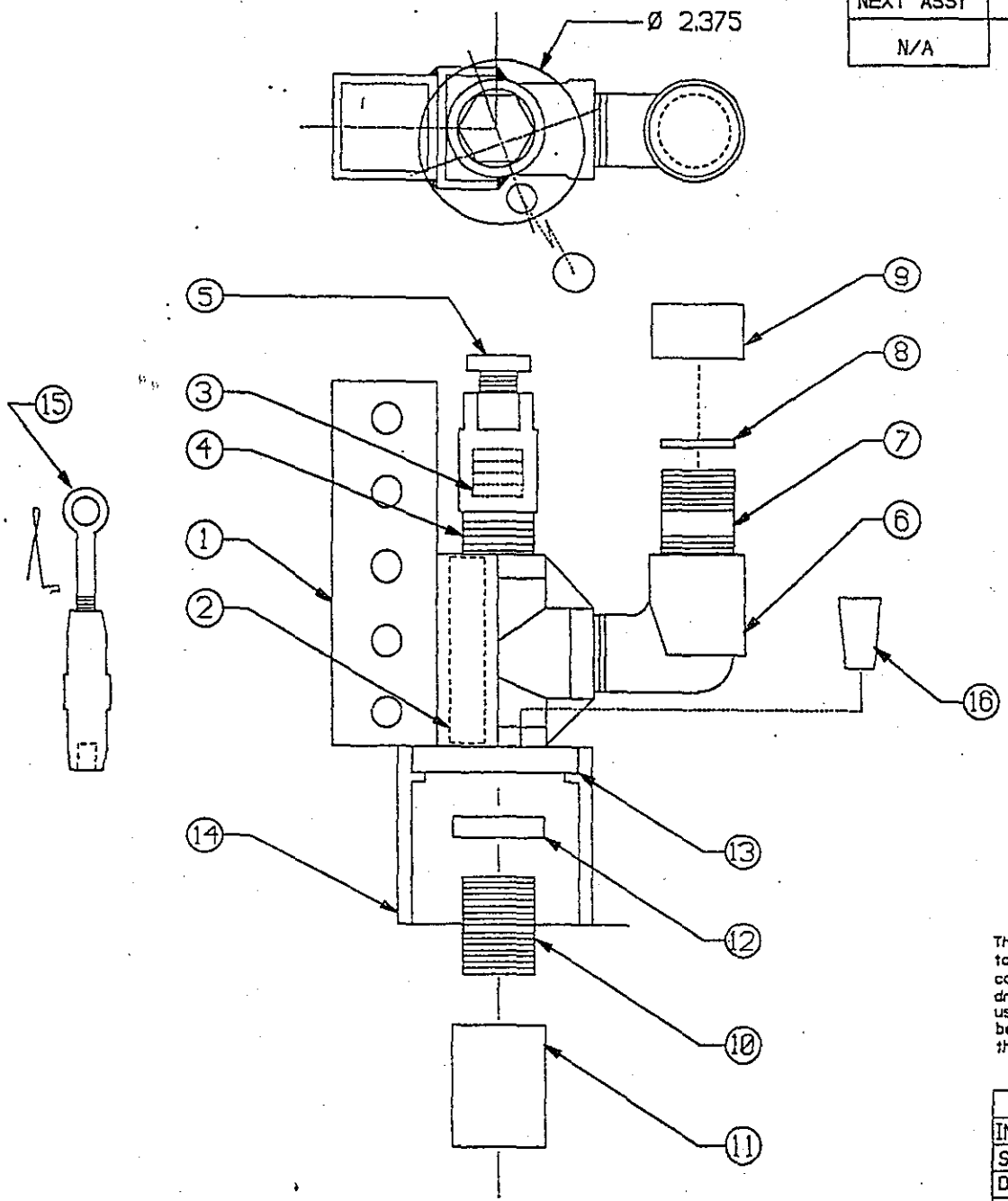
| | | |
|---|---|---|
| 3-B-020 | | |
| INW P/N | MATERIAL | FINISH |
| SCALE: NONE | AIR MOTOR ASSY., 2.00" X 12" | DRAWN BY JKC |
| DATE: 4-9-92 | | INSP BY |
| INSTRUMENTATION NORTHWEST 14072 NE 31ST CIRCLE REDMOND, WA 98052 (206) 885-3720 © 1991 | TOL .XX .XXX ANG | APPROVED BY SHT 1 OF 2 |
| | | DRAWING # 2A00084 REV B |

ORIGINAL

190

RPP-6485 REV. 0

| NEXT ASSY | DESCRIPTION | REV |
|---|---|---|
| N/A | | |




INSTRUMENTATION NORTHWEST, INC.

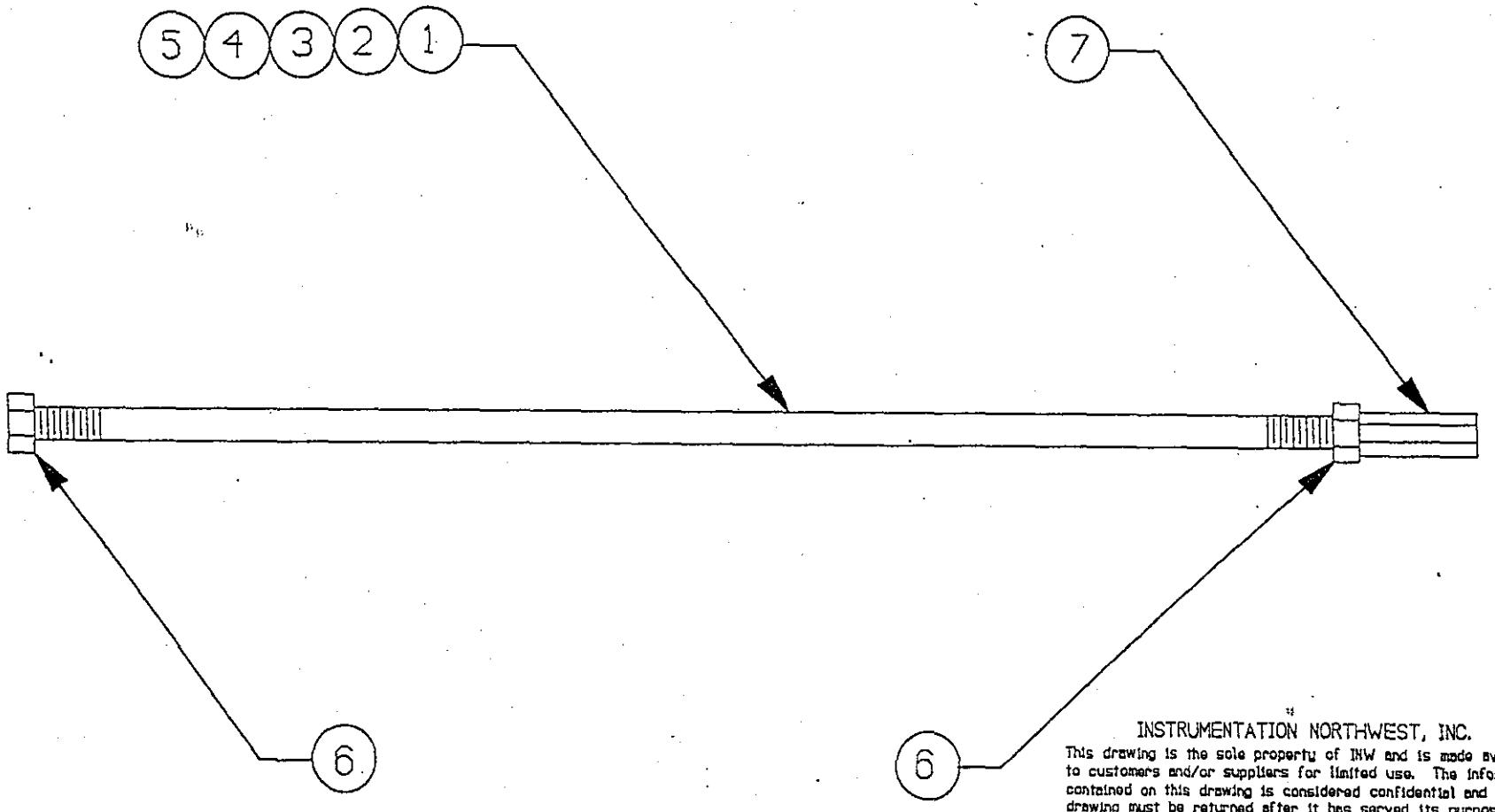
This drawing is the sole property of INW and is made available to customers and/or suppliers for limited use. The information contained on this drawing is considered confidential and this drawing must be returned after it has served its purpose. No use or disclosure of this drawing is authorized for any purposes beyond that specified when transmitted. Any unauthorized use of this drawing shall be subject to the penalties provided under law.

| | | |
|---|---|---|
| 3-E-502 | | |
| INW P/N | MATERIAL | FINISH |
| SCALE: NONE | WELL COMPLETION ASSY PVC/AL/PVC 2" | DRAWN BY JMK |
| DATE: 10-21-98 | | INSP BY |
| INSTRUMENTATION NORTHWEST 14972 N.E. 91ST CIRCLE REDMOND, WA 98052 (206) 885-3729 © 1998 | TOL ±XX ±XXX ANG | APPROVED BY SHT 2 OF 2 |
| | | DRAWING # 2A0020 REV A |

-1

RPP-4455 REV. 0

| NEXT ASSYS | DESCRIPTION | REV |
|---|---|---|
| 8665<br>8708 | | |




-1,-2,-3,-4,-5 SHOWN

INSTRUMENTATION NORTHWEST, INC.
This drawing is the sole property of INW and is made available to customers and/or suppliers for limited use. The information contained on this drawing is considered confidential and this drawing must be returned after it has served its purpose. No use or disclosure of this drawing is authorized for any purposes beyond that specified when transmitted. Any unauthorized use of this drawing shall be subject to the penalties provided under law.

| | | |
|---|---|---|
| SEE B/M | | |
| INW P/N | MATERIAL | FINISH |
| SCALE: NONE | ROD ASSEMBLY 1/4" | DRAWN BY NJE |
| DATE: 8-29-90 | 1', 2', 3', 5', 10' | INSP BY |
| INSTRUMENTATION NORTHWEST<br>14972 N.E. 31ST CIRCLE<br>REDMOND, WA 98052<br>(206) 885-3729 © 1990 | TOL ±XX ±XXX ANG | APPROVED BYGSG<br>SHT 2 OF 2<br>DRAWING # 2D0025 REV A |

142

RPP-6485 Rev. 0

# APPENDIX F
# SPARE PARTS

## Reberger, Dan W

**From:** Reberger, Dan W
**Sent:** Tuesday, June 13, 2000 11:01 AM
**To:** Roueche, Donald F
**Subject:** FW: Jumper Components for Central Pump Pits

**Importance:** High

Central Pump Pit Jumper Drawings to support Annulus Pumping
AN Farm H-2-72025
AP Farm H-2-90726
AW Farm H-2-70444
AY/AZ Farm H-2-64457
SY Farm H-2-37800

-----Original Message-----
**From:** Romine, Ricky L
**Sent:** Tuesday, June 13, 2000 9:16 AM
**To:** Reberger, Dan W; Rarig, Bradley K
**Subject:** RE: Jumper Components for Central Pump Pits

Dan,

Going to need the following parts:

| Quantity | Item |
|---|---|
| 1 | 2" Horizontal Connector |
| 1 | 3" Horizontal Connector |
| 1 | 2" Gasket |
| 1 | 3" Gasket |
| 1 | Lifting Bail (H-2-30777) |
| 1 | 2" Horizontal Lifting Bail (H-2-90162-2) |
| 1 | 3" Horizontal Lifting Bail (H-2-90162-3) |
| 2 | 2" Sched 40 SR 90 Degree Elbow (ASTM A403 304-L SST) |
| 2 | 2" Sched 40 LR 90 Degree Elbow (ASTM A403 304-L SST) |
| 2 | 2" Sched 40 LR 90 Degree Elbow (ASTM A234 GR WPB CS) |
| 10'-0" | 2" Schedule 40 Pipe (ASTM A312 304-L SST) |
| 10'-0" | 2" Schedule 40 Pipe (ASTM A53 Type S GR B CS) |
| 10'-0" | 2" Flex Hose |

The jumper for AP Central Pump Pit is a "Flex" ... the rest are rigid. That's why the callout for the Flex Hose and Horizontal Lifting Bails.

.... Rick Romine
*Fluor Federal Services*
*372-1140*

-----Original Message-----
**From:** Reberger, Dan W
**Sent:** Tuesday, June 13, 2000 8:28 AM
**To:** Rarig, Bradley K
**Cc:** Romine, Ricky L
**Subject:** Jumper Components for Central Pump Pits

Bradley,
As we discussed we need a list of parts (ie, connector heads, pipe, elbows etc.) for jumpers needed to support annulus pumping for the Central Pump pits in the six tank farms.

I need just the bare essentials to make any one jumper, no matter which one. I believe Rick has the drawings, let me know if you need anything else.

Thanks

RPP-6485 Rev. 0

# 3/20/00 12:58:14 PM Insight - Report

```
SP-001                                    HANFORD INVENTORY PROGRAM
                          DATE   8/29/98
                                              SPARE PARTS CATALOG
                          PAGE     206
 STOCK CLASS/CAPTION  6111


                                BPF/CVI
 STOCK NUMBER BASIC              PLANT EQUIPMENT DESCRIPTION            IAR NO
EQUIPMENT COG ENGINEER    BLDG CODE      NO


                                   SYS
  STOCK NUMBER      IL/SC                PART DESCRIPTION               UOI    UNIT PRICE
 MAXIMUM    MINIMUM   BLDG CODE    NUM
  6111-5500-5350      4    PLATE; MOUNTING;                             EA          42.45
        8           3  2282          E60
                          (P/N 1050472) IL



                                   SYS
  STOCK NUMBER      IL/SC                PART DESCRIPTION               UOI    UNIT PRICE
 MAXIMUM    MINIMUM   BLDG CODE    NUM
  6111-5500-5650      4    PUMP;                                        EA         580.00
       12           4  2282          E60
                          (SATURN, TEFLON, FLUID HANDLING,

                          FLUORCARBON MODEL NO. SP-4000) IL


    6111-5514             PUMP EP NO.:P-24-TX-2; MFG.:FLYGT            087137

                                CORP.; TYPE; SUBMERSIBLE; MODEL:

                                 B-2060; VENDOR; TURNER SALES

                                CO., SPOKANE WA.

                               VENDOR: DUSTY SPOKANE PUMPS OR

                               TIM-CO; SPECIAL HANDLING: 241-TX

                               FARM (244-TX DCRT); ADD. INFO:

                               P=PUMP - SUMP PUMP -- SEE ITEM

                               -5670 LISTED BELOW --


                                   SYS
  STOCK NUMBER      IL/SC                PART DESCRIPTION               UOI    UNIT PRICE
 MAXIMUM    MINIMUM   BLDG CODE    NUM
  6111-5514-5670      4    PUMP, SUMP;                                  EA        3829.58
       10           5  2225
                          PUMP, SUMP, SUBMERSIBLE, STAINLESS

                               STEEL, 3.7HP RATED, 3PH. 460VAC,

                               60HZ. 3300 RPM, 40 GPM, 75 FT.

                               HD. BOTTOM VERTICAL INLET

                               HORIZONTAL DISCHARGE. FLYGT CORP.

                               MODEL B-2060.
```

552920

SH RIFAEY

7 IN STOCK

C:\PROGRAM FILES\NSA\INSIGHT\print.txt 8,712 bytes

# 3/20/00 12:46:58 PM Insight - Report

```
PUMP; SUBMERSIBLE; STAINLESS STEEL; 1    9900-4399-7001  4       2,016.00 EBP-C01-A00
 1   EA   GALIOTO, THOMAS M
1/2 HP, 2-7 GPM                                          4

PUMP; LIQUID; 91-765;                    9900-4450-8001  2           1.00 ECP-B12-BOO
10   EA   DANIEL, JAMES P
                                                         2

PUMP; MIXER;                             9900-4837-3001  4            .00 EDX-B02-000
 1   EA   BENEGAS, TONY R
HMR #3 SPARE 101-SY MIXER PUMP,                          4

SUBMERSIBLE SLURRY PUMP, 200HP, 2800GPM,

REFERENCE DWG. H-14-100320

PUMP; SUBMERSIBLE;                       9900-4865-8002  Q      10,000.00 EEP-M06-B00
 1   EA   WIGGINS, DIRK D
FLYGT MODEL B-2060 (MODIFIED)-REQUESTOR                  Q

HAS RUN-IN DATA. OWNED BY SALTWELLS.

                                         9900-4920-1001  4         100.00
 0   EA   DAY, JAMES L
                                                         4

                                         9900-4920-1007  4         100.00
 0   EA   DAY, JAMES L
                                                         4

PUMP; SUBMERSIBLE; 1/3 HP                9900-5015-6001  4         138.75 EBO-E08-A00
 2   EA   BISSELL, ROBERT L
SUMP PUMP, AUTOMATIC, STOCK #IN363.                      4

PUMP;                                    9900-5082-0001  4       6,000.00 EBP-A04-B00
 1   EA   VIGUE, JERRY L
MAG. DRIVE, ANSIMAG MODEL 1516-CA                        4

PUMP;                                    9900-5101-3001  4         100.00 EBP-C01-B00
 1   EA   SHOEMAKE, NANCY C
CHEMICAL DISTRIBUTION SUMP FLOW PUMP                     4

PUMP; 1X1                                9900-5105-3001  4            .01 EEP-J03-B00
 1   EA   HUNTER, JAMES A
GOULD MODEL 3196 50-B                                    4

PUMP;                                    9900-5106-2001  4           1.00 EY4-R04-000
 1   EA   HUNTER, JAMES A
U.S. PUMP TURBINE WITH MARATHON ELECTRIC                 4

PUMP (T839369) S/N 1121 MODEL 2110 3530

RPM.
```

SPARE
MODIFIED

C:\PROGRAM FILES\NSA\INSIGHT\print.txt 8,248 bytes

# APPENDIX G
# JUMPERS

# Annulus/Primary Tank Pump-out Jumpers
## Best Case (Assumes a Flex/Rigid design)

| | | | | Total Jumpers Primary Route | Total Jumpers Annulus Route |
|---|---|---|---|---|---|
| AN Primary Tank Transfer Jumper | | H-2-72026 | AN-01A, 02A, 06A, 07A (All unique as-built dimensions) | 1 | |
| | | H-2-94863 | AN-03A, 04A, 05A (All unique as-built dimensions) | 1 | |
| Annulus Jumper Central Pit | | H-2-72025 | Fits All Pits | | 1 |
| Annulus Jumper Annulus Pit | | H-2-72028 | Fits All Pits(Needs modification) | | 1 |
| AP Primary Tank Transfer Jumper | | H-2-90725 | Assem 1 AP-02A, 04A, 05A, 07A (All unique as-built dimensions) | 1 | |
| | | | Assem 2 AP-01A, 03A, 06A, 08A (All unique as-built dimensions) | 1 | |
| Annulus Jumper Central Pit | (Flex) | H-2-90726 | Fits All Pits (need 2 type rigids) | | 2 |
| Annulus Jumper Annulus Pit | (Flex) | H-2-90729 | Fits All Pits(Needs modification 2 different orientations) | | 2 |
| AW Primary Tank Transfer Jumper | | H-2-70445 | AW-01A, 03A, 04A, 05A, 06A (Dimensions maybe same for all pits) | 1 | |
| | | H-2-70466 | AW-02E | | |
| | | H-2-70467 | (Jumpers maintained, Evap Camp) | | |
| | | H-2-70468 | | | |
| | | H-2-70470 | | | |
| Annulus Jumper Central Pit | | H-2-70444 | Fits All Pits | | 1 |
| Annulus Jumper Annulus Pit | | H-2-70451 | Fits All Pits(Needs modification) | | 1 |
| AY Primary Tank Transfer Jumper (D Pit) | | H-2-70772 | AY-01D (Needs as-built unknown pump) | 1 | |
| | | H-2-70774 | AY-02D | 1 | |
| Annulus Jumper Central Pit | | H-2-64457 | Fits Both Pits (Plus AZ Farm) | | 1 |
| Annulus Jumper Annulus Pit to Tank | | H-2-64441 | Fits Both Pits (Plus AZ Farm) (Needs Modification) | | 1 |
| Annulus Jumper Annulus Pit to Pit | | H-2-64458 | Fits Both Pits (Plus AZ Farm) (Needs Modification) | | 1 |
| AZ Primary Tank Transfer Jumper | | H-2-64436 | Fits Both Pits | 1 | |
| Annulus Jumper Central Pit | | H-2-64457 | Same Jumper as AY Farm | | |
| Annulus Jumper Annulus Pit to Tank | | H-2-64441 | Same Jumper as AY Farm | | |
| Annulus Jumper Annulus Pit to Pit | | H-2-64458 | Same Jumper as AY Farm | | |
| SY Primary Tank Transfer Jumper | | H-2-46251 | SY-01A & 03A (Dimensions are same for both pits) | 1 | |
| | | H-2-76536 | SY-02A | | |
| | | H-2-76537 | (Jumpers maintained for Cross-site) | | |
| Annulus Jumper Central Pit | | H-2-37800 | Fits All Pits | | 1 |
| Annulus Jumper Annulus Pit | | H-2-68388 | Fits All Pits(Needs modification) | | 1 |
| | | | Jumper Totals | 9 | 13 |

# Annulus/Primary Tank Pump-out Jumpers
(Worst Case)

| | | | | Total Jumpers Primary Route | Total Jumpers Annulus Route |
|---|---|---|---|---|---|
| AN Primary Tank Transfer Jumper | | H-2-72026 | AN-01A, 02A, 06A, 07A (All unique as-built dimensions) | 4 | |
| | | H-2-94863 | AN-03A, 04A, 05A (All unique as-built dimensions) | 3 | |
| Annulus Jumper Central Pit | | H-2-72025 | Fits All Pits | | 7 |
| Annulus Jumper Annulus Pit | | H-2-72028 | Fits All Pits(Needs modification) | | 7 |
| AP Primary Tank Transfer Jumper | | H-2-90725 | Assem 1 AP-02A, 04A, 05A, 07A (All unique as-built dimensions) | 4 | |
| | | | Assem 2 AP-01A, 03A, 06A, 08A (All unique as-built dimensions) | 4 | |
| Annulus Jumper Central Pit | (Flex) | H-2-90726 | Fits All Pits (need 2 type rigids) | | 8 |
| Annulus Jumper Annulus Pit | (Flex) | H-2-90729 | Fits All Pits(Needs modification 2 different orientations) | | 8 |
| AW Primary Tank Transfer Jumper | | H-2-70445 | AW-01A, 03A, 04A, 05A, 06A (Dimensions maybe same for all pits) | 5 | |
| | | H-2-70466 | AW-02E | 4 | |
| | | H-2-70467 | (Jumpers maintained, Evap Camp) | | |
| | | H-2-70468 | | | |
| | | H-2-70470 | | | |
| Annulus Jumper Central Pit | | H-2-70444 | Fits All Pits | | 6 |
| Annulus Jumper Annulus Pit | | H-2-70451 | Fits All Pits(Needs modification) | | 6 |
| AY Primary Tank Transfer Jumper (D Pit) | | H-2-70772 | AY-01D (Needs as-built unknown pump) | 1 | |
| | | H-2-70774 | AY-02D | 1 | |
| Annulus Jumper Central Pit | | H-2-64457 | Fits Both Pits (Plus AZ Farm) | | 2 |
| Annulus Jumper Annulus Pit to Tank | | H-2-64441 | Fits Both Pits (Plus AZ Farm) (Needs Modification) | | 2 |
| Annulus Jumper Annulus Pit to Pit | | H-2-64458 | Fits Both Pits (Plus AZ Farm) (Needs Modification) | | 2 |
| AZ Primary Tank Transfer Jumper | | H-2-64436 | Fits Both Pits | 2 | |
| Annulus Jumper Central Pit | | H-2-64457 | Same Jumper as AY Farm | | 2 |
| Annulus Jumper Annulus Pit to Tank | | H-2-64441 | Same Jumper as AY Farm | | 2 |
| Annulus Jumper Annulus Pit to Pit | | H-2-64458 | Same Jumper as AY Farm | | 2 |
| SY Primary Tank Transfer Jumper | | H-2-46251 | SY-01A & 03A (Dimensions are same for both pits) | 2 | |
| | | H-2-76536 | SY-02A | 2 | |
| | | H-2-76537 | (Jumpers maintained for Cross-site) | | |
| Annulus Jumper Central Pit | | H-2-37800 | Fits All Pits | | 3 |
| Annulus Jumper Annulus Pit | | H-2-68388 | Fits All Pits(Needs modification) | | 3 |
| | | | Jumper Totals | 32 | 60 |

# Annulus/Primary Tank Pump-out Jumpers
(Planning Case)

| | | | | Total Jumpers Primary Route | Total Jumpers Annulus Route |
|---|---|---|---|---|---|
| AN Primary Tank Transfer Jumper | | H-2-72026 | AN-01A, 02A, 06A, 07A (All unique as-built dimensions) | 4 | |
| | | H-2-94863 | AN-03A, 04A, 05A (All unique as-built dimensions) | 3 | |
| Annulus Jumper Central Pit | | H-2-72025 | Fits All Pits | | 1 |
| Annulus Jumper Annulus Pit | | H-2-72028 | Fits All Pits(Needs modification) | | 1 |
| AP Primary Tank Transfer Jumper | | H-2-90725 | Assem 1 AP-02A, 04A, 05A, 07A (All unique as-built dimensions) | 4 | |
| | | | Assem 2 AP-01A, 03A, 06A, 08A (All unique as-built dimensions) | 4 | |
| Annulus Jumper Central Pit | (Flex) | H-2-90726 | Fits All Pits (need 2 type rigids) | | 2 |
| Annulus Jumper Annulus Pit | (Flex) | H-2-90729 | Fits All Pits(Needs modification 2 different orientations) | | 2 |
| AW Primary Tank Transfer Jumper | | H-2-70445 | AW-01A, 03A, 04A, 05A, 06A (Dimensions maybe same for all pits) | 1 | |
| | | H-2-70466 | AW-02E | | |
| | | H-2-70467 | (Jumpers maintained, Evap Camp) | | |
| | | H-2-70468 | | | |
| | | H-2-70470 | | | |
| Annulus Jumper Central Pit | | H-2-70444 | Fits All Pits | | 1 |
| Annulus Jumper Annulus Pit | | H-2-70451 | Fits All Pits(Needs modification) | | 1 |
| AY Primary Tank Transfer Jumper (D Pit) | | H-2-70772 | AY-01D (Needs as-built unknown pump) | 1 | |
| | | H-2-70774 | AY-02D | 1 | |
| Annulus Jumper Central Pit | | H-2-64457 | Fits Both Pits (Plus AZ Farm) | | 1 |
| Annulus Jumper Annulus Pit to Tank | | H-2-64441 | Fits Both Pits (Plus AZ Farm) (Needs Modification) | | 1 |
| Annulus Jumper Annulus Pit to Pit | | H-2-64458 | Fits Both Pits (Plus AZ Farm) (Needs Modification) | | 1 |
| AZ Primary Tank Transfer Jumper | | H-2-64436 | Fits Both Pits | 1 | |
| Annulus Jumper Central Pit | | H-2-64457 | Same Jumper as AY Farm | | |
| Annulus Jumper Annulus Pit to Tank | | H-2-64441 | Same Jumper as AY Farm | | |
| Annulus Jumper Annulus Pit to Pit | | H-2-64458 | Same Jumper as AY Farm | | |
| SY Primary Tank Transfer Jumper | | H-2-46251 | SY-01A & 03A (Dimensions are same for both pits) | 1 | |
| | | H-2-76536 | SY-02A | | |
| | | H-2-76537 | (Jumpers maintained for Cross-site) | | |
| Annulus Jumper Central Pit | | H-2-37800 | Fits All Pits | | 1 |
| Annulus Jumper Annulus Pit | | H-2-68388 | Fits All Pits(Needs modification) | | 1 |
| | | | Jumper Totals | 20 | 13 |

# APPENDIX H
# CALCULATIONS

RPP-6485 REV. 0

| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX | Page: i of ii<br>Date: 02/08/00 |
|---|---|---|

This sheet shows the status and description of the attached Design Analysis sheets

Discipline: 454 Project/Area/Unit: 65100541/25/9 Calculation No.: DSTAP-P-001

Project No. & Name: Double Shell Tank Annulus Pumping

Calculation Item: DST Annulus Pump Line Losses

These calculations apply to:

Drawing No.: N/A Rev. No:

Drawing No.: Rev. No:

Other (Study, CDR): Rev. No.

The status of these calculations is:

[] Preliminary Calculations

[X] Final Calculations

[] Check Calculations (On Calculation Dated )

[] Void Calculation (Reason Voided )

Incorporated in Final Drawings? [X] Yes [] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | Paul M Dorsh 02/08/00 | | |
| Checked by | [illegible] 4/18/00 | | |
| Approved by | JM Hanchi 4/27/00 | | |
| Checked Against Approved Vendor Data | | | |

INDEX


| Design Analysis Page No. | Description |
|---|---|
| 1 | Objective, Design Criteria, Methods, Assumptions |
| 2 | Assumptions Cont, References, Conclusions |
| 3-10 | Calculations |
| Appendix A | Attached References |
| A1-A3 | Transfer Route Walkdown |
| A4-A6 | Crane Technical Paper No. 410 |
| A7-A8 | E-mail consisting of Revised Design Parameters. |
| A9 | E-mail pertaining to Flow Rates |
| A10-A13 | Engineering Fluid Mechanics |
| A14-A15 | PBM Catalog Cut Sheets |
| A16 | ARES Sketch of Double Shell Tank Annulus Pumping Data |

RPP-6485 Rev. 0

| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX<br>Continuation Sheet | Page ii of ii<br>Date: 02/08/00 |
|---|---|---|

Discipline: 454 | Project/Area/Unit: 65100541/25/9 | Calculation No.: DSTAP-P-001

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | Paul M. Davis 02/08/00 | | |
| Checked by | [illegible] 4/13/00 | | |

## INDEX

| Design Analysis Page No. | Description |
|---|---|
| A17-A18 | Statement of Work for Annulus Pumping |
| A18a | E-mail consisting of Original Design Parameters. |
| Appendix B | Referenced Drawings |
| B1-B38 | Various Drawings |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

## REVISION

| Revision No. | Description |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

RRP-L495 Rev. 0

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-001
Revision No.: 0
Page No.: 1 of 11

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 02 / 08 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By:
Revised: By:

## OBJECTIVE:

The objective of this calculation is to determine the line losses of a piping route that transfers waste from the annulus in tank AN-106 to tank AP-104, via existing lines. The line losses will then be used to select an annulus pump that will satisfy the pressure requirements of the route.

## DESIGN CRITERIA / INPUT:

| | | |
|---|---|---|
| Flow Rate: | 40 GPM minimum | (Ref. 4) |
| Dynamic Viscosity: | 30 centipoise maximum | (Ref. 3) |
| Specific Gravity: | 1.47 maximum | (Ref. 3) |
| Temperature: | 140° F maximum | (Ref. 3) |
| Safety Classification: | General Service | (Ref. 9) |

## METHODS:

1.) The Darcy-Weisbach equation is used in determining the friction pressure losses.

2.) Friction losses due to standard fittings are calculated using the pipe resistance coefficients (K factors) found in Crane Technical Paper No. 410.

3.) The total pressure losses of the system is determined using Bernoulli's equation.

The worst case route for an annulus pump is to transfer from tank AN-106 to AP-106 via existing lines. A transfer route walkdown (Ref. 1) consisting of all the transfer lines was given by the client. However, the walkdown considers a transfer from tank AN-106 to AP-104. This route can be considered equivalent in losses to the AN-106 to AP-106 route with minimal error. Therefore, pump selection shall be based on the results of the transfer from AN-106 to AP-104 (Ref. 1).

The components (valve types, fittings, bends, length of pipe) of the piping in each individual process pit and transfer line used in the transfer route were determined. Similar components were then summed together and a resistance coefficient was determined for each type of component. All resistance coefficients were then summed together and used to determine the head loss due to friction.

RPP-6485 REV. 0



Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 02 / 08 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By:
Revised: By:

## ASSUMPTIONS:

1.) The Purex nozzles are equivalent in resistance to a 90 degree miter bend.

2.) Clean Out Boxes on the transfer lines are equivalent in resistance to a "thru" tee.

3.) The equivalent roughness of carbon and stainless steel pipe is 0.00015 ft.

4.) Bends in the 2" and 3" transfer lines have a bend radius of 36".

5.) The discharge of the pump is located near the bottom of tank AN-106 in the annulus area.

6.) The velocity of the fluid at the pump discharge is equal to the velocity of the fluid entering tank AN-104.

7.) All 2 and 3-way ball valves in the transfer route have flow coefficients equivalent to PBM SP 30-40 series (2-way) and MP 70-80 series (3-way) valves.

8.) The changes between the 2" and 3" pipe are all located within a purex nozzle and will be considered sudden.

9.) Because of the nature of the transfer route, a few of the pits require new jumper designs. Assumptions for the jumper designs will be made based on the configuration of the pit and are as noted in the calculation.

10.) Assume that the pressure in tank AP-104 is atmospheric.

11.) It is reasonable to expect that pipe flow will be laminar for Reynolds number less than 2000 and turbulent for Reynolds numbers greater than 3000. When the Reynolds number is between 2000 and 3000 the type of flow is very unpredictable and often changes back and forth between laminar and turbulent states. However, since there will be vibrations in the piping system due to the pumping operation, it is safe to assume that for Reynolds numbers approaching 2000, the flow is turbulent.

## REFERENCES:

1.) AN-106 to AP-104 transfer route walkdown, Document No. TO-001-181.

2.) Crane Technical Paper No. 410, *Flow of Fluids Through Valves, Fittings, and Pipe.*

3.) E-mail dated 1/25/00 from Dan Reberger to Marshall Hauck consisting of Revised Design Criteria.

4.) E-mail dated 2/8/00 from Dan Reberger to Paul Dorsh, pertaining to Flow Rates.

5.) *Engineering Fluid Mechanics*, Sixth Edition, Roberson and Crowe.

6.) PBM Catalog.

7.) Sketch from ARES showing Double Shell Tank Annulus Pumping Data.

8.) Statement of Work for Annulus Pumping, Revision No. 0, Contract 4975.

## REFERENCES CONT:

9.) E-mail dated December 17, 1999 from Dan Reberger to Bradley Rarig, stating Design Criteria

10.) Various reference drawings supporting the transfer route walkdown (Ref. 1).

References are located in Appendix A.

## CONCLUSIONS:

The total line loss of the transfer route, at a fluid discharge of 40 GPM, is 175 ft. Therefore, a pump should be selected that will satisfy this operating condition. Multiple pumps operating in tandem are acceptable, if necessary, to achieve this discharge head.

Due to other criteria for selecting a pump, i.e., physical dimensions, material composition, and flammable gas classification, an "off the shelf" pump(s) of this performance level may not be assessable. Because of the long length of pipe, a smaller flow rate will dramatically drop the required pump discharge head. For example, a 30 GPM flow rate would require only 130 ft of discharge head. Thus, a pump which satisfies the other criteria, but operates slightly below the performance criteria (175 ft @ 40 GPM), may need to be selected.

**FLUOR FEDERAL SERVICES**



**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 02 / 08 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By:
Revised: By:

---

**Fluid Properties**

| | | | |
|---|---|---|---|
| Desired Flow Rate | $Q := 40 \cdot GPM$ | $Q = 154 \cdot \frac{in^3}{sec}$ | (Ref. 4, A9) |
| Specific Gravity of Fluid | $SG := 1.47$ | | (Ref. 3, A7) |
| Temperature of Fluid | $T := 140 \cdot F$ | | (Ref. 3, A7) |
| Density of Water @ 140 F | $\rho_w := 61.38 \cdot \frac{lb}{ft^3}$ | | (Ref. 5, A13) |
| Density of Fluid @ 140 F | $\rho := \rho_w \cdot SG$ | $\rho = 90.23 \cdot \frac{lb}{ft^3}$ | |
| Dynamic Viscosity | $\mu := 30 \cdot cp$ | | (Ref. 3, A7) |
| Pipe Roughness | $k_s := 0.00015 \cdot ft$ | | (Ref. 5, A10) |

**3" Sch 40 Pipe Properties**

| | | | |
|---|---|---|---|
| Inside Diameter of 3" Sch 40 Pipe | $D_3 := 3.068 \cdot in$ | | |
| Inside Area of Pipe | $A_3 := \frac{\pi}{4} \cdot D_3^2$ | $A_3 = 7.39 \cdot in^2$ | |
| Velocity of Fluid | $V_3 := \frac{Q}{A_3}$ | $V_3 = 1.74 \cdot \frac{ft}{sec}$ | |
| Reynolds Number | $Re_3 := \frac{V_3 \cdot D_3 \cdot \rho}{\mu}$ | $Re_3 = 1986.4$ | (assumed turbulent) |
| Friction Factor | $f_3 := \frac{0.25}{\log\left(\frac{k_s}{3.7 \cdot D_3} + \frac{5.74}{Re_3^{0.9}}\right)^2}$ | $f_3 = 0.052$ | (Ref. 5, A11) |
| Friction Factor in Zone of Complete Turbulence | $f_{t3} := .018$ | | (Ref. 2, A4) |

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-001
Revision No.: 0
Page No.: 5 of 11

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 02 / 08 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By: [illegible]
Revised: By:

| | | | |
|---|---|---|---|
| Flow Coefficient of 3 Way T-Port Through (GPM) | $Cv_{t3} := 460$ | | (Ref. 6, A15) |
| Flow Coefficient of 3 Way T- Port Branch (GPM) | $Cv_{b3} := 270$ | | (Ref. 6, A15) |
| Flow Coefficient of 2 Way Ball Valve (GPM) | $Cv_3 := 625$ | | (Ref. 6, A14) |

**2" Sch 40 Pipe Properties**

| | | | |
|---|---|---|---|
| Inside Diameter of 3" Sch 40 Pipe | $D_2 := 2.067 \cdot in$ | | |
| Inside Area of Pipe | $A_2 := \frac{\pi}{4} \cdot D_2^2$ | $A_2 = 3.36 \cdot in^2$ | |
| Velocity of Fluid | $V_2 := \frac{Q}{A_2}$ | $V_2 = 3.82 \cdot \frac{ft}{sec}$ | |
| Reynolds Number | $Re_2 := \frac{V_2 \cdot D_2 \cdot \rho}{\mu}$ | $Re_2 = 2948.4$ | (assumed turbulent) |
| Friction Factor | $f_2 := \frac{0.25}{\log\left(\frac{k_s}{3.7 \cdot D_2} + \frac{5.74}{Re_2^{0.9}}\right)^2}$ | $f_2 = 0.046$ | (Ref. 5, A11) |
| Friction Factor in Zone of Complete Turbulence | $f_{t2} := .019$ | | (Ref. 2, A4) |
| Flow Coefficient of 3 Way T-Port Through (GPM) | $Cv_{t2} := 176$ | | (Ref. 6, A15) |
| Flow Coefficient of 3 Way T- Port Branch (GPM) | $Cv_{b2} := 108$ | | (Ref. 6, A15) |
| Flow Coefficient of 2 Way Ball Valve (GPM) | $Cv_2 := 300$ | | (Ref. 6, A14) |

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-001
Revision No.: 0
Page No.: 6 of 11

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 02 / 08 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By: [illegible]
Revised: By:

**Transfer Pits and Components** (Ref. 1 & 10)

Annulus Pump Pit 06B

Pipe Diameter - 2"
L.R. Bends - 3
Purex Connectors - 2
3 Way B.V. (Branch),
new design - 1
Length of Pipe - 10 ft
Additional Annulus Pipe
(Inside of Tank Annulus) - 45 ft
Ref Dwg - B1/Assumption

Central Pump Pit 241-AN-06A

Pipe Diameter - 2"
L.R. Bends - 2
Purex Connectors - 2
10" Rad Bends - 1
Sudden Expansion - 1
Length of Pipe - 10 ft
Ref Dwg - B3 & B4

Valve Pit 241-AN-A

Pipe Diameter - 3"
L.R. Bends - 2
Purex Connectors - 3
3 Way B.V. (Branch) - 3
3 Way B.V. (Thru) - 2
2 Way B.V. - 2
Length of Pipe - 14 ft
Ref Dwg - B6 & B7

Valve Pit 241-AN-B

Pipe Diameter - 3"
L.R. Bends - 1
Purex Connectors - 3
3 Way B.V. (Thru) - 1
2 Way B.V. - 2
Sudden Contraction - 1
Length of Pipe - 11 ft
Ref Dwg - B8/Assumption

Pump Pit 241-AZ-02B

Pipe Diameter - 2"
L.R. Bends - 2
Purex Connectors - 2
Sudden Expansion - 1
Length of Pipe - 8.5 ft
Ref Dwg - B12

Valve Pit 241-AX-A

Pipe Diameter - 3"
L.R. Bends - 1
Purex Connectors - 2
15" Rad Bends - 1
Length of Pipe - 9 ft
Ref Dwg - B16

Valve Pit 241-A-A

Pipe Diameter - 3"
L.R. Bends - 3
S.R. Bends - 1
Purex Connectors - 2
3 Way B.V. (Branch) - 1
Length of Pipe - 7.5 ft
Ref Dwg - B23

Valve Pit 241-AW-A

Pipe Diameter - 3"
L.R. Bends - 2
Purex Connectors - 3
2 Way B.V. - 2
15" Rad Bends - 2 (1 + 2 @ 45deg)
Length of Pipe - 20 ft
Ref Dwg - B26, B27 & B28

Central Pump Pit 241-AW-02A

Pipe Diameter - 3"
L.R. Bends - 4
Purex Connectors - 2
3 Way B.V. (Thru) - 1
Length of Pipe - 10 ft
Ref Dwg - B29, B30

Valve Pit 241-AP

Pipe Diameter - 3"
L.R. Bends - 12
Purex Connectors - 5
3 Way B.V. (Branch) - 1
3 Way B.V. (Thru) - 2
2 Way B.V. - 3
15" Rad Bends - 1
Length of Pipe - 30 ft
Ref Dwg - B35 & B36

Pump Pit 241-AP-04A

Pipe Diameter - 3"
Purex Connectors - 2
3 Way B.V. (Branch) - 1
15" Rad Bends - 1
Length of Pipe - 5 ft
Ref Dwg - B38

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-001
Revision No.: 0
Page No.: 7 of 11

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 02 / 08 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By: [illegible]
Revised: By:

**Total 2" Pit Components**

L.R. Bends - 7
Purex Connectors - 6
3 Way B.V. (Branch) - 1
10" Rad Bends - 1
Sudden Expansions - 2
Length of Pipe - 63.5 ft

**Total 3" Pit Components**

L.R. Bends - 25
S.R. Bends - 1
Purex Connectors - 22
3 Way B.V. (Branch) - 6
3 Way B.V. (Thru) - 6
2 Way B.V. - 9
15" Rad Bends - 5
Sudden Contraction - 1
Length of Pipe - 106.5 ft

**Resistance Coefficients for 3" Pits**

L.R. Bends
Qty = 25

$K_1 := (14 \cdot f_{t3}) \cdot 25$ $\quad K_1 = 6.3$ (Ref. 2, A5)

Purex Connectors
Qty = 22

$K_2 := (60 \cdot f_{t3}) \cdot 22$ $\quad K_2 = 23.76$ (Ref. 2, A5)

Diameter of Ball Valve (in)

$D := 3.0$

3 Way Ball Valves (Branch)
Qty = 6

$K_3 := \left(891 \cdot \frac{D^4}{Cv_{b3}^{\,2}}\right) \cdot 6$ $\quad K_3 = 5.94$ (Ref. 2, A6)

3 Way Ball Valves (Thru)
Qty = 6

$K_4 := \left(891 \cdot \frac{D^4}{Cv_{t3}^{\,2}}\right) \cdot 6$ $\quad K_4 = 2.05$ (Ref. 6, A6)

2 Way Ball Valves
Qty = 9

$K_5 := \left(891 \cdot \frac{D^4}{Cv_{3}^{\,2}}\right) \cdot 9$ $\quad K_5 = 1.66$ (Ref. 2, A6)

S.R. Bends
Qty = 1

$K_6 := (20 \cdot f_{t3}) \cdot 1$ $\quad K_6 = 0.36$ (Ref. 2, A5)

15" Rad Bends
Qty = 5

$K_7 := (15.5 \cdot f_{t3}) \cdot 5$ $\quad K_7 = 1.39$ (Ref. 2, A5)

Length of Pipe

$L := 106.5 \cdot ft$

$K_8 := f_3 \cdot \frac{L}{D_3}$ $\quad K_8 = 21.55$

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-001
Revision No.: 0
Page No.: 8 of 11

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 02 / 08 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By: MLe
Revised: By:

---

| | | | |
|---|---|---|---|
| Sudden Contraction<br>Qty = 1 | $K_9 := 0.25$ | | (Ref. 5, A12) |
| Sum of the Resistance Coefficients for the 3" Pits | $K_{p3} := \sum_{i=1}^{9} K_i$ | $K_{p3} = 63.26$ | |

**Resistance Coefficients for 2" Pits**

| | | | |
|---|---|---|---|
| L.R. Bends<br>Qty = 7 | $K_1 := (14 \cdot f_{t2}) \cdot 8$ | $K_1 = 2.13$ | (Ref. 2, A5) |
| Purex Connectors<br>Qty = 6 | $K_2 := (60 \cdot f_{t2}) \cdot 9$ | $K_2 = 10.26$ | (Ref. 2, A5) |
| Diameter of Ball Valve (in) | $D := 2.0$ | | |
| 3 Way Ball Valves (Branch)<br>Qty = 1 | $K_3 := \left(891 \cdot \frac{D^4}{Cv_{b2}^{\ 2}}\right) \cdot 1$ | $K_3 = 1.22$ | (Ref. 2, A6) |
| 10" Rad Bends<br>Qty = 1 | $K_4 := (15.5 \cdot f_{t2}) \cdot 1$ | $K_4 = 0.29$ | (Ref. 2, A5) |
| Sudden Expansion<br>Qty = 2 | $K_5 := 0.35 \cdot 2$ | $K_5 = 0.7$ | (Ref. 5, A12) |
| Length of Pipe | $L := 63.5 \cdot ft$ | | |
| | $K_6 := f_2 \cdot \frac{L}{D_2}$ | $K_6 = 16.82$ | |
| Sum of the Resistance Coefficients for the Pits | $K_{p2} := \sum_{i=1}^{6} K_i$ | $K_{p2} = 31.43$ | |

RPP-6485 Rev. 0



**Transfer Lines and Components** (Ref. 1 & 10)

2" PW-476

36" Rad Bends - 1
Length of Pipe - 35 ft
Ref Dwg - B2

3" SN-266

36" Rad Bends - 5
Length of Pipe - 99 ft
Ref Dwg - A1, B2 & B5

3" SN-268

36" Rad Bends - 4
Length of Pipe - 25 ft
Ref Dwg - A1, B5

2" SN-260

36" Rad Bends - 9
Length of Pipe - 375 ft
COB - 3
Ref Dwg - A2, B9, B10 & B11

2" SN-600

36" Rad Bends - 16
Length of Pipe - 783 ft
COB - 5
Ref Dwg - B13 & B14

3" SN-201/ SN-214

36" Rad Bends - 15
Length of Pipe - 573 ft
COB - 5
Ref Dwg - B18, B19, & B20

3" SN-220

36" Rad Bends - 12
Length of Pipe - 568 ft
COB - 3
Ref Dwg - B21, B24, & B25

3" SN-267

36" Rad Bends - 5
Length of Pipe - 110 ft
Ref Dwg - B25

3" SN-609

36" Rad Bends - 13
Length of Pipe - 715 ft
Ref Dwg - B31, B32, B33, & B34

3" SN-614

36" Rad Bends - 6
Length of Pipe - 299 ft
Ref Doc - TO-001-181 (A3)

**Total 2" Line Components**

36" Rad Bends - 26
Length of Pipe - 1193 ft
COB - 8

**Total 3" Line Components**

36" Rad Bends - 60
Length of Pipe - 2389 ft
COB - 8

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-001
Revision No.: 0
Page No.: 10 of 11

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP LINE LOSSES
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 02 / 08 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By: [illegible]
Revised: By:

**Resistance Coefficients for 3" Lines**

| | | | |
|---|---|---|---|
| 36" Rad Bends<br>Qty = 60 | $K_1 := (34 \cdot f_{t3}) \cdot 60$ | $K_1 = 36.72$ | (Ref. 2, A5) |
| COB<br>Qty = 8 | $K_2 := (20 \cdot f_{t3}) \cdot 8$ | $K_2 = 2.88$ | (Ref. 2, A5) |
| *Length of Pipe* | $L := 2389 \cdot ft$ | | |
| | $K_3 := f_3 \cdot \frac{L}{D_3}$ | $K_3 = 483.38$ | |
| Sum of the Resistance Coefficients for the 3" Lines | $K_{13} := \sum_{i=1}^{3} K_i$ | $K_{13} = 522.98$ | |
| **Total Value of 3" Resistance Coefficients** | $K_3 := K_{p3} + K_{13}$ | $K_3 = 586.24$ | |
| **Total Head Loss of 3" Components** | $h_3 := K_3 \cdot \frac{V_3^2}{2 \cdot g}$ | $h_3 = 27.45 \cdot ft$ | |

**Resistance Coefficients for 2" Lines**

| | | | |
|---|---|---|---|
| 36" Rad Bends<br>Qty = 26 | $K_1 := (46 \cdot f_{t2}) \cdot 26$ | $K_1 = 22.72$ | (Ref. 2, A5) |
| COB<br>Qty = 8 | $K_2 := (20 \cdot f_{t2}) \cdot 8$ | $K_2 = 3.04$ | (Ref. 2, A5) |
| Length of Pipe | $L := 1193 \cdot ft$ | | |
| | $K_3 := f_2 \cdot \frac{L}{D_2}$ | $K_3 = 316.02$ | |

| | | |
|---|---|---|
| Sum of the Resistance Coefficients for the 2" Lines | $K_{12} := \sum_{i=1}^{3} K_i$ | $K_{12} = 341.79$ |
| **Total Value of 2" Resistance Coefficients** | $K_2 := K_{p2} + K_{12}$ | $K_2 = 373.21$ |
| **Total Head Loss of 2" Components** | $h_2 := K_2 \cdot \frac{V_2^2}{2 \cdot g}$ | $h_2 = 84.83 \cdot ft$ |

**Total Frictional Head Loss**

| | | |
|---|---|---|
| Combined 2" and 3" Components | $h_L := h_2 + h_3$ | $h_L = 112.29 \cdot ft$ |

**Static Head**

| | | |
|---|---|---|
| Elevation of Pump Discharge | $z_a := 612.3 \cdot ft$ | (Ref dwg B1 & A16) |
| Elevation of Pipe End | $z_b := 675 \cdot ft$ | (Ref dwg B38) |

Considering Bernoulli's equation, $P_a/\gamma + V_a^2/2g + z_a = P_b/\gamma + V_b^2/2g + z_b + \Sigma K_{ab}V^2/2g$, with position "a" located at the discharge of the annulus pump and position "b" located at the purex nozzle going into tank AN04 (point e), we find the required pressure head of the annulus pump to be:

$$P_a/\gamma = P_b/\gamma + (V_b^2/2g - V_a^2/2g) + (z_b - z_a) + \Sigma K_{ab}V^2/2g$$

or, with zero terms canceled out ($P_b$ is atmospheric) and in terms of feet ($P_a/\gamma$ is the pressure head = H, $\Sigma K_{ab}V^2/2g$ is the friction head = $h_L$, $V_a = V_2$ and $V_b = V_3$):

$$H = h_L + (V_3^2/2g - V_2^2/2g) + (z_b - z_a)$$

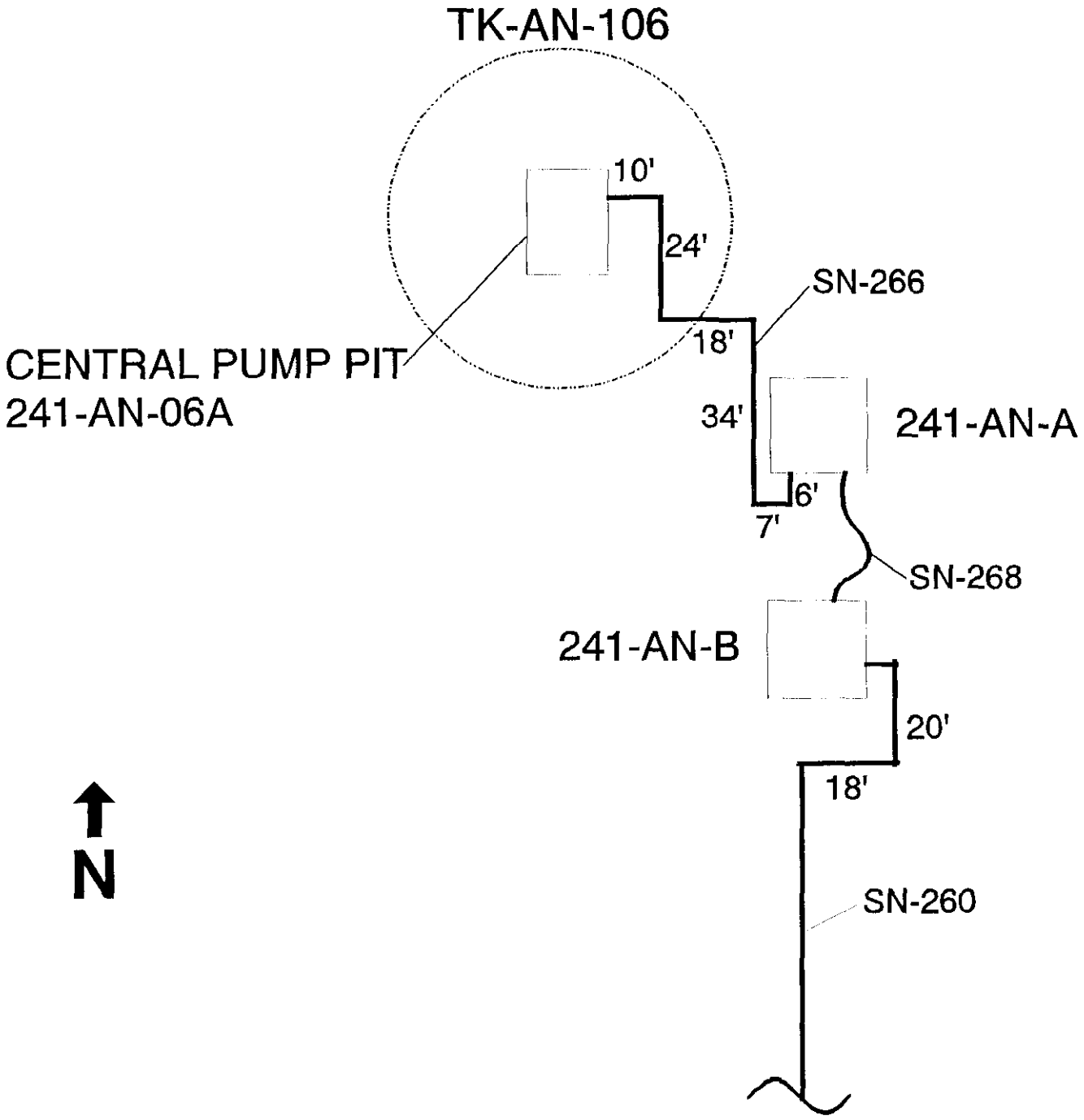
| | | |
|---|---|---|
| Required Pressure Head | $H := h_L + \left(\frac{V_3^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g}\right) + (z_b - z_a)$ | $H = 174.81 \cdot ft$ |
| Required Pressure | $P := \frac{H \cdot SG}{2.31}$ | $P = 111.24 \cdot psi$ |

# APPENDIX A

# References

FIGURE 16 - TK-AN-106 TO 241-AN-B EXCAVATION WALKDOWN





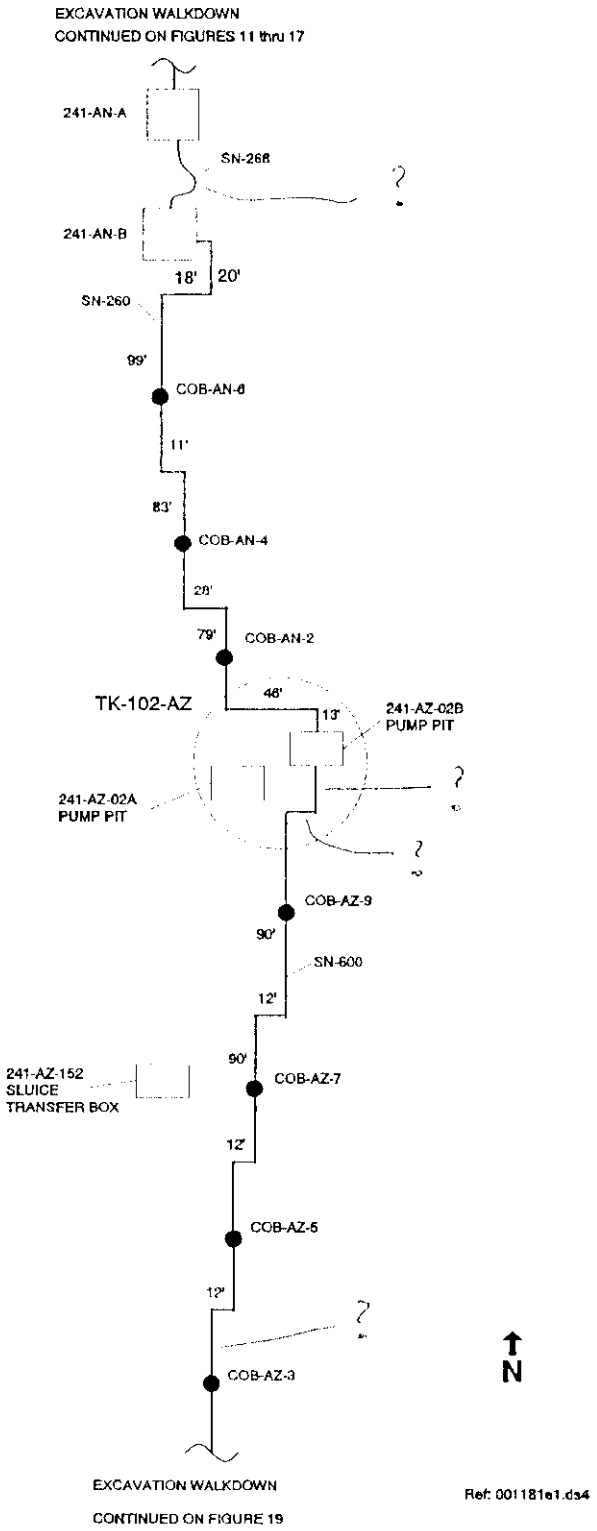

Ref: 001181e8.ds4

EXCAVATION WALKDOWN
CONTINUED ON FIGURE 18

Rpp-6485 Rev. 0

# FIGURE 18 - 241-AN-A TO COB-AZ-3 EXCAVATION WALKDOWN

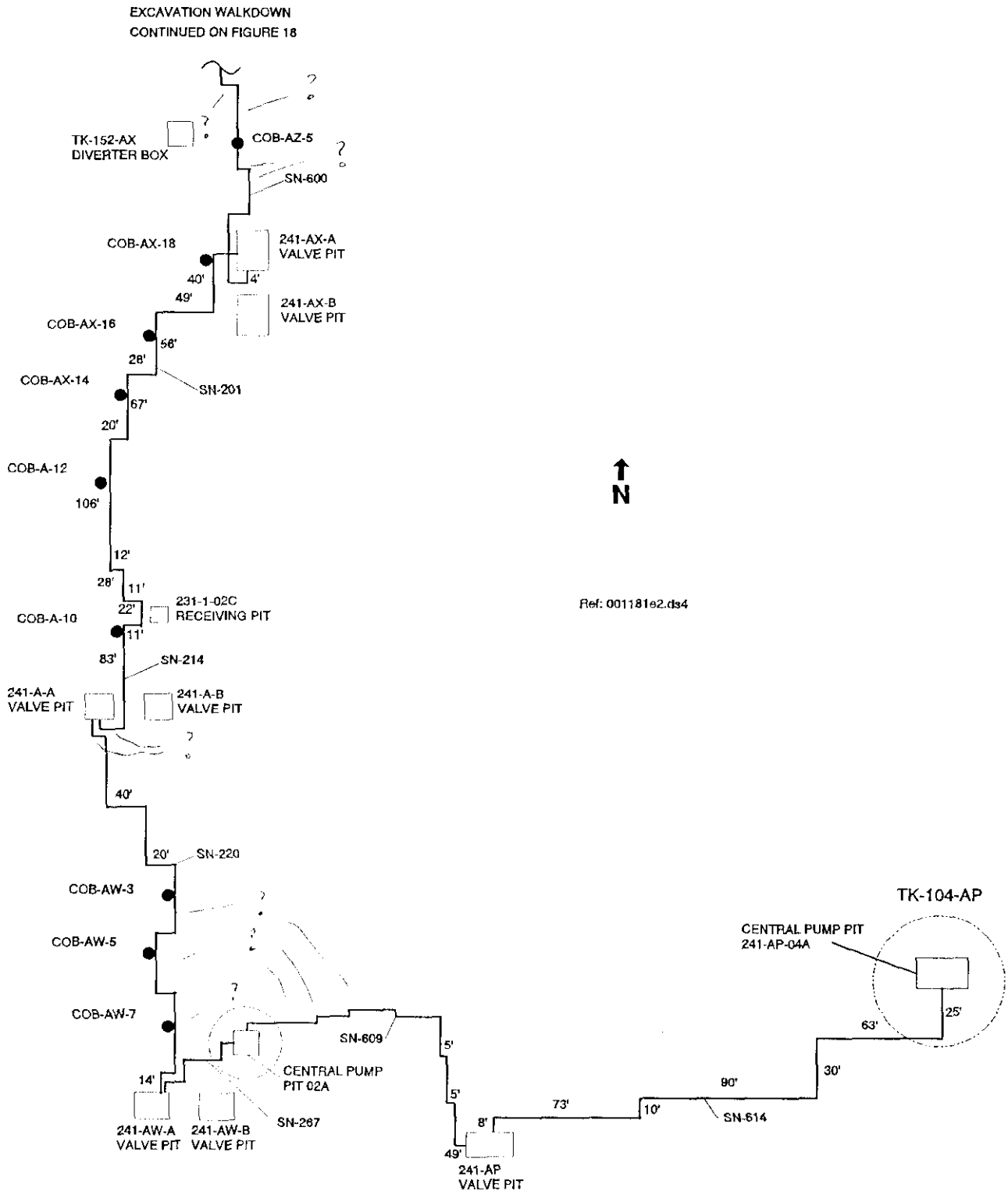




RPP-6988 Rev. 0

# FIGURE 19 - COB-AZ-1 TO TK-104-AP EXCAVATION WALKDOWN

Calc No: DSTAP-P-001, Rev. 0
Ref. 1 A3 of A18



"K" FACTOR TABLE—SHEET 1 of 4

# Representative Resistance Coefficients (K) for Valves and Fittings

*("K" is based on use of schedule pipe as listed on page 2-10)*

## PIPE FRICTION DATA FOR CLEAN COMMERCIAL STEEL PIPE WITH FLOW IN ZONE OF COMPLETE TURBULENCE

| Nominal Size | ½" | ¾" | 1" | 1¼" | 1½" | 2" | 2½, 3" | 4" | 5" | 6" | 8-10" | 12-16" | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Friction Factor ($f_T$) | .027 | .025 | .023 | .022 | .021 | .019 | .018 | .017 | .016 | .015 | .014 | .013 | . |

## FORMULAS FOR CALCULATING "K" FACTORS* FOR VALVES AND FITTINGS WITH REDUCED PORT

(Ref: Pages 2-11 and 3-4)

- **Formula 1**

$$K_2 = \frac{0.8\left(\sin\frac{\theta}{2}\right)(1-\beta^2)}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 2**

$$K_2 = \frac{0.5\,(1-\beta^2)\sqrt{\sin\frac{\theta}{2}}}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 3**

$$K_2 = \frac{2.6\left(\sin\frac{\theta}{2}\right)(1-\beta^2)^2}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 4**

$$K_2 = \frac{(1-\beta^2)^2}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 5**

$$K_2 = \frac{K_1}{\beta^4} + \text{Formula 1} + \text{Formula 3}$$

$$K_2 = \frac{K_1 + \sin\frac{\theta}{2}\left[0.8\,(1-\beta^2) + 2.6\,(1-\beta^2)^2\right]}{\beta^4}$$

- **Formula 6**

$$K_2 = \frac{K_1}{\beta^4} + \text{Formula 2} + \text{Formula 4}$$

$$K_2 = \frac{K_1 + 0.5\sqrt{\sin\frac{\theta}{2}}\,(1-\beta^2) + (1-\beta^2)^2}{\beta^4}$$

- **Formula 7**

$$K_2 = \frac{K_1}{\beta^4} + \beta\,(\text{Formula 2} + \text{Formula 4}) \text{ when } \theta =$$

$$K_2 = \frac{K_1 + \beta\left[0.5\,(1-\beta^2) + (1-\beta^2)^2\right]}{\beta^4}$$

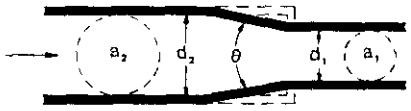
$$\beta = \frac{d_1}{d_2}$$

$$\beta^2 = \left(\frac{d_1}{d_2}\right)^2 = \frac{a_1}{a_2}$$

Subscript 1 defines dimensions and coefficients with reference to the smaller diameter.
Subscript 2 refers to the larger diameter.

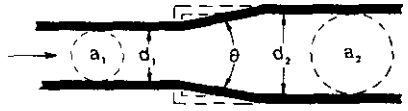
***Use "K" furnished by valve or fitting supplier when available.**

### SUDDEN AND GRADUAL CONTRACTION




If: $\theta \leq 45°$ . . . . . $K_2$ = Formula 1
$45° < \theta \leq 180°$ . . . $K_2$ = Formula 2

### SUDDEN AND GRADUAL ENLARGEMENT




If: $\theta \leq 45°$ . . . . . $K_2$ = Formula 3
$45° < \theta \leq 180°$ . . . $K_2$ = Formula 4

RPP-6485 REV.0





"K" FACTOR TABLE—SHEET 4 of 4

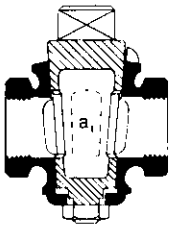
# Representative Resistance Coefficients (K) for Valves and Fittings

*(for formulas and friction data, see page A-26)*

*("K" is based on use of schedule pipe as listed on page 2-10)*

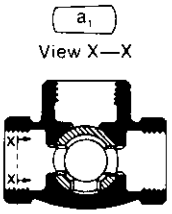
## PLUG VALVES AND COCKS

**Straight-Way**

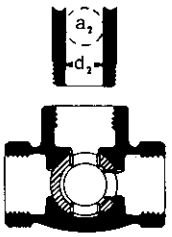



If: $\beta = 1$, $K_1 = 18\, f_T$

**3-Way**



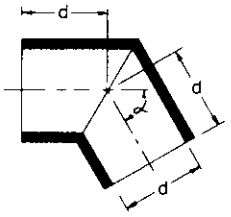

If: $\beta = 1$, $K_1 = 30\, f_T$




If: $\beta = 1$, $K_1 = 90\, f_T$

If: $\beta < 1 \ldots K_2$ = Formula 6

## MITRE BENDS




| α | K |
|---|---|
| 0° | 2 $f_T$ |
| 15° | 4 $f_T$ |
| 30° | 8 $f_T$ |
| 45° | 15 $f_T$ |
| 60° | 25 $f_T$ |
| 75° | 40 $f_T$ |
| 90° | 60 $f_T$ |

## 90° PIPE BENDS AND FLANGED OR BUTT-WELDING 90° ELBOWS

SR
LR

| r/d | K | r/d | K |
|---|---|---|---|
| 1 | 20 $f_T$ | 8 | 24 $f_T$ |
| 1.5 | 14 $f_T$ | 10 | 30 $f_T$ |
| 2 | 12 $f_T$ | 12 | 34 $f_T$ |
| 3 | 12 $f_T$ | 14 | 38 $f_T$ |
| 4 | 14 $f_T$ | 16 | 42 $f_T$ |
| 6 | 17 $f_T$ | 20 | 50 $f_T$ |

The resistance coefficient, $K_B$, for pipe bends other than 90° may be determined as follows:

$$K_B = (n - 1)\left(0.25\,\pi\, f_T \frac{r}{d} + 0.5\,K\right) + K$$

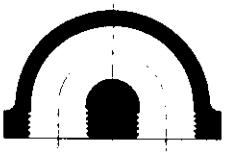
$n$ = number of 90° bends
$K$ = resistance coefficient for one 90° bend (per table)

$\frac{r}{d} = \frac{15''}{3''} = 5$

$\frac{r}{d} = \frac{10''}{2''} = 5$

$K = 15.5 f_t$

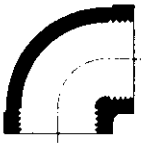
## CLOSE PATTERN RETURN BENDS



$K = 50\, f_T$

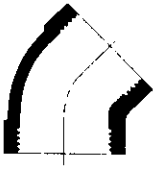
## STANDARD ELBOWS

90°



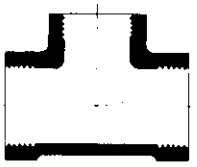
$K = 30\, f_T$

45°



$K = 16\, f_T$

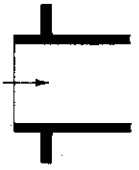
## STANDARD TEES



Flow thru run . . . . . $K = 20\, f_T$
Flow thru branch . . . . $K = 60\, f_T$

## PIPE ENTRANCE

**Inward Projecting**

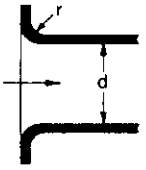


$K = 0.78$

| r/d | K |
|---|---|
| 0.00* | 0.5 |
| 0.02 | 0.28 |
| 0.04 | 0.24 |
| 0.06 | 0.15 |
| 0.10 | 0.09 |
| 0.15 & up | 0.04 |

*Sharp-edged

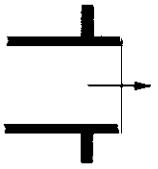
**Flush**




For $K$, see table

## PIPE EXIT

**Projecting**

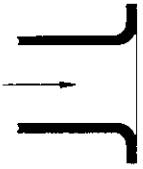


$K = 1.0$

**Sharp-Edged**

$K = 1.0$

**Rounded**



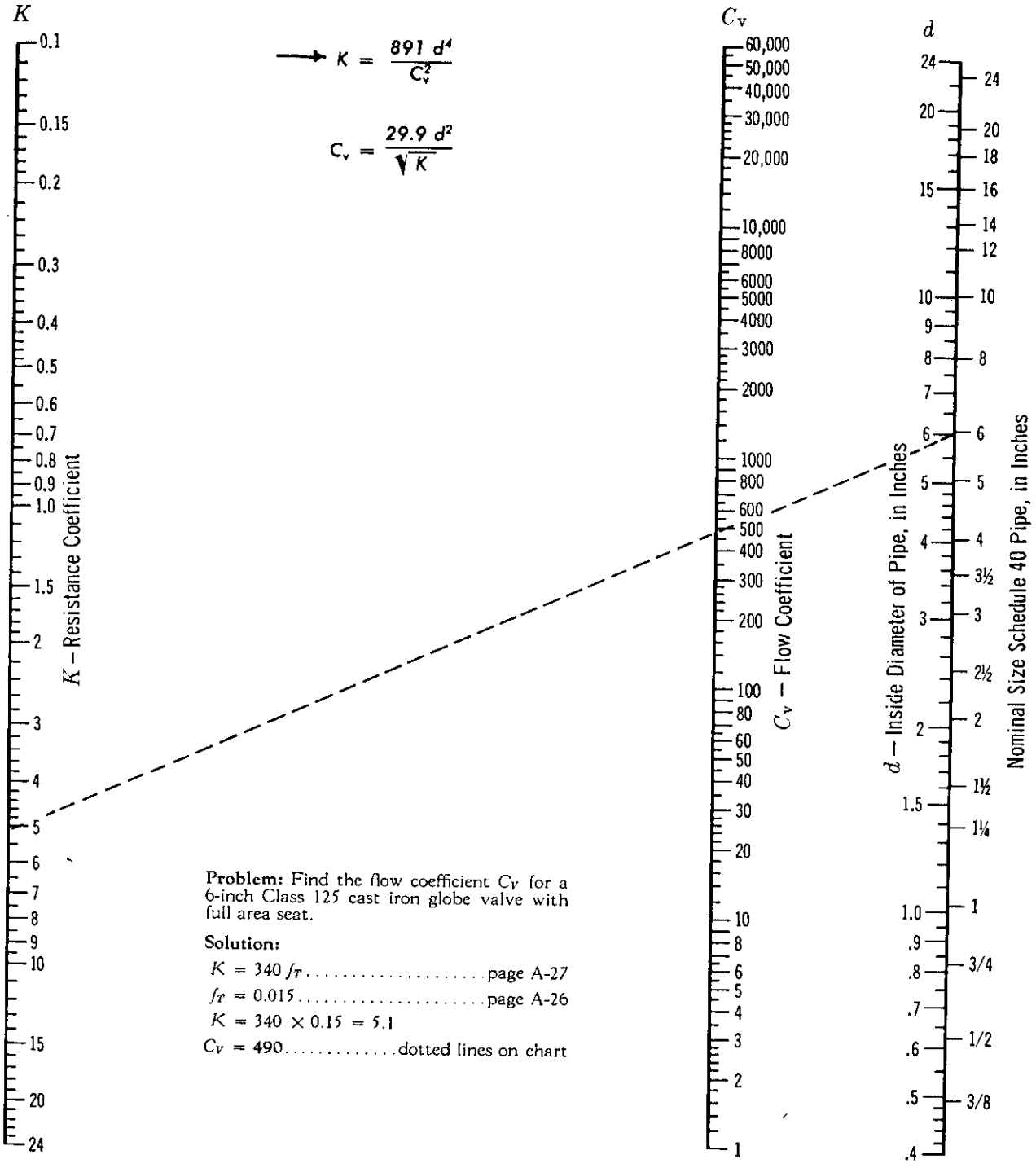
$K = 1.0$

# Equivalents of Resistance Coefficient *K* And Flow Coefficient $C_v$

Calc No: DSTAP-P-001, Rev. 0
Ref. 2 A6 of A18

$$K = \frac{891\, d^4}{C_v^2}$$

$$C_v = \frac{29.9\, d^2}{\sqrt{K}}$$




**Problem:** Find the flow coefficient $C_V$ for a 6-inch Class 125 cast iron globe valve with full area seat.

**Solution:**

$K = 340\, f_T$ ..... page A-27

$f_T = 0.015$ ..... page A-26

$K = 340 \times 0.15 = 5.1$

$C_V = 490$ ..... dotted lines on chart

**Dorsh, Paul M**

**From:** Reberger, Dan W
**Sent:** Tuesday, January 25, 2000 7:38 AM
**To:** Hauck, Frank M (Marshall)
**Cc:** Rarig, Bradley K; Dorsh, Paul M; Peck, David J; Leshikar, Gregory A
**Subject:** Draft Design Criteria for Annulus pumps -Revision

I forgot the criteria on Flammable Gas Controls and pressure.

---

In our recent meetings on annulus pumping, it was apparent that the pumping specifications previously provided were not adequate. I'm currently in the process of developing a technical rational for the Pump Design Criteria. The following is a draft of the criteria. Let me know if there are any questions or concerns.

**Submersible Centrifugal**

| | |
|---|---|
| Total Flow | 50 - 300* gpm |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centipoise |
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$F |
| Discharge Pressure | 230 maximum** |
| Flammable Gas Controls or equivalent)*** | Ignition Source Control Set #1 (Class 1 Division 1 GroupB |
| Waste Flow | 33 - 200 gpm**** |
| Dilution water Flow | 17 - 100 gpm**** |

* The maximum flow rate of 300 gpm is based on an accident in the Tank Farm FSAR 3.4.2.7 Surface Leak Resulting in a Pool.

** Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

*** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**** The dilution water flow may be required to be as high as 50% of the waste flow. It's recognized that design constraints may prevent reaching dilution water flows above 40 gpm. In this case throttling existing waste line valves will be used to set the proper dilution. The design constraints anticipated are water supply pressure, pressure drop through hose connections, and the limiting pipe diameter that can be coupled with the pump assemblies.

**Heel Pump**

| | |
|---|---|
| Total Flow | 2 - 5 gpm |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centipoise |

| | |
|---|---|
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$F |
| Discharge Pressure | 230 maximum* |
| Flammable Gas Controls or equivalent)** | Ignition Source Control Set #1 (Class 1 Division 1 GroupB |
| Dilution water Flow | None Required |

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

*Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

**Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**Dorsh, Paul M**

**From:** Reberger, Dan W
**Sent:** Tuesday, February 08, 2000 4:09 PM
**To:** Dorsh, Paul M
**Subject:** RE: Annulus Pump Flow Rates

I'm reducing it to 40 to 140 as a range, and documenting it in a letter, which I hope to get to you soon.

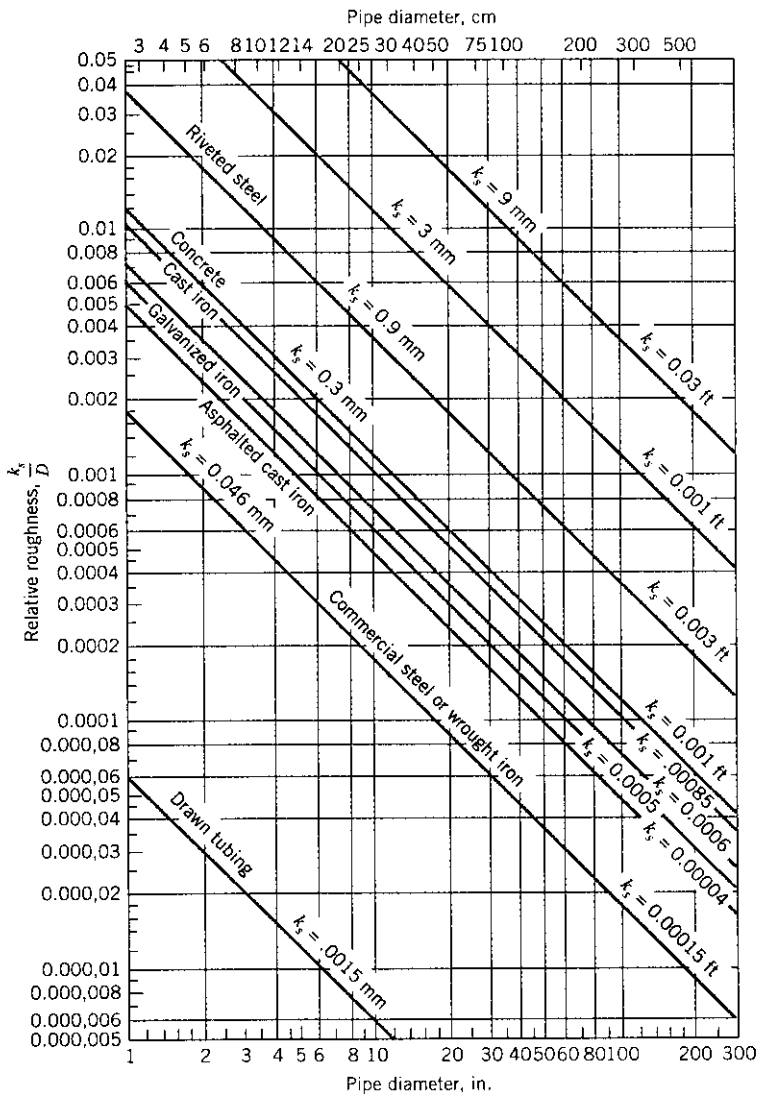
-----Original Message-----
**From:** Dorsh, Paul M
**Sent:** Tuesday, February 08, 2000 1:00 PM
**To:** Reberger, Dan W
**Subject:** Annulus Pump Flow Rates

Dan,

I was "officially" updating the line loss calculation for the DST Annulus Pumps. The latest Design Criteria e-mail I have from you considers flow rates from 50 - 300 GPM. I know some talk has been made about lowering the flow rate to 40 GPM or lower. Has the flow rate criteria changed or is 50 GPM still the number?

**Paul Dorsh**
**Fluor Federal Services**
**372-0289**

RE 10.9
tive roughness for
us kinds of pipe.
f Moody (29).
nted with
nission from the
M.E.]



Colebrook–White formula, from which the Moody diagram was developed, Swamee and Jain (39) developed explicit formulas relating $f$, $h_f$, $Q$, and $D$. It is reported that their formulas yield results that deviate no more than 3% from those obtained from the Moody diagram for the following ranges of $k_s/D$ and Re: $10^{-5} < k_s/D < 2 \times 10^{-2}$ and $4 \times 10^3 < \text{Re} < 10^8$. The formulas for $f$ and $Q$ are

$$f = \frac{0.25}{\left[\log\left(\frac{k_s}{3.7D} + \frac{5.74}{\text{Re}^{0.9}}\right)\right]^2} \tag{10.26}$$

$$Q = -2.22D^{5/2}\sqrt{gh_f/L}\,\log\left(\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2}\sqrt{gh_f/L}}\right) \tag{10.27}$$

They also developed a formula for the explicit determination of $D$. A modified version of that formula, given by Streeter and Wylie (38), is

$$D = 0.66\left[k_s^{1.25}\left(\frac{LQ^2}{gh_f}\right)^{4.75} + \nu Q^{9.4}\left(\frac{L}{gh_f}\right)^{5.2}\right]^{0.04} \tag{10.28}$$

If you want to solve for head loss given $Q$, $L$, $D$, $k_s$, and $\nu$, simply solve for $f$ by Eq. (10.26) and compute $h_f$ with the Darcy–Weisbach equation, Eq. (10.22). Straightforward calculations for $Q$ and $D$ can also be made if $h_f$ is known. However, for problems involving head losses in addition to $h_f$, an iterative solution is required. For computing $Q$, you can assume an $f$ and solve for $Q$ from the energy equation after substituting $Q/A$ in that equation. Then compute Re and use the result in Eq. (10.26) to get a better estimate of $f$, and so on, until $Q$ converges analogous to the procedure for determining $Q$ using the Moody diagram. In this case, however, Eq. (10.26) is substituted for the Moody diagram. Similarly, you can determine $D$ if you are given $Q$, $\nu$, the change in pressure or head, and the geometric configuration.

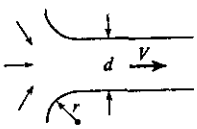
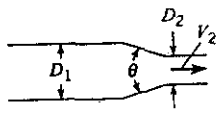
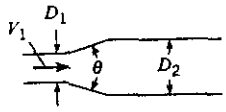
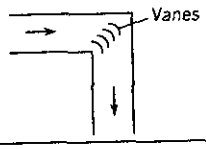
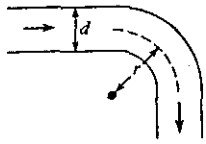
**EXAMPLE 10.8** Solve Example 10.5 using Eq. (10.27).

***Solution*** From Fig. 10.8, $k_s$ for asphalted cast-iron pipe is given as $1.2 \times 10^{-4}$ m. From the given conditions, $h_f/L = 0.0122$. Assume $T = 20°\text{C}$, so $\nu = 10^{-6}$ m²/s. Then, using Eq. (10.27), we have

$$Q = -2.22(0.20\text{ m})^{5/2}\sqrt{9.81\text{ m/s}^2 \times 0.0122} \times \log\left(\frac{1.2 \times 10^{-4}\text{ m}}{3.7 \times 0.20\text{ m}} + \frac{1.78 \times 10^{-6}\text{ m}^2/\text{s}}{(0.20\text{ m})^{3/2}\sqrt{9.81\text{ m/s}^2 \times 0.0122}}\right)$$

$$= 0.050\text{ m}^3/\text{s}$$

TABLE 10.2 LOSS COEFFICIENTS FOR VARIOUS TRANSITIONS AND FITTINGS

| Description | Sketch | Additional Data | K | Source |
|---|---|---|---|---|
| Pipe entrance<br>$h_L = K_e V^2/2g$ |  | $r/d$<br>0.0<br>0.1<br>>0.2 | $K_e$<br>0.50<br>0.12<br>0.03 | (2)* |
| Contraction<br>$h_L = K_C V_2^2/2g$ |  | $D_2/D_1$<br>0.0<br>0.20<br>0.40<br>0.60<br>0.80<br>0.90 | $K_C$ $\theta = 60°$<br>0.08<br>0.08<br>0.07<br>0.06<br>0.06<br>0.06 | $K_C$ $\theta = 180°$<br>0.50<br>0.49<br>0.42<br>0.27<br>0.20<br>0.10 | (2) |
| Expansion<br>$h_L = K_E V_1^2/2g$ |  | $D_1/D_2$<br>0.0<br>0.20<br>0.40<br>0.60<br>0.80 | $K_E$ $\theta = 20°$<br><br>0.30<br>0.25<br>0.15<br>0.10 | $K_E$ $\theta = 180°$<br>1.00<br>0.87<br>0.70<br>0.41<br>0.15 | (2) |
| 90° miter bend |  | Without vanes | $K_b = 1.1$ | (37) |
| | | With vanes | $K_b = 0.2$ | (37) |
| 90° smooth bend |  | $r/d$<br>1<br>2<br>4<br>6<br>8<br>10 | <br>$K_b = 0.35$<br>0.19<br>0.16<br>0.21<br>0.28<br>0.32 | (5) and (19) |
| Threaded pipe fittings | Globe valve—wide open<br>Angle valve—wide open<br>Gate valve—wide open<br>Gate valve—half open<br>Return bend<br>Tee<br>straight-through flow<br>side-outlet flow<br>90° elbow<br>45° elbow | $K_v = 10.0$<br>$K_v = 5.0$<br>$K_v = 0.2$<br>$K_v = 5.6$<br>$K_b = 2.2$<br><br>$K_t = 0.4$<br>$K_t = 1.8$<br>$K_b = 0.9$<br>$K_b = 0.4$ | | (37) |

*Reprinted by permission of the American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, Georgia, from the 1981 ASHRAE Handbook-Fundamentals.

| $D_2/D_1$ | $K_C$ $\theta = 180°$ |
|---|---|
| 2/3 | ≈ 0.35 |

| $D_1/D_2$ | $K_E$ $\theta = 180°$ |
|---|---|
| 2/3 | ≈ 0.25 |

RPP-6485 Rev 0



TABLE A.5 APPROXIMATE PHYSICAL PROPERTIES OF WATER* AT ATMOSPHERIC PRESSURE

| Temperature | Density | Specific weight | Dynamic viscosity | Kinematic viscosity | Vapor pressure |
|---|---|---|---|---|---|
| | kg/m³ | N/m³ | N • s/m² | m²/s | N/m² abs. |
| 0°C | 1000 | 9810 | $1.79 \times 10^{-3}$ | $1.79 \times 10^{-6}$ | 611 |
| 5°C | 1000 | 9810 | $1.51 \times 10^{-3}$ | $1.51 \times 10^{-6}$ | 872 |
| 10°C | 1000 | 9810 | $1.31 \times 10^{-3}$ | $1.31 \times 10^{-6}$ | 1230 |
| 15°C | 999 | 9800 | $1.14 \times 10^{-3}$ | $1.14 \times 10^{-6}$ | 1700 |
| 20°C | 998 | 9790 | $1.00 \times 10^{-3}$ | $1.00 \times 10^{-6}$ | 2340 |
| 25°C | 997 | 9781 | $8.91 \times 10^{-4}$ | $8.94 \times 10^{-7}$ | 3170 |
| 30°C | 996 | 9771 | $7.97 \times 10^{-4}$ | $8.00 \times 10^{-7}$ | 4250 |
| 35°C | 994 | 9751 | $7.20 \times 10^{-4}$ | $7.24 \times 10^{-7}$ | 5630 |
| 40°C | 992 | 9732 | $6.53 \times 10^{-4}$ | $6.58 \times 10^{-7}$ | 7380 |
| 50°C | 988 | 9693 | $5.47 \times 10^{-4}$ | $5.53 \times 10^{-7}$ | 12,300 |
| 60°C | 983 | 9643 | $4.66 \times 10^{-4}$ | $4.74 \times 10^{-7}$ | 20,000 |
| 70°C | 978 | 9594 | $4.04 \times 10^{-4}$ | $4.13 \times 10^{-7}$ | 31,200 |
| 80°C | 972 | 9535 | $3.54 \times 10^{-4}$ | $3.64 \times 10^{-7}$ | 47,400 |
| 90°C | 965 | 9467 | $3.15 \times 10^{-4}$ | $3.26 \times 10^{-7}$ | 70,100 |
| 100°C | 958 | 9398 | $2.82 \times 10^{-4}$ | $2.94 \times 10^{-7}$ | 101,300 |
| | slugs/ft³ | lbf/ft³ | lbf-s/ft² | ft²/s | psia |
| 40°F | 1.94 | 62.43 | $3.23 \times 10^{-5}$ | $1.66 \times 10^{-5}$ | 0.122 |
| 50°F | 1.94 | 62.40 | $2.73 \times 10^{-5}$ | $1.41 \times 10^{-5}$ | 0.178 |
| 60°F | 1.94 | 62.37 | $2.36 \times 10^{-5}$ | $1.22 \times 10^{-5}$ | 0.256 |
| 70°F | 1.94 | 62.30 | $2.05 \times 10^{-5}$ | $1.06 \times 10^{-5}$ | 0.363 |
| 80°F | 1.93 | 62.22 | $1.80 \times 10^{-5}$ | $0.930 \times 10^{-5}$ | 0.506 |
| 100°F | 1.93 | 62.00 | $1.42 \times 10^{-5}$ | $0.739 \times 10^{-5}$ | 0.949 |
| 120°F | 1.92 | 61.72 | $1.17 \times 10^{-5}$ | $0.609 \times 10^{-5}$ | 1.69 |
| 140°F | 1.91 | 61.38 | $0.981 \times 10^{-5}$ | $0.514 \times 10^{-5}$ | 2.89 |
| 160°F | 1.90 | 61.00 | $0.838 \times 10^{-5}$ | $0.442 \times 10^{-5}$ | 4.74 |
| 180°F | 1.88 | 60.58 | $0.726 \times 10^{-5}$ | $0.385 \times 10^{-5}$ | 7.51 |
| 200°F | 1.87 | 60.12 | $0.637 \times 10^{-5}$ | $0.341 \times 10^{-5}$ | 11.53 |
| 212°F | 1.86 | 59.83 | $0.593 \times 10^{-5}$ | $0.319 \times 10^{-5}$ | 14.70 |

*Notes: (1) Bulk modulus $E_v$ of water is approximately 2.2 G $P_a$ ($3.2 \times 10^5$ psi); (2) Water–air surface tension is approximately $7.3 \times 10^{-2}$ N/m ($5 \times 10^{-3}$ lbf/ft) from 10°C to 50°C.

SOURCE: Reprinted with permission from R. E. Bolz and G. L. Tuve, *Handbook of Tables for Applied Engineering Science*, CRC Press, Inc., Cleveland, 1973. Copyright 1973 by The Chemical Rubber Co., CRC Press, Inc.

## $C_V$ Factors for SP Series Valves

$C_V$ is defined as the number of U.S. gallons per minute, of ambient temperature water, that will flow through a valve at 1 psi pressure drop.

| SP 30-40 Series | | | |
|---|---|---|---|
| Size Code | Pipe Size | Port Diameter | $C_V$ |
| SP-32 | 1/2" | 0.62 | 20 |
| SP-33 | 3/4" | 0.81 | 36 |
| SP-34 | 1" | 1.00 | 58 |
| SP-35 | 1-1/4" | 1.25 | 100 |
| SP-36 | 1-1/2" | 1.50 | 160 |
| SP-37 | 2" | 1.94 | 300 |
| SP-38 | 2-1/2" | 2.50 | 540 |
| SP-39 | 3" | 2.75 | 625 |
| SP-40 | 4" | 3.50 | 675 |
| SP-42 | 6" | 5.25 | 1950 |
| SP-44 | 8" | 6.25 | 2150 |

| SI 70-80 Series | | | |
|---|---|---|---|
| Size Code | Pipe Size | True-Bore Port Diameter | $C_V$ |
| SI-72 | 1/2" | 0.37 | 8 |
| SI-73 | 3/4" | 0.62 | 29 |
| SI-74 | 1" | 0.87 | 66 |
| SI-76 | 1-1/2" | 1.37 | 192 |
| SI-77 | 2" | 1.87 | 434 |
| SI-78 | 2-1/2" | 2.37 | 723 |
| SI-79 | 3" | 2.87 | 1124 |
| SI-80 | 4" | 3.83 | 2100 |
| SI-82 | 6" | 5.83 | 4500 |

## Vacuum and Cycle Tests for SP Series Valves

### Vacuum Performance

PBM valves excel under vacuum conditions as well as under pressure conditions. Typical test results showing helium leakage at $10^{-8}$ Torr are provided.

| Typical Vacuum Test Results | | | | |
|---|---|---|---|---|
| Valve Size | PBM Code | | Body Leakage (cc/sec.) | Seat Leakage (cc/sec.) |
| | SP Series | SI Series | | |
| 1" | SPH-34-F152 | SBH-74-TT3 | $7 \times 10^{-8}$ | $6 \times 10^{-8}$ |
| 2" | SPH-37-F152 | SBH-77-TT3 | $3 \times 10^{-7}$ | $1 \times 10^{-7}$ |
| 4" | SPH-40-F152 | SBH-80-TT3 | $2 \times 10^{-6}$ | $8 \times 10^{-8}$ |

### Cycle Testing

The life of a ball valve is dependent upon service conditions, and therefore impossible to predict. However, PBM cycle-tests valves using 100 psid of ambient temperature water pressure across the seats with the valve in the closed position. These test conditions represent a typical wear-causing force on the seats and packings. PBM also tests valves in a steam environment up to 380°F.

Replacement of valve gaskets or O rings is recommended at each disassembly. Replacement of other non-moving parts would only be dictated by the corrosion or erosion caused by the flow media. In most applications, PBM ball valves will operate trouble-free for many years.

## $C_V$ FACTORS — MP/MI 70-80 SERIES

$C_V$ is defined as the number of U.S. gallons of water per minute of ambient temperature water that will flow through a valve at 1 psi pressure drop.

### MP 70-80 SERIES $C_V$ FACTORS (MEASURED IN GPM)

| Valve Code | Pipe Size | Port Diameter | 45° Port | 45° Port Through | 45° Port Bracket | 45° Port Side Entry | 45° Port Bottom Entry | 45° Port Through | 45° Port Bracket |
|---|---|---|---|---|---|---|---|---|---|
| MP-72 | 1/2" | .62" | 12[2] | 14[2] | 9[2] | 12[2] | 12[2] | 14[2] | 9[2] |
| MP-73 | 3/4" | .75" | 12[2] | 14[2] | 9[2] | 12[2] | 12[2] | 14[2] | 9[2] |
| MP-74 | 1" | 1.00" | 33 | 38 | 24 | 29 | 33 | 38 | 24 |
| MP-75 | 1-1/4" | 1.00" | 32[2] | 36[2] | 24[2] | 27[2] | 31[2] | 36[2] | 24[2] |
| MP-76 | 1-1/2" | 1.50" | 78 | 93 | 58 | 67 | 78 | 93 | 58 |
| MP-77 | 2" | 2.00" | 148 | 176 | 108 | 124 | 148 | 176 | 108 |
| MP-79 | 3" | 3.00" | 380 | 460 | 270 | 300 | 380 | 460 | 270 |
| MP-80 | 4" | 4.00" | 680 | 820 | 490 | 530 | 680 | 820 | 490 |
| MP-42 | 6" | 6.00" | 1541 | 1851 | 1111 | 1210 | 1541 | 1851 | 1111 |

**NOTES:**

1. Most values represent MP Series valves with 150# flanged end fittings.
2. MP Series valves with Female NPT end fittings.
3. Flanged end fittings are not available for MP 75 (1-1/4").
4. 1-1/4" and double angle port are not full-port design.

### MI 70-80 SERIES $C_V$ FACTORS (MEASURED IN GPM)

| Valve Code | Pipe Size | Port Diameter | 45° Port | 45° Port Through | 45° Port Bracket | 45° Port Side Entry | 45° Port Bottom Entry | 45° Port Through | 45° Port Bracket |
|---|---|---|---|---|---|---|---|---|---|
| MI-72 | 1/2" | 0.37" | 3.5 | 5.3 | 3.0 | 3.5 | 2.9 | 3.7 | 2.6 |
| MI-73 | 3/4" | 0.62" | 11 | 16 | 9.2 | 11 | 8.8 | 11 | 8.0 |
| MI-74 | 1" | 0.87" | 22 | 33 | 16 | 22 | 18 | 23 | 17 |
| MI-76 | 1-1/2" | 1.37" | 56 | 85 | 49 | 56 | 47 | 60 | 42 |
| MI-77 | 2" | 1.87" | 110 | 160 | 93 | 110 | 90 | 110 | 79 |
| MI-79 | 3" | 2.87" | 270 | 410 | 240 | 270 | 230 | 290 | 210 |
| MI-80 | 4" | 3.83" | 500 | 760 | 440 | 500 | 420 | 540 | 380 |
| MI-42 | 6" | Consult PBM | | | | | | | |

**NOTES:**

1. 6" and double angle port are not True-Bore design.

## VACUUM AND CYCLE TESTS — MP/MI 70-80 SERIES

### Vacuum Testing

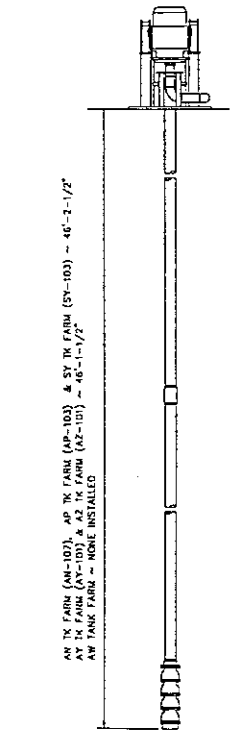
PBM valves excel under vacuum conditions as well as under pressure conditions. Typical test results showing helium leakage at $10^{-5}$ Torr are provided.

| Vacuum Test Results | | | |
|---|---|---|---|
| **Valve Size** | **PBM Code** | **Body Leakage (cc/sec.)** | **Seat Leakage (cc/sec.)** |
| 2" | MPH-77-F152/POC1 | $1.8 \times 10^{-7}$ | $3.4 \times 10^{-7}$ |
| 2" | MIH-77-TT3/POC1 | $3 \times 10^{-7}$ | $1 \times 10^{-7}$ |

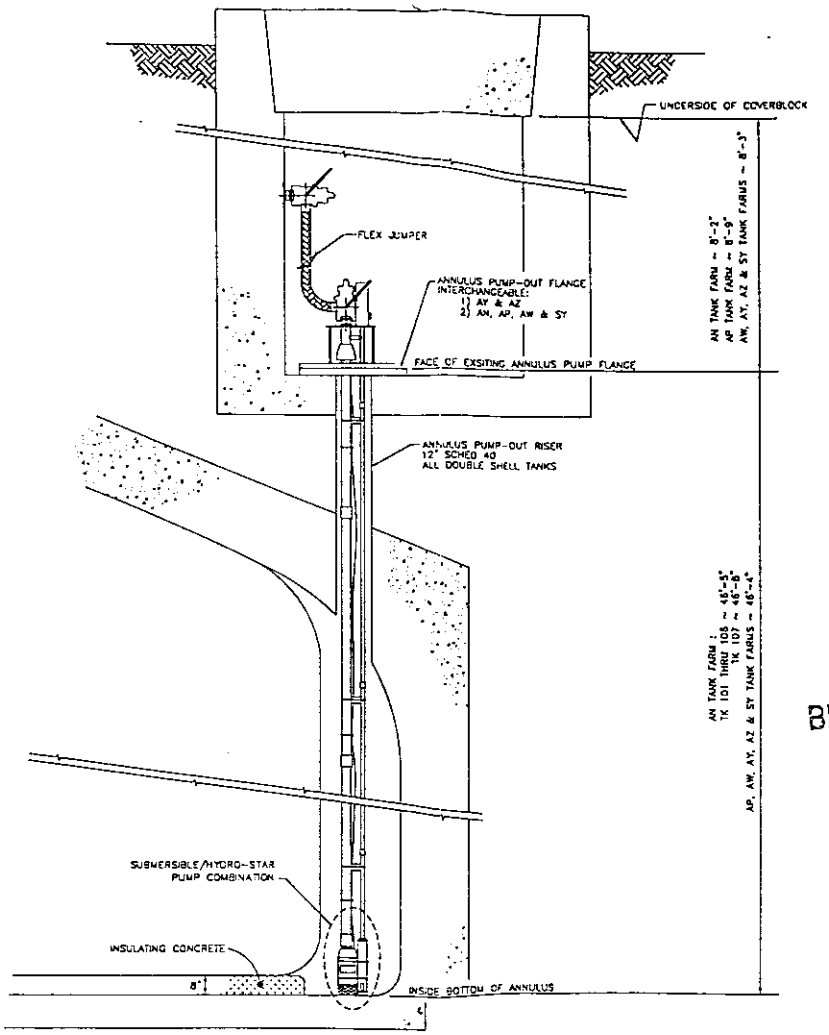
### Cycle Testing

The life of a ball valve is dependent upon service conditions and, therefore, impossible to predict. However, PBM cycle-tests valves using 100 psid of ambient temperature water pressure across the seats with the valve in the closed position. These test conditions represent a typical wear-causing force on the seats and packings. PBM also tests valves in a steam environment up to 380°F.

Replacement of valve gaskets or O-rings is recommended at each disassembly. Replacement of other non-moving parts is dictated only by the corrosion caused by the flow media. In most applications, PBM ball valves will operate trouble-free for many years.




EXISTING ANNULUS PUMP




TYPICAL DOUBLE SHELL TANK ANNULUS

40-50 GPM
1.3 SG
140°F

BEST AVAILABLE COPY

| NO. | DATE | CLASS REV. | REVISIONS | DWN | DES | DWG | NO. | SUB | REC | APP |
|---|---|---|---|---|---|---|---|---|---|---|

ARES CORPORATION — Applied Research & Engineering Sciences

DOUBLE SHELL TANK
ANNULUS PUMPING DATA

DRAWN
DESIGN
CHECKED
RELEASED
DATE

SUBMITTED — APPROVED FOR RELEASE

LOCKHEED MARTIN
LOCKHEED MARTIN HANFORD CORP.

SHEET 1 OF

CLASSIFICATION — REVIEWER — DATE/DATE

PROJECT ID — DRAWING NO. — REV. A

SCALE — FILE/

RPP-6485 Rev. 0

Calc No: DSTAP-P-001, Rev. 0
Ref. 7 A16 of A18

182

**Title – Statement of Work for Annulus Pumping**
**Contract 4975 – Fluor Daniel Northwest**
**Revision Number - 0**
**Date – December 9, 1999**

**Objective:**
This task order is to authorize Fluor Daniel Northwest to provide engineering support for identifying, supporting procurement, testing, and final design of a pump assembly for waste removal in the Double-Shell Tank Annulus.

**Background/Introduction:**
The objective is to provide a combination of two pumps capable of high flow removal of waste for the DST Annulus, and removal of the heel to the extent possible. The pumping scheme should follow that addressed in an ARES Report Number 9905303-001, March 1999, "Double-Shell Tank Annulus Pumping Alternative Evaluation" unless changed with LMHC concurrence. A spare pumping system will also be procured. These activities support Tasks 19DAPB " Prepare Procurement Specification & Procure Pump" and 19DAPC "Design, Procure, Fabricate, Receive & Store Jumpers & Pump Assemblies" of the schedule attached to correspondence LMHC-9954506R2 October 25, 1999.

**Scope:**
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:

Task 19DAPB
1. Review of piping system and prepare preliminary design (6 DST Farms transferring to 106-AP)
2. Prepare procurement specification for pumps
3. Support procurement activities
4. Evaluate bids, and select vendor
5. Prepare acceptance test procedure
6. Evaluate run-in data for the tested pumps
7. Develop Certified Vendor Information File

4/11/00

Task 19DAPC
8. Final design of pump assemblies and farm specific flanges
9. Fabrication support of pump assemblies
10. Identification of common spare jumper parts
11. Prepare spare parts list

6/2/00

**References:**
Piping pressure drop calculations for the Cross-site transfer route to AP Tank Farm have been documented in Project W-058 files in calculation numbers W058-P-044 and 048. Schematics with transfer line lengths have been developed for most tank farm routings to AP farm and can be found in the Emergency Transfer procedures TO-001-181, 182, 183, 184 and TO-430-500 as excavation schematics.

**Deliverables:**
Design drawings, procurement specification, acceptance test procedure all prepared in accordance with LMHC approved procedures.

**Acceptance Criteria:**
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

**Period of Performance:**
Activities associated with this SOW are expected to be initiated as soon as possible after receipt of the Task Order, with completion on or before April 11, 2000 for Task 19DAPB and June 2, 2000 for Task 19DAPC.

**Technical Point of Contact:**
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering
- Administrative Contact: A. B. Johnson, L.K. Martin LMHC, Financial Control
- Project Engineer: S. J. Lepka, LMHC, Operational Configuration Management.

**Applicable ES&H requirements:**
Standard ES&H requirements (without ISMS) are warranted for this work.

**Safety Requirements:**
N/A

**Requirements (Including Quality Assurance Requirements):**
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), *Quality Assurance Requirements*, and the enforcement actions under 10 CFR 820, *General Statement of Enforcement Policy.*

**Hold Points:**
N/A

**Configuration Management Requirements:**
N/A

**Work Location/Potential Access Requirements:**
N/A

**Training:**
N/A

**Qualifications:**
Degreed Engineering support as required.

**Special Requirements:**
N/A

**Reporting/Administration:**
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.

RPP-6485 Rev. 0



**Hauck, Frank M (Marshall)**

**From:** Reberger, Dan W
**Sent:** Friday, December 17, 1999 12:53 PM
**To:** Rarig, Bradley K
**Cc:** Hauck, Frank M (Marshall); Baide, Daniel G (Dan); Lepka, Stanley J (Stan)
**Subject:** Design Procedures and Criteria for Annulus Pumping

The design of any jumper or pump piping assembly for annulus pumping, is expected to have Design Pressure, Thermal Expansion, Sustained and Seismic load calculations performed and documented. The calculation documentation should be issued as a Supporting Document. The preferred material for the pump assembly is stainless steel. All materials for trailer racks and instrument skids can be carbon steel.

**Design Criteria:**
The design and analysis of jumper/pump piping shall be in accordance with the following criteria:
1. HNF-PRO-097, Rev-0 Engineering Design and Evaluation
2. WHC-SD-W236A-DA-002, Rev-0 Stress Analysis of Single port Jumper Connectors

**Design Codes & Standards:**
1. ASME Code B31.3a 1996 "Process Piping"
2. WHC-SD-RE-DGS-002 Rev -3 Jumper Design Standard

**Design Parameters:**

| | |
|---|---|
| 1. Design Pressure | 300 psig |
| 2. Design Temperature | 340° F |
| 3. Corrosion Allowance | 1.0 mils/yr. |
| 4. Waste Specific Gravity | 1.30 |
| 5. Classification | General Service |

UPDATED, SEE REF. 3

**This document was too large to scan as a single document. It has been divided into smaller sections.**

**Section 2 of 2**

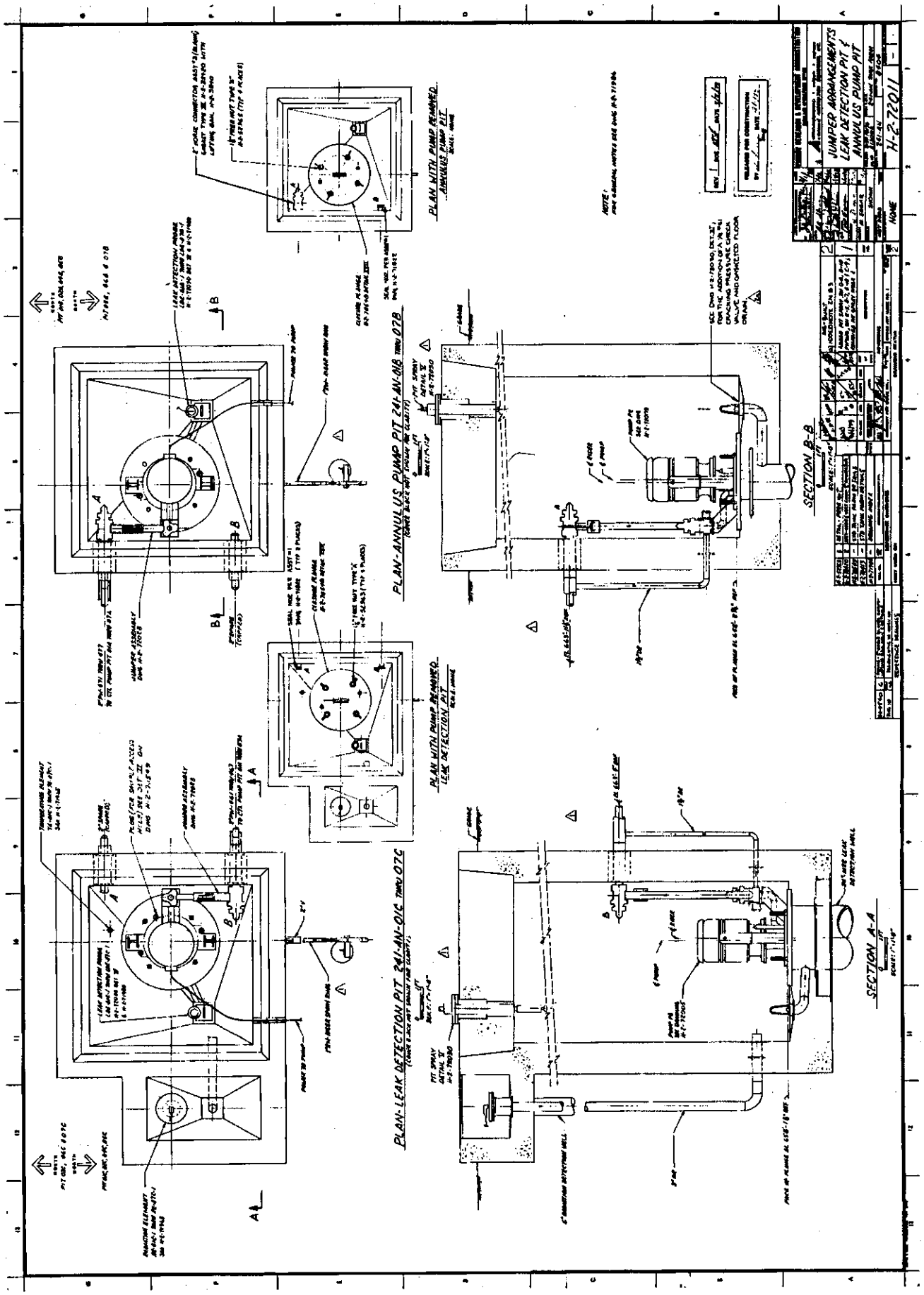
| Document Information | | | |
|---|---|---|---|
| **Document #** | **RPP-6485** | **Revision** | **0** |
| **Title** | TECHNICAL INFORMATION TO SUPPORT DST EMERGENCY ANNULUS PUMPING | | |
| **Date** | **09/14/2000** | | |
| **Originator** | **REBERGER DW** | **Originator Co.** | **CHG** |
| **Recipient** | | **Recipient Co.** | |
| **References** | | | |
| **Keywords** | | | |
| **Projects** | | | |
| **Other Information** | | | |

# APPENDIX B

# Referenced Drawings

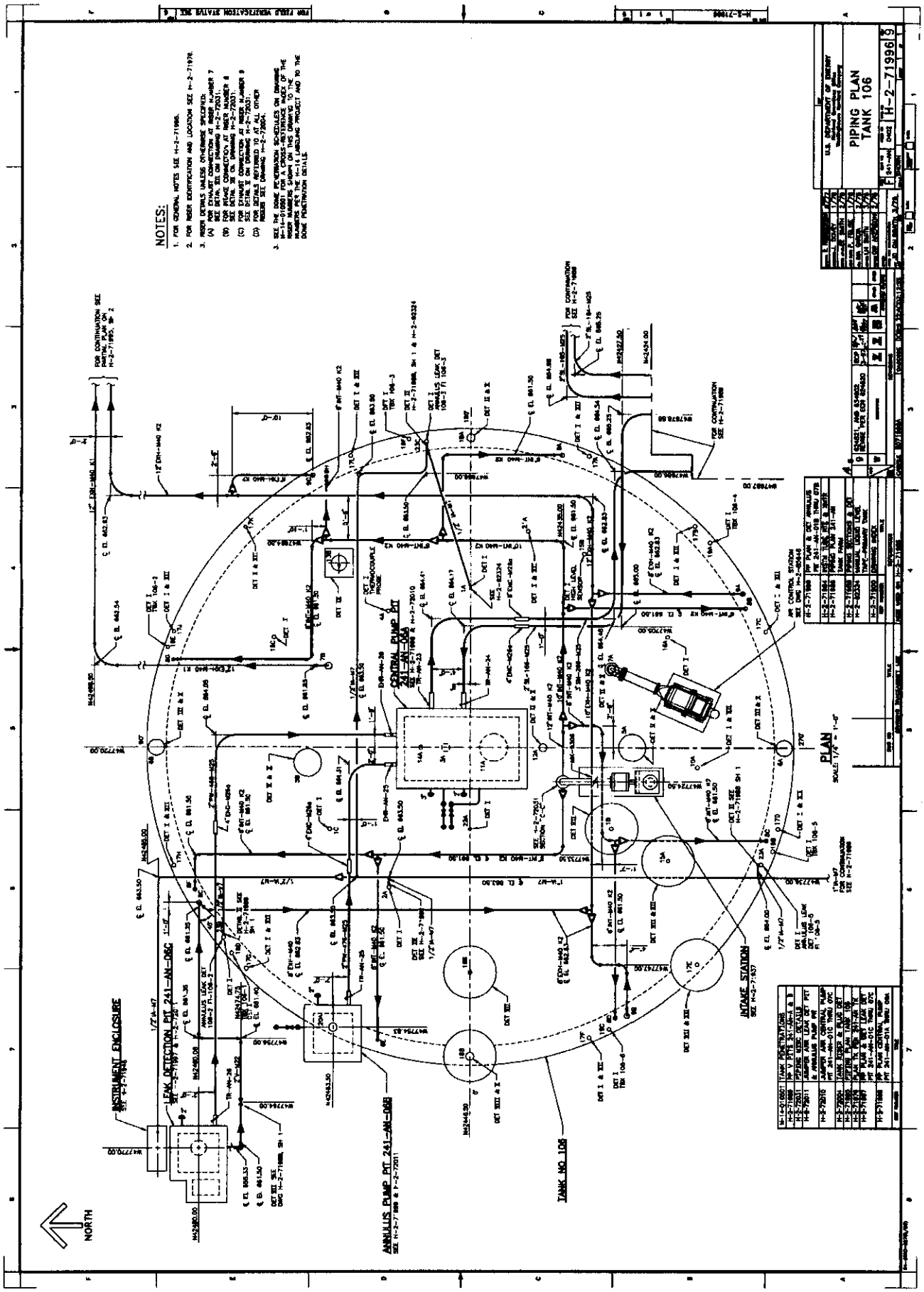
RPP-6485 Rev. 0

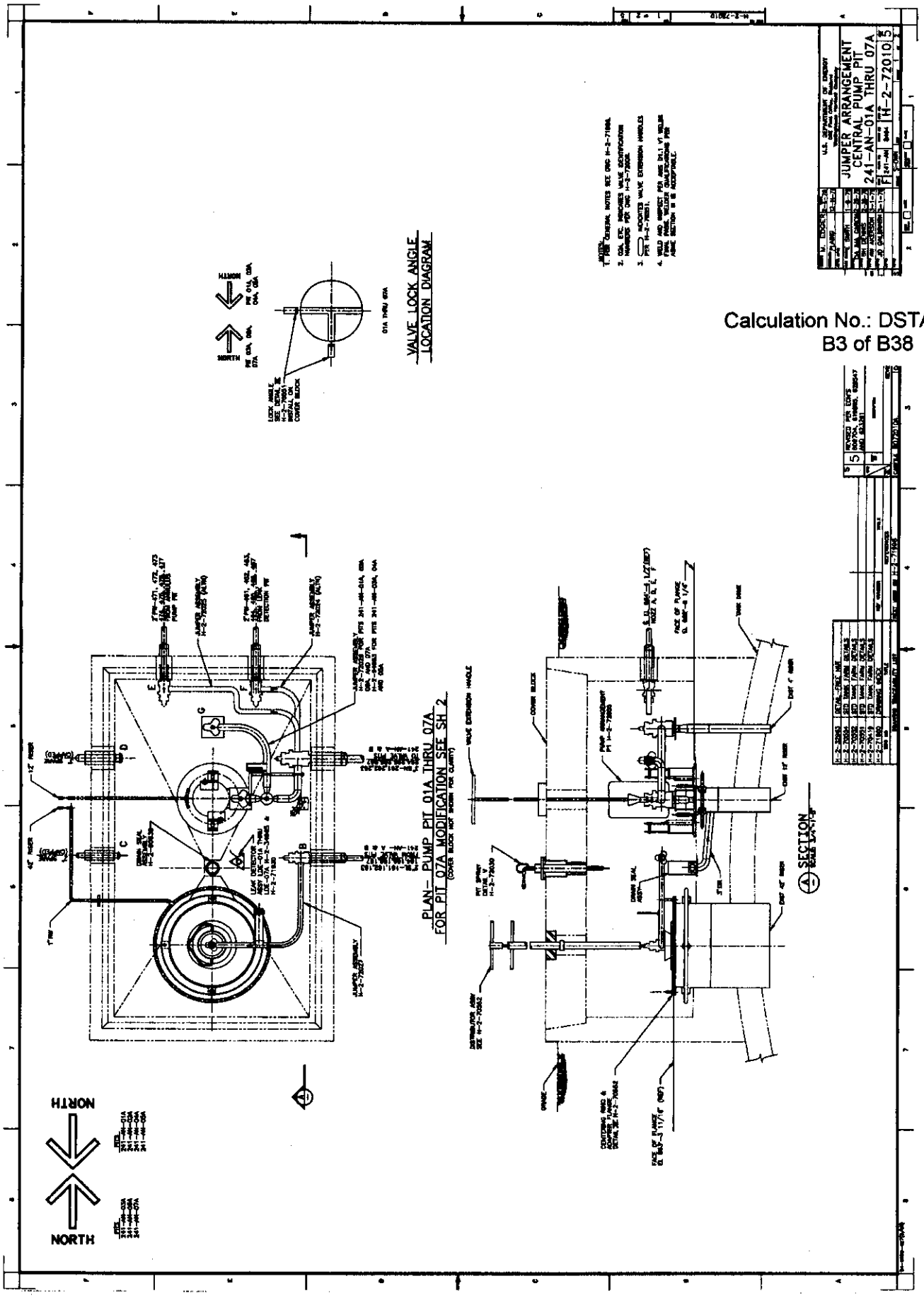




RPP-6485 Rev. 0

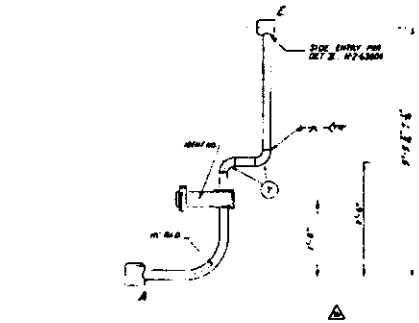




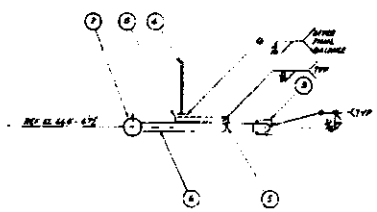



Calculation No.: DSTAP-P-001
B3 of B38

Rpp-6485 Rev. 0



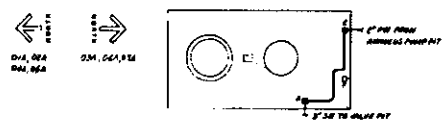

PLAN



ELEVATION

1 ASSEMBLY

SCALE: 1" = 1'-0"




KEY PLAN

SCALE: NONE

| REV. | PART NO. | DESCRIPTION | MATERIAL |
|---|---|---|---|
| X | 1 | ASSEMBLY | |
| 1 | 2 | 3" HOSE CONN ASSY #3 GASKET TYPE III | H-2-32430 |
| 1 | 3 | 2" HOSE CONN ASSY #1 GASKET TYPE III | H-2-32410 |
| 1 | 4 | LIFTING EAR | H-2-30777 |
| 1 | 5 | HANGAR ALL MATL ASTM A36 CS | H-2-63804 DET III |
| AR | 6 | 2" SCHED 80 PIPE | ASTM A53 TYPE S GR B CS |
| 1 | 7 | 2" SCHED 80 90° LR WELD ELBOW | ASTM A234 GR WPB CS |
| 1 | 8 | CS x S.S. x 1'-3" | ASTM A36 CS |

GENERAL NOTES

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH SHIPPED SPECIFICATION 9940-[illegible], SHEETS 1, 2. ALL SHOP WORK SHALL BE THE RESPONSIBILITY.
2. HYDROSTATIC TEST AT 200 PSIG.
3. FINAL AIR FABRICATION TOLERANCE TO BE 1/8", HANDLE RECEIVER FUNNELS TO BE LOCATED FRACTIONALLY 1/16".

RELEASED FOR CONSTRUCTION
BY [illegible] DATE [illegible]

| | | | |
|---|---|---|---|
| H-2-32010 | 0 | JUMPER HOSE C.D. PUMP PIT | |
| H-2-31140 | 0 | | |
| | | | |

NEXT USED ON H-2-72040

AS BUILT
CHANGED BOLTING, S/N 0-2
CHANGED ZINER
SEWR. CHANGED TOLERANCE

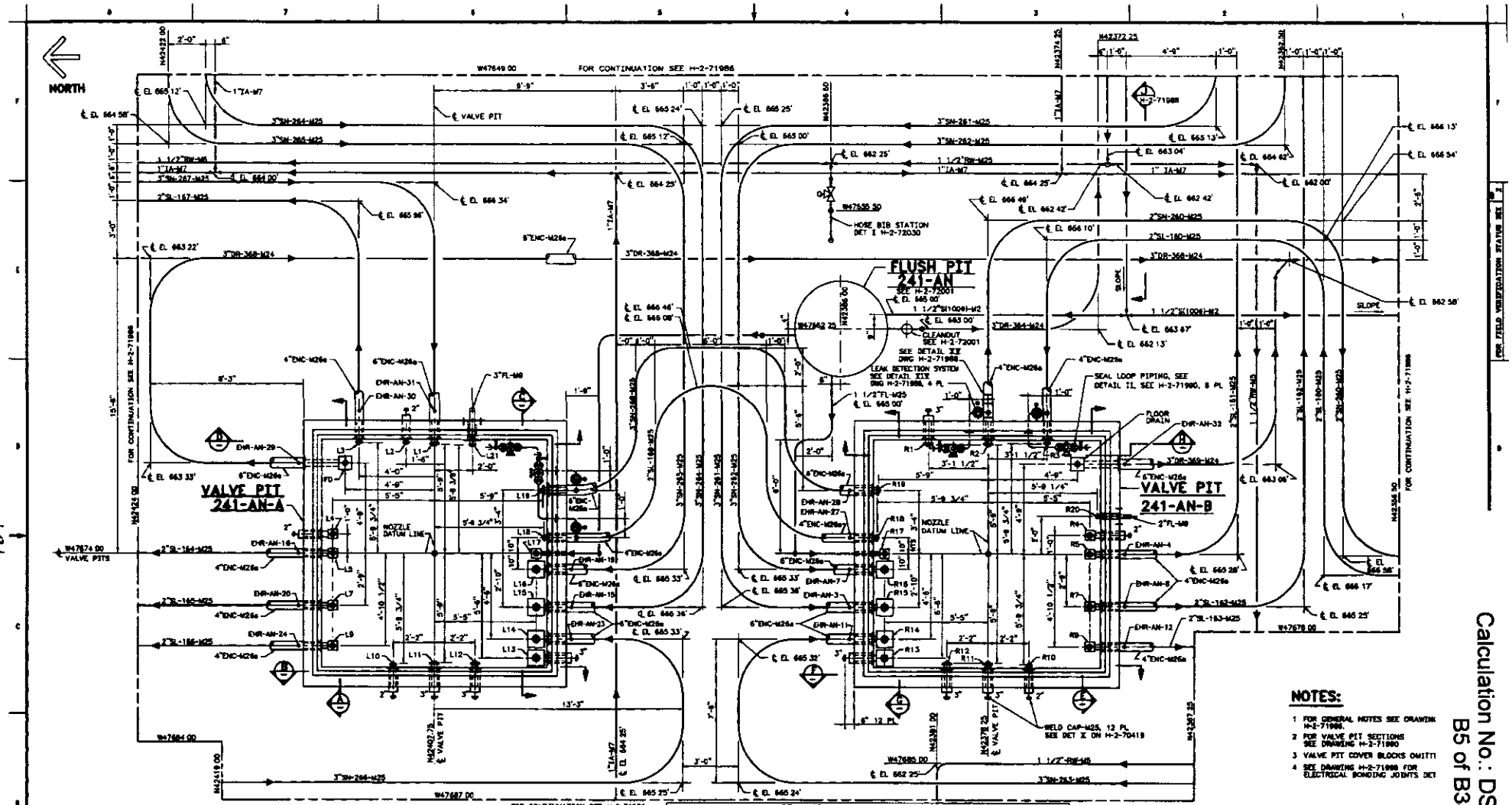
DOE/RL/RCA
[illegible]

CHEMICAL RESEARCH & DEVELOPMENT ADMINISTRATION
[illegible]

JUMPER ASSEMBLY
A TO E (ALTN)
CENTRAL PUMP PIT 241-AN-104 THRU 107

NONE

H-2-72025




## NOTES:

1. FOR GENERAL NOTES SEE DRAWING H-2-71986.
2. FOR VALVE PIT SECTIONS SEE DRAWING H-2-71990
3. VALVE PIT COVER BLOCKS OMITTED
4. SEE DRAWING H-2-71988 FOR ELECTRICAL BONDING JOINTS DET

## ENLARGED PLAN

SCALE 1/2"=1'-0"
SEE H-2-71986

### AS BUILT DATA

| VALVE PIT "A" | | | | VALVE PIT "B" | | | |
|---|---|---|---|---|---|---|---|
| NOZ | X | Y | Z | NOZ | X | Y | Z |
| L-1 | (-)68 63/64" | 0 0/64" | 666'-5 27/64" | R-1 | (-)69 0/64" | 37 31/64" | 666'-5 33/64" |
| L-2 | (-)68 48/64" | 18 4/64" | 666'-5 59/64" | R-2 | (-)68 3/64" | -0- | 666'-5 32/64" |
| L-3 | (-)68 45/64" | 46 3/64" | 666'-0 58/64" | R-3 | (-)68 47/64" | (-)37 30/64" | 666'-1 0/64" |
| L-4 | (-)12 1/64" | 64 61/64" | 665'-10 32/64" | R-4 | (-)12 3/64" | (-)65 3/64" | 665'-10 33/64" |
| L-5 | 0 3/64" | 64 61/64" | 665'-10 32/64" | R-5 | (-)0 2/64" | (-)65 3/64" | 665'-10 36/64" |
| L-7 | 33 0/64" | 65 0/64" | 665'-10 33/64" | R-7 | 32 62/64" | (-)65 2/64" | 665'-10 32/64" |
| L-9 | 58 32/64" | 65 2/64" | 665'-10 32/64" | R-9 | 58 32/64" | (-)64 63/64" | 665'-10 31/64" |
| L-10 | 69 46/64" | 25 2/64" | 666'-0 61/64" | R-10 | 69 46/64" | (-)26 7/64" | 666'-2 59/64" |
| L-11 | 68 62/64" | (-)0 1/64" | 666'-5 29/64" | R-11 | 68 63/64" | (-)0 4/64" | 666'-5 30/64" |
| L-12 | 68 62/64" | (-)26 2/64" | 666'-5 29/64" | R-12 | 69 3/64" | 25 63/64" | 666'-5 30/64" |
| L-13 | 65 56/64" | (-)65 0/64" | 666'-1 57/64" | R-13 | 65 3/64" | 65 5/64" | 666'-1 51/64" |
| L-14 | 53 60/64" | (-)65 2/64" | 666'-1 36/64" | R-14 | 54 2/64" | 64 62/64" | 666'-1 42/64" |
| L-15 | 33 61/64" | (-)65 3/64" | 666'-1 56/64" | R-15 | 34 0/64" | 65 2/64" | 666'-1 56/64" |
| L-16 | 10 0/64" | (-)65 14/64" | 666'-1 56/64" | R-16 | 10 2/64" | 65 3/64" | 666'-1 57/64" |
| L-17 | 0 1/64" | (-)64 62/64" | 666'-11 0/64" | R-17 | (-)0 2/64" | 65 0/64" | 666'-10 58/64" |
| L-18 | (-)8 63/64" | (-)67 52/64" | 666'-0 60/64" | R-18 | (-)8 58/64" | 68 48/64" | 666'-0 58/64" |
| L-19 | (-)38 61/64" | (-)67 6/64" | 666'-5 30/64" | R-19 | (-)38 60/64" | 68 61/64" | 666'-5 26/64" |
| L-21 | (-)66 23/64" | (-)24 0/64" | 667'-4 62/64" | R-20 | (-)24 6/64" | (-)69 17/64" | 666'-11 55/64" |

### VALVE PIT NOZZLE INSTALLATION DETAILS

| NOZZLE NO | CONN PIPE MATL | DET NO H-2-70419 | NOZZLE NO | CONN PIPE MATL | DET NO H-2-70419 |
|---|---|---|---|---|---|
| L-1 | M-25 | I | R-1 | M-25 ● | I |
| L-2 | M-25 ● | II | R-2 | M-25 | I |
| L-3 | M-25 | II | R-3 | M-25 | II |
| L-4 | M-25 ● | III | R-4 | M-25 ● | III |
| L-5 | M-25 | III | R-5 | M-25 | III |
| L-7 | M-25 | III | R-7 | M-25 | III |
| L-9 | M-25 | III | R-9 | M-25 | III |
| L-10 | M-25 ● | II | R-10 | M-25 ● | II |
| L-11 | M-25 ● | I | R-11 | M-25 ● | I |
| L-12 | M-25 ● | I | R-12 | M-25 ● | I |
| L-13 | M-25 ● | II | R-13 | M-25 ● | II |
| L-14 | M-25 | IV | R-14 | M-25 | IV |
| L-15 | M-25 | IV | R-15 | M-25 | IV |
| L-16 | M-25 | IV | R-16 | M-25 | IV |
| L-17 | M-25 | V | R-17 | M-25 | V |
| L-18 | M-25 | II | R-18 | M-25 | II |
| L-19 | M-25 | I | R-19 | M-25 | I |
| L-21 | M-9 | H-14-100974 | R-20 | M-9 | H-14-100974 |

● DENOTES WELD CAP ON SPARE NOZZLE AND SEE DET X ON DWG H-2-70419

| | |
|---|---|
| H-2-71986 | PIPING PLAN 241-AN TANK FARM |
| H-2-72030 | STD TK FARM DETAILS |
| H-2-72001 | PP PLAN & DET FL 241-AN |
| H-2-70419 | STD TK FARM DETAILS |
| H-2-71990 | PP SECT & DET VALVE PIT 241-AN-A & B |
| H-2-71988 | PP SECTIONS & DETAILS |

REF NUMBER | TITLE
REFERENCES

| | |
|---|---|
| H-2-71988 | PP PLAN & DET ANNULUS PIT 241-AN-01B THRU 07B |
| H-2-71986 | PP PLAN 241-AN TK FARM |
| H-2-71900 | DRAWING INDEX |

REF NUMBER | TITLE
REFERENCES

| REV | DESCRIPTION | APPD |
|---|---|---|
| 4 | 65400 & 65304 REVISION PER ECNs | |

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
Westinghouse Hanford Company

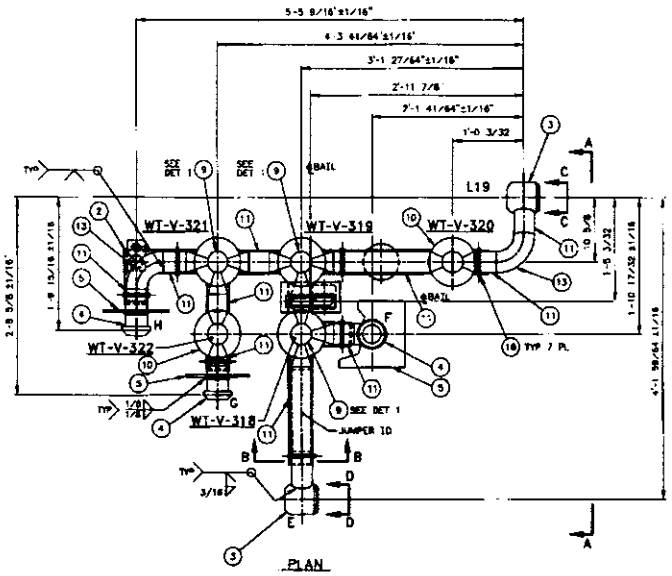
PIPING PLAN
VALVE PITS
241-AN-A & b

F | 241-AN | 0402 | H-2-71989 | 4

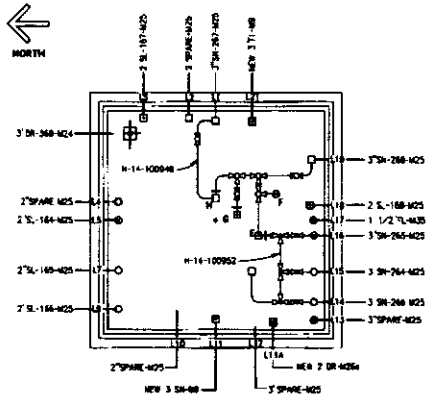
Calculation No.: DSTAP-P-001
B5 of B38

RPP-6485 Rev 0

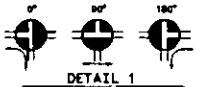
RPP-6483 Rev 0



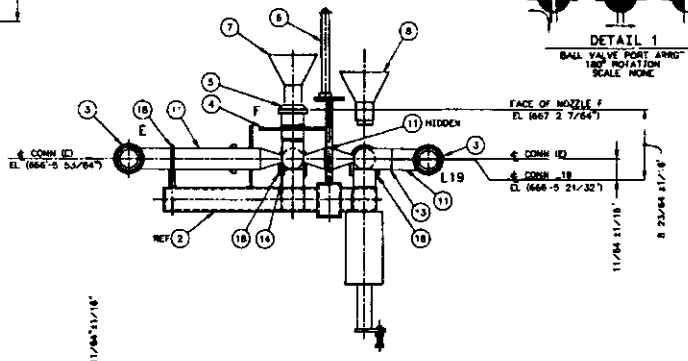

PLAN



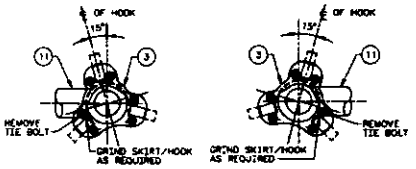

KEY PLAN
VALVE PIT 241-AN-A
SCALE NONE




DETAIL 1
BALL VALVE PORT ARRG
180° ROTATION
SCALE NONE

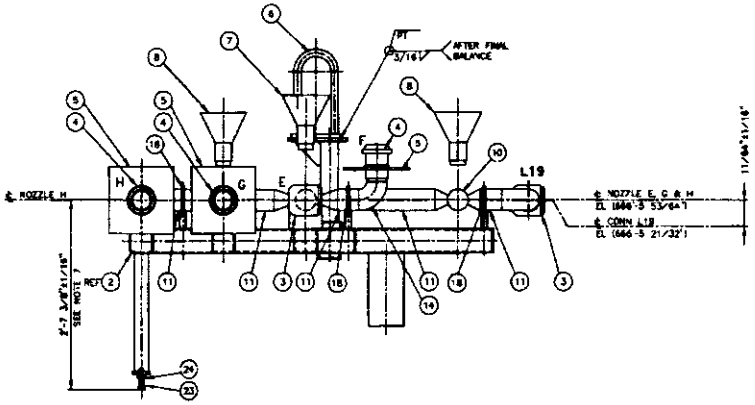



VIEW A-A
SCALE 1 1/2"=1'-0"



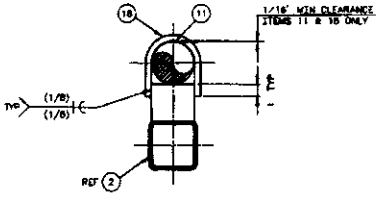

VIEW C-C
SCALE NONE

VIEW D-D
SCALE NONE




ELEVATION

1 ASSEMBLY
SCALE 1 1/2"=1'-0"




SECTION B-B
SCALE 3"=1'-0

## PARTS/MATERIAL LIST

| QTY REQD -020 | QTY REQD -010 | PART/DASH NUMBER | NOMENCLATURE/DESCRIPTION | MATERIAL/REFERENCE | SHT | ITEM NO |
|---|---|---|---|---|---|---|
| | X | -010 | ASSEMBLY | | 1 | 1 |
| X | 1 | -020 | SUB-ASSEMBLY | | 1 | 2 |
| | 2 | H-2-32430-1 | CONNECTOR, HORIZ, 3" | GASKET, TYPE V | 1 | 3 |
| | 3 | H-2-80186-2 | MALE NOZZLE, 3" | | 1 | 4 |
| | 3 | H-2-30600-5 | STD SQUARE KICK-OFF PLATE, 3 | | 1 | 5 |
| | 1 | H-14-100973-010 | LIFTING BAIL | | 1 | 6 |
| | 3 | H-14-100971-010 | FUNNEL ASSY 3" 3-WAY | | 1 | 7 |
| | 2 | H-14-100971-030 | FUNNEL ASSY 3" 2-WAY | | 1 | 8 |
| | 3 | | BALL VALVE 3" 3-WAY | PRCMT SPEC W-314-P1 | 1 | 9 |
| | 2 | | BALL VALVE 3 2-WAY | PRCMT SPEC W-314-P1 | 1 | 10 |
| | AR | | PIPE, 3" SCHED 40S SEAMLESS | ASTM A312 TP 304L | 1 | 11 |
| AR | | | PIPE, 2" SCHED 40S SEAMLESS | ASTM A312 TP 304L | 2 | 12 |
| | 2 | | ELBOW, 3" 90° LR SCHED 40S, BTWLD | ASTM A403 WP-S 304L | 1 | 13 |
| | 1 | | ELBOW, 3" 90° SR SCHED 40S, BTWLD | ASTM A403 WP-S 304L | 1 | 14 |
| AR | | | TS, 4 X 4 X 25 WALL | ASTM A554 MT-304/304L | 2 | 15 |
| 7 | | | PLATE, 1/4" X 4 X 4 L | ASTM A240 TYPE 304/304L | 2 | 16 |
| 7 | | | PLATE, 4" X 3" W X 3 5/8"L | ASTM A240 TYPE 304/304L | 2 | 17 |
| | 7 | | BAR, 1/2"W X LENGTH AS REQD | ASTM A276 TYPE 304/304L | 2 | 18 |
| 1 | | | BAR, 6"W X 12"L | ASTM A276 TYPE 304/304L | 2 | 19 |
| 1 | | -C01 | GUSSET PLATE, 1/4" | ASTM A240 TYPE 304/304L | 2 | 20 |
| 1 | | | PLATE, 1/2" X 10" X 5" | ASTM A240 TYPE 304/304L | 2 | 21 |
| 1 | | | PLATE, 1/2" THK | ASTM A240 TYPE 304/304L | 2 | 22 |
| | 1 | | BOLT, HEX HD, 3/4"-10UNC-2A X 3"L | ASTM A193 GR B8 304 | 1 | 23 |
| | 1 | | NUT, HEX, 3/4-10UNC-2B | ASTM A194 GR 8F 303 | 1 | 24 |
| | 1 | | BAR, 1"W X 3" W X LENGTH AS REQD | ASTM A276 TYPE 304/304L | 2 | 25 |

## NOTES:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION W-314-C1, SECTION 15483, APPENDIX A
2. HYDROSTATIC TEST SHALL BE AT 600 PSIG
3. JUMPER WEIGHT IS APPROXIMATELY 1050 LBS
4. SEAL WELD ALL CREVICES ON STRUCTURAL SUPPORT STEEL
5. ALL CALCULATIONS REQUIRED TO SUPPORT JUMPER DESIGN, PIPE STRESS, BALANCING AND CRITICAL DIMENSIONS ARE IDENTIFIED BY CALCULATION PACKAGE NUMBERS W314-P-001, W314-P-003, AND W314-P-007
6. FINAL FABRICATION SHALL NOT BE COMPLETED UNTIL VERIFICATION OF VALVE PIT AS-BUILT DATA HAS BEEN PROVIDED
7. DIMENSION LISTED IS FOR INITIAL SHOP FABRICATION ONLY IF NECESSARY, ADJUSTMENTS CAN BE MADE AT INSTALLATION TO MEET EXISTING PIT CONDITIONS

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
FLUOR DANIEL HANFORD, INC.

JUMPER ASSEMBLY
241-AN-A
L19-(E-F-G&H)

H-14-100953

DRAWING TRACEABILITY LIST

| DWG NO | TITLE | REF NUMBER | TITLE |
|---|---|---|---|
| JUMPER ASSEMBLY L1-L19-D | H-14-100929 | DRAWING LIST | |
| VALVE PIT 241-AN-A | | | |

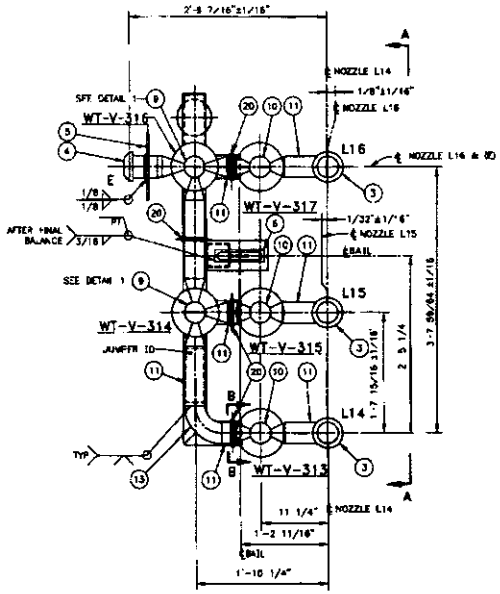
NEXT USED ON H-14-100844

REVISIONS

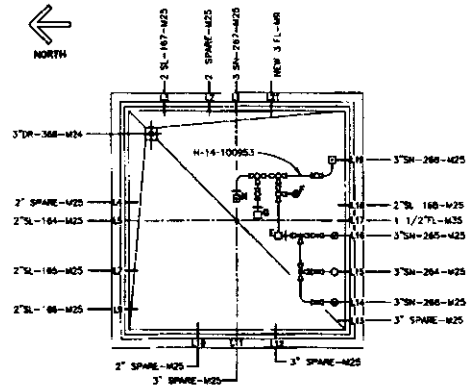
| REV | DESCRIPTION |
|---|---|
| 2 | W314 PROJECT DRAWING PER ECN W314-MC-012 INCORP ECN W314-MC-065 |
| 1 | & -035 SHIP VERIFIED AS BUILT INCORP ECN W314-MC-003, -018 |

2 PLOT SCALE 1=0

RPP-6485 Rev. 0

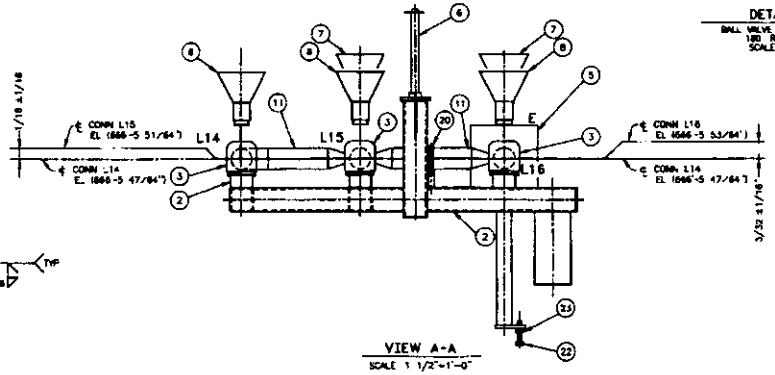



PLAN

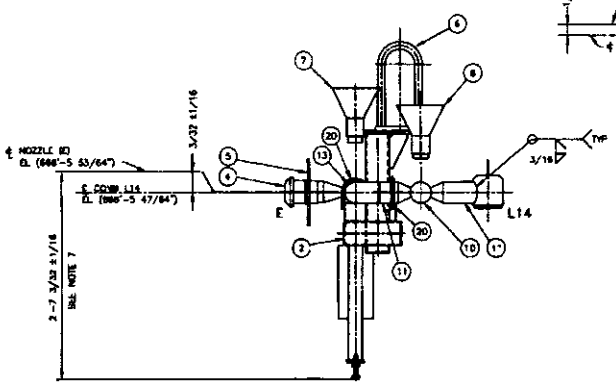



KEY PLAN
VALVE PIT 241-AN-A
SCALE NONE

DETAIL 1
BALL VALVE PORT ARRGT
180 ROTATION
SCALE NONE

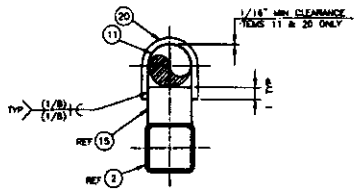



VIEW A-A
SCALE 1 1/2"=1'-0"




ELEVATION

1 ASSEMBLY
SCALE 1 1/2"=1'-0"




SECTION B-B
SCALE 3"=1'-0"

## PARTS/MATERIAL LIST

| QTY -020 | QTY -010 | PART/DASH NUMBER | NOMENCLATURE/DESCRIPTION | MATERIAL/REFERENCE | SHT | ITEM NO |
|---|---|---|---|---|---|---|
| | X | -010 | ASSEMBLY | | 1 | 1 |
| X | 1 | -020 | SUB ASSEMBLY | | 2 | 2 |
| | 3 | H-2-32430-2 | CONN, VERTICAL 3 | GASKET, TYPE V | 1 | 3 |
| | 1 | H-2-90186-2 | NOZZLE, MALE 3" | | 1 | 4 |
| | 1 | H-2-30600-5 | STD SQUARE KICK-OFF PLATE, 3" | | 1 | 5 |
| | 1 | H-14-100973-010 | LIFTING BAIL | | 1 | 6 |
| | 2 | H-14-100971-010 | FUNNEL ASSY 3" 3-WAY | | 1 | 7 |
| | 3 | H-14-100971-030 | FUNNEL ASSY 3" 2-WAY | | 1 | 8 |
| | 2 | | 3" BALL VALVE, 3-WAY CLASS 300 | SEE PROMT SPEC W-314-P1 | 1 | 9 |
| | 3 | | 3" BALL VALVE, 2-WAY CLASS 300 | SEE PROMT SPEC W-314-P1 | 1 | 10 |
| | AR | | PIPE, 3" SCHED 40S SEAMLESS | ASTM A312 TP 304L | 1 | 11 |
| AR | | | PIPE, 2 SCHED 40S SEAMLESS | ASTM A312 TP 304L | 2 | 12 |
| | 1 | | ELBOW, 3" 90° LR, SCHED 40S, BTWLD | ASTM A403 WP-S 304L | 1 | 13 |
| AR | | | TS, 4" X 4 x 25 WALL | ASTM A554 MT-304/304L | 2 | 14 |
| 4 | | | PLATE, 1' X 3" x 3 3/8 L | ASTM A240 TYPE 304/304L | 2 | 15 |
| 1 | | | PLATE, 1/2' x 5' X 10 1/2'L | ASTM A240 TYPE 304/304L | 2 | 16 |
| 1 | | -001 | GUSSET PLATE, 1/4' | ASTM A240 TYPE 304/304L | 2 | 17 |
| 5 | | | PLATE, 1/4' x 4 x 4 L | ASTM A240 TYPE 304/304L | 2 | 18 |
| 1 | | | PLATE, 1/2 THK | ASTM A240 TYPE 304/304L | 2 | 19 |
| | 4 | | BAR, 1/2 # X LENGTH AS REQ'D | ASTM A276 TYPE 304/304L | 1 | 20 |
| 1 | | | BAR, 8'# X 12"L | ASTM A276 TYPE 304/304L | 2 | 21 |
| | 1 | | BOLT,HEX HD,3/4"-10UNC-2A x3 1/2 L | ASTM A193 GR B8 304 | 1 | 22 |
| | 1 | | NUT, HEX, 3/4'-10UNC-2B | ASTM A194 GR 8F 303 | 1 | 23 |

## NOTES:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION W-314-C1, SECTION 15483, APPENDIX A
2. HYDROSTATIC TEST SHALL BE AT 900 PSIG
3. JUMPER WEIGHT IS APPROXIMATELY 940 LBS
4. SEAL WELD ALL ORIFICES ON STRUCTURAL SUPPORT STEEL
5. ALL CALCULATIONS REQUIRED TO SUPPORT JUMPER DESIGN, PIPE STRESS, BALANCING AND CRITICAL DIMENSIONS ARE IDENTIFIED BY CALCULATION PACKAGE NUMBERS W314-P-001, W314-P-003, AND W314-P-007
6. FINAL FABRICATION SHALL NOT BE COMPLETED UNTIL VERIFICATION OF VALVE PIT AS-BUILT DATA HAS BEEN PROVIDED
7. DIMENSION LISTED IS FOR INITIAL SHOP FABRICATION ONLY IF NECESSARY, ADJUSTMENTS CAN BE MADE AT INSTALLATION TO MEET EXISTING PIT CONDITIONS

| DWG NO | TITLE |
|---|---|
| H-2-72019 | JUMPER ASSEMBLY L14-L15-C & R14-R15-D VALVE PIT 241-AN-A & B |
| H-2-73023 | JUMPER ASSEMBLY L16-L17-C-D VALVE PIT 241-AN-A |

DRAWING TRACEABILITY LIST

| REF NUMBER | TITLE |
|---|---|
| H-14-100829 | DRAWING LIST |

REFERENCES
NEXT USED ON H-14-100844

| REV | DESCRIPTION |
|---|---|
| 3 | B SH PROJECT DRAWING PER FCN 4C-138 INCORP ECN W314-4C-085 |
| 2 | SHOP VERIFIED AS BUILT INCORP ECN W314-4C-034 |
| 1 | PER ECN W-314-4C-023 TO REFLECT JUMPER CHANGES GENERAL REVISION, REDRAWN |

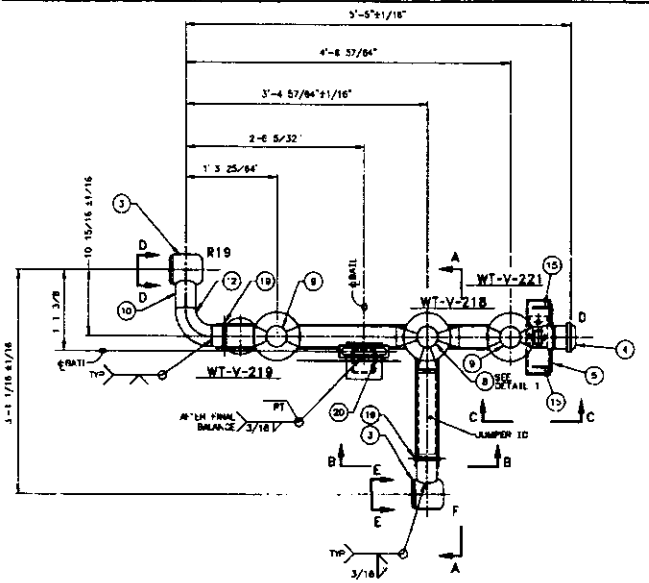
REVISIONS

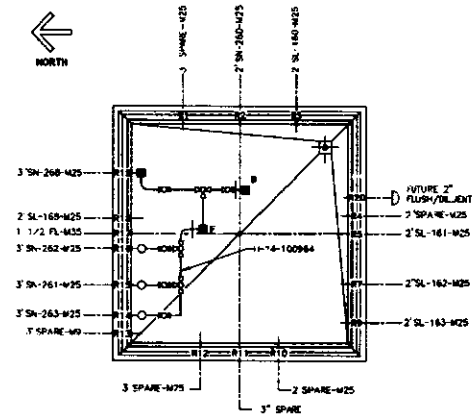
U.S. DEPARTMENT OF ENERGY
Richland Operations Office
FLUOR DANIEL NORTHWEST, INC.

JUMPER ASSEMBLY
241-AN-A
L14-L15-L16-(E)

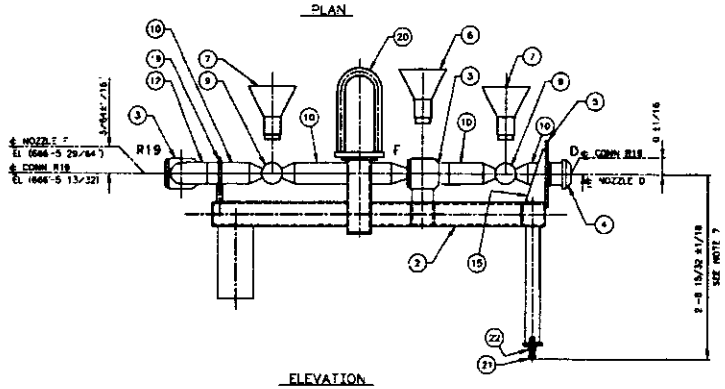
241-AN
H-14-100952

SCALE SHOWN 1 = 1
DATE 818123
2 PLOT SCALE 1=6

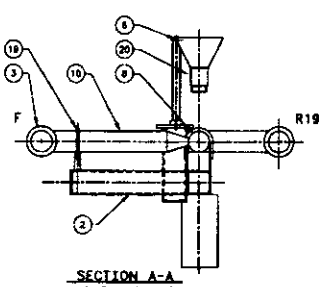


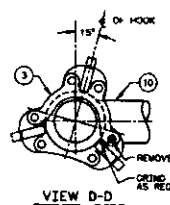

| QTY REQD 20-21 | QTY REQD 20-21 | PART/DASH NUMBER | NOMENCLATURE/DESCRIPTION | MATERIAL/REFERENCE | SHT | ITEM NO. |
|---|---|---|---|---|---|---|
| | X | -010 | ASSEMBLY | | 1 | 1 |
| X | 1 | -020 | SUB-ASSEMBLY | | 2 | 2 |
| | 2 | H 2-32430-1 | CONN. HORIZ 3" | GASKET, TYPE V | 1 | 3 |
| | 1 | H-2-90186-2 | NOZZLE, MALE 3 | | 1 | 4 |
| | 1 | H-2-30600-5 | STD SQUARE KICK-OFF PLATE 3" | | 1 | 5 |
| | 1 | H-14-100971-010 | FUNNEL ASSY, 3 3-WAY | | 1 | 6 |
| | 2 | H-14-100971-030 | FUNNEL ASSY, 3" 2-WAY | | 1 | 7 |
| | 1 | | BALL VALVE, 3" 3-WAY CLASS 300 | SEE PROMT SPEC W-314-P1 | 1 | 8 |
| | 2 | | BALL VALVE, 3 2-WAY CLASS 300 | SEE PROMT SPEC W-314-P1 | 1 | 9 |
| | AR | | PIPE, 3 SCHED 40S SEAMLESS | ASTM A312 GR TP 304L | 1 | 10 |
| AR | | | PIPE, 2" SCHED 40S SEAMLESS | ASTM A312 GR TP 304L | 2 | 11 |
| | 1 | | ELBOW, 3" SCHED 40S-90° LR BTWLD | ASTM A403 WP-S 304L | 1 | 12 |
| AR | | | TS 4 X 4" X .25" WALL | ASTM A554 MT 304/304L | 2 | 13 |
| 1 | | | PLATE 6" X 6" X 1/2 THK | ASTM A240 TYPE 304/304L | 2 | 14 |
| | 2 | -001 | GUSSET PLATE 1/4" THK | ASTM A240 TYPE 304/304L | 2 | 15 |
| 2 | | | PLATE 3 5/8" X 3 X 1" THK | ASTM A240 TYPE 304/304L | 2 | 16 |
| 5 | | | PLATE 4" X 4 X 1/4" THK | ASTM A240 TYPE 304/304L | 2 | 17 |
| 1 | | | PLATE, 1/2 THK | ASTM A240 TYPE 304/304L | 2 | 18 |
| | 2 | | BAR 1/2"W X LENGTH AS REQUIRED | ASTM A276 TYPE 304/304L | 1 | 19 |
| | 1 | H-14-100973-010 | LIFTING BAIL | | 1 | 20 |
| | 1 | | BOLT, HEX HD, 3/4"-10UNC-2A X 3"L | ASTM A193 GR B8 304 | 1 | 21 |
| | 1 | | NUT, HEX, 3/4"-10UNC-2B | ASTM A194 GR 8F 303 | 1 | 22 |
| | | | BAR 6" X 12"L | ASTM A276 TYPE 304/304L | 2 | 23 |



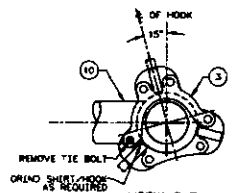

1 ASSEMBLY
SCALE 1 1/2"=1'-0"




SECTION A-A
SCALE 1 1/2"=1'-0"




VIEW D-D
SCALE NONE

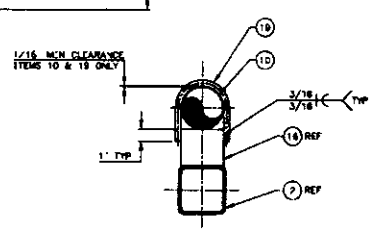



VIEW E-E
SCALE NONE

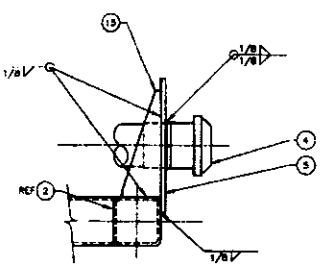
DETAIL 1
BALL VALVE PORT ARRGT 180° ROTATION
SCALE NONE

## NOTES:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION W-314-C1, SECTION 15483, APPENDIX A
2. HYDROSTATIC TEST SHALL BE AT 600 PSIG
3. JUMPER WEIGHT IS APPROXIMATELY 680 LB
4. SEAL WELD ALL CREVICES ON STRUCTURAL SUPPORT STEEL
5. ALL CALCULATIONS REQUIRED TO SUPPORT JUMPER DESIGN, PIPE STRESS, BALANCING AND CRITICAL DIMENSIONS ARE IDENTIFIED BY CALCULATION PACKAGE NUMBERS W314-P-002, W314-P-004, AND W314-P-007
6. FINAL FABRICATION SHALL NOT BE COMPLETED UNTIL VERIFICATION OF VALVE PIT AS-BUILT DATA HAS BEEN PROVIDED
7. DIMENSION LISTED IS FOR INITIAL SHOP FABRICATION ONLY IF NECESSARY, ADJUSTMENTS CAN BE MADE AT INSTALLATION TO MEET EXISTING PIT CONDITIONS




SECTION B-B
SCALE 3"=1'-0"




VIEW C-C
SCALE 3"=1'-0"

| | | | |
|---|---|---|---|
| 2 | | | |
| 1 | | | |

REVISIONS

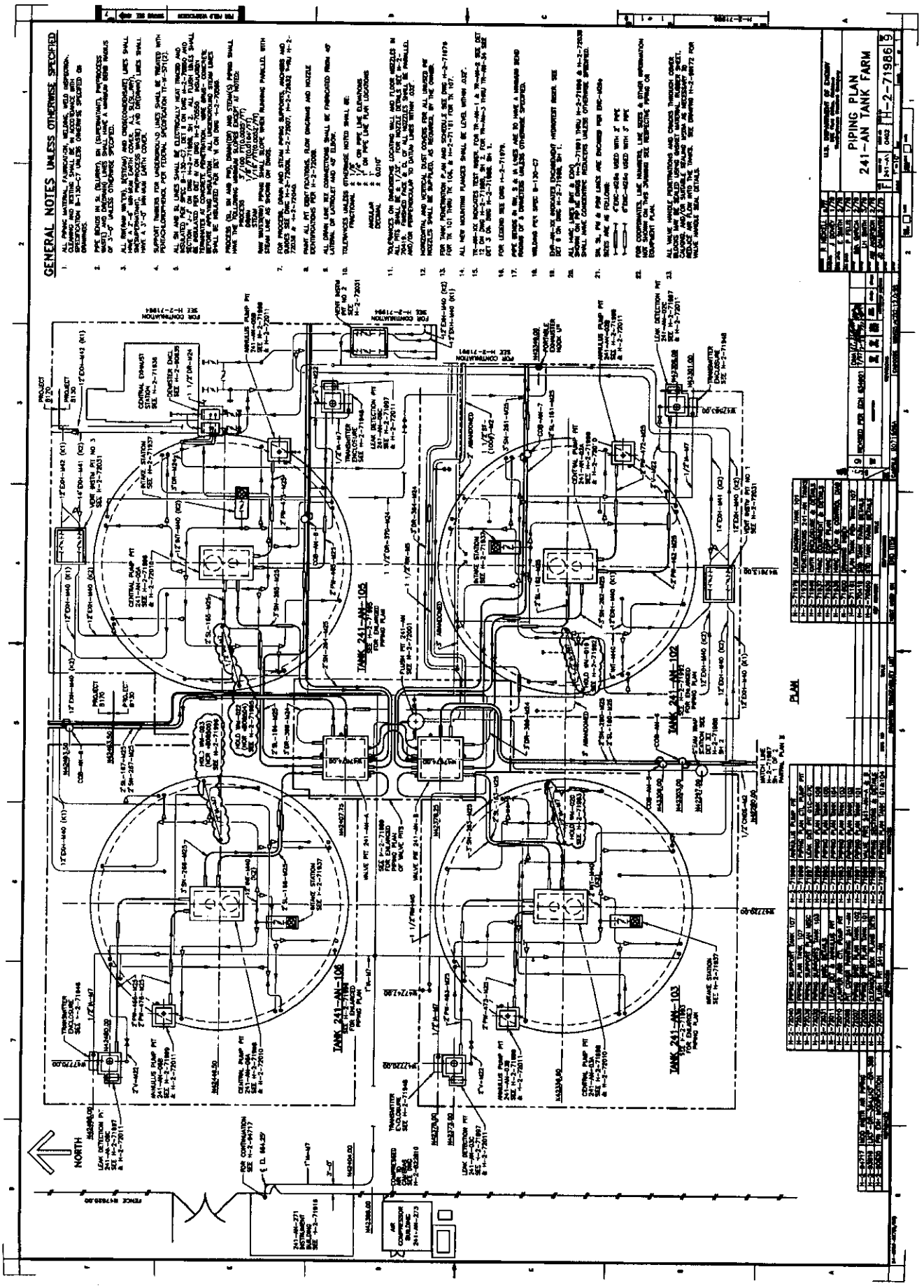
U S DEPARTMENT OF ENERGY
Richland Operations Office
FLUOR DANIEL NORTHWEST, INC.

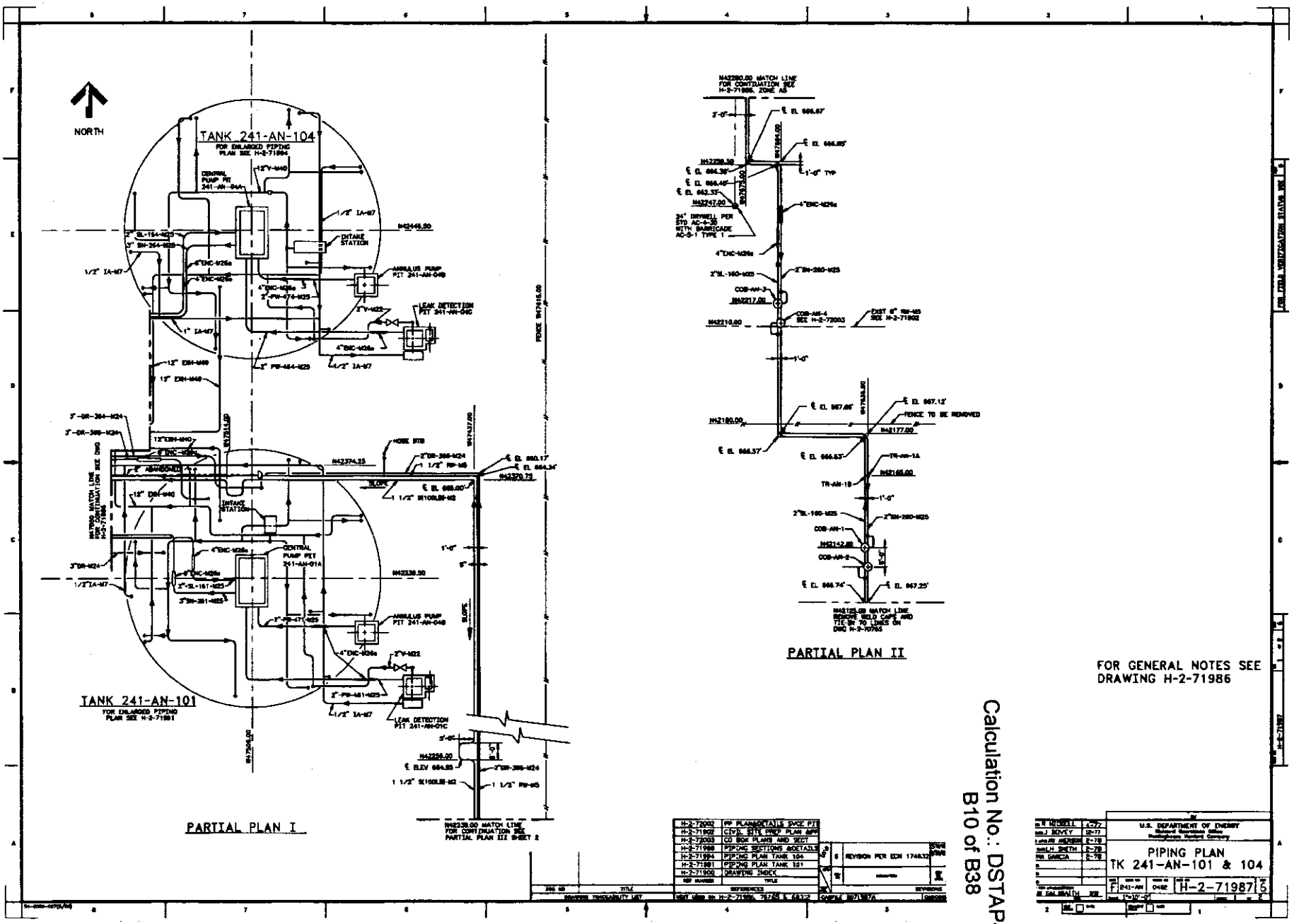
JUMPER ASSEMBLY
241-AN-B
R19-(D&F)

H-14-100965 2

RPP-6485 REV.0

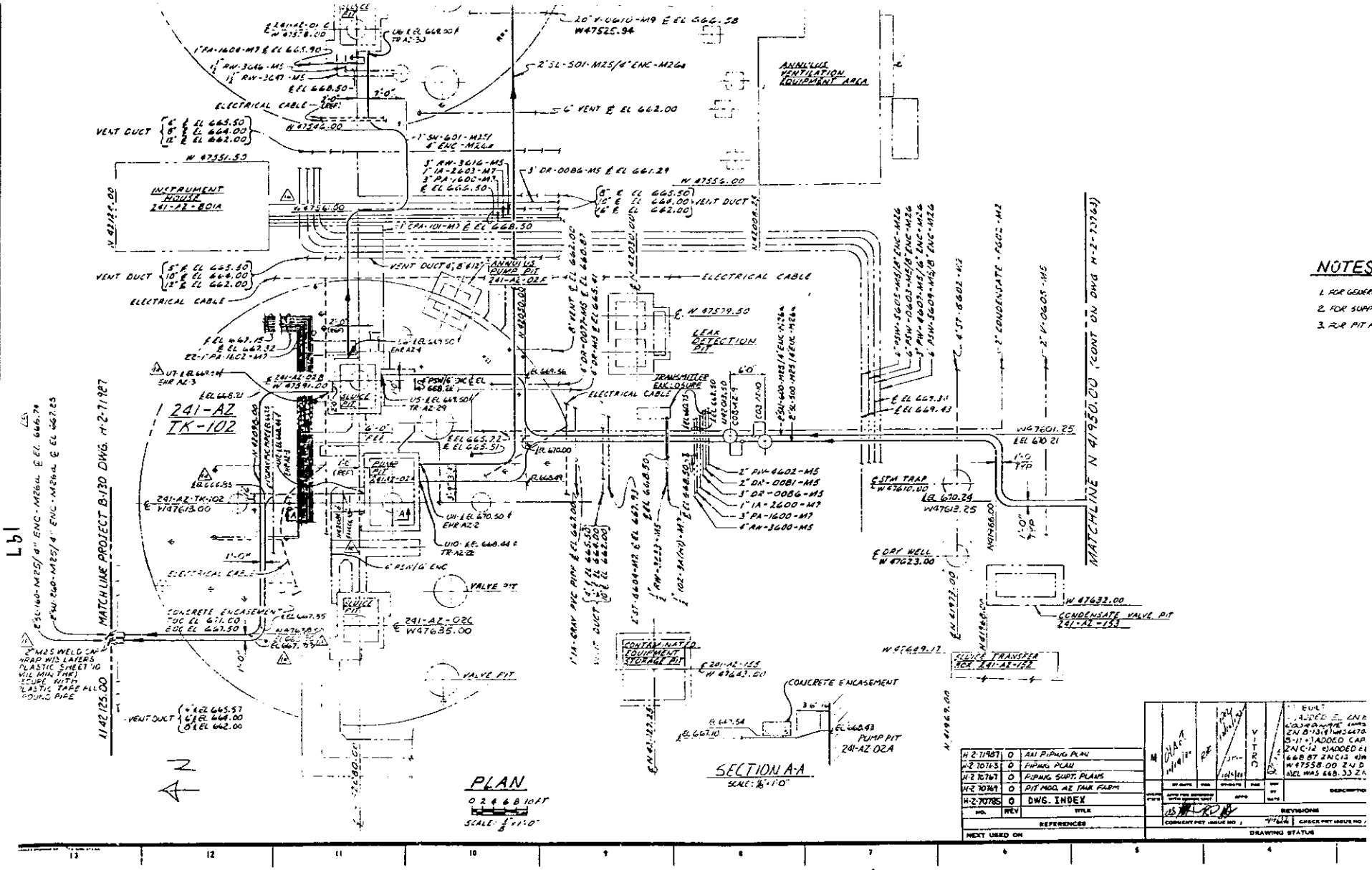







Calculation No.: DSTAP-P-001
B10 of B38

RPP-6485 Rev 0



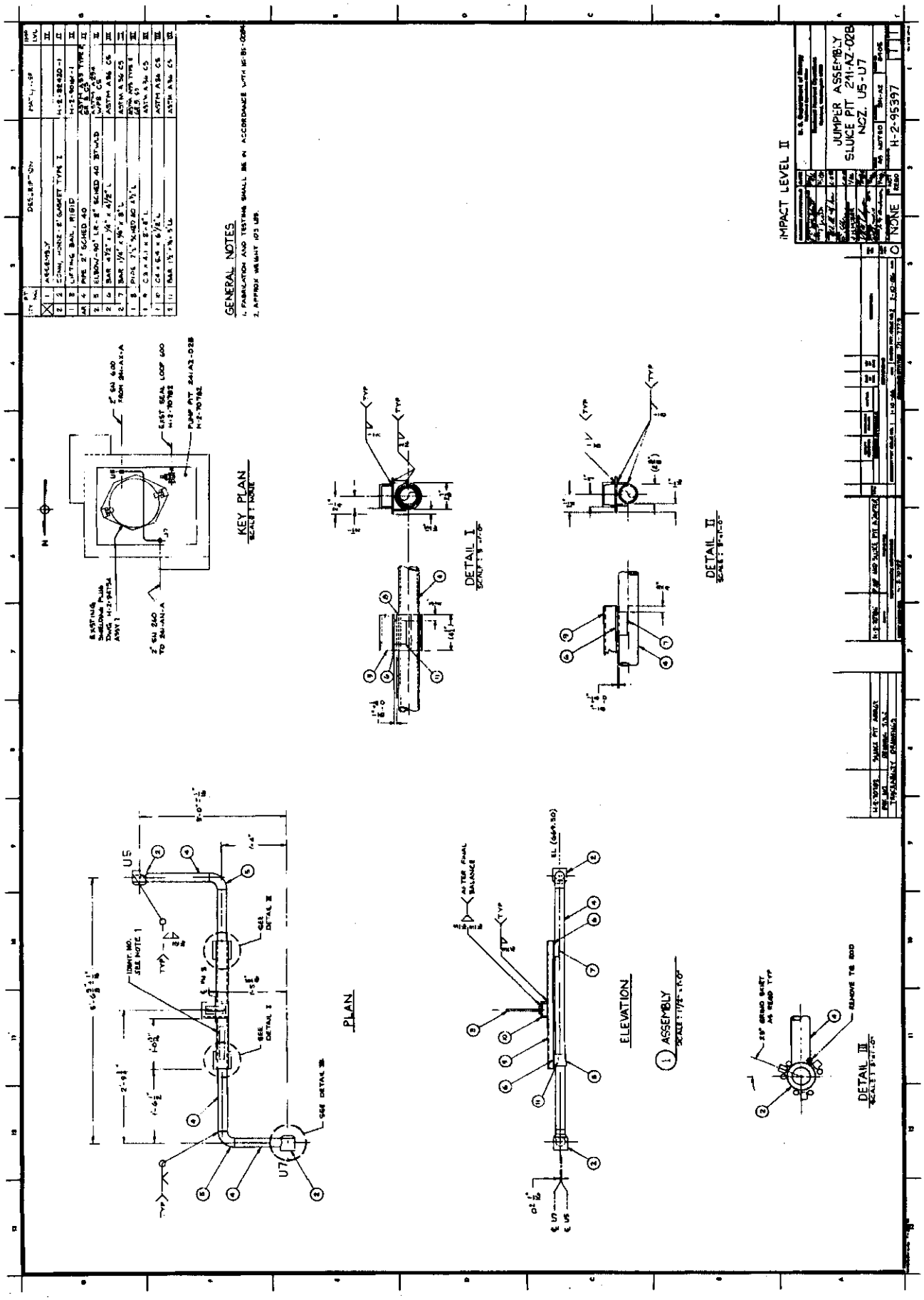

RPP-6485 Rev. 0

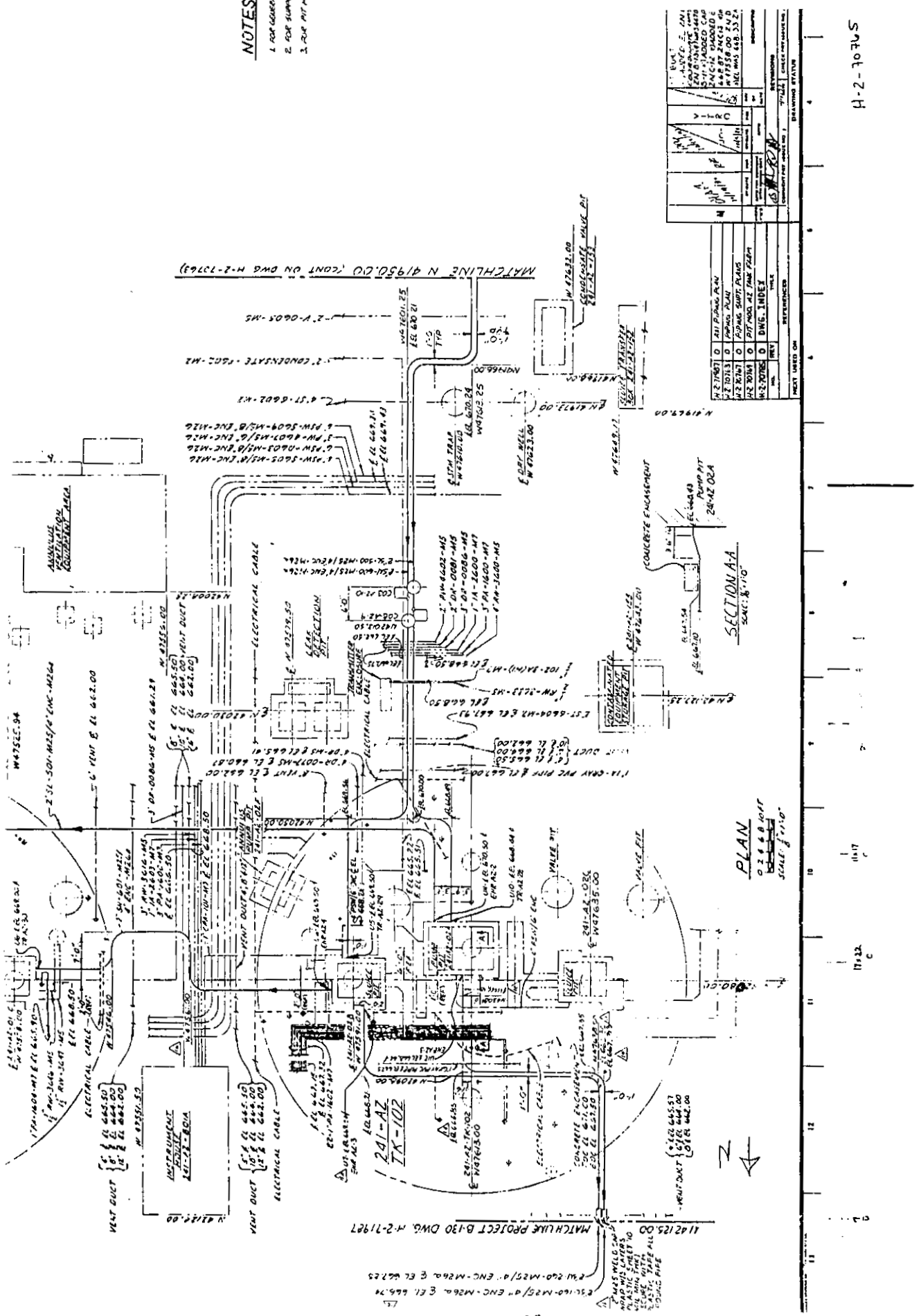
Calculation No.: DSTAP-P-001
B11 of B38

171

RPP-6485 Rev. 0

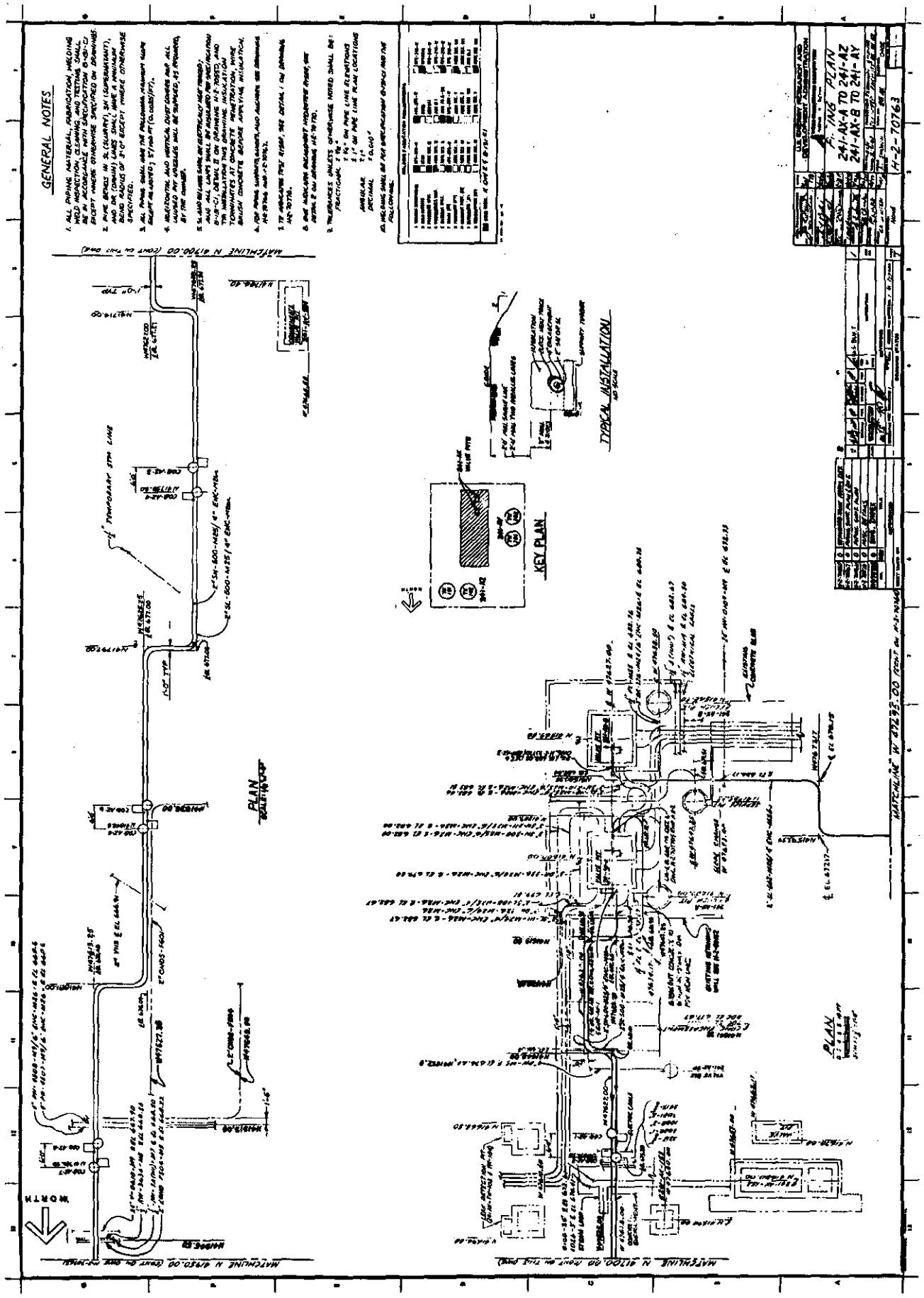





NOTES
1. FOR GENERAL NOTES SEE DWG. H-2-70
2. FOR SUPPORT PLAN SEE DWG. H-2
3. FOR PIT MODIFICATION SEE DWG.
MATCHLINE N 41950.00 (CONT ON DWG H-2-70763)
MATCHLINE PROJECT B-130 DWG. H-2-71987
PLAN
SECTION A-A
241-AZ TK-102
ANNULUS VENTILATION CONTAINMENT AREA
INSTRUMENT SHELTER 241-AZ-601A
VALVE PIT
CONCRETE ENCASEMENT
ELECTRICAL CABLE
VENT DUCT
DRAWING STATUS
DWG. INDEX
REFERENCED
NEXT USED ON
H-2-70763

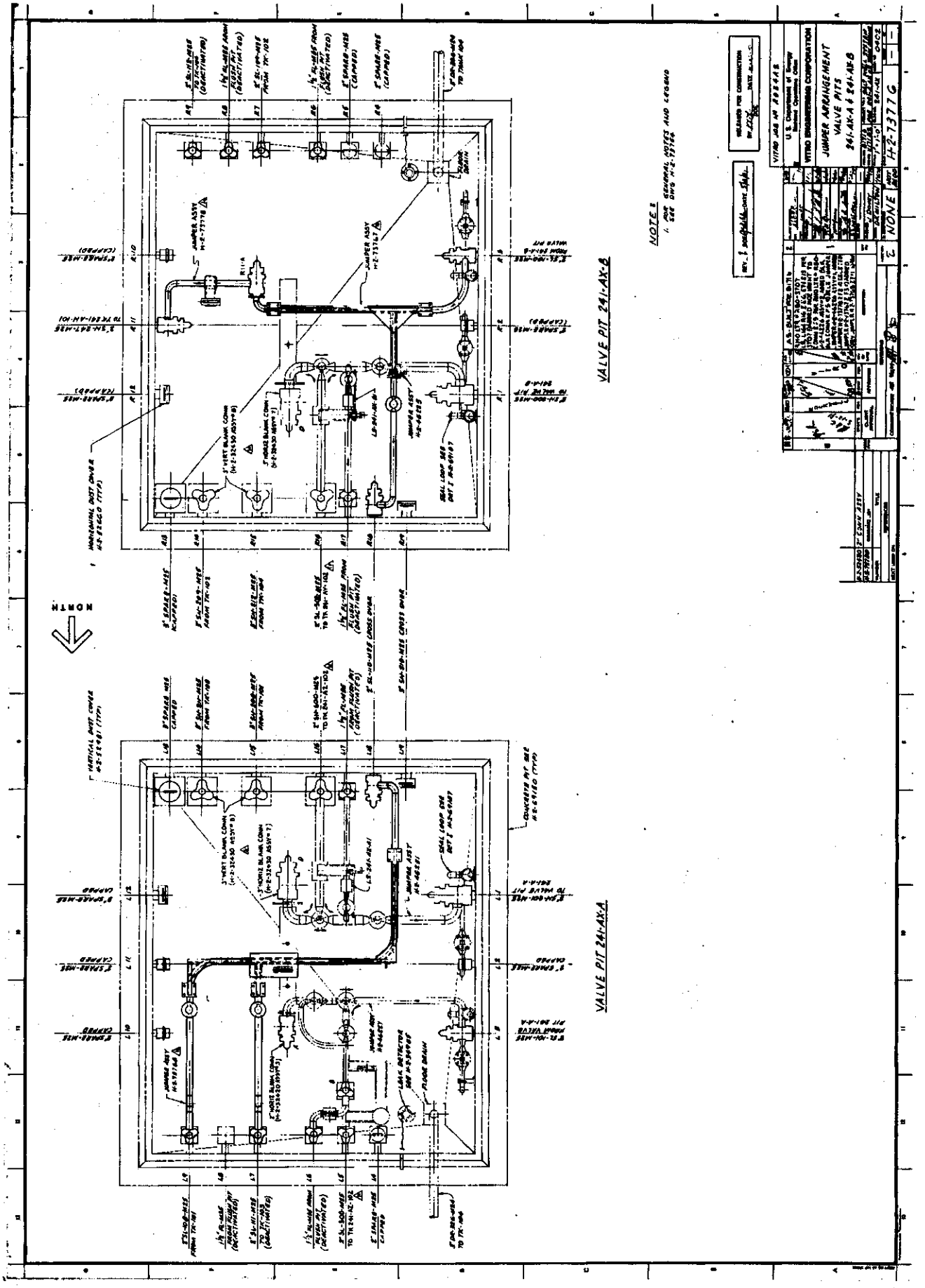
RPP-6485 REV. 0





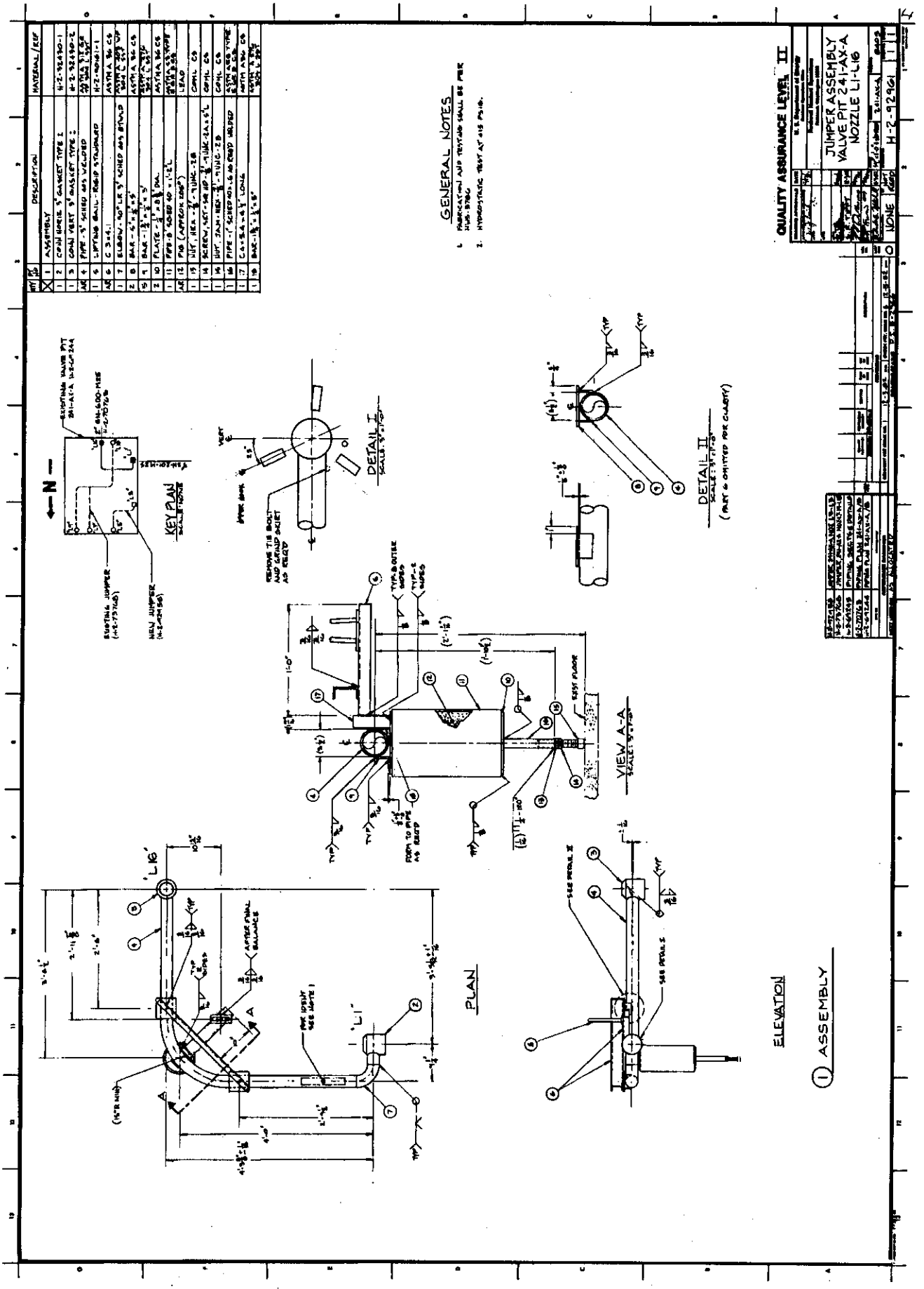
RPP-6485 Rev. 0

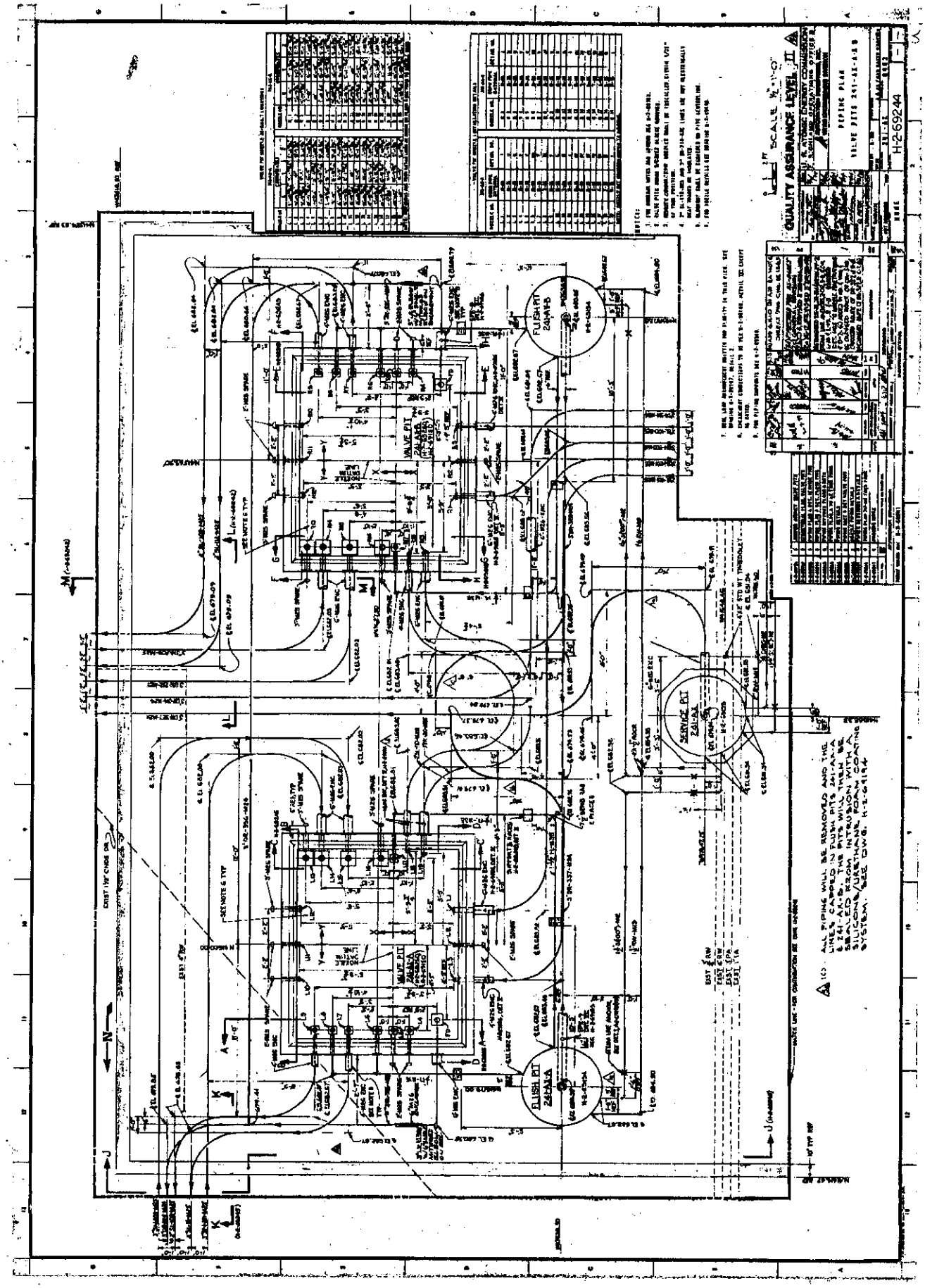


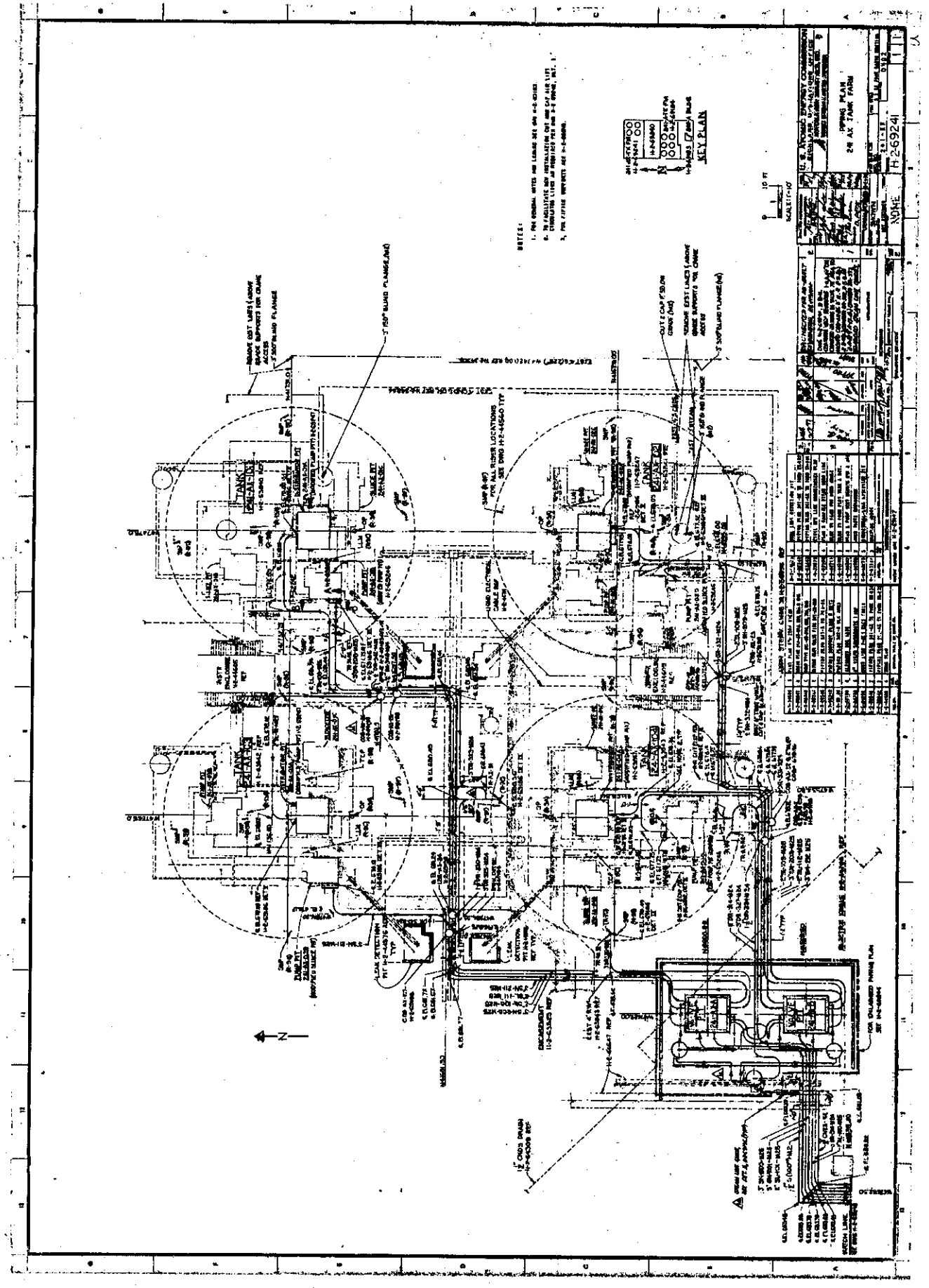


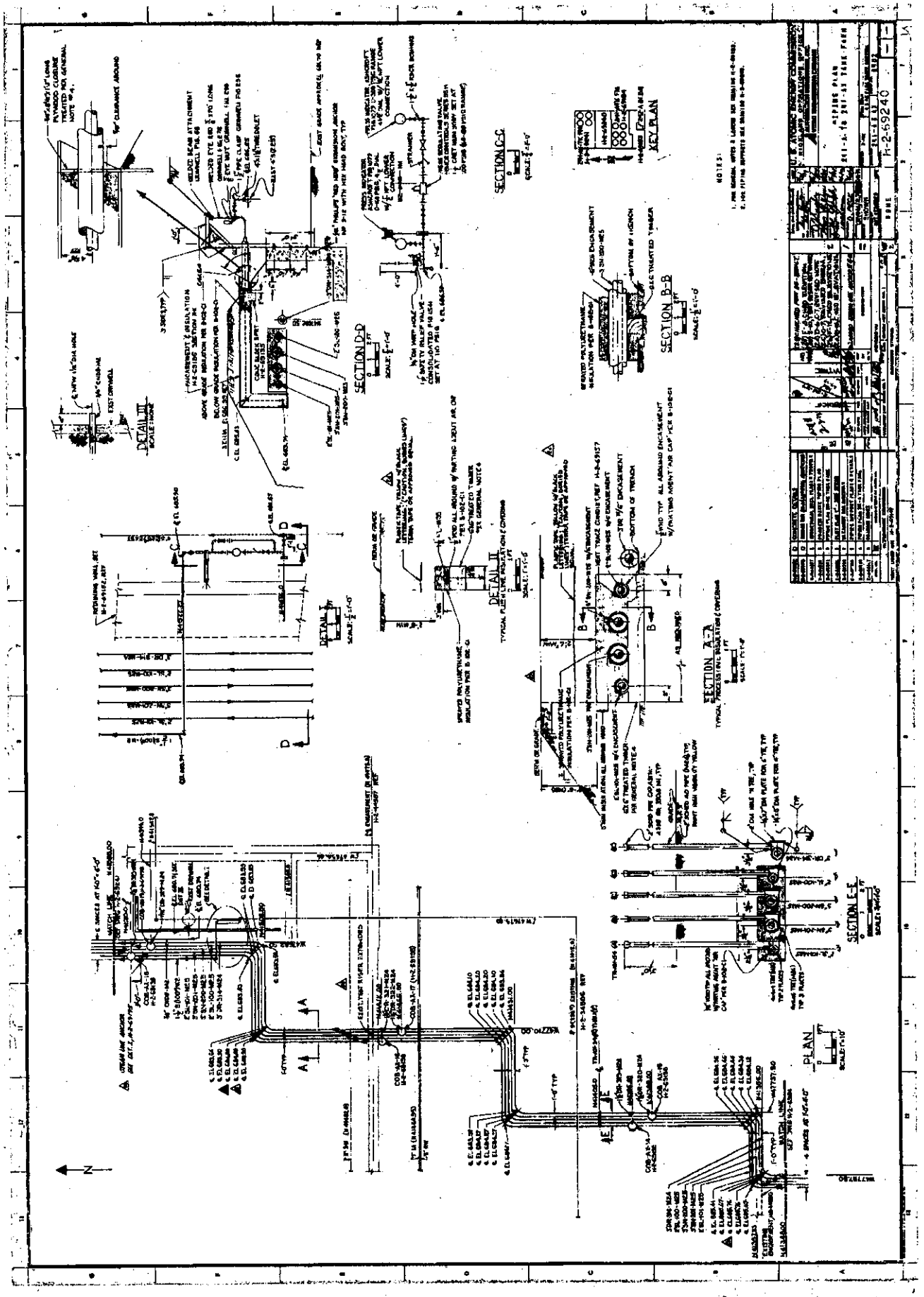
RPP-6485 Rev. 0

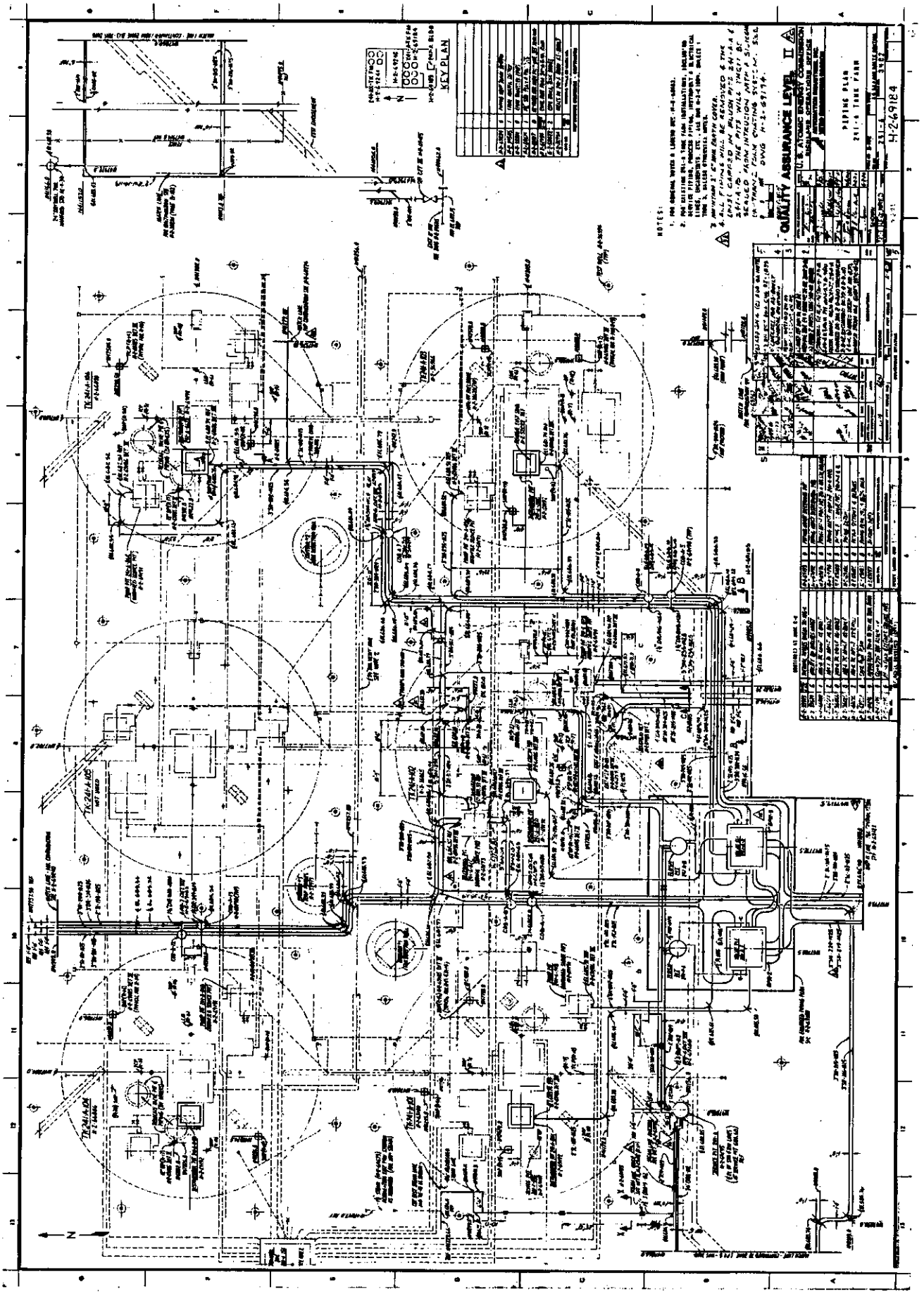





QUALITY ASSURANCE LEVEL II
SCALE 1/4"=1'-0"
PIPING PLAN
VALVE PITS 241-AZ-A & B
H-2-69244
FLUSH PIT 241-AY-B
VALVE PIT 241-AY-A
SERVICE PIT 241-AY-A
FLUSH PIT 241-AY-A
ALL PIPING WILL BE REMOVED AND THE LINES CAPPED IN FLUSH PITS 241-AY-A & 241-AY-B. THE PITS WILL THEN BE FILLED WITH NITROGEN WITH A SILICONE FLUSH, NITROGEN BLANKETING SYSTEM. SEE DWG. H-2-69194

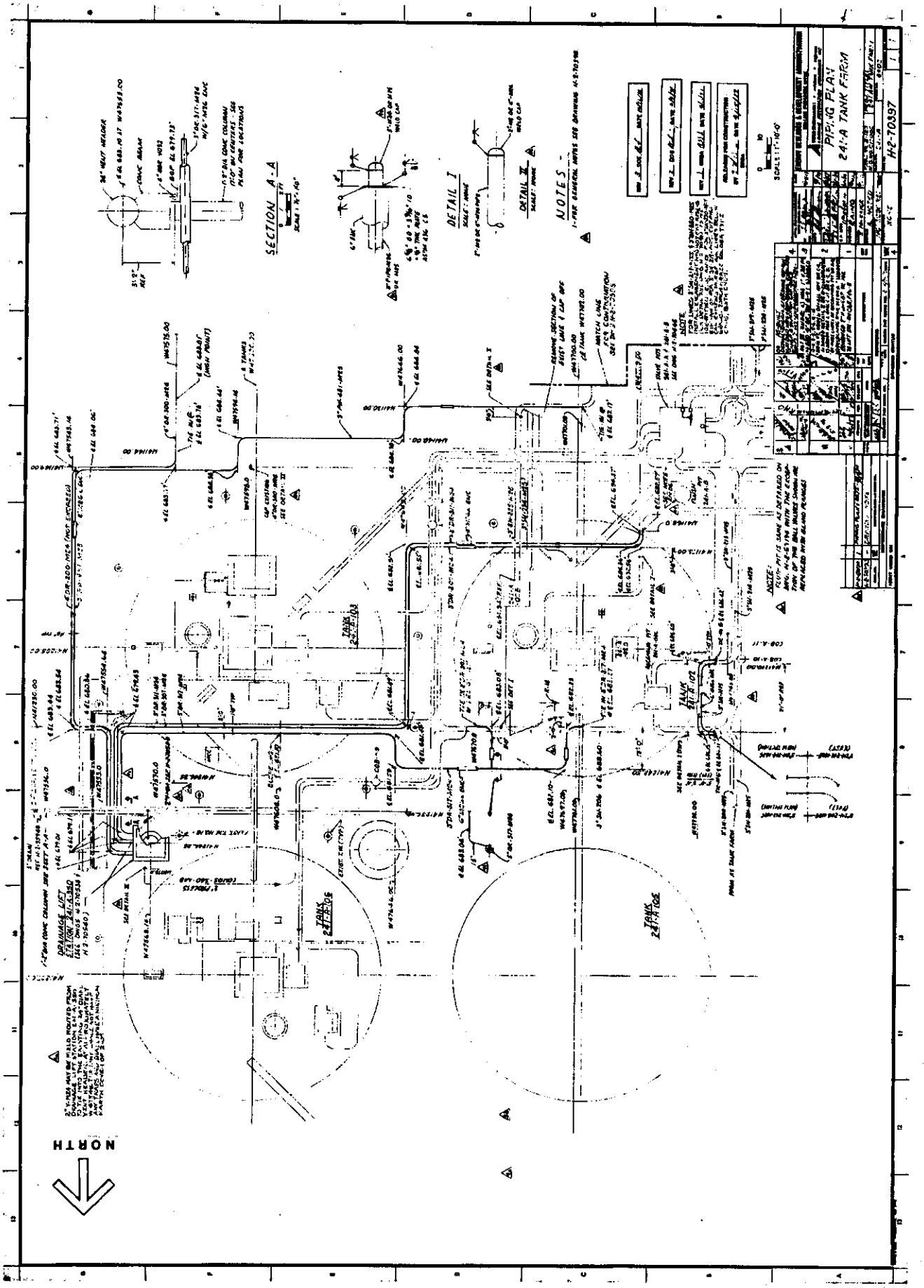

KEY PLAN
NOTES:
PIPING PLAN
2/6 AX TANK FARM
NONE
H-2-69241
SCALE: 1"=10'
10 FT
TANK
Z


DETAIL II
SECTION D-D
SECTION C-C
SECTION B-B
KEY PLAN
SECTION A-A
SECTION E-E
PLAN
H-2-69240


KEY PLAN
QUALITY ASSURANCE LEVEL II
U.S. ATOMIC ENERGY COMMISSION
PIPING PLAN
241-A TANK FARM
H-2-69184
TK-241-A-105
TK-241-A-106
TK-241-A-107
TK-241-A-108
TK-241-A-109
TK-241-A-110
TK-241-A-111
TK-241-A-112
TK-241-A-113
TK-241-A-114
TK-241-A-115
TK-241-A-116
TK-241-A-117
TK-241-A-118
TK-241-A-119
TK-241-A-120
TK-241-A-121
TK-241-A-122
TK-241-A-123
TK-241-A-124
TK-241-A-125
TK-241-A-126
TK-241-A-127
TK-241-A-128
TK-241-A-129
TK-241-A-130
TK-241-A-131
TK-241-A-132
TK-241-A-133
TK-241-A-134
TK-241-A-135
TK-241-A-136
TK-241-A-137
TK-241-A-138
TK-241-A-139
TK-241-A-140
TK-241-A-141
TK-241-A-142
TK-241-A-143
TK-241-A-144
TK-241-A-145
TK-241-A-146
TK-241-A-147
TK-241-A-148
TK-241-A-149
TK-241-A-150
TK-241-A-151
TK-241-A-152
TK-241-A-153
TK-241-A-154
TK-241-A-155
TK-241-A-156
TK-241-A-157
TK-241-A-158
TK-241-A-159
TK-241-A-160
TK-241-A-161
TK-241-A-162
TK-241-A-163
TK-241-A-164
TK-241-A-165
TK-241-A-166
TK-241-A-167
TK-241-A-168
TK-241-A-169
TK-241-A-170
TK-241-A-171
TK-241-A-172
TK-241-A-173
TK-241-A-174
TK-241-A-175
TK-241-A-176
TK-241-A-177
TK-241-A-178
TK-241-A-179
TK-241-A-180
TK-241-A-181
TK-241-A-182
TK-241-A-183
TK-241-A-184
TK-241-A-185
TK-241-A-186
TK-241-A-187
TK-241-A-188
TK-241-A-189
TK-241-A-190
TK-241-A-191
TK-241-A-192
TK-241-A-193
TK-241-A-194
TK-241-A-195
TK-241-A-196
TK-241-A-197
TK-241-A-198
TK-241-A-199
TK-241-A-200
TK-241-A-201
TK-241-A-202
TK-241-A-203
TK-241-A-204
TK-241-A-205
TK-241-A-206
TK-241-A-207
TK-241-A-208
TK-241-A-209
TK-241-A-210
TK-241-A-211
TK-241-A-212
TK-241-A-213
TK-241-A-214
TK-241-A-215
TK-241-A-216
TK-241-A-217
TK-241-A-218
TK-241-A-219
TK-241-A-220
TK-241-A-221
TK-241-A-222
TK-241-A-223
TK-241-A-224
TK-241-A-225
TK-241-A-226
TK-241-A-227
TK-241-A-228
TK-241-A-229
TK-241-A-230
TK-241-A-231
TK-241-A-232
TK-241-A-233
TK-241-A-234
TK-241-A-235
TK-241-A-236
TK-241-A-237
TK-241-A-238
TK-241-A-239
TK-241-A-240
TK-241-A-241
TK-241-A-242
TK-241-A-243
TK-241-A-244
TK-241-A-245
TK-241-A-246
TK-241-A-247
TK-241-A-248
TK-241-A-249
TK-241-A-250
TK-241-A-251
TK-241-A-252
TK-241-A-253
TK-241-A-254
TK-241-A-255
TK-241-A-256
TK-241-A-257
TK-241-A-258
TK-241-A-259
TK-241-A-260
TK-241-A-261
TK-241-A-262
TK-241-A-263
TK-241-A-264
TK-241-A-265
TK-241-A-266
TK-241-A-267
TK-241-A-268
TK-241-A-269
TK-241-A-270
TK-241-A-271
TK-241-A-272
TK-241-A-273
TK-241-A-274
TK-241-A-275
TK-241-A-276
TK-241-A-277
TK-241-A-278
TK-241-A-279
TK-241-A-280
TK-241-A-281
TK-241-A-282
TK-241-A-283
TK-241-A-284
TK-241-A-285
TK-241-A-286
TK-241-A-287
TK-241-A-288
TK-241-A-289
TK-241-A-290
TK-241-A-291
TK-241-A-292
TK-241-A-293
TK-241-A-294
TK-241-A-295
TK-241-A-296
TK-241-A-297
TK-241-A-298
TK-241-A-299
TK-241-A-300
TK-241-A-301
TK-241-A-302
TK-241-A-303
TK-241-A-304
TK-241-A-305
TK-241-A-306
TK-241-A-307
TK-241-A-308
TK-241-A-309
TK-241-A-310
TK-241-A-311
TK-241-A-312
TK-241-A-313
TK-241-A-314
TK-241-A-315
TK-241-A-316
TK-241-A-317
TK-241-A-318
TK-241-A-319
TK-241-A-320
TK-241-A-321
TK-241-A-322
TK-241-A-323
TK-241-A-324
TK-241-A-325
TK-241-A-326
TK-241-A-327
TK-241-A-328
TK-241-A-329
TK-241-A-330
TK-241-A-331
TK-241-A-332
TK-241-A-333
TK-241-A-334
TK-241-A-335
TK-241-A-336
TK-241-A-337
TK-241-A-338
TK-241-A-339
TK-241-A-340
TK-241-A-341
TK-241-A-342
TK-241-A-343
TK-241-A-344
TK-241-A-345
TK-241-A-346
TK-241-A-347
TK-241-A-348
TK-241-A-349
TK-241-A-350
TK-241-A-351
TK-241-A-352
TK-241-A-353
TK-241-A-354
TK-241-A-355
TK-241-A-356
TK-241-A-357
TK-241-A-358
TK-241-A-359
TK-241-A-360
TK-241-A-361
TK-241-A-362
TK-241-A-363
TK-241-A-364
TK-241-A-365
TK-241-A-366
TK-241-A-367
TK-241-A-368
TK-241-A-369
TK-241-A-370
TK-241-A-371
TK-241-A-372
TK-241-A-373
TK-241-A-374
TK-241-A-375
TK-241-A-376
TK-241-A-377
TK-241-A-378
TK-241-A-379
TK-241-A-380
TK-241-A-381
TK-241-A-382
TK-241-A-383
TK-241-A-384
TK-241-A-385
TK-241-A-386
TK-241-A-387
TK-241-A-388
TK-241-A-389
TK-241-A-390
TK-241-A-391
TK-241-A-392
TK-241-A-393
TK-241-A-394
TK-241-A-395
TK-241-A-396
TK-241-A-397
TK-241-A-398
TK-241-A-399
TK-241-A-400
TK-241-A-401
TK-241-A-402
TK-241-A-403
TK-241-A-404
TK-241-A-405
TK-241-A-406
TK-241-A-407
TK-241-A-408
TK-241-A-409
TK-241-A-410
TK-241-A-411
TK-241-A-412
TK-241-A-413
TK-241-A-414
TK-241-A-415
TK-241-A-416
TK-241-A-417
TK-241-A-418
TK-241-A-419
TK-241-A-420
TK-241-A-421
TK-241-A-422
TK-241-A-423
TK-241-A-424
TK-241-A-425
TK-241-A-426
TK-241-A-427
TK-241-A-428
TK-241-A-429
TK-241-A-430
TK-241-A-431
TK-241-A-432
TK-241-A-433
TK-241-A-434
TK-241-A-435
TK-241-A-436
TK-241-A-437
TK-241-A-438
TK-241-A-439
TK-241-A-440
TK-241-A-441
TK-241-A-442
TK-241-A-443
TK-241-A-444
TK-241-A-445
TK-241-A-446
TK-241-A-447
TK-241-A-448
TK-241-A-449
TK-241-A-450
TK-241-A-451
TK-241-A-452
TK-241-A-453
TK-241-A-454
TK-241-A-455
TK-241-A-456
TK-241-A-457
TK-241-A-458
TK-241-A-459
TK-241-A-460
TK-241-A-461
TK-241-A-462
TK-241-A-463
TK-241-A-464
TK-241-A-465
TK-241-A-466
TK-241-A-467
TK-241-A-468
TK-241-A-469
TK-241-A-470
TK-241-A-471
TK-241-A-472
TK-241-A-473
TK-241-A-474
TK-241-A-475
TK-241-A-476
TK-241-A-477
TK-241-A-478
TK-241-A-479
TK-241-A-480
TK-241-A-481
TK-241-A-482
TK-241-A-483
TK-241-A-484
TK-241-A-485
TK-241-A-486
TK-241-A-487
TK-241-A-488
TK-241-A-489
TK-241-A-490
TK-241-A-491
TK-241-A-492
TK-241-A-493
TK-241-A-494
TK-241-A-495
TK-241-A-496
TK-241-A-497
TK-241-A-498
TK-241-A-499
TK-241-A-500
TK-241-A-501
TK-241-A-502
TK-241-A-503
TK-241-A-504
TK-241-A-505
TK-241-A-506
TK-241-A-507
TK-241-A-508
TK-241-A-509
TK-241-A-510
TK-241-A-511
TK-241-A-512
TK-241-A-513
TK-241-A-514
TK-241-A-515
TK-241-A-516
TK-241-A-517
TK-241-A-518
TK-241-A-519
TK-241-A-520
TK-241-A-521
TK-241-A-522
TK-241-A-523
TK-241-A-524
TK-241-A-525
TK-241-A-526
TK-241-A-527
TK-241-A-528
TK-241-A-529
TK-241-A-530
TK-241-A-531
TK-241-A-532
TK-241-A-533
TK-241-A-534
TK-241-A-535
TK-241-A-536
TK-241-A-537
TK-241-A-538
TK-241-A-539
TK-241-A-540
TK-241-A-541
TK-241-A-542
TK-241-A-543
TK-241-A-544
TK-241-A-545
TK-241-A-546
TK-241-A-547
TK-241-A-548
TK-241-A-549
TK-241-A-550
TK-241-A-551
TK-241-A-552
TK-241-A-553
TK-241-A-554
TK-241-A-555
TK-241-A-556
TK-241-A-557
TK-241-A-558
TK-241-A-559
TK-241-A-560
TK-241-A-561
TK-241-A-562
TK-241-A-563
TK-241-A-564
TK-241-A-565
TK-241-A-566
TK-241-A-567
TK-241-A-568
TK-241-A-569
TK-241-A-570
TK-241-A-571
TK-241-A-572
TK-241-A-573
TK-241-A-574
TK-241-A-575
TK-241-A-576
TK-241-A-577
TK-241-A-578
TK-241-A-579
TK-241-A-580
TK-241-A-581
TK-241-A-582
TK-241-A-583
TK-241-A-584
TK-241-A-585
TK-241-A-586
TK-241-A-587
TK-241-A-588
TK-241-A-589
TK-241-A-590
TK-241-A-591
TK-241-A-592
TK-241-A-593
TK-241-A-594
TK-241-A-595
TK-241-A-596
TK-241-A-597
TK-241-A-598
TK-241-A-599
TK-241-A-600
TK-241-A-601
TK-241-A-602
TK-241-A-603
TK-241-A-604
TK-241-A-605
TK-241-A-606
TK-241-A-607
TK-241-A-608
TK-241-A-609
TK-241-A-610
TK-241-A-611
TK-241-A-612
TK-241-A-613
TK-241-A-614
TK-241-A-615
TK-241-A-616
TK-241-A-617
TK-241-A-618
TK-241-A-619
TK-241-A-620
TK-241-A-621
TK-241-A-622
TK-241-A-623
TK-241-A-624
TK-241-A-625
TK-241-A-626
TK-241-A-627
TK-241-A-628
TK-241-A-629
TK-241-A-630
TK-241-A-631
TK-241-A-632
TK-241-A-633
TK-241-A-634
TK-241-A-635
TK-241-A-636
TK-241-A-637
TK-241-A-638
TK-241-A-639
TK-241-A-640
TK-241-A-641
TK-241-A-642
TK-241-A-643
TK-241-A-644
TK-241-A-645
TK-241-A-646
TK-241-A-647
TK-241-A-648
TK-241-A-649
TK-241-A-650
TK-241-A-651
TK-241-A-652
TK-241-A-653
TK-241-A-654
TK-241-A-655
TK-241-A-656
TK-241-A-657
TK-241-A-658
TK-241-A-659
TK-241-A-660
TK-241-A-661
TK-241-A-662
TK-241-A-663
TK-241-A-664
TK-241-A-665
TK-241-A-666
TK-241-A-667
TK-241-A-668
TK-241-A-669
TK-241-A-670
TK-241-A-671
TK-241-A-672
TK-241-A-673
TK-241-A-674
TK-241-A-675
TK-241-A-676
TK-241-A-677
TK-241-A-678
TK-241-A-679
TK-241-A-680
TK-241-A-681
TK-241-A-682
TK-241-A-683
TK-241-A-684
TK-241-A-685
TK-241-A-686
TK-241-A-687
TK-241-A-688
TK-241-A-689
TK-241-A-690
TK-241-A-691
TK-241-A-692
TK-241-A-693
TK-241-A-694
TK-241-A-695
TK-241-A-696
TK-241-A-697
TK-241-A-698
TK-241-A-699
TK-241-A-700
TK-241-A-701
TK-241-A-702
TK-241-A-703
TK-241-A-704
TK-241-A-705
TK-241-A-706
TK-241-A-707
TK-241-A-708
TK-241-A-709
TK-241-A-710
TK-241-A-711
TK-241-A-712
TK-241-A-713
TK-241-A-714
TK-241-A-715
TK-241-A-716
TK-241-A-717
TK-241-A-718
TK-241-A-719
TK-241-A-720
TK-241-A-721
TK-241-A-722
TK-241-A-723
TK-241-A-724
TK-241-A-725
TK-241-A-726
TK-241-A-727
TK-241-A-728
TK-241-A-729
TK-241-A-730
TK-241-A-731
TK-241-A-732
TK-241-A-733
TK-241-A-734
TK-241-A-735
TK-241-A-736
TK-241-A-737
TK-241-A-738
TK-241-A-739
TK-241-A-740
TK-241-A-741
TK-241-A-742
TK-241-A-743
TK-241-A-744
TK-241-A-745
TK-241-A-746
TK-241-A-747
TK-241-A-748
TK-241-A-749
TK-241-A-750
TK-241-A-751
TK-241-A-752
TK-241-A-753
TK-241-A-754
TK-241-A-755
TK-241-A-756
TK-241-A-757
TK-241-A-758
TK-241-A-759
TK-241-A-760
TK-241-A-761
TK-241-A-762
TK-241-A-763
TK-241-A-764
TK-241-A-765
TK-241-A-766
TK-241-A-767
TK-241-A-768
TK-241-A-769
TK-241-A-770
TK-241-A-771
TK-241-A-772
TK-241-A-773
TK-241-A-774
TK-241-A-775
TK-241-A-776
TK-241-A-777
TK-241-A-778
TK-241-A-779
TK-241-A-780
TK-241-A-781
TK-241-A-782
TK-241-A-783
TK-241-A-784
TK-241-A-785
TK-241-A-786
TK-241-A-787
TK-241-A-788
TK-241-A-789
TK-241-A-790
TK-241-A-791
TK-241-A-792
TK-241-A-793
TK-241-A-794
TK-241-A-795
TK-241-A-796
TK-241-A-797
TK-241-A-798
TK-241-A-799
TK-241-A-800
TK-241-A-801
TK-241-A-802
TK-241-A-803
TK-241-A-804
TK-241-A-805
TK-241-A-806
TK-241-A-807
TK-241-A-808
TK-241-A-809
TK-241-A-810
TK-241-A-811
TK-241-A-812
TK-241-A-813
TK-241-A-814
TK-241-A-815
TK-241-A-816
TK-241-A-817
TK-241-A-818
TK-241-A-819
TK-241-A-820
TK-241-A-821
TK-241-A-822
TK-241-A-823
TK-241-A-824
TK-241-A-825
TK-241-A-826
TK-241-A-827
TK-241-A-828
TK-241-A-829
TK-241-A-830
TK-241-A-831
TK-241-A-832
TK-241-A-833
TK-241-A-834
TK-241-A-835
TK-241-A-836
TK-241-A-837
TK-241-A-838
TK-241-A-839
TK-241-A-840
TK-241-A-841
TK-241-A-842
TK-241-A-843
TK-241-A-844
TK-241-A-845
TK-241-A-846
TK-241-A-847
TK-241-A-848
TK-241-A-849
TK-241-A-850
TK-241-A-851
TK-241-A-852
TK-241-A-853
TK-241-A-854
TK-241-A-855
TK-241-A-856
TK-241-A-857
TK-241-A-858
TK-241-A-859
TK-241-A-860
TK-241-A-861
TK-241-A-862
TK-241-A-863
TK-241-A-864
TK-241-A-865
TK-241-A-866
TK-241-A-867
TK-241-A-868
TK-241-A-869
TK-241-A-870
TK-241-A-871
TK-241-A-872
TK-241-A-873
TK-241-A-874
TK-241-A-875
TK-241-A-876
TK-241-A-877
TK-241-A-878
TK-241-A-879
TK-241-A-880
TK-241-A-881
TK-241-A-882
TK-241-A-883
TK-241-A-884
TK-241-A-885
TK-241-A-886
TK-241-A-887
TK-241-A-888
TK-241-A-889
TK-241-A-890
TK-241-A-891
TK-241-A-892
TK-241-A-893
TK-241-A-894
TK-241-A-895
TK-241-A-896
TK-241-A-897
TK-241-A-898
TK-241-A-899
TK-241-A-900
TK-241-A-901
TK-241-A-902
TK-241-A-903
TK-241-A-904
TK-241-A-905
TK-241-A-906
TK-241-A-907
TK-241-A-908
TK-241-A-909
TK-241-A-910
TK-241-A-911
TK-241-A-912
TK-241-A-913
TK-241-A-914
TK-241-A-915
TK-241-A-916
TK-241-A-917
TK-241-A-918
TK-241-A-919
TK-241-A-920
TK-241-A-921
TK-241-A-922
TK-241-A-923
TK-241-A-924
TK-241-A-925
TK-241-A-926
TK-241-A-927
TK-241-A-928
TK-241-A-929
TK-241-A-930
TK-241-A-931
TK-241-A-932
TK-241-A-933
TK-241-A-934
TK-241-A-935
TK-241-A-936
TK-241-A-937
TK-241-A-938
TK-241-A-939
TK-241-A-940
TK-241-A-941
TK-241-A-942
TK-241-A-943
TK-241-A-944
TK-241-A-945
TK-241-A-946
TK-241-A-947
TK-241-A-948
TK-241-A-949
TK-241-A-950
TK-241-A-951
TK-241-A-952
TK-241-A-953
TK-241-A-954
TK-241-A-955
TK-241-A-956
TK-241-A-957
TK-241-A-958
TK-241-A-959
TK-241-A-960
TK-241-A-961
TK-241-A-962
TK-241-A-963
TK-241-A-964
TK-241-A-965
TK-241-A-966
TK-241-A-967
TK-241-A-968
TK-241-A-969
TK-241-A-970
TK-241-A-971
TK-241-A-972
TK-241-A-973
TK-241-A-974
TK-241-A-975
TK-241-A-976
TK-241-A-977
TK-241-A-978
TK-241-A-979
TK-241-A-980
TK-241-A-981
TK-241-A-982
TK-241-A-983
TK-241-A-984
TK-241-A-985
TK-241-A-986
TK-241-A-987
TK-241-A-988
TK-241-A-989
TK-241-A-990
TK-241-A-991
TK-241-A-992
TK-241-A-993
TK-241-A-994
TK-241-A-995
TK-241-A-996
TK-241-A-997
TK-241-A-998
TK-241-A-999
TK-241-A-1000

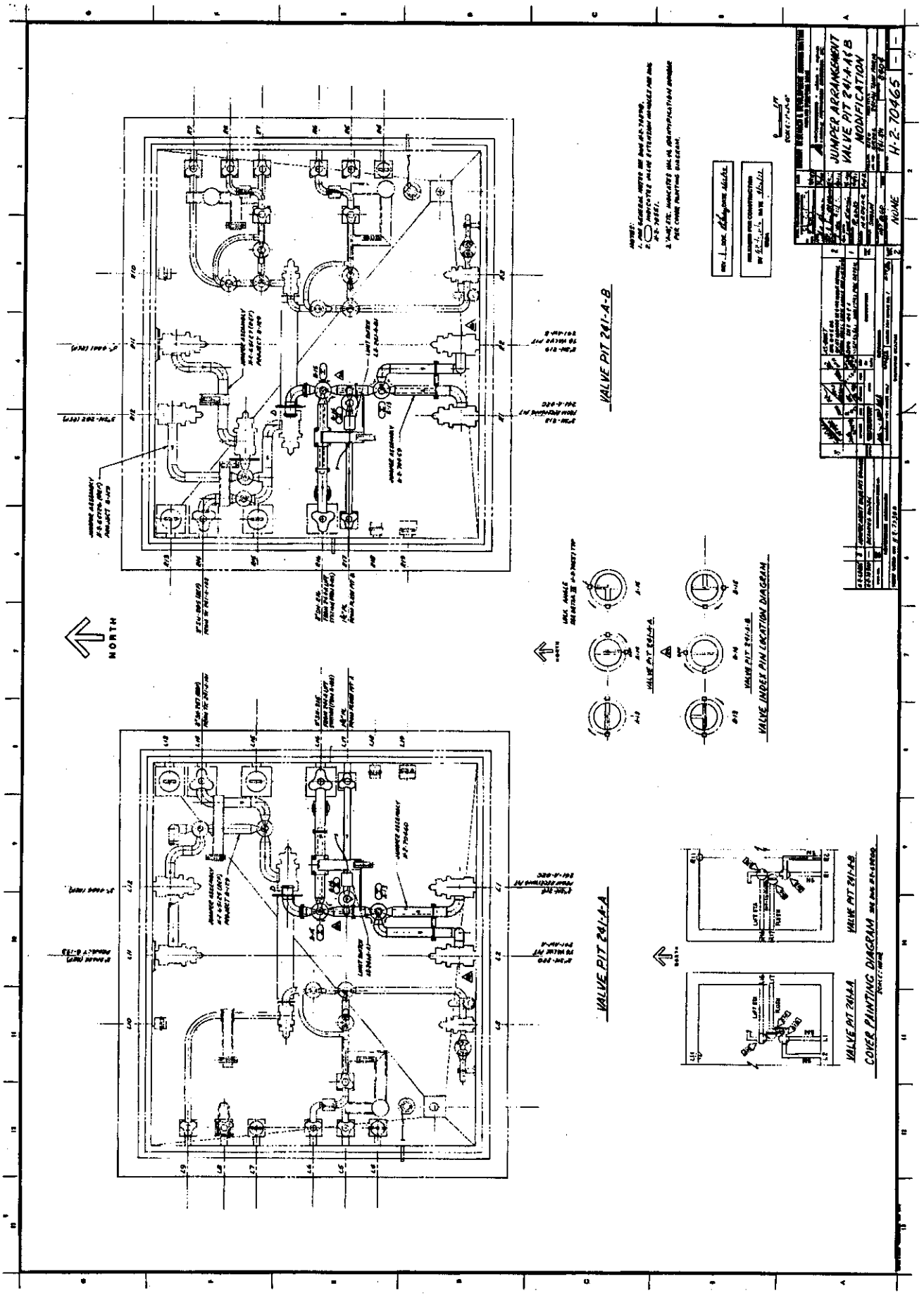
RPP. 6485 REV. 0





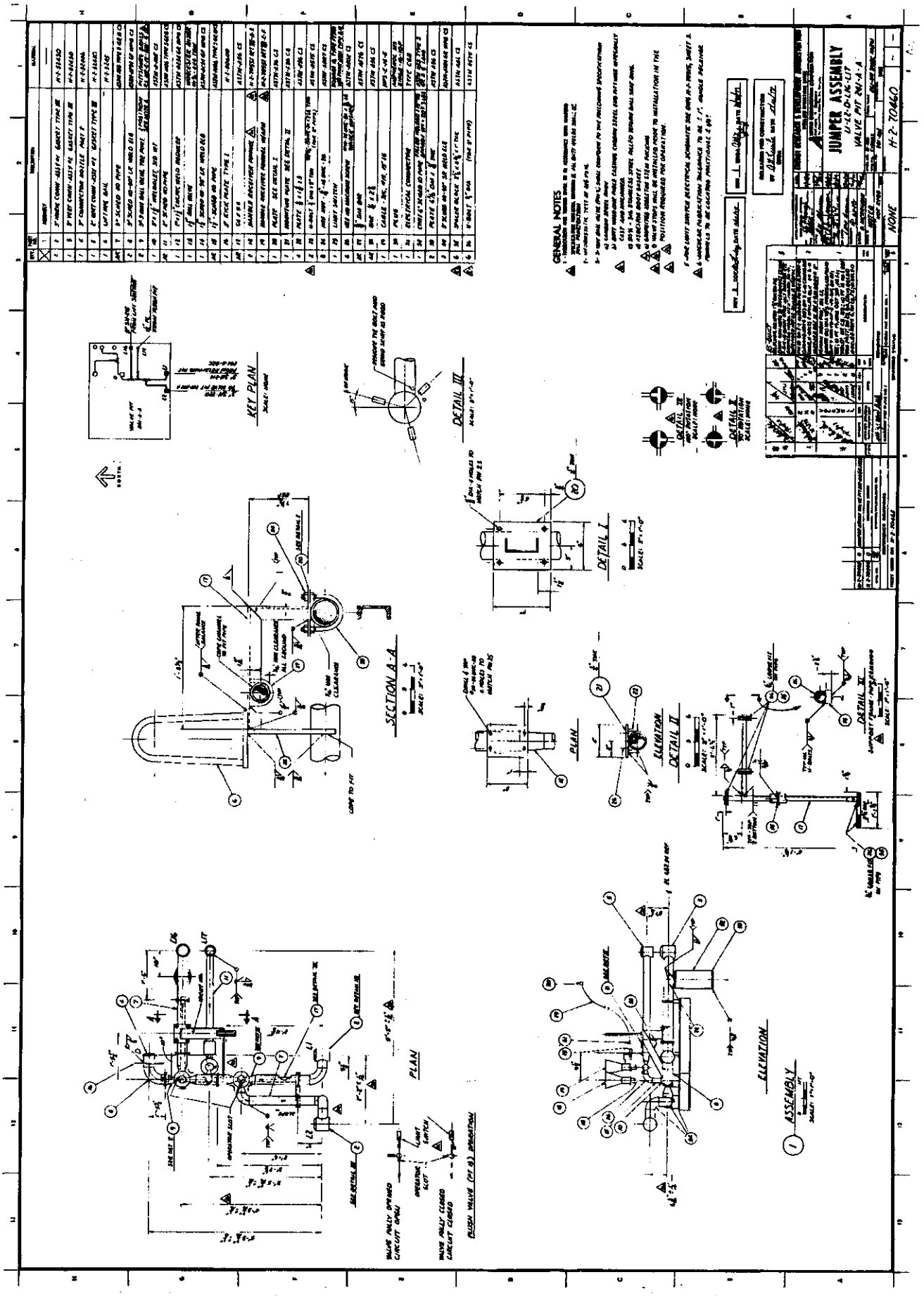
RPP-6481 Rev. 8





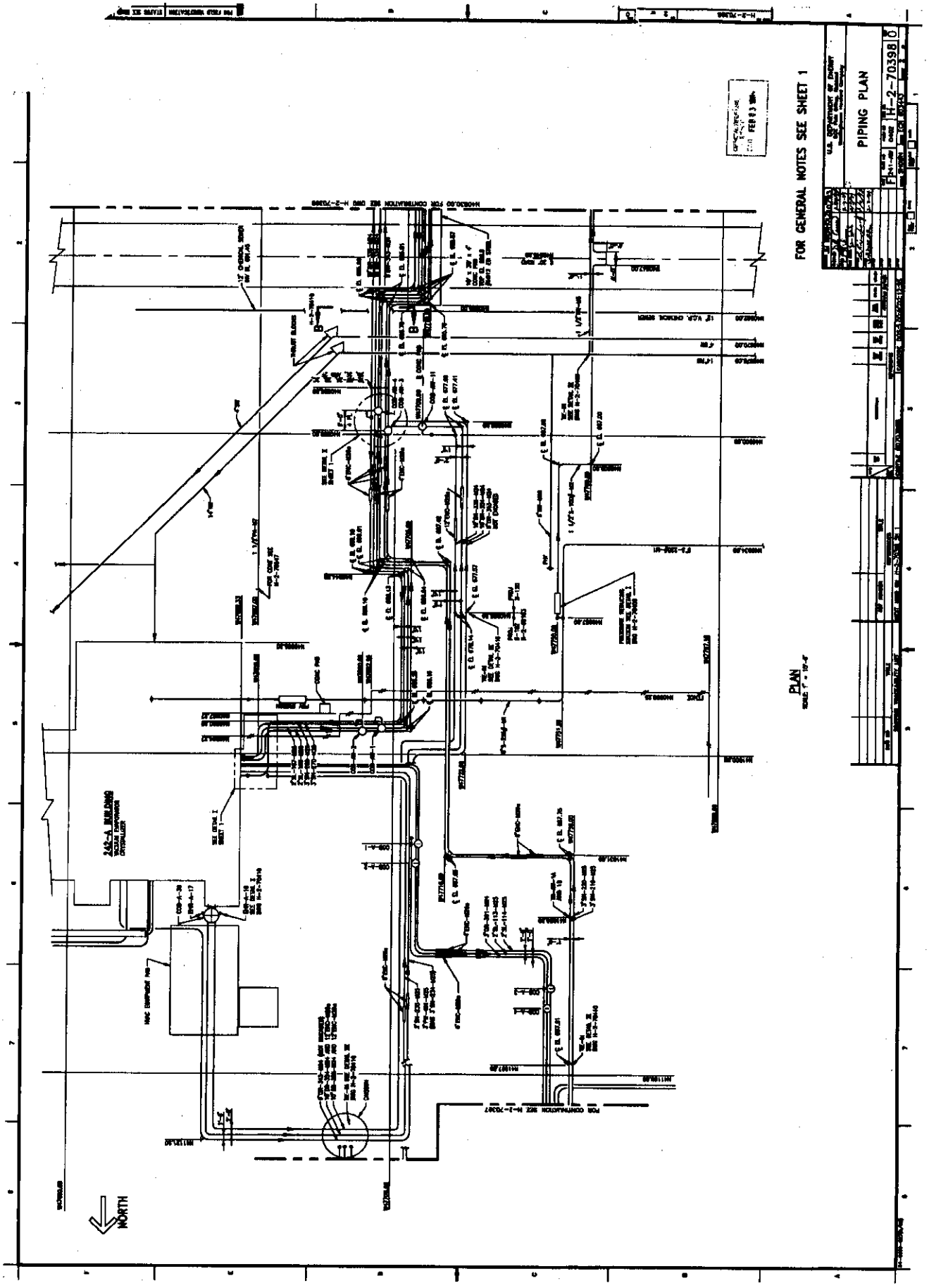
RPP-6485 Rev 0





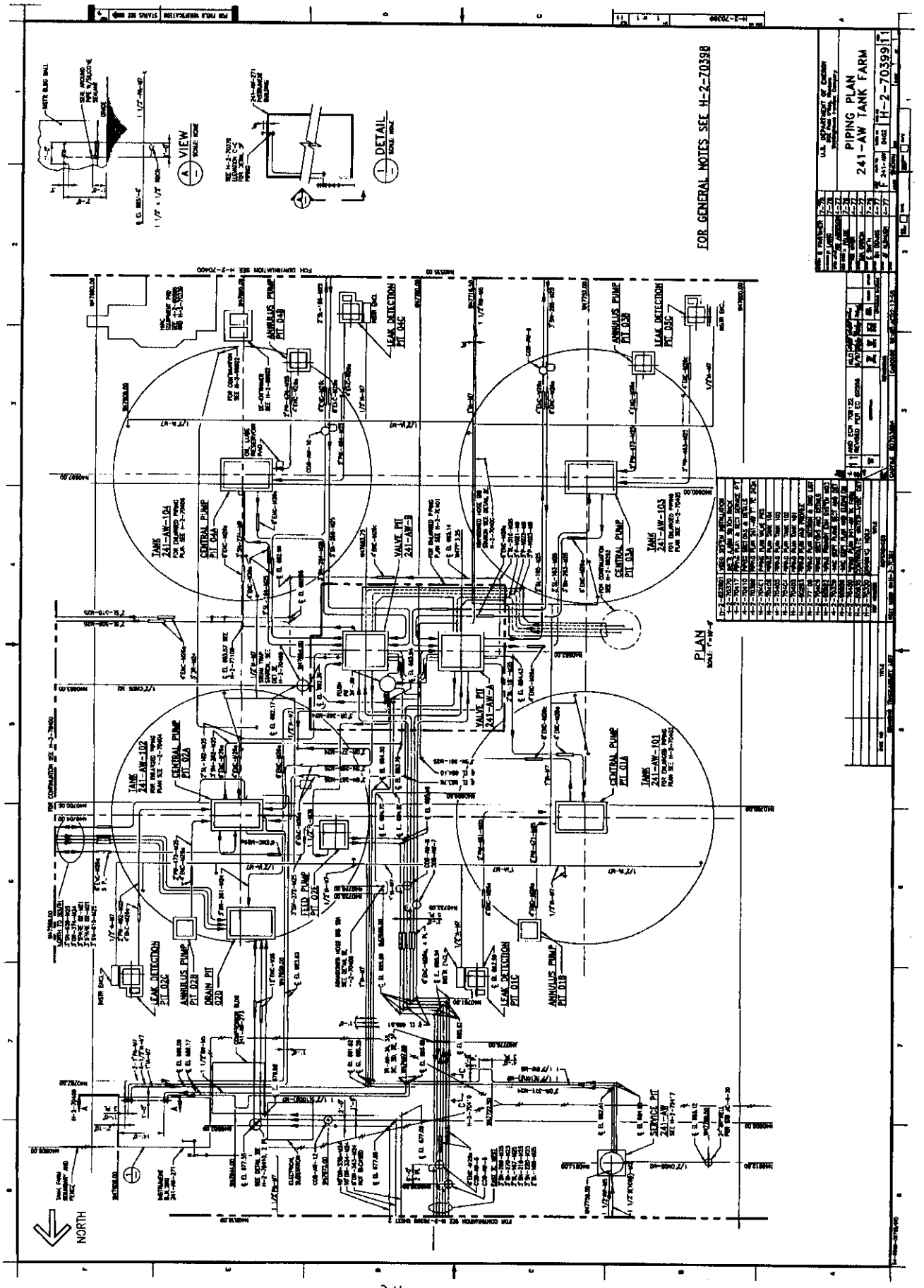
RPP-6485 Rev. 0





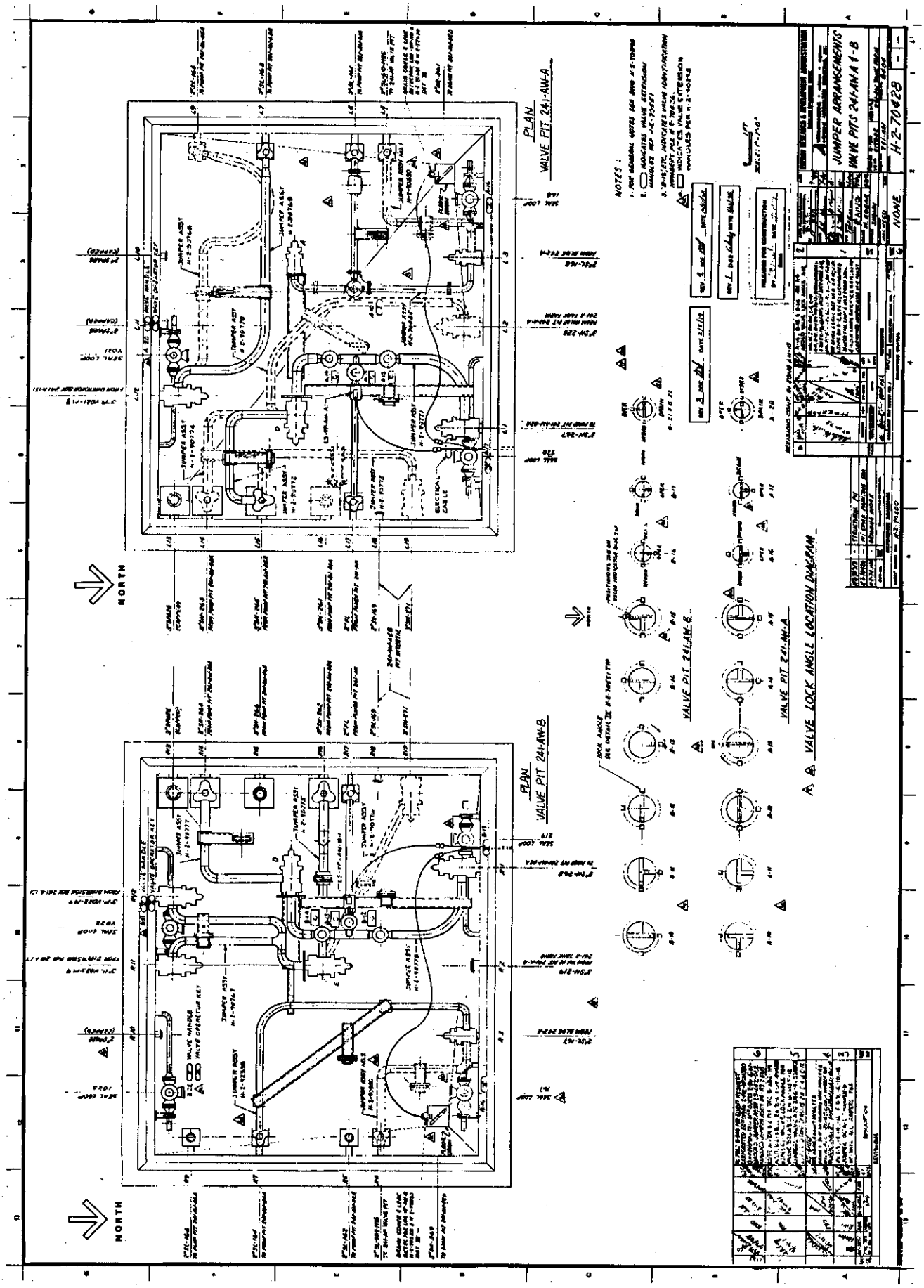
RPP-6485 Rev. 0





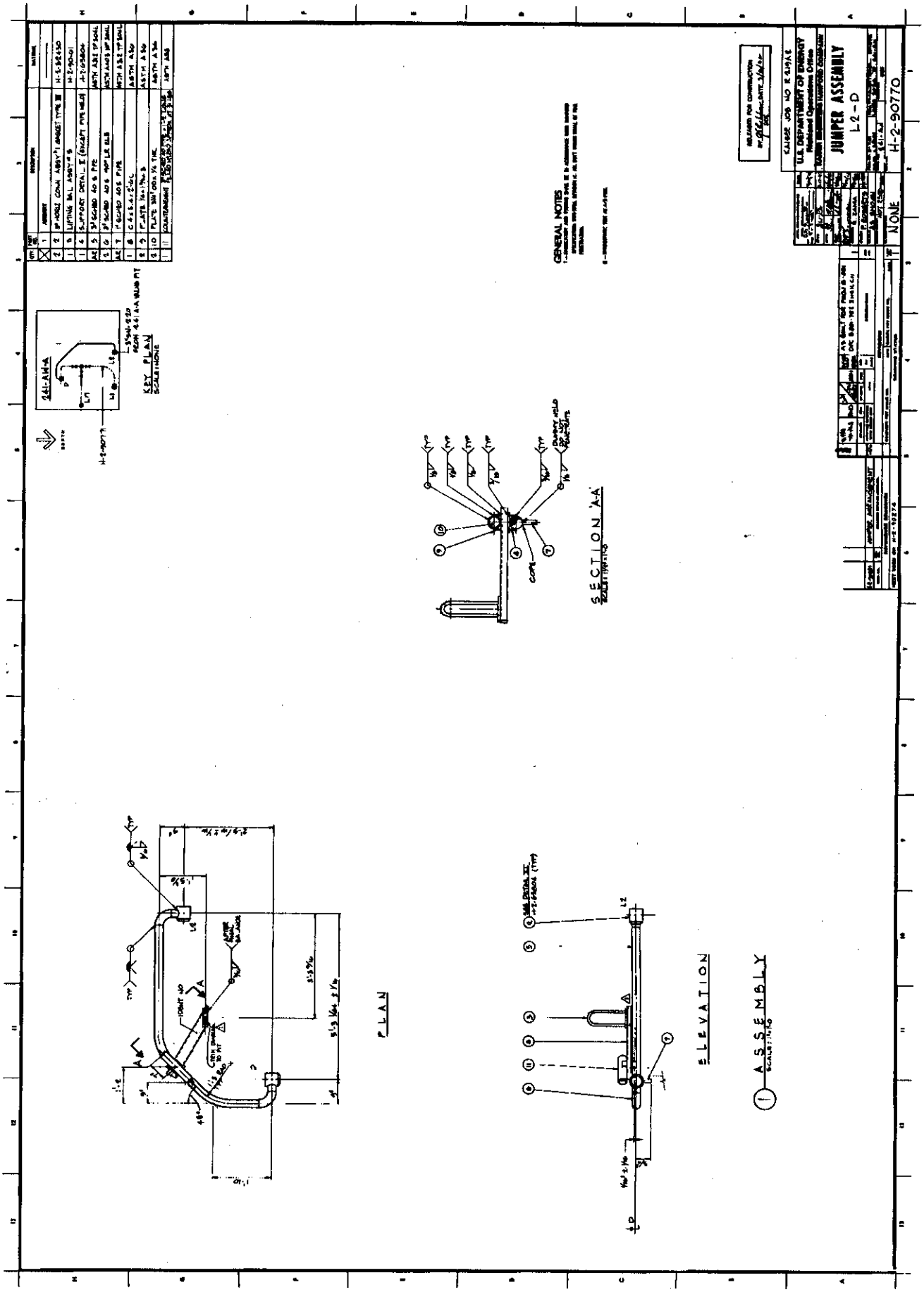
RPP-6485 Rev. 0





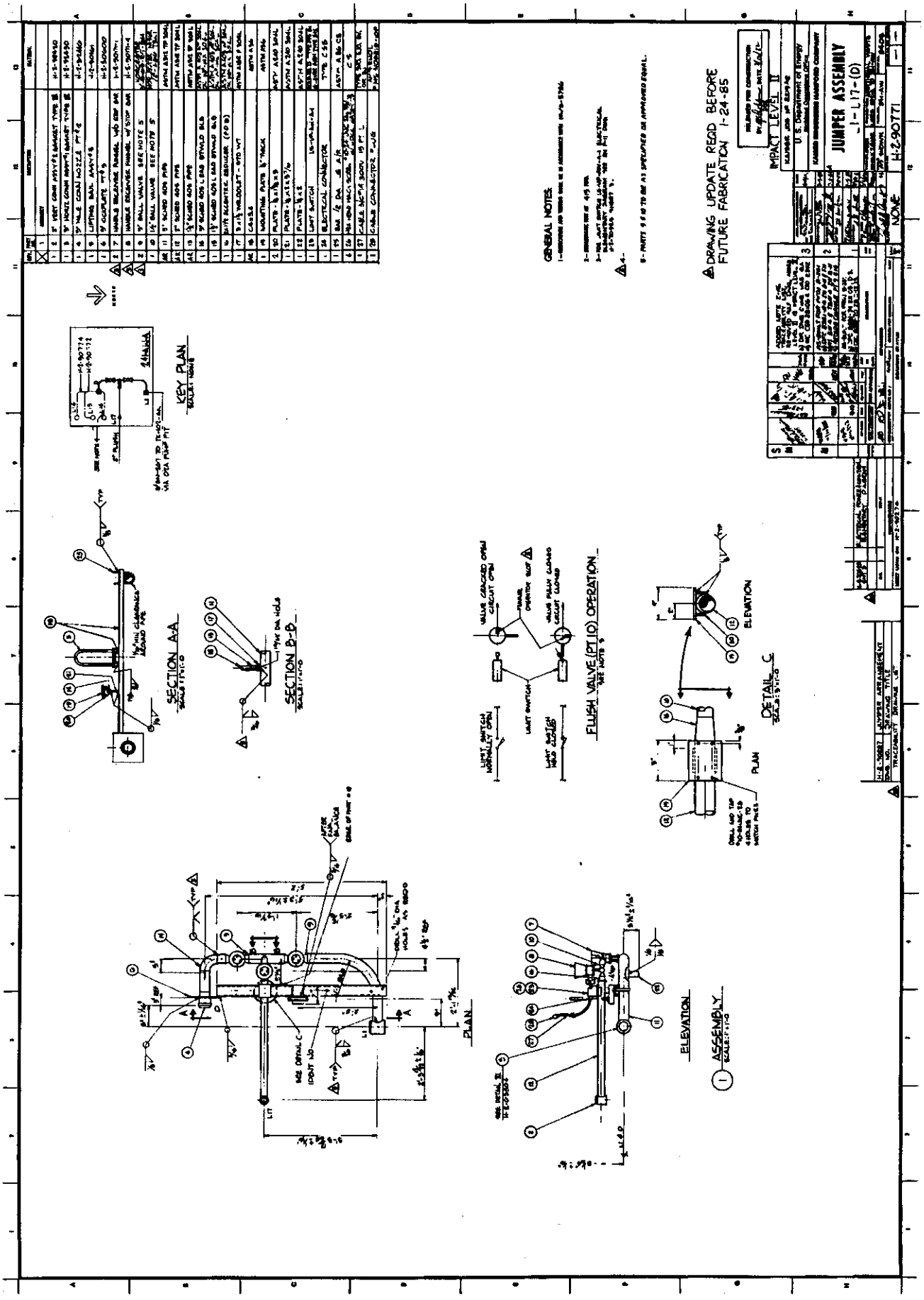
RPP-6485 Rev. 0





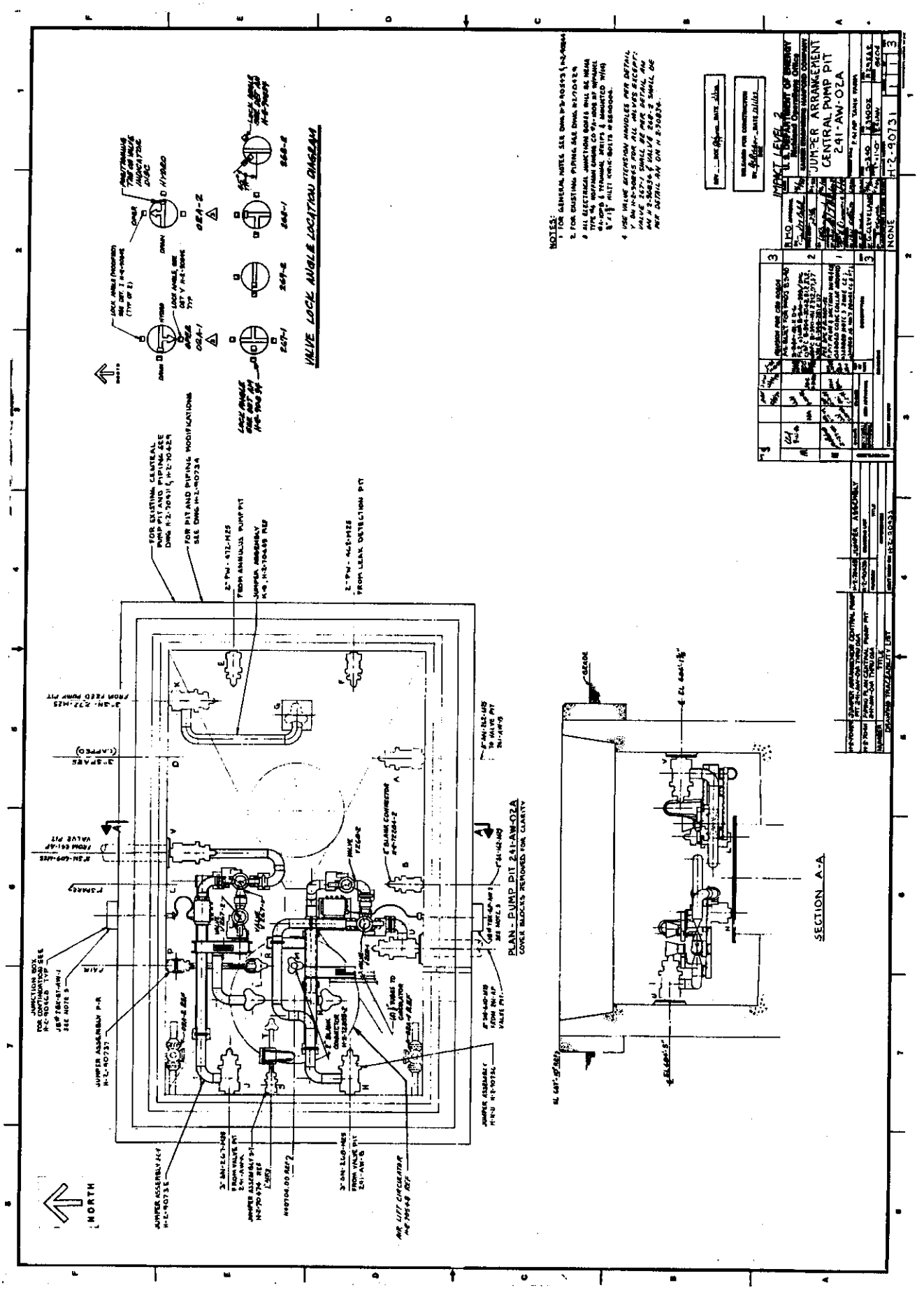
RPP-6485 Rev. 0



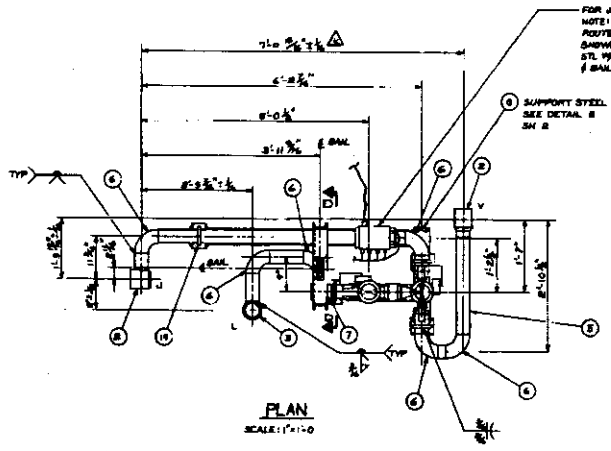


RPP-6485 Rev. 0

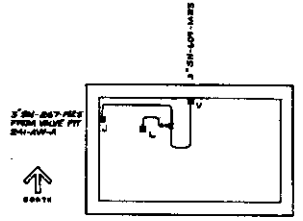




RPP-16485 Rev. 0




PLAN
SCALE: 1"=1'-0

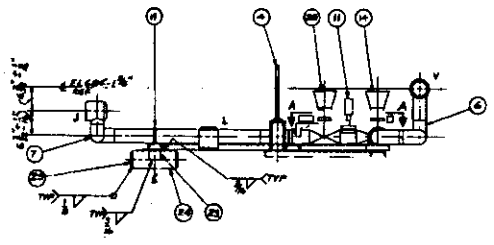



241 AW-02A
CENTRAL PUMP PIT

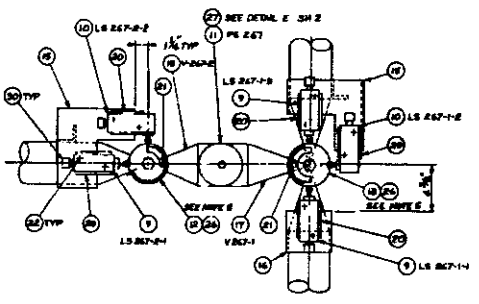
KEY PLAN
SCALE: NONE

| QTY | PN | DESCRIPTION | MATERIAL |
|---|---|---|---|
| X | 1 | ASSEMBLY | —— |
| 2 | 2 | 3" HORIZ CONN A36 #1 GASKET TYPE III | H-2-82430 |
| 1 | 3 | 3" VERT CONN A53 #2 GASKET TYPE III | H-2-82430 |
| 1 | 4 | LIFTING BAIL ASSEMBLY PT #5 | H-2-90161 |
| AR | 5 | PIPE 3" SCHED 40 | ASTM A53 TYPE S GR B |
| 7 | 6 | ELBOW 3" SCHED 40 90° LR BUTT WELD | ASTM A234 GR WPB |
| 2 | 7 | ELBOW 3" SCHED 40 90° SR BUTT WELD | ASTM A234 GR WPB |
| AR | 8 | CHANNEL C4X5.4 | ASTM A 36 |
| 3 | 9 | LIMIT SWITCH | SEE NOTE 3 & 8 |
| 2 | 10 | LIMIT SWITCH | SEE NOTE 3 & 8 |
| 1 | 11 | PRESSURE SWITCH ASSEMBLY | SEE PROCUREMENT SPEC. B 260-P1 |
| 1 | 12 | LIMIT SWITCH ACTUATOR DET B | H-2-90852 |
| 1 | 13 | LIMIT SWITCH ACTUATOR DET C | H-2-90852 |
| 1 | 14 | VALVE FUNNEL DET X1 | H-2-90852 |
| 2 | 15 | LIMIT SWITCH MTG BRKT DET J | H-2-90852 |
| 1 | 16 | LIMIT SWITCH MTG BRKT DET T | H-2-90853 |
| 1 | 17 | 3" 3-WAY BALL VALVE, SEE NOTE #4 | PYC-[illegible] |
| 1 | 18 | 3" 2-WAY BALL VALVE, SEE NOTE #4 | PYC-[illegible] |
| 4 | 19 | U-BOLT 1/2" DIA FOR 3" PIPE | ASTM A36 |
| 5 | 20 | LIMIT SWITCH MTG PLATE DET L | H-2-90852 |
| 2 | 21 | STOP PIN DET X | H-2-90853 |
| 10 | 22 | ALLEN CAP SCREW 10-32 X 1/2" LG W/ 1/2" IND LG | ASTM-A193 GR B8 SS 300 SRT |
| 1 | 23 | SUPPORT DETAIL 3CC | H-2-83804 |
| 1 | 24 | COUNTERWEIGHT 4" SCHED 40 PIPE X 12" LONG FILLED W/ LEAD APPROX WT 72 LB | ASTM A53 [illegible] TYPE S GR B / [illegible] |
| 2 | 25 | PLATE 1/4" X 4 1/2" DIA | ASTM A36 |
| 2 | 26 | PIPE SEGMENT DET D | H-2-90852 |
| 1 | 27 | CGB FITTING | CROSSE-HINDS 9 CGB-252 |
| 1 | 28 | VALVE FUNNEL DET X5 | H-2-90852 |
| AR | 29 | WORM SCREW CLAMP | SST |
| 5 | 30 | CGB FITTING | CROSSE-HINDS 9 CGB-252 |

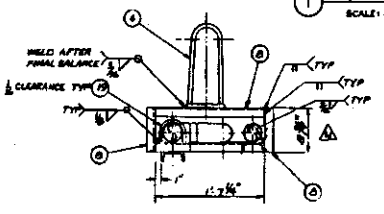
CONTINUTED ON SHT 2



ELEVATION
ASSEMBLY
SCALE: 1"=1'-0"




SECTION A-A
SCALE: NONE




SECTION D-D
SCALE: 1 1/2"=1'-0"

## GENERAL NOTES:

1. FABRICATION & TESTING SHALL BE IN ACCORDANCE WITH HANFORD SPECIFICATION HNF-5795 REV 12, OR CURRENT REVISION
2. HYDROSTATIC TEST AT 600 PSIG.
3. LIMIT SWITCH PN 9 SHALL BE SQUARE-D TYPE C, AND SHALL WITH TYPE 9007 CS4D TOP POWER PLUNGER, LIMIT SWITCH PN 10 TO BE SAME AS ABOVE EXCEPT WITH TYPE 9007 CS4F SIDE POWER PLUNGER.
4. 2-WAY AND 3-WAY BALL VALVES PN 17 & 18 SHALL CONFORM TO THE FOLLOWING SPECIFICATIONS.
   a) CARBON STEEL BODY
   b) BUTTWELD ONE PIECE CASTING CARBON STEEL END FITTINGS
   c) 80 PERCENT, 316 STAINLESS STEEL FILLED TEFLON BALL SEAT RINGS
   d) ANSI 150 BODY GASKET (SPIRALS)
   e) GRAPHITEX ASBESTOS STEM PACKING
   f) DRAIN HANDLE
   g) GLASS FILLED TEFLON BODY FILLER- PT 18 ONLY
   h) DRILL TAP VALVES TO ACCEPT FITTING MOTOR ACTUATORS.
5. FOR VALVE FUNNEL ASSEMBLY INSTRUCTIONS SEE DETAIL (A) H-2-90853

CONTINUTED ON SHEET 2

RELEASED FOR CONSTRUCTION
BY [illegible] DATE [illegible]

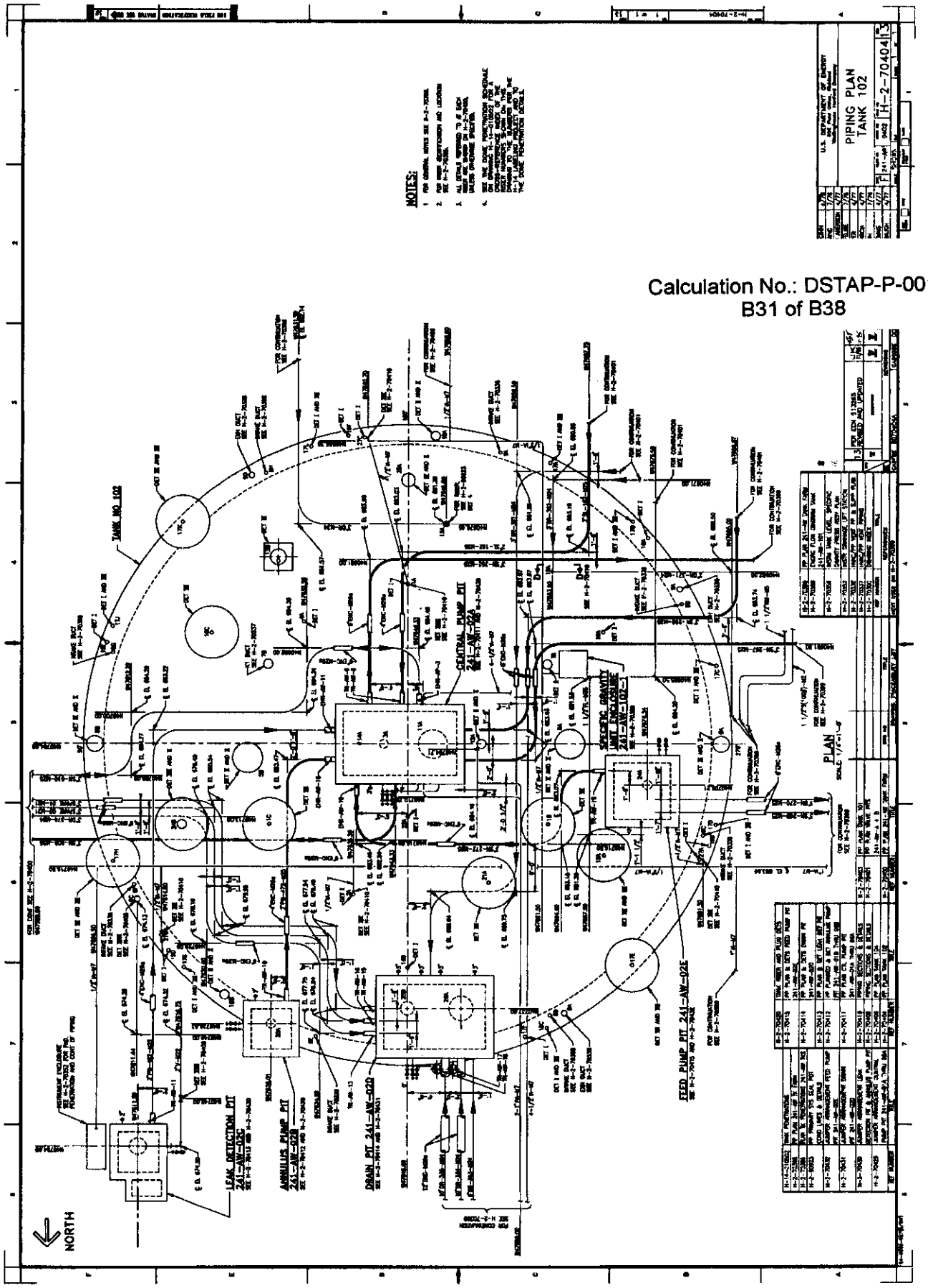
U. S. DEPARTMENT OF ENERGY
Richland Operations Office
KAISER ENGINEERS HANFORD COMPANY

JUMPER ASSEMBLY
J-L-V
241-AW-02A

241-AP TANK FARM

B-340 | 2 94406 | PURVIS
241-AW | B-340

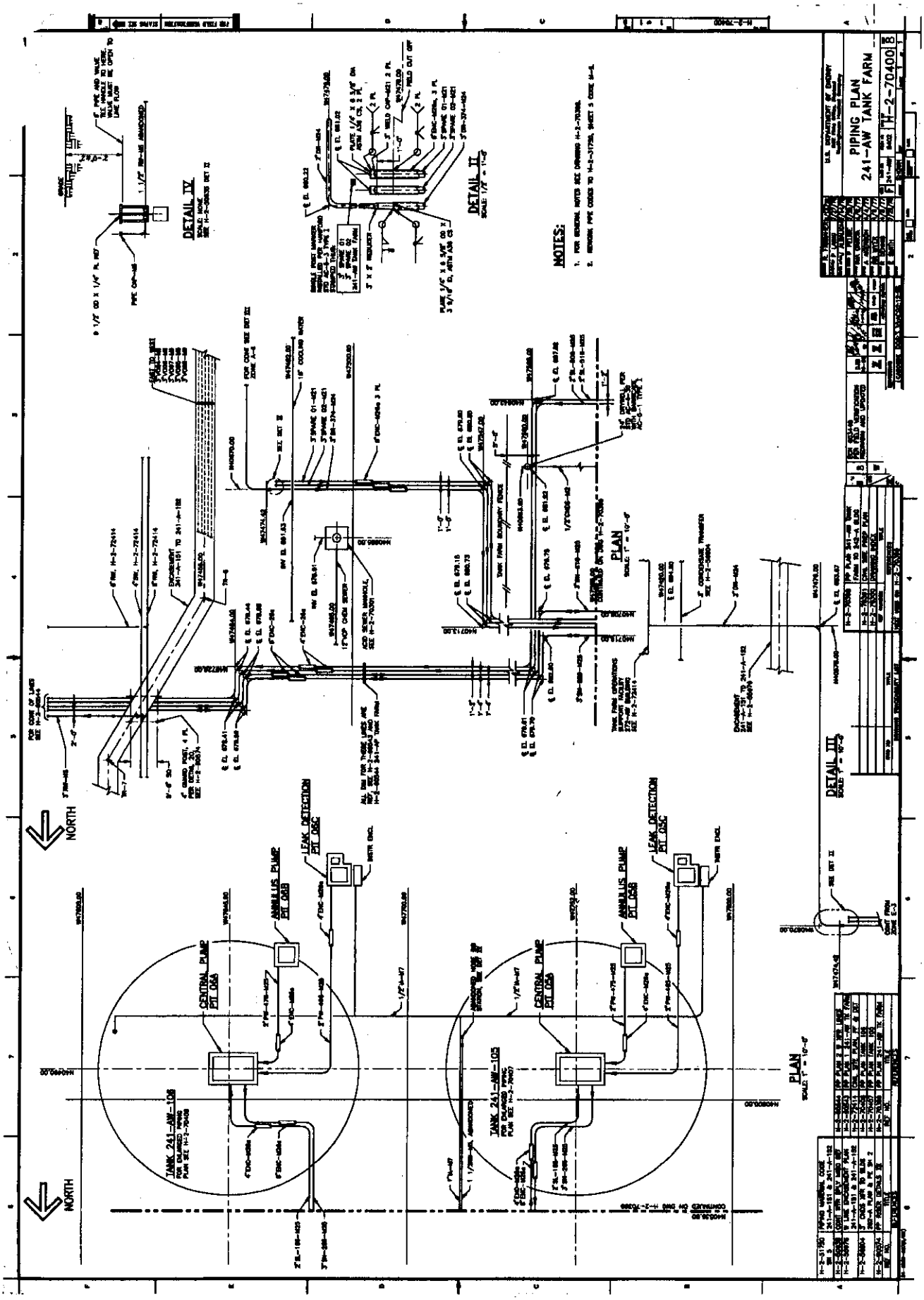
NONE | H-2-90735 | 1 | 3 | 1




Calculation No.: DSTAP-P-001
B31 of B38

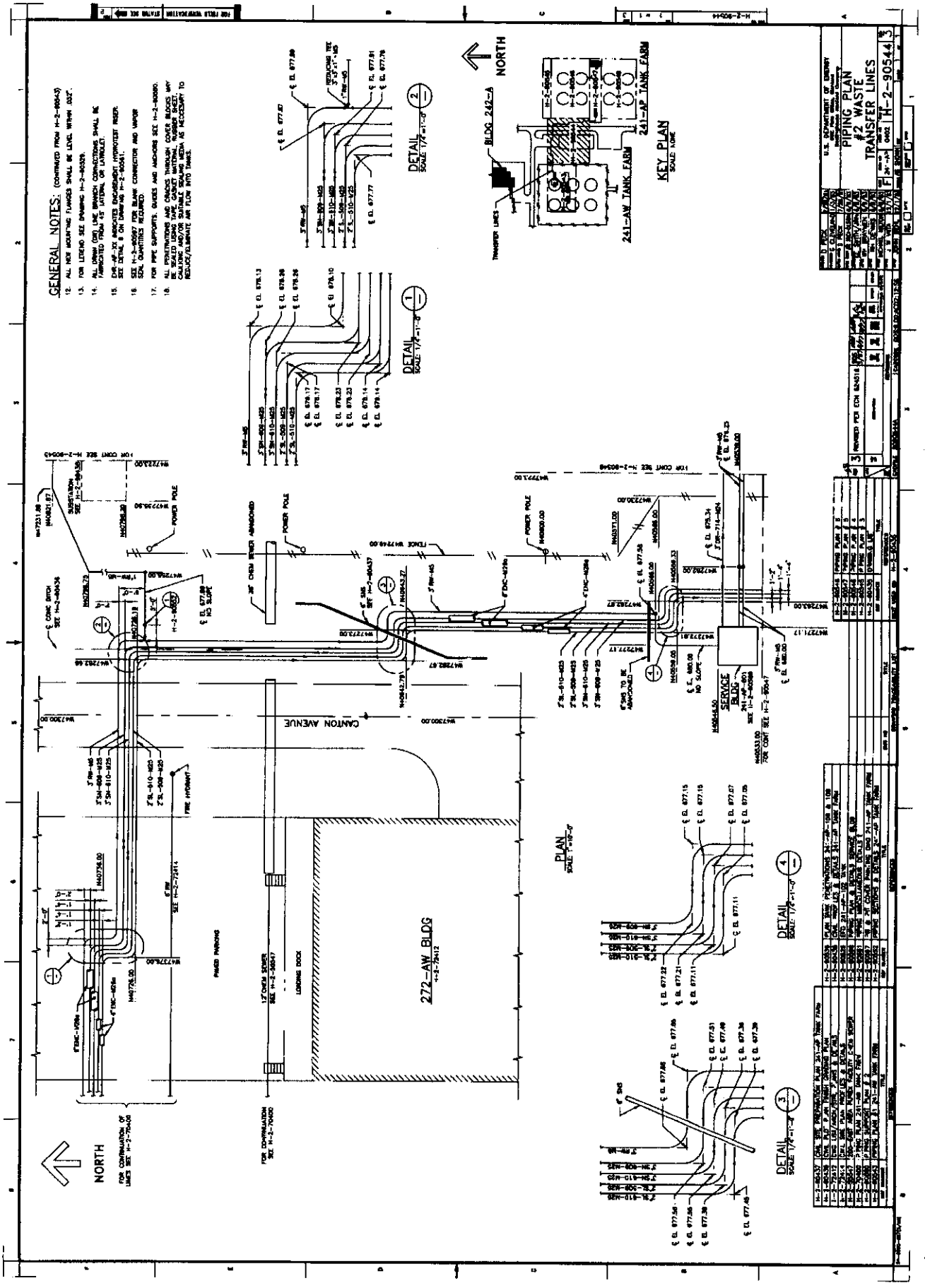
RPP-6485 Rev. 0

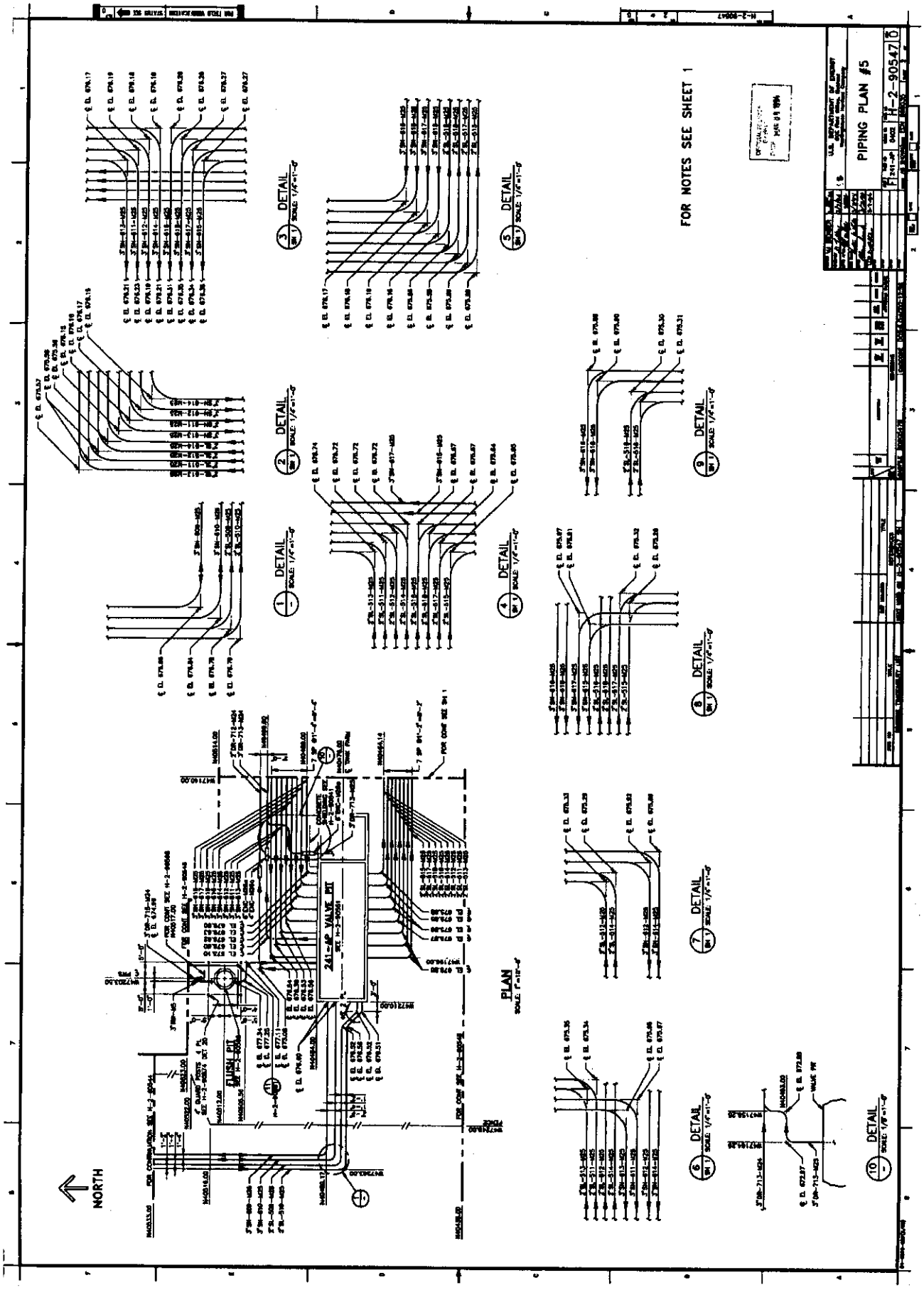


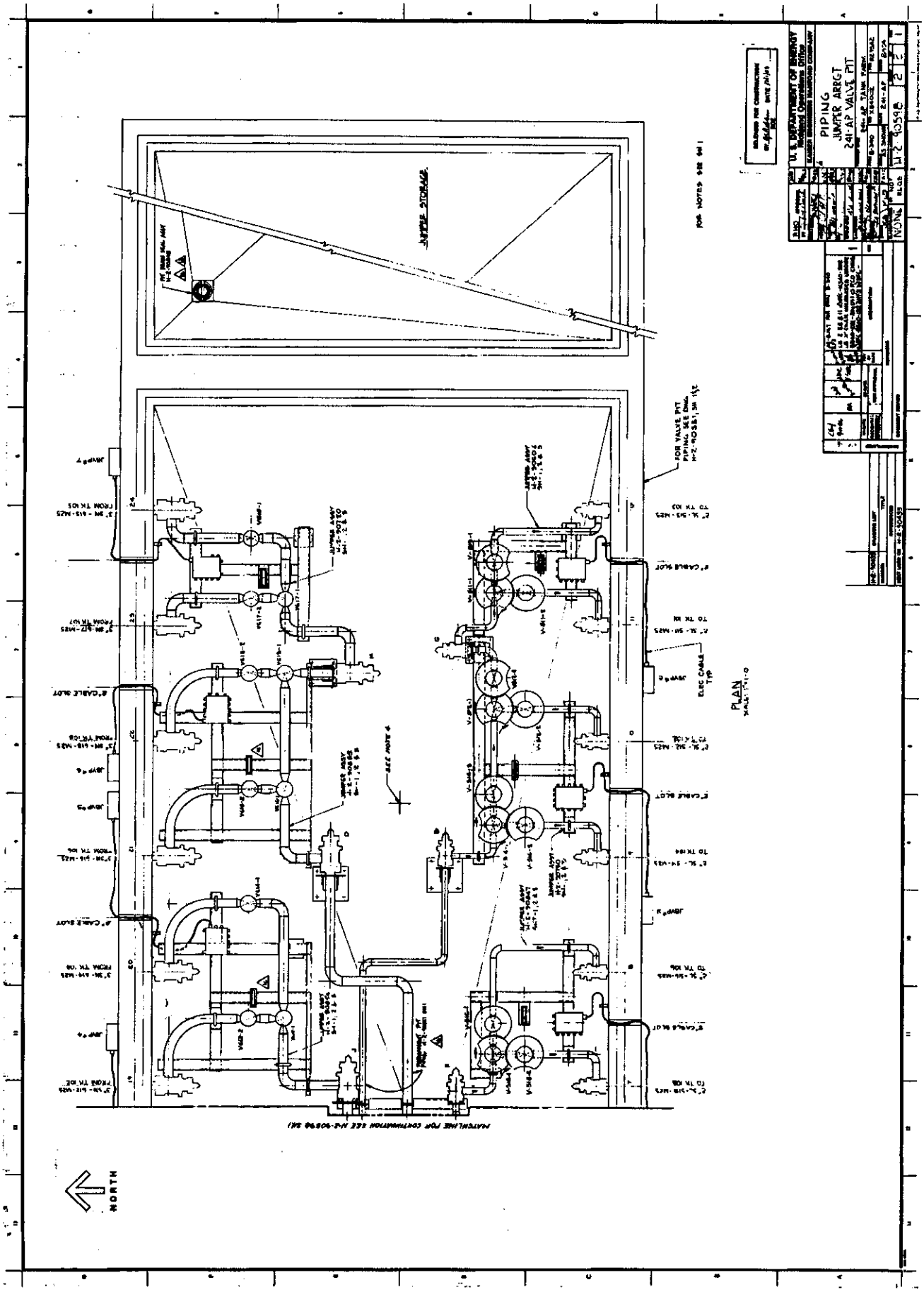


RPP-6485 Rev. 0



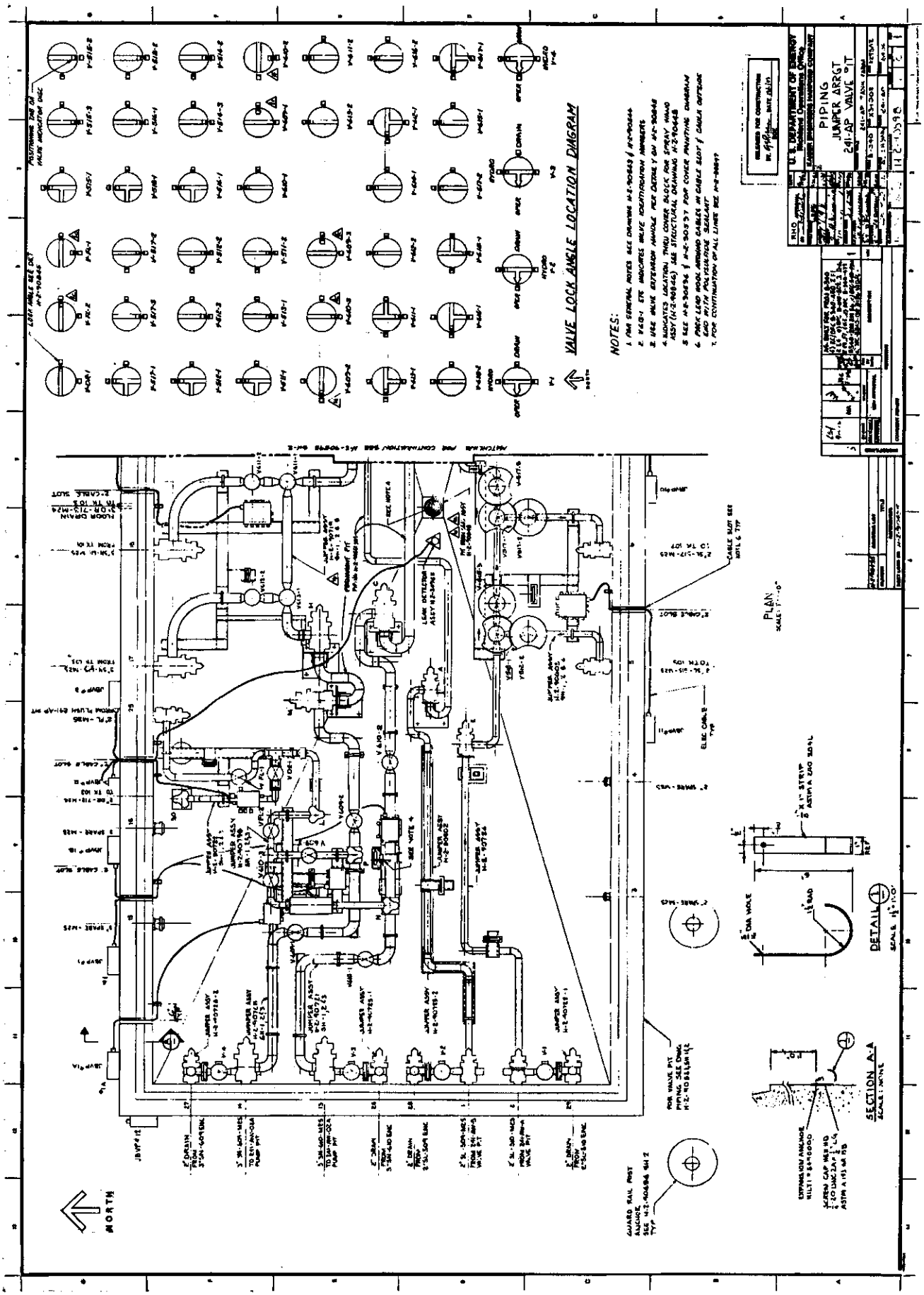


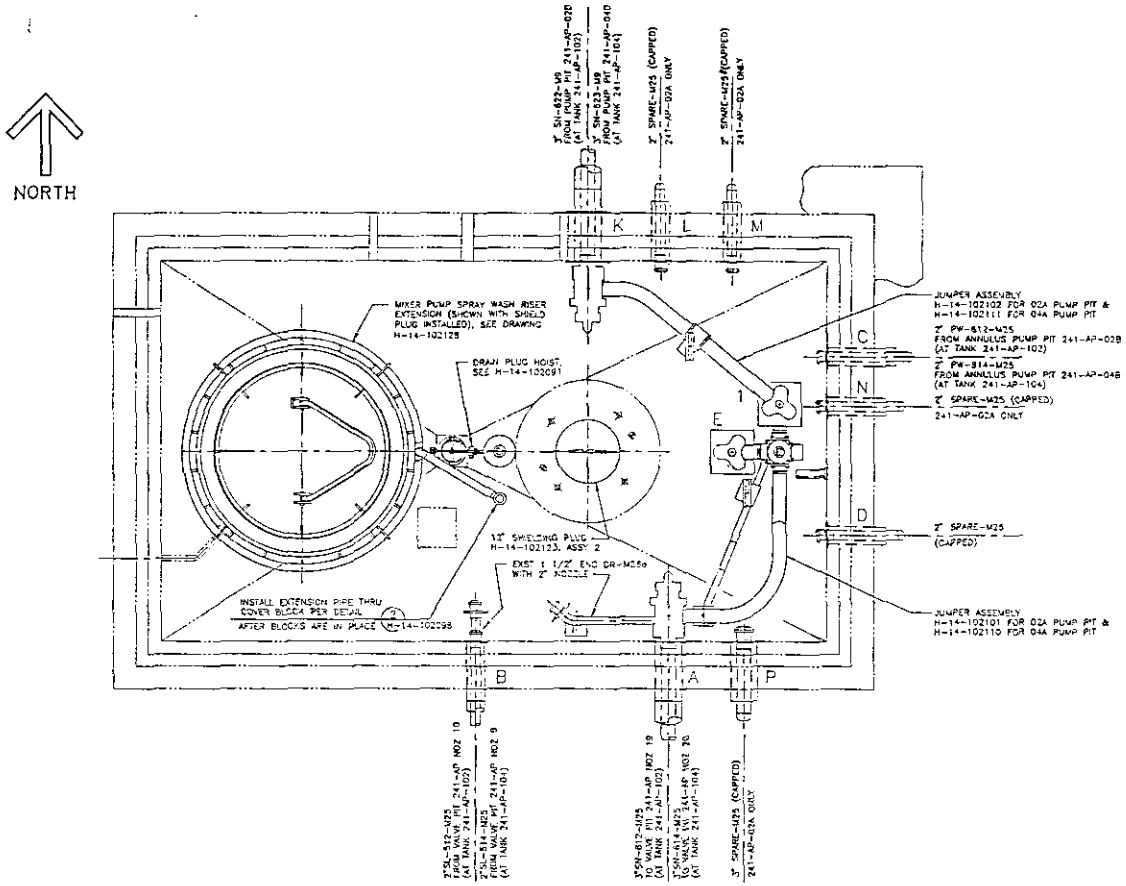

FOR NOTES SEE SHEET 1
PIPING PLAN #5
H-2-905470
DETAIL
PLAN
241-AP VALVE PIT
FLUSH PIT
NORTH


U.S. DEPARTMENT OF ENERGY
Richland Operations Office
PIPING
JUMPER ARRGT
241-AP VALVE PIT
PLAN
NORTH
JUMPER STORAGE
FOR NOTES SEE H-1
FOR VALVE PIT PIPING SEE DWG. H-2-90551, SH 1/2
ELEC CABLE TYP
SEE NOTE 4
MATCHLINE FOR CONTINUATION SEE H-2-90596 SH1

RPP-6485 Rev. 0








PLAN
CENTRAL PUMP PIT
241-AP-02A & 04A (SHOWN WITH COVER BLOCKS REMOVED)

GENERAL NOTES:

1. FOR COVER BLOCK PAINTING DIAGRAM SEE H-14-102099.
2. THE FOLLOWING SEQUENCE IS RECOMMENDED FOR JUMPER INSTALLATION: 1st JUMPER ASS'Y H-14-102101 OR H-14-102110
   2nd JUMPER ASS'Y H-14-102102 OR H-14-102111
3. FOR EXISTING NOZZLE "AS-BUILT" LOCATIONS SEE DRAWING H-2-90562.
4. FOR NEW NOZZLE K "AS-BUILT" LOCATION SEE DRAWING H-14-102091.

| DWG NO | TITLE | REFERENCES | NEXT USED ON |
|---|---|---|---|
| H-2-92599 | JUMPER ARRANGEMENT CENTRAL PUMP PIT 241-AP-02A THRU 04A | H-14-102054 DRAWING LIST & AREA MAP | |
| | | REF NUMBER / TITLE | |

DRAWING TRACEABILITY LIST

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
FLUOR DANIEL NORTHWEST, INC.

JUMPER ARRANGEMENT
PUMP PITS
241-AP-02A & 04A

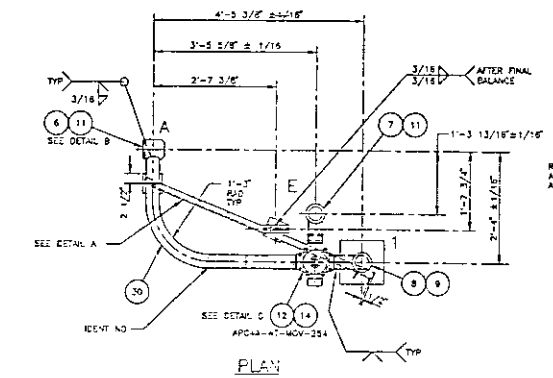
H-14-102096 0

2 PLOT SCALE 1=12

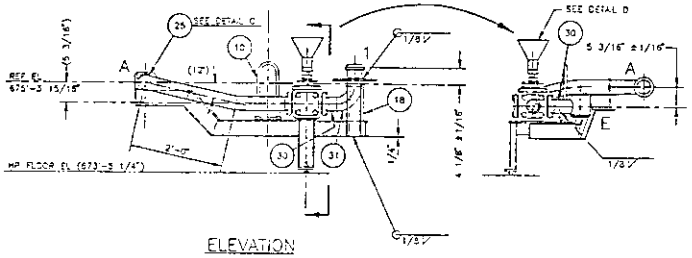
Calculation No.: DSTAP-P-001
B37 of B38

223

RPP-6485 Rev. 0

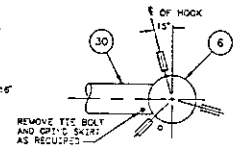



PLAN

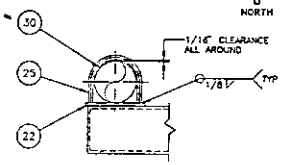



ELEVATION

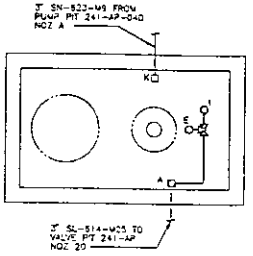
1 ASSEMBLY
SCALE: 1" = 1'-0"




DETAIL B
SCALE: NONE

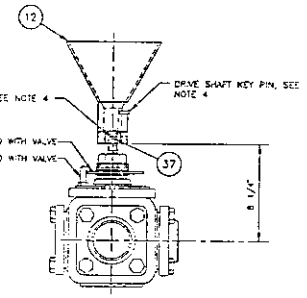



DETAIL C
SCALE: 3" = 1'-0"

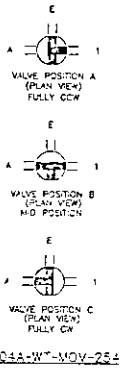



PUMP PIT 241-AP-04A

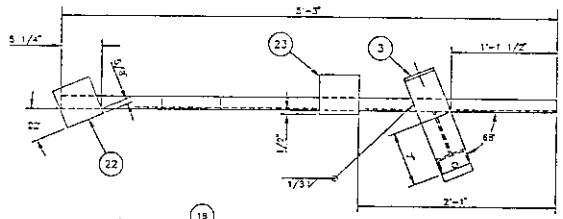
KEY PLAN
SCALE: NONE



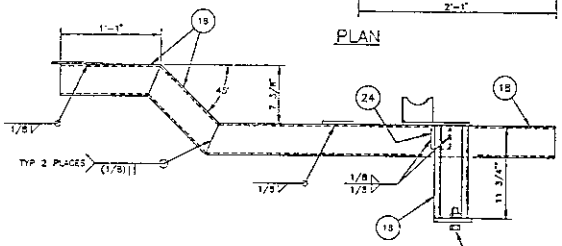

DETAIL D
SCALE: NONE




AP04A-W"-MOV-254

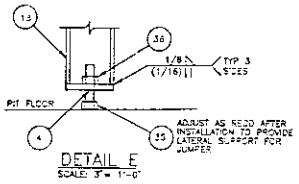



PLAN

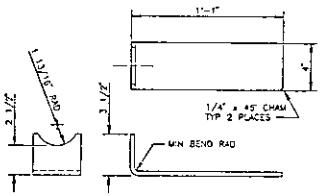



ELEVATION

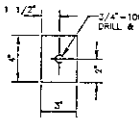
DETAIL A
SCALE: 2" = 1'-0"




DETAIL E
SCALE: 3" = 1'-0"




3 ATTACHMENT
SCALE: 3" = 1'-0"
MATL: 3/8" THICK




4 PLATE
SCALE: 3" = 1'-0"
MATL: 1/2" THICK

PARTS/MATERIAL LIST

| QTY REQD | PART/CASH NUMBER | NOMENCLATURE/DESCRIPTION | MATERIAL/REFERENCE | SHT | ITEM NO. |
|---|---|---|---|---|---|
| | -010 | ASSEMBLY | | | 1 |
| | | | | | 2 |
| 1 | -001 | ATTACHMENT | ASTM A 240 TP 304L | | 3 |
| 1 | -002 | PLATE | ASTM A 36 | | 4 |
| | | | | | 5 |
| 1 | H-2-32430-1 | CONN, HORZ 3" | | | 6 |
| 1 | H-2-32430-2 | CONN, VERT 3" | | | 7 |
| 1 | H-2-95135-2 | CONN, NOZ 3" MALE | | | 8 |
| 1 | H-2-30602-5 | KICKOFF PLATE 3" SQUARE | | | 9 |
| 1 | H-2-93181-5 | LIFTING BAIL | | | 10 |
| 2 | H-2-3337-7 | GASKET 3" TYPE H | | | 11 |
| 1 | H-14-102122-1 | FUNNEL ASSY | | | 12 |
| | | | | | 13 |
| 1 | AP04A-W"-MOV-254 | BALL VALVE, 3" 3 WAY | SEE SPECIFICATION W-211-AP2A-01, SEC 13410 | | 14 |
| | | | | | 15 |
| | | | | | 16 |
| | | | | | 17 |
| AR | | CHANNEL C4 x 5.4 | ASTM A 36 | | 18 |
| | | | | | 19 |
| | | | | | 20 |
| | | | | | 21 |
| 1 | | PLATE 5" x 1/4" x 5" | ASTM A 36 | | 22 |
| 1 | | PLATE 5" x 3/8" x 5" | ASTM A 36 | | 23 |
| 1 | | PLATE 3" x 1/4" x 5 3/4" | ASTM A 36 | | 24 |
| AR | | BAR, 3/8" DIA | ASTM A 36 | | 25 |
| | | | | | 26 |
| | | | | | 27 |
| | | | | | 28 |
| | | | | | 29 |
| AR | | PIPE, 3" SCHED 40S | ASTM A312 GR TP 304L | | 30 |
| 1 | | ELBOW, 3" SCHED 40S 90° LR BW | ASTM A403 WP-S 304L | | 31 |
| | | | | | 32 |
| | | | | | 33 |
| | | | | | 34 |
| 1 | | SCRW, HEX HD 3/4-10 UNC-2A x 2" L | ANSI B18.2.1, C5 | | 35 |
| 1 | | HEX NUT, 3/4-10 UNC-2B | ANSI B18.2.2, C3 | | 36 |
| 1 | | PIN, 1/4" DIA x 2 1/2" L SHEAR-PROOF | DRIVE-LOK | | 37 |

GENERAL NOTES:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH CONSTRUCTION SPECIFICATION, W-211-AP2A-01, SECTION 15437 APPENDIX A, JUMPER FABRICATION UNLESS OTHERWISE NOTED ON THIS DWG.
2. HYDROSTATIC TEST SHALL BE AT 600 PSIG.
3. JUMPER WEIGHT IS APPROXIMATELY 450 LB
4. FUNNEL (ITEM 12) INSTALLATION:

STEP 1- TURN THE VALVE TO POSITION "A" AND CHECK FOR BALL TO PORT ALIGNMENT.

STEP 2- SCREW THE FUNNEL ONTO THE VALVE STEM, DOWN TO THE DIMENSION SHOWN. ALIGN THE FUNNEL'S KEY PIN WITH THE CENTER (BRANCH) PORT IN THE BALL.

STEP 3- SELECT THE 1/4" HOLE IN THE FUNNEL THAT ALIGNS ITS SELF WITH THE FULL THICKNESS OF THE VALVE'S STEM. USE THE HOLE FOR MATCH DRILLING THRU THE STEM AND BACK SIDE OF THE FUNNEL. DO NOT DRILL THRU THE FLAT OF THE STEM

STEP 4- INSTALL THE DRIVE-LOK PIN (ITEM 37)

| DWG NO | TITLE |
|---|---|
| DRAWING TRACEABILITY LIST | |

| REF NUMBER | TITLE |
|---|---|
| H-14-102054 | DRAWING LIST & AREA MAP |
| REFERENCES | |
| NEXT USED ON H-14-102096 | |

CADFILE H102110A

U.S. DEPARTMENT OF ENERGY
Richland Operations Office
FLUOR DANIEL NORTHWEST, INC.

JUMPER ASSEMBLY
AP04A-A-E-(1)
PUMP PIT 241-AP-04A

W-211, INITIAL TANK RETRIEVAL SYSTEMS

H-14-102110 0

CONSTRUCTION

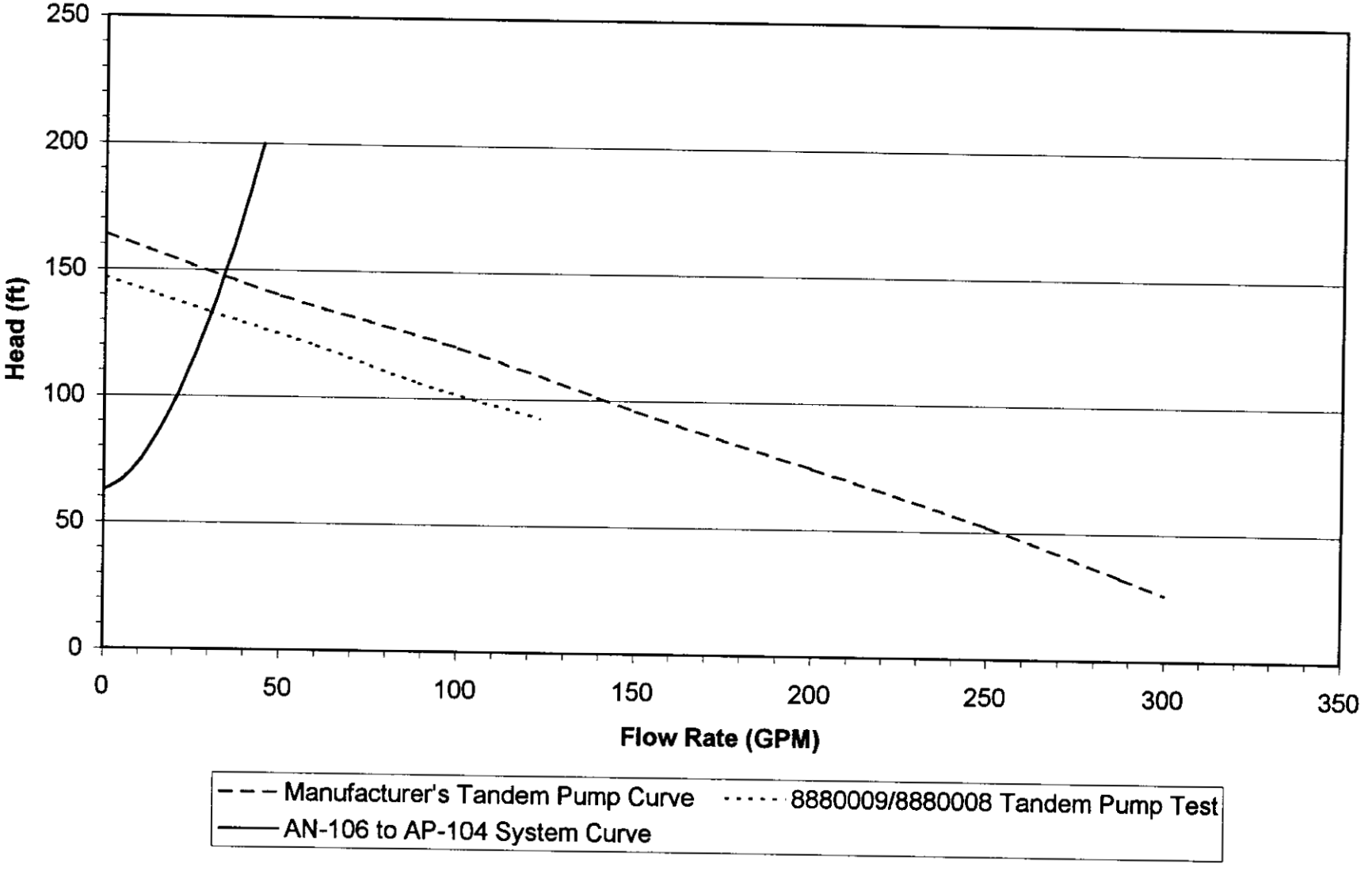
SCALE: 1=10

Calculation No.: DSTAP-P-001
B38 of B38

RPP-6485 Rev. 0

224

# AN-106 to AP-104 System and Pump Curves



| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX | Page: i of ii<br>Date: 03/24/00 |
|---|---|---|

This sheet shows the status and description of the attached Design Analysis sheets

Discipline: 454 Project/Area/Unit: 65100541/25/9 Calculation No.: DSTAP-P-002

Project No. & Name: Double Shell Tank Annulus Pumping

Calculation Item: Annulus Jumper Orifice Design

These calculations apply to:

Drawing No.: N/A Rev. No:

Drawing No.: Rev. No:

Other (Study, CDR): Rev. No.

The status of these calculations is:

[] Preliminary Calculations

[X] Final Calculations

[] Check Calculations (On Calculation Dated )

[] Void Calculation (Reason Voided )

Incorporated in Final Drawings? [X] Yes [] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | Paul M. Doak 3/24/00 | | |
| Checked by | [illegible] 4/13/00 | | |
| Approved by | JM Daniel 4/17/00 | | |
| Checked Against Approved Vendor Data | | | |

INDEX


| Design Analysis Page No. | Description |
|---|---|
| 1 | Objective, Design Criteria, Methods |
| 2 | Assumptions, References, Conclusions |
| 3-7 | Calculations |
| Appendix A | Attached References |
| A1-A3 | Crane Technical Paper No. 410 |
| A4-A5 | E-mail consisting of Design Parameters. |
| A6 | E-mail pertaining to Flow Rates |
| A7-A12 | Engineering Fluid Mechanics |
| A13 | Flygt Catalog Cut Sheet |
| A14 | PBM Catalog Cut Sheet |

| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX<br>Continuation Sheet | Page ii of ii<br>Date: 03/24/00 |
|---|---|---|

Discipline: 454 | Project/Area/Unit: 65100541/25/9 | Calculation No.: DSTAP-P-002

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | Paul M. Dosch 3/24/00 | | |
| Checked by | [illegible] 4/13/00 | | |

## INDEX


| Design Analysis Page No. | Description |
|---|---|
| A15 | ARES Sketch of Double Shell Tank Annulus Pumping Data |
| A16-A17 | Sketches of Annulus Pump Pit Layout |
| A18-A19 | Statement of Work for Annulus Pumping |


## REVISION

| Revision No. | Description |
|---|---|
| | |

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-002
Revision No.: 0
Page No.: 1 of 7

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
ANNULUS JUMPER ORIFICE DESIGN
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 03 / 24 / 00 By: P. M. DORSH PMD
Checked: 4/13/00 By:
Revised: By:

## OBJECTIVE:

The objective of this calculation is to size an orifice, which will be used to reduce the flow rate in the annulus pump pit transfer piping. The transfer line connecting the annulus pump pit to the central pump pit in the AY-101, AY-102, and AZ-102 tanks are not contained within encasement piping (they are direct buried). Therefore, a flow rate restriction of 50 GPM is placed on these lines. If a leak occurs past the first shell of the double shell tanks, an electric submersible pump will be used to transfer waste out of the annulus area. An orifice will be placed in the annulus pump pit jumper and will be sized to restrict the flow rate discharged from the pump to 50 GPM, when measured at the annulus jumper / transfer line connection.

## DESIGN CRITERIA / INPUT:

| | | |
|---|---|---|
| Flow Rate: | 50 GPM maximum | (Ref. 3) |
| Dynamic Viscosity: | 30 centipoise maximum | (Ref. 2) |
| Specific Gravity: | 1.47 maximum | (Ref. 2) |
| Temperature: | 140° F maximum | (Ref. 2) |
| Discharge Pressure | 78 ft | (Ref. 5) |

## METHODS:

1.) The Darcy-Weisbach equation is used in determining the friction pressure losses.

2.) Friction losses due to standard fittings are calculated using the pipe resistance coefficients (K factors) found in Crane Technical Paper No. 410.

3.) The total pressure losses of the system is determined using Bernoulli's equation.

The Flygt pump performance curve will be used to determine the system's operating pressure required to achieve a 50 GPM flow rate. A pressure drop due to the resistance of the components will be compared to this operating pressure and a difference in pressure will be established. The orifice will be sized in a way that produces a pressure drop equal to the difference, and thus produce a flow rate equal to 50 GPM at the entrance of the "directly buried" transfer line.

Because of the similarity between the annulus pit arrangements in tanks AY-101, AY-102 and AZ-102, only one "generalized" calculation will be completed. The results of the calculation can be applied to any of these tanks with very minimal error.

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-002
Revision No.: 0
Page No.: 2 of 7

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
ANNULUS JUMPER ORIFICE DESIGN
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 03 / 24 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By:
Revised: By:

## ASSUMPTIONS:

1.) The Purex nozzles are equivalent in resistance to a 90 degree miter bend.

2.) The equivalent roughness of stainless steel pipe is 0.00015 ft.

3.) The discharge of the pump is will be at the bottom of the tank in the annulus area.

4.) Only one pump (Flygt BS 2060.390) will be used to transfer the waste. (i.e. no tandem operation)

5.) The 3-way ball valve used in the annulus jumper has a flow coefficient equivalent to PBM MP 70-80 series (3-way) valve.

6.) 3" schedule 80 pipe will be used from the discarge of the pump to the pump flange. 2" schedule 40 pipe will be used on the annulus jumper.

7.) The orifice will have an assumed flow coefficient of K = 0.65.

## REFERENCES:

1.) Crane Technical Paper No. 410, *Flow of Fluids Through Valves, Fittings, and Pipe*.

2.) E-mail dated 1/25/00 from Dan Reberger to Marshall Hauck consisting of Revised Design Criteria.

3.) E-mail dated 3/15/00 from Dan Reberger to Marshal Hauck, pertaining to Flow Restrictions.

4.) *Engineering Fluid Mechanics*, Sixth Edition, Roberson and Crowe.

5.) Flygt Pump BS-2060.390, Performance Data Sheet.

6.) PBM Catalog Cut Sheet.

7.) Referenced Drawing, ARES sketch of Double Shell Tank Annulus Pumping Data.

8.) Sketches showing the typical annulus pump pit assembly and jumper layout.

9.) Statement of Work for Annulus Pumping, Revision No. 0, Contract 4975.

References are attached in Appendix A

## CONCLUSIONS:

A centrally located orifice with a diameter of 0.9" should be used in an annulus jumper which requires a 50 GPM flow restriction. Again, this number assumes that only one Flgyt submersible pump is used (as opposed to a tandem operation).

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-002
Revision No.: 0
Page No.: 3 of 7

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING ANNULUS JUMPER ORIFICE DESIGN
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 03 / 24 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By:
Revised: By:

**Fluid Properties**

| | | | |
|---|---|---|---|
| Maximum Flow Rate | $Q := 50 \cdot GPM$ | $Q = 192.5 \cdot \frac{in^3}{sec}$ | (Ref. 3, A6) |
| Specific Gravity of Fluid | $SG := 1.47$ | | (Ref. 2, A4) |
| Temperature of Fluid | $T := 140 \cdot F$ | | (Ref. 2, A4) |
| Density of Water @ 140 F | $\rho_w := 61.38 \cdot \frac{lb}{ft^3}$ | | (Ref. 4, A10) |
| Density of Fluid @ 140 F | $\rho := \rho_w \cdot SG$ | $\rho = 90.229 \cdot \frac{lb}{ft^3}$ | |
| Dynamic Viscosity | $\mu := 30 \cdot cp$ | | (Ref. 2, A4) |
| Pipe Roughness | $k_s := 0.00015 \cdot ft$ | | (Ref. 4, A11) |

**2" Sch 40 Pipe Properties**

| | | | |
|---|---|---|---|
| Inside Diameter of 2" Sch 40 Pipe | $D_2 := 2.067 \cdot in$ | | |
| Inside Area of Pipe | $A_2 := \frac{\pi}{4} \cdot D_2^2$ | $A_2 = 3.356 \cdot in^2$ | |
| Velocity of Fluid | $V_2 := \frac{Q}{A_2}$ | $V_2 = 4.781 \cdot \frac{ft}{sec}$ | |
| Reynolds Number | $Re_2 := \frac{V_2 \cdot D_2 \cdot \rho}{\mu}$ | $Re_2 = 3685.5$ | (flow is turbulent) |
| Friction Factor | $f_2 := \frac{0.25}{\log\left(\frac{k_s}{3.7 \cdot D_2} + \frac{5.74}{Re_2^{0.9}}\right)^2}$ | $f_2 = 0.043$ | (Ref. 4, A7) |

Friction Factor in Zone of Complete Turbulence $f_{t2} := .019$ (Ref. 1, A1)

Flow Coefficient of 3 Way T-Port Through $Cv_{t2} := 176$ (Ref. 6, A14)

**3" Sch 80 Pipe Properties**

Inside Diameter of 3" Sch 80 Pipe $D_3 := 2.9 \cdot in$

Inside Area of Pipe $A_3 := \frac{\pi}{4} \cdot D_3^2$ $A_3 = 6.605 \cdot in^2$

Velocity of Fluid $V_3 := \frac{Q}{A_3}$ $V_3 = 2.429 \cdot \frac{ft}{sec}$

Reynolds Number $Re_3 := \frac{V_3 \cdot D_3 \cdot \rho}{\mu}$ $Re_3 = 2626.9$

It is reasonable to expect that pipe flow will be laminar for Reynolds number less than 2000 and turbulent for Reynolds numbers greater than 3000. When the Reynolds number is between 2000 and 3000 the type of flow is very unpredictable and often changes back and forth between laminar and turbulent states. However, since there will be vibrations in the piping system due to the pumping operation, it is safe to assume that the flow is turbulent. (Ref. 4, A12)

Friction Factor $f_3 := \frac{0.25}{\log\left(\frac{k_s}{3.7 \cdot D_3} + \frac{5.74}{Re_3^{0.9}}\right)^2}$ $f_3 = 0.047$ (Ref. 4, A7)

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-002
Revision No.: 0
Page No.: 5 of 7

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING ANNULUS JUMPER ORIFICE DESIGN
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 03 / 24 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By:
Revised: By:

**Resistance Coefficients for 2" Pipe**

| | | | |
|---|---|---|---|
| L.R. Bends<br>Qty = 3 | $K_1 := (14 \cdot f_{t2}) \cdot 3$ | $K_1 = 0.798$ | (Ref. 1, A2) |
| Purex Connectors<br>Qty = 2 | $K_2 := (60 \cdot f_{t2}) \cdot 2$ | $K_2 = 2.28$ | (Ref. 1, A2) |
| Inside Diameter of<br>2" Sch 40 Pipe (in) | $D := 2.067$ | | |
| 3 Way Ball Valves (Branch)<br>Qty = 1 | $K_3 := \left(891 \cdot \frac{D^4}{Cv_{t2}^2}\right) \cdot 1$ | $K_3 = 0.525$ | (Ref. 1, A3) |
| 3" x 2" Contraction<br>Assume $\theta$ = 60° | $\frac{D_2}{D_3} = 0.713$ | $K_4 := 0.06$ | (Ref. 4, A8) |
| Approx. Length of<br>2" Sch 40 Pipe | $L_2 := 7 \cdot ft$ | | (Ref. 8, A16) |
| | $K_5 := f_2 \cdot \frac{L_2}{D_2}$ | $K_5 = 1.731$ | |
| **Sum of 2" Coefficient Resistance Factors** | $K_2 := \sum_{i=1}^{5} K_i$ | $K_2 = 5.394$ | |
| **Head Loss due to Friction in 2" Pipe** | $h_{L2} := \frac{V_2^2}{2 \cdot g} \cdot K_2$ | $h_{L2} = 1.916 \cdot ft$ | |

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-002
Revision No.: 0
Page No.: 6 of 7

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING ANNULUS JUMPER ORIFICE DESIGN
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 03 / 24 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By:
Revised: By:

**Resistance Coefficients for 3" Pipe**

Pipe Entrance $K_1 := 0.78$ (Ref. 1, A2)

Approx. Length of 3" Sch 80 Pipe $L_3 := 47 \cdot ft$ (Ref. 7, A15)

$$K_2 := f_3 \cdot \frac{L_3}{D_3} \qquad K_2 = 9.162$$

**Sum of 3" Coefficient Resistance Factors**

$$K_3 := \sum_{i=1}^{2} K_i \qquad K_3 = 9.942$$

**Head Loss due to Friction in 3" Pipe**

$$h_{L3} := \frac{V_3^2}{2 \cdot g} \cdot K_3 \qquad h_{L2} = 1.916 \cdot ft$$

**Static Head**

Approx. Elevation of Pump Discharge $z_a := 0 \cdot ft$

Approx. Elevation of Pit Nozzle $z_b := 47 \cdot ft + 5 \cdot ft$

(Ref. 7, A15)

**Single Pump Discharge Head at 50 GPM**

Pump Discharge $H_p := 78 \cdot ft$ (Ref. 5, A13)

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-002
Revision No.: 0
Page No.: 7 of 7

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING ANNULUS JUMPER ORIFICE DESIGN
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 03 / 24 / 00 By: P. M. DORSH PMD
Checked: 4 / 13 / 00 By:
Revised: By:

Considering Bernoulli's equation, $P_a/\gamma + V_a^2/2g + z_a = P_b/\gamma + V_b^2/2g + z_b + \Sigma K_{ab}V^2/2g + h_o$, with position "a" located at the discharge of the annulus pump and position "b" located at the purex nozzle connecting the annulus jumper to the pit wall, we find the required pressure drop of the orifice to be:

$$h_o = (P_a/\gamma - P_b/\gamma) + (V_a^2/2g - V_b^2/2g) + (z_a - z_b) - \Sigma K_{ab}V^2/2g$$

or, with zero terms canceled out ($P_b$ is atmospheric) and in terms of feet ($P_a/\gamma$ is the pressure head = $H_p$, $\Sigma K_{ab}V^2/2g$ is the friction head = $h_L$, and $h_o$ is the head loss due to the orifice):

$$h_o = H_p + (V_a^2/2g - V_b^2/2g) + (z_a - z_b) - h_{L3} - h_{L2}$$

Required Head Loss of Orifice

$$h_o := H_p + \left(\frac{V_3^2}{2 \cdot g} - \frac{V_2^2}{2 \cdot g}\right) - (z_a + z_b) - h_{L3} - h_{L2}$$

$$h_o = 22.91 \cdot ft$$

Assumed Flow Coefficient $K := 0.65$ (Assumption 7)

Orifice Area $A_o := \frac{Q}{K \cdot \sqrt{2 \cdot g \cdot h_o}}$ $A_o = 0.643 \cdot in^2$ (Ref. 4, A9)

Diameter of Orifice $d := \sqrt{\frac{A_o \cdot 4}{\pi}}$ $d = 0.905 \cdot in$

**Check Assumed Flow Coefficient**

Ratio of Diameters $\frac{d}{D_2} = 0.438$ (apply the Reynolds number of 3700 and the Ratio of Diameters to the graph on page A9 to find the Flow Coefficient)

Check of Flow Coefficient w/ Re = 3700 $K := 0.65$ (Ref. 4, A9)

As seen by the graph (Ref. 4, A9) the Flow Coefficient, K is approximately equal to 0.65. Thus, the flow coefficient assumption and the orifice diameter are correct.

# CALCULATION No: DSTAP-P-002, Rev. 0
# APPENDIX A

## References

"K" FACTOR TABLE—SHEET 1 of 4

# Representative Resistance Coefficients (K) for Valves and Fittings

*("K" is based on use of schedule pipe as listed on page 2-10)*

## PIPE FRICTION DATA FOR CLEAN COMMERCIAL STEEL PIPE WITH FLOW IN ZONE OF COMPLETE TURBULENCE

| Nominal Size | ½" | ¾" | 1" | 1¼" | 1½" | 2" | 2½, 3" | 4" | 5" | 6" | 8-10" | 12-16" | 18-24" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Friction Factor ($f_T$) | .027 | .025 | .023 | .022 | .021 | .019 | .018 | .017 | .016 | .015 | .014 | .013 | .012 |

## FORMULAS FOR CALCULATING "K" FACTORS* FOR VALVES AND FITTINGS WITH REDUCED PORT

(Ref: Pages 2-11 and 3-4)

- **Formula 1**

$$K_2 = \frac{0.8\left(\sin\frac{\theta}{2}\right)(1-\beta^2)}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 2**

$$K_2 = \frac{0.5\,(1-\beta^2)\sqrt{\sin\frac{\theta}{2}}}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 3**

$$K_2 = \frac{2.6\left(\sin\frac{\theta}{2}\right)(1-\beta^2)^2}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 4**

$$K_2 = \frac{(1-\beta^2)^2}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 5**

$$K_2 = \frac{K_1}{\beta^4} + \text{Formula 1} + \text{Formula 3}$$

$$K_2 = \frac{K_1 + \sin\frac{\theta}{2}\left[0.8\,(1-\beta^2) + 2.6\,(1-\beta^2)^2\right]}{\beta^4}$$

- **Formula 6**

$$K_2 = \frac{K_1}{\beta^4} + \text{Formula 2} + \text{Formula 4}$$

$$K_2 = \frac{K_1 + 0.5\sqrt{\sin\frac{\theta}{2}}\,(1-\beta^2) + (1-\beta^2)^2}{\beta^4}$$

- **Formula 7**

$$K_2 = \frac{K_1}{\beta^4} + \beta\,(\text{Formula 2} + \text{Formula 4}) \text{ when } \theta = 180^\circ$$

$$K_2 = \frac{K_1 + \beta\left[0.5\,(1-\beta^2) + (1-\beta^2)^2\right]}{\beta^4}$$

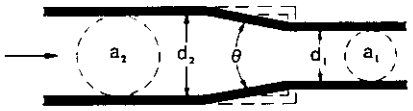
$$\beta = \frac{d_1}{d_2}$$

$$\beta^2 = \left(\frac{d_1}{d_2}\right)^2 = \frac{a_1}{a_2}$$

Subscript 1 defines dimensions and coefficients with reference to the smaller diameter.
Subscript 2 refers to the larger diameter.

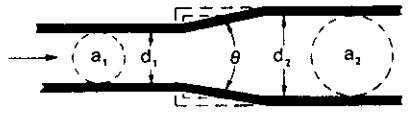
*** Use "K" furnished by valve or fitting supplier when available.**

### SUDDEN AND GRADUAL CONTRACTION




If: $\theta \leq 45^\circ$ . . . . . $K_2$ = Formula 1
$45^\circ < \theta \leq 180^\circ$ . . . $K_2$ = Formula 2

### SUDDEN AND GRADUAL ENLARGEMENT




If: $\theta \leq 45^\circ$ . . . . . $K_2$ = Formula 3
$45^\circ < \theta \leq 180^\circ$ . . . $K_2$ = Formula 4

"K" FACTOR TABLE—SHEET 4 of 4

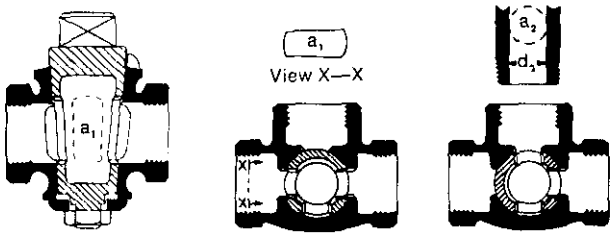
# Representative Resistance Coefficients (K) for Valves and Fittings

*(for formulas and friction data, see page A-26)*

*("K" is based on use of schedule pipe as listed on page 2-10)*

## PLUG VALVES AND COCKS

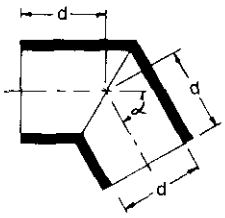
**Straight-Way** **3-Way**




If: $\beta = 1$, $K_1 = 18\, f_T$ | If: $\beta = 1$, $K_1 = 30\, f_T$ | If: $\beta = 1$, $K_1 = 90\, f_T$

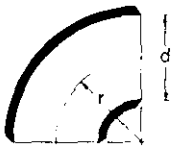
If: $\beta < 1 \ldots K_2 =$ Formula 6

## MITRE BENDS




| α | K |
|---|---|
| 0° | 2 $f_T$ |
| 15° | 4 $f_T$ |
| 30° | 8 $f_T$ |
| 45° | 15 $f_T$ |
| 60° | 25 $f_T$ |
| 75° | 40 $f_T$ |
| 90° | 60 $f_T$ |

## 90° PIPE BENDS AND FLANGED OR BUTT-WELDING 90° ELBOWS



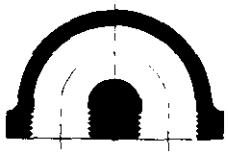

| | r/d | K | r/d | K |
|---|---|---|---|---|
| SR | 1 | 20 $f_T$ | 8 | 24 $f_T$ |
| LR | 1.5 | 14 $f_T$ | 10 | 30 $f_T$ |
| | 2 | 12 $f_T$ | 12 | 34 $f_T$ |
| | 3 | 12 $f_T$ | 14 | 38 $f_T$ |
| | 4 | 14 $f_T$ | 16 | 42 $f_T$ |
| | 6 | 17 $f_T$ | 20 | 50 $f_T$ |

The resistance coefficient, $K_B$, for pipe bends other than 90° may be determined as follows:

$$K_B = (n - 1)\left(0.25\ \pi\ f_T \frac{r}{d} + 0.5\ K\right) + K$$

$n$ = number of 90° bends
$K$ = resistance coefficient for one 90° bend (per table)

## CLOSE PATTERN RETURN BENDS



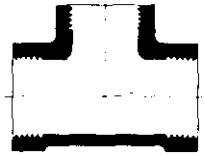
$K = 50\, f_T$

## STANDARD ELBOWS

90° 45°

$K = 30\, f_T$ $K = 16\, f_T$

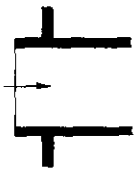
## STANDARD TEES



Flow thru run. . . . . $K = 20\, f_T$
Flow thru branch. . . . $K = 60\, f_T$

## PIPE ENTRANCE

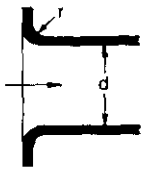
**Inward Projecting** **Flush**



$K = 0.78$

| r/d | K |
|---|---|
| 0.00* | 0.5 |
| 0.02 | 0.28 |
| 0.04 | 0.24 |
| 0.06 | 0.15 |
| 0.10 | 0.09 |
| 0.15 & up | 0.04 |

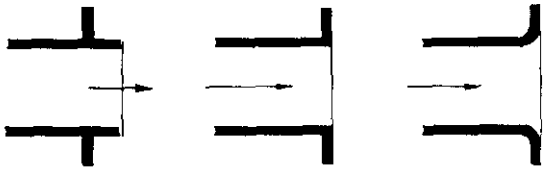
*Sharp-edged




For $K$, see table

## PIPE EXIT

**Projecting** **Sharp-Edged** **Rounded**



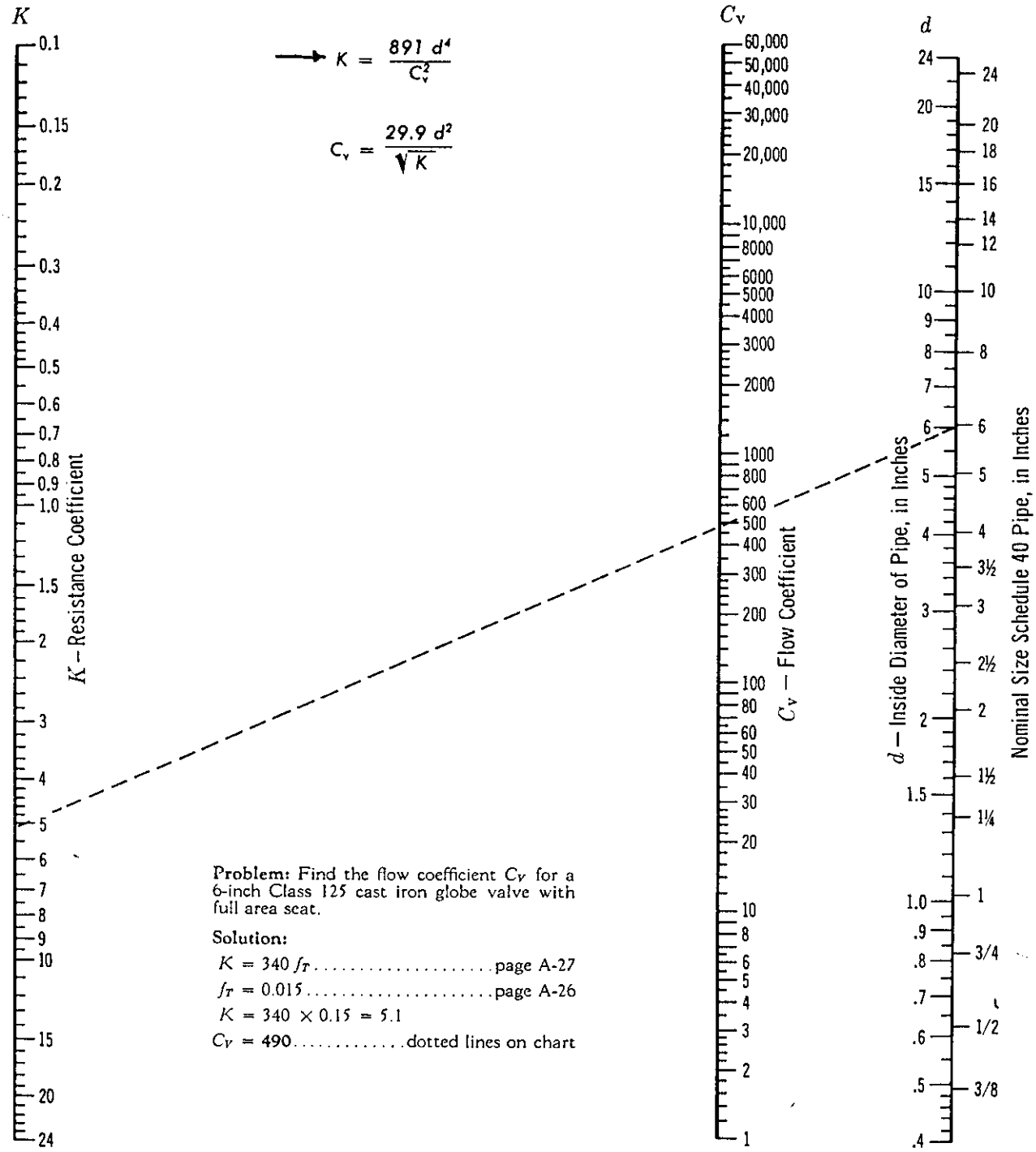
$K = 1.0$ $K = 1.0$ $K = 1.0$

# Equivalents of Resistance Coefficient *K* And Flow Coefficient $C_v$

Calc No: DSTAP-P-002, Rev. 0
Ref. 1 A3 of A19

$$K = \frac{891\, d^4}{C_v^2}$$

$$C_v = \frac{29.9\, d^2}{\sqrt{K}}$$




**Problem:** Find the flow coefficient $C_V$ for a 6-inch Class 125 cast iron globe valve with full area seat.

**Solution:**

$K = 340\, f_T$ ..... page A-27

$f_T = 0.015$ ..... page A-26

$K = 340 \times 0.15 = 5.1$

$C_V = 490$ ..... dotted lines on chart

**Dorsh, Paul M**

**From:** Reberger, Dan W
**Sent:** Tuesday, January 25, 2000 7:38 AM
**To:** Hauck, Frank M (Marshall)
**Cc:** Rarig, Bradley K; Dorsh, Paul M; Peck, David J; Leshikar, Gregory A
**Subject:** Draft Design Criteria for Annulus pumps -Revision

I forgot the criteria on Flammable Gas Controls and pressure.

---

In our recent meetings on annulus pumping, it was apparent that the pumping specifications previously provided were not adequate. I'm currently in the process of developing a technical rational for the Pump Design Criteria. The following is a draft of the criteria. Let me know if there are any questions or concerns.

**Submersible Centrifugal**

| | |
|---|---|
| Total Flow | 50 - 300* gpm |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centipoise |
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$F |
| Discharge Pressure | 230 maximum** |
| Flammable Gas Controls or equivalent)*** | Ignition Source Control Set #1 (Class 1 Division 1 GroupB |
| Waste Flow | 33 - 200 gpm**** |
| Dilution water Flow | 17 - 100 gpm**** |

*The maximum flow rate of 300 gpm is based on an accident in the Tank Farm FSAR 3.4.2.7 Surface Leak Resulting in a Pool.

**Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

*** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**** The dilution water flow may be required to be as high as 50% of the waste flow. It's recognized that design constraints may prevent reaching dilution water flows above 40 gpm. In this case throttling existing waste line valves will be used to set the proper dilution. The design constraints anticipated are water supply pressure, pressure drop through hose connections, and the limiting pipe diameter that can be coupled with the pump assemblies.

**Heel Pump**

| | |
|---|---|
| Total Flow | 2 - 5 gpm |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centipoise |

| | |
|---|---|
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$F |
| Discharge Pressure | 230 maximum* |
| Flammable Gas Controls or equivalent)** | Ignition Source Control Set #1 (Class 1 Division 1 GroupB |
| Dilution water Flow | None Required |

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

*Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

**Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**Dorsh, Paul M**

**From:** Rarig, Bradley K
**Sent:** Wednesday, March 15, 2000 11:39 AM
**To:** Hauck, Frank M (Marshall)
**Cc:** Dorsh, Paul M
**Subject:** RE: 50 gpm flow limit in AY & AZ Tank Farms for Annulus pumps

Yes, I sent an email to Dan and he agreed. Copy was forwarded to Contracts.
bkr

-----Original Message-----
**From:** Hauck, Frank M (Marshall)
**Sent:** Wednesday, March 15, 2000 11:17 AM
**To:** Rarig, Bradley K
**Cc:** Dorsh, Paul M
**Subject:** FW: 50 gpm flow limit in AY & AZ Tank Farms for Annulus pumps

Bradley,

Can we proceed with the design of this orifice, ie is it now in the "scope of supply"?

Marshall
-----Original Message-----
**From:** Reberger, Dan W
**Sent:** Wednesday, March 15, 2000 10:59 AM
**To:** Hauck, Frank M (Marshall)
**Cc:** Dorsh, Paul M; Rarig, Bradley K
**Subject:** 50 gpm flow limit in AY & AZ Tank Farms for Annulus pumps

Marshall,
The flow restriction of 50 gpm for annulus pumping applies to transfer lines from Tanks 101-AY, 102-AY and 102-AZ.
The transfer lines from these three tanks are direct buried and the flow rate must be lower than 50gpm.
The flow should be calculated at the pipe position just outside the annulus pump pit. If a breach in the pipe at the outside pit wall were to occur, the breached flow should not exceed 50 gpm.

Call me if you have any questions.

Colebrook–White formula, from which the Moody diagram was developed, Swamee and Jain (39) developed explicit formulas relating $f$, $h_f$, $Q$, and $D$. It is reported that their formulas yield results that deviate no more than 3% from those obtained from the Moody diagram for the following ranges of $k_s/D$ and Re: $10^{-5} < k_s/D < 2 \times 10^{-2}$ and $4 \times 10^3 < \text{Re} < 10^8$. The formulas for $f$ and $Q$ are

$$f = \frac{0.25}{\left[\log\left(\frac{k_s}{3.7D} + \frac{5.74}{\text{Re}^{0.9}}\right)\right]^2} \tag{10.26}$$

$$Q = -2.22D^{5/2}\sqrt{gh_f/L}\,\log\left(\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2}\sqrt{gh_f/L}}\right) \tag{10.27}$$

They also developed a formula for the explicit determination of $D$. A modified version of that formula, given by Streeter and Wylie (38), is

$$D = 0.66\left[k_s^{1.25}\left(\frac{LQ^2}{gh_f}\right)^{4.75} + \nu Q^{9.4}\left(\frac{L}{gh_f}\right)^{5.2}\right]^{0.04} \tag{10.28}$$

If you want to solve for head loss given $Q$, $L$, $D$, $k_s$, and $\nu$, simply solve for $f$ by Eq. (10.26) and compute $h_f$ with the Darcy–Weisbach equation, Eq. (10.22). Straightforward calculations for $Q$ and $D$ can also be made if $h_f$ is known. However, for problems involving head losses in addition to $h_f$, an iterative solution is required. For computing $Q$, you can assume an $f$ and solve for $Q$ from the energy equation after substituting $Q/A$ in that equation. Then compute Re and use the result in Eq. (10.26) to get a better estimate of $f$, and so on, until $Q$ converges analogous to the procedure for determining $Q$ using the Moody diagram. In this case, however, Eq. (10.26) is substituted for the Moody diagram. Similarly, you can determine $D$ if you are given $Q$, $\nu$, the change in pressure or head, and the geometric configuration.

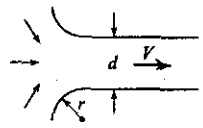
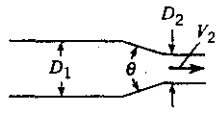
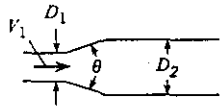
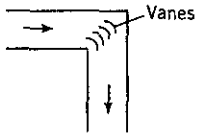
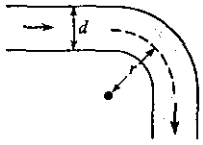
**EXAMPLE 10.8** Solve Example 10.5 using Eq. (10.27).

***Solution*** From Fig. 10.8, $k_s$ for asphalted cast-iron pipe is given as $1.2 \times 10^{-4}$ m. From the given conditions, $h_f/L = 0.0122$. Assume $T = 20°\text{C}$, so $\nu = 10^{-6}\ \text{m}^2/\text{s}$. Then, using Eq. (10.27), we have

$$\begin{aligned} Q &= -2.22(0.20\ \text{m})^{5/2}\sqrt{9.81\ \text{m/s}^2 \times 0.0122} \\ &\quad \times \log\left(\frac{1.2 \times 10^{-4}\ \text{m}}{3.7 \times 0.20\ \text{m}} + \frac{1.78 \times 10^{-6}\ \text{m}^2/\text{s}}{(0.20\ \text{m})^{3/2}\sqrt{9.81\ \text{m/s}^2 \times 0.0122}}\right) \\ &= 0.050\ \text{m}^3/\text{s} \end{aligned}$$

◄

TABLE 10.2 LOSS COEFFICIENTS FOR VARIOUS TRANSITIONS AND FITTINGS

| Description | Sketch | Additional Data | K | | Source |
|---|---|---|---|---|---|
| Pipe entrance |  | $r/d$ | $K_e$ | | (2)* |
| | | 0.0 | 0.50 | | |
| | | 0.1 | 0.12 | | |
| $h_L = K_e V^2/2g$ | | >0.2 | 0.03 | | |
| Contraction |  | $D_2/D_1$ | $K_C$ $\theta = 60°$ | $K_C$ $\theta = 180°$ | (2) |
| | | 0.0 | 0.08 | 0.50 | |
| | | 0.20 | 0.08 | 0.49 | |
| | | 0.40 | 0.07 | 0.42 | |
| | | 0.60 | 0.06 | 0.27 | |
| | | 0.80 | 0.06 | 0.20 | |
| $h_L = K_C V_2^2/2g$ | | 0.90 | 0.06 | 0.10 | |
| Expansion |  | $D_1/D_2$ | $K_E$ $\theta = 20°$ | $K_E$ $\theta = 180°$ | (2) |
| | | 0.0 | | 1.00 | |
| | | 0.20 | 0.30 | 0.87 | |
| | | 0.40 | 0.25 | 0.70 | |
| | | 0.60 | 0.15 | 0.41 | |
| $h_L = K_E V_1^2/2g$ | | 0.80 | 0.10 | 0.15 | |
| 90° miter bend |  | Without vanes | $K_b = 1.1$ | | (37) |
| | | With vanes | $K_b = 0.2$ | | (37) |
| 90° smooth bend |  | $r/d$ | | | (5) and (19) |
| | | 1 | $K_b = 0.35$ | | |
| | | 2 | 0.19 | | |
| | | 4 | 0.16 | | |
| | | 6 | 0.21 | | |
| | | 8 | 0.28 | | |
| | | 10 | 0.32 | | |
| Threaded pipe fittings | Globe valve—wide open | $K_v = 10.0$ | | | (37) |
| | Angle valve—wide open | $K_v = 5.0$ | | | |
| | Gate valve—wide open | $K_v = 0.2$ | | | |
| | Gate valve—half open | $K_v = 5.6$ | | | |
| | Return bend | $K_b = 2.2$ | | | |
| | Tee | | | | |
| | straight-through flow | $K_t = 0.4$ | | | |
| | side-outlet flow | $K_t = 1.8$ | | | |
| | 90° elbow | $K_b = 0.9$ | | | |
| | 45° elbow | $K_b = 0.4$ | | | |

*Reprinted by permission of the American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, Georgia, from the 1981 ASHRAE Handbook-Fundamentals.

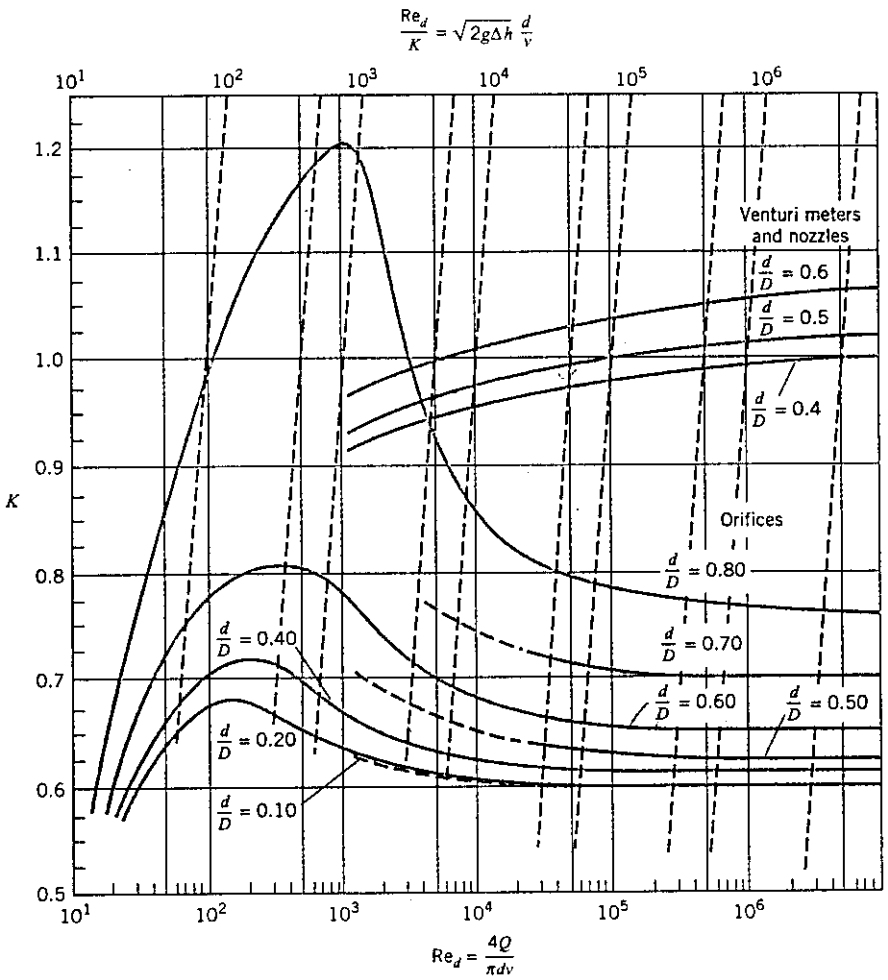
If $\Delta h$ is defined as $h_1 - h_2$, then the final form of the discharge equation for an orifice reduces to

$$Q = KA_o\sqrt{2g\Delta h} \tag{13.3a}$$

If a differential pressure transducer is connected across the orifice, it will sense a pressure change, which is equivalent to $\gamma\Delta h$ so the discharge equation becomes

$$Q = KA_o\sqrt{2\frac{\Delta p}{\rho}} \tag{13.3b}$$

Experimentally determined values of $K$ as a function of $d/D$ and Reynolds number based on orifice size are given in Fig. 13.13. If $Q$ is given, $\mathrm{Re}_d$ is equal to




RE 13.13

*coefficient* K *and* K *versus the* olds number *for* es, nozzles, *and* ri meters. *[After* (20) *and* ASME (1)*]* ission to use Tuve ed by umentation & rol Systems zine, *formerly* uments *magazine.*

TABLE A.5 APPROXIMATE PHYSICAL PROPERTIES OF WATER* AT ATMOSPHERIC PRESSURE

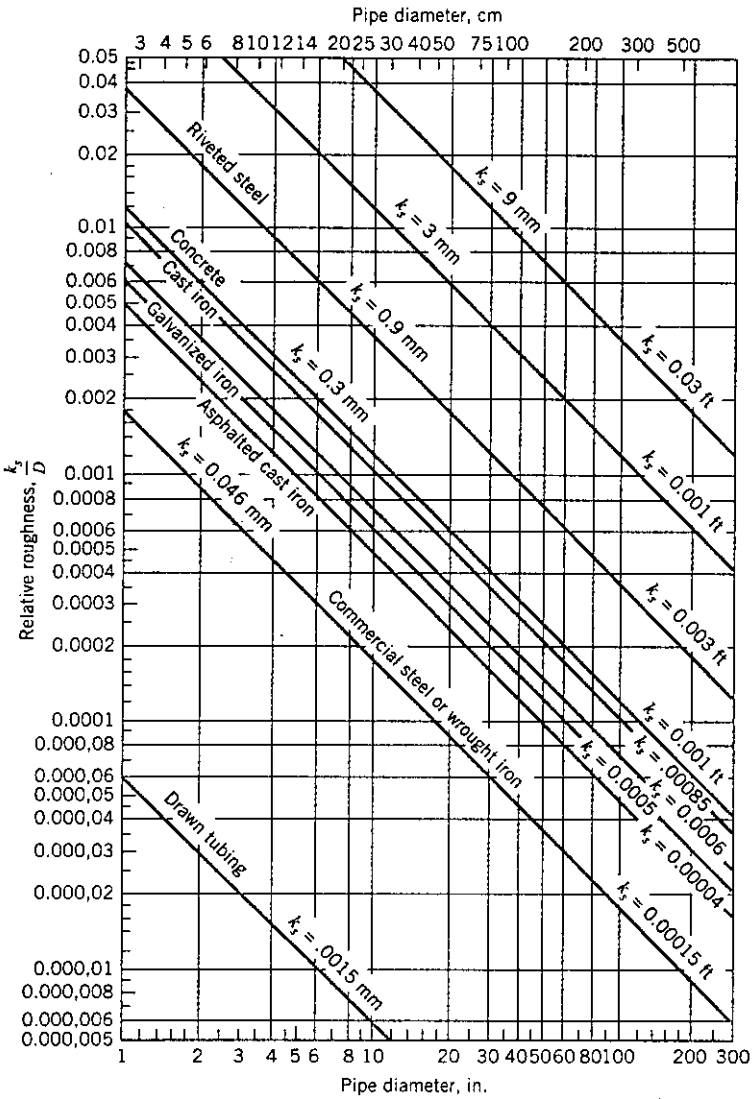
| Temperature | Density | Specific weight | Dynamic viscosity | Kinematic viscosity | Vapor pressure |
|---|---|---|---|---|---|
| | kg/m³ | N/m³ | N • s/m² | m²/s | N/m² abs. |
| 0°C | 1000 | 9810 | $1.79 \times 10^{-3}$ | $1.79 \times 10^{-6}$ | 611 |
| 5°C | 1000 | 9810 | $1.51 \times 10^{-3}$ | $1.51 \times 10^{-6}$ | 872 |
| 10°C | 1000 | 9810 | $1.31 \times 10^{-3}$ | $1.31 \times 10^{-6}$ | 1230 |
| 15°C | 999 | 9800 | $1.14 \times 10^{-3}$ | $1.14 \times 10^{-6}$ | 1700 |
| 20°C | 998 | 9790 | $1.00 \times 10^{-3}$ | $1.00 \times 10^{-6}$ | 2340 |
| 25°C | 997 | 9781 | $8.91 \times 10^{-4}$ | $8.94 \times 10^{-7}$ | 3170 |
| 30°C | 996 | 9771 | $7.97 \times 10^{-4}$ | $8.00 \times 10^{-7}$ | 4250 |
| 35°C | 994 | 9751 | $7.20 \times 10^{-4}$ | $7.24 \times 10^{-7}$ | 5630 |
| 40°C | 992 | 9732 | $6.53 \times 10^{-4}$ | $6.58 \times 10^{-7}$ | 7380 |
| 50°C | 988 | 9693 | $5.47 \times 10^{-4}$ | $5.53 \times 10^{-7}$ | 12,300 |
| 60°C | 983 | 9643 | $4.66 \times 10^{-4}$ | $4.74 \times 10^{-7}$ | 20,000 |
| 70°C | 978 | 9594 | $4.04 \times 10^{-4}$ | $4.13 \times 10^{-7}$ | 31,200 |
| 80°C | 972 | 9535 | $3.54 \times 10^{-4}$ | $3.64 \times 10^{-7}$ | 47,400 |
| 90°C | 965 | 9467 | $3.15 \times 10^{-4}$ | $3.26 \times 10^{-7}$ | 70,100 |
| 100°C | 958 | 9398 | $2.82 \times 10^{-4}$ | $2.94 \times 10^{-7}$ | 101,300 |
| | slugs/ft³ | lbf/ft³ | lbf-s/ft² | ft²/s | psia |
| 40°F | 1.94 | 62.43 | $3.23 \times 10^{-5}$ | $1.66 \times 10^{-5}$ | 0.122 |
| 50°F | 1.94 | 62.40 | $2.73 \times 10^{-5}$ | $1.41 \times 10^{-5}$ | 0.178 |
| 60°F | 1.94 | 62.37 | $2.36 \times 10^{-5}$ | $1.22 \times 10^{-5}$ | 0.256 |
| 70°F | 1.94 | 62.30 | $2.05 \times 10^{-5}$ | $1.06 \times 10^{-5}$ | 0.363 |
| 80°F | 1.93 | 62.22 | $1.80 \times 10^{-5}$ | $0.930 \times 10^{-5}$ | 0.506 |
| 100°F | 1.93 | 62.00 | $1.42 \times 10^{-5}$ | $0.739 \times 10^{-5}$ | 0.949 |
| 120°F | 1.92 | 61.72 | $1.17 \times 10^{-5}$ | $0.609 \times 10^{-5}$ | 1.69 |
| 140°F | 1.91 | 61.38 | $0.981 \times 10^{-5}$ | $0.514 \times 10^{-5}$ | 2.89 |
| 160°F | 1.90 | 61.00 | $0.838 \times 10^{-5}$ | $0.442 \times 10^{-5}$ | 4.74 |
| 180°F | 1.88 | 60.58 | $0.726 \times 10^{-5}$ | $0.385 \times 10^{-5}$ | 7.51 |
| 200°F | 1.87 | 60.12 | $0.637 \times 10^{-5}$ | $0.341 \times 10^{-5}$ | 11.53 |
| 212°F | 1.86 | 59.83 | $0.593 \times 10^{-5}$ | $0.319 \times 10^{-5}$ | 14.70 |

*Notes: (1) Bulk modulus $E_v$ of water is approximately 2.2 G $P_a$ ($3.2 \times 10^5$ psi); (2) Water–air surface tension is approximately $7.3 \times 10^{-2}$ N/m ($5 \times 10^{-3}$ lbf/ft) from 10°C to 50°C.

SOURCE: Reprinted with permission from R. E. Bolz and G. L. Tuve, *Handbook of Tables for Applied Engineering Science*, CRC Press, Inc., Cleveland, 1973. Copyright 1973 by The Chemical Rubber Co., CRC Press, Inc.

10.9

*roughness for*
*inds of pipe.*
*ody (29).*
*l with*
*m from the*
*l*



tially laminar but then changed from laminar to turbulent flow at a Reynolds number in the neighborhood of 2100. However, Reynolds found that if the fluid was initially completely motionless and if there was no vibration in the equipment while the flow was increased, it was possible to reach a much higher Reynolds number before the flow became turbulent. He also found that, when going from high-velocity turbulent flow to low-velocity flow, the change from turbulent flow always occurred at a Reynolds number of about 2000.

These experiments of Reynolds indicate that under carefully controlled conditions it is possible to have laminar flow in pipes at Reynolds numbers much higher than 2000. However, the slightest disturbances will trigger the onset of turbulence at high values of Re. Because most engineering applications involve some vibration or flow disturbance, it is reasonable to expect that pipe flow will be laminar for Reynolds numbers less than 2000 and turbulent for Reynolds numbers greater than 3000. When Re is between 2000 and 3000, the type of flow is very unpredictable and often changes back and forth between laminar and turbulent states. Fortunately, however, most engineering applications either are not in this range or are not significantly affected by the unstable flow.

**EXAMPLE 10.2** Oil (S = 0.85) with a kinematic viscosity of $6 \times 10^{-4}$ $m^2/s$ flows in a 15-cm pipe at a rate of 0.020 $m^3/s$. What is the head loss per 100 m of length of pipe?

***Solution*** First we determine whether the flow is laminar or turbulent by checking to see if the Reynolds number is below 2000 or above 3000.

$$V = \frac{Q}{A} = \frac{0.020\ \text{m}^3/\text{s}}{(\pi/4)D^2\ \text{m}^2} = \frac{0.020\ \text{m}^3/\text{s}}{0.785(0.15^2\ \text{m}^2)} = 1.13\ \text{m/s}$$

Then
$$\text{Re} = \frac{VD}{\nu} = \frac{(1.13\ \text{m/s})(0.15\ \text{m})}{6 \times 10^{-4}\ \text{m}^2/\text{s}} = 283$$

Since the Reynolds number is less than 2000, the flow is laminar. The head loss per 100 m is obtained from Eq. (10.17):

$$h_f = \frac{32\mu LV}{\gamma D^2}$$

Here $\mu/\gamma = \nu/g$; hence

$$h_f = \frac{32\nu LV}{gD^2}$$

Then
$$h_f = \frac{32(6)(10^{-4}\ \text{m}^2/\text{s})(100\ \text{m})(1.13\ \text{m/s})}{(9.81\ \text{m/s}^2)(0.15^2\ \text{m}^2)} = 9.83\ \text{m}$$

The head loss is 9.83 m/100 m of length. ◄

From Flygt BS-2060.390 Performance Data, at 50 GPM the discharge pressure is 78 feet.

# $C_V$ FACTORS — MP/MI 70-80 SERIES

$C_V$ is defined as the number of U.S. gallons of water per minute of ambient temperature water that will flow through a valve at 1 psi pressure drop.

## MP 70-80 SERIES $C_V$ FACTORS (MEASURED IN GPM)

| Valve Code | Pipe Size | Port Diameter | 1 Port | 1 Port Through | 1 Port Branched | 1 Port Side Entry | 1 Port Bottom Entry | 1 Port Through | 1 Port Branched |
|---|---|---|---|---|---|---|---|---|---|
| MP-72 | 1/2" | .62" | 12[2] | 14[2] | 9[2] | 12[2] | 12[2] | 14[2] | 9[2] |
| MP-73 | 3/4" | .75" | 12[2] | 14[2] | 9[2] | 12[2] | 12[2] | 14[2] | 9[2] |
| MP-74 | 1" | 1.00" | 33 | 38 | 24 | 29 | 33 | 38 | 24 |
| MP-75 | 1-1/4" | 1.00" | 32[2] | 36[2] | 24[2] | 27[2] | 31[2] | 36[2] | 24[2] |
| MP-76 | 1-1/2" | 1.50" | 78 | 93 | 58 | 67 | 78 | 93 | 58 |
| MP-77 | 2" | 2.00" | 148 | 176 | 108 | 124 | 148 | 176 | 108 |
| MP-79 | 3" | 3.00" | 380 | 460 | 270 | 300 | 380 | 460 | 270 |
| MP-80 | 4" | 4.00" | 680 | 820 | 490 | 530 | 680 | 820 | 490 |
| MP-42 | 6" | 6.00" | 1541 | 1851 | 1111 | 1210 | 1541 | 1851 | 1111 |

NOTES:

1. Most values represent MP Series valves with 150# flanged end fittings.
2. MP Series valves with Female NPT end fittings.
3. Flanged end fittings are not available for MP 75 (1-1/4").
4. 1-1/4" and double angle port are not full-port design.

## MI 70-80 SERIES $C_V$ FACTORS (MEASURED IN GPM)

| Valve Code | Pipe Size | True-Bore Port Diameter | 1 Port | 1 Port Through | 1 Port Branched | 1 Port Side Entry | 1 Port Bottom Entry | 1 Port Through | 1 Port Branched |
|---|---|---|---|---|---|---|---|---|---|
| MI-72 | 1/2" | 0.37" | 3.5 | 5.3 | 3.0 | 3.5 | 2.9 | 3.7 | 2.6 |
| MI-73 | 3/4" | 0.62" | 11 | 16 | 9.2 | 11 | 8.8 | 11 | 8.0 |
| MI-74 | 1" | 0.87" | 22 | 33 | 16 | 22 | 18 | 23 | 17 |
| MI-76 | 1-1/2" | 1.37" | 56 | 85 | 49 | 56 | 47 | 60 | 42 |
| MI-77 | 2" | 1.87" | 110 | 160 | 93 | 110 | 90 | 110 | 79 |
| MI-79 | 3" | 2.87" | 270 | 410 | 240 | 270 | 230 | 290 | 210 |
| MI-80 | 4" | 3.83" | 500 | 760 | 440 | 500 | 420 | 540 | 380 |
| MI-42 | 6" | Consult PBM | | | | | | | |

NOTES:

1. 6" and double angle port are not True-Bore design.

# VACUUM AND CYCLE TESTS — MP/MI 70-80 SERIES

## Vacuum Testing

PBM valves excel under vacuum conditions as well as under pressure conditions. Typical test results showing helium leakage at $10^{-5}$ Torr are provided.

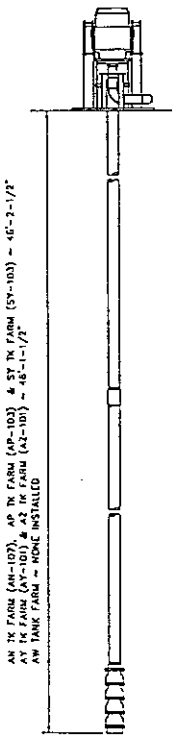
| Vacuum Test Results | | | |
|---|---|---|---|
| **Valve Size** | **PBM Code** | **Body Leakage** (cc/sec.) | **Seat Leakage** (cc/sec.) |
| 2" | MPH-77-F152/POC1 | $1.8 \times 10^{-7}$ | $3.4 \times 10^{-7}$ |
| 2" | MIH-77-TT3/POC1 | $3 \times 10^{-7}$ | $1 \times 10^{-7}$ |

## Cycle Testing

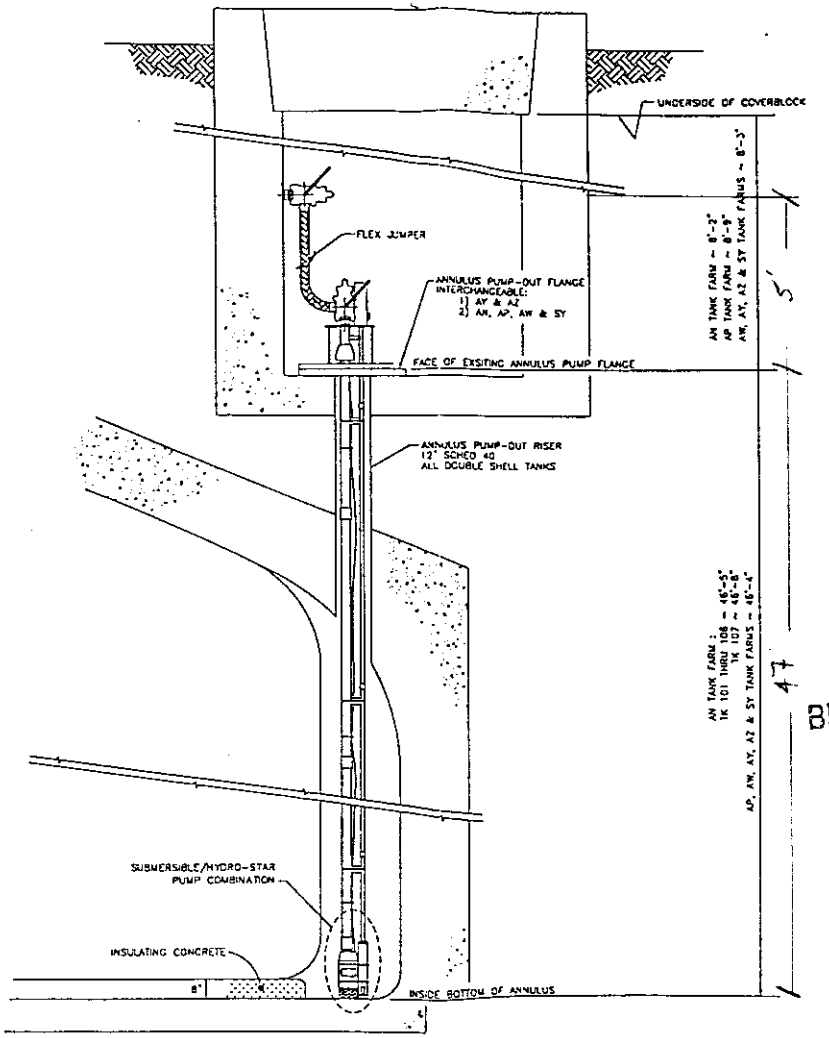
The life of a ball valve is dependent upon service conditions and, therefore, impossible to predict. However, PBM cycle-tests valves using 100 psid of ambient temperature water pressure across the seats with the valve in the closed position. These test conditions represent a typical wear-causing force on the seats and packings. PBM also tests valves in a steam environment up to 380°F.

Replacement of valve gaskets or O-rings is recommended at each disassembly. Replacement of other non-moving parts is dictated only by the corrosion caused by the flow media. In most applications, PBM ball valves will operate trouble-free for many years.

RPP-6155 Rev. 0




EXISTING ANNULUS PUMP




TYPICAL DOUBLE SHELL TANK ANNULUS

40-50 GPM
1.3 SG
140°F

BEST AVAILABLE COPY

| NO. | DATE | CLASS. REV. | REVISIONS | DWN | DES | CHKD | REL | SUB | REC | APP |
|---|---|---|---|---|---|---|---|---|---|---|

ARES CORPORATION
Applied Research & Engineering Sciences

DOUBLE SHELL TANK
ANNULUS PUMPING DATA

DRAWN
DESIGN
CHECKED
RELEASED
DATE

SUBMITTED
APPROVED FOR RELEASE

LOCKHEED MARTIN
LOCKHEED MARTIN HANFORD CORP.

SHEET 1 OF

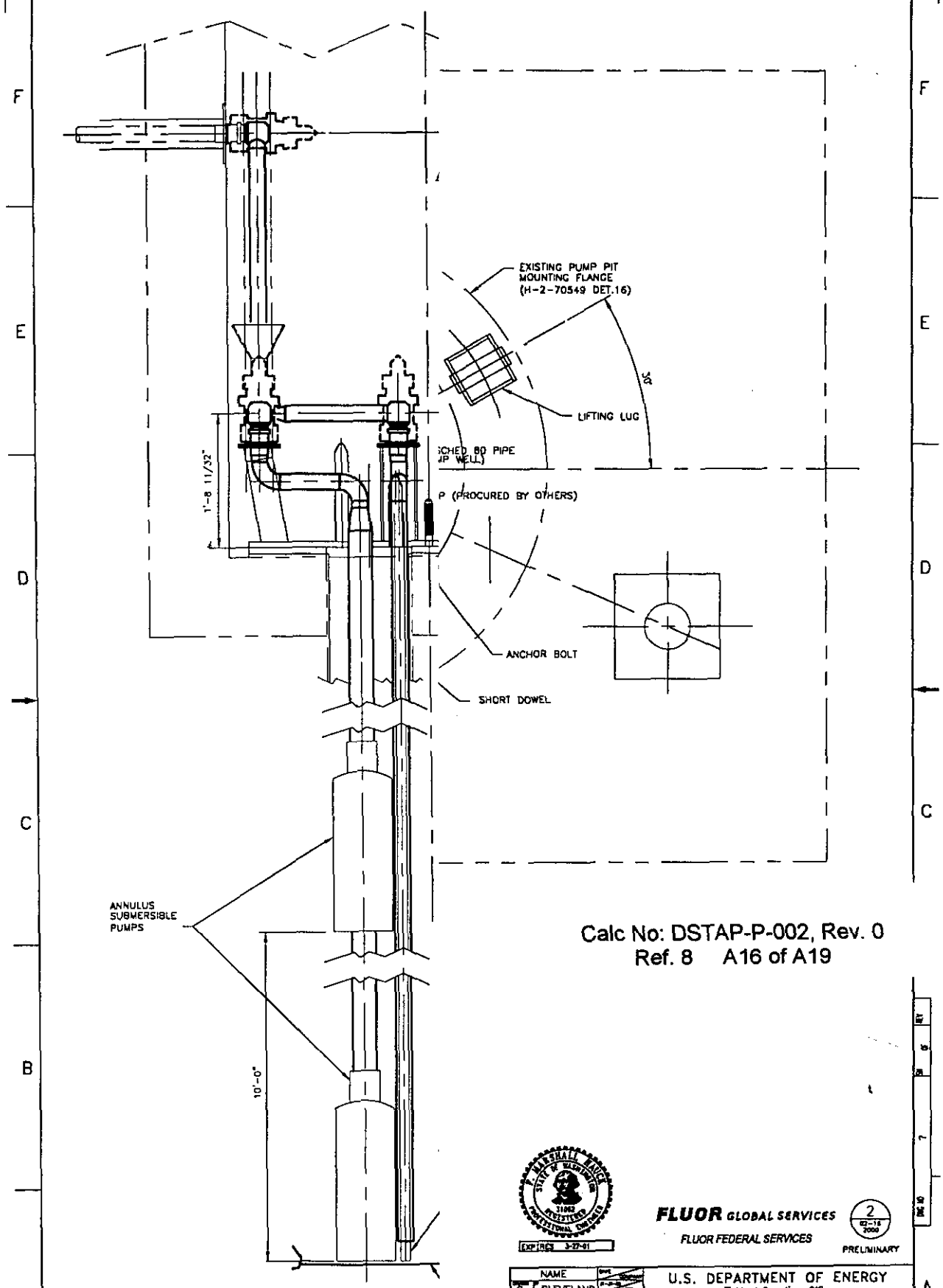
CLASSIFICATION REVIEWER DATE/DATE

PROJECT ID
DRAWING NO.
REV. A

SCALE FILE#

250

RPP-6485 Rev. 0




Calc No: DSTAP-P-002, Rev. 0
Ref. 8 A16 of A19

FIGURE 1
SCALE: 1 1/2" =1'-0"

FLUOR GLOBAL SERVICES
FLUOR FEDERAL SERVICES
PRELIMINARY

EXPIRES 3-27-01

| NAME | |
|---|---|
| G. J. CLEVELAND | |

U.S. DEPARTMENT OF ENERGY
Richland Operations Office

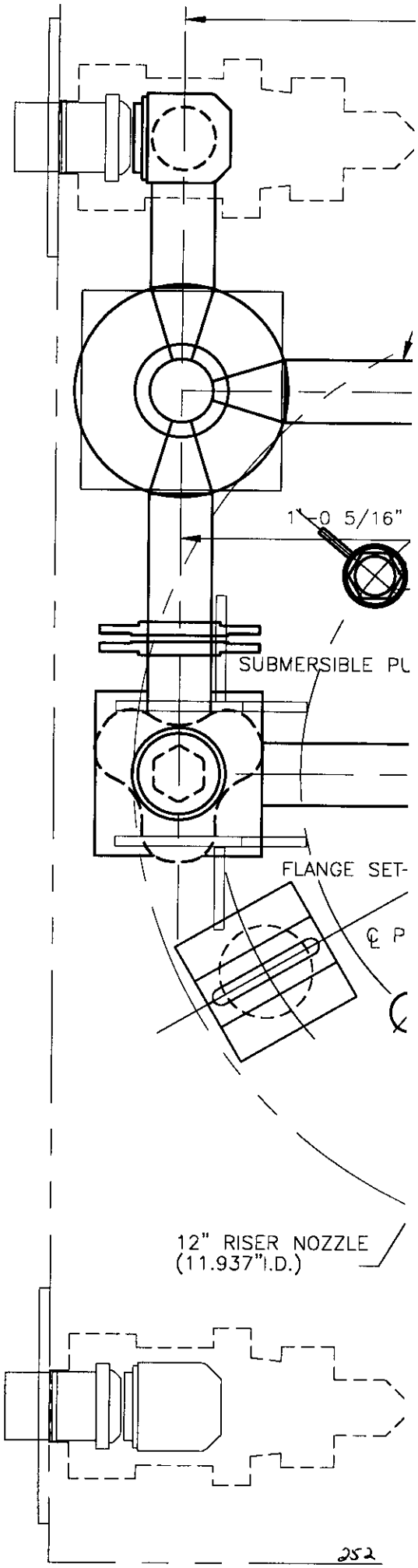
PUMPS LAYOUT
ANNULUS PUMP PIT
241-AN-01B THRU 07B

F | 241-AN | 0 | SHEET 1 OF 1 | SHOWN

ps_sketch PLOT SCALE: 1=8

RPP-6485 Rev. 0






252

# Title – Statement of Work for Annulus Pumping
# Contract 4975 – Fluor Daniel Northwest
# Revision Number - 0
# Date – December 9, 1999

## Objective:
This task order is to authorize Fluor Daniel Northwest to provide engineering support for identifying, supporting procurement, testing, and final design of a pump assembly for waste removal in the Double-Shell Tank Annulus.

## Background/Introduction:
The objective is to provide a combination of two pumps capable of high flow removal of waste for the DST Annulus, and removal of the heel to the extent possible. The pumping scheme should follow that addressed in an ARES Report Number 9905303-001, March 1999, "Double-Shell Tank Annulus Pumping Alternative Evaluation" unless changed with LMHC concurrence. A spare pumping system will also be procured. These activities support Tasks 19DAPB " Prepare Procurement Specification & Procure Pump" and 19DAPC "Design, Procure, Fabricate, Receive & Store Jumpers & Pump Assemblies" of the schedule attached to correspondence LMHC-9954506R2 October 25, 1999.

## Scope:
This Task Order allows Fluor Daniel Northwest to perform, as required, the following minimum activities:

100

Task 19DAPB
1. Review of piping system and prepare preliminary design (6 DST Farms transferring to 106-AP)
2. Prepare procurement specification for pumps
3. Support procurement activities
4. Evaluate bids, and select vendor
5. Prepare acceptance test procedure
6. Evaluate run-in data for the tested pumps
7. Develop Certified Vendor Information File

100

Task 19DAPC
8. Final design of pump assemblies and farm specific flanges
9. Fabrication support of pump assemblies
10. Identification of common spare jumper parts
11. Prepare spare parts list

## References:
*Piping pressure drop calculations for the Cross-site transfer route to AP Tank Farm have been documented in Project W-058 files in* calculation numbers W058-P-044 and 048. Schematics with transfer line lengths have been developed for most tank farm routings to AP farm and can be found in the Emergency Transfer procedures TO-001-181, 182, 183, 184 and TO-430-500 as excavation schematics.

## Deliverables:
Design drawings, procurement specification, acceptance test procedure all prepared in accordance with LMHC approved procedures.

## Acceptance Criteria:
Documentation with the appropriate LMHC and FDNW approvals as established in current procedures.

## Period of Performance:
Activities associated with this SOW are expected to be initiated as soon as possible after receipt of the Task Order, with completion on or before April 11, 2000 for Task 19DAPB and June 2, 2000 for Task 19DAPC.

## Technical Point of Contact:
The following personnel are assigned as liaison with Fluor Daniel Northwest for the scope of work described:

- Technical Contact: D. W Reberger, LMHC, Double Shell Tank Engineering
- Administrative Contact: A. B. Johnson, L.K. Martin LMHC, Financial Control
- Project Engineer: S. J. Lepka, LMHC, Operational Configuration Management

**Applicable ES&H requirements:**
Standard ES&H requirements (without ISMS) are warranted for this work.

**Safety Requirements:**
N/A

**Requirements (Including Quality Assurance Requirements):**
The subcontractor is subject to Title 10, Code of Federal Regulations, Part 830.120 (10 CFR 830.120), *Quality Assurance Requirements*, and the enforcement actions under 10 CFR 820, *General Statement of Enforcement Policy.*

**Hold Points:**
N/A

**Configuration Management Requirements:**
N/A

**Work Location/Potential Access Requirements:**
N/A

**Training:**
N/A

**Qualifications:**
Degreed Engineering support as required.

**Special Requirements:**
N/A

**Reporting/Administration:**
Status Meetings will be as requested by LMHC or FDNW. Any documentation computer files such as Supporting Documents will be prepared in Word Perfect or Microsoft Word.

RPP-6485 REV.0

| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX | Page: i of i<br>Date: 04/25/00 |
|---|---|---|

This sheet shows the status and description of the attached Design Analysis sheets

Discipline: 454 Project/Area/Unit: 65100541/25/9 Calculation No.: DSTAP-P-003

Project No. & Name: Double Shell Tank Annulus Pumping

Calculation Item: DST Annulus Pump Transfer Line Pressure

These calculations apply to:

Drawing No.: N/A Rev. No:

Drawing No.: Rev. No:

Other (Study, CDR): Rev. No.

The status of these calculations is:

[] Preliminary Calculations

[X] Final Calculations

[] Check Calculations (On Calculation Dated )

[] Void Calculation (Reason Voided )

Incorporated in Final Drawings? [] Yes [X] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | Paul M. Daub 4/25/00 | | |
| Checked by | J M Hamch 4/26/00 | | |
| Approved by | J M Hamch 4/26/00 | | |
| Checked Against Approved Vendor Data | | | |

## INDEX


| Design Analysis Page No. | Description |
|---|---|
| 1 | Objective, Design Input, Assumptions, Methods, References, Conclusions |
| 2 | Calculation |
| Appendix A | Attached References |
| A1 | Dayton Air Compressor Cut-Sheet |
| A2 | E-mail consisting of Design Parameters |
| A3 | Instrumentation Northwest, Inc. Hydrostar System Air Motors |
| | |
| | |
| | |
| | |

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-003
Revision No.: 0
Page No.: 1 of 2

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP TRANSFER LINE PRESSURE
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 25 / 00 By: P. M. DORSH
Checked: 4-/ 26 / 00 By:
Revised: By:

## OBJECTIVE:

The objective of this calculation is to determine if the Hydrostar air motor/pump can pressurize a transfer line above its design pressure. An obstruction in the transfer line could prevent a flow of fluid. This would create a closed system in which the pressure in the air motor could be amplified and transmitted to the transfer line. The maximum design pressure of the lines is 230 psi. If the operating pressure exceeds the maximum design pressure, a pressure relief valve may be required to protect the transfer lines.

## DESIGN INPUT:

1.) The design pressure of the piping is 230 psi. (Ref. 2, A2)

2.) The maximum air pressure produced be the air compressor is 135 psi. (Ref. 1, A1)

3.) A 2" air motor was recommended for use by the pump manufacturer.

4.) The pump piston diameter is 1.5". (Ref. 3, A3)

## ASSUMPTIONS:

1.) The air compressor is able to pressurize the air motor to 135 psi.

2.) There is no "blow-by" of air past the piston seals used in the air motor.

2.) There is no "blow-by" of fluid past the piston seals used in the pump.

## METHODS:

1.) Calculations are performed using Mathcad 6.0

The Hydrostar pump is a positive displacement, piston driven pump. The piston in the pump is driven by a rod, which is actuated by an air operated motor. The air motor cylinder is pressurized, causing the piston to move. The force of the motor piston is transferred to the actuating rod. The rod transmits the force to the piston in the pump. The force moves the pump piston, which positively displaces fluid. By fluid static principles of a closed system, a pressure change produced at one point in the system will be transmitted throughout the entire system. Thus, the pressure produced at the pump piston will be transmitted throughout the entire transfer line.

## REFERENCES:

1.) Dayton Air Compressor cut-sheet, from Grainger 1995 General Catalog No. 386.

2.) E-mail dated 1/25/00 from Dan Reberger to Marshall Hauck consisting of Revised Design Criteria.

3.) Instrumentation Northwest, Inc. Hydrostar System Air Motors

## CONCLUSION:

There is a possibility that the air motor can pressurize the transfer line to 240 psi. This is above the design pressure of 230 psi. A pressure relief valve should be installed in the piping.

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-003
Revision No.: 0
Page No.: 2 of 2

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP TRANSFER LINE PRESSURE
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 25 / 00 By: P. M. DORSH
Checked: 4 / 26 / 00 By:
Revised: By:

**CALCULATION:**

| | | | |
|---|---|---|---|
| Air Motor Piston Diameter | $D_m := 2.0 \cdot in$ | | |
| Air Motor Piston Surface Area | $A_m := D_m^2 \cdot \frac{\pi}{4}$ | $A_m = 3.142 \cdot in^2$ | |
| Max Pressure Induced in Air Motor | $P_m := 135 \cdot psi$ | | (Ref 1, A1) |
| Max Lifting Force of Air Motor / Rod | $F := P_m \cdot A_m$ | $F = 424.1 \cdot lb$ | |
| Pump Piston Diameter | $D_p := 1.5 \cdot in$ | | (Ref 3, A3) |
| Pump Piston Surface Area | $A_p := D_p^2 \cdot \frac{\pi}{4}$ | $A_p = 1.767 \cdot in^2$ | |
| Pump Piston Pressure | $P_p := \frac{F}{A_p}$ | $P_p = 240 \cdot psi$ | |

# CALCULATION NO: DSTAP-P-003, Rev. 0
# APPENDIX A

## References

NEW ITEM ON THIS PAGE

**AIR COMPRESSORS**

# STATIONARY TANK MOUNTED AND BASE PLATE AIR COMPRESSORS

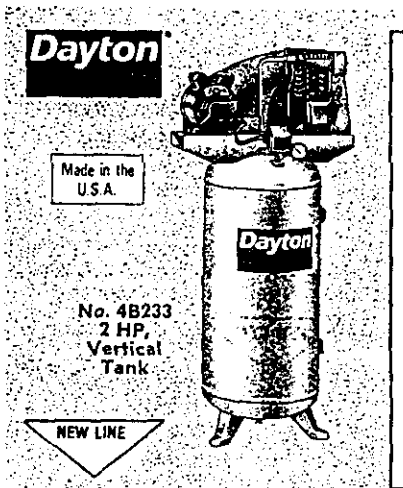
**EXCLUSIVE DAYTON DESIGN RELIABLY POWERS AIR TOOLS, PAINT SPRAYERS, SANDBLAST EQUIPMENT, AIR CYLINDERS, AND SMALL MACHINES**

### THE DAYTON CAST IRON DIFFERENCE

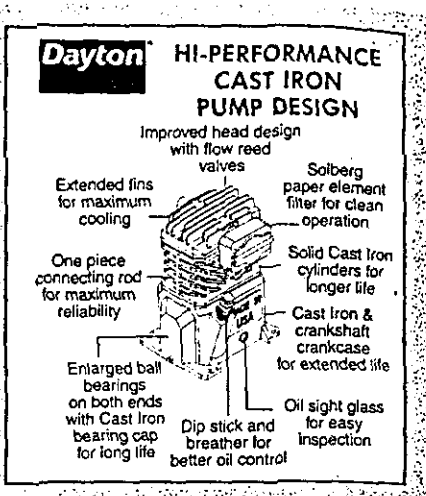
- Longer life—up to 100% longer pump life than comparable air compressors
- Higher Air Flow—Up to 10% more CFM than comparable models
- Higher Pressure—Maximum 135 PSI for a broader range of applications
- Higher Duty Cycle—Runs up to a 65% duty cycle vs. the standard 50/50 duty cycle

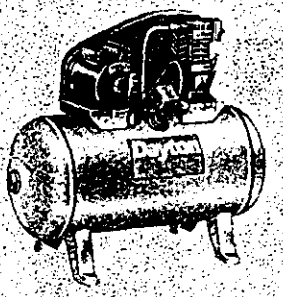
### TANK MOUNT MODELS INCLUDE

- High flow air cooling system reduces pump temperature
- Copper discharge tube for improved durability and cooling
- Single and 3-phase open dripproof motors with thermal protection
- NEMA 1 enclosure pressure switch with gauge
- 30 gallon stationary ASME air tank
- Pressure switch setting 95 PSI On and 135 PSI Off (Except Base Plate Nos. 4B242 and 4B243)
- Comply with State of California code 462 (L) (2)
- Charcoal gray metallic finish



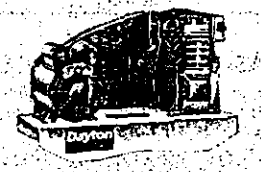

No. 4B233
2 HP,
Vertical
Tank



No. 4B234
2 HP,
Horizontal
Tank

Except
Nos. 4B242
& 4B243



No. 4B243
Base Plate

## PUMP SPECIFICATIONS

| Free Air CFM @ PSI 40 | 90 | Displ. CFM | Max. PSI | Rated Pump Life (Hrs)† | Max. Duty Cycle | RPM | Cyls. | Bore (In.) | Stroke (In.) | Oil Cap. | Repl. Pump Stock No. | Compressor Stock No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.9 | 5.7 | 8.8 | 100 | 5000 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 oz. | 4B246 | 4B232 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B233 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B234 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B235 |
| 11.0 | 9.4 | 13.7 | 135 | 4200 | 65/35 | 1000 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B237 |
| 11.2 | — | 13.7 | 40 | 5000 | 65/35 | 1000 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B242 |
| 14.1 | — | 16.8 | 40 | 5000 | 65/35 | 1225 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B243 |

### BASE PLATE MODELS Nos. 4B242 and 4B243

- Suitable for fire sprinkler applications (verify local codes and regulations for compliance)
- Prewired (240V) with pneumatic control package
- Pressure switch setting 30 PSI On and 40 PSI Off

SIGN HERE

## ORDERING DATA

| Peak Developed HP* | Running Motor HP* | Gal. | Tank Type | Volts, 60 Hz | Phase | Amp Draw | NPT Outlet, In. | Dimensions, In. L | W | H | Stock No. | List | Each | Shpg. Wt. | With Magnetic Starter# Volts, 60 Hz | Stock No. | List | Each | Shpg. Wt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 30‡ | Horizontal | 120/240 | 1 | 17.8/8.9 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B232▲ | $748.75 | $585.00▲ | 177.0 | 120<br>240 | 7Z021▲<br>7Z022▲ | $915.00<br>910.00 | $729.00▲<br>715.00▲ | 184.2<br>184.2 |
| 2 | 2.00 | 30‡ | Vertical | 120/240 | 1 | 24.0/12.0 | 1/4(F) | 26¼ | 19 | 52 | 4B233▲ | 798.75 | 599.00▲ | 170.0 | 120<br>240 | 7Z023▲<br>7Z024▲ | 939.00<br>915.00 | 750.00▲<br>729.00▲ | 177.3<br>177.2 |
| 2 | 2.00 | 30‡ | Horizontal | 120/240 | 1 | 24.0/12.0 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B234▲ | 798.75 | 599.00▲ | 179.0 | 120<br>240 | 7Z025▲<br>7Z026▲ | 939.00<br>915.00 | 750.00▲<br>729.00▲ | 186.3<br>186.2 |
| 2 | 2.00 | 30‡ | Vertical | 208/240/480 | 3 | 5.6/2.8 | 1/4(F) | 26¼ | 19 | 52 | 4B235▲ | 836.25 | 639.00▲ | 170.0 | 208/240<br>480 | 7Z027▲<br>7Z028▲ | 960.00<br>960.00 | 765.00▲<br>765.00▲ | 172.8<br>177.5 |
| 3 | 3.00 | 30‡ | Horizontal | 208/240/480 | 3 | 8.0/4.0 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B237▲ | 873.75 | 675.00▲ | 180.0 | 208/240<br>480 | 7Z029▲<br>7Z030▲ | 870.00<br>870.00 | 695.00▲<br>695.00▲ | 182.5<br>187.5 |
| 2 | 2.00 | | Base Plate | 120/240 | 1 | 15.0/7.5 | 1/2(F) | 22½ | 15½ | 14¾ | 4B242▲ | 581.25 | 465.00▲ | 89.0 | 120<br>240 | 7Z048▲<br>7Z049▲ | 769.00<br>750.00 | 615.00▲<br>599.00▲ | 96.3<br>96.2 |
| 3 | 3.00 | | Base Plate | 208/240/480 | 3 | 8.0/4.0 | 1/2(F) | 22½ | 15½ | 14¾ | 4B243▲ | 645.00 | 515.00▲ | 90.0 | 240<br>480 | 7Z100▲<br>7Z101▲ | 799.00<br>859.00 | 639.00▲<br>685.00▲ | 92.8<br>97.5 |

(*) For specific HP rating explanations, see page 2214. (‡) ASME code air tanks. (†) As rated by the standard B-10 bearing life of the pump. Individual compressor life will vary depending on duty cycle, ambient temperature, maintenance performed, air intake quality, and manufacturing part tolerances. (#) Magnetic starters not mounted and wired; provided separately.



▲Net Prices, Not Subject To Discounts

**Dorsh, Paul M**

**From:** Reberger, Dan W
**Sent:** Tuesday, January 25, 2000 7:38 AM
**To:** Hauck, Frank M (Marshall)
**Cc:** Rarig, Bradley K; Dorsh, Paul M; Peck, David J; Leshikar, Gregory A
**Subject:** Draft Design Criteria for Annulus pumps -Revision

I forgot the criteria on Flammable Gas Controls and pressure.

---

In our recent meetings on annulus pumping, it was apparent that the pumping specifications previously provided were not adequate. I'm currently in the process of developing a technical rational for the Pump Design Criteria. The following is a draft of the criteria. Let me know if there are any questions or concerns.

**Heel Pump**

| | |
|---|---|
| Total Flow | 2 - 5 gpm |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centipoise |
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$F |
| Discharge Pressure | 230 maximum* |
| Flammable Gas Controls or equivalent)** | Ignition Source Control Set #1 (Class 1 Division 1 GroupB |
| Dilution water Flow | None Required |

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

*Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

**Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

# Instrumentation Northwest, Inc.

APPLICATION NOTE:
**Hydrostar System Air Motors**
May 5, 1992

Calc No: DSTAP-P-003, Rev. 0
Ref. 3 A3 of A3

## Introduction

When sizing an air-driven system one must consider the air motor cylinder size being used, the stroke rate desired to produce a certain production rate (GPM) and the air consumption of the air motor.

## Air Cylinder Size

Without going through the formulas, outlined below is a general guideline table for selecting the proper size air motor depending on the installation depth of the HydroStar. For each motor size a range of values is given: the Maximum Full Speed Depth (MFSD) and the Maximum Recommended Depth (MRD). The Maximum Full Speed Depth is the installation depth where some loss in air motor performance will begin to occur. The Maximum Recommended Depth is the deepest installation depth we would recommend using this size air motor.

**Depth Chart (In Feet)**

| Cylinder size (in) | 1.5 | 2.0 | 2.5 | 3.25 | 4 |
|---|---|---|---|---|---|
| MFSD (ft) | 76 | 146 | 240 | 392 | 617 |
| MRD (ft) | 106 | 205 | 337 | 549 | 865 |

## Production Due to Stroke Rate

The HS-8000 and HS-8001 pumps are 1.5" diameter pump cylinders with a stroke rate of 12 inches. If we assume that the pumps operate at 90% efficiency the production factor of the pumps is .082 gallons per stroke. Note: Actual field studies rate the efficiency of the HydroStar pumps better than 90% at their rated operating depth capacity *(see pump curves)*.

Example: If your pump is operating at 40 strokes per minute your production rate would be 40 * .082 = 3.29 gallons per minute.

## Air Consumption *(at 80 PSI operation)*

Air consumption is a factor of the cylinder size you use and the stroke rate of the cylinder. The HydroStar system can operate up to 60 strokes per minute down to less than 1 stroke per minute so naturally the air consumption will vary depending on the desired operating speed.

Below is a table of factors one can use to determine the air consumption of your system in Standard Cubic Feet (SCF). (These factors are just guidelines since a number of additional variables can effect air consumption).

| Cylinder Size (in) | 1.5 | 2.0 | 2.5 | 3.25 | 4 |
|---|---|---|---|---|---|
| Air consumption *(SCF per stroke)* | .10 | .18 | .30 | .49 | .76 |

Example: A HydroStar system operating at 40 strokes per minute using a 1.5 inch cylinder would need .1 * 40 = 4 SCFM of air.

*(cont.)*

**Fluor Federal Services, INC** CALCULATION IDENTIFICATION AND INDEX

Page i of

Date 6 / 08 /2000

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline 27,Piping and Vess WO/Job No: Calculati DSTAP-P-004

Project No. & Nam TANK FARM PUMP PITS ANNULUS PUMPING

Calculation Item Annulus Jumper Piping Stress Analysis

These calculations apply to:

Dwg. No. H-14-104128 through H-14-104133 Rev. No. 0

Dwg. No. Rev. No.

Other (Study, CDR)

The status of these calculations is:

o Preliminary Calculations

x Final Calculations

o Check Calculations (On Calculation Dated

o Void Calculation (Reason Voided

Incorporated in Final Drawings? x Yes o No

This calculation verified by independent "check" calculation? o Yes x No

Original and Revised Calculation Approvals:

| | Rev. 0 Signature / Date | Rev. 1 Signature / Date | Rev. 2 Signature / Date | |
|---|---|---|---|---|
| Originator | MM Ahmed 6/8/00 | | | |
| Checked by | Jennifer Williamson 6/9/00 | | | |
| Approved by | JM Hanch 6/14/00 | | | |
| Checked Against Approved Vendor Data | | | | |

Design Analysis INDEX

| Page No. | Descriptio |
|---|---|
| i | Calculation Identification and Index |
| 1 | Objective, Design Criteria, Codes & Standards and Design Parameters |
| 2 | Design loads and Acceptance criteria |
| 3 | Design Methodology |
| 4 | Assumptions, References, Calculation & Conclusion |
| Appdx-A | AutoPipe File: AY01F&02F Stress Report |
| Appdx-B | AutoPipe File: AZ01-07B Stress Report |
| Appdx-C | AutoPipe File: AN01_07B Stress Report |
| Appdx-D | AutoPipe File: AP&SY Stress Report |

# FLUOR FEDERAL SERVICES



## DESIGN ANALYSIS

| | | | |
|---|---|---|---|
| Client | Numatec Hanford Inc | WO/Job No. | Filename: anul-jump |
| Subject | Annulus Jumper Piping Stress Analysis | Date: June 8, 2000 | By: M. M. Ahmed |
| | | Checked | By: |
| Location | Tank Farms | Revised | By: |

**OBJECTIVE:**

The objective of this calculation is to perform static & seismic analysis for Jumper piping for annulus pumping located in pump pits for Tanks AN, AP, AW, AY, AZ and SY in accordance with General Services requirements and be in compliance with ASME Code B31.3 requirements.

**DESIGN CRITERIA:**

The design and analysis of jumper piping is in accordance with the following criteria:

1. DOE Criteria 6430.1A
2. HNF-PRO-97, Rev-0. Engineering Design and Evaluation — Ref:5
3. WHC-SD-W236A-DA-002, Rev-0. Stress Analysis of Single Port (ISB) Jumper Connectors For 2-, 3- and 4-in Sizes. — Ref:3
4. Letter dated 12-17-1999 from Bradley K. Rarig "Design Procedures and Criteria for Annulus Pumping" — Ref:4

**DESIGN CODES & STANDARDS:**

1. ASME Code B31.3a-1996 " Process Piping" — Ref:1
2. Piping Stress Analysis Software program "AUTOPIPE" Version-6.0 by Rebis Co. — Ref:2
3. SD-RE-DGS-002, Rev-3. Purex Connector Standards — Ref:6

**DESIGN PARAMETERS:**

| | | |
|---|---|---|
| 1. Design Pressure | 300 psig | Ref:4 |
| 2. Design Temperature | 340° F | Ref:4 |
| 3. Ambient Temperature | 65° F | Assumed |
| 4. Corrosion Allowance | 0.4 mils/year | Assumed |
| 5. Project Life | 40 years | Assumed |
| 6. Waste fluid specific weight | 1.47 | Ref:4 |
| 7. Seismic Safety Class | General Service | Ref:4 |

# FLUOR FEDERAL SERVICES



## DESIGN ANALYSIS

| | | | |
|---|---|---|---|
| Client | Numatec Hanford Inc | WO/Job No. | Filename: anul-jump |
| Subject | Annulus Jumper Piping Stress Analysis | Date: June 8, 2000 | By: M. M. Ahmed |
| | | Checked | By: |
| Location | Tank Farms | Revised | By: |

**DESIGN LOADS:**

**DESIGN PRESSURE LOAD:**
A design pressure of 300 psig is considered in the analysis to compute pressure stresses. AutoPipe (Ref:2) software program is used for stress analysis. AutoPipe program computes the "Hoop Stress" (pipe wall circumference stress) and longitudinal pressure stress as required by Code ASME B31.3 (Ref:1).

**THERMAL EXPANSION LOADS:**
Thermal expansion stress due to increase of pipe metal temperature from 65° F to 340° F is calculated in AutoPipe program to meet code criteria.

**SUSTAINED LOADS:**
The weight of pipe material, contents, pipe components and supporting dunnage steel are included in AutoPipe analysis. The AutoPipe program computes the mechanical stresses resulting from sustained loads.

**SEISMIC LOADS:**
Since the jumper piping is classified as General Service, In accordance with the requirements of HNF-PRO-97 (Ref:5), the UBC methodology to compute the Latertal earth quake forces is supposed to be used. However a dynamic analysis using Table D-4 (Ref:5) response spectra designated for Safety Significant PC3 structures is performed which is conservative for General Service.

**ACCEPTANCE CRITERIA:**

ASME Code B31.3 criteria for allowable pipe stresses is adopted as acceptance criteria. Allowable stress "$S_h$" for given material at given design temperature are obtained from Appendix-A of the code.

1. Hoop stress $< S_h$ — Ref:1, Para 302.3.5(a)
   (Circumferential pressure stress)

2. Sustained Stress $< S_h$ — Ref:1, Para 302.3.5
   (Longitudinal pressure + Gravity stress)

3. Thermal (Displacement) stress $< f(1.25S_c + 0.25S_h)$ — Ref:1, Eqn-1a
   (Thermal expansion stress)

4. Seismic (Occasional) stress $< 1.33S_h$ — Ref:1, Para 302.3.6
   (Sustained + Seismic stress)

# FLUOR FEDERAL SERVICES



**DESIGN ANALYSIS**

Client Numatec Hanford Inc
Subject Annulus Jumper Piping Stress Analysis
Location Tank Farms

WO/Job No.
Date: June 8, 2000
Checked
Revised

Filename: anul-jump
By: M. M. Ahmed
By:
By:

**DESIGN METHODOLOGY:**

The jumper piping analysis is performed using the Autopipe (Ref:2) software program which has been verified and validated in accordance with Fluor Daniel practice no: 134 200 0960.

The jumper piping assemblies basically consists of multiple jumper piping connected between tanks/ pit wall nozzles through Purex type jumper (Ref:6) connectors. Each jumper piping is attached to dunnage (supporting) steel and bail assembly. The Purex type connectors are welded to pipe at both ends. The jumper piping is remotely installed in the pit by using crane. When set in position, the Purex connectors are remotely connected to the existing nozzles in the pit.

The Purex type connectors (Ref:6) are modeled as a short radius elbows with a flexible joint on the nozzle side. The translation and rotational stiffness of ISB connectors (Ref:3) are used in the model since both ISB and Purex connectors are assumed to have similar rigidity. The weights of the Purex connectors, nozzles and kick plates are considered as concentrated loads at connector locations.

The three way valves are modeled as three different valves with 1/3 of weight of the valve, because of the in-ability of AutoPipe program to model a three way valve.

The jumper piping terminal attachments to Pump pit wall structure and Waste tanks risers are considered as rigid anchors in the model.

The function of structural (Dunnage) steel attached to jumper piping is to balance piping during jumper assembly installation in the pit. Hence the structural steel is subjected to dead weight of jumper piping assembly during installation only. The structural steel is reviewed for adequacy to withstand the weight of jumper assemblies and determined to be adequate by inspection.

Once installed the pipe will bear the weight of the steel. As such the weight of steel is calculated and imposed at appropriate node points (steel attachment to pipe) in the model.

The bail assembly and it's welds are reviewed and found to be structurally adequate to carry the weight of the jumper piping assembly during installation.

PUREX CONNECTORS:
The Purex connectors application is acceptable based on historical precedence. The ASME B31.3 code paragraph 304.7.2(a) states that "unlisted components and elements may be utilized based on extensive, successful service experience under comparable conditions with similarly proportioned components of same or like material." The PUREX connectors have been in service successfully for approximately 40 years. As such analytical qualification of the PUREX connectors is not required.

# FLUOR FEDERAL SERVICES



## DESIGN ANALYSIS

| | | | |
|---|---|---|---|
| Client | Numatec Hanford Inc | WO/Job No. | Filename: anul-jump |
| Subject | Annulus Jumper Piping Stress Analysis | Date: June 8, 2000 | By: M. M. Ahmed |
| | | Checked | By: |
| Location | Tank Farms | Revised | By: |

**ASSUMPTIONS:**

1. The stiffness factors used in the model for Purex type connectors are obtained from ISB connectors (Ref:3) data. Assumed that these stiffness factors are valid.

2. Pit wall structures and tank risers are structurally adequate to support piping loads.

3. A separate analysis will be performed for Pit wall Anchors for the combined piping loads from Jumper piping and buried transfer

**REFERENCES:**

1. ASME Code B31.3a-1996, with 1998 Addenda "Process Piping Code".

2. AutoPipe, Version 6.0 software program by Rebis Co.

3. WHC-SD-W236A-DA-002, Rev-0 "Analysis of 2-, 3-, 4-in ISB Jumper Connectors Under operational and Seismic Loading Conditions.

4. Letter dated 12-17-1999 from Bradley K. Rarig "Design Procedures and Criteria for Annulus Pumping"

5 HNF-PRO-97 Rev-0, Engineering Design and Evaluation.

6. SD-RE-DGS-002, Rev-3. PUREX Connector Design Standard.

7. Drawings: H-14-104128 Rev-0 thru H-14-104133, Rev-0.

**CALCULATION:**

The AutoPipe analysis results are documented in Appendices to this calculation as listed below. The Jumper piping assemblies with similar configuration are grouped for the purpose of analysis.

| | | |
|---|---|---|
| Appendix-A | AutoPipe File:AY01&02F | Pump Pits 241-AY-01F & -02F |
| Appendix-B | AutoPipe File:AZ01&02F | Pump Pits 241-AZ-01F & -02F |
| Appendix-C | AutoPipe File:AN01-07B | Pump Pits 241-AN-01B THRU -07B<br>241-AW-01B THRU -06B and<br>241-AP-01A, 03A, 06A & 08A |
| Appendix-D | AutoPipe File:AP&SY | Pump pits 241-AP-02A, 04A, 05A & 07A<br>241-SY-01B, 02B & 03B |

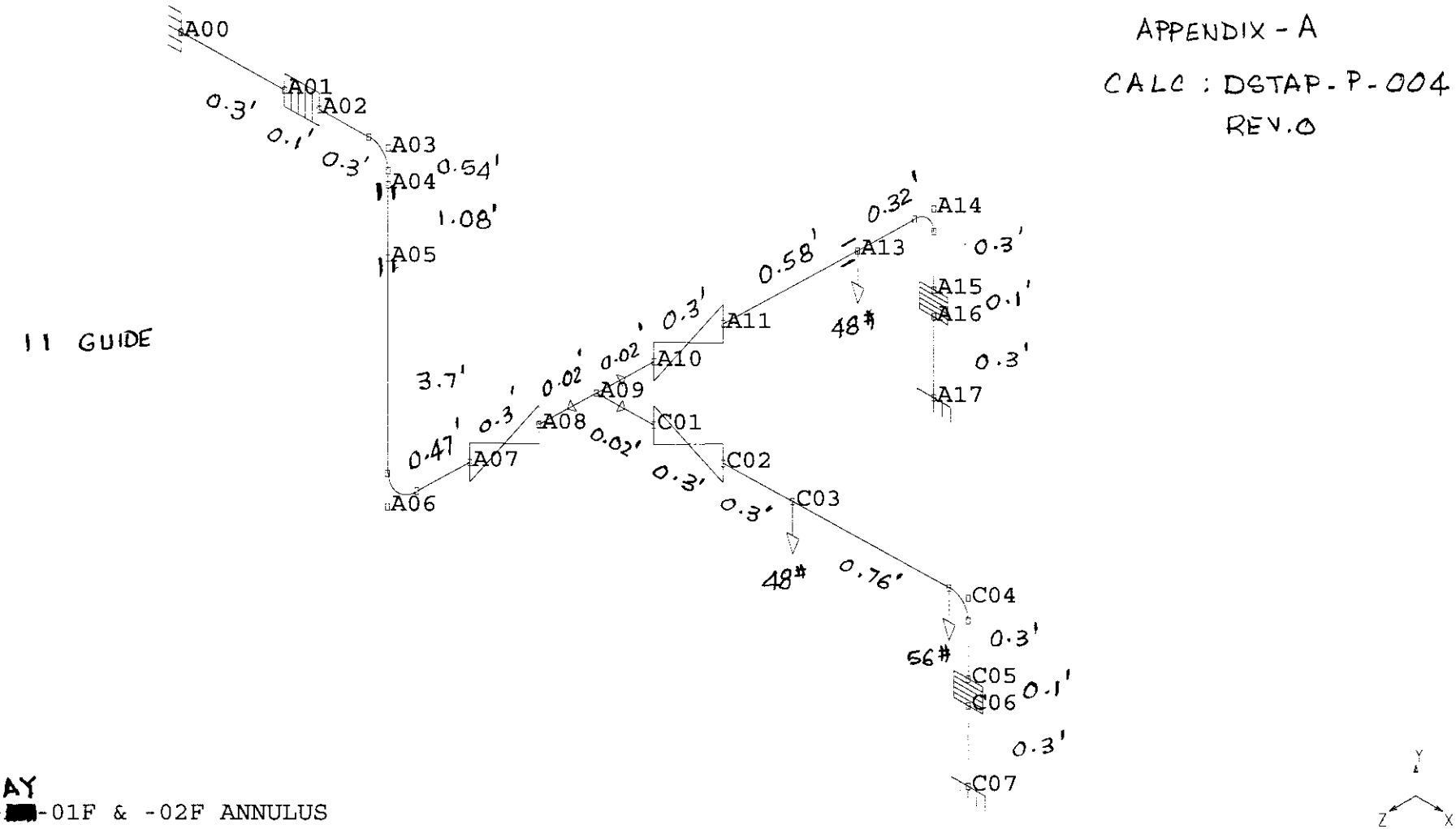
**CONCLUSION:**

The review of AutoPipe analysis indicates that the piping stresses meets Code B31.3a criteria as stated in Acceptance Criteria above.

APPENDIX - A

CALC : DSTAP - P - 004

REV. 0




AY
241-[redacted]-01F & -02F ANNULUS
PUMP PIT JUMPER ASSEMBLY ANALYSIS

FILE : AY01 & 02F

REF DWGS : H-14-104131 (2 SHTS) REV. 0.

RPP-6485 REV. 0

```
     *                          *******   **  *******   *******
    ***             **          **    **  **  **    **  **
   ** **           ******        **    **  **  **    **  **
  **   **    **   **  **   *****  *******   **  *******   *****
 *********  **   **  **  **   **  **        **  **        **
**       **  **   **  **  **   **  **        **  **        **
**        **  *****   **   *****  **        **  **        *******
```

Pipe Stress Analysis and Design Program

Version: 6.00.16

Edition: Plus-Win

Developed and Maintained by

REBIS Industrial Workgroup Software
1600 Riviera Ave., Suite 300
Walnut Creek, CA 94596

RPP-6465 Rev.D



```
**************************************************************
**                                                          **
**              AUTOPIPE SYSTEM DATA LISTING                **
**                                                          **
**************************************************************
```

SYSTEM NAME : AY01&02F

PROJECT ID : 241-AY-01F & -02F ANNULUS
PUMP PIT JUMPER ASSEMBLY ANALYSIS

PREPARED BY : M.M. Ahmed
M.M. AHMED

CHECKED BY : Jennifer Williamson

PIPING CODE : B31.3

VERTICAL AXIS : Y

AMBIENT TEMPERATURE : 65.0 deg F

COMPONENT LIBRARY : AUTOPIPE

MATERIAL LIBRARY : AUTOB313

MODEL REVISION NUMBER : 11

## POINT DATA LISTING

| POINT NAME | TYPE | OFFSETS (ft) X | Y | Z | DESCRIPTION |
|---|---|---|---|---|---|
| *** SEGMENT A | | | | | |
| A00 | Run | 0 | 0 | 0 | PIPE ID = 2"PIPE |
| A01 | Flex | 0.30 | 0 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| A02 | Run | 0.10 | 0 | 0 | |
| A03 | Bend | 0.30 | 0 | 0 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| A04 | Run | 0 | -0.54 | 0 | |
| A05 | Run | 0 | -1.08 | 0 | |
| A06 | Bend | 0 | -3.70 | 0 | Long Elbow, Radius = 3.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 1.73, Out = 1.44<br>Flex = 4.404 |
| A07 | Valv | 0 | 0 | -0.47 | GATE-F , Rating = 300<br>Weight = 16 lb<br>Surface factor = 4.20<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| A08 | Run | 0 | 0 | -0.30 | |
| A09 | Tee | 0 | 0 | -0.02 | |
| A10 | Valv | 0 | 0 | -0.02 | GATE-F , Rating = 300<br>Weight = 16 lb<br>Surface factor = 4.20<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| A11 | Run | 0 | 0 | -0.30 | |
| A13 | Run | 0 | 0 | -0.58 | |
| A14 | Bend | 0 | 0 | -0.33 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| A15 | Flex | 0 | -0.30 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| A16 | Run | 0 | -0.10 | 0 | |
| A17 | Run | 0 | -0.30 | 0 | |
| *** SEGMENT C | | | | | |
| A09 | Tee | 0.70 | -5.32 | -0.79 | PIPE ID = 2"PIPE |
| C01 | Valv | 0.02 | 0 | 0 | GATE-F , Rating = 300 |



## POINT DATA LISTING

| POINT NAME | TYPE | OFFSETS (ft) X | Y | Z | DESCRIPTION |
|---|---|---|---|---|---|
| | | | | | Weight = 16 lb<br>Surface factor = 4.20<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| C02 | Run | 0.30 | 0 | 0 | |
| C03 | Run | 0.30 | 0 | 0 | |
| C04 | Bend | 0.76 | 0 | 0 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| C05 | Flex | 0 | -0.30 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| C06 | Run | 0 | -0.10 | 0 | |
| C07 | Run | 0 | -0.30 | 0 | |

Total weight of empty pipes : 35 lb

KPP-1485 Rev.0

## COMPONENT DATA LISTING

| POINT NAME | COORDINATE(ft) X | Y | Z | DATA TYPE | DESCRIPTION |
|---|---|---|---|---|---|
| *** SEGMENT A | | | | | |
| A00 | 0.00 | 0.00 | 0.00 | ANCHOR | Rigid<br>Thermal movements : None |
| A01 | 0.30 | 0.00 | 0.00 | | |
| A02 | 0.40 | 0.00 | 0.00 | | |
| A03 N | 0.53 | 0.00 | 0.00 | | |
| A03 | 0.70 | 0.00 | 0.00 | TI | |
| A03 F | 0.70 | -0.17 | 0.00 | | |
| A04 | 0.70 | -0.54 | 0.00 | GUIDE | ID : A04 1, Connected to Ground<br>Stiffness = RIGID<br>Gap -Z = 0.06 inch<br>Gap +Z = 0.06 inch<br>Gap -X = 0.06 inch<br>Gap +X = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| A05 | 0.70 | -1.62 | 0.00 | GUIDE | ID : A05 1, Connected to Ground<br>Stiffness = RIGID<br>Gap -Z = 0.06 inch<br>Gap +Z = 0.06 inch<br>Gap -X = 0.06 inch<br>Gap +X = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| A06 N | 0.70 | -5.07 | 0.00 | | |
| A06 | 0.70 | -5.32 | 0.00 | TI | |
| A06 F | 0.70 | -5.32 | -0.25 | | |
| A07 | 0.70 | -5.32 | -0.47 | | |
| A08 | 0.70 | -5.32 | -0.77 | | |
| A09 | 0.70 | -5.32 | -0.79 | TEE | B16.9 welding tee<br>SIF - In = 1.19, Out = 1.25 |
| A10 | 0.70 | -5.32 | -0.81 | | |
| A11 | 0.70 | -5.32 | -1.11 | | |
| A13 | 0.70 | -5.32 | -1.69 | GUIDE | ID : A14 1, Connected to Ground<br>Stiffness = RIGID<br>Gap-down = 0.06 inch<br>Gap-Above = 0.00 inch<br>Gap-left = 0.00 inch<br>Gap-Right = 0.00 inch<br>Friction = 0.00<br>Gaps set Weightless |
| | | | | WEIGHT | 48 lb , No offsets |
| A14 N | 0.70 | -5.32 | -1.85 | | |
| A14 | 0.70 | -5.32 | -2.02 | TI | |
| A14 F | 0.70 | -5.49 | -2.02 | | |
| A15 | 0.70 | -5.62 | -2.02 | | |
| A16 | 0.70 | -5.72 | -2.02 | | |
| A17 | 0.70 | -6.02 | -2.02 | ANCHOR | Rigid<br>Thermal movements : None |
| *** SEGMENT C | | | | | |
| A09 | 0.70 | -5.32 | -0.79 | TEE | B16.9 welding tee |



## COMPONENT DATA LISTING

| POINT NAME | COORDINATE(ft) X | Y | Z | DATA TYPE | DESCRIPTION |
|---|---|---|---|---|---|
| | | | | | SIF - In = 1.19, Out = 1.25 |
| C01 | 0.72 | -5.32 | -0.79 | | |
| C02 | 1.02 | -5.32 | -0.79 | | |
| C03 | 1.32 | -5.32 | -0.79 | GUIDE | ID : C03 1, Connected to Ground<br>Stiffness = RIGID<br>Gap-down = 0.06 inch<br>Gap-Above = 0.00 inch<br>Gap-left = 0.00 inch<br>Gap-Right = 0.00 inch<br>Friction = 0.00<br>Gaps set Weightless |
| | | | | WEIGHT | 48 lb , No offsets |
| C04 N | 1.91 | -5.32 | -0.79 | WEIGHT | 56 lb , Offsets in ft<br>DX = 0.83, DY = 0.00, DZ = 0.00 |
| C04 | 2.08 | -5.32 | -0.79 | TI | |
| C04 F | 2.08 | -5.49 | -0.79 | | |
| C05 | 2.08 | -5.62 | -0.79 | | |
| C06 | 2.08 | -5.72 | -0.79 | | |
| C07 | 2.08 | -6.02 | -0.79 | ANCHOR | Rigid<br>Thermal movements : None |

Number of points in the system : 33



RAP-6485 Rev. 0

278

KCT4PRINT

## P I P E  D A T A  L I S T I N G

| Pipe ID/ Material | Nom/ Sch | O.D. inch | Thickness(inch) W.Th. | Corr | Mill | Insu | Ling | Spec Grav | Weight(lb/ft) Pipe | Other | Total | ZL/ ZC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2"PIPE | 2.000 | 2.375 | 0.154 | 0.02 | 0.02 | 0 | 0 | 1.50 | 3.74 | 0 | 5.92 | 1.00 |
| A312-TP304L | STD | | | | | | | | | | | 1.00 |



## M A T E R I A L  D A T A  L I S T I N G

| Material Name | Pipe ID | Density lb/cu.ft | Pois. Ratio | Temper. deg F | Modulus E6 psi Axial | Hoop | Shear | Expans. in/100ft |
|---|---|---|---|---|---|---|---|---|
| A312-TP304L | 2"PIPE | 501.0 | 0.30 | 65.0 | 28.320 | 28.320 | 10.892 | |
| | | | | 340.0 | 26.802 | | | 3.1325 |

RPP-6465 Rev.0



K/14PRINT

## M A T E R I A L  A L L O W A B L E  D A T A  L I S T I N G

| Material Name | Pipe ID | Temper. deg F | Allow. psi |
|---|---|---|---|
| A312-TP304L | 2"PIPE | 65.0 | 16700.0 |
| | | 340.0 | 16340.0 |



## TEMPERATURE AND PRESSURE DATA

| POINT NAME | CASE 1 PRESS. psi | CASE 1 TEMPER deg F | CASE 1 EXPAN. in/100ft | CASE 2 PRESS. psi | CASE 2 TEMPER deg F | CASE 2 EXPAN. in/100ft | CASE 3 PRESS. psi | CASE 3 TEMPER deg F | CASE 3 EXPAN. in/100ft |
|---|---|---|---|---|---|---|---|---|---|
| *** SEGMENT A | | | | | | | | | |
| A00 | 300 | 340 | 3.133 | | | | | | |
| A17 | 300 | 340 | 3.133 | | | | | | |
| *** SEGMENT C | | | | | | | | | |
| A09 | 300 | 340 | 3.133 | | | | | | |
| C07 | 300 | 340 | 3.133 | | | | | | |



Rpp-4488 Rev.0
272
1C/4PRINT

H O T M O D U L U S (E6 psi )

| POINT NAME | CASE 1 | CASE 2 | CASE 3 |
|---|---|---|---|
| *** SEGMENT A | | | |
| A00 | 26.802 | | |
| A17 | 26.802 | | |
| *** SEGMENT C | | | |
| A09 | 26.802 | | |
| C07 | 26.802 | | |

* Non-standard material



H O T A L L O W A B L E S (psi )

| POINT NAME | CASE 1 ALLOW | CASE 1 NOT USED | CASE 1 NOT USED | CASE 2 ALLOW | CASE 2 NOT USED | CASE 2 NOT USED | CASE 3 ALLOW | CASE 3 NOT USED | CASE 3 NOT USED |
|---|---|---|---|---|---|---|---|---|---|
| *** SEGMENT A | | | | | | | | | |
| A00 | 16340 | | | | | | | | |
| A17 | 16340 | | | | | | | | |
| *** SEGMENT C | | | | | | | | | |
| A09 | 16340 | | | | | | | | |
| C07 | 16340 | | | | | | | | |

< User-defined code allowable
* Non-code material

RPP-6445 Rev.0

273

## A N A L Y S I S  S U M M A R Y

Current model revision number : 11

```
Static - Date and Time of analysis ............. Jun 2, 2000   10:38 AM
         Model Revision Number ................. 11
         Number of load cases .................. 3
         Load cases analyzed ................... GR T1 P1
         Gaps/Friction/Soil considered ......... Yes
         Tolerance - Force, Displacement ....... 100.00 lb   0.0162 in
         Friction - Scale Factor, Tolerance .... 1.00   0.10
         Hanger design run ..................... No
         Cut short included .................... No
         Include Bourdon rotational effect ..... No
         Pipe radius for Bourdon calculation ... Mean
         Occasional load analysis type ......... Nonlinear
         Non-linear analysis summary file ...... AY01&02F.LOG
         Use default load sequence ............. Yes
         Base load cases for nonlinear analysis
                                                   GR = None
                                                   T1 = GR
                                                   P1 = T1
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No

Modal  - Date and Time of analysis ............. Jun 2, 2000   10:38 AM
         Model Revision Number ................. 11
         Number of modes ....................... 0
         Cutoff frequency (Hz) ................. 33.0
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No

Response - Date and Time of analysis ............ Jun 2, 2000   10:40 AM
         Model Revision Number ................. 11
         Number of load cases .................. 3
         Load cases analyzed ................... R1 R2 R3
         Date and time of modal analysis ....... Jun 2, 2000   10:38 AM
         Number of modes ....................... 0
         Cutoff frequency (Hz) ................. 33.0
         Model revision of modal analysis ...... 11
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No
```



### CODE COMPLIANCE COMBINATIONS

| Combination | Category | Method | Load | Factor | M/S | Allowable | Remarks |
|---|---|---|---|---|---|---|---|
| GR + Max P | Sustain | Sum | Gravity | 1.00 | | Automatic | Default |
| | | | Max Long | 1.00 | | | |
| Cold to T1 | Expansion | Sum | Thermal 1 | 1.00 | | Automatic | Default |
| Sus. + R1 | Occasion | Abs sum | Response 1 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Sus. + R2 | Occasion | Abs sum | Response 2 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Sus. + R3 | Occasion | Abs sum | Response 3 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Max P | Hoop | | Max Hoop | 1.00 | | Automatic | Default |

RPP-6485 Rev.0

374

OTHER USER COMBINATIONS

| Combination | Method | Load | Factor | Remarks |
|---|---|---|---|---|
| GR | Sum | Gravity | 1.00 | Default |
| T1 | Sum | Thermal 1 | 1.00 | Default |
| R1 | Sum | Response 1 | 1.00 | Default |
| R2 | Sum | Response 2 | 1.00 | Default |
| R3 | Sum | Response 3 | 1.00 | Default |
| SEISMIC | SRSS | Response 1 | 1.00 | User |
| | | Response 2 | 1.00 | |
| | | Response 3 | 1.00 | |
| GR+T1+P1 | Sum | Gravity | 1.00 | User |
| | | Thermal 1 | 1.00 | |
| | | Press 1 | 1.00 | |
| TOTAL | Abs sum | GR+T1+P1 | 1.00 | User |
| | | SEISMIC | 1.00 | |
| P1 | Sum | Press 1 | 1.00 | User |



CODE COMPLIANCE

Y - Factor ..... 0.40
Weld efficiency factor ..... 1.00
Range reduction factor ..... 1.00
Design Pressure Factor ..... 1.00
Minimum stress ratio used in reports... 0.00
Number of stress points per span ..... 0
Include corrosion in stress calcs. .... Y
Include torsion in code stress ..... N
Include axial force in code stress .... N
Set sustained SIF to 1.00 ..... N
Use proposed B31.3, h = 3.1*T/r ..... N
Apply cold/hot modulus ratio ..... N
Total stress ..... Octahedral
Direct shear ..... None
Longitudinal pressure calculation ..... PD/4t
Include rigorous pressure ..... N

RPP-6485 Rev. 0

RESPONSE SPECTRUM LOAD CASES :

Number of load cases analysed : 3

Load case 1 - R1

Missing mass : Yes
ZPA : No

Combination method : SRSS

X- Spectrum : SS(H)OLD
Multiplier : 1.00

SS(H)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.04 | 0.500 | 0.10 | 1.000 | 0.19 |
| 2.000 | 0.29 | 3.300 | 0.37 | 5.000 | 0.39 |
| 10.000 | 0.32 | 13.300 | 0.26 | 33.300 | 0.18 |
| 100.000 | 0.18 | | | | |



Load case 2 - R2

Missing mass : Yes
ZPA : No

Combination method : SRSS

Y- Spectrum : SS(V)OLD
Multiplier : 1.00

SS(V)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.03 | 0.500 | 0.06 | 1.000 | 0.08 |
| 2.000 | 0.12 | 3.300 | 0.19 | 5.000 | 0.22 |
| 10.000 | 0.23 | 13.300 | 0.22 | 50.000 | 0.12 |
| 100.000 | 0.12 | | | | |



RPP-6485 Rev. 0

276

1K/14PRINT

Load case 3 - R3

Missing mass : Yes
ZPA : No

Combination method : SRSS

Z- Spectrum : SS(H)OLD
Multiplier : 1.00

SS(H)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.04 | 0.500 | 0.10 | 1.000 | 0.19 |
| 2.000 | 0.29 | 3.300 | 0.37 | 5.000 | 0.39 |
| 10.000 | 0.32 | 13.300 | 0.26 | 33.300 | 0.18 |
| 100.000 | 0.18 | | | | |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| *** Segment A begin *** | | | | | | | |
| A00 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| A01 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | -0.003 |
| | T1 | 0.009 | 0.002 | 0.000 | -0.002 | -0.003 | 0.031 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.009 | 0.002 | 0.000 | -0.002 | -0.003 | 0.028 |
| | TOTAL | 0.009 | 0.002 | 0.000 | 0.002 | 0.003 | 0.028 |
| A02 | GR | 0.000 | -0.003 | 0.000 | -0.001 | 0.000 | -0.016 |
| | T1 | 0.009 | 0.034 | 0.003 | -0.129 | -0.021 | 0.136 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | GR+T1+P1 | 0.009 | 0.031 | 0.003 | -0.131 | -0.022 | 0.120 |
| | TOTAL | 0.009 | 0.031 | 0.003 | 0.131 | 0.022 | 0.120 |
| A03 N | GR | 0.000 | -0.004 | 0.000 | -0.001 | 0.000 | -0.016 |
| | T1 | 0.014 | 0.038 | 0.003 | -0.130 | -0.021 | 0.134 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | GR+T1+P1 | 0.014 | 0.035 | 0.003 | -0.132 | -0.022 | 0.118 |
| | TOTAL | 0.014 | 0.035 | 0.003 | 0.132 | 0.023 | 0.118 |
| A03 F | GR | 0.000 | -0.004 | 0.000 | -0.001 | 0.000 | -0.010 |
| | T1 | 0.021 | 0.037 | 0.009 | -0.133 | -0.021 | 0.004 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | GR+T1+P1 | 0.021 | 0.033 | 0.009 | -0.135 | -0.022 | -0.006 |
| | TOTAL | 0.021 | 0.033 | 0.009 | 0.135 | 0.023 | 0.006 |
| A04 | GR | -0.001 | -0.004 | 0.000 | -0.001 | 0.000 | -0.008 |
| | T1 | 0.020 | 0.025 | 0.019 | -0.131 | -0.019 | -0.028 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | GR+T1+P1 | 0.019 | 0.021 | 0.019 | -0.133 | -0.019 | -0.036 |
| | TOTAL | 0.019 | 0.021 | 0.019 | 0.133 | 0.021 | 0.037 |
| A05 | GR | -0.002 | -0.004 | 0.001 | -0.001 | 0.000 | -0.003 |
| | T1 | 0.006 | -0.008 | 0.047 | -0.105 | -0.013 | -0.085 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.001 |
| | GR+T1+P1 | 0.003 | -0.013 | 0.047 | -0.107 | -0.013 | -0.089 |
| | TOTAL | 0.003 | 0.013 | 0.047 | 0.107 | 0.015 | 0.089 |



RPP-6487 Rev.0
LL2
K/14PRINT

D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A06 N | GR | -0.001 | -0.004 | 0.000 | 0.003 | 0.000 | 0.007 |
| | T1 | -0.028 | -0.115 | 0.035 | 0.194 | 0.008 | 0.080 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.003 | 0.002 |
| | GR+T1+P1 | -0.029 | -0.120 | 0.035 | 0.198 | 0.008 | 0.088 |
| | TOTAL | 0.031 | 0.120 | 0.036 | 0.198 | 0.011 | 0.089 |
| A06 F | GR | 0.000 | -0.004 | 0.000 | 0.008 | -0.001 | 0.009 |
| | T1 | -0.019 | -0.106 | 0.013 | 0.376 | -0.044 | 0.225 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.020 | -0.110 | 0.013 | 0.385 | -0.045 | 0.236 |
| | TOTAL | 0.021 | 0.111 | 0.013 | 0.386 | 0.049 | 0.237 |
| A07 | GR | 0.000 | -0.004 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.017 | -0.088 | 0.006 | 0.377 | -0.047 | 0.264 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.018 | -0.092 | 0.006 | 0.388 | -0.047 | 0.275 |
| | TOTAL | 0.019 | 0.092 | 0.006 | 0.388 | 0.051 | 0.276 |
| A08 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.064 | -0.004 | 0.377 | -0.047 | 0.264 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.015 | -0.068 | -0.004 | 0.387 | -0.047 | 0.276 |
| | TOTAL | 0.015 | 0.068 | 0.004 | 0.388 | 0.051 | 0.277 |
| A09 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.063 | -0.004 | 0.374 | -0.047 | 0.268 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.014 | -0.066 | -0.004 | 0.385 | -0.048 | 0.279 |
| | TOTAL | 0.015 | 0.066 | 0.005 | 0.385 | 0.052 | 0.280 |
| A10 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.061 | -0.005 | 0.372 | -0.053 | 0.266 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.014 | -0.064 | -0.005 | 0.383 | -0.054 | 0.277 |
| | TOTAL | 0.015 | 0.065 | 0.006 | 0.384 | 0.058 | 0.278 |
| A11 | GR | 0.000 | -0.002 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.011 | -0.038 | -0.014 | 0.372 | -0.053 | 0.265 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.011 | -0.040 | -0.014 | 0.383 | -0.054 | 0.277 |
| | TOTAL | 0.011 | 0.040 | 0.015 | 0.384 | 0.058 | 0.278 |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A13 | GR | 0.000 | -0.001 | 0.000 | 0.013 | -0.001 | 0.008 |
| | T1 | 0.000 | 0.003 | -0.032 | 0.296 | -0.084 | 0.202 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.001 |
| | GR+T1+P1 | 0.000 | 0.002 | -0.032 | 0.312 | -0.085 | 0.211 |
| | TOTAL | 0.000 | 0.002 | 0.033 | 0.312 | 0.090 | 0.212 |
| A14 N | GR | 0.000 | 0.000 | 0.000 | 0.013 | -0.001 | 0.007 |
| | T1 | 0.003 | 0.013 | -0.037 | 0.269 | -0.078 | 0.184 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.001 |
| | GR+T1+P1 | 0.003 | 0.013 | -0.037 | 0.285 | -0.079 | 0.193 |
| | TOTAL | 0.003 | 0.013 | 0.038 | 0.285 | 0.083 | 0.194 |
| A14 F | GR | 0.000 | 0.000 | 0.000 | 0.008 | 0.001 | 0.004 |
| | T1 | 0.009 | 0.014 | -0.045 | 0.006 | -0.029 | 0.107 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.002 |
| | GR+T1+P1 | 0.010 | 0.014 | -0.046 | 0.015 | -0.028 | 0.112 |
| | TOTAL | 0.010 | 0.014 | 0.046 | 0.016 | 0.032 | 0.114 |
| A15 | GR | 0.000 | 0.000 | -0.001 | 0.008 | 0.001 | 0.004 |
| | T1 | 0.012 | 0.009 | -0.045 | -0.003 | -0.029 | 0.100 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.002 |
| | GR+T1+P1 | 0.013 | 0.009 | -0.046 | 0.006 | -0.028 | 0.105 |
| | TOTAL | 0.013 | 0.009 | 0.046 | 0.007 | 0.032 | 0.107 |
| A16 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.009 | -0.002 | -0.029 | -0.001 | -0.001 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.009 | -0.002 | -0.029 | -0.001 | -0.001 |
| | TOTAL | 0.000 | 0.009 | 0.002 | 0.029 | 0.001 | 0.001 |
| A17 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*** Segment A end ***

*** Segment C begin ***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A09 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.063 | -0.004 | 0.374 | -0.047 | 0.268 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.014 | -0.066 | -0.004 | 0.385 | -0.048 | 0.279 |
| | TOTAL | 0.015 | 0.066 | 0.005 | 0.385 | 0.052 | 0.280 |

RPP-6485 REV.0

278

D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| C01 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.062 | -0.004 | 0.372 | -0.042 | 0.272 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.014 | -0.065 | -0.004 | 0.382 | -0.043 | 0.284 |
| | TOTAL | 0.015 | 0.065 | 0.005 | 0.383 | 0.047 | 0.285 |
| C02 | GR | 0.000 | -0.002 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.004 | -0.044 | -0.002 | 0.371 | -0.042 | 0.273 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.004 | -0.047 | -0.002 | 0.382 | -0.043 | 0.284 |
| | TOTAL | 0.005 | 0.047 | 0.002 | 0.383 | 0.047 | 0.285 |
| C03 | GR | 0.000 | -0.002 | 0.000 | 0.008 | -0.001 | 0.011 |
| | T1 | 0.005 | -0.026 | 0.000 | 0.340 | -0.038 | 0.299 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.003 | 0.001 |
| | GR+T1+P1 | 0.005 | -0.028 | 0.000 | 0.349 | -0.038 | 0.312 |
| | TOTAL | 0.006 | 0.028 | 0.000 | 0.350 | 0.041 | 0.312 |
| C04 N | GR | 0.000 | 0.000 | 0.000 | 0.007 | -0.001 | 0.007 |
| | T1 | 0.023 | 0.012 | 0.006 | 0.277 | -0.058 | 0.278 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.000 |
| | GR+T1+P1 | 0.023 | 0.011 | 0.007 | 0.285 | -0.059 | 0.287 |
| | TOTAL | 0.024 | 0.011 | 0.007 | 0.286 | 0.062 | 0.287 |
| C04 F | GR | 0.000 | 0.000 | 0.000 | 0.005 | -0.002 | 0.007 |
| | T1 | 0.033 | 0.013 | 0.001 | 0.200 | -0.095 | 0.065 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 |
| | GR+T1+P1 | 0.034 | 0.014 | 0.001 | 0.206 | -0.097 | 0.073 |
| | TOTAL | 0.034 | 0.014 | 0.001 | 0.207 | 0.099 | 0.075 |
| C05 | GR | 0.000 | 0.000 | 0.000 | 0.004 | -0.002 | 0.007 |
| | T1 | 0.035 | 0.009 | -0.005 | 0.192 | -0.094 | 0.056 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 |
| | GR+T1+P1 | 0.035 | 0.009 | -0.005 | 0.197 | -0.097 | 0.063 |
| | TOTAL | 0.036 | 0.009 | 0.005 | 0.198 | 0.098 | 0.065 |
| C06 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.001 | 0.009 | 0.000 | 0.011 | -0.002 | -0.018 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | GR+T1+P1 | 0.001 | 0.009 | 0.000 | 0.011 | -0.002 | -0.018 |
| | TOTAL | 0.001 | 0.009 | 0.000 | 0.011 | 0.002 | 0.019 |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| C07 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*** Segment C end ***

RPP-6485 Rev. 0

279

## RESTRAINT REACTIONS

| Point name | Load combination | FORCES (lb) X | Y | Z | Result | MOMENTS (ft-lb) X | Y | Z | Result |
|---|---|---|---|---|---|---|---|---|---|
| A00 | Anchor | | | | | | | | |
| | GR | 1 | -96 | 1 | 96 | 0 | 0 | -41 | 41 |
| | T1 | -101 | 854 | 63 | 862 | -14 | -34 | 368 | 369 |
| | SEISMIC | 10 | 8 | 6 | 14 | 0 | 1 | 3 | 3 |
| | GR+T1+P1 | -100 | 760 | 64 | 770 | -14 | -35 | 328 | 330 |
| | TOTAL | 110 | 768 | 70 | 779 | 14 | 36 | 330 | 333 |
| A04 | Guide [ID: A04 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | SEISMIC | 6 | 0 | 4 | 7 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOTAL | 6 | 0 | 4 | 7 | 0 | 0 | 0 | 0 |
| A05 | Guide [ID: A05 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | SEISMIC | 8 | 0 | 3 | 9 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOTAL | 8 | 0 | 3 | 9 | 0 | 0 | 0 | 0 |
| A13 | Guide [ID: A14 1] | | | | | | | | |
| | GR | -22 | 0 | 0 | 22 | 0 | 0 | 0 | 0 |
| | T1 | -1195 | 0 | 0 | 1195 | 0 | 0 | 0 | 0 |
| | SEISMIC | 34 | 25 | 0 | 42 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | -1224 | 17 | 0 | 1224 | 0 | 0 | 0 | 0 |
| | TOTAL | 1258 | 42 | 0 | 1258 | 0 | 0 | 0 | 0 |
| A17 | Anchor | | | | | | | | |
| | GR | 10 | -111 | -20 | 113 | -2 | 0 | -1 | 2 |
| | T1 | 358 | -218 | -1189 | 1261 | -399 | -3 | -59 | 404 |
| | SEISMIC | 1 | 15 | 12 | 19 | 5 | 0 | 1 | 5 |
| | GR+T1+P1 | 370 | -344 | -1216 | 1317 | -403 | -3 | -60 | 407 |
| | TOTAL | 371 | 359 | 1228 | 1333 | 407 | 3 | 62 | 412 |
| C03 | Guide [ID: C03 1] | | | | | | | | |
| | GR | 0 | 0 | 24 | 24 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 1317 | 1317 | 0 | 0 | 0 | 0 |
| | SEISMIC | 0 | 27 | 43 | 51 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 1349 | 1349 | 0 | 0 | 0 | 0 |
| | TOTAL | 0 | 27 | 1392 | 1392 | 0 | 0 | 0 | 0 |



## RESTRAINT REACTIONS

| Point name | Load combination | FORCES (lb) X | Y | Z | Result | MOMENTS (ft-lb) X | Y | Z | Result |
|---|---|---|---|---|---|---|---|---|---|
| C07 | Anchor | | | | | | | | |
| | GR | 10 | -165 | -5 | 165 | 1 | 0 | 1 | 1 |
| | T1 | 939 | -636 | -191 | 1150 | 52 | -10 | -280 | 285 |
| | SEISMIC | 21 | 9 | 8 | 25 | 3 | 0 | 8 | 9 |
| | GR+T1+P1 | 954 | -805 | -198 | 1263 | 53 | -10 | -281 | 286 |
| | TOTAL | 975 | 814 | 206 | 1287 | 56 | 10 | 289 | 295 |

RPP-6495 Rev. 2

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. (Stress in psi) | Load type | Code Stress | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| *** Segment A begin *** | | | | | | | | | | |
| A00 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 41 | 0 | | 1.00 | 1.00 | (18) | SUST | 2304 | 16340 |
| | Cold to T1 | 368 | 34 | 14 | 1.00 | 1.00 | (17) | DISP | 7906 | 24960 |
| | Sus. + R1 | 41 | 1 | | 1.00 | 1.00 | (18) | OCC | 2311 | 21732 |
| | Sus. + R2 | 43 | 1 | | 1.00 | 1.00 | (18) | OCC | 2368 | 21732 |
| | Sus. + R3 | 41 | 2 | | 1.00 | 1.00 | (18) | OCC | 2337 | 21732 |
| A01 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 0 | | 1.00 | 1.00 | (18) | SUST | 1622 | 16340 |
| | Cold to T1 | 111 | 15 | 14 | 1.00 | 1.00 | (17) | DISP | 2424 | 24960 |
| | Sus. + R1 | 12 | 1 | | 1.00 | 1.00 | (18) | OCC | 1630 | 21732 |
| | Sus. + R2 | 13 | 0 | | 1.00 | 1.00 | (18) | OCC | 1631 | 21732 |
| | Sus. + R3 | 12 | 1 | | 1.00 | 1.00 | (18) | OCC | 1631 | 21732 |
| A02 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 0 | | 1.00 | 1.00 | (18) | SUST | 1443 | 16340 |
| | Cold to T1 | 26 | 9 | 14 | 1.00 | 1.00 | (17) | DISP | 656 | 24960 |
| | Sus. + R1 | 5 | 1 | | 1.00 | 1.00 | (18) | OCC | 1453 | 21732 |
| | Sus. + R2 | 5 | 0 | | 1.00 | 1.00 | (18) | OCC | 1446 | 21732 |
| | Sus. + R3 | 5 | 1 | | 1.00 | 1.00 | (18) | OCC | 1456 | 21732 |
| A03 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 0 | | 1.00 | 1.00 | (18) | SUST | 1393 | 16340 |
| | Cold to T1 | 88 | 0 | 14 | 1.00 | 1.00 | (17) | DISP | 1902 | 24960 |
| | Sus. + R1 | 3 | 1 | | 1.00 | 1.00 | (18) | OCC | 1407 | 21732 |
| | Sus. + R2 | 3 | 0 | | 1.00 | 1.00 | (18) | OCC | 1403 | 21732 |
| | Sus. + R3 | 3 | 0 | | 1.00 | 1.00 | (18) | OCC | 1402 | 21732 |
| A03 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 0 | | 2.27 | 1.89 | (18) | SUST | 1474 | 16340 |
| | Cold to T1 | 88 | 0 | 14 | 2.27 | 1.89 | (17) | DISP | 4276 | 24960 |
| | Sus. + R1 | 3 | 1 | | 2.27 | 1.89 | (18) | OCC | 1501 | 21732 |
| | Sus. + R2 | 3 | 0 | | 2.27 | 1.89 | (18) | OCC | 1496 | 21732 |
| | Sus. + R3 | 3 | 0 | | 2.27 | 1.89 | (18) | OCC | 1491 | 21732 |
| A03 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 0 | | 2.27 | 1.89 | (18) | SUST | 1955 | 16340 |
| | Cold to T1 | 213 | 3 | 10 | 2.27 | 1.89 | (17) | DISP | 10360 | 24960 |
| | Sus. + R1 | 12 | 0 | | 2.27 | 1.89 | (18) | OCC | 1966 | 21732 |
| | Sus. + R2 | 12 | 0 | | 2.27 | 1.89 | (18) | OCC | 1980 | 21732 |
| | Sus. + R3 | 12 | 0 | | 2.27 | 1.89 | (18) | OCC | 1966 | 21732 |
| A03 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 0 | 12 | | 1.00 | 1.00 | (18) | SUST | 1605 | 16340 |
| | Cold to T1 | 3 | 213 | 10 | 1.00 | 1.00 | (17) | DISP | 4570 | 24960 |
| | Sus. + R1 | 0 | 12 | | 1.00 | 1.00 | (18) | OCC | 1610 | 21732 |
| | Sus. + R2 | 0 | 12 | | 1.00 | 1.00 | (18) | OCC | 1616 | 21732 |
| | Sus. + R3 | 0 | 12 | | 1.00 | 1.00 | (18) | OCC | 1611 | 21732 |



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. (Stress in psi) | Load type | Code Stress | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A04 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 0 | 11 | | 1.00 | 1.00 | (18) | SUST | 1592 | 16340 |
| | Cold to T1 | 21 | 175 | 10 | 1.00 | 1.00 | (17) | DISP | 3786 | 24960 |
| | Sus. + R1 | 1 | 12 | | 1.00 | 1.00 | (18) | OCC | 1619 | 21732 |
| | Sus. + R2 | 0 | 11 | | 1.00 | 1.00 | (18) | OCC | 1595 | 21732 |
| | Sus. + R3 | 1 | 11 | | 1.00 | 1.00 | (18) | OCC | 1617 | 21732 |
| A05 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 9 | | 1.00 | 1.00 | (18) | SUST | 1557 | 16340 |
| | Cold to T1 | 89 | 66 | 10 | 1.00 | 1.00 | (17) | DISP | 2379 | 24960 |
| | Sus. + R1 | 2 | 13 | | 1.00 | 1.00 | (18) | OCC | 1649 | 21732 |
| | Sus. + R2 | 1 | 10 | | 1.00 | 1.00 | (18) | OCC | 1568 | 21732 |
| | Sus. + R3 | 2 | 10 | | 1.00 | 1.00 | (18) | OCC | 1581 | 21732 |
| A06 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 4 | | 1.00 | 1.00 | (18) | SUST | 1473 | 16340 |
| | Cold to T1 | 307 | 284 | 10 | 1.00 | 1.00 | (17) | DISP | 8960 | 24960 |
| | Sus. + R1 | 5 | 7 | | 1.00 | 1.00 | (18) | OCC | 1524 | 21732 |
| | Sus. + R2 | 5 | 5 | | 1.00 | 1.00 | (18) | OCC | 1498 | 21732 |
| | Sus. + R3 | 4 | 5 | | 1.00 | 1.00 | (18) | OCC | 1488 | 21732 |
| A06 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 4 | | 1.73 | 1.44 | (18) | SUST | 1555 | 16340 |
| | Cold to T1 | 307 | 284 | 10 | 1.73 | 1.44 | (17) | DISP | 14382 | 24960 |
| | Sus. + R1 | 5 | 7 | | 1.73 | 1.44 | (18) | OCC | 1631 | 21732 |
| | Sus. + R2 | 5 | 5 | | 1.73 | 1.44 | (18) | OCC | 1596 | 21732 |
| | Sus. + R3 | 4 | 5 | | 1.73 | 1.44 | (18) | OCC | 1580 | 21732 |
| A06 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 0 | | 1.73 | 1.44 | (18) | SUST | 1742 | 16340 |
| | Cold to T1 | 110 | 15 | 309 | 1.73 | 1.44 | (17) | DISP | 7785 | 24960 |
| | Sus. + R1 | 11 | 1 | | 1.73 | 1.44 | (18) | OCC | 1787 | 21732 |
| | Sus. + R2 | 10 | 0 | | 1.73 | 1.44 | (18) | OCC | 1749 | 21732 |
| | Sus. + R3 | 10 | 1 | | 1.73 | 1.44 | (18) | OCC | 1749 | 21732 |
| A06 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 0 | | 1.00 | 1.00 | (18) | SUST | 1567 | 16340 |
| | Cold to T1 | 110 | 15 | 309 | 1.00 | 1.00 | (17) | DISP | 7032 | 24960 |
| | Sus. + R1 | 11 | 1 | | 1.00 | 1.00 | (18) | OCC | 1595 | 21732 |
| | Sus. + R2 | 10 | 0 | | 1.00 | 1.00 | (18) | OCC | 1572 | 21732 |
| | Sus. + R3 | 10 | 1 | | 1.00 | 1.00 | (18) | OCC | 1572 | 21732 |
| A07 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 15 | 1 | | 1.00 | 1.00 | (18) | SUST | 1681 | 16340 |
| | Cold to T1 | 78 | 37 | 309 | 1.00 | 1.00 | (17) | DISP | 6873 | 24960 |
| | Sus. + R1 | 16 | 1 | | 1.00 | 1.00 | (18) | OCC | 1711 | 21732 |
| | Sus. + R2 | 15 | 1 | | 1.00 | 1.00 | (18) | OCC | 1693 | 21732 |
| | Sus. + R3 | 15 | 1 | | 1.00 | 1.00 | (18) | OCC | 1689 | 21732 |

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A08 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 18 | 1 | | 1.00 | 1.00 | (18) | SUST | 1772 | 16340 |
| | Cold to T1 | 334 | 68 | 309 | 1.00 | 1.00 | (17) | DISP | 9853 | 24960 |
| | Sus. + R1 | 20 | 1 | | 1.00 | 1.00 | (18) | OCC | 1805 | 21732 |
| | Sus. + R2 | 20 | 1 | | 1.00 | 1.00 | (18) | OCC | 1814 | 21732 |
| | Sus. + R3 | 19 | 2 | | 1.00 | 1.00 | (18) | OCC | 1783 | 21732 |
| A09 - | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 19 | | 1.19 | 1.25 | (18) | SUST | 1885 | 16340 |
| | Cold to T1 | 70 | 351 | 309 | 1.19 | 1.25 | (17) | DISP | 11637 | 24960 |
| | Sus. + R1 | 1 | 20 | | 1.19 | 1.25 | (18) | OCC | 1928 | 21732 |
| | Sus. + R2 | 1 | 20 | | 1.19 | 1.25 | (18) | OCC | 1941 | 21732 |
| | Sus. + R3 | 2 | 19 | | 1.19 | 1.25 | (18) | OCC | 1899 | 21732 |
| A09 + | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 7 | 23 | | 1.19 | 1.25 | (18) | SUST | 2051 | 16340 |
| | Cold to T1 | 632 | 165 | 192 | 1.19 | 1.25 | (17) | DISP | 17177 | 24960 |
| | Sus. + R1 | 19 | 26 | | 1.19 | 1.25 | (18) | OCC | 2383 | 21732 |
| | Sus. + R2 | 8 | 25 | | 1.19 | 1.25 | (18) | OCC | 2097 | 21732 |
| | Sus. + R3 | 12 | 24 | | 1.19 | 1.25 | (18) | OCC | 2169 | 21732 |
| A10 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 23 | 7 | | 1.00 | 1.00 | (18) | SUST | 1907 | 16340 |
| | Cold to T1 | 170 | 616 | 192 | 1.00 | 1.00 | (17) | DISP | 14269 | 24960 |
| | Sus. + R1 | 26 | 18 | | 1.00 | 1.00 | (18) | OCC | 2179 | 21732 |
| | Sus. + R2 | 24 | 8 | | 1.00 | 1.00 | (18) | OCC | 1944 | 21732 |
| | Sus. + R3 | 24 | 11 | | 1.00 | 1.00 | (18) | OCC | 2005 | 21732 |
| A11 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 21 | 4 | | 1.00 | 1.00 | (18) | SUST | 1833 | 16340 |
| | Cold to T1 | 235 | 364 | 192 | 1.00 | 1.00 | (17) | DISP | 10147 | 24960 |
| | Sus. + R1 | 22 | 10 | | 1.00 | 1.00 | (18) | OCC | 1993 | 21732 |
| | Sus. + R2 | 22 | 4 | | 1.00 | 1.00 | (18) | OCC | 1866 | 21732 |
| | Sus. + R3 | 21 | 6 | | 1.00 | 1.00 | (18) | OCC | 1900 | 21732 |
| A13 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 3 | | 1.00 | 1.00 | (18) | SUST | 1591 | 16340 |
| | Cold to T1 | 361 | 121 | 192 | 1.00 | 1.00 | (17) | DISP | 9132 | 24960 |
| | Sus. + R1 | 12 | 6 | | 1.00 | 1.00 | (18) | OCC | 1677 | 21732 |
| | Sus. + R2 | 12 | 3 | | 1.00 | 1.00 | (18) | OCC | 1639 | 21732 |
| | Sus. + R3 | 11 | 4 | | 1.00 | 1.00 | (18) | OCC | 1603 | 21732 |
| A14 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 2 | | 1.00 | 1.00 | (18) | SUST | 1372 | 16340 |
| | Cold to T1 | 397 | 63 | 192 | 1.00 | 1.00 | (17) | DISP | 9529 | 24960 |
| | Sus. + R1 | 1 | 3 | | 1.00 | 1.00 | (18) | OCC | 1414 | 21732 |
| | Sus. + R2 | 2 | 2 | | 1.00 | 1.00 | (18) | OCC | 1394 | 21732 |
| | Sus. + R3 | 1 | 2 | | 1.00 | 1.00 | (18) | OCC | 1377 | 21732 |



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A14 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 2 | | 2.27 | 1.89 | (18) | SUST | 1412 | 16340 |
| | Cold to T1 | 397 | 63 | 192 | 2.27 | 1.89 | (17) | DISP | 19874 | 24960 |
| | Sus. + R1 | 1 | 3 | | 2.27 | 1.89 | (18) | OCC | 1493 | 21732 |
| | Sus. + R2 | 2 | 2 | | 2.27 | 1.89 | (18) | OCC | 1464 | 21732 |
| | Sus. + R3 | 1 | 2 | | 2.27 | 1.89 | (18) | OCC | 1422 | 21732 |
| A14 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 5 | | 2.27 | 1.89 | (18) | SUST | 1852 | 16340 |
| | Cold to T1 | 235 | 132 | 3 | 2.27 | 1.89 | (17) | DISP | 12602 | 24960 |
| | Sus. + R1 | 10 | 5 | | 2.27 | 1.89 | (18) | OCC | 1922 | 21732 |
| | Sus. + R2 | 9 | 5 | | 2.27 | 1.89 | (18) | OCC | 1869 | 21732 |
| | Sus. + R3 | 9 | 5 | | 2.27 | 1.89 | (18) | OCC | 1866 | 21732 |
| A14 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 5 | | 1.00 | 1.00 | (18) | SUST | 1567 | 16340 |
| | Cold to T1 | 235 | 132 | 3 | 1.00 | 1.00 | (17) | DISP | 5769 | 24960 |
| | Sus. + R1 | 10 | 5 | | 1.00 | 1.00 | (18) | OCC | 1599 | 21732 |
| | Sus. + R2 | 9 | 5 | | 1.00 | 1.00 | (18) | OCC | 1576 | 21732 |
| | Sus. + R3 | 9 | 5 | | 1.00 | 1.00 | (18) | OCC | 1574 | 21732 |
| A15 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 6 | 3 | | 1.00 | 1.00 | (18) | SUST | 1494 | 16340 |
| | Cold to T1 | 76 | 84 | 3 | 1.00 | 1.00 | (17) | DISP | 2435 | 24960 |
| | Sus. + R1 | 6 | 4 | | 1.00 | 1.00 | (18) | OCC | 1513 | 21732 |
| | Sus. + R2 | 6 | 3 | | 1.00 | 1.00 | (18) | OCC | 1501 | 21732 |
| | Sus. + R3 | 6 | 3 | | 1.00 | 1.00 | (18) | OCC | 1500 | 21732 |
| A16 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 2 | | 1.00 | 1.00 | (18) | SUST | 1440 | 16340 |
| | Cold to T1 | 43 | 48 | 3 | 1.00 | 1.00 | (17) | DISP | 1381 | 24960 |
| | Sus. + R1 | 5 | 3 | | 1.00 | 1.00 | (18) | OCC | 1477 | 21732 |
| | Sus. + R2 | 4 | 2 | | 1.00 | 1.00 | (18) | OCC | 1445 | 21732 |
| | Sus. + R3 | 4 | 2 | | 1.00 | 1.00 | (18) | OCC | 1446 | 21732 |
| A17 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 2 | 1 | | 1.00 | 1.00 | (18) | SUST | 1383 | 16340 |
| | Cold to T1 | 399 | 59 | 3 | 1.00 | 1.00 | (17) | DISP | 8639 | 24960 |
| | Sus. + R1 | 6 | 2 | | 1.00 | 1.00 | (18) | OCC | 1483 | 21732 |
| | Sus. + R2 | 2 | 1 | | 1.00 | 1.00 | (18) | OCC | 1383 | 21732 |
| | Sus. + R3 | 4 | 1 | | 1.00 | 1.00 | (18) | OCC | 1442 | 21732 |

*** Segment A end ***

*** Segment C begin ***

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A09 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 10 | | 1.19 | 1.25 | (18) | SUST | 1726 | 16340 |
| | Cold to T1 | 563 | 501 | 186 | 1.19 | 1.25 | (17) | DISP | 20012 | 24960 |
| | Sus. + R1 | 20 | 14 | | 1.19 | 1.25 | (18) | OCC | 2071 | 21732 |
| | Sus. + R2 | 9 | 12 | | 1.19 | 1.25 | (18) | OCC | 1768 | 21732 |
| | Sus. + R3 | 13 | 11 | | 1.19 | 1.25 | (18) | OCC | 1857 | 21732 |

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| C01 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 8 | | 1.00 | 1.00 | (18) | SUST | 1648 | 16340 |
| | Cold to T1 | 488 | 540 | 186 | 1.00 | 1.00 | (17) | DISP | 16082 | 24960 |
| | Sus. + R1 | 14 | 20 | | 1.00 | 1.00 | (18) | OCC | 1931 | 21732 |
| | Sus. + R2 | 12 | 9 | | 1.00 | 1.00 | (18) | OCC | 1679 | 21732 |
| | Sus. + R3 | 11 | 12 | | 1.00 | 1.00 | (18) | OCC | 1750 | 21732 |
| C02 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 2 | | 1.00 | 1.00 | (18) | SUST | 1551 | 16340 |
| | Cold to T1 | 297 | 202 | 186 | 1.00 | 1.00 | (17) | DISP | 8664 | 24960 |
| | Sus. + R1 | 10 | 11 | | 1.00 | 1.00 | (18) | OCC | 1751 | 21732 |
| | Sus. + R2 | 10 | 3 | | 1.00 | 1.00 | (18) | OCC | 1584 | 21732 |
| | Sus. + R3 | 9 | 4 | | 1.00 | 1.00 | (18) | OCC | 1590 | 21732 |
| C03 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 4 | | 1.00 | 1.00 | (18) | SUST | 1469 | 16340 |
| | Cold to T1 | 107 | 136 | 186 | 1.00 | 1.00 | (17) | DISP | 5425 | 24960 |
| | Sus. + R1 | 5 | 9 | | 1.00 | 1.00 | (18) | OCC | 1592 | 21732 |
| | Sus. + R2 | 9 | 4 | | 1.00 | 1.00 | (18) | OCC | 1570 | 21732 |
| | Sus. + R3 | 5 | 11 | | 1.00 | 1.00 | (18) | OCC | 1658 | 21732 |
| C04 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 34 | 1 | | 1.00 | 1.00 | (18) | SUST | 2141 | 16340 |
| | Cold to T1 | 271 | 22 | 186 | 1.00 | 1.00 | (17) | DISP | 7048 | 24960 |
| | Sus. + R1 | 37 | 2 | | 1.00 | 1.00 | (18) | OCC | 2219 | 21732 |
| | Sus. + R2 | 34 | 1 | | 1.00 | 1.00 | (18) | OCC | 2146 | 21732 |
| | Sus. + R3 | 35 | 1 | | 1.00 | 1.00 | (18) | OCC | 2161 | 21732 |
| C04 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 13 | 1 | | 2.27 | 1.89 | (18) | SUST | 2017 | 16340 |
| | Cold to T1 | 271 | 22 | 186 | 2.27 | 1.89 | (17) | DISP | 13777 | 24960 |
| | Sus. + R1 | 16 | 2 | | 2.27 | 1.89 | (18) | OCC | 2190 | 21732 |
| | Sus. + R2 | 13 | 1 | | 2.27 | 1.89 | (18) | OCC | 2026 | 21732 |
| | Sus. + R3 | 13 | 1 | | 2.27 | 1.89 | (18) | OCC | 2062 | 21732 |
| C04 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 6 | 4 | | 2.27 | 1.89 | (18) | SUST | 1704 | 16340 |
| | Cold to T1 | 221 | 154 | 10 | 2.27 | 1.89 | (17) | DISP | 12394 | 24960 |
| | Sus. + R1 | 8 | 4 | | 2.27 | 1.89 | (18) | OCC | 1800 | 21732 |
| | Sus. + R2 | 6 | 4 | | 2.27 | 1.89 | (18) | OCC | 1717 | 21732 |
| | Sus. + R3 | 7 | 4 | | 2.27 | 1.89 | (18) | OCC | 1727 | 21732 |
| C04 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 6 | | 1.00 | 1.00 | (18) | SUST | 1502 | 16340 |
| | Cold to T1 | 154 | 221 | 10 | 1.00 | 1.00 | (17) | DISP | 5760 | 24960 |
| | Sus. + R1 | 4 | 8 | | 1.00 | 1.00 | (18) | OCC | 1544 | 21732 |
| | Sus. + R2 | 4 | 6 | | 1.00 | 1.00 | (18) | OCC | 1508 | 21732 |
| | Sus. + R3 | 4 | 7 | | 1.00 | 1.00 | (18) | OCC | 1511 | 21732 |



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| C05 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 5 | | 1.00 | 1.00 | (18) | SUST | 1465 | 16340 |
| | Cold to T1 | 128 | 95 | 10 | 1.00 | 1.00 | (17) | DISP | 3430 | 24960 |
| | Sus. + R1 | 3 | 5 | | 1.00 | 1.00 | (18) | OCC | 1474 | 21732 |
| | Sus. + R2 | 3 | 5 | | 1.00 | 1.00 | (18) | OCC | 1470 | 21732 |
| | Sus. + R3 | 3 | 5 | | 1.00 | 1.00 | (18) | OCC | 1472 | 21732 |
| C06 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 4 | | 1.00 | 1.00 | (18) | SUST | 1437 | 16340 |
| | Cold to T1 | 109 | 2 | 10 | 1.00 | 1.00 | (17) | DISP | 2349 | 24960 |
| | Sus. + R1 | 4 | 6 | | 1.00 | 1.00 | (18) | OCC | 1489 | 21732 |
| | Sus. + R2 | 3 | 4 | | 1.00 | 1.00 | (18) | OCC | 1442 | 21732 |
| | Sus. + R3 | 3 | 4 | | 1.00 | 1.00 | (18) | OCC | 1449 | 21732 |
| C07 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 1 | | 1.00 | 1.00 | (18) | SUST | 1358 | 16340 |
| | Cold to T1 | 52 | 280 | 10 | 1.00 | 1.00 | (17) | DISP | 6100 | 24960 |
| | Sus. + R1 | 4 | 9 | | 1.00 | 1.00 | (18) | OCC | 1567 | 21732 |
| | Sus. + R2 | 1 | 1 | | 1.00 | 1.00 | (18) | OCC | 1361 | 21732 |
| | Sus. + R3 | 2 | 2 | | 1.00 | 1.00 | (18) | OCC | 1409 | 21732 |

*** Segment C end ***

RPP-6487 REV.0

283

## SYSTEM SUMMARY

### Maximum displacements (in)

| | | | |
|---|---|---|---|
| Maximum X : | 0.036 | Point : C05 | Load Comb.: TOTAL |
| Maximum Y : | 0.120 | Point : A06 N | Load Comb.: TOTAL |
| Maximum Z : | 0.047 | Point : A05 | Load Comb.: GR+T1+P1 |
| Max. total: | 0.129 | Point : A06 N | Load Comb.: TOTAL |

### Maximum rotations (deg)

| | | | |
|---|---|---|---|
| Maximum X : | 0.388 | Point : A07 | Load Comb.: TOTAL |
| Maximum Y : | 0.099 | Point : C04 F | Load Comb.: TOTAL |
| Maximum Z : | 0.312 | Point : C03 | Load Comb.: TOTAL |
| Max. total: | 0.480 | Point : C02 | Load Comb.: TOTAL |

### Maximum restraint forces (lb)

| | | | |
|---|---|---|---|
| Maximum X : | 1258 | Point : A13 | Load Comb.: TOTAL |
| Maximum Y : | 854 | Point : A00 | Load Comb.: T1 |
| Maximum Z : | 1392 | Point : C03 | Load Comb.: TOTAL |
| Max. total: | 1392 | Point : C03 | Load Comb.: TOTAL |

### Maximum restraint moments (ft-lb)

| | | | |
|---|---|---|---|
| Maximum X : | 407 | Point : A17 | Load Comb.: TOTAL |
| Maximum Y : | 36 | Point : A00 | Load Comb.: TOTAL |
| Maximum Z : | 368 | Point : A00 | Load Comb.: T1 |
| Max. total: | 412 | Point : A17 | Load Comb.: TOTAL |



## SYSTEM SUMMARY

### Maximum sustained stress

Point : A00
Stress psi : 2304
Allowable psi : 16340
Ratio : 0.14
Load combination : GR + Max P

### Maximum displacement stress

Point : A09
Stress psi : 20012
Allowable psi : 24960
Ratio : 0.80
Load combination : Cold to T1

### Maximum occasional stress

Point : A09
Stress psi : 2383
Allowable psi : 21732
Ratio : 0.11
Load combination : Sus. + R1

### Maximum hoop stress

Point : A00
Stress psi : 2978
Allowable psi : 16340
Ratio : 0.18
Load combination : Max P

RPP-6485 REV.0

## S Y S T E M  S U M M A R Y

Maximum sustained stress ratio

```
Point            : A00
Stress    psi    : 2304
Allowable psi    : 16340
Ratio            : 0.14
Load combination : GR + Max P
```

Maximum displacement stress ratio

```
Point            : A09
Stress    psi    : 20012
Allowable psi    : 24960
Ratio            : 0.80
Load combination : Cold to T1
```

Maximum occasional stress ratio

```
Point            : A09
Stress    psi    : 2383
Allowable psi    : 21732
Ratio            : 0.11
Load combination : Sus. + R1
```

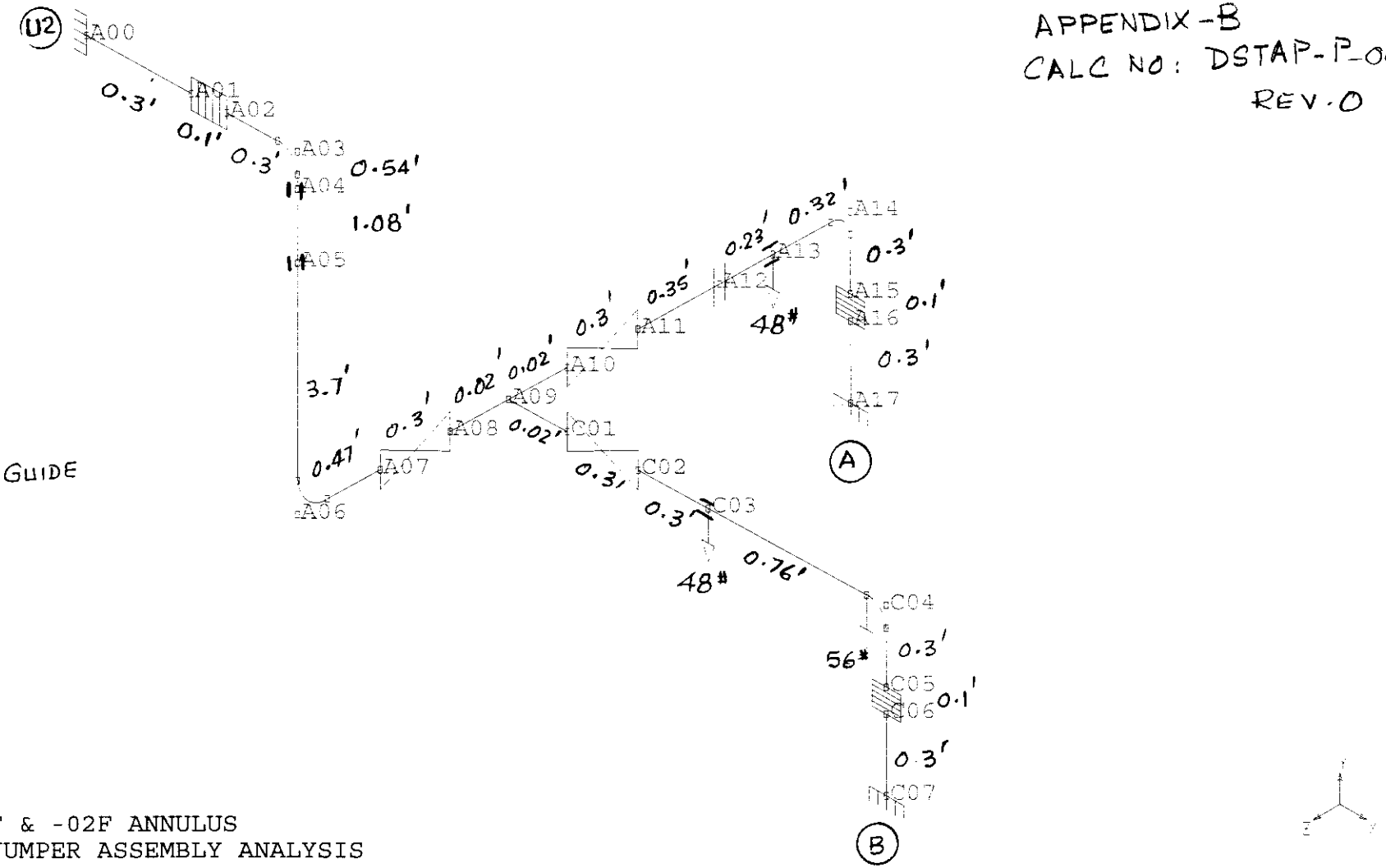
Maximum hoop stress ratio

```
Point            : A00
Stress    psi    : 2978
Allowable psi    : 16340
Ratio            : 0.18
Load combination : Max P
```

* * * The system satisfies ASME B31.3 code requirements * * *
* * * for the selected options * * *

RPP-6485 Rev.0

APPENDIX-B
CALC NO: DSTAP-P-004
REV. 0




241-AZ-01F & -02F ANNULUS
PUMP PIT JUMPER ASSEMBLY ANALYSIS

FILE: AZ01&02F

REF DWGS: H-14-104132 (2-SHTS) REV. 0

RPP-6485 REV. 0

```
  *                          *******   **  *******   *******
 ***             **          **    **  **  **    **  **
** **            ******       **    **  **  **    **  **
**   **    **   **  **  *****  *******   **  *******   *****
*********  **   **  **  **   **  **        **  **        **
**       **  **   **  **  **   **  **        **  **        **
**        **  *****   **   *****  **        **  **        *******
```

Pipe Stress Analysis and Design Program

Version: 6.00.16

Edition: Plus-Win

Developed and Maintained by

REBIS Industrial Workgroup Software
1600 Riviera Ave., Suite 300
Walnut Creek, CA 94596



```
**************************************************************
**                                                          **
**              AUTOPIPE SYSTEM DATA LISTING                **
**                                                          **
**************************************************************
```

SYSTEM NAME : AZ01&02F

PROJECT ID : 241-AZ-01F & -02F ANNULUS
PUMP PIT JUMPER ASSEMBLY ANALYSIS

PREPARED BY : M. Ahmed
M.M. AHMED

CHECKED BY : Jennifer Williamson

PIPING CODE : B31.3

VERTICAL AXIS : Y

AMBIENT TEMPERATURE : 65.0 deg F

COMPONENT LIBRARY : AUTOPIPE

MATERIAL LIBRARY : AUTOB313

MODEL REVISION NUMBER : 10

RPP-6465 Rev. 0

## POINT DATA LISTING

| POINT NAME | TYPE | OFFSETS (ft) X | Y | Z | DESCRIPTION |
|---|---|---|---|---|---|
| *** SEGMENT A | | | | | |
| A00 | Run | 0 | 0 | 0 | PIPE ID = 2"PIPE |
| A01 | Flex | 0.30 | 0 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| A02 | Run | 0.10 | 0 | 0 | |
| A03 | Bend | 0.30 | 0 | 0 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| A04 | Run | 0 | -0.54 | 0 | |
| A05 | Run | 0 | -1.08 | 0 | |
| A06 | Bend | 0 | -3.70 | 0 | Long Elbow, Radius = 3.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 1.73, Out = 1.44<br>Flex = 4.404 |
| A07 | Valv | 0 | 0 | -0.47 | GATE-F , Rating = 300<br>Weight = 16 lb<br>Surface factor = 4.20<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| A08 | Run | 0 | 0 | -0.30 | |
| A09 | Tee | 0 | 0 | -0.02 | |
| A10 | Valv | 0 | 0 | -0.02 | GATE-F , Rating = 300<br>Weight = 16 lb<br>Surface factor = 4.20<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| A11 | Run | 0 | 0 | -0.30 | |
| A12 | Run | 0 | 0 | -0.35 | |
| A13 | Run | 0 | 0 | -0.23 | |
| A14 | Bend | 0 | 0 | -0.33 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| A15 | Flex | 0 | -0.30 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| A16 | Run | 0 | -0.10 | 0 | |
| A17 | Run | 0 | -0.30 | 0 | |
| *** SEGMENT C | | | | | |
| A09 | Tee | 0.70 | -5.32 | -0.79 | PIPE ID = 2"PIPE |



## POINT DATA LISTING

| POINT NAME | TYPE | OFFSETS (ft) X | Y | Z | DESCRIPTION |
|---|---|---|---|---|---|
| C01 | Valv | 0.02 | 0 | 0 | GATE-F , Rating = 300<br>Weight = 16 lb<br>Surface factor = 4.20<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| C02 | Run | 0.30 | 0 | 0 | |
| C03 | Run | 0.30 | 0 | 0 | |
| C04 | Bend | 0.76 | 0 | 0 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| C05 | Flex | 0 | -0.30 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| C06 | Run | 0 | -0.10 | 0 | |
| C07 | Run | 0 | -0.30 | 0 | |

Total weight of empty pipes : 35 lb

RPP-6485 Rev 0

## C O M P O N E N T D A T A L I S T I N G

| POINT NAME | COORDINATE(ft) X | Y | Z | DATA TYPE | DESCRIPTION |
|---|---|---|---|---|---|
| *** SEGMENT A | | | | | |
| A00 | 0.00 | 0.00 | 0.00 | ANCHOR | Rigid<br>Thermal movements : None |
| A01 | 0.30 | 0.00 | 0.00 | | |
| A02 | 0.40 | 0.00 | 0.00 | | |
| A03 N | 0.53 | 0.00 | 0.00 | | |
| A03 | 0.70 | 0.00 | 0.00 | TI | |
| A03 F | 0.70 | -0.17 | 0.00 | | |
| A04 | 0.70 | -0.54 | 0.00 | GUIDE | ID : A04 1, Connected to Ground<br>Stiffness = RIGID<br>Gap -Z = 0.06 inch<br>Gap +Z = 0.06 inch<br>Gap -X = 0.06 inch<br>Gap +X = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| A05 | 0.70 | -1.62 | 0.00 | GUIDE | ID : A05 1, Connected to Ground<br>Stiffness = RIGID<br>Gap -Z = 0.06 inch<br>Gap +Z = 0.06 inch<br>Gap -X = 0.06 inch<br>Gap +X = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| A06 N | 0.70 | -5.07 | 0.00 | | |
| A06 | 0.70 | -5.32 | 0.00 | TI | |
| A06 F | 0.70 | -5.32 | -0.25 | | |
| A07 | 0.70 | -5.32 | -0.47 | | |
| A08 | 0.70 | -5.32 | -0.77 | | |
| A09 | 0.70 | -5.32 | -0.79 | TEE | B16.9 welding tee<br>SIF - In = 1.19, Out = 1.25 |
| A10 | 0.70 | -5.32 | -0.81 | | |
| A11 | 0.70 | -5.32 | -1.11 | | |
| A12 | 0.70 | -5.32 | -1.46 | FLANGE | SLIP-ON , Butt welded, SIF = 1.00<br>Rating = 150, Weight = 5 lb<br>Perform ANSI check = No<br>Without taper, Offset = 0.000 inch |
| | | | | FLANGE | SLIP-ON , Butt welded, SIF = 1.00<br>Rating = 150, Weight = 5 lb<br>Perform ANSI check = No<br>Without taper, Offset = 0.000 inch |
| A13 | 0.70 | -5.32 | -1.69 | GUIDE | ID : A14 1, Connected to Ground<br>Stiffness = RIGID<br>Gap-down = 0.06 inch<br>Gap-Above = 0.00 inch<br>Gap-left = 0.00 inch<br>Gap-Right = 0.00 inch<br>Friction = 0.00<br>Gaps set Weightless |
| | | | | WEIGHT | 48 lb , No offsets |
| A14 N | 0.70 | -5.32 | -1.85 | | |
| A14 | 0.70 | -5.32 | -2.02 | TI | |



## C O M P O N E N T D A T A L I S T I N G

| POINT NAME | COORDINATE(ft) X | Y | Z | DATA TYPE | DESCRIPTION |
|---|---|---|---|---|---|
| A14 F | 0.70 | -5.49 | -2.02 | | |
| A15 | 0.70 | -5.62 | -2.02 | | |
| A16 | 0.70 | -5.72 | -2.02 | | |
| A17 | 0.70 | -6.02 | -2.02 | ANCHOR | Rigid<br>Thermal movements : None |
| *** SEGMENT C | | | | | |
| A09 | 0.70 | -5.32 | -0.79 | TEE | B16.9 welding tee<br>SIF - In = 1.19, Out = 1.25 |
| C01 | 0.72 | -5.32 | -0.79 | | |
| C02 | 1.02 | -5.32 | -0.79 | | |
| C03 | 1.32 | -5.32 | -0.79 | GUIDE | ID : C03 1, Connected to Ground<br>Stiffness = RIGID<br>Gap-down = 0.06 inch<br>Gap-Above = 0.00 inch<br>Gap-left = 0.00 inch<br>Gap-Right = 0.00 inch<br>Friction = 0.00<br>Gaps set Weightless |
| | | | | WEIGHT | 48 lb , No offsets |
| C04 N | 1.91 | -5.32 | -0.79 | WEIGHT | 56 lb , Offsets in ft<br>DX = 0.83, DY = 0.00, DZ = 0.00 |
| C04 | 2.08 | -5.32 | -0.79 | TI | |
| C04 F | 2.08 | -5.49 | -0.79 | | |
| C05 | 2.08 | -5.62 | -0.79 | | |
| C06 | 2.08 | -5.72 | -0.79 | | |
| C07 | 2.08 | -6.02 | -0.79 | ANCHOR | Rigid<br>Thermal movements : None |

Number of points in the system : 34

RPP-4985 Rev. 0

284

## P I P E  D A T A  L I S T I N G

| Pipe ID/ Material | Nom/ Sch | O.D. inch | Thickness(inch) W.Th. | Corr | Mill | Insu | Ling | Spec Grav | Weight(lb/ft) Pipe | Other | Total | ZL/ ZC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2"PIPE | 2.000 | 2.375 | 0.154 | 0.02 | 0.02 | 0 | 0 | 1.50 | 3.74 | 0 | 5.92 | 1.00 |
| A312-TP304L | STD | | | | | | | | | | | 1.00 |



## M A T E R I A L  D A T A  L I S T I N G

| Material Name | Pipe ID | Density lb/cu.ft | Pois. Ratio | Temper. deg F | Modulus E6 psi Axial | Hoop | Shear | Expans. in/100ft |
|---|---|---|---|---|---|---|---|---|
| A312-TP304L | 2"PIPE | 501.0 | 0.30 | 65.0 | 28.320 | 28.320 | 10.892 | |
| | | | | 340.0 | 26.802 | | | 3.1325 |

RPP-6485 Rev. 0



290

K/T4PRINT

## M A T E R I A L  A L L O W A B L E  D A T A  L I S T I N G

| Material Name | Pipe ID | Temper. deg F | Allow. psi |
|---|---|---|---|
| A312-TP304L | 2"PIPE | 65.0 | 16700.0 |
| | | 340.0 | 16340.0 |



## TEMPERATURE AND PRESSURE DATA

| POINT NAME | CASE 1 PRESS. psi | CASE 1 TEMPER deg F | CASE 1 EXPAN. in/100ft | CASE 2 PRESS. psi | CASE 2 TEMPER deg F | CASE 2 EXPAN. in/100ft | CASE 3 PRESS. psi | CASE 3 TEMPER deg F | CASE 3 EXPAN. in/100ft |
|---|---|---|---|---|---|---|---|---|---|
| *** SEGMENT A | | | | | | | | | |
| A00 | 300 | 340 | 3.133 | | | | | | |
| A17 | 300 | 340 | 3.133 | | | | | | |
| *** SEGMENT C | | | | | | | | | |
| A09 | 300 | 340 | 3.133 | | | | | | |
| C07 | 300 | 340 | 3.133 | | | | | | |

RPP-6485 Rev. 0





K/T4PRINT

H O T M O D U L U S (E6 psi )

| POINT NAME | CASE 1 | CASE 2 | CASE 3 |
|---|---|---|---|
| *** SEGMENT A | | | |
| A00 | 26.802 | | |
| A17 | 26.802 | | |
| *** SEGMENT C | | | |
| A09 | 26.802 | | |
| C07 | 26.802 | | |

* Non-standard material



H O T A L L O W A B L E S (psi )

| POINT NAME | CASE 1 ALLOW | CASE 1 NOT USED | CASE 1 NOT USED | CASE 2 ALLOW | CASE 2 NOT USED | CASE 2 NOT USED | CASE 3 ALLOW | CASE 3 NOT USED | CASE 3 NOT USED |
|---|---|---|---|---|---|---|---|---|---|
| *** SEGMENT A | | | | | | | | | |
| A00 | 16340 | | | | | | | | |
| A17 | 16340 | | | | | | | | |
| *** SEGMENT C | | | | | | | | | |
| A09 | 16340 | | | | | | | | |
| C07 | 16340 | | | | | | | | |

< User-defined code allowable
* Non-code material



292

DOP-6485 Rev. 6

## A N A L Y S I S  S U M M A R Y

Current model revision number : 10

```
Static - Date and Time of analysis ............. Jun 2, 2000   10:45 AM
         Model Revision Number ................. 10
         Number of load cases .................. 3
         Load cases analyzed ................... GR T1 P1
         Gaps/Friction/Soil considered ......... Yes
         Tolerance - Force, Displacement ....... 100.00 lb   0.0162 in
         Friction - Scale Factor, Tolerance .... 1.00   0.10
         Hanger design run ..................... No
         Cut short included .................... No
         Include Bourdon rotational effect ..... No
         Pipe radius for Bourdon calculation ... Mean
         Occasional load analysis type ......... Nonlinear
         Non-linear analysis summary file ...... AZ01&02F.LOG
         Use default load sequence ............. Yes
         Base load cases for nonlinear analysis
                                                   GR = None
                                                   T1 = GR
                                                   P1 = T1
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No

Modal  - Date and Time of analysis ............. Jun 2, 2000   10:45 AM
         Model Revision Number ................. 10
         Number of modes ....................... 0
         Cutoff frequency (Hz) ................. 33.0
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No

Response - Date and Time of analysis ............ Jun 2, 2000   10:47 AM
         Model Revision Number ................. 10
         Number of load cases .................. 3
         Load cases analyzed ................... R1 R2 R3
         Date and time of modal analysis ....... Jun 2, 2000   10:45 AM
         Number of modes ....................... 0
         Cutoff frequency (Hz) ................. 33.0
         Model revision of modal analysis ...... 10
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No
```



## CODE COMPLIANCE COMBINATIONS

| Combination | Category | Method | Load | Factor | M/S | Allowable | Remarks |
|---|---|---|---|---|---|---|---|
| GR + Max P | Sustain | Sum | Gravity | 1.00 | | Automatic | Default |
| | | | Max Long | 1.00 | | | |
| Cold to T1 | Expansion | Sum | Thermal 1 | 1.00 | | Automatic | Default |
| Sus. + R1 | Occasion | Abs sum | Response 1 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Sus. + R2 | Occasion | Abs sum | Response 2 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Sus. + R3 | Occasion | Abs sum | Response 3 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Max P | Hoop | | Max Hoop | 1.00 | | Automatic | Default |



RPP-6445 Rev. 0
293
K/T 4PRINT

OTHER USER COMBINATIONS

| Combination | Method | Load | Factor | Remarks |
|---|---|---|---|---|
| GR | Sum | Gravity | 1.00 | Default |
| T1 | Sum | Thermal 1 | 1.00 | Default |
| R1 | Sum | Response 1 | 1.00 | Default |
| R2 | Sum | Response 2 | 1.00 | Default |
| R3 | Sum | Response 3 | 1.00 | Default |
| SEISMIC | SRSS | Response 1 | 1.00 | User |
| | | Response 2 | 1.00 | |
| | | Response 3 | 1.00 | |
| GR+T1+P1 | Sum | Gravity | 1.00 | User |
| | | Thermal 1 | 1.00 | |
| | | Press 1 | 1.00 | |
| TOTAL | Abs sum | GR+T1+P1 | 1.00 | User |
| | | SEISMIC | 1.00 | |



CODE COMPLIANCE

Y - Factor ..... 0.40
Weld efficiency factor ..... 1.00
Range reduction factor ..... 1.00
Design Pressure Factor ..... 1.00
Minimum stress ratio used in reports... 0.00
Number of stress points per span ..... 0
Include corrosion in stress calcs. .... Y
Include torsion in code stress ..... N
Include axial force in code stress .... N
Set sustained SIF to 1.00 ..... N
Use proposed B31.3, h = 3.1*T/r ..... N
Apply cold/hot modulus ratio ..... N
Total stress ..... Octahedral
Direct shear ..... None
Longitudinal pressure calculation ..... PD/4t
Include rigorous pressure ..... N



RPP-6485 Rev.0

294

1C/14-PRINT

RESPONSE SPECTRUM LOAD CASES :

Number of load cases analysed : 3

Load case 1 - R1

Missing mass : Yes
ZPA : No

Combination method : SRSS

X- Spectrum : SS(H)OLD
Multiplier : 1.00

SS(H)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.04 | 0.500 | 0.10 | 1.000 | 0.19 |
| 2.000 | 0.29 | 3.300 | 0.37 | 5.000 | 0.39 |
| 10.000 | 0.32 | 13.300 | 0.26 | 33.300 | 0.18 |
| 100.000 | 0.18 | | | | |



Load case 2 - R2

Missing mass : Yes
ZPA : No

Combination method : SRSS

Y- Spectrum : SS(V)OLD
Multiplier : 1.00

SS(V)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.03 | 0.500 | 0.06 | 1.000 | 0.08 |
| 2.000 | 0.12 | 3.300 | 0.19 | 5.000 | 0.22 |
| 10.000 | 0.23 | 13.300 | 0.22 | 50.000 | 0.12 |
| 100.000 | 0.12 | | | | |

Rep-6455 Rev. 0

Sbc

Load case 3 - R3

Missing mass : Yes
ZPA : No

Combination method : SRSS

Z- Spectrum : SS(H)OLD
Multiplier : 1.00

SS(H)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.04 | 0.500 | 0.10 | 1.000 | 0.19 |
| 2.000 | 0.29 | 3.300 | 0.37 | 5.000 | 0.39 |
| 10.000 | 0.32 | 13.300 | 0.26 | 33.300 | 0.18 |
| 100.000 | 0.18 | | | | |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| *** Segment A begin *** | | | | | | | |
| A00 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| A01 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | -0.004 |
| | T1 | 0.009 | 0.002 | 0.000 | -0.002 | -0.003 | 0.031 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.009 | 0.002 | 0.000 | -0.002 | -0.003 | 0.028 |
| | TOTAL | 0.009 | 0.002 | 0.000 | 0.002 | 0.003 | 0.028 |
| A02 | GR | 0.000 | -0.003 | 0.000 | -0.001 | 0.000 | -0.017 |
| | T1 | 0.009 | 0.034 | 0.003 | -0.129 | -0.021 | 0.136 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | GR+T1+P1 | 0.009 | 0.031 | 0.003 | -0.131 | -0.022 | 0.119 |
| | TOTAL | 0.009 | 0.031 | 0.003 | 0.131 | 0.022 | 0.120 |
| A03 N | GR | 0.000 | -0.004 | 0.000 | -0.001 | 0.000 | -0.017 |
| | T1 | 0.014 | 0.038 | 0.003 | -0.130 | -0.021 | 0.134 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | GR+T1+P1 | 0.014 | 0.035 | 0.003 | -0.132 | -0.022 | 0.117 |
| | TOTAL | 0.014 | 0.035 | 0.003 | 0.132 | 0.023 | 0.118 |
| A03 F | GR | 0.000 | -0.004 | 0.000 | -0.001 | 0.000 | -0.010 |
| | T1 | 0.021 | 0.037 | 0.009 | -0.133 | -0.021 | 0.004 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | GR+T1+P1 | 0.021 | 0.032 | 0.009 | -0.135 | -0.021 | -0.007 |
| | TOTAL | 0.021 | 0.033 | 0.009 | 0.135 | 0.023 | 0.007 |
| A04 | GR | -0.001 | -0.004 | 0.000 | -0.001 | 0.000 | -0.009 |
| | T1 | 0.020 | 0.025 | 0.019 | -0.131 | -0.019 | -0.028 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | GR+T1+P1 | 0.019 | 0.021 | 0.019 | -0.133 | -0.019 | -0.037 |
| | TOTAL | 0.019 | 0.021 | 0.019 | 0.133 | 0.021 | 0.037 |
| A05 | GR | -0.003 | -0.004 | 0.001 | -0.001 | 0.000 | -0.004 |
| | T1 | 0.006 | -0.008 | 0.047 | -0.105 | -0.013 | -0.085 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.001 |
| | GR+T1+P1 | 0.003 | -0.013 | 0.047 | -0.107 | -0.013 | -0.089 |
| | TOTAL | 0.003 | 0.013 | 0.047 | 0.107 | 0.015 | 0.089 |

RPP-6485 REV. 0

296

D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A06 N | GR | -0.001 | -0.004 | 0.000 | 0.003 | 0.000 | 0.007 |
| | T1 | -0.028 | -0.115 | 0.035 | 0.194 | 0.008 | 0.080 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.003 | 0.002 |
| | GR+T1+P1 | -0.029 | -0.120 | 0.035 | 0.198 | 0.008 | 0.088 |
| | TOTAL | 0.031 | 0.121 | 0.036 | 0.198 | 0.011 | 0.090 |
| A06 F | GR | 0.000 | -0.004 | 0.000 | 0.008 | -0.001 | 0.010 |
| | T1 | -0.019 | -0.106 | 0.013 | 0.376 | -0.044 | 0.225 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.020 | -0.110 | 0.013 | 0.385 | -0.045 | 0.236 |
| | TOTAL | 0.021 | 0.111 | 0.013 | 0.386 | 0.049 | 0.237 |
| A07 | GR | 0.000 | -0.004 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.017 | -0.088 | 0.006 | 0.377 | -0.047 | 0.264 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.018 | -0.092 | 0.006 | 0.388 | -0.047 | 0.276 |
| | TOTAL | 0.019 | 0.092 | 0.006 | 0.388 | 0.051 | 0.277 |
| A08 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.064 | -0.004 | 0.377 | -0.047 | 0.264 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.015 | -0.068 | -0.004 | 0.387 | -0.047 | 0.276 |
| | TOTAL | 0.015 | 0.068 | 0.004 | 0.388 | 0.052 | 0.277 |
| A09 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.063 | -0.004 | 0.374 | -0.047 | 0.268 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.014 | -0.066 | -0.004 | 0.385 | -0.048 | 0.280 |
| | TOTAL | 0.015 | 0.066 | 0.005 | 0.385 | 0.052 | 0.281 |
| A10 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.061 | -0.005 | 0.372 | -0.053 | 0.266 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.014 | -0.065 | -0.005 | 0.383 | -0.054 | 0.278 |
| | TOTAL | 0.015 | 0.065 | 0.006 | 0.384 | 0.058 | 0.278 |
| A11 | GR | 0.000 | -0.002 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.011 | -0.038 | -0.014 | 0.372 | -0.053 | 0.265 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.011 | -0.041 | -0.014 | 0.383 | -0.054 | 0.277 |
| | TOTAL | 0.011 | 0.041 | 0.015 | 0.384 | 0.058 | 0.278 |
| A12 | GR | 0.000 | -0.002 | 0.000 | 0.012 | -0.001 | 0.009 |
| | T1 | -0.005 | -0.012 | -0.025 | 0.330 | -0.087 | 0.227 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.001 |
| | GR+T1+P1 | -0.005 | -0.014 | -0.025 | 0.345 | -0.088 | 0.237 |
| | TOTAL | 0.005 | 0.014 | 0.026 | 0.345 | 0.093 | 0.238 |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A13 | GR | 0.000 | -0.001 | 0.000 | 0.014 | -0.001 | 0.008 |
| | T1 | 0.000 | 0.003 | -0.032 | 0.296 | -0.084 | 0.202 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.005 | 0.001 |
| | GR+T1+P1 | 0.000 | 0.002 | -0.032 | 0.313 | -0.085 | 0.211 |
| | TOTAL | 0.000 | 0.002 | 0.033 | 0.313 | 0.090 | 0.213 |
| A14 N | GR | 0.000 | -0.001 | 0.000 | 0.014 | -0.001 | 0.007 |
| | T1 | 0.003 | 0.013 | -0.037 | 0.269 | -0.078 | 0.184 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.001 |
| | GR+T1+P1 | 0.003 | 0.013 | -0.037 | 0.286 | -0.078 | 0.193 |
| | TOTAL | 0.003 | 0.013 | 0.038 | 0.286 | 0.083 | 0.194 |
| A14 F | GR | 0.000 | 0.000 | 0.000 | 0.009 | 0.001 | 0.005 |
| | T1 | 0.009 | 0.014 | -0.045 | 0.006 | -0.029 | 0.107 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.002 |
| | GR+T1+P1 | 0.010 | 0.014 | -0.046 | 0.016 | -0.028 | 0.112 |
| | TOTAL | 0.010 | 0.014 | 0.046 | 0.017 | 0.032 | 0.114 |
| A15 | GR | 0.000 | 0.000 | -0.001 | 0.008 | 0.001 | 0.004 |
| | T1 | 0.012 | 0.009 | -0.045 | -0.003 | -0.029 | 0.100 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 | 0.002 |
| | GR+T1+P1 | 0.013 | 0.009 | -0.046 | 0.006 | -0.028 | 0.106 |
| | TOTAL | 0.013 | 0.009 | 0.046 | 0.008 | 0.032 | 0.107 |
| A16 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.009 | -0.002 | -0.029 | -0.001 | -0.001 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.009 | -0.002 | -0.029 | -0.001 | -0.001 |
| | TOTAL | 0.000 | 0.009 | 0.002 | 0.029 | 0.001 | 0.001 |
| A17 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*** Segment A end ***

*** Segment C begin ***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A09 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.063 | -0.004 | 0.374 | -0.047 | 0.268 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.014 | -0.066 | -0.004 | 0.385 | -0.048 | 0.280 |
| | TOTAL | 0.015 | 0.066 | 0.005 | 0.385 | 0.052 | 0.281 |

RPP-6995 Rev. 0

297

## D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| C01 | GR | 0.000 | -0.003 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.014 | -0.062 | -0.004 | 0.372 | -0.042 | 0.272 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.014 | -0.065 | -0.004 | 0.382 | -0.043 | 0.284 |
| | TOTAL | 0.015 | 0.065 | 0.005 | 0.383 | 0.047 | 0.285 |
| C02 | GR | 0.000 | -0.002 | 0.000 | 0.009 | -0.001 | 0.010 |
| | T1 | -0.004 | -0.044 | -0.002 | 0.371 | -0.042 | 0.273 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.004 | 0.001 |
| | GR+T1+P1 | -0.004 | -0.047 | -0.002 | 0.382 | -0.043 | 0.285 |
| | TOTAL | 0.005 | 0.047 | 0.002 | 0.383 | 0.047 | 0.286 |
| C03 | GR | 0.000 | -0.002 | 0.000 | 0.008 | -0.001 | 0.011 |
| | T1 | 0.005 | -0.026 | 0.000 | 0.340 | -0.038 | 0.299 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.003 | 0.001 |
| | GR+T1+P1 | 0.005 | -0.028 | 0.000 | 0.349 | -0.038 | 0.312 |
| | TOTAL | 0.006 | 0.028 | 0.000 | 0.350 | 0.041 | 0.313 |
| C04 N | GR | 0.000 | 0.000 | 0.000 | 0.007 | -0.001 | 0.007 |
| | T1 | 0.023 | 0.012 | 0.006 | 0.277 | -0.058 | 0.278 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.000 |
| | GR+T1+P1 | 0.023 | 0.011 | 0.007 | 0.285 | -0.059 | 0.287 |
| | TOTAL | 0.024 | 0.011 | 0.007 | 0.286 | 0.061 | 0.287 |
| C04 F | GR | 0.000 | 0.000 | 0.000 | 0.005 | -0.002 | 0.007 |
| | T1 | 0.033 | 0.013 | 0.001 | 0.200 | -0.095 | 0.065 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 |
| | GR+T1+P1 | 0.034 | 0.014 | 0.001 | 0.206 | -0.097 | 0.073 |
| | TOTAL | 0.034 | 0.014 | 0.001 | 0.207 | 0.099 | 0.075 |
| C05 | GR | 0.000 | 0.000 | 0.000 | 0.004 | -0.002 | 0.007 |
| | T1 | 0.035 | 0.009 | -0.005 | 0.192 | -0.094 | 0.056 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 |
| | GR+T1+P1 | 0.035 | 0.009 | -0.005 | 0.197 | -0.096 | 0.063 |
| | TOTAL | 0.036 | 0.009 | 0.005 | 0.198 | 0.098 | 0.065 |
| C06 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.001 | 0.009 | 0.000 | 0.011 | -0.002 | -0.018 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| | GR+T1+P1 | 0.001 | 0.009 | 0.000 | 0.011 | -0.002 | -0.018 |
| | TOTAL | 0.001 | 0.009 | 0.000 | 0.011 | 0.002 | 0.019 |
| C07 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*** Segment C end ***



## R E S T R A I N T R E A C T I O N S

| Point name | Load combination | FORCES (lb ) X | Y | Z | Result | MOMENTS (ft-lb ) X | Y | Z | Result |
|---|---|---|---|---|---|---|---|---|---|
| A00 | Anchor | | | | | | | | |
| | GR | 1 | -98 | 1 | 98 | 0 | 0 | -42 | 42 |
| | T1 | -101 | 854 | 63 | 862 | -14 | -34 | 368 | 369 |
| | SEISMIC | 10 | 8 | 6 | 14 | 0 | 1 | 3 | 3 |
| | GR+T1+P1 | -100 | 758 | 64 | 768 | -14 | -35 | 327 | 329 |
| | TOTAL | 110 | 766 | 70 | 777 | 14 | 36 | 329 | 332 |
| A04 | Guide [ID: A04 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | SEISMIC | 6 | 0 | 4 | 7 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOTAL | 6 | 0 | 4 | 7 | 0 | 0 | 0 | 0 |
| A05 | Guide [ID: A05 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | SEISMIC | 9 | 0 | 3 | 9 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOTAL | 9 | 0 | 3 | 9 | 0 | 0 | 0 | 0 |
| A13 | Guide [ID: A14 1] | | | | | | | | |
| | GR | -23 | 0 | 0 | 23 | 0 | 0 | 0 | 0 |
| | T1 | -1195 | 0 | 0 | 1195 | 0 | 0 | 0 | 0 |
| | SEISMIC | 36 | 27 | 0 | 44 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | -1225 | 17 | 0 | 1225 | 0 | 0 | 0 | 0 |
| | TOTAL | 1260 | 44 | 0 | 1261 | 0 | 0 | 0 | 0 |
| A17 | Anchor | | | | | | | | |
| | GR | 11 | -118 | -22 | 120 | -2 | 0 | -1 | 2 |
| | T1 | 358 | -218 | -1189 | 1261 | -399 | -3 | -59 | 404 |
| | SEISMIC | 1 | 15 | 13 | 20 | 5 | 0 | 1 | 5 |
| | GR+T1+P1 | 371 | -351 | -1217 | 1320 | -403 | -3 | -60 | 407 |
| | TOTAL | 372 | 366 | 1230 | 1336 | 408 | 3 | 62 | 412 |
| C03 | Guide [ID: C03 1] | | | | | | | | |
| | GR | 0 | 0 | 26 | 26 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 1317 | 1317 | 0 | 0 | 0 | 0 |
| | SEISMIC | 0 | 28 | 45 | 53 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 1351 | 1351 | 0 | 0 | 0 | 0 |
| | TOTAL | 0 | 28 | 1395 | 1396 | 0 | 0 | 0 | 0 |

RPP-L495 Rev.0

## RESTRAINT REACTIONS

| Point name | Load combination | FORCES (lb) X | Y | Z | Result | MOMENTS (ft-lb) X | Y | Z | Result |
|---|---|---|---|---|---|---|---|---|---|
| C07 | Anchor | | | | | | | | |
| | GR | 11 | -165 | -5 | 166 | 1 | 0 | 0 | 1 |
| | T1 | 939 | -636 | -191 | 1150 | 52 | -10 | -280 | 285 |
| | SEISMIC | 22 | 9 | 8 | 25 | 3 | 0 | 8 | 9 |
| | GR+T1+P1 | 954 | -805 | -198 | 1264 | 53 | -10 | -281 | 286 |
| | TOTAL | 976 | 814 | 206 | 1288 | 56 | 10 | 289 | 295 |



## ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | (Moments in ft-lb) In-Pl. Moment | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | (Stress in psi) Code Stress | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| *** Segment A begin *** | | | | | | | | | | |
| A00 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 42 | 0 | | 1.00 | 1.00 | (18) | SUST | 2328 | 16340 |
| | Cold to T1 | 368 | 34 | 14 | 1.00 | 1.00 | (17) | DISP | 7906 | 24960 |
| | Sus. + R1 | 42 | 0 | | 1.00 | 1.00 | (18) | OCC | 2336 | 21732 |
| | Sus. + R2 | 44 | 0 | | 1.00 | 1.00 | (18) | OCC | 2393 | 21732 |
| | Sus. + R3 | 42 | 2 | | 1.00 | 1.00 | (18) | OCC | 2361 | 21732 |
| A01 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 13 | 0 | | 1.00 | 1.00 | (18) | SUST | 1632 | 16340 |
| | Cold to T1 | 111 | 15 | 14 | 1.00 | 1.00 | (17) | DISP | 2424 | 24960 |
| | Sus. + R1 | 13 | 1 | | 1.00 | 1.00 | (18) | OCC | 1640 | 21732 |
| | Sus. + R2 | 13 | 0 | | 1.00 | 1.00 | (18) | OCC | 1641 | 21732 |
| | Sus. + R3 | 13 | 1 | | 1.00 | 1.00 | (18) | OCC | 1641 | 21732 |
| A02 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 0 | | 1.00 | 1.00 | (18) | SUST | 1448 | 16340 |
| | Cold to T1 | 26 | 9 | 14 | 1.00 | 1.00 | (17) | DISP | 656 | 24960 |
| | Sus. + R1 | 5 | 1 | | 1.00 | 1.00 | (18) | OCC | 1458 | 21732 |
| | Sus. + R2 | 5 | 0 | | 1.00 | 1.00 | (18) | OCC | 1451 | 21732 |
| | Sus. + R3 | 5 | 1 | | 1.00 | 1.00 | (18) | OCC | 1461 | 21732 |
| A03 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 0 | | 1.00 | 1.00 | (18) | SUST | 1395 | 16340 |
| | Cold to T1 | 88 | 0 | 14 | 1.00 | 1.00 | (17) | DISP | 1902 | 24960 |
| | Sus. + R1 | 3 | 1 | | 1.00 | 1.00 | (18) | OCC | 1409 | 21732 |
| | Sus. + R2 | 3 | 0 | | 1.00 | 1.00 | (18) | OCC | 1404 | 21732 |
| | Sus. + R3 | 3 | 0 | | 1.00 | 1.00 | (18) | OCC | 1404 | 21732 |
| A03 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 0 | | 2.27 | 1.89 | (18) | SUST | 1478 | 16340 |
| | Cold to T1 | 88 | 0 | 14 | 2.27 | 1.89 | (17) | DISP | 4276 | 24960 |
| | Sus. + R1 | 3 | 1 | | 2.27 | 1.89 | (18) | OCC | 1505 | 21732 |
| | Sus. + R2 | 3 | 0 | | 2.27 | 1.89 | (18) | OCC | 1500 | 21732 |
| | Sus. + R3 | 3 | 0 | | 2.27 | 1.89 | (18) | OCC | 1496 | 21732 |
| A03 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 0 | | 2.27 | 1.89 | (18) | SUST | 1977 | 16340 |
| | Cold to T1 | 213 | 3 | 10 | 2.27 | 1.89 | (17) | DISP | 10360 | 24960 |
| | Sus. + R1 | 12 | 0 | | 2.27 | 1.89 | (18) | OCC | 1988 | 21732 |
| | Sus. + R2 | 12 | 0 | | 2.27 | 1.89 | (18) | OCC | 2002 | 21732 |
| | Sus. + R3 | 12 | 0 | | 2.27 | 1.89 | (18) | OCC | 1988 | 21732 |
| A03 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 0 | 12 | | 1.00 | 1.00 | (18) | SUST | 1615 | 16340 |
| | Cold to T1 | 3 | 213 | 10 | 1.00 | 1.00 | (17) | DISP | 4570 | 24960 |
| | Sus. + R1 | 0 | 12 | | 1.00 | 1.00 | (18) | OCC | 1620 | 21732 |
| | Sus. + R2 | 0 | 12 | | 1.00 | 1.00 | (18) | OCC | 1626 | 21732 |
| | Sus. + R3 | 0 | 12 | | 1.00 | 1.00 | (18) | OCC | 1621 | 21732 |



RPP-6485 Rev. 0

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A04 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 0 | 11 | | 1.00 | 1.00 | (18) | SUST | 1602 | 16340 |
| | Cold to T1 | 21 | 175 | 10 | 1.00 | 1.00 | (17) | DISP | 3786 | 24960 |
| | Sus. + R1 | 1 | 12 | | 1.00 | 1.00 | (18) | OCC | 1628 | 21732 |
| | Sus. + R2 | 0 | 11 | | 1.00 | 1.00 | (18) | OCC | 1605 | 21732 |
| | Sus. + R3 | 1 | 12 | | 1.00 | 1.00 | (18) | OCC | 1626 | 21732 |
| A05 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 10 | | 1.00 | 1.00 | (18) | SUST | 1565 | 16340 |
| | Cold to T1 | 89 | 66 | 10 | 1.00 | 1.00 | (17) | DISP | 2379 | 24960 |
| | Sus. + R1 | 2 | 13 | | 1.00 | 1.00 | (18) | OCC | 1658 | 21732 |
| | Sus. + R2 | 1 | 10 | | 1.00 | 1.00 | (18) | OCC | 1576 | 21732 |
| | Sus. + R3 | 2 | 11 | | 1.00 | 1.00 | (18) | OCC | 1592 | 21732 |
| A06 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 5 | | 1.00 | 1.00 | (18) | SUST | 1475 | 16340 |
| | Cold to T1 | 307 | 284 | 10 | 1.00 | 1.00 | (17) | DISP | 8960 | 24960 |
| | Sus. + R1 | 4 | 7 | | 1.00 | 1.00 | (18) | OCC | 1527 | 21732 |
| | Sus. + R2 | 5 | 5 | | 1.00 | 1.00 | (18) | OCC | 1501 | 21732 |
| | Sus. + R3 | 4 | 5 | | 1.00 | 1.00 | (18) | OCC | 1492 | 21732 |
| A06 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 5 | | 1.73 | 1.44 | (18) | SUST | 1557 | 16340 |
| | Cold to T1 | 307 | 284 | 10 | 1.73 | 1.44 | (17) | DISP | 14382 | 24960 |
| | Sus. + R1 | 4 | 7 | | 1.73 | 1.44 | (18) | OCC | 1633 | 21732 |
| | Sus. + R2 | 5 | 5 | | 1.73 | 1.44 | (18) | OCC | 1598 | 21732 |
| | Sus. + R3 | 4 | 5 | | 1.73 | 1.44 | (18) | OCC | 1584 | 21732 |
| A06 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 0 | | 1.73 | 1.44 | (18) | SUST | 1759 | 16340 |
| | Cold to T1 | 110 | 15 | 309 | 1.73 | 1.44 | (17) | DISP | 7785 | 24960 |
| | Sus. + R1 | 11 | 1 | | 1.73 | 1.44 | (18) | OCC | 1805 | 21732 |
| | Sus. + R2 | 11 | 0 | | 1.73 | 1.44 | (18) | OCC | 1766 | 21732 |
| | Sus. + R3 | 10 | 1 | | 1.73 | 1.44 | (18) | OCC | 1768 | 21732 |
| A06 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 0 | | 1.00 | 1.00 | (18) | SUST | 1577 | 16340 |
| | Cold to T1 | 110 | 15 | 309 | 1.00 | 1.00 | (17) | DISP | 7032 | 24960 |
| | Sus. + R1 | 11 | 1 | | 1.00 | 1.00 | (18) | OCC | 1605 | 21732 |
| | Sus. + R2 | 11 | 0 | | 1.00 | 1.00 | (18) | OCC | 1582 | 21732 |
| | Sus. + R3 | 10 | 1 | | 1.00 | 1.00 | (18) | OCC | 1583 | 21732 |
| A07 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 16 | 1 | | 1.00 | 1.00 | (18) | SUST | 1702 | 16340 |
| | Cold to T1 | 78 | 37 | 309 | 1.00 | 1.00 | (17) | DISP | 6873 | 24960 |
| | Sus. + R1 | 17 | 1 | | 1.00 | 1.00 | (18) | OCC | 1732 | 21732 |
| | Sus. + R2 | 16 | 1 | | 1.00 | 1.00 | (18) | OCC | 1713 | 21732 |
| | Sus. + R3 | 16 | 1 | | 1.00 | 1.00 | (18) | OCC | 1711 | 21732 |



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A08 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 20 | 1 | | 1.00 | 1.00 | (18) | SUST | 1807 | 16340 |
| | Cold to T1 | 334 | 68 | 309 | 1.00 | 1.00 | (17) | DISP | 9853 | 24960 |
| | Sus. + R1 | 21 | 1 | | 1.00 | 1.00 | (18) | OCC | 1841 | 21732 |
| | Sus. + R2 | 22 | 1 | | 1.00 | 1.00 | (18) | OCC | 1848 | 21732 |
| | Sus. + R3 | 20 | 2 | | 1.00 | 1.00 | (18) | OCC | 1820 | 21732 |
| A09 - | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 20 | | 1.19 | 1.25 | (18) | SUST | 1931 | 16340 |
| | Cold to T1 | 70 | 351 | 309 | 1.19 | 1.25 | (17) | DISP | 11637 | 24960 |
| | Sus. + R1 | 2 | 21 | | 1.19 | 1.25 | (18) | OCC | 1974 | 21732 |
| | Sus. + R2 | 1 | 22 | | 1.19 | 1.25 | (18) | OCC | 1986 | 21732 |
| | Sus. + R3 | 2 | 20 | | 1.19 | 1.25 | (18) | OCC | 1947 | 21732 |
| A09 + | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 8 | 25 | | 1.19 | 1.25 | (18) | SUST | 2101 | 16340 |
| | Cold to T1 | 632 | 165 | 192 | 1.19 | 1.25 | (17) | DISP | 17177 | 24960 |
| | Sus. + R1 | 19 | 28 | | 1.19 | 1.25 | (18) | OCC | 2437 | 21732 |
| | Sus. + R2 | 8 | 26 | | 1.19 | 1.25 | (18) | OCC | 2146 | 21732 |
| | Sus. + R3 | 13 | 25 | | 1.19 | 1.25 | (18) | OCC | 2234 | 21732 |
| A10 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 25 | 8 | | 1.00 | 1.00 | (18) | SUST | 1949 | 16340 |
| | Cold to T1 | 170 | 616 | 192 | 1.00 | 1.00 | (17) | DISP | 14269 | 24960 |
| | Sus. + R1 | 28 | 19 | | 1.00 | 1.00 | (18) | OCC | 2224 | 21732 |
| | Sus. + R2 | 26 | 8 | | 1.00 | 1.00 | (18) | OCC | 1984 | 21732 |
| | Sus. + R3 | 25 | 12 | | 1.00 | 1.00 | (18) | OCC | 2058 | 21732 |
| A11 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 23 | 4 | | 1.00 | 1.00 | (18) | SUST | 1892 | 16340 |
| | Cold to T1 | 235 | 364 | 192 | 1.00 | 1.00 | (17) | DISP | 10147 | 24960 |
| | Sus. + R1 | 24 | 11 | | 1.00 | 1.00 | (18) | OCC | 2057 | 21732 |
| | Sus. + R2 | 24 | 4 | | 1.00 | 1.00 | (18) | OCC | 1923 | 21732 |
| | Sus. + R3 | 23 | 7 | | 1.00 | 1.00 | (18) | OCC | 1966 | 21732 |
| A12 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 18 | 1 | | 1.00 | 1.00 | (18) | SUST | 1763 | 16340 |
| | Cold to T1 | 311 | 71 | 192 | 1.00 | 1.00 | (17) | DISP | 7972 | 24960 |
| | Sus. + R1 | 19 | 2 | | 1.00 | 1.00 | (18) | OCC | 1795 | 21732 |
| | Sus. + R2 | 20 | 1 | | 1.00 | 1.00 | (18) | OCC | 1801 | 21732 |
| | Sus. + R3 | 18 | 2 | | 1.00 | 1.00 | (18) | OCC | 1798 | 21732 |
| A13 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 3 | | 1.00 | 1.00 | (18) | SUST | 1629 | 16340 |
| | Cold to T1 | 361 | 121 | 192 | 1.00 | 1.00 | (17) | DISP | 9132 | 24960 |
| | Sus. + R1 | 14 | 6 | | 1.00 | 1.00 | (18) | OCC | 1717 | 21732 |
| | Sus. + R2 | 14 | 4 | | 1.00 | 1.00 | (18) | OCC | 1681 | 21732 |
| | Sus. + R3 | 12 | 4 | | 1.00 | 1.00 | (18) | OCC | 1643 | 21732 |

RPP-6485 Rev. 0

306

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A14 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 0 | 2 | | 1.00 | 1.00 | (18) | SUST | 1370 | 16340 |
| | Cold to T1 | 397 | 63 | 192 | 1.00 | 1.00 | (17) | DISP | 9529 | 24960 |
| | Sus. + R1 | 1 | 3 | | 1.00 | 1.00 | (18) | OCC | 1412 | 21732 |
| | Sus. + R2 | 1 | 2 | | 1.00 | 1.00 | (18) | OCC | 1394 | 21732 |
| | Sus. + R3 | 0 | 2 | | 1.00 | 1.00 | (18) | OCC | 1376 | 21732 |
| A14 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 0 | 2 | | 2.27 | 1.89 | (18) | SUST | 1407 | 16340 |
| | Cold to T1 | 397 | 63 | 192 | 2.27 | 1.89 | (17) | DISP | 19874 | 24960 |
| | Sus. + R1 | 1 | 3 | | 2.27 | 1.89 | (18) | OCC | 1488 | 21732 |
| | Sus. + R2 | 1 | 2 | | 2.27 | 1.89 | (18) | OCC | 1462 | 21732 |
| | Sus. + R3 | 0 | 2 | | 2.27 | 1.89 | (18) | OCC | 1417 | 21732 |
| A14 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 5 | | 2.27 | 1.89 | (18) | SUST | 1885 | 16340 |
| | Cold to T1 | 235 | 132 | 3 | 2.27 | 1.89 | (17) | DISP | 12602 | 24960 |
| | Sus. + R1 | 11 | 5 | | 2.27 | 1.89 | (18) | OCC | 1957 | 21732 |
| | Sus. + R2 | 10 | 5 | | 2.27 | 1.89 | (18) | OCC | 1902 | 21732 |
| | Sus. + R3 | 10 | 5 | | 2.27 | 1.89 | (18) | OCC | 1903 | 21732 |
| A14 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 5 | | 1.00 | 1.00 | (18) | SUST | 1582 | 16340 |
| | Cold to T1 | 235 | 132 | 3 | 1.00 | 1.00 | (17) | DISP | 5769 | 24960 |
| | Sus. + R1 | 11 | 5 | | 1.00 | 1.00 | (18) | OCC | 1614 | 21732 |
| | Sus. + R2 | 10 | 5 | | 1.00 | 1.00 | (18) | OCC | 1591 | 21732 |
| | Sus. + R3 | 10 | 5 | | 1.00 | 1.00 | (18) | OCC | 1590 | 21732 |
| A15 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 7 | 3 | | 1.00 | 1.00 | (18) | SUST | 1506 | 16340 |
| | Cold to T1 | 76 | 84 | 3 | 1.00 | 1.00 | (17) | DISP | 2435 | 24960 |
| | Sus. + R1 | 7 | 4 | | 1.00 | 1.00 | (18) | OCC | 1524 | 21732 |
| | Sus. + R2 | 7 | 4 | | 1.00 | 1.00 | (18) | OCC | 1512 | 21732 |
| | Sus. + R3 | 7 | 3 | | 1.00 | 1.00 | (18) | OCC | 1511 | 21732 |
| A16 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 2 | | 1.00 | 1.00 | (18) | SUST | 1448 | 16340 |
| | Cold to T1 | 43 | 48 | 3 | 1.00 | 1.00 | (17) | DISP | 1381 | 24960 |
| | Sus. + R1 | 5 | 3 | | 1.00 | 1.00 | (18) | OCC | 1486 | 21732 |
| | Sus. + R2 | 4 | 2 | | 1.00 | 1.00 | (18) | OCC | 1453 | 21732 |
| | Sus. + R3 | 5 | 2 | | 1.00 | 1.00 | (18) | OCC | 1455 | 21732 |
| A17 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 2 | 1 | | 1.00 | 1.00 | (18) | SUST | 1383 | 16340 |
| | Cold to T1 | 399 | 59 | 3 | 1.00 | 1.00 | (17) | DISP | 8639 | 24960 |
| | Sus. + R1 | 6 | 2 | | 1.00 | 1.00 | (18) | OCC | 1485 | 21732 |
| | Sus. + R2 | 2 | 1 | | 1.00 | 1.00 | (18) | OCC | 1383 | 21732 |
| | Sus. + R3 | 5 | 1 | | 1.00 | 1.00 | (18) | OCC | 1447 | 21732 |

*** Segment A end ***

*** Segment C begin ***



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A09 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 11 | | 1.19 | 1.25 | (18) | SUST | 1747 | 16340 |
| | Cold to T1 | 563 | 501 | 186 | 1.19 | 1.25 | (17) | DISP | 20012 | 24960 |
| | Sus. + R1 | 21 | 14 | | 1.19 | 1.25 | (18) | OCC | 2095 | 21732 |
| | Sus. + R2 | 10 | 12 | | 1.19 | 1.25 | (18) | OCC | 1789 | 21732 |
| | Sus. + R3 | 14 | 12 | | 1.19 | 1.25 | (18) | OCC | 1894 | 21732 |
| C01 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 11 | 9 | | 1.00 | 1.00 | (18) | SUST | 1665 | 16340 |
| | Cold to T1 | 488 | 540 | 186 | 1.00 | 1.00 | (17) | DISP | 16082 | 24960 |
| | Sus. + R1 | 14 | 20 | | 1.00 | 1.00 | (18) | OCC | 1950 | 21732 |
| | Sus. + R2 | 12 | 9 | | 1.00 | 1.00 | (18) | OCC | 1696 | 21732 |
| | Sus. + R3 | 12 | 13 | | 1.00 | 1.00 | (18) | OCC | 1779 | 21732 |
| C02 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 3 | | 1.00 | 1.00 | (18) | SUST | 1558 | 16340 |
| | Cold to T1 | 297 | 202 | 186 | 1.00 | 1.00 | (17) | DISP | 8664 | 24960 |
| | Sus. + R1 | 11 | 11 | | 1.00 | 1.00 | (18) | OCC | 1760 | 21732 |
| | Sus. + R2 | 11 | 3 | | 1.00 | 1.00 | (18) | OCC | 1592 | 21732 |
| | Sus. + R3 | 10 | 4 | | 1.00 | 1.00 | (18) | OCC | 1594 | 21732 |
| C03 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 4 | | 1.00 | 1.00 | (18) | SUST | 1473 | 16340 |
| | Cold to T1 | 107 | 136 | 186 | 1.00 | 1.00 | (17) | DISP | 5425 | 24960 |
| | Sus. + R1 | 5 | 9 | | 1.00 | 1.00 | (18) | OCC | 1597 | 21732 |
| | Sus. + R2 | 9 | 4 | | 1.00 | 1.00 | (18) | OCC | 1576 | 21732 |
| | Sus. + R3 | 5 | 12 | | 1.00 | 1.00 | (18) | OCC | 1668 | 21732 |
| C04 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 34 | 1 | | 1.00 | 1.00 | (18) | SUST | 2148 | 16340 |
| | Cold to T1 | 271 | 22 | 186 | 1.00 | 1.00 | (17) | DISP | 7048 | 24960 |
| | Sus. + R1 | 37 | 2 | | 1.00 | 1.00 | (18) | OCC | 2227 | 21732 |
| | Sus. + R2 | 34 | 1 | | 1.00 | 1.00 | (18) | OCC | 2152 | 21732 |
| | Sus. + R3 | 35 | 1 | | 1.00 | 1.00 | (18) | OCC | 2170 | 21732 |
| C04 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 1 | | 2.27 | 1.89 | (18) | SUST | 2002 | 16340 |
| | Cold to T1 | 271 | 22 | 186 | 2.27 | 1.89 | (17) | DISP | 13777 | 24960 |
| | Sus. + R1 | 15 | 2 | | 2.27 | 1.89 | (18) | OCC | 2178 | 21732 |
| | Sus. + R2 | 13 | 1 | | 2.27 | 1.89 | (18) | OCC | 2011 | 21732 |
| | Sus. + R3 | 13 | 1 | | 2.27 | 1.89 | (18) | OCC | 2053 | 21732 |
| C04 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 6 | 4 | | 2.27 | 1.89 | (18) | SUST | 1717 | 16340 |
| | Cold to T1 | 221 | 154 | 10 | 2.27 | 1.89 | (17) | DISP | 12394 | 24960 |
| | Sus. + R1 | 8 | 4 | | 2.27 | 1.89 | (18) | OCC | 1814 | 21732 |
| | Sus. + R2 | 6 | 4 | | 2.27 | 1.89 | (18) | OCC | 1730 | 21732 |
| | Sus. + R3 | 7 | 4 | | 2.27 | 1.89 | (18) | OCC | 1742 | 21732 |

RPP-6485 Rev. 0

301

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| C04 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 6 | | 1.00 | 1.00 | (18) | SUST | 1507 | 16340 |
| | Cold to T1 | 154 | 221 | 10 | 1.00 | 1.00 | (17) | DISP | 5760 | 24960 |
| | Sus. + R1 | 4 | 8 | | 1.00 | 1.00 | (18) | OCC | 1550 | 21732 |
| | Sus. + R2 | 4 | 6 | | 1.00 | 1.00 | (18) | OCC | 1514 | 21732 |
| | Sus. + R3 | 4 | 7 | | 1.00 | 1.00 | (18) | OCC | 1518 | 21732 |
| C05 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 5 | | 1.00 | 1.00 | (18) | SUST | 1468 | 16340 |
| | Cold to T1 | 128 | 95 | 10 | 1.00 | 1.00 | (17) | DISP | 3430 | 24960 |
| | Sus. + R1 | 3 | 5 | | 1.00 | 1.00 | (18) | OCC | 1478 | 21732 |
| | Sus. + R2 | 3 | 5 | | 1.00 | 1.00 | (18) | OCC | 1474 | 21732 |
| | Sus. + R3 | 3 | 5 | | 1.00 | 1.00 | (18) | OCC | 1476 | 21732 |
| C06 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 4 | | 1.00 | 1.00 | (18) | SUST | 1439 | 16340 |
| | Cold to T1 | 109 | 2 | 10 | 1.00 | 1.00 | (17) | DISP | 2349 | 24960 |
| | Sus. + R1 | 4 | 6 | | 1.00 | 1.00 | (18) | OCC | 1491 | 21732 |
| | Sus. + R2 | 3 | 4 | | 1.00 | 1.00 | (18) | OCC | 1444 | 21732 |
| | Sus. + R3 | 3 | 4 | | 1.00 | 1.00 | (18) | OCC | 1453 | 21732 |
| C07 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 0 | | 1.00 | 1.00 | (18) | SUST | 1356 | 16340 |
| | Cold to T1 | 52 | 280 | 10 | 1.00 | 1.00 | (17) | DISP | 6100 | 24960 |
| | Sus. + R1 | 4 | 9 | | 1.00 | 1.00 | (18) | OCC | 1567 | 21732 |
| | Sus. + R2 | 1 | 1 | | 1.00 | 1.00 | (18) | OCC | 1358 | 21732 |
| | Sus. + R3 | 2 | 2 | | 1.00 | 1.00 | (18) | OCC | 1408 | 21732 |

*** Segment C end ***



## S Y S T E M S U M M A R Y

### Maximum displacements (in)

| | | | |
|---|---|---|---|
| Maximum X : | 0.036 | Point : C05 | Load Comb.: TOTAL |
| Maximum Y : | 0.121 | Point : A06 N | Load Comb.: TOTAL |
| Maximum Z : | 0.047 | Point : A05 | Load Comb.: GR+T1+P1 |
| Max. total: | 0.129 | Point : A06 N | Load Comb.: TOTAL |

### Maximum rotations (deg)

| | | | |
|---|---|---|---|
| Maximum X : | 0.388 | Point : A07 | Load Comb.: TOTAL |
| Maximum Y : | 0.099 | Point : C04 F | Load Comb.: TOTAL |
| Maximum Z : | 0.313 | Point : C03 | Load Comb.: TOTAL |
| Max. total: | 0.480 | Point : C02 | Load Comb.: TOTAL |

### Maximum restraint forces (lb)

| | | | |
|---|---|---|---|
| Maximum X : | 1260 | Point : A13 | Load Comb.: TOTAL |
| Maximum Y : | 854 | Point : A00 | Load Comb.: T1 |
| Maximum Z : | 1395 | Point : C03 | Load Comb.: TOTAL |
| Max. total: | 1396 | Point : C03 | Load Comb.: TOTAL |

### Maximum restraint moments (ft-lb)

| | | | |
|---|---|---|---|
| Maximum X : | 408 | Point : A17 | Load Comb.: TOTAL |
| Maximum Y : | 36 | Point : A00 | Load Comb.: TOTAL |
| Maximum Z : | 368 | Point : A00 | Load Comb.: T1 |
| Max. total: | 412 | Point : A17 | Load Comb.: TOTAL |

RPP-6485 Rev. 0

362

## S Y S T E M  S U M M A R Y

Maximum sustained stress

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2328 |
| Allowable psi | : 16340 |
| Ratio | : 0.14 |
| Load combination | : GR + Max P |

Maximum displacement stress

| | |
|---|---|
| Point | : A09 |
| Stress psi | : 20012 |
| Allowable psi | : 24960 |
| Ratio | : 0.80 |
| Load combination | : Cold to T1 |

Maximum occasional stress

| | |
|---|---|
| Point | : A09 |
| Stress psi | : 2437 |
| Allowable psi | : 21732 |
| Ratio | : 0.11 |
| Load combination | : Sus. + R1 |

Maximum hoop stress

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2978 |
| Allowable psi | : 16340 |
| Ratio | : 0.18 |
| Load combination | : Max P |



## S Y S T E M  S U M M A R Y

Maximum sustained stress ratio

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2328 |
| Allowable psi | : 16340 |
| Ratio | : 0.14 |
| Load combination | : GR + Max P |

Maximum displacement stress ratio

| | |
|---|---|
| Point | : A09 |
| Stress psi | : 20012 |
| Allowable psi | : 24960 |
| Ratio | : 0.80 |
| Load combination | : Cold to T1 |

Maximum occasional stress ratio

| | |
|---|---|
| Point | : A09 |
| Stress psi | : 2437 |
| Allowable psi | : 21732 |
| Ratio | : 0.11 |
| Load combination | : Sus. + R1 |

Maximum hoop stress ratio

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2978 |
| Allowable psi | : 16340 |
| Ratio | : 0.18 |
| Load combination | : Max P |

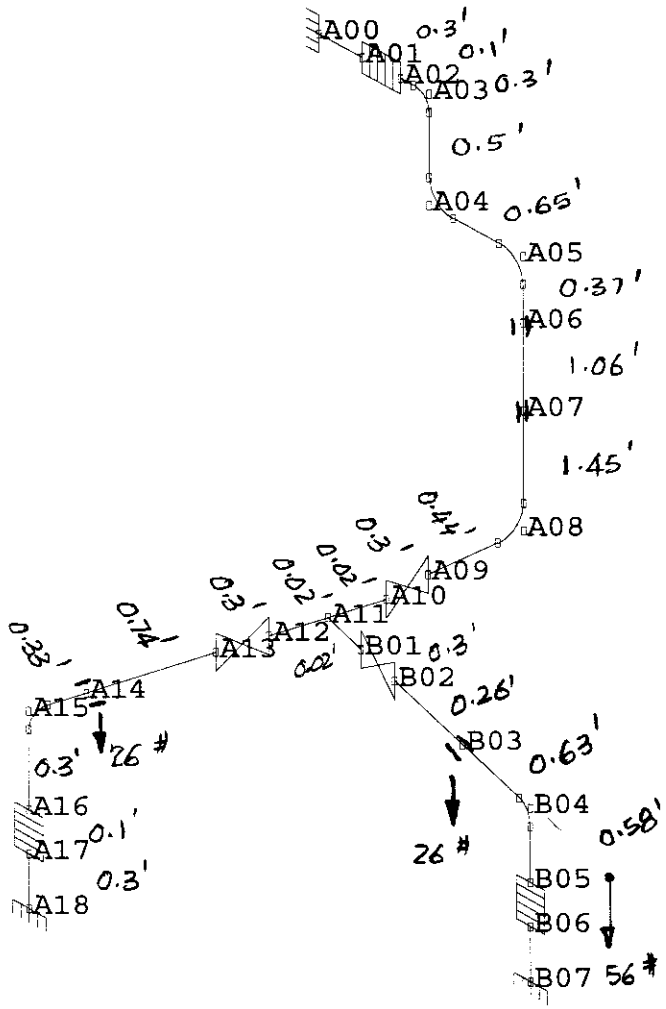
* * * The system satisfies ASME B31.3 code requirements * * *
* * * for the selected options * * *

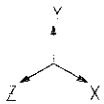
APPENDIX - C

CALC NO: DSTAP-P-004

REV. 0.

= GUIDE




PUMP PIT 241-AN-01B THRU -07B
JUMPER PIPING ANALYSIS

FILE: AN01-07b.

REF DWGS: H-14-104128 (2 SHTS) REV. 0
H-14-104129 (1 OF 2) REV. 0.
H-14-104130 (2 SHTS) REV. 0.

RPP-6485 REV. 0

## A N A L Y S I S  S U M M A R Y

Current model revision number : 4

```
Static - Date and Time of analysis ............. Jun 2, 2000   11:16 AM
         Model Revision Number .................. 4
         Number of load cases ................... 3
         Load cases analyzed .................... GR T1 P1
         Gaps/Friction/Soil considered ......... Yes
         Tolerance - Force, Displacement ....... 100.00 lb   0.0162 in
         Friction - Scale Factor, Tolerance .... 1.00   0.10
         Hanger design run ...................... No
         Cut short included ..................... No
         Include Bourdon rotational effect ..... No
         Pipe radius for Bourdon calculation ... Mean
         Occasional load analysis type ......... Nonlinear
         Non-linear analysis summary file ...... AN01-07B.LOG
         Use default load sequence ............. Yes
         Base load cases for nonlinear analysis
                                                   GR = None
                                                   T1 = GR
                                                   P1 = T1
         Weight of contents included ........... Yes
         Pressure stiffening case ............... 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No

Modal - Date and Time of analysis ............. Jun 2, 2000   11:16 AM
        Model Revision Number .................. 4
        Number of modes ........................ 0
        Cutoff frequency (Hz) .................. 33.0
        Weight of contents included ........... Yes
        Pressure stiffening case ............... 0
        Water elevation for buoyancy loads .... Not considered
        Hot modulus case used in analysis ..... 0
        Use corroded thickness in analysis .... No

Response - Date and Time of analysis ........... Jun 2, 2000   11:17 AM
           Model Revision Number ................ 4
           Number of load cases ................. 3
           Load cases analyzed .................. R1 R2 R3
           Date and time of modal analysis ...... Jun 2, 2000   11:16 AM
           Number of modes ...................... 0
           Cutoff frequency (Hz) ................ 33.0
           Model revision of modal analysis ..... 4
           Weight of contents included ........... Yes
           Pressure stiffening case ............... 0
           Water elevation for buoyancy loads .... Not considered
           Hot modulus case used in analysis ..... 0
           Use corroded thickness in analysis .... No
```



### CODE COMPLIANCE COMBINATIONS

| Combination | Category | Method | Load | Factor | M/S | Allowable | Remarks |
|---|---|---|---|---|---|---|---|
| GR + Max P | Sustain | Sum | Gravity | 1.00 | | Automatic | Default |
| | | | Max Long | 1.00 | | | |
| Cold to T1 | Expansion | Sum | Thermal 1 | 1.00 | | Automatic | Default |
| Sus. + R1 | Occasion | Abs sum | Response 1 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Sus. + R2 | Occasion | Abs sum | Response 2 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Sus. + R3 | Occasion | Abs sum | Response 3 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Max P | Hoop | | Max Hoop | 1.00 | | Automatic | Default |

RPP-4985 Rev.0





1C7-4-PRINT

OTHER USER COMBINATIONS

| Combination | Method | Load | Factor | Remarks |
|---|---|---|---|---|
| GR | Sum | Gravity | 1.00 | Default |
| T1 | Sum | Thermal 1 | 1.00 | Default |
| P1 | Sum | Press 1 | 1.00 | Default |
| R1 | Sum | Response 1 | 1.00 | Default |
| R2 | Sum | Response 2 | 1.00 | Default |
| R3 | Sum | Response 3 | 1.00 | Default |
| GR+T1+P1 | Sum | Gravity | 1.00 | User |
| | | Thermal 1 | 1.00 | |
| | | Press 1 | 1.00 | |
| SEISMIC | SRSS | Response 1 | 1.00 | User |
| | | Response 2 | 1.00 | |
| | | Response 3 | 1.00 | |
| TOTAL | Abs sum | GR+T1+P1 | 1.00 | User |
| | | SEISMIC | 1.00 | |



CODE COMPLIANCE

Y - Factor ..... 0.40
Weld efficiency factor ..... 1.00
Range reduction factor ..... 1.00
Design Pressure Factor ..... 1.00
Minimum stress ratio used in reports... 0.00
Number of stress points per span ..... 0
Include corrosion in stress calcs. .... Y
Include torsion in code stress ..... N
Include axial force in code stress .... N
Set sustained SIF to 1.00 ..... N
Use proposed B31.3, h = 3.1*T/r ..... N
Apply cold/hot modulus ratio ..... N
Total stress ..... Octahedral
Direct shear ..... None
Longitudinal pressure calculation ..... PD/4t
Include rigorous pressure ..... N

RESPONSE SPECTRUM LOAD CASES :

Number of load cases analysed : 3

Load case 1 - R1

Missing mass : Yes
ZPA : No

Combination method : SRSS

X- Spectrum : SS(H)OLD
Multiplier : 1.00

SS(H)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.04 | 0.500 | 0.10 | 1.000 | 0.19 |
| 2.000 | 0.29 | 3.300 | 0.37 | 5.000 | 0.39 |
| 10.000 | 0.32 | 13.300 | 0.26 | 33.300 | 0.18 |
| 100.000 | 0.18 | | | | |



Load case 2 - R2

Missing mass : Yes
ZPA : No

Combination method : SRSS

Y- Spectrum : SS(V)OLD
Multiplier : 1.00

SS(V)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.03 | 0.500 | 0.06 | 1.000 | 0.08 |
| 2.000 | 0.12 | 3.300 | 0.19 | 5.000 | 0.22 |
| 10.000 | 0.23 | 13.300 | 0.22 | 50.000 | 0.12 |
| 100.000 | 0.12 | | | | |

RPP-LVPS REV. 0

313

Load case 3 - R3

Missing mass : Yes
ZPA : No

Combination method : SRSS

Z- Spectrum : SS(H)OLD
Multiplier : 1.00

SS(H)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.04 | 0.500 | 0.10 | 1.000 | 0.19 |
| 2.000 | 0.29 | 3.300 | 0.37 | 5.000 | 0.39 |
| 10.000 | 0.32 | 13.300 | 0.26 | 33.300 | 0.18 |
| 100.000 | 0.18 | | | | |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| *** Segment A begin *** | | | | | | | |
| A00 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| A01 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | -0.004 |
| | T1 | 0.009 | 0.001 | 0.000 | 0.003 | 0.007 | 0.026 |
| | GR+T1+P1 | 0.009 | 0.001 | 0.000 | 0.003 | 0.007 | 0.022 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.009 | 0.001 | 0.000 | 0.003 | 0.007 | 0.022 |
| A02 | GR | 0.000 | -0.003 | 0.000 | 0.005 | 0.005 | -0.026 |
| | T1 | 0.009 | 0.021 | -0.004 | 0.172 | 0.053 | 0.170 |
| | GR+T1+P1 | 0.009 | 0.019 | -0.005 | 0.177 | 0.057 | 0.145 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.009 | 0.019 | 0.005 | 0.177 | 0.057 | 0.145 |
| A03 N | GR | 0.000 | -0.004 | 0.000 | 0.005 | 0.005 | -0.027 |
| | T1 | 0.014 | 0.026 | -0.006 | 0.173 | 0.054 | 0.172 |
| | GR+T1+P1 | 0.014 | 0.023 | -0.006 | 0.179 | 0.058 | 0.147 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.014 | 0.023 | 0.006 | 0.179 | 0.058 | 0.147 |
| A03 F | GR | -0.001 | -0.005 | -0.001 | 0.005 | 0.005 | -0.027 |
| | T1 | 0.024 | 0.027 | -0.014 | 0.178 | 0.058 | 0.144 |
| | GR+T1+P1 | 0.023 | 0.022 | -0.015 | 0.184 | 0.063 | 0.118 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.023 | 0.023 | 0.015 | 0.184 | 0.063 | 0.118 |
| A04 N | GR | -0.001 | -0.005 | -0.001 | 0.005 | 0.005 | -0.027 |
| | T1 | 0.027 | 0.024 | -0.017 | 0.178 | 0.058 | 0.143 |
| | GR+T1+P1 | 0.025 | 0.020 | -0.018 | 0.183 | 0.062 | 0.117 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.025 | 0.020 | 0.018 | 0.184 | 0.063 | 0.117 |
| A04 F | GR | -0.003 | -0.006 | -0.001 | 0.005 | 0.005 | -0.025 |
| | T1 | 0.042 | 0.023 | -0.029 | 0.166 | 0.046 | 0.114 |
| | GR+T1+P1 | 0.039 | 0.018 | -0.031 | 0.171 | 0.050 | 0.091 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | TOTAL | 0.039 | 0.018 | 0.031 | 0.172 | 0.051 | 0.091 |

RPP-6485 REV. 0

314

D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A05 N | GR | -0.003 | -0.007 | -0.002 | 0.005 | 0.005 | -0.024 |
| | T1 | 0.046 | 0.027 | -0.031 | 0.163 | 0.043 | 0.106 |
| | GR+T1+P1 | 0.044 | 0.021 | -0.032 | 0.168 | 0.048 | 0.083 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | TOTAL | 0.044 | 0.021 | 0.032 | 0.169 | 0.049 | 0.083 |
| A05 F | GR | -0.004 | -0.008 | -0.002 | 0.003 | 0.004 | -0.008 |
| | T1 | 0.054 | 0.022 | -0.040 | 0.132 | 0.009 | -0.070 |
| | GR+T1+P1 | 0.051 | 0.014 | -0.042 | 0.136 | 0.012 | -0.078 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | TOTAL | 0.051 | 0.015 | 0.042 | 0.136 | 0.013 | 0.078 |
| A06 | GR | -0.004 | -0.008 | -0.002 | 0.003 | 0.004 | -0.007 |
| | T1 | 0.052 | 0.018 | -0.043 | 0.129 | 0.004 | -0.082 |
| | GR+T1+P1 | 0.049 | 0.011 | -0.045 | 0.132 | 0.007 | -0.089 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | TOTAL | 0.049 | 0.011 | 0.045 | 0.132 | 0.008 | 0.089 |
| A07 | GR | -0.004 | -0.008 | -0.003 | 0.000 | 0.003 | 0.003 |
| | T1 | 0.026 | -0.015 | -0.067 | 0.073 | -0.038 | -0.130 |
| | GR+T1+P1 | 0.022 | -0.023 | -0.069 | 0.073 | -0.036 | -0.128 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| | TOTAL | 0.022 | 0.023 | 0.069 | 0.074 | 0.036 | 0.129 |
| A08 N | GR | -0.002 | -0.008 | -0.002 | -0.006 | 0.001 | 0.010 |
| | T1 | -0.001 | -0.052 | -0.071 | -0.050 | -0.085 | -0.056 |
| | GR+T1+P1 | -0.003 | -0.060 | -0.073 | -0.055 | -0.084 | -0.046 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 |
| | TOTAL | 0.003 | 0.060 | 0.073 | 0.055 | 0.085 | 0.049 |
| A08 F | GR | -0.002 | -0.007 | -0.001 | -0.018 | 0.002 | 0.014 |
| | T1 | -0.005 | -0.052 | -0.058 | -0.222 | -0.042 | 0.075 |
| | GR+T1+P1 | -0.007 | -0.059 | -0.059 | -0.241 | -0.040 | 0.089 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 |
| | TOTAL | 0.007 | 0.059 | 0.059 | 0.242 | 0.041 | 0.090 |
| A09 | GR | -0.001 | -0.007 | -0.001 | -0.020 | 0.002 | 0.015 |
| | T1 | -0.008 | -0.043 | -0.052 | -0.237 | -0.041 | 0.115 |
| | GR+T1+P1 | -0.010 | -0.050 | -0.054 | -0.259 | -0.039 | 0.131 |
| | SEISMIC | 0.001 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.011 | 0.050 | 0.054 | 0.260 | 0.040 | 0.132 |
| A10 | GR | -0.001 | -0.006 | -0.001 | -0.020 | 0.002 | 0.015 |
| | T1 | -0.013 | -0.031 | -0.044 | -0.237 | -0.041 | 0.116 |
| | GR+T1+P1 | -0.015 | -0.037 | -0.045 | -0.259 | -0.039 | 0.132 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.015 | 0.037 | 0.045 | 0.260 | 0.040 | 0.132 |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A11 | GR | -0.001 | -0.006 | -0.001 | -0.021 | 0.002 | 0.015 |
| | T1 | -0.014 | -0.030 | -0.043 | -0.237 | -0.040 | 0.121 |
| | GR+T1+P1 | -0.015 | -0.035 | -0.045 | -0.259 | -0.038 | 0.136 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.015 | 0.036 | 0.045 | 0.259 | 0.039 | 0.137 |
| A12 | GR | -0.001 | -0.005 | -0.001 | -0.021 | 0.002 | 0.015 |
| | T1 | -0.014 | -0.029 | -0.043 | -0.236 | -0.036 | 0.121 |
| | GR+T1+P1 | -0.015 | -0.035 | -0.044 | -0.258 | -0.035 | 0.137 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.016 | 0.035 | 0.044 | 0.258 | 0.036 | 0.137 |
| A13 | GR | -0.001 | -0.004 | -0.001 | -0.021 | 0.002 | 0.015 |
| | T1 | -0.019 | -0.017 | -0.034 | -0.235 | -0.036 | 0.121 |
| | GR+T1+P1 | -0.020 | -0.021 | -0.036 | -0.257 | -0.034 | 0.137 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.020 | 0.021 | 0.036 | 0.258 | 0.036 | 0.137 |
| A14 | GR | -0.001 | -0.001 | -0.001 | -0.025 | 0.002 | 0.011 |
| | T1 | -0.024 | 0.010 | -0.012 | -0.192 | 0.026 | 0.133 |
| | GR+T1+P1 | -0.025 | 0.009 | -0.013 | -0.217 | 0.028 | 0.145 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.001 |
| | TOTAL | 0.025 | 0.009 | 0.013 | 0.218 | 0.030 | 0.146 |
| A15 N | GR | -0.001 | -0.001 | -0.001 | -0.024 | 0.002 | 0.010 |
| | T1 | -0.024 | 0.015 | -0.007 | -0.183 | 0.030 | 0.136 |
| | GR+T1+P1 | -0.025 | 0.015 | -0.008 | -0.208 | 0.033 | 0.146 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.001 |
| | TOTAL | 0.025 | 0.015 | 0.008 | 0.209 | 0.035 | 0.147 |
| A15 F | GR | 0.000 | 0.000 | 0.000 | -0.017 | 0.001 | 0.009 |
| | T1 | -0.019 | 0.014 | 0.003 | -0.098 | 0.037 | 0.150 |
| | GR+T1+P1 | -0.020 | 0.014 | 0.003 | -0.116 | 0.037 | 0.159 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.020 | 0.014 | 0.003 | 0.116 | 0.039 | 0.161 |
| A16 | GR | 0.000 | 0.000 | 0.000 | -0.017 | 0.001 | 0.008 |
| | T1 | -0.015 | 0.009 | 0.006 | -0.093 | 0.036 | 0.148 |
| | GR+T1+P1 | -0.015 | 0.010 | 0.006 | -0.110 | 0.037 | 0.157 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.015 | 0.010 | 0.006 | 0.111 | 0.039 | 0.158 |
| A17 | GR | 0.000 | 0.000 | 0.000 | -0.001 | 0.000 | 0.001 |
| | T1 | -0.001 | 0.009 | 0.000 | -0.003 | 0.001 | 0.020 |
| | GR+T1+P1 | -0.001 | 0.009 | 0.000 | -0.004 | 0.001 | 0.021 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.001 | 0.009 | 0.000 | 0.004 | 0.001 | 0.021 |

RPP-6485 REV 0

315

D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A18 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| *** Segment A end *** | | | | | | | |
| *** Segment B begin *** | | | | | | | |
| A11 | GR | -0.001 | -0.006 | -0.001 | -0.021 | 0.002 | 0.015 |
| | T1 | -0.014 | -0.030 | -0.043 | -0.237 | -0.040 | 0.121 |
| | GR+T1+P1 | -0.015 | -0.035 | -0.045 | -0.259 | -0.038 | 0.136 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.015 | 0.036 | 0.045 | 0.259 | 0.039 | 0.137 |
| B01 | GR | -0.001 | -0.005 | -0.001 | -0.021 | 0.002 | 0.015 |
| | T1 | -0.014 | -0.029 | -0.043 | -0.237 | -0.041 | 0.123 |
| | GR+T1+P1 | -0.015 | -0.035 | -0.044 | -0.259 | -0.039 | 0.139 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.016 | 0.035 | 0.044 | 0.260 | 0.041 | 0.140 |
| B02 | GR | -0.001 | -0.004 | -0.001 | -0.021 | 0.002 | 0.015 |
| | T1 | -0.005 | -0.018 | -0.038 | -0.237 | -0.041 | 0.123 |
| | GR+T1+P1 | -0.007 | -0.022 | -0.039 | -0.259 | -0.039 | 0.139 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.001 |
| | TOTAL | 0.007 | 0.022 | 0.040 | 0.260 | 0.041 | 0.140 |
| B03 | GR | -0.001 | -0.003 | -0.001 | -0.021 | 0.002 | 0.017 |
| | T1 | 0.002 | -0.007 | -0.033 | -0.240 | -0.060 | 0.142 |
| | GR+T1+P1 | 0.000 | -0.010 | -0.035 | -0.262 | -0.059 | 0.160 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 |
| | TOTAL | 0.001 | 0.010 | 0.035 | 0.263 | 0.060 | 0.160 |
| B04 N | GR | -0.001 | -0.001 | -0.002 | -0.021 | 0.001 | 0.017 |
| | T1 | 0.014 | 0.013 | -0.022 | -0.234 | -0.077 | 0.139 |
| | GR+T1+P1 | 0.013 | 0.013 | -0.024 | -0.256 | -0.077 | 0.157 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | TOTAL | 0.013 | 0.013 | 0.024 | 0.256 | 0.077 | 0.157 |
| B04 F | GR | -0.001 | 0.000 | -0.001 | -0.017 | 0.002 | 0.014 |
| | T1 | 0.020 | 0.013 | -0.011 | -0.186 | -0.077 | 0.024 |
| | GR+T1+P1 | 0.020 | 0.014 | -0.012 | -0.204 | -0.075 | 0.038 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 |
| | TOTAL | 0.020 | 0.014 | 0.012 | 0.204 | 0.076 | 0.039 |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| B05 | GR | 0.000 | 0.000 | 0.000 | -0.016 | 0.002 | 0.014 |
| | T1 | 0.021 | 0.009 | -0.006 | -0.180 | -0.076 | 0.019 |
| | GR+T1+P1 | 0.020 | 0.009 | -0.006 | -0.197 | -0.074 | 0.033 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 |
| | TOTAL | 0.021 | 0.009 | 0.006 | 0.198 | 0.075 | 0.034 |
| B06 | GR | 0.000 | 0.000 | 0.000 | -0.001 | 0.000 | 0.001 |
| | T1 | 0.001 | 0.009 | -0.001 | -0.016 | -0.001 | -0.012 |
| | GR+T1+P1 | 0.001 | 0.009 | -0.001 | -0.018 | -0.001 | -0.011 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.001 | 0.009 | 0.001 | 0.018 | 0.001 | 0.011 |
| B07 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | SEISMIC | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| *** Segment B end *** | | | | | | | |

RPP-6485 Rev. 0

## RESTRAINT REACTIONS

| Point name | Load combination | FORCES (lb) X | Y | Z | Result | MOMENTS (ft-lb) X | Y | Z | Result |
|---|---|---|---|---|---|---|---|---|---|
| A00 | Anchor | | | | | | | | |
| | GR | 5 | -85 | -5 | 85 | 1 | 4 | -43 | 43 |
| | T1 | -215 | 499 | -99 | 552 | 18 | 65 | 269 | 278 |
| | GR+T1+P1 | -211 | 417 | -104 | 479 | 19 | 69 | 228 | 239 |
| | SEISMIC | 10 | 7 | 7 | 14 | 0 | 2 | 2 | 3 |
| | TOTAL | 221 | 425 | 111 | 491 | 19 | 71 | 231 | 242 |
| A06 | Guide [ID: A06 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | SEISMIC | 8 | 0 | 2 | 8 | 0 | 0 | 0 | 0 |
| | TOTAL | 8 | 0 | 2 | 8 | 0 | 0 | 0 | 0 |
| A07 | Guide [ID: A07 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | -3 | 3 | 0 | 0 | 0 | 0 |
| | SEISMIC | 16 | 0 | 2 | 16 | 0 | 0 | 0 | 0 |
| | TOTAL | 16 | 0 | 5 | 17 | 0 | 0 | 0 | 0 |
| A14 | Guide [ID: A14 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | SEISMIC | 21 | 15 | 6 | 26 | 0 | 0 | 0 | 0 |
| | TOTAL | 21 | 15 | 6 | 26 | 0 | 0 | 0 | 0 |
| A18 | Anchor | | | | | | | | |
| | GR | -3 | -95 | 10 | 96 | -7 | 0 | 6 | 9 |
| | T1 | -337 | 15 | 185 | 385 | 6 | 4 | 202 | 202 |
| | GR+T1+P1 | -341 | -80 | 197 | 402 | -1 | 4 | 209 | 209 |
| | SEISMIC | 4 | 8 | 6 | 11 | 2 | 0 | 0 | 2 |
| | TOTAL | 345 | 88 | 203 | 410 | 3 | 4 | 209 | 209 |
| B03 | Guide [ID: B03 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | SEISMIC | 9 | 24 | 31 | 40 | 0 | 0 | 0 | 0 |
| | TOTAL | 9 | 24 | 31 | 40 | 0 | 0 | 0 | 0 |



## RESTRAINT REACTIONS

| Point name | Load combination | FORCES (lb) X | Y | Z | Result | MOMENTS (ft-lb) X | Y | Z | Result |
|---|---|---|---|---|---|---|---|---|---|
| B07 | Anchor | | | | | | | | |
| | GR | -2 | -120 | -5 | 120 | -12 | 0 | 9 | 15 |
| | T1 | 552 | -514 | -86 | 759 | -138 | -8 | -173 | 221 |
| | GR+T1+P1 | 553 | -637 | -90 | 848 | -149 | -8 | -165 | 223 |
| | SEISMIC | 12 | 2 | 7 | 14 | 2 | 0 | 4 | 5 |
| | TOTAL | 565 | 639 | 97 | 859 | 152 | 8 | 169 | 228 |

RPP-6955 Rev.0

317

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| *** Segment A begin *** | | | | | | | | | | |
| A00 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 43 | 4 | | 1.00 | 1.00 | (18) | SUST | 2365 | 16340 |
| | Cold to T1 | 269 | 65 | 18 | 1.00 | 1.00 | (17) | DISP | 5942 | 24960 |
| | Sus. + R1 | 43 | 4 | | 1.00 | 1.00 | (18) | OCC | 2373 | 21732 |
| | Sus. + R2 | 45 | 4 | | 1.00 | 1.00 | (18) | OCC | 2422 | 21732 |
| | Sus. + R3 | 43 | 7 | | 1.00 | 1.00 | (18) | OCC | 2416 | 21732 |
| A01 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 18 | 3 | | 1.00 | 1.00 | (18) | SUST | 1761 | 16340 |
| | Cold to T1 | 120 | 35 | 18 | 1.00 | 1.00 | (17) | DISP | 2696 | 24960 |
| | Sus. + R1 | 18 | 3 | | 1.00 | 1.00 | (18) | OCC | 1761 | 21732 |
| | Sus. + R2 | 18 | 3 | | 1.00 | 1.00 | (18) | OCC | 1767 | 21732 |
| | Sus. + R3 | 18 | 3 | | 1.00 | 1.00 | (18) | OCC | 1762 | 21732 |
| A02 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 11 | 2 | | 1.00 | 1.00 | (18) | SUST | 1607 | 16340 |
| | Cold to T1 | 70 | 25 | 18 | 1.00 | 1.00 | (17) | DISP | 1634 | 24960 |
| | Sus. + R1 | 11 | 3 | | 1.00 | 1.00 | (18) | OCC | 1610 | 21732 |
| | Sus. + R2 | 11 | 2 | | 1.00 | 1.00 | (18) | OCC | 1610 | 21732 |
| | Sus. + R3 | 11 | 3 | | 1.00 | 1.00 | (18) | OCC | 1617 | 21732 |
| A03 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 2 | | 1.00 | 1.00 | (18) | SUST | 1465 | 16340 |
| | Cold to T1 | 3 | 12 | 18 | 1.00 | 1.00 | (17) | DISP | 473 | 24960 |
| | Sus. + R1 | 6 | 2 | | 1.00 | 1.00 | (18) | OCC | 1471 | 21732 |
| | Sus. + R2 | 6 | 2 | | 1.00 | 1.00 | (18) | OCC | 1471 | 21732 |
| | Sus. + R3 | 5 | 2 | | 1.00 | 1.00 | (18) | OCC | 1474 | 21732 |
| A03 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 2 | | 2.27 | 1.89 | (18) | SUST | 1631 | 16340 |
| | Cold to T1 | 3 | 12 | 18 | 2.27 | 1.89 | (17) | DISP | 643 | 24960 |
| | Sus. + R1 | 6 | 2 | | 2.27 | 1.89 | (18) | OCC | 1646 | 21732 |
| | Sus. + R2 | 6 | 2 | | 2.27 | 1.89 | (18) | OCC | 1647 | 21732 |
| | Sus. + R3 | 5 | 2 | | 2.27 | 1.89 | (18) | OCC | 1650 | 21732 |
| A03 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 0 | | 2.27 | 1.89 | (18) | SUST | 1390 | 16340 |
| | Cold to T1 | 44 | 2 | 4 | 2.27 | 1.89 | (17) | DISP | 2149 | 24960 |
| | Sus. + R1 | 1 | 0 | | 2.27 | 1.89 | (18) | OCC | 1391 | 21732 |
| | Sus. + R2 | 1 | 0 | | 2.27 | 1.89 | (18) | OCC | 1405 | 21732 |
| | Sus. + R3 | 1 | 0 | | 2.27 | 1.89 | (18) | OCC | 1391 | 21732 |
| A03 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 0 | 1 | | 1.00 | 1.00 | (18) | SUST | 1356 | 16340 |
| | Cold to T1 | 2 | 44 | 4 | 1.00 | 1.00 | (17) | DISP | 951 | 24960 |
| | Sus. + R1 | 0 | 1 | | 1.00 | 1.00 | (18) | OCC | 1357 | 21732 |
| | Sus. + R2 | 0 | 1 | | 1.00 | 1.00 | (18) | OCC | 1363 | 21732 |
| | Sus. + R3 | 0 | 1 | | 1.00 | 1.00 | (18) | OCC | 1357 | 21732 |



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A04 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 1 | | 1.00 | 1.00 | (18) | SUST | 1352 | 16340 |
| | Cold to T1 | 7 | 26 | 4 | 1.00 | 1.00 | (17) | DISP | 587 | 24960 |
| | Sus. + R1 | 1 | 1 | | 1.00 | 1.00 | (18) | OCC | 1357 | 21732 |
| | Sus. + R2 | 1 | 1 | | 1.00 | 1.00 | (18) | OCC | 1356 | 21732 |
| | Sus. + R3 | 1 | 1 | | 1.00 | 1.00 | (18) | OCC | 1353 | 21732 |
| A04 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 1 | | 1.73 | 1.44 | (18) | SUST | 1366 | 16340 |
| | Cold to T1 | 26 | 7 | 4 | 1.73 | 1.44 | (17) | DISP | 999 | 24960 |
| | Sus. + R1 | 1 | 1 | | 1.73 | 1.44 | (18) | OCC | 1374 | 21732 |
| | Sus. + R2 | 1 | 1 | | 1.73 | 1.44 | (18) | OCC | 1372 | 21732 |
| | Sus. + R3 | 1 | 1 | | 1.73 | 1.44 | (18) | OCC | 1366 | 21732 |
| A04 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 0 | | 1.73 | 1.44 | (18) | SUST | 1727 | 16340 |
| | Cold to T1 | 97 | 29 | 31 | 1.73 | 1.44 | (17) | DISP | 3776 | 24960 |
| | Sus. + R1 | 10 | 0 | | 1.73 | 1.44 | (18) | OCC | 1747 | 21732 |
| | Sus. + R2 | 10 | 0 | | 1.73 | 1.44 | (18) | OCC | 1730 | 21732 |
| | Sus. + R3 | 10 | 0 | | 1.73 | 1.44 | (18) | OCC | 1736 | 21732 |
| A04 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 0 | | 1.00 | 1.00 | (18) | SUST | 1559 | 16340 |
| | Cold to T1 | 97 | 29 | 31 | 1.00 | 1.00 | (17) | DISP | 2275 | 24960 |
| | Sus. + R1 | 10 | 0 | | 1.00 | 1.00 | (18) | OCC | 1571 | 21732 |
| | Sus. + R2 | 10 | 0 | | 1.00 | 1.00 | (18) | OCC | 1561 | 21732 |
| | Sus. + R3 | 10 | 0 | | 1.00 | 1.00 | (18) | OCC | 1565 | 21732 |
| A05 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 16 | 1 | | 1.00 | 1.00 | (18) | SUST | 1702 | 16340 |
| | Cold to T1 | 172 | 44 | 31 | 1.00 | 1.00 | (17) | DISP | 3861 | 24960 |
| | Sus. + R1 | 16 | 1 | | 1.00 | 1.00 | (18) | OCC | 1710 | 21732 |
| | Sus. + R2 | 16 | 1 | | 1.00 | 1.00 | (18) | OCC | 1705 | 21732 |
| | Sus. + R3 | 16 | 1 | | 1.00 | 1.00 | (18) | OCC | 1705 | 21732 |
| A05 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 16 | 1 | | 1.73 | 1.44 | (18) | SUST | 1975 | 16340 |
| | Cold to T1 | 172 | 44 | 31 | 1.73 | 1.44 | (17) | DISP | 6557 | 24960 |
| | Sus. + R1 | 16 | 1 | | 1.73 | 1.44 | (18) | OCC | 1988 | 21732 |
| | Sus. + R2 | 16 | 1 | | 1.73 | 1.44 | (18) | OCC | 1980 | 21732 |
| | Sus. + R3 | 16 | 1 | | 1.73 | 1.44 | (18) | OCC | 1979 | 21732 |
| A05 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 24 | 3 | | 1.73 | 1.44 | (18) | SUST | 2323 | 16340 |
| | Cold to T1 | 243 | 56 | 69 | 1.73 | 1.44 | (17) | DISP | 9293 | 24960 |
| | Sus. + R1 | 24 | 3 | | 1.73 | 1.44 | (18) | OCC | 2342 | 21732 |
| | Sus. + R2 | 24 | 3 | | 1.73 | 1.44 | (18) | OCC | 2329 | 21732 |
| | Sus. + R3 | 24 | 4 | | 1.73 | 1.44 | (18) | OCC | 2339 | 21732 |

RPP-LV85 Rev. 0

3/8

K/L 4PRINT

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A05 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 24 | | 1.00 | 1.00 | (18) | SUST | 1905 | 16340 |
| | Cold to T1 | 56 | 243 | 69 | 1.00 | 1.00 | (17) | DISP | 5540 | 24960 |
| | Sus. + R1 | 3 | 24 | | 1.00 | 1.00 | (18) | OCC | 1916 | 21732 |
| | Sus. + R2 | 3 | 24 | | 1.00 | 1.00 | (18) | OCC | 1908 | 21732 |
| | Sus. + R3 | 4 | 24 | | 1.00 | 1.00 | (18) | OCC | 1915 | 21732 |
| A06 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 23 | | 1.00 | 1.00 | (18) | SUST | 1892 | 16340 |
| | Cold to T1 | 68 | 217 | 69 | 1.00 | 1.00 | (17) | DISP | 5091 | 24960 |
| | Sus. + R1 | 4 | 24 | | 1.00 | 1.00 | (18) | OCC | 1907 | 21732 |
| | Sus. + R2 | 4 | 23 | | 1.00 | 1.00 | (18) | OCC | 1898 | 21732 |
| | Sus. + R3 | 4 | 23 | | 1.00 | 1.00 | (18) | OCC | 1906 | 21732 |
| A07 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 18 | | 1.00 | 1.00 | (18) | SUST | 1802 | 16340 |
| | Cold to T1 | 173 | 11 | 69 | 1.00 | 1.00 | (17) | DISP | 3998 | 24960 |
| | Sus. + R1 | 9 | 25 | | 1.00 | 1.00 | (18) | OCC | 1971 | 21732 |
| | Sus. + R2 | 9 | 18 | | 1.00 | 1.00 | (18) | OCC | 1811 | 21732 |
| | Sus. + R3 | 9 | 18 | | 1.00 | 1.00 | (18) | OCC | 1812 | 21732 |
| A08 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 15 | 11 | | 1.00 | 1.00 | (18) | SUST | 1775 | 16340 |
| | Cold to T1 | 292 | 269 | 69 | 1.00 | 1.00 | (17) | DISP | 8631 | 24960 |
| | Sus. + R1 | 15 | 13 | | 1.00 | 1.00 | (18) | OCC | 1820 | 21732 |
| | Sus. + R2 | 16 | 12 | | 1.00 | 1.00 | (18) | OCC | 1801 | 21732 |
| | Sus. + R3 | 15 | 11 | | 1.00 | 1.00 | (18) | OCC | 1780 | 21732 |
| A08 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 15 | | 1.73 | 1.44 | (18) | SUST | 2024 | 16340 |
| | Cold to T1 | 217 | 333 | 69 | 1.73 | 1.44 | (17) | DISP | 13133 | 24960 |
| | Sus. + R1 | 12 | 16 | | 1.73 | 1.44 | (18) | OCC | 2091 | 21732 |
| | Sus. + R2 | 12 | 15 | | 1.73 | 1.44 | (18) | OCC | 2065 | 21732 |
| | Sus. + R3 | 12 | 15 | | 1.73 | 1.44 | (18) | OCC | 2034 | 21732 |
| A08 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 18 | 3 | | 1.73 | 1.44 | (18) | SUST | 2100 | 16340 |
| | Cold to T1 | 102 | 11 | 391 | 1.73 | 1.44 | (17) | DISP | 9203 | 24960 |
| | Sus. + R1 | 20 | 5 | | 1.73 | 1.44 | (18) | OCC | 2177 | 21732 |
| | Sus. + R2 | 19 | 3 | | 1.73 | 1.44 | (18) | OCC | 2117 | 21732 |
| | Sus. + R3 | 18 | 3 | | 1.73 | 1.44 | (18) | OCC | 2104 | 21732 |
| A08 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 18 | 3 | | 1.00 | 1.00 | (18) | SUST | 1776 | 16340 |
| | Cold to T1 | 102 | 11 | 391 | 1.00 | 1.00 | (17) | DISP | 8662 | 24960 |
| | Sus. + R1 | 20 | 5 | | 1.00 | 1.00 | (18) | OCC | 1826 | 21732 |
| | Sus. + R2 | 19 | 3 | | 1.00 | 1.00 | (18) | OCC | 1786 | 21732 |
| | Sus. + R3 | 18 | 3 | | 1.00 | 1.00 | (18) | OCC | 1779 | 21732 |



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A09 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 22 | 4 | | 1.00 | 1.00 | (18) | SUST | 1870 | 16340 |
| | Cold to T1 | 6 | 34 | 391 | 1.00 | 1.00 | (17) | DISP | 8410 | 24960 |
| | Sus. + R1 | 24 | 7 | | 1.00 | 1.00 | (18) | OCC | 1948 | 21732 |
| | Sus. + R2 | 22 | 4 | | 1.00 | 1.00 | (18) | OCC | 1875 | 21732 |
| | Sus. + R3 | 22 | 4 | | 1.00 | 1.00 | (18) | OCC | 1872 | 21732 |
| A10 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 28 | 5 | | 1.00 | 1.00 | (18) | SUST | 2000 | 16340 |
| | Cold to T1 | 42 | 105 | 418 | 1.00 | 1.00 | (17) | DISP | 9261 | 24960 |
| | Sus. + R1 | 28 | 9 | | 1.00 | 1.00 | (18) | OCC | 2101 | 21732 |
| | Sus. + R2 | 28 | 5 | | 1.00 | 1.00 | (18) | OCC | 2024 | 21732 |
| | Sus. + R3 | 28 | 5 | | 1.00 | 1.00 | (18) | OCC | 2008 | 21732 |
| A11 - | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 27 | | 1.19 | 1.25 | (18) | SUST | 2166 | 16340 |
| | Cold to T1 | 109 | 52 | 418 | 1.19 | 1.25 | (17) | DISP | 9464 | 24960 |
| | Sus. + R1 | 9 | 28 | | 1.19 | 1.25 | (18) | OCC | 2289 | 21732 |
| | Sus. + R2 | 6 | 29 | | 1.19 | 1.25 | (18) | OCC | 2200 | 21732 |
| | Sus. + R3 | 5 | 28 | | 1.19 | 1.25 | (18) | OCC | 2176 | 21732 |
| A11 + | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 0 | 26 | | 1.19 | 1.25 | (18) | SUST | 2111 | 16340 |
| | Cold to T1 | 382 | 150 | 1 | 1.19 | 1.25 | (17) | DISP | 10512 | 24960 |
| | Sus. + R1 | 8 | 29 | | 1.19 | 1.25 | (18) | OCC | 2333 | 21732 |
| | Sus. + R2 | 1 | 27 | | 1.19 | 1.25 | (18) | OCC | 2148 | 21732 |
| | Sus. + R3 | 7 | 26 | | 1.19 | 1.25 | (18) | OCC | 2293 | 21732 |
| A12 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 26 | 0 | | 1.00 | 1.00 | (18) | SUST | 1954 | 16340 |
| | Cold to T1 | 149 | 376 | 1 | 1.00 | 1.00 | (17) | DISP | 8670 | 24960 |
| | Sus. + R1 | 29 | 8 | | 1.00 | 1.00 | (18) | OCC | 2137 | 21732 |
| | Sus. + R2 | 27 | 1 | | 1.00 | 1.00 | (18) | OCC | 1982 | 21732 |
| | Sus. + R3 | 26 | 7 | | 1.00 | 1.00 | (18) | OCC | 2104 | 21732 |
| A13 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 23 | 0 | | 1.00 | 1.00 | (18) | SUST | 1873 | 16340 |
| | Cold to T1 | 145 | 293 | 1 | 1.00 | 1.00 | (17) | DISP | 7000 | 24960 |
| | Sus. + R1 | 24 | 5 | | 1.00 | 1.00 | (18) | OCC | 1999 | 21732 |
| | Sus. + R2 | 23 | 1 | | 1.00 | 1.00 | (18) | OCC | 1895 | 21732 |
| | Sus. + R3 | 23 | 5 | | 1.00 | 1.00 | (18) | OCC | 1980 | 21732 |
| A14 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 0 | | 1.00 | 1.00 | (18) | SUST | 1452 | 16340 |
| | Cold to T1 | 134 | 88 | 1 | 1.00 | 1.00 | (17) | DISP | 3422 | 24960 |
| | Sus. + R1 | 7 | 2 | | 1.00 | 1.00 | (18) | OCC | 1510 | 21732 |
| | Sus. + R2 | 7 | 0 | | 1.00 | 1.00 | (18) | OCC | 1488 | 21732 |
| | Sus. + R3 | 5 | 0 | | 1.00 | 1.00 | (18) | OCC | 1463 | 21732 |

RPP-6485 Rev. 0

319

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A15 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 0 | | 1.00 | 1.00 | (18) | SUST | 1412 | 16340 |
| | Cold to T1 | 131 | 42 | 1 | 1.00 | 1.00 | (17) | DISP | 2950 | 24960 |
| | Sus. + R1 | 4 | 1 | | 1.00 | 1.00 | (18) | OCC | 1436 | 21732 |
| | Sus. + R2 | 4 | 0 | | 1.00 | 1.00 | (18) | OCC | 1428 | 21732 |
| | Sus. + R3 | 4 | 0 | | 1.00 | 1.00 | (18) | OCC | 1419 | 21732 |
| A15 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 0 | | 2.27 | 1.89 | (18) | SUST | 1516 | 16340 |
| | Cold to T1 | 131 | 42 | 1 | 2.27 | 1.89 | (17) | DISP | 6598 | 24960 |
| | Sus. + R1 | 4 | 1 | | 2.27 | 1.89 | (18) | OCC | 1564 | 21732 |
| | Sus. + R2 | 4 | 0 | | 2.27 | 1.89 | (18) | OCC | 1553 | 21732 |
| | Sus. + R3 | 4 | 0 | | 2.27 | 1.89 | (18) | OCC | 1531 | 21732 |
| A15 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 11 | 7 | | 2.27 | 1.89 | (18) | SUST | 1995 | 16340 |
| | Cold to T1 | 84 | 45 | 4 | 2.27 | 1.89 | (17) | DISP | 4488 | 24960 |
| | Sus. + R1 | 11 | 7 | | 2.27 | 1.89 | (18) | OCC | 2021 | 21732 |
| | Sus. + R2 | 11 | 8 | | 2.27 | 1.89 | (18) | OCC | 2011 | 21732 |
| | Sus. + R3 | 11 | 7 | | 2.27 | 1.89 | (18) | OCC | 1999 | 21732 |
| A15 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 4 | | 1.00 | 1.00 | (18) | SUST | 1639 | 16340 |
| | Cold to T1 | 93 | 22 | 4 | 1.00 | 1.00 | (17) | DISP | 2051 | 24960 |
| | Sus. + R1 | 13 | 5 | | 1.00 | 1.00 | (18) | OCC | 1650 | 21732 |
| | Sus. + R2 | 12 | 5 | | 1.00 | 1.00 | (18) | OCC | 1647 | 21732 |
| | Sus. + R3 | 12 | 4 | | 1.00 | 1.00 | (18) | OCC | 1640 | 21732 |
| A16 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 11 | 5 | | 1.00 | 1.00 | (18) | SUST | 1612 | 16340 |
| | Cold to T1 | 68 | 67 | 4 | 1.00 | 1.00 | (17) | DISP | 2052 | 24960 |
| | Sus. + R1 | 11 | 5 | | 1.00 | 1.00 | (18) | OCC | 1628 | 21732 |
| | Sus. + R2 | 11 | 5 | | 1.00 | 1.00 | (18) | OCC | 1619 | 21732 |
| | Sus. + R3 | 11 | 5 | | 1.00 | 1.00 | (18) | OCC | 1618 | 21732 |
| A17 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 5 | | 1.00 | 1.00 | (18) | SUST | 1594 | 16340 |
| | Cold to T1 | 50 | 101 | 4 | 1.00 | 1.00 | (17) | DISP | 2407 | 24960 |
| | Sus. + R1 | 10 | 6 | | 1.00 | 1.00 | (18) | OCC | 1614 | 21732 |
| | Sus. + R2 | 10 | 5 | | 1.00 | 1.00 | (18) | OCC | 1599 | 21732 |
| | Sus. + R3 | 10 | 5 | | 1.00 | 1.00 | (18) | OCC | 1598 | 21732 |
| A18 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 7 | 6 | | 1.00 | 1.00 | (18) | SUST | 1546 | 16340 |
| | Cold to T1 | 6 | 202 | 4 | 1.00 | 1.00 | (17) | DISP | 4321 | 24960 |
| | Sus. + R1 | 8 | 6 | | 1.00 | 1.00 | (18) | OCC | 1588 | 21732 |
| | Sus. + R2 | 7 | 6 | | 1.00 | 1.00 | (18) | OCC | 1548 | 21732 |
| | Sus. + R3 | 8 | 6 | | 1.00 | 1.00 | (18) | OCC | 1579 | 21732 |

*** Segment A end ***

*** Segment B begin ***



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A11 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 6 | 4 | | 1.19 | 1.25 | (18) | SUST | 1531 | 16340 |
| | Cold to T1 | 273 | 92 | 378 | 1.19 | 1.25 | (17) | DISP | 10944 | 24960 |
| | Sus. + R1 | 9 | 6 | | 1.19 | 1.25 | (18) | OCC | 1636 | 21732 |
| | Sus. + R2 | 6 | 4 | | 1.19 | 1.25 | (18) | OCC | 1558 | 21732 |
| | Sus. + R3 | 12 | 5 | | 1.19 | 1.25 | (18) | OCC | 1722 | 21732 |
| B01 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 6 | | 1.00 | 1.00 | (18) | SUST | 1496 | 16340 |
| | Cold to T1 | 87 | 267 | 378 | 1.00 | 1.00 | (17) | DISP | 10085 | 24960 |
| | Sus. + R1 | 6 | 9 | | 1.00 | 1.00 | (18) | OCC | 1581 | 21732 |
| | Sus. + R2 | 4 | 6 | | 1.00 | 1.00 | (18) | OCC | 1518 | 21732 |
| | Sus. + R3 | 5 | 12 | | 1.00 | 1.00 | (18) | OCC | 1655 | 21732 |
| B02 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 18 | 4 | | 1.00 | 1.00 | (18) | SUST | 1768 | 16340 |
| | Cold to T1 | 233 | 198 | 17 | 1.00 | 1.00 | (17) | DISP | 6557 | 24960 |
| | Sus. + R1 | 20 | 7 | | 1.00 | 1.00 | (18) | OCC | 1860 | 21732 |
| | Sus. + R2 | 19 | 5 | | 1.00 | 1.00 | (18) | OCC | 1806 | 21732 |
| | Sus. + R3 | 18 | 6 | | 1.00 | 1.00 | (18) | OCC | 1800 | 21732 |
| B03 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 3 | | 1.00 | 1.00 | (18) | SUST | 1627 | 16340 |
| | Cold to T1 | 99 | 138 | 17 | 1.00 | 1.00 | (17) | DISP | 3661 | 24960 |
| | Sus. + R1 | 13 | 6 | | 1.00 | 1.00 | (18) | OCC | 1701 | 21732 |
| | Sus. + R2 | 16 | 3 | | 1.00 | 1.00 | (18) | OCC | 1732 | 21732 |
| | Sus. + R3 | 12 | 7 | | 1.00 | 1.00 | (18) | OCC | 1717 | 21732 |
| B04 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 11 | 1 | | 1.00 | 1.00 | (18) | SUST | 1604 | 16340 |
| | Cold to T1 | 141 | 30 | 17 | 1.00 | 1.00 | (17) | DISP | 3102 | 24960 |
| | Sus. + R1 | 13 | 2 | | 1.00 | 1.00 | (18) | OCC | 1647 | 21732 |
| | Sus. + R2 | 12 | 1 | | 1.00 | 1.00 | (18) | OCC | 1619 | 21732 |
| | Sus. + R3 | 11 | 1 | | 1.00 | 1.00 | (18) | OCC | 1613 | 21732 |
| B04 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 1 | | 2.27 | 1.89 | (18) | SUST | 1530 | 16340 |
| | Cold to T1 | 141 | 30 | 17 | 2.27 | 1.89 | (17) | DISP | 6950 | 24960 |
| | Sus. + R1 | 5 | 2 | | 2.27 | 1.89 | (18) | OCC | 1626 | 21732 |
| | Sus. + R2 | 4 | 1 | | 2.27 | 1.89 | (18) | OCC | 1564 | 21732 |
| | Sus. + R3 | 4 | 1 | | 2.27 | 1.89 | (18) | OCC | 1547 | 21732 |
| B04 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 6 | | 2.27 | 1.89 | (18) | SUST | 1949 | 16340 |
| | Cold to T1 | 142 | 56 | 8 | 2.27 | 1.89 | (17) | DISP | 7238 | 24960 |
| | Sus. + R1 | 11 | 7 | | 2.27 | 1.89 | (18) | OCC | 1995 | 21732 |
| | Sus. + R2 | 10 | 7 | | 2.27 | 1.89 | (18) | OCC | 1960 | 21732 |
| | Sus. + R3 | 10 | 6 | | 2.27 | 1.89 | (18) | OCC | 1951 | 21732 |

RPP-64YS Rev. 0

320

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| B04 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 8 | | 1.00 | 1.00 | (18) | SUST | 1615 | 16340 |
| | Cold to T1 | 92 | 121 | 8 | 1.00 | 1.00 | (17) | DISP | 3261 | 24960 |
| | Sus. + R1 | 9 | 9 | | 1.00 | 1.00 | (18) | OCC | 1636 | 21732 |
| | Sus. + R2 | 9 | 8 | | 1.00 | 1.00 | (18) | OCC | 1621 | 21732 |
| | Sus. + R3 | 9 | 8 | | 1.00 | 1.00 | (18) | OCC | 1616 | 21732 |
| B05 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 8 | | 1.00 | 1.00 | (18) | SUST | 1633 | 16340 |
| | Cold to T1 | 103 | 48 | 8 | 1.00 | 1.00 | (17) | DISP | 2440 | 24960 |
| | Sus. + R1 | 10 | 8 | | 1.00 | 1.00 | (18) | OCC | 1637 | 21732 |
| | Sus. + R2 | 10 | 8 | | 1.00 | 1.00 | (18) | OCC | 1638 | 21732 |
| | Sus. + R3 | 10 | 8 | | 1.00 | 1.00 | (18) | OCC | 1640 | 21732 |
| B06 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 8 | | 1.00 | 1.00 | (18) | SUST | 1646 | 16340 |
| | Cold to T1 | 112 | 7 | 8 | 1.00 | 1.00 | (17) | DISP | 2404 | 24960 |
| | Sus. + R1 | 11 | 9 | | 1.00 | 1.00 | (18) | OCC | 1670 | 21732 |
| | Sus. + R2 | 10 | 9 | | 1.00 | 1.00 | (18) | OCC | 1650 | 21732 |
| | Sus. + R3 | 10 | 9 | | 1.00 | 1.00 | (18) | OCC | 1650 | 21732 |
| B07 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 9 | | 1.00 | 1.00 | (18) | SUST | 1685 | 16340 |
| | Cold to T1 | 138 | 173 | 8 | 1.00 | 1.00 | (17) | DISP | 4736 | 24960 |
| | Sus. + R1 | 14 | 14 | | 1.00 | 1.00 | (18) | OCC | 1803 | 21732 |
| | Sus. + R2 | 12 | 9 | | 1.00 | 1.00 | (18) | OCC | 1690 | 21732 |
| | Sus. + R3 | 13 | 9 | | 1.00 | 1.00 | (18) | OCC | 1718 | 21732 |

*** Segment B end ***



## S Y S T E M S U M M A R Y

### Maximum displacements (in)

| | | | |
|---|---|---|---|
| Maximum X : | 0.054 | Point : A05 F | Load Comb.: T1 |
| Maximum Y : | 0.060 | Point : A08 N | Load Comb.: TOTAL |
| Maximum Z : | 0.073 | Point : A08 N | Load Comb.: TOTAL |
| Max. total: | 0.095 | Point : A08 N | Load Comb.: TOTAL |

### Maximum rotations (deg)

| | | | |
|---|---|---|---|
| Maximum X : | 0.263 | Point : B03 | Load Comb.: TOTAL |
| Maximum Y : | 0.085 | Point : A08 N | Load Comb.: TOTAL |
| Maximum Z : | 0.172 | Point : A03 N | Load Comb.: T1 |
| Max. total: | 0.313 | Point : B03 | Load Comb.: TOTAL |

### Maximum restraint forces (lb)

| | | | |
|---|---|---|---|
| Maximum X : | 565 | Point : B07 | Load Comb.: TOTAL |
| Maximum Y : | 639 | Point : B07 | Load Comb.: TOTAL |
| Maximum Z : | 203 | Point : A18 | Load Comb.: TOTAL |
| Max. total: | 859 | Point : B07 | Load Comb.: TOTAL |

### Maximum restraint moments (ft-lb)

| | | | |
|---|---|---|---|
| Maximum X : | 152 | Point : B07 | Load Comb.: TOTAL |
| Maximum Y : | 71 | Point : A00 | Load Comb.: TOTAL |
| Maximum Z : | 269 | Point : A00 | Load Comb.: T1 |
| Max. total: | 278 | Point : A00 | Load Comb.: T1 |

RPP-6495 Rev. 0

321

## S Y S T E M  S U M M A R Y

Maximum sustained stress

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2365 |
| Allowable psi | : 16340 |
| Ratio | : 0.14 |
| Load combination | : GR + Max P |

Maximum displacement stress

| | |
|---|---|
| Point | : A08 N |
| Stress psi | : 13133 |
| Allowable psi | : 24960 |
| Ratio | : 0.53 |
| Load combination | : Cold to T1 |

Maximum occasional stress

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2422 |
| Allowable psi | : 21732 |
| Ratio | : 0.11 |
| Load combination | : Sus. + R2 |

Maximum hoop stress

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2978 |
| Allowable psi | : 16340 |
| Ratio | : 0.18 |
| Load combination | : Max P |



## S Y S T E M  S U M M A R Y

Maximum sustained stress ratio

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2365 |
| Allowable psi | : 16340 |
| Ratio | : 0.14 |
| Load combination | : GR + Max P |

Maximum displacement stress ratio

| | |
|---|---|
| Point | : A08 N |
| Stress psi | : 13133 |
| Allowable psi | : 24960 |
| Ratio | : 0.53 |
| Load combination | : Cold to T1 |

Maximum occasional stress ratio

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2422 |
| Allowable psi | : 21732 |
| Ratio | : 0.11 |
| Load combination | : Sus. + R2 |

Maximum hoop stress ratio

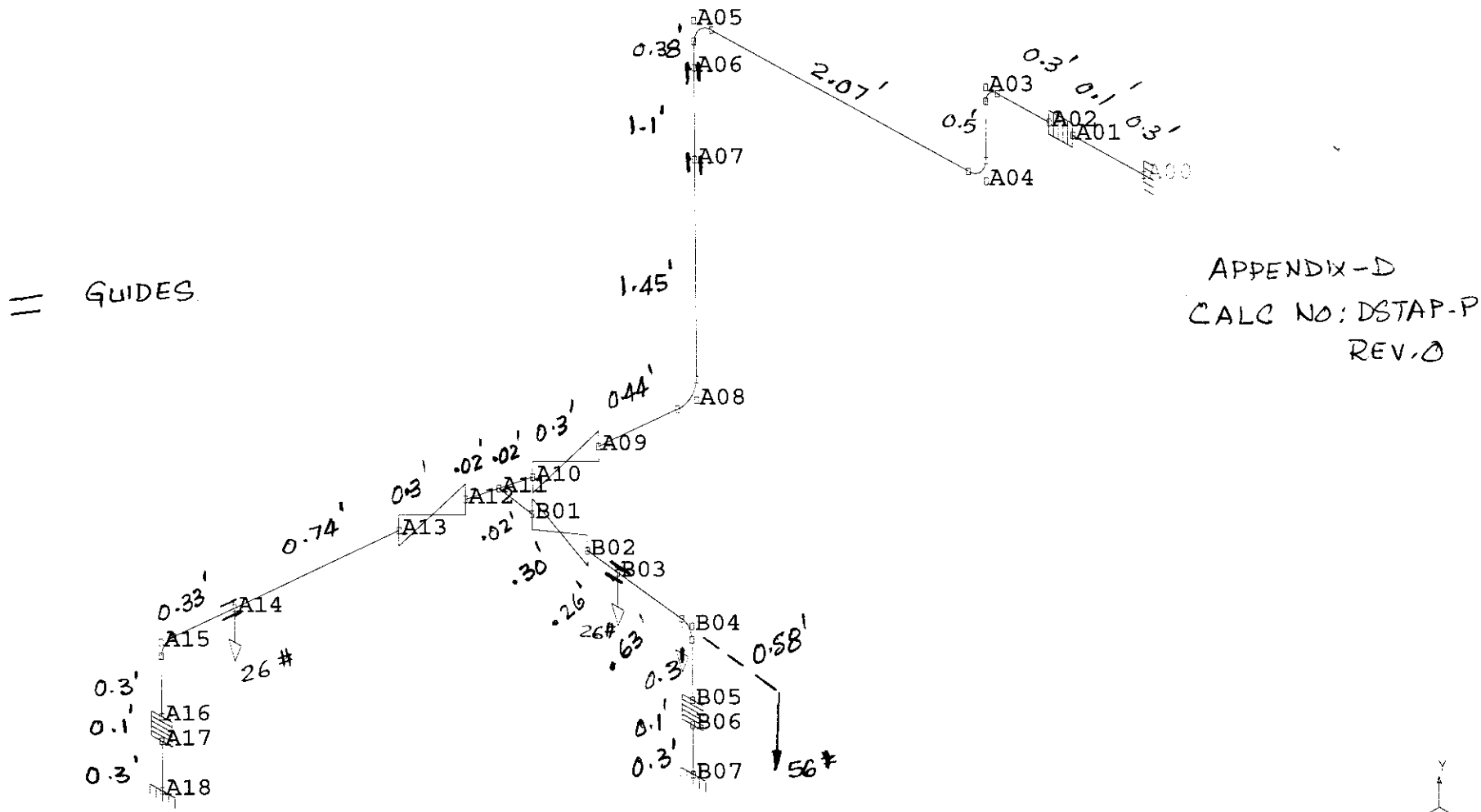
| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2978 |
| Allowable psi | : 16340 |
| Ratio | : 0.18 |
| Load combination | : Max P |

* * * The system satisfies ASME B31.3 code requirements * * *
* * * for the selected options * * *

RPP-6485 Rev. 0

322

K/L 4PRINT




APPENDIX-D
CALC NO: DSTAP-P-004
REV.0

PUMP PITS 241-AP-02A, 04A, 05A, 07A &
SY-01B, 02B, 03B JUMPER STRESS ANALYSIS

FILE : AP&SY

REF DWGS: H-14-104133 (2-Sheets) REV.0
H-14-104129 (2 OF 2) REV.0.

RPP-6485 Rev.0

```
     *                          *******   **  *******   *******
    ***              **         **    **  **  **    **  **
   ** **            ******       **    **  **  **    **  **
  **   **    **   **  **   *****  *******   **  *******   *****
 *********  **   **  **  **   **  **        **  **        **
**       **  **   **  **  **   **  **        **  **        **
**        **  *****   **   *****  **        **  **        *******
```

Pipe Stress Analysis and Design Program

Version: 6.00.16

Edition: Plus-Win

Developed and Maintained by

REBIS Industrial Workgroup Software
1600 Riviera Ave., Suite 300
Walnut Creek, CA 94596

RPP-6985 Rev. 0



```
************************************************************
**                                                        **
**              AUTOPIPE SYSTEM DATA LISTING              **
**                                                        **
************************************************************
```

SYSTEM NAME : AP&SY

PROJECT ID : PUMP PITS 241-AP-02A, 04A, 05A, 07A &
SY-01B, 02B, 03B JUMPER STRESS ANALYSIS

PREPARED BY : M.M. AHMED

CHECKED BY : Jennifer Williamson

PIPING CODE : B31.3

VERTICAL AXIS : Y

AMBIENT TEMPERATURE : 65.0 deg F

COMPONENT LIBRARY : AUTOPIPE

MATERIAL LIBRARY : AUTOB313

MODEL REVISION NUMBER : 2

324

## POINT DATA LISTING

| POINT NAME | TYPE | OFFSETS (ft) X | Y | Z | DESCRIPTION |
|---|---|---|---|---|---|
| *** SEGMENT A | | | | | |
| A00 | Run | 0 | 0 | 0 | PIPE ID = 2"PIPE |
| A01 | Flex | -0.30 | 0 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| A02 | Run | -0.10 | 0 | 0 | |
| A03 | Bend | -0.30 | 0 | 0 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| A04 | Bend | 0 | -0.50 | 0 | Long Elbow, Radius = 3.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 1.73, Out = 1.44<br>Flex = 4.404 |
| A05 | Bend | -2.07 | 0 | 0 | Long Elbow, Radius = 3.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 1.73, Out = 1.44<br>Flex = 4.404 |
| A06 | Run | 0 | -0.38 | 0 | |
| A07 | Run | 0 | -1.10 | 0 | |
| A08 | Bend | 0 | -1.45 | 0 | Long Elbow, Radius = 3.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 1.73, Out = 1.44<br>Flex = 4.404 |
| A09 | Valv | -0.11 | 0 | 0.43 | GATE-F , Rating = Non-standard<br>Weight = 20 lb<br>Surface factor = 1.00<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| A10 | Run | -0.08 | 0 | 0.29 | |
| A11 | Tee | -0.01 | 0 | 0.02 | |
| A12 | Valv | -0.01 | 0 | 0.02 | GATE-F , Rating = Non-standard<br>Weight = 20 lb<br>Surface factor = 1.00<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| A13 | Run | -0.08 | 0 | 0.29 | |
| A14 | Run | -0.20 | 0 | 0.72 | |
| A15 | Bend | -0.09 | 0 | 0.32 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| A16 | Flex | 0 | -0.30 | 0 | Wt= 38 lb , Ar= 3.4 sq.in |



## POINT DATA LISTING

| POINT NAME | TYPE | OFFSETS (ft) X | Y | Z | DESCRIPTION |
|---|---|---|---|---|---|
| | | | | | Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| A17 | Run | 0 | -0.10 | 0 | |
| A18 | Run | 0 | -0.30 | 0 | |
| *** SEGMENT B | | | | | |
| A11 | Tee | -2.97 | -3.43 | 0.74 | PIPE ID = 2"PIPE |
| B01 | Valv | 0.02 | 0 | 0.01 | GATE-F , Rating = Non-standard<br>Weight = 20 lb<br>Surface factor = 1.00<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| B02 | Run | 0.29 | 0 | 0.08 | |
| B03 | Run | 0.25 | 0 | 0.07 | |
| B04 | Bend | 0.61 | 0 | 0.17 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| B05 | Flex | 0 | -0.30 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| B06 | Run | 0 | -0.10 | 0 | |
| B07 | Run | 0 | -0.30 | 0 | |

Total weight of empty pipes : 35 lb

RPP-WWS Rev. 0

325

## COMPONENT DATA LISTING

| POINT NAME | COORDINATE(ft) X | Y | Z | DATA TYPE | DESCRIPTION |
|---|---|---|---|---|---|
| *** SEGMENT A | | | | | |
| A00 | 0.00 | 0.00 | 0.00 | ANCHOR | Rigid<br>Thermal movements : None |
| A01 | -0.30 | 0.00 | 0.00 | | |
| A02 | -0.40 | 0.00 | 0.00 | | |
| A03 N | -0.53 | 0.00 | 0.00 | | |
| A03 | -0.70 | 0.00 | 0.00 | TI | |
| A03 F | -0.70 | -0.17 | 0.00 | | |
| A04 N | -0.70 | -0.25 | 0.00 | | |
| A04 | -0.70 | -0.50 | 0.00 | TI | |
| A04 F | -0.95 | -0.50 | 0.00 | | |
| A05 N | -2.52 | -0.50 | 0.00 | | |
| A05 | -2.77 | -0.50 | 0.00 | TI | |
| A05 F | -2.77 | -0.75 | 0.00 | | |
| A06 | -2.77 | -0.88 | 0.00 | GUIDE | ID : A06 1, Connected to Ground<br>Stiffness = RIGID<br>Gap -Z = 0.06 inch<br>Gap +Z = 0.06 inch<br>Gap -X = 0.06 inch<br>Gap +X = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| A07 | -2.77 | -1.98 | 0.00 | GUIDE | ID : A07 1, Connected to Ground<br>Stiffness = RIGID<br>Gap -Z = 0.06 inch<br>Gap +Z = 0.06 inch<br>Gap -X = 0.06 inch<br>Gap +X = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| A08 N | -2.77 | -3.18 | 0.00 | | |
| A08 | -2.77 | -3.43 | 0.00 | TI | |
| A08 F | -2.83 | -3.43 | 0.24 | | |
| A09 | -2.88 | -3.43 | 0.43 | | |
| A10 | -2.96 | -3.43 | 0.72 | | |
| A11 | -2.97 | -3.43 | 0.74 | TEE | B16.9 welding tee<br>SIF - In = 1.19, Out = 1.25 |
| A12 | -2.98 | -3.43 | 0.76 | | |
| A13 | -3.06 | -3.43 | 1.05 | | |
| A14 | -3.26 | -3.43 | 1.77 | GUIDE | ID : A14 1, Connected to Ground<br>Stiffness = RIGID<br>Gap-down = 0.06 inch<br>Gap-Above = 0.06 inch<br>Gap-left = 0.06 inch<br>Gap-Right = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| | | | | WEIGHT | 26 lb , No offsets |
| A15 N | -3.31 | -3.43 | 1.93 | | |
| A15 | -3.35 | -3.43 | 2.09 | TI | |
| A15 F | -3.35 | -3.60 | 2.09 | | |
| A16 | -3.35 | -3.73 | 2.09 | | |



## COMPONENT DATA LISTING

| POINT NAME | COORDINATE(ft) X | Y | Z | DATA TYPE | DESCRIPTION |
|---|---|---|---|---|---|
| A17 | -3.35 | -3.83 | 2.09 | | |
| A18 | -3.35 | -4.13 | 2.09 | ANCHOR | Rigid<br>Thermal movements : None |
| *** SEGMENT B | | | | | |
| A11 | -2.97 | -3.43 | 0.74 | TEE | B16.9 welding tee<br>SIF - In = 1.19, Out = 1.25 |
| B01 | -2.95 | -3.43 | 0.75 | | |
| B02 | -2.66 | -3.43 | 0.83 | | |
| B03 | -2.41 | -3.43 | 0.90 | GUIDE | ID : B03 1, Connected to Ground<br>Stiffness = RIGID<br>Gap-down = 0.06 inch<br>Gap-Above = 0.06 inch<br>Gap-left = 0.06 inch<br>Gap-Right = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| | | | | WEIGHT | 26 lb , No offsets |
| B04 N | -1.97 | -3.43 | 1.02 | WEIGHT | 56 lb , Offsets in ft<br>DX = 0.56, DY = 0.00, DZ = 0.15 |
| B04 | -1.80 | -3.43 | 1.07 | TI | |
| B04 F | -1.80 | -3.60 | 1.07 | | |
| B05 | -1.80 | -3.73 | 1.07 | | |
| B06 | -1.80 | -3.83 | 1.07 | | |
| B07 | -1.80 | -4.13 | 1.07 | ANCHOR | Rigid<br>Thermal movements : None |

Number of points in the system : 39

RPP-6485 Rev.0

324

K/L4PRINT

## P I P E  D A T A  L I S T I N G

| Pipe ID/ Material | Nom/ Sch | O.D. inch | -----Thickness(inch)----- W.Th. | Corr | Mill | Insu | Ling | Spec Grav | Weight(lb/ft ) Pipe | Other | Total | ZL/ ZC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2"PIPE | 2.000 | 2.375 | 0.154 | 0.02 | 0.02 | 0 | 0 | 1.50 | 3.74 | 0 | 5.92 | 1.00 |
| A312-TP304L | STD | | | | | | | | | | | 1.00 |



## M A T E R I A L  D A T A  L I S T I N G

| Material Name | Pipe ID | Density lb/cu.ft | Pois. Ratio | Temper. deg F | Modulus E6 psi Axial | Hoop | Shear | Expans. in/100ft |
|---|---|---|---|---|---|---|---|---|
| A312-TP304L | 2"PIPE | 501.0 | 0.30 | 65.0 | 28.320 | 28.320 | 10.892 | |
| | | | | 340.0 | 26.802 | | | 3.1325 |



App-6485 Rev.0
327
KA 4PRINT

## M A T E R I A L  A L L O W A B L E  D A T A  L I S T I N G

| Material Name | Pipe ID | Temper. deg F | Allow. psi |
|---|---|---|---|
| A312-TP304L | 2"PIPE | 65.0 | 16700.0 |
| | | 340.0 | 16340.0 |



## TEMPERATURE AND PRESSURE DATA

| POINT NAME | CASE 1 PRESS. psi | CASE 1 TEMPER deg F | CASE 1 EXPAN. in/100ft | CASE 2 PRESS. psi | CASE 2 TEMPER deg F | CASE 2 EXPAN. in/100ft | CASE 3 PRESS. psi | CASE 3 TEMPER deg F | CASE 3 EXPAN. in/100ft |
|---|---|---|---|---|---|---|---|---|---|
| *** SEGMENT A | | | | | | | | | |
| A00 | 300 | 340 | 3.133 | | | | | | |
| A18 | 300 | 340 | 3.133 | | | | | | |
| *** SEGMENT B | | | | | | | | | |
| A11 | 300 | 340 | 3.133 | | | | | | |
| B07 | 300 | 340 | 3.133 | | | | | | |

RPP-6448 Rev. 0

328

K/74PRINT

H O T M O D U L U S (E6 psi )

| POINT NAME | CASE 1 | CASE 2 | CASE 3 |
|---|---|---|---|
| *** SEGMENT A | | | |
| A00 | 26.802 | | |
| A18 | 26.802 | | |
| *** SEGMENT B | | | |
| A11 | 26.802 | | |
| B07 | 26.802 | | |

* Non-standard material



H O T A L L O W A B L E S (psi )

| POINT NAME | CASE 1 ALLOW | CASE 1 NOT USED | CASE 1 NOT USED | CASE 2 ALLOW | CASE 2 NOT USED | CASE 2 NOT USED | CASE 3 ALLOW | CASE 3 NOT USED | CASE 3 NOT USED |
|---|---|---|---|---|---|---|---|---|---|
| *** SEGMENT A | | | | | | | | | |
| A00 | 16340 | | | | | | | | |
| A18 | 16340 | | | | | | | | |
| *** SEGMENT B | | | | | | | | | |
| A11 | 16340 | | | | | | | | |
| B07 | 16340 | | | | | | | | |

< User-defined code allowable
* Non-code material

RPP-LV85 Rev.0

329

## A N A L Y S I S  S U M M A R Y

Current model revision number : 2

```
Static - Date and Time of analysis ............. Jun 6, 2000   10:07 AM
         Model Revision Number ................. 2
         Number of load cases .................. 3
         Load cases analyzed ................... GR T1 P1
         Gaps/Friction/Soil considered ......... Yes
         Tolerance - Force, Displacement ....... 100.00 lb   0.0162 in
         Friction - Scale Factor, Tolerance .... 1.00   0.10
         Hanger design run ..................... No
         Cut short included .................... No
         Include Bourdon rotational effect ..... No
         Pipe radius for Bourdon calculation ... Mean
         Occasional load analysis type ......... Nonlinear
         Non-linear analysis summary file ...... AP&SY.LOG
         Use default load sequence ............. Yes
         Base load cases for nonlinear analysis
                                                   GR = None
                                                   T1 = GR
                                                   P1 = T1
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No

Modal  - Date and Time of analysis ............. Jun 6, 2000   10:07 AM
         Model Revision Number ................. 2
         Number of modes ....................... 0
         Cutoff frequency (Hz) ................. 33.0
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No

Response - Date and Time of analysis ............ Jun 6, 2000   10:09 AM
         Model Revision Number ................. 2
         Number of load cases .................. 3
         Load cases analyzed ................... R1 R2 R3
         Date and time of modal analysis ....... Jun 6, 2000   10:07 AM
         Number of modes ....................... 0
         Cutoff frequency (Hz) ................. 33.0
         Model revision of modal analysis ...... 2
         Weight of contents included ........... Yes
         Pressure stiffening case .............. 0
         Water elevation for buoyancy loads .... Not considered
         Hot modulus case used in analysis ..... 0
         Use corroded thickness in analysis .... No
```



### CODE COMPLIANCE COMBINATIONS

| Combination | Category | Method | Load | Factor | M/S | Allowable | Remarks |
|---|---|---|---|---|---|---|---|
| GR + Max P | Sustain | Sum | Gravity | 1.00 | | Automatic | Default |
| | | | Max Long | 1.00 | | | |
| Cold to T1 | Expansion | Sum | Thermal 1 | 1.00 | | Automatic | Default |
| Sus. + R1 | Occasion | Abs sum | Response 1 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Sus. + R2 | Occasion | Abs sum | Response 2 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Sus. + R3 | Occasion | Abs sum | Response 3 | 1.00 | | Automatic | Default |
| | | | Max Sus | 1.00 | | | |
| Max P | Hoop | | Max Hoop | 1.00 | | Automatic | Default |

RPP-6485 Rev. 0

33b

OTHER USER COMBINATIONS

| Combination | Method | Load | Factor | Remarks |
|---|---|---|---|---|
| GR | Sum | Gravity | 1.00 | Default |
| T1 | Sum | Thermal 1 | 1.00 | Default |
| P1 | Sum | Press 1 | 1.00 | Default |
| R1 | Sum | Response 1 | 1.00 | Default |
| R2 | Sum | Response 2 | 1.00 | Default |
| R3 | Sum | Response 3 | 1.00 | Default |
| GR+T1+P1 | Sum | Gravity | 1.00 | User |
| | | Thermal 1 | 1.00 | |
| | | Press 1 | 1.00 | |
| SEISMIC | SRSS | Response 1 | 1.00 | User |
| | | Response 2 | 1.00 | |
| | | Response 3 | 1.00 | |
| TOTAL | Abs sum | GR+T1+P1 | 1.00 | User |
| | | SEISMIC | 1.00 | |



CODE COMPLIANCE

Y - Factor ..... 0.40
Weld efficiency factor ..... 1.00
Range reduction factor ..... 1.00
Design Pressure Factor ..... 1.00
Minimum stress ratio used in reports... 0.00
Number of stress points per span ..... 0
Include corrosion in stress calcs. .... Y
Include torsion in code stress ..... N
Include axial force in code stress .... N
Set sustained SIF to 1.00 ..... N
Use proposed B31.3, h = 3.1*T/r ..... N
Apply cold/hot modulus ratio ..... N
Total stress ..... Octahedral
Direct shear ..... None
Longitudinal pressure calculation ..... PD/4t
Include rigorous pressure ..... N

RPP-6485 Rev. 0

3.31

RESPONSE SPECTRUM LOAD CASES :

Number of load cases analysed : 3

Load case 1 - R1

Missing mass : Yes
ZPA : No

Combination method : SRSS

X- Spectrum : SS(H)OLD
Multiplier : 1.00

SS(H)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.04 | 0.500 | 0.10 | 1.000 | 0.19 |
| 2.000 | 0.29 | 3.300 | 0.37 | 5.000 | 0.39 |
| 10.000 | 0.32 | 13.300 | 0.26 | 33.300 | 0.18 |
| 100.000 | 0.18 | | | | |



Load case 2 - R2

Missing mass : Yes
ZPA : No

Combination method : SRSS

Y- Spectrum : SS(V)OLD
Multiplier : 1.00

SS(V)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.03 | 0.500 | 0.06 | 1.000 | 0.08 |
| 2.000 | 0.12 | 3.300 | 0.19 | 5.000 | 0.22 |
| 10.000 | 0.23 | 13.300 | 0.22 | 50.000 | 0.12 |
| 100.000 | 0.12 | | | | |

RPP-6485 Rev.0

332

Load case 3 - R3

Missing mass : Yes
ZPA : No

Combination method : SRSS

Z- Spectrum : SS(H)OLD
Multiplier : 1.00

SS(H)OLD

| Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) | Freq(Hz) | Grav( ) |
|---|---|---|---|---|---|
| 0.250 | 0.04 | 0.500 | 0.10 | 1.000 | 0.19 |
| 2.000 | 0.29 | 3.300 | 0.37 | 5.000 | 0.39 |
| 10.000 | 0.32 | 13.300 | 0.26 | 33.300 | 0.18 |
| 100.000 | 0.18 | | | | |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| *** Segment A begin *** | | | | | | | |
| A00 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| A01 | GR | 0.000 | 0.000 | 0.000 | 0.000 | -0.001 | 0.003 |
| | T1 | -0.009 | 0.000 | 0.000 | 0.001 | -0.002 | -0.004 |
| | GR+T1+P1 | -0.009 | 0.000 | 0.000 | 0.001 | -0.004 | -0.001 |
| | TOTAL | 0.009 | 0.000 | 0.000 | 0.001 | 0.004 | 0.002 |
| A02 | GR | 0.000 | -0.002 | 0.000 | -0.005 | -0.014 | 0.017 |
| | T1 | -0.009 | 0.015 | -0.001 | 0.059 | -0.028 | 0.077 |
| | GR+T1+P1 | -0.009 | 0.013 | -0.001 | 0.055 | -0.041 | 0.097 |
| | TOTAL | 0.009 | 0.014 | 0.001 | 0.056 | 0.042 | 0.097 |
| A03 N | GR | 0.000 | -0.002 | -0.001 | -0.005 | -0.015 | 0.018 |
| | T1 | -0.013 | 0.013 | -0.001 | 0.060 | -0.028 | 0.083 |
| | GR+T1+P1 | -0.013 | 0.011 | -0.002 | 0.056 | -0.043 | 0.103 |
| | TOTAL | 0.013 | 0.011 | 0.002 | 0.056 | 0.043 | 0.104 |
| A03 F | GR | 0.001 | -0.003 | -0.001 | -0.004 | -0.018 | 0.019 |
| | T1 | -0.013 | 0.004 | -0.005 | 0.065 | -0.036 | 0.157 |
| | GR+T1+P1 | -0.013 | 0.001 | -0.006 | 0.062 | -0.054 | 0.180 |
| | TOTAL | 0.013 | 0.001 | 0.006 | 0.062 | 0.054 | 0.180 |
| A04 N | GR | 0.001 | -0.003 | -0.001 | -0.004 | -0.018 | 0.019 |
| | T1 | -0.010 | 0.001 | -0.006 | 0.066 | -0.037 | 0.154 |
| | GR+T1+P1 | -0.009 | -0.002 | -0.007 | 0.062 | -0.055 | 0.177 |
| | TOTAL | 0.009 | 0.002 | 0.007 | 0.063 | 0.055 | 0.178 |
| A04 F | GR | 0.002 | -0.004 | -0.002 | -0.004 | -0.021 | 0.024 |
| | T1 | -0.013 | -0.008 | -0.012 | 0.070 | -0.044 | -0.077 |
| | GR+T1+P1 | -0.011 | -0.012 | -0.014 | 0.066 | -0.065 | -0.053 |
| | TOTAL | 0.011 | 0.013 | 0.014 | 0.067 | 0.065 | 0.054 |
| A05 N | GR | 0.002 | -0.011 | -0.009 | -0.007 | -0.022 | 0.016 |
| | T1 | -0.061 | 0.034 | -0.027 | 0.073 | -0.050 | -0.091 |
| | GR+T1+P1 | -0.059 | 0.022 | -0.036 | 0.067 | -0.071 | -0.075 |
| | TOTAL | 0.059 | 0.023 | 0.036 | 0.067 | 0.072 | 0.075 |
| A05 F | GR | 0.002 | -0.012 | -0.010 | -0.009 | -0.020 | -0.001 |
| | T1 | -0.066 | 0.026 | -0.034 | 0.074 | -0.051 | 0.111 |
| | GR+T1+P1 | -0.063 | 0.014 | -0.043 | 0.066 | -0.071 | 0.112 |
| | TOTAL | 0.063 | 0.014 | 0.043 | 0.066 | 0.072 | 0.112 |

KPP-6485 Rev. 0

333

D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A06 | GR | 0.002 | -0.012 | -0.010 | -0.009 | -0.020 | -0.002 |
| | T1 | -0.062 | 0.022 | -0.036 | 0.074 | -0.051 | 0.112 |
| | GR+T1+P1 | -0.060 | 0.010 | -0.045 | 0.066 | -0.071 | 0.111 |
| | TOTAL | 0.060 | 0.010 | 0.045 | 0.066 | 0.071 | 0.111 |
| A07 | GR | 0.001 | -0.012 | -0.007 | -0.013 | -0.017 | -0.006 |
| | T1 | -0.040 | -0.012 | -0.053 | 0.073 | -0.052 | 0.089 |
| | GR+T1+P1 | -0.039 | -0.024 | -0.060 | 0.061 | -0.070 | 0.083 |
| | TOTAL | 0.039 | 0.025 | 0.060 | 0.061 | 0.070 | 0.084 |
| A08 N | GR | 0.000 | -0.012 | -0.003 | -0.020 | -0.015 | 0.002 |
| | T1 | -0.017 | -0.049 | -0.065 | -0.005 | -0.053 | 0.101 |
| | GR+T1+P1 | -0.017 | -0.062 | -0.068 | -0.025 | -0.069 | 0.104 |
| | TOTAL | 0.017 | 0.062 | 0.068 | 0.025 | 0.069 | 0.107 |
| A08 F | GR | 0.000 | -0.011 | -0.002 | -0.031 | -0.006 | 0.017 |
| | T1 | -0.015 | -0.051 | -0.053 | -0.216 | -0.020 | 0.124 |
| | GR+T1+P1 | -0.014 | -0.063 | -0.056 | -0.249 | -0.027 | 0.141 |
| | TOTAL | 0.015 | 0.063 | 0.056 | 0.250 | 0.028 | 0.143 |
| A09 | GR | 0.000 | -0.010 | -0.002 | -0.032 | -0.005 | 0.021 |
| | T1 | -0.017 | -0.044 | -0.048 | -0.235 | -0.017 | 0.138 |
| | GR+T1+P1 | -0.017 | -0.054 | -0.050 | -0.269 | -0.022 | 0.159 |
| | TOTAL | 0.018 | 0.054 | 0.050 | 0.270 | 0.024 | 0.160 |
| A10 | GR | 0.000 | -0.008 | -0.002 | -0.032 | -0.005 | 0.021 |
| | T1 | -0.021 | -0.032 | -0.039 | -0.235 | -0.017 | 0.138 |
| | GR+T1+P1 | -0.021 | -0.040 | -0.041 | -0.269 | -0.022 | 0.160 |
| | TOTAL | 0.021 | 0.040 | 0.041 | 0.270 | 0.024 | 0.161 |
| A11 | GR | 0.000 | -0.008 | -0.002 | -0.032 | -0.005 | 0.021 |
| | T1 | -0.021 | -0.031 | -0.038 | -0.235 | -0.016 | 0.140 |
| | GR+T1+P1 | -0.021 | -0.039 | -0.041 | -0.270 | -0.021 | 0.162 |
| | TOTAL | 0.022 | 0.039 | 0.041 | 0.271 | 0.023 | 0.163 |
| A12 | GR | 0.000 | -0.008 | -0.002 | -0.033 | -0.005 | 0.021 |
| | T1 | -0.021 | -0.030 | -0.038 | -0.235 | -0.012 | 0.140 |
| | GR+T1+P1 | -0.022 | -0.038 | -0.040 | -0.270 | -0.018 | 0.162 |
| | TOTAL | 0.022 | 0.039 | 0.040 | 0.271 | 0.019 | 0.163 |
| A13 | GR | 0.000 | -0.006 | -0.002 | -0.033 | -0.005 | 0.021 |
| | T1 | -0.025 | -0.018 | -0.029 | -0.235 | -0.012 | 0.140 |
| | GR+T1+P1 | -0.025 | -0.025 | -0.031 | -0.270 | -0.017 | 0.162 |
| | TOTAL | 0.026 | 0.025 | 0.031 | 0.271 | 0.019 | 0.163 |



D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| A14 | GR | -0.001 | -0.002 | -0.002 | -0.034 | -0.003 | 0.017 |
| | T1 | -0.027 | 0.010 | -0.005 | -0.207 | 0.046 | 0.143 |
| | GR+T1+P1 | -0.028 | 0.008 | -0.008 | -0.242 | 0.043 | 0.161 |
| | TOTAL | 0.028 | 0.008 | 0.008 | 0.243 | 0.046 | 0.162 |
| A15 N | GR | -0.001 | -0.001 | -0.002 | -0.034 | -0.003 | 0.016 |
| | T1 | -0.027 | 0.015 | 0.000 | -0.196 | 0.050 | 0.145 |
| | GR+T1+P1 | -0.028 | 0.014 | -0.002 | -0.231 | 0.047 | 0.162 |
| | TOTAL | 0.028 | 0.014 | 0.003 | 0.232 | 0.050 | 0.163 |
| A15 F | GR | -0.001 | 0.000 | -0.001 | -0.027 | -0.004 | 0.013 |
| | T1 | -0.021 | 0.014 | 0.010 | -0.086 | 0.053 | 0.162 |
| | GR+T1+P1 | -0.021 | 0.014 | 0.008 | -0.114 | 0.048 | 0.176 |
| | TOTAL | 0.022 | 0.014 | 0.009 | 0.115 | 0.051 | 0.178 |
| A16 | GR | 0.000 | 0.000 | -0.001 | -0.026 | -0.004 | 0.013 |
| | T1 | -0.016 | 0.009 | 0.012 | -0.081 | 0.052 | 0.159 |
| | GR+T1+P1 | -0.016 | 0.009 | 0.011 | -0.107 | 0.048 | 0.173 |
| | TOTAL | 0.017 | 0.009 | 0.012 | 0.108 | 0.050 | 0.174 |
| A17 | GR | 0.000 | 0.000 | 0.000 | -0.002 | 0.000 | 0.001 |
| | T1 | -0.001 | 0.009 | 0.000 | 0.002 | 0.001 | 0.021 |
| | GR+T1+P1 | -0.001 | 0.009 | 0.000 | 0.000 | 0.001 | 0.023 |
| | TOTAL | 0.001 | 0.009 | 0.000 | 0.000 | 0.001 | 0.023 |
| A18 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*** Segment A end ***

*** Segment B begin ***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A11 | GR | 0.000 | -0.008 | -0.002 | -0.032 | -0.005 | 0.021 |
| | T1 | -0.021 | -0.031 | -0.038 | -0.235 | -0.016 | 0.140 |
| | GR+T1+P1 | -0.021 | -0.039 | -0.041 | -0.270 | -0.021 | 0.162 |
| | TOTAL | 0.022 | 0.039 | 0.041 | 0.271 | 0.023 | 0.163 |
| B01 | GR | 0.000 | -0.008 | -0.002 | -0.032 | -0.005 | 0.022 |
| | T1 | -0.021 | -0.030 | -0.038 | -0.236 | -0.018 | 0.141 |
| | GR+T1+P1 | -0.021 | -0.038 | -0.040 | -0.270 | -0.023 | 0.164 |
| | TOTAL | 0.021 | 0.038 | 0.040 | 0.271 | 0.025 | 0.165 |

RPP-6485 Rev. 0

334

## D I S P L A C E M E N T S

| Point name | Load combination | TRANSLATIONS (in ) X | Y | Z | ROTATIONS (deg ) X | Y | Z |
|---|---|---|---|---|---|---|---|
| B02 | GR | 0.000 | -0.006 | -0.002 | -0.032 | -0.005 | 0.022 |
| | T1 | -0.012 | -0.018 | -0.034 | -0.236 | -0.018 | 0.142 |
| | GR+T1+P1 | -0.012 | -0.024 | -0.036 | -0.270 | -0.024 | 0.164 |
| | TOTAL | 0.013 | 0.024 | 0.037 | 0.271 | 0.025 | 0.165 |
| B03 | GR | 0.000 | -0.004 | -0.002 | -0.031 | -0.004 | 0.024 |
| | T1 | -0.004 | -0.006 | -0.031 | -0.235 | -0.037 | 0.147 |
| | GR+T1+P1 | -0.005 | -0.011 | -0.032 | -0.268 | -0.042 | 0.173 |
| | TOTAL | 0.005 | 0.011 | 0.033 | 0.269 | 0.043 | 0.173 |
| B04 N | GR | 0.000 | -0.001 | -0.001 | -0.028 | -0.004 | 0.023 |
| | T1 | 0.008 | 0.013 | -0.022 | -0.227 | -0.054 | 0.135 |
| | GR+T1+P1 | 0.008 | 0.012 | -0.023 | -0.256 | -0.058 | 0.160 |
| | TOTAL | 0.008 | 0.012 | 0.024 | 0.257 | 0.059 | 0.160 |
| B04 F | GR | 0.000 | 0.000 | 0.000 | -0.021 | -0.001 | 0.016 |
| | T1 | 0.015 | 0.014 | -0.012 | -0.183 | -0.054 | 0.034 |
| | GR+T1+P1 | 0.015 | 0.014 | -0.012 | -0.205 | -0.055 | 0.051 |
| | TOTAL | 0.016 | 0.014 | 0.012 | 0.206 | 0.056 | 0.052 |
| B05 | GR | 0.001 | 0.000 | 0.000 | -0.020 | -0.001 | 0.016 |
| | T1 | 0.016 | 0.009 | -0.007 | -0.177 | -0.054 | 0.029 |
| | GR+T1+P1 | 0.017 | 0.009 | -0.006 | -0.198 | -0.055 | 0.045 |
| | TOTAL | 0.017 | 0.009 | 0.007 | 0.199 | 0.056 | 0.047 |
| B06 | GR | 0.000 | 0.000 | 0.000 | -0.001 | 0.000 | 0.001 |
| | T1 | 0.001 | 0.009 | -0.001 | -0.017 | -0.001 | -0.008 |
| | GR+T1+P1 | 0.001 | 0.009 | -0.001 | -0.018 | -0.001 | -0.007 |
| | TOTAL | 0.001 | 0.009 | 0.001 | 0.018 | 0.001 | 0.008 |
| B07 | GR | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | T1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | GR+T1+P1 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | TOTAL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

*** Segment B end ***



## R E S T R A I N T R E A C T I O N S

| Point name | Load combination | FORCES (lb ) X | Y | Z | Result | MOMENTS (ft-lb ) X | Y | Z | Result |
|---|---|---|---|---|---|---|---|---|---|
| A00 | Anchor | | | | | | | | |
| | GR | -19 | -66 | -5 | 69 | 0 | -10 | 31 | 33 |
| | T1 | 1344 | 433 | -6 | 1412 | 6 | -19 | -98 | 100 |
| | GR+T1+P1 | 1345 | 372 | -11 | 1395 | 6 | -29 | -67 | 73 |
| | TOTAL | 1353 | 379 | 19 | 1405 | 6 | 31 | 69 | 76 |
| A06 | Guide [ID: A06 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | -1407 | 0 | 0 | 1407 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | -1429 | 0 | 0 | 1429 | 0 | 0 | 0 | 0 |
| | TOTAL | 1434 | 0 | 2 | 1434 | 0 | 0 | 0 | 0 |
| A07 | Guide [ID: A07 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | -232 | 232 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | -236 | 236 | 0 | 0 | 0 | 0 |
| | TOTAL | 17 | 0 | 238 | 239 | 0 | 0 | 0 | 0 |
| A14 | Guide [ID: A14 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOTAL | 23 | 17 | 6 | 29 | 0 | 0 | 0 | 0 |
| A18 | Anchor | | | | | | | | |
| | GR | -5 | -83 | -9 | 83 | -19 | 0 | 9 | 21 |
| | T1 | -367 | -131 | 349 | 523 | 68 | 6 | 219 | 229 |
| | GR+T1+P1 | -373 | -214 | 342 | 550 | 49 | 5 | 229 | 235 |
| | TOTAL | 377 | 224 | 349 | 560 | 52 | 5 | 230 | 235 |
| B03 | Guide [ID: B03 1] | | | | | | | | |
| | GR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | T1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GR+T1+P1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOTAL | 10 | 27 | 36 | 46 | 0 | 0 | 0 | 0 |
| B07 | Anchor | | | | | | | | |
| | GR | 24 | -190 | 14 | 192 | -7 | 0 | 1 | 7 |
| | T1 | 430 | -302 | -111 | 536 | -144 | -6 | -126 | 191 |
| | GR+T1+P1 | 458 | -496 | -95 | 681 | -152 | -6 | -125 | 197 |
| | TOTAL | 472 | 500 | 104 | 695 | 155 | 6 | 131 | 203 |

RPP-6485 Rev. 0

335

K/74+PRINT

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| *** Segment A begin *** | | | | | | | | | | |
| A00 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 31 | 10 | | 1.00 | 1.00 | (18) | SUST | 2123 | 16340 |
| | Cold to T1 | 98 | 19 | 6 | 1.00 | 1.00 | (17) | DISP | 2140 | 24960 |
| | Sus. + R1 | 32 | 10 | | 1.00 | 1.00 | (18) | OCC | 2130 | 21732 |
| | Sus. + R2 | 34 | 10 | | 1.00 | 1.00 | (18) | OCC | 2183 | 21732 |
| | Sus. + R3 | 31 | 13 | | 1.00 | 1.00 | (18) | OCC | 2189 | 21732 |
| A01 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 9 | | 1.00 | 1.00 | (18) | SUST | 1683 | 16340 |
| | Cold to T1 | 32 | 17 | 6 | 1.00 | 1.00 | (17) | DISP | 782 | 24960 |
| | Sus. + R1 | 12 | 9 | | 1.00 | 1.00 | (18) | OCC | 1688 | 21732 |
| | Sus. + R2 | 12 | 9 | | 1.00 | 1.00 | (18) | OCC | 1691 | 21732 |
| | Sus. + R3 | 12 | 9 | | 1.00 | 1.00 | (18) | OCC | 1689 | 21732 |
| A02 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 7 | 8 | | 1.00 | 1.00 | (18) | SUST | 1594 | 16340 |
| | Cold to T1 | 75 | 16 | 6 | 1.00 | 1.00 | (17) | DISP | 1649 | 24960 |
| | Sus. + R1 | 7 | 8 | | 1.00 | 1.00 | (18) | OCC | 1598 | 21732 |
| | Sus. + R2 | 7 | 8 | | 1.00 | 1.00 | (18) | OCC | 1596 | 21732 |
| | Sus. + R3 | 7 | 9 | | 1.00 | 1.00 | (18) | OCC | 1600 | 21732 |
| A03 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 8 | | 1.00 | 1.00 | (18) | SUST | 1534 | 16340 |
| | Cold to T1 | 133 | 15 | 6 | 1.00 | 1.00 | (17) | DISP | 2863 | 24960 |
| | Sus. + R1 | 4 | 8 | | 1.00 | 1.00 | (18) | OCC | 1537 | 21732 |
| | Sus. + R2 | 4 | 8 | | 1.00 | 1.00 | (18) | OCC | 1541 | 21732 |
| | Sus. + R3 | 4 | 8 | | 1.00 | 1.00 | (18) | OCC | 1543 | 21732 |
| A03 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 8 | | 2.27 | 1.89 | (18) | SUST | 1732 | 16340 |
| | Cold to T1 | 133 | 15 | 6 | 2.27 | 1.89 | (17) | DISP | 6479 | 24960 |
| | Sus. + R1 | 4 | 8 | | 2.27 | 1.89 | (18) | OCC | 1739 | 21732 |
| | Sus. + R2 | 4 | 8 | | 2.27 | 1.89 | (18) | OCC | 1749 | 21732 |
| | Sus. + R3 | 4 | 8 | | 2.27 | 1.89 | (18) | OCC | 1750 | 21732 |
| A03 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 1 | | 2.27 | 1.89 | (18) | SUST | 1492 | 16340 |
| | Cold to T1 | 19 | 5 | 14 | 2.27 | 1.89 | (17) | DISP | 1003 | 24960 |
| | Sus. + R1 | 3 | 1 | | 2.27 | 1.89 | (18) | OCC | 1494 | 21732 |
| | Sus. + R2 | 3 | 1 | | 2.27 | 1.89 | (18) | OCC | 1507 | 21732 |
| | Sus. + R3 | 3 | 1 | | 2.27 | 1.89 | (18) | OCC | 1497 | 21732 |
| A03 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 1 | 3 | | 1.00 | 1.00 | (18) | SUST | 1403 | 16340 |
| | Cold to T1 | 5 | 19 | 14 | 1.00 | 1.00 | (17) | DISP | 524 | 24960 |
| | Sus. + R1 | 1 | 3 | | 1.00 | 1.00 | (18) | OCC | 1404 | 21732 |
| | Sus. + R2 | 1 | 3 | | 1.00 | 1.00 | (18) | OCC | 1410 | 21732 |
| | Sus. + R3 | 1 | 3 | | 1.00 | 1.00 | (18) | OCC | 1406 | 21732 |



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A04 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 2 | 4 | | 1.00 | 1.00 | (18) | SUST | 1443 | 16340 |
| | Cold to T1 | 5 | 131 | 14 | 1.00 | 1.00 | (17) | DISP | 2826 | 24960 |
| | Sus. + R1 | 2 | 4 | | 1.00 | 1.00 | (18) | OCC | 1445 | 21732 |
| | Sus. + R2 | 2 | 5 | | 1.00 | 1.00 | (18) | OCC | 1447 | 21732 |
| | Sus. + R3 | 2 | 4 | | 1.00 | 1.00 | (18) | OCC | 1447 | 21732 |
| A04 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 2 | | 1.73 | 1.44 | (18) | SUST | 1522 | 16340 |
| | Cold to T1 | 131 | 5 | 14 | 1.73 | 1.44 | (17) | DISP | 4874 | 24960 |
| | Sus. + R1 | 4 | 2 | | 1.73 | 1.44 | (18) | OCC | 1525 | 21732 |
| | Sus. + R2 | 5 | 2 | | 1.73 | 1.44 | (18) | OCC | 1528 | 21732 |
| | Sus. + R3 | 4 | 2 | | 1.73 | 1.44 | (18) | OCC | 1528 | 21732 |
| A04 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 6 | | 1.73 | 1.44 | (18) | SUST | 1576 | 16340 |
| | Cold to T1 | 359 | 13 | 3 | 1.73 | 1.44 | (17) | DISP | 13313 | 24960 |
| | Sus. + R1 | 4 | 6 | | 1.73 | 1.44 | (18) | OCC | 1584 | 21732 |
| | Sus. + R2 | 4 | 6 | | 1.73 | 1.44 | (18) | OCC | 1577 | 21732 |
| | Sus. + R3 | 4 | 6 | | 1.73 | 1.44 | (18) | OCC | 1600 | 21732 |
| A04 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 6 | | 1.00 | 1.00 | (18) | SUST | 1489 | 16340 |
| | Cold to T1 | 359 | 13 | 3 | 1.00 | 1.00 | (17) | DISP | 7689 | 24960 |
| | Sus. + R1 | 4 | 6 | | 1.00 | 1.00 | (18) | OCC | 1494 | 21732 |
| | Sus. + R2 | 4 | 6 | | 1.00 | 1.00 | (18) | OCC | 1491 | 21732 |
| | Sus. + R3 | 4 | 6 | | 1.00 | 1.00 | (18) | OCC | 1507 | 21732 |
| A05 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 23 | 2 | | 1.00 | 1.00 | (18) | SUST | 1875 | 16340 |
| | Cold to T1 | 320 | 3 | 3 | 1.00 | 1.00 | (17) | DISP | 6855 | 24960 |
| | Sus. + R1 | 23 | 3 | | 1.00 | 1.00 | (18) | OCC | 1894 | 21732 |
| | Sus. + R2 | 23 | 3 | | 1.00 | 1.00 | (18) | OCC | 1883 | 21732 |
| | Sus. + R3 | 23 | 2 | | 1.00 | 1.00 | (18) | OCC | 1877 | 21732 |
| A05 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 23 | 2 | | 1.73 | 1.44 | (18) | SUST | 2272 | 16340 |
| | Cold to T1 | 320 | 3 | 3 | 1.73 | 1.44 | (17) | DISP | 11871 | 24960 |
| | Sus. + R1 | 23 | 3 | | 1.73 | 1.44 | (18) | OCC | 2305 | 21732 |
| | Sus. + R2 | 23 | 3 | | 1.73 | 1.44 | (18) | OCC | 2286 | 21732 |
| | Sus. + R3 | 23 | 2 | | 1.73 | 1.44 | (18) | OCC | 2276 | 21732 |
| A05 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 21 | 4 | | 1.73 | 1.44 | (18) | SUST | 2196 | 16340 |
| | Cold to T1 | 92 | 2 | 1 | 1.73 | 1.44 | (17) | DISP | 3425 | 24960 |
| | Sus. + R1 | 21 | 4 | | 1.73 | 1.44 | (18) | OCC | 2212 | 21732 |
| | Sus. + R2 | 21 | 4 | | 1.73 | 1.44 | (18) | OCC | 2206 | 21732 |
| | Sus. + R3 | 21 | 4 | | 1.73 | 1.44 | (18) | OCC | 2200 | 21732 |

RPP-6485 Rev 0

336

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A05 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 4 | 21 | | 1.00 | 1.00 | (18) | SUST | 1833 | 16340 |
| | Cold to T1 | 2 | 92 | 1 | 1.00 | 1.00 | (17) | DISP | 1978 | 24960 |
| | Sus. + R1 | 4 | 21 | | 1.00 | 1.00 | (18) | OCC | 1842 | 21732 |
| | Sus. + R2 | 4 | 21 | | 1.00 | 1.00 | (18) | OCC | 1839 | 21732 |
| | Sus. + R3 | 4 | 21 | | 1.00 | 1.00 | (18) | OCC | 1835 | 21732 |
| A06 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 5 | 18 | | 1.00 | 1.00 | (18) | SUST | 1778 | 16340 |
| | Cold to T1 | 1 | 82 | 1 | 1.00 | 1.00 | (17) | DISP | 1762 | 24960 |
| | Sus. + R1 | 5 | 18 | | 1.00 | 1.00 | (18) | OCC | 1780 | 21732 |
| | Sus. + R2 | 5 | 18 | | 1.00 | 1.00 | (18) | OCC | 1788 | 21732 |
| | Sus. + R3 | 5 | 18 | | 1.00 | 1.00 | (18) | OCC | 1785 | 21732 |
| A07 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 11 | 3 | | 1.00 | 1.00 | (18) | SUST | 1595 | 16340 |
| | Cold to T1 | 6 | 13 | 1 | 1.00 | 1.00 | (17) | DISP | 314 | 24960 |
| | Sus. + R1 | 11 | 12 | | 1.00 | 1.00 | (18) | OCC | 1790 | 21732 |
| | Sus. + R2 | 11 | 3 | | 1.00 | 1.00 | (18) | OCC | 1605 | 21732 |
| | Sus. + R3 | 11 | 4 | | 1.00 | 1.00 | (18) | OCC | 1614 | 21732 |
| A08 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 17 | 27 | | 1.00 | 1.00 | (18) | SUST | 2085 | 16340 |
| | Cold to T1 | 292 | 62 | 1 | 1.00 | 1.00 | (17) | DISP | 6398 | 24960 |
| | Sus. + R1 | 17 | 29 | | 1.00 | 1.00 | (18) | OCC | 2137 | 21732 |
| | Sus. + R2 | 18 | 27 | | 1.00 | 1.00 | (18) | OCC | 2115 | 21732 |
| | Sus. + R3 | 17 | 27 | | 1.00 | 1.00 | (18) | OCC | 2091 | 21732 |
| A08 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 30 | | 1.73 | 1.44 | (18) | SUST | 2440 | 16340 |
| | Cold to T1 | 267 | 135 | 1 | 1.73 | 1.44 | (17) | DISP | 10729 | 24960 |
| | Sus. + R1 | 10 | 32 | | 1.73 | 1.44 | (18) | OCC | 2517 | 21732 |
| | Sus. + R2 | 10 | 31 | | 1.73 | 1.44 | (18) | OCC | 2489 | 21732 |
| | Sus. + R3 | 9 | 30 | | 1.73 | 1.44 | (18) | OCC | 2450 | 21732 |
| A08 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 8 | 9 | | 1.73 | 1.44 | (18) | SUST | 1769 | 16340 |
| | Cold to T1 | 212 | 29 | 165 | 1.73 | 1.44 | (17) | DISP | 8672 | 24960 |
| | Sus. + R1 | 9 | 11 | | 1.73 | 1.44 | (18) | OCC | 1859 | 21732 |
| | Sus. + R2 | 8 | 9 | | 1.73 | 1.44 | (18) | OCC | 1785 | 21732 |
| | Sus. + R3 | 8 | 9 | | 1.73 | 1.44 | (18) | OCC | 1777 | 21732 |
| A08 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 8 | 9 | | 1.00 | 1.00 | (18) | SUST | 1608 | 16340 |
| | Cold to T1 | 212 | 29 | 165 | 1.00 | 1.00 | (17) | DISP | 5791 | 24960 |
| | Sus. + R1 | 9 | 11 | | 1.00 | 1.00 | (18) | OCC | 1667 | 21732 |
| | Sus. + R2 | 8 | 9 | | 1.00 | 1.00 | (18) | OCC | 1618 | 21732 |
| | Sus. + R3 | 8 | 9 | | 1.00 | 1.00 | (18) | OCC | 1614 | 21732 |



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A09 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 6 | 13 | | 1.00 | 1.00 | (18) | SUST | 1667 | 16340 |
| | Cold to T1 | 128 | 53 | 165 | 1.00 | 1.00 | (17) | DISP | 4615 | 24960 |
| | Sus. + R1 | 8 | 16 | | 1.00 | 1.00 | (18) | OCC | 1756 | 21732 |
| | Sus. + R2 | 6 | 13 | | 1.00 | 1.00 | (18) | OCC | 1676 | 21732 |
| | Sus. + R3 | 6 | 13 | | 1.00 | 1.00 | (18) | OCC | 1671 | 21732 |
| A10 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 6 | 19 | | 1.00 | 1.00 | (18) | SUST | 1804 | 16340 |
| | Cold to T1 | 36 | 90 | 163 | 1.00 | 1.00 | (17) | DISP | 4055 | 24960 |
| | Sus. + R1 | 9 | 24 | | 1.00 | 1.00 | (18) | OCC | 1936 | 21732 |
| | Sus. + R2 | 8 | 19 | | 1.00 | 1.00 | (18) | OCC | 1851 | 21732 |
| | Sus. + R3 | 7 | 19 | | 1.00 | 1.00 | (18) | OCC | 1809 | 21732 |
| A11 - | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 19 | 7 | | 1.19 | 1.25 | (18) | SUST | 1915 | 16340 |
| | Cold to T1 | 94 | 46 | 163 | 1.19 | 1.25 | (17) | DISP | 4395 | 24960 |
| | Sus. + R1 | 24 | 9 | | 1.19 | 1.25 | (18) | OCC | 2075 | 21732 |
| | Sus. + R2 | 20 | 9 | | 1.19 | 1.25 | (18) | OCC | 1979 | 21732 |
| | Sus. + R3 | 19 | 7 | | 1.19 | 1.25 | (18) | OCC | 1922 | 21732 |
| A11 + | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 10 | 13 | | 1.19 | 1.25 | (18) | SUST | 1809 | 16340 |
| | Cold to T1 | 357 | 6 | 10 | 1.19 | 1.25 | (17) | DISP | 9085 | 24960 |
| | Sus. + R1 | 20 | 15 | | 1.19 | 1.25 | (18) | OCC | 2087 | 21732 |
| | Sus. + R2 | 11 | 14 | | 1.19 | 1.25 | (18) | OCC | 1854 | 21732 |
| | Sus. + R3 | 16 | 13 | | 1.19 | 1.25 | (18) | OCC | 1973 | 21732 |
| A12 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 13 | 10 | | 1.00 | 1.00 | (18) | SUST | 1723 | 16340 |
| | Cold to T1 | 3 | 353 | 10 | 1.00 | 1.00 | (17) | DISP | 7563 | 24960 |
| | Sus. + R1 | 15 | 20 | | 1.00 | 1.00 | (18) | OCC | 1952 | 21732 |
| | Sus. + R2 | 14 | 11 | | 1.00 | 1.00 | (18) | OCC | 1758 | 21732 |
| | Sus. + R3 | 13 | 16 | | 1.00 | 1.00 | (18) | OCC | 1859 | 21732 |
| A13 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 8 | | 1.00 | 1.00 | (18) | SUST | 1670 | 16340 |
| | Cold to T1 | 39 | 275 | 11 | 1.00 | 1.00 | (17) | DISP | 5943 | 24960 |
| | Sus. + R1 | 13 | 15 | | 1.00 | 1.00 | (18) | OCC | 1829 | 21732 |
| | Sus. + R2 | 13 | 9 | | 1.00 | 1.00 | (18) | OCC | 1698 | 21732 |
| | Sus. + R3 | 12 | 12 | | 1.00 | 1.00 | (18) | OCC | 1766 | 21732 |
| A14 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 3 | | 1.00 | 1.00 | (18) | SUST | 1433 | 16340 |
| | Cold to T1 | 137 | 80 | 11 | 1.00 | 1.00 | (17) | DISP | 3401 | 24960 |
| | Sus. + R1 | 5 | 5 | | 1.00 | 1.00 | (18) | OCC | 1500 | 21732 |
| | Sus. + R2 | 5 | 3 | | 1.00 | 1.00 | (18) | OCC | 1471 | 21732 |
| | Sus. + R3 | 4 | 3 | | 1.00 | 1.00 | (18) | OCC | 1448 | 21732 |

RPP-6985 REV. 0

337

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | (Moments in ft-lb ) In-Pl. Moment | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | (Stress in psi ) Load type | Code Stress | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A15 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 2 | | 1.00 | 1.00 | (18) | SUST | 1419 | 16340 |
| | Cold to T1 | 158 | 38 | 11 | 1.00 | 1.00 | (17) | DISP | 3490 | 24960 |
| | Sus. + R1 | 4 | 3 | | 1.00 | 1.00 | (18) | OCC | 1447 | 21732 |
| | Sus. + R2 | 4 | 2 | | 1.00 | 1.00 | (18) | OCC | 1436 | 21732 |
| | Sus. + R3 | 3 | 2 | | 1.00 | 1.00 | (18) | OCC | 1426 | 21732 |
| A15 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 3 | 2 | | 2.27 | 1.89 | (18) | SUST | 1527 | 16340 |
| | Cold to T1 | 158 | 38 | 11 | 2.27 | 1.89 | (17) | DISP | 7841 | 24960 |
| | Sus. + R1 | 4 | 3 | | 2.27 | 1.89 | (18) | OCC | 1581 | 21732 |
| | Sus. + R2 | 4 | 2 | | 2.27 | 1.89 | (18) | OCC | 1566 | 21732 |
| | Sus. + R3 | 3 | 2 | | 2.27 | 1.89 | (18) | OCC | 1542 | 21732 |
| A15 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 11 | 10 | | 2.27 | 1.89 | (18) | SUST | 2107 | 16340 |
| | Cold to T1 | 108 | 54 | 6 | 2.27 | 1.89 | (17) | DISP | 5669 | 24960 |
| | Sus. + R1 | 12 | 10 | | 2.27 | 1.89 | (18) | OCC | 2139 | 21732 |
| | Sus. + R2 | 12 | 11 | | 2.27 | 1.89 | (18) | OCC | 2124 | 21732 |
| | Sus. + R3 | 12 | 10 | | 2.27 | 1.89 | (18) | OCC | 2115 | 21732 |
| A15 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 14 | 7 | | 1.00 | 1.00 | (18) | SUST | 1698 | 16340 |
| | Cold to T1 | 118 | 23 | 6 | 1.00 | 1.00 | (17) | DISP | 2581 | 24960 |
| | Sus. + R1 | 14 | 7 | | 1.00 | 1.00 | (18) | OCC | 1712 | 21732 |
| | Sus. + R2 | 14 | 7 | | 1.00 | 1.00 | (18) | OCC | 1707 | 21732 |
| | Sus. + R3 | 14 | 7 | | 1.00 | 1.00 | (18) | OCC | 1702 | 21732 |
| A16 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 15 | 7 | | 1.00 | 1.00 | (18) | SUST | 1731 | 16340 |
| | Cold to T1 | 72 | 72 | 6 | 1.00 | 1.00 | (17) | DISP | 2178 | 24960 |
| | Sus. + R1 | 15 | 8 | | 1.00 | 1.00 | (18) | OCC | 1750 | 21732 |
| | Sus. + R2 | 15 | 8 | | 1.00 | 1.00 | (18) | OCC | 1738 | 21732 |
| | Sus. + R3 | 15 | 8 | | 1.00 | 1.00 | (18) | OCC | 1738 | 21732 |
| A17 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 16 | 8 | | 1.00 | 1.00 | (18) | SUST | 1756 | 16340 |
| | Cold to T1 | 37 | 109 | 6 | 1.00 | 1.00 | (17) | DISP | 2459 | 24960 |
| | Sus. + R1 | 17 | 9 | | 1.00 | 1.00 | (18) | OCC | 1780 | 21732 |
| | Sus. + R2 | 16 | 8 | | 1.00 | 1.00 | (18) | OCC | 1761 | 21732 |
| | Sus. + R3 | 16 | 8 | | 1.00 | 1.00 | (18) | OCC | 1762 | 21732 |
| A18 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 19 | 9 | | 1.00 | 1.00 | (18) | SUST | 1829 | 16340 |
| | Cold to T1 | 68 | 219 | 6 | 1.00 | 1.00 | (17) | DISP | 4905 | 24960 |
| | Sus. + R1 | 21 | 10 | | 1.00 | 1.00 | (18) | OCC | 1880 | 21732 |
| | Sus. + R2 | 19 | 9 | | 1.00 | 1.00 | (18) | OCC | 1831 | 21732 |
| | Sus. + R3 | 20 | 10 | | 1.00 | 1.00 | (18) | OCC | 1856 | 21732 |

*** Segment A end ***

*** Segment B begin ***



ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | (Moments in ft-lb ) In-Pl. Moment | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | (Stress in psi ) Load type | Code Stress | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| A11 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 9 | 45 | | 1.19 | 1.25 | (18) | SUST | 2688 | 16340 |
| | Cold to T1 | 263 | 180 | 16 | 1.19 | 1.25 | (17) | DISP | 8254 | 24960 |
| | Sus. + R1 | 13 | 49 | | 1.19 | 1.25 | (18) | OCC | 2874 | 21732 |
| | Sus. + R2 | 10 | 46 | | 1.19 | 1.25 | (18) | OCC | 2744 | 21732 |
| | Sus. + R3 | 15 | 45 | | 1.19 | 1.25 | (18) | OCC | 2856 | 21732 |
| B01 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 44 | 9 | | 1.00 | 1.00 | (18) | SUST | 2397 | 16340 |
| | Cold to T1 | 174 | 259 | 16 | 1.00 | 1.00 | (17) | DISP | 6683 | 24960 |
| | Sus. + R1 | 48 | 13 | | 1.00 | 1.00 | (18) | OCC | 2548 | 21732 |
| | Sus. + R2 | 45 | 10 | | 1.00 | 1.00 | (18) | OCC | 2439 | 21732 |
| | Sus. + R3 | 44 | 14 | | 1.00 | 1.00 | (18) | OCC | 2531 | 21732 |
| B02 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 28 | 6 | | 1.00 | 1.00 | (18) | SUST | 2024 | 16340 |
| | Cold to T1 | 83 | 192 | 17 | 1.00 | 1.00 | (17) | DISP | 4501 | 24960 |
| | Sus. + R1 | 31 | 10 | | 1.00 | 1.00 | (18) | OCC | 2144 | 21732 |
| | Sus. + R2 | 30 | 7 | | 1.00 | 1.00 | (18) | OCC | 2070 | 21732 |
| | Sus. + R3 | 29 | 6 | | 1.00 | 1.00 | (18) | OCC | 2035 | 21732 |
| B03 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 5 | | 1.00 | 1.00 | (18) | SUST | 1640 | 16340 |
| | Cold to T1 | 5 | 135 | 17 | 1.00 | 1.00 | (17) | DISP | 2910 | 24960 |
| | Sus. + R1 | 14 | 8 | | 1.00 | 1.00 | (18) | OCC | 1738 | 21732 |
| | Sus. + R2 | 17 | 5 | | 1.00 | 1.00 | (18) | OCC | 1761 | 21732 |
| | Sus. + R3 | 12 | 10 | | 1.00 | 1.00 | (18) | OCC | 1768 | 21732 |
| B04 N- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 30 | 1 | | 1.00 | 1.00 | (18) | SUST | 2049 | 16340 |
| | Cold to T1 | 136 | 31 | 17 | 1.00 | 1.00 | (17) | DISP | 3012 | 24960 |
| | Sus. + R1 | 32 | 2 | | 1.00 | 1.00 | (18) | OCC | 2106 | 21732 |
| | Sus. + R2 | 30 | 1 | | 1.00 | 1.00 | (18) | OCC | 2057 | 21732 |
| | Sus. + R3 | 30 | 1 | | 1.00 | 1.00 | (18) | OCC | 2057 | 21732 |
| B04 N+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 2 | 1 | | 2.27 | 1.89 | (18) | SUST | 1475 | 16340 |
| | Cold to T1 | 136 | 31 | 17 | 2.27 | 1.89 | (17) | DISP | 6742 | 24960 |
| | Sus. + R1 | 5 | 2 | | 2.27 | 1.89 | (18) | OCC | 1602 | 21732 |
| | Sus. + R2 | 3 | 1 | | 2.27 | 1.89 | (18) | OCC | 1493 | 21732 |
| | Sus. + R3 | 3 | 1 | | 2.27 | 1.89 | (18) | OCC | 1492 | 21732 |
| B04 F- | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 18 | 10 | | 2.27 | 1.89 | (18) | SUST | 2404 | 16340 |
| | Cold to T1 | 122 | 54 | 6 | 2.27 | 1.89 | (17) | DISP | 6337 | 24960 |
| | Sus. + R1 | 19 | 11 | | 2.27 | 1.89 | (18) | OCC | 2462 | 21732 |
| | Sus. + R2 | 18 | 11 | | 2.27 | 1.89 | (18) | OCC | 2417 | 21732 |
| | Sus. + R3 | 18 | 11 | | 2.27 | 1.89 | (18) | OCC | 2413 | 21732 |

RPP-6485 Rev. 0

338

ASME B31.3b (1997) CODE COMPLIANCE

| Point name | Load combination | In-Pl. Moment (Moments in ft-lb) | Out-Pl. Moment | Torsion Moment | S.I.F In | S.I.F Out | Eq. no. | Load type | Code Stress (Stress in psi) | Code Allow. |
|---|---|---|---|---|---|---|---|---|---|---|
| B04 F+ | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 15 | 14 | | 1.00 | 1.00 | (18) | SUST | 1823 | 16340 |
| | Cold to T1 | 85 | 103 | 6 | 1.00 | 1.00 | (17) | DISP | 2867 | 24960 |
| | Sus. + R1 | 15 | 15 | | 1.00 | 1.00 | (18) | OCC | 1849 | 21732 |
| | Sus. + R2 | 15 | 14 | | 1.00 | 1.00 | (18) | OCC | 1830 | 21732 |
| | Sus. + R3 | 15 | 14 | | 1.00 | 1.00 | (18) | OCC | 1827 | 21732 |
| B05 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 13 | 11 | | 1.00 | 1.00 | (18) | SUST | 1737 | 16340 |
| | Cold to T1 | 100 | 46 | 6 | 1.00 | 1.00 | (17) | DISP | 2356 | 24960 |
| | Sus. + R1 | 13 | 11 | | 1.00 | 1.00 | (18) | OCC | 1740 | 21732 |
| | Sus. + R2 | 13 | 11 | | 1.00 | 1.00 | (18) | OCC | 1743 | 21732 |
| | Sus. + R3 | 13 | 11 | | 1.00 | 1.00 | (18) | OCC | 1743 | 21732 |
| B06 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 12 | 9 | | 1.00 | 1.00 | (18) | SUST | 1674 | 16340 |
| | Cold to T1 | 111 | 3 | 6 | 1.00 | 1.00 | (17) | DISP | 2377 | 24960 |
| | Sus. + R1 | 12 | 10 | | 1.00 | 1.00 | (18) | OCC | 1705 | 21732 |
| | Sus. + R2 | 12 | 9 | | 1.00 | 1.00 | (18) | OCC | 1679 | 21732 |
| | Sus. + R3 | 12 | 9 | | 1.00 | 1.00 | (18) | OCC | 1678 | 21732 |
| B07 | Max P | | | | | | (3a) | HOOP | 2978 | 16340 |
| | GR + Max P | 7 | 1 | | 1.00 | 1.00 | (18) | SUST | 1508 | 16340 |
| | Cold to T1 | 144 | 126 | 6 | 1.00 | 1.00 | (17) | DISP | 4095 | 24960 |
| | Sus. + R1 | 10 | 7 | | 1.00 | 1.00 | (18) | OCC | 1647 | 21732 |
| | Sus. + R2 | 7 | 1 | | 1.00 | 1.00 | (18) | OCC | 1514 | 21732 |
| | Sus. + R3 | 9 | 2 | | 1.00 | 1.00 | (18) | OCC | 1557 | 21732 |

*** Segment B end ***

RPP-6485 Rev. 0



## S Y S T E M  S U M M A R Y

### Maximum displacements (in)

| | | | |
|---|---|---|---|
| Maximum X : | -0.066 | Point : A05 F | Load Comb.: T1 |
| Maximum Y : | 0.063 | Point : A08 F | Load Comb.: TOTAL |
| Maximum Z : | 0.068 | Point : A08 N | Load Comb.: TOTAL |
| Max. total: | 0.094 | Point : A08 N | Load Comb.: TOTAL |

### Maximum rotations (deg)

| | | | |
|---|---|---|---|
| Maximum X : | 0.271 | Point : B02 | Load Comb.: TOTAL |
| Maximum Y : | 0.072 | Point : A05 N | Load Comb.: TOTAL |
| Maximum Z : | 0.180 | Point : A03 F | Load Comb.: TOTAL |
| Max. total: | 0.323 | Point : B03 | Load Comb.: TOTAL |

### Maximum restraint forces (lb)

| | | | |
|---|---|---|---|
| Maximum X : | 1434 | Point : A06 | Load Comb.: TOTAL |
| Maximum Y : | 500 | Point : B07 | Load Comb.: TOTAL |
| Maximum Z : | 349 | Point : A18 | Load Comb.: T1 |
| Max. total: | 1434 | Point : A06 | Load Comb.: TOTAL |

### Maximum restraint moments (ft-lb)

| | | | |
|---|---|---|---|
| Maximum X : | 155 | Point : B07 | Load Comb.: TOTAL |
| Maximum Y : | 31 | Point : A00 | Load Comb.: TOTAL |
| Maximum Z : | 230 | Point : A18 | Load Comb.: TOTAL |
| Max. total: | 235 | Point : A18 | Load Comb.: TOTAL |

339

## SYSTEM SUMMARY

Maximum sustained stress

| | |
|---|---|
| Point | : A11 |
| Stress psi | : 2688 |
| Allowable psi | : 16340 |
| Ratio | : 0.16 |
| Load combination | : GR + Max P |

Maximum displacement stress

| | |
|---|---|
| Point | : A04 F |
| Stress psi | : 13313 |
| Allowable psi | : 24960 |
| Ratio | : 0.53 |
| Load combination | : Cold to T1 |

Maximum occasional stress

| | |
|---|---|
| Point | : A11 |
| Stress psi | : 2874 |
| Allowable psi | : 21732 |
| Ratio | : 0.13 |
| Load combination | : Sus. + R1 |

Maximum hoop stress

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2978 |
| Allowable psi | : 16340 |
| Ratio | : 0.18 |
| Load combination | : Max P |



## SYSTEM SUMMARY

Maximum sustained stress ratio

| | |
|---|---|
| Point | : A11 |
| Stress psi | : 2688 |
| Allowable psi | : 16340 |
| Ratio | : 0.16 |
| Load combination | : GR + Max P |

Maximum displacement stress ratio

| | |
|---|---|
| Point | : A04 F |
| Stress psi | : 13313 |
| Allowable psi | : 24960 |
| Ratio | : 0.53 |
| Load combination | : Cold to T1 |

Maximum occasional stress ratio

| | |
|---|---|
| Point | : A11 |
| Stress psi | : 2874 |
| Allowable psi | : 21732 |
| Ratio | : 0.13 |
| Load combination | : Sus. + R1 |

Maximum hoop stress ratio

| | |
|---|---|
| Point | : A00 |
| Stress psi | : 2978 |
| Allowable psi | : 16340 |
| Ratio | : 0.18 |
| Load combination | : Max P |

* * * The system satisfies ASME B31.3 code requirements * * *
* * * for the selected options * * *

RPP-6485 Rev.0

340

RPP-6485 Rev. 0

## Ahmed, Mohammed M

**From:** Dorsh, Paul M
**Sent:** Tuesday, May 30, 2000 11:46 AM
**To:** Ahmed, Mohammed M
**Subject:** Annulus Pumps

Mo,

On the annulus pumping calculation number-

Start with DSTAP-P-004 and sequentially increase the number if needed. Please let me know what numbers you use and the title of the calculation:

**Paul M. Dorsh**
**Fluor Federal Services**
**(509) 372-0289**

RPP- 6485 REV. 0

## Ahmed, Mohammed M

**From:** Dorsh, Paul M
**Sent:** Tuesday, May 02, 2000 8:16 AM
**To:** Ahmed, Mohammed M
**Subject:** FW: Annulus Pump Pit Jumper Analysis

Mo,

Attached are references to the annulus jumper design criteria. The second has a revision to the SpG.

Design Pressure - 300 psi
Design Temperature - 340 F
Ambient Temperature - 65 F (assumed)
Fluid Specific Gravity - 1.47 (in Draft Desing Criteria)
Safety Classification - General Service

The torque required to operate a 2" 3-way ball valve is not nearly as much as the torque needed to operate the 3" valves. Therefore, I don't believe it is necessary to include torque in the analysis.

FW Design Procedures and Crite... Draft Design Criteria for Annu...

-----Original Message-----
**From:** Hauck, Frank M (Marshall)
**Sent:** Tuesday, May 02, 2000 6:59 AM
**To:** Dorsh, Paul M
**Subject:** FW: Annulus Pump Pit Jumper Analysis

Paul,

Can you gather up this information and send it back to Mo?

Thanks,

Marshall

-----Original Message-----
**From:** Ahmed, Mohammed M
**Sent:** Monday, May 01, 2000 8:36 AM
**To:** Hauck, Frank M (Marshall)
**Cc:** Ahmed, Mohammed M
**Subject:** Annulus Pump Pit Jumper Analysis

Marshall,

I have received AZ-01B & -02B Jumper drawings from Gary Cleveland. What I need from you is Design specifications such as:

Design Pressure
Design Temperature
Ambient Temperature
Fluid Specific weight
Would there be any torque applied to Valve for opening & closing. If so how much torque?
Jumper piping Safety Category?
Any other data you think is pertinent.

***Mohammed M. Ahmed***
***Fluor Federal Services***
***376-9120***

**Dorsh, Paul M**
**From:** Rarig, Bradley K
**Sent:** Friday, December 17, 1999 1:35 PM
**To:** Dorsh, Paul M; Messinger, David S
**Subject:** FW: Design Procedures and Criteria for Annulus Pumping

-----Original Message-----
**From:** Reberger, Dan W
**Sent:** Friday, December 17, 1999 12:53 PM
**To:** Rarig, Bradley K
**Cc:** Hauck, Frank M (Marshall); Baide, Daniel G (Dan); Lepka, Stanley J (Stan)
**Subject:** Design Procedures and Criteria for Annulus Pumping

The design of any jumper or pump piping assembly for annulus pumping, is expected to have Design Pressure, Thermal Expansion, Sustained and Seismic load calculations performed and documented. The calculation documentation should be issued as a Supporting Document. The preferred material for the pump assembly is stainless steel. All materials for trailer racks and instrument skids can be carbon steel.

**Design Criteria:**
The design and analysis of jumper/pump piping shall be in accordance with the following criteria:
1. HNF-PRO-097, Rev-0 Engineering Design and Evaluation
2. WHC-SD-W236A-DA-002, Rev-0 Stress Analysis of Single port Jumper Connectors

**Design Codes & Standards:**
1. ASME Code B31.3a 1996 "Process Piping"
2. WHC-SD-RE-DGS-002 Rev -3 Jumper Design Standard

**Design Parameters:**

| | |
|---|---|
| 1. Design Pressure | 300 psig |
| 2. Design Temperature | 340° F |
| 3. Corrosion Allowance | 1.0 mils/yr. |
| 4. Waste Specific Gravity | 1.30 |
| 5. Classification | General Service |

**Dorsh, Paul M**
**From:** Reberger, Dan W
**Sent:** Tuesday, January 25, 2000 7:38 AM
**To:** Hauck, Frank M (Marshall)
**Cc:** Rarig, Bradley K; Dorsh, Paul M; Peck, David J; Leshikar, Gregory A
**Subject:** Draft Design Criteria for Annulus pumps -Revision
I forgot the criteria on Flammable Gas Controls and pressure.

---

In our recent meetings on annulus pumping, it was apparent that the pumping specifications previously provided were not adequate. I'm currently in the process of developing a technical rational for the Pump Design Criteria. The following is a draft of the criteria. Let me know if there are any questions or concerns.

**Submersible Centrifugal**

| | |
|---|---|
| Total Flow | 50 - 300* gpm |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centipoise |
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$ F |
| Discharge Pressure | 230 maximum** |
| Flammable Gas Controls | Ignition Source Control Set #1 (Class 1 Division 1 GroupB or equivalent)*** |
| Waste Flow | 33 - 200 gpm**** |
| Dilution water Flow | 17 - 100 gpm**** |

* The maximum flow rate of 300 gpm is based on an accident in the Tank Farm FSAR 3.4.2.7 Surface Leak Resulting in a Pool.

** Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

*** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**** The dilution water flow may be required to be as high as 50% of the waste flow. It's recognized that design constraints may prevent reaching dilution water flows above 40 gpm. In this case throttling existing waste line valves will be used to set the proper dilution. The design constraints anticipated are water supply pressure, pressure drop through hose connections, and the limiting pipe diameter that can be coupled with the pump assemblies.

**Heel Pump**

| | |
|---|---|
| Total Flow | 2 - 5 gpm |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centipoise |
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$ F |
| Discharge Pressure | 230 maximum* |
| Flammable Gas Controls | Ignition Source Control Set #1 (Class 1 Division 1 GroupB or equivalent)** |
| Dilution water Flow | None Required |

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

* Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

## M A T E R I A L  A L L O W A B L E  D A T A  L I S T I N G

| Material Name | Pipe ID | Temper. deg F | Allow. psi |
|---|---|---|---|
| A312-TP304L | 2"PIPE | 65.0 | 16700.0 |
| | | 340.0 | 16340.0 |



## TEMPERATURE AND PRESSURE DATA

| POINT NAME | CASE 1 PRESS. psi | CASE 1 TEMPER deg F | CASE 1 EXPAN. in/100ft | CASE 2 PRESS. psi | CASE 2 TEMPER deg F | CASE 2 EXPAN. in/100ft | CASE 3 PRESS. psi | CASE 3 TEMPER deg F | CASE 3 EXPAN. in/100ft |
|---|---|---|---|---|---|---|---|---|---|
| *** SEGMENT A | | | | | | | | | |
| A00 | 300 | 340 | 3.133 | | | | | | |
| A18 | 300 | 340 | 3.133 | | | | | | |
| *** SEGMENT B | | | | | | | | | |
| A11 | 300 | 340 | 3.133 | | | | | | |
| B07 | 300 | 340 | 3.133 | | | | | | |

RPP-4485 REV.0

309

H O T M O D U L U S (E6 psi )

| POINT NAME | CASE 1 | CASE 2 | CASE 3 |
|---|---|---|---|
| *** SEGMENT A | | | |
| A00 | 26.802 | | |
| A18 | 26.802 | | |
| *** SEGMENT B | | | |
| A11 | 26.802 | | |
| B07 | 26.802 | | |

* Non-standard material



H O T A L L O W A B L E S (psi )

| POINT NAME | CASE 1 ALLOW | CASE 1 NOT USED | CASE 1 NOT USED | CASE 2 ALLOW | CASE 2 NOT USED | CASE 2 NOT USED | CASE 3 ALLOW | CASE 3 NOT USED | CASE 3 NOT USED |
|---|---|---|---|---|---|---|---|---|---|
| *** SEGMENT A | | | | | | | | | |
| A00 | 16340 | | | | | | | | |
| A18 | 16340 | | | | | | | | |
| *** SEGMENT B | | | | | | | | | |
| A11 | 16340 | | | | | | | | |
| B07 | 16340 | | | | | | | | |

< User-defined code allowable
* Non-code material

RPP. 6485 Rev. 0

```
     *                        *******   **  *******   *******
    ***             **        **    **  **  **    **  **
   ** **           ******      **    **  **  **    **  **
  **   **    **   **  **   *****  *******   **  *******   *****
 *********  **   **  **  **   **  **        **  **        **
**       **  **   **  **  **   **  **        **  **        **
**        **  *****   **   *****   **        **  **        *******
```

Pipe Stress Analysis and Design Program

Version: 6.00.16

Edition: Plus-Win

Developed and Maintained by

REBIS Industrial Workgroup Software
1600 Riviera Ave., Suite 300
Walnut Creek, CA 94596



```
************************************************************
**                                                        **
**            AUTOPIPE SYSTEM DATA LISTING                **
**                                                        **
************************************************************
```

SYSTEM NAME : AN01-07B

PROJECT ID : PUMP PIT 241-AN-01B THRU -07B
JUMPER PIPING ANALYSIS

PREPARED BY : M. Ahmed
M.M. AHMED

CHECKED BY : Jennifer Williamson

PIPING CODE : B31.3

VERTICAL AXIS : Y

AMBIENT TEMPERATURE : 65.0 deg F

COMPONENT LIBRARY : AUTOPIPE

MATERIAL LIBRARY : AUTOB313

MODEL REVISION NUMBER : 4

RPP-14485 Rev.0

365

## POINT DATA LISTING

| POINT NAME | TYPE | OFFSETS (ft) X | Y | Z | DESCRIPTION |
|---|---|---|---|---|---|
| *** SEGMENT A | | | | | |
| A00 | Run | 0 | 0 | 0 | PIPE ID = 2"PIPE |
| A01 | Flex | 0.30 | 0 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| A02 | Run | 0.10 | 0 | 0 | |
| A03 | Bend | 0.30 | 0 | 0 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| A04 | Bend | 0 | -0.50 | 0 | Long Elbow, Radius = 3.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 1.73, Out = 1.44<br>Flex = 4.404 |
| A05 | Bend | 0.65 | 0 | 0 | Long Elbow, Radius = 3.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 1.73, Out = 1.44<br>Flex = 4.404 |
| A06 | Run | 0 | -0.37 | 0 | |
| A07 | Run | 0 | -1.06 | 0 | |
| A08 | Bend | 0 | -1.45 | 0 | Long Elbow, Radius = 3.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 1.73, Out = 1.44<br>Flex = 4.404 |
| A09 | Valv | -0.11 | 0 | 0.43 | GATE-F , Rating = Non-standard<br>Weight = 20 lb<br>Surface factor = 1.00<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| A10 | Run | -0.08 | 0 | 0.29 | |
| A11 | Tee | 0 | 0 | 0.02 | |
| A12 | Valv | -0.01 | 0 | 0.02 | GATE-F , Rating = Non-standard<br>Weight = 20 lb<br>Surface factor = 1.00<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| A13 | Run | -0.08 | 0 | 0.29 | |
| A14 | Run | -0.19 | 0 | 0.71 | |
| A15 | Bend | -0.09 | 0 | 0.32 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| A16 | Flex | 0 | -0.30 | 0 | Wt= 38 lb , Ar= 3.4 sq.in |



## POINT DATA LISTING

| POINT NAME | TYPE | OFFSETS (ft) X | Y | Z | DESCRIPTION |
|---|---|---|---|---|---|
| | | | | | Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| A17 | Run | 0 | -0.10 | 0 | |
| A18 | Run | 0 | -0.30 | 0 | |
| *** SEGMENT B | | | | | |
| A11 | Tee | 1.16 | -3.38 | 0.74 | PIPE ID = 2"PIPE |
| B01 | Valv | 0 | 0 | 0.01 | GATE-F , Rating = Non-standard<br>Weight = 20 lb<br>Surface factor = 1.00<br>Butt welded, SIF = 1.00<br>Without taper, Offset = 0.000 inch |
| B02 | Run | 0.29 | 0 | 0.08 | |
| B03 | Run | 0.25 | 0 | 0.07 | |
| B04 | Bend | 0.61 | 0 | 0.17 | Short Elbow, Radius = 2.00 inch<br>Bend angle change = 90.00 deg<br>SIF - In 2.27, Out = 1.89<br>Flex = 6.606 |
| B05 | Flex | 0 | -0.30 | 0 | Wt= 38 lb , Ar= 3.4 sq.in<br>Axial= 13500000 Tors= 108.0<br>Y-Shear= 27800.0 Bend= 656.0<br>Z-Shear= 27800.0 Bend= 656.0 |
| B06 | Run | 0 | -0.10 | 0 | |
| B07 | Run | 0 | -0.30 | 0 | |

Total weight of empty pipes : 29 lb



RAP-6485 Rev. 0

306

1/1 4PRINT

## COMPONENT DATA LISTING

| POINT NAME | COORDINATE(ft) X | Y | Z | DATA TYPE | DESCRIPTION |
|---|---|---|---|---|---|
| *** SEGMENT A | | | | | |
| A00 | 0.00 | 0.00 | 0.00 | ANCHOR | Rigid<br>Thermal movements : None |
| A01 | 0.30 | 0.00 | 0.00 | | |
| A02 | 0.40 | 0.00 | 0.00 | | |
| A03 N | 0.53 | 0.00 | 0.00 | | |
| A03 | 0.70 | 0.00 | 0.00 | TI | |
| A03 F | 0.70 | -0.17 | 0.00 | | |
| A04 N | 0.70 | -0.25 | 0.00 | | |
| A04 | 0.70 | -0.50 | 0.00 | TI | |
| A04 F | 0.95 | -0.50 | 0.00 | | |
| A05 N | 1.10 | -0.50 | 0.00 | | |
| A05 | 1.35 | -0.50 | 0.00 | TI | |
| A05 F | 1.35 | -0.75 | 0.00 | | |
| A06 | 1.35 | -0.87 | 0.00 | GUIDE | ID : A06 1, Connected to Ground<br>Stiffness = RIGID<br>Gap -Z = 0.06 inch<br>Gap +Z = 0.06 inch<br>Gap -X = 0.06 inch<br>Gap +X = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| A07 | 1.35 | -1.93 | 0.00 | GUIDE | ID : A07 1, Connected to Ground<br>Stiffness = RIGID<br>Gap -Z = 0.06 inch<br>Gap +Z = 0.06 inch<br>Gap -X = 0.06 inch<br>Gap +X = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| A08 N | 1.35 | -3.13 | 0.00 | | |
| A08 | 1.35 | -3.38 | 0.00 | TI | |
| A08 F | 1.29 | -3.38 | 0.24 | | |
| A09 | 1.24 | -3.38 | 0.43 | | |
| A10 | 1.16 | -3.38 | 0.72 | | |
| A11 | 1.16 | -3.38 | 0.74 | TEE | B16.9 welding tee<br>SIF - In = 1.19, Out = 1.25 |
| A12 | 1.15 | -3.38 | 0.76 | | |
| A13 | 1.08 | -3.38 | 1.05 | | |
| A14 | 0.89 | -3.38 | 1.76 | GUIDE | ID : A14 1, Connected to Ground<br>Stiffness = RIGID<br>Gap-down = 0.06 inch<br>Gap-Above = 0.06 inch<br>Gap-left = 0.06 inch<br>Gap-Right = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| | | | | WEIGHT | 26 lb , No offsets |
| A15 N | 0.84 | -3.38 | 1.92 | | |
| A15 | 0.80 | -3.38 | 2.08 | TI | |
| A15 F | 0.80 | -3.55 | 2.08 | | |
| A16 | 0.80 | -3.68 | 2.08 | | |



## COMPONENT DATA LISTING

| POINT NAME | COORDINATE(ft) X | Y | Z | DATA TYPE | DESCRIPTION |
|---|---|---|---|---|---|
| A17 | 0.80 | -3.78 | 2.08 | | |
| A18 | 0.80 | -4.08 | 2.08 | ANCHOR | Rigid<br>Thermal movements : None |
| *** SEGMENT B | | | | | |
| A11 | 1.16 | -3.38 | 0.74 | TEE | B16.9 welding tee<br>SIF - In = 1.19, Out = 1.25 |
| B01 | 1.16 | -3.38 | 0.75 | | |
| B02 | 1.45 | -3.38 | 0.83 | | |
| B03 | 1.70 | -3.38 | 0.90 | GUIDE | ID : B03 1, Connected to Ground<br>Stiffness = RIGID<br>Gap-down = 0.06 inch<br>Gap-Above = 0.06 inch<br>Gap-left = 0.06 inch<br>Gap-Right = 0.06 inch<br>Friction = 0.00<br>Gaps set Weightless |
| | | | | WEIGHT | 26 lb , No offsets |
| B04 N | 2.15 | -3.38 | 1.03 | WEIGHT | 26 lb , Offsets in ft<br>DX = 0.60, DY = 0.00, DZ = 0.00 |
| B04 | 2.31 | -3.38 | 1.07 | TI | |
| B04 F | 2.31 | -3.55 | 1.07 | | |
| B05 | 2.31 | -3.68 | 1.07 | | |
| B06 | 2.31 | -3.78 | 1.07 | | |
| B07 | 2.31 | -4.08 | 1.07 | ANCHOR | Rigid<br>Thermal movements : None |

Number of points in the system : 39

RPP-6495 Rev.0

317

## PIPE DATA LISTING

| Pipe ID/ Material | Nom/ Sch | O.D. inch | Thickness(inch) W.Th. | Corr | Mill | Insu | Ling | Spec Grav | Weight(lb/ft) Pipe | Other | Total | ZL/ ZC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2"PIPE | 2.000 | 2.375 | 0.154 | 0.02 | 0.02 | 0 | 0 | 1.50 | 3.74 | 0 | 5.92 | 1.00 |
| A312-TP304L | STD | | | | | | | | | | | 1.00 |



## MATERIAL DATA LISTING

| Material Name | Pipe ID | Density lb/cu.ft | Pois. Ratio | Temper. deg F | Modulus E6 psi Axial | Hoop | Shear | Expans. in/100ft |
|---|---|---|---|---|---|---|---|---|
| A312-TP304L | 2"PIPE | 501.0 | 0.30 | 65.0 | 28.320 | 28.320 | 10.892 | |
| | | | | 340.0 | 26.802 | | | 3.1325 |

RPP-6485 REV. 0

308

| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX | Page: i of ii<br>Date: 07/11/00 |
|---|---|---|

This sheet shows the status and description of the attached Design Analysis sheets

Discipline: 454 Project/Area/Unit: 65100541/25/9 Calculation No.: DSTAP-P-005

Project No. & Name: Double Shell Tank Annulus Pumping

Calculation Item: DST Annulus Pump Test Piping Line Loss

These calculations apply to:

Drawing No.: N/A Rev. No:

Drawing No.: Rev. No:

Other (Study, CDR): Rev. No.

The status of these calculations is:

[] Preliminary Calculations

[X] Final Calculations

[] Check Calculations (On Calculation Dated )

[] Void Calculation (Reason Voided )

Incorporated in Final Drawings? [] Yes [X] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | Paul M. Dirk 7/11/00 | | |
| Checked by | Jennifer Williamson 7/17/00 | | |
| Approved by | JM Hanson 7/18/00 | | |
| Checked Against Approved Vendor Data | | | |

INDEX


| Design Analysis Page No. | Description |
|---|---|
| 1 | Objective, Design Criteria, Methods, Assumptions |
| 2 | Assumptions Cont, References, Conclusions |
| 3-10 | Calculations |
| Appendix A | Attached References |
| A1-A6 | Crane Technical Paper No. 410 |
| A7-A8 | Engineering Fluid Mechanics |
| A9 | Engineering Sketch ES-259-001, Rev. 0 |
| Appendix B | Test System Curve |
| B1 | DST Annulus Pumping Test System Curve |
| | |
| | |

RPP-6485 Rev. 0

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-005
Revision No.: 0
Page No.: 1 of 4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP TEST PIPING LINE LOSS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 07 / 11 / 00 By: P. M. DORSH
Checked: 7/17/00 By: J. Williamson
Revised: By:

## OBJECTIVE:

The objective of this calculation is to determine the line loss, at various flow rates, of the piping used to test the Double Shell Tank Annulus Pumps and develop a system curve from this information.

## DESIGN INPUT:

1.) Test Skid Submersible Pump Arrangement, Engineering Sketch ES-259-001, Rev. 0.

## METHODS:

1.) The Darcy-Weisbach equation is used in determining the friction pressure losses.

2.) Friction losses due to standard fittings are calculated using the pipe resistance coefficients (K factors) found in Crane Technical Paper No. 410.

3.) For this calculation, a flow rate value of 90 GPM was arbitrarily chosen to show how the line losses were determined. This value was then varied throughout the range of 0 to 160 GPM and the corresponding line loss value recorded. These points were then used to develop a system curve.

## ASSUMPTIONS:

1.) The test fluid will be water and the temperature will not be above 80 degrees F during the testing.

2.) There are no losses through the magnetic flow meter.

3.) The equivalent roughness of the pipe is 0.00015 ft.

## REFERENCES:

1.) Crane Technical Paper No. 410, *Flow of Fluids Through Valves, Fittings, and Pipe*.

2.) *Engineering Fluid Mechanics*, Sixth Edition, Roberson and Crowe.

3.) Test Skid Submersible Pump Arrangement, Engineering Sketch ES-259-001, Rev. 0.

All References are located in Appendix A.

## CONCLUSIONS:

The head required by the test piping at 90 GPM is 50.9 ft. A chart of the head required by the test piping at various flow rates is seen on page 4. A Test System Curve can be seen in Appendix B.

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-005
Revision No.: 0
Page No.: 2 of 4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP TEST PIPING LINE LOSS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 07 / 11 / 00 By: P. M. DORSH
Checked: 7/17/00 By: J Williamson
Revised: By:

---

**Fluid Characteristics**

| | | | |
|---|---|---|---|
| Flow Rate | $Q := 90 \cdot GPM$ | | |
| Density of Water @ 80 F | $\rho := 62.22 \cdot \frac{lb}{ft^3}$ | | (Ref. 2, A8) |
| Dynamic Viscosity | $\mu := 0.85 \cdot cp$ | | (Ref. 1, A2) |
| Pipe Roughness | $k_s := 0.00015 \cdot ft$ | | (Assum. 3) |

**Resistance Coefficients - 3" sch 40 Pipe**

| | | | |
|---|---|---|---|
| Pipe Inside Diameter | $D_2 := 3.068 \cdot in$ | | |
| Inside Area | $A := \frac{\pi \cdot D_2^2}{4}$ | $A = 7.393 \cdot in^2$ | |
| Fluid Velocity | $V := \frac{Q}{A}$ | $V = 3.906 \cdot \frac{ft}{sec}$ | |
| 3" Complete Turbulence Friction Factor | $f_t := 0.018$ | | (Ref. 1, A3) |
| 90 Degree Elbow | $K_1 := 30 \cdot f_t$ | $K_1 = 0.54$ | (Ref. 1, A6) |
| Reynolds Number | $Re := \frac{V \cdot D_2 \cdot \rho}{\mu}$ | $Re = 1.1 \cdot 10^5$ | |
| Friction Factor | $f := \frac{0.25}{\log\left(\frac{k_s}{3.7 \cdot D_2} + \frac{5.74}{Re^{0.9}}\right)^2}$ | $f = 0.021$ | (Ref. 2, A7) |
| Approximate Length of 3" Pipe | $L := 3 \cdot ft$ | | |
| 3" Friction Head Loss | $h_1 := \left(K_1 + f \cdot \frac{L}{D_2}\right) \cdot \frac{V^2}{2 \cdot g}$ | $h_1 = 0.185 \cdot ft$ | (Ref. 1, A1) |

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-005
Revision No.: 0
Page No.: 3 of 4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP TEST PIPING LINE LOSS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 07 / 11 / 00 By: P. M. DORSH
Checked: 7 / 17 / 00 By: J. Williamsons
Revised: By:

---

**Resistance Coefficients - 1-1/2" sch 40 Pipe**

| | | | |
|---|---|---|---|
| Pipe Inside Diameter | $D_1 := 1.61 \cdot in$ | | |
| Inside Area | $A := \frac{\pi \cdot D_1^2}{4}$ | $A = 2.036 \cdot in^2$ | |
| Fluid Velocity | $V := \frac{Q}{A}$ | $V = 14.183 \cdot \frac{ft}{sec}$ | |
| 1-1/2" Complete Turbulence Friction Factor | $f_t := 0.021$ | | |
| 3" to 1-1/2" Contraction (Sudden) | $\beta := \frac{D_1}{D_2}$ | $\beta = 0.525$ | (Ref. 1, A3) |
| | $K_1 := \frac{0.5 \cdot (1 - \beta^2) \cdot \sqrt{\sin\left(\frac{180 \cdot deg}{2}\right)}}{\beta^4}$ | $K_1 = 4.777$ | (Ref. 1, A3) |
| Tee - Run Flow Qty = 2 | $K_2 := (20 \cdot f_t) \cdot 2$ | $K_2 = 0.84$ | (Ref. 1, A6) |
| Tee - Branch Flow Qty = 1 | $K_3 := 60 \cdot f_t$ | $K_3 = 1.26$ | (Ref. 1, A6) |
| Globe Valve Qty = 1 | $K_4 := 340 \cdot f_t$ | $K_4 = 7.14$ | (Ref. 1, A4) |
| Ball Valve Qty = 1 | $K_5 := 3 \cdot f_t$ | $K_5 = 0.063$ | (Ref. 1, A5) |
| Pipe Exit | $K_6 := 1$ | | (Ref. 1, A6) |
| Total Resistance Coefficients | $K := \sum_{i=1}^{6} K_i$ | $K = 15.08$ | |
| Reynolds Number | $Re := \frac{V \cdot D_1 \cdot \rho}{\mu}$ | $Re = 2.1 \cdot 10^5$ | |

**FLUOR FEDERAL SERVICES**

Calc. No.: DSTAP-P-005
Revision No.: 0
Page No.: 4 of 4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP TEST PIPING LINE LOSS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 07 / 11 / 00 By: P. M. DORSH
Checked: 7/17/00 By: J. Williamson
Revised: By:

Friction Factor $f := \frac{0.25}{\log\left(\frac{k_s}{3.7 \cdot D_1} + \frac{5.74}{Re^{0.9}}\right)^2}$ $f = 0.022$ (Ref. 2, A7)

Approximate Length of 1-1/2" Pipe $L := 7 \cdot ft$

1-1/2" Friction Head Loss $h_2 := \left(K + f \cdot \frac{L}{D_1}\right) \cdot \frac{V^2}{2 \cdot g}$ $h_2 = 50.669 \cdot ft$ (Ref. 1, A1)

**Total Friction Head Loss** $h_L := h_1 + h_2$ $h_L = 50.854 \cdot ft$

The following is a chart of the test piping head requirements at various flow rates. The Test System Curve can be seen in Appendix B.

| Test System Curve | |
|---|---|
| Flow Rate (GPM) | Head (ft) |
| 0 | 0 |
| 30 | 5.7 |
| 60 | 22.6 |
| 90 | 50.9 |
| 120 | 90.3 |
| 140 | 122.9 |
| 160 | 160.4 |

# CALCULATION NO: DSTAP-P-005, Rev. 0
# APPENDIX A

## References

NOMENCLATURE

EQUATIONS

## Summary of Formulas

### ● Head loss and pressure drop through valves and fittings

Head loss through valves and fittings is generally given in terms of resistance coefficient $K$ which indicates static head loss through a valve in terms of "velocity head", or, equivalent length in pipe diameters $L/D$ that will cause the same head loss as the valve.

From Darcy's formula, head loss through a pipe is:

$$h_L = f \frac{L}{D} \frac{v^2}{2g} \qquad \textbf{Equation 3-5}$$

and head loss through a valve is:

$$h_L = K \frac{v^2}{2g} \qquad \textbf{Equation 3-14}$$

therefore: $$K = f \frac{L}{D} \qquad \textbf{Equation 3-15}$$

To eliminate needless duplication of formulas, the following are all given in terms of $K$. Whenever necessary, substitute $(f\ L/D)$ for $(K)$.

$$h_L = \frac{522\ Kq^2}{d^4} = 0.002\,59 \frac{KQ^2}{d^4} \qquad \textbf{Equation 3-14}$$

$$h_L = 0.001\,270 \frac{KB^2}{d^4} = 0.000\,0403 \frac{KW'^2\overline{V}^2}{d^4}$$

$$\Delta P = 0.000\,1078\ K\rho v^2 = 0.000\,000\,0300\ K\rho V^2$$

$$\Delta P = 3.62 \frac{K\rho q^2}{d^4} = 0.000\,017\,99 \frac{K\rho Q^2}{d^4}$$

$$\Delta P = 0.000\,008\,82 \frac{K\rho B^2}{d^4}$$

$$\Delta P = 0.000\,000\,280 \frac{KW'^2\overline{V}}{d^4}$$

$$\Delta P = 0.000\,000\,000\,605 \frac{K(q'_h)^2\ T\ S_g}{d^4\ P'}$$

$$\Delta P = 0.000\,000\,001\,633 \frac{K\ (q'_h)^2\ S_g^2}{d^4\ \rho}$$

For compressible flow with $h_L$ or $\Delta P$ greater than approximately 10% of inlet absolute pressure, the denominator should be multiplied by $Y^2$. For values of Y, see page A-22.

### ● Pressure drop and flow of liquids of low viscosity using flow coefficient

$$\Delta P = \left(\frac{Q}{C_V}\right)^2 \frac{\rho}{62.4} \qquad \textbf{Equation 3-16}$$

$$Q = C_V \sqrt{\Delta P \frac{62.4}{\rho}} = 7.90\ C_V \sqrt{\frac{\Delta P}{\rho}}$$

$$C_V = Q \sqrt{\frac{\rho}{\Delta P\ (62.4)}} = \frac{29.9\ d^2}{\sqrt{f L/D}} = \frac{29.9\ d^2}{\sqrt{K}}$$

$$K = \frac{891\ d^4}{(C_V)^2}$$

### ● Resistance coefficient, K, for sudden and gradual enlargements in pipes

If, $\theta \leq 45°$,

$$K_1 = 2.6 \sin \frac{\theta}{2} (1 - \beta^2)^2 \qquad \textbf{*Equation 3-17}$$

If, $45° < \theta \leq 180°$,

$$K_1 = (1 - \beta^2)^2 \qquad \textbf{*Equation 3-17.1}$$

### ● Resistance coefficient, K, for sudden and gradual contractions in pipes

If, $\theta \leq 45°$,

$$K_1 = 0.8 \sin \frac{\theta}{2} (1 - \beta^2) \qquad \textbf{*Equation 3-18}$$

If, $45° < \theta \leq 180°$,

$$K_1 = 0.5 \sqrt{\sin \frac{\theta}{2}}\ (1 - \beta^2) \qquad \textbf{*Equation 3-18.1}$$

**Note:* The values of the resistance coefficients ($K$) in equations 3-17, 3-17.1, 3-18, and 3-18.1 are based on the velocity in the small pipe. To determine $K$ values in terms of the greater diameter, divide the equations by $\beta^4$.

### ● Discharge of fluid through valves, fittings, and pipe; Darcy's formula

**Liquid flow:** **Equation 3-19**

$$q = 0.0438\ d^2 \sqrt{\frac{h_L}{K}} = 0.525\ d^2 \sqrt{\frac{\Delta P}{K\rho}}$$

$$Q = 19.65\ d^2 \sqrt{\frac{h_L}{K}} = 236\ d^2 \sqrt{\frac{\Delta P}{K\rho}}$$

$$w = 0.0438\ \rho d^2 \sqrt{\frac{h_L}{K}} = 0.525\ d^2 \sqrt{\frac{\Delta P \rho}{K}}$$

$$W = 157.6\ \rho d^2 \sqrt{\frac{h_L}{K}} = 1891\ d^2 \sqrt{\frac{\Delta P \rho}{K}}$$

**Compressible flow:**

$$q'_h = 40\,700\ Yd^2 \sqrt{\frac{\Delta P\ P'_1}{KT_1\ S_g}} \qquad \textbf{Equation 3-20}$$

$$q'_h = 24\,700 \frac{Yd^2}{S_g} \sqrt{\frac{\Delta P\ \rho_1}{K}}$$

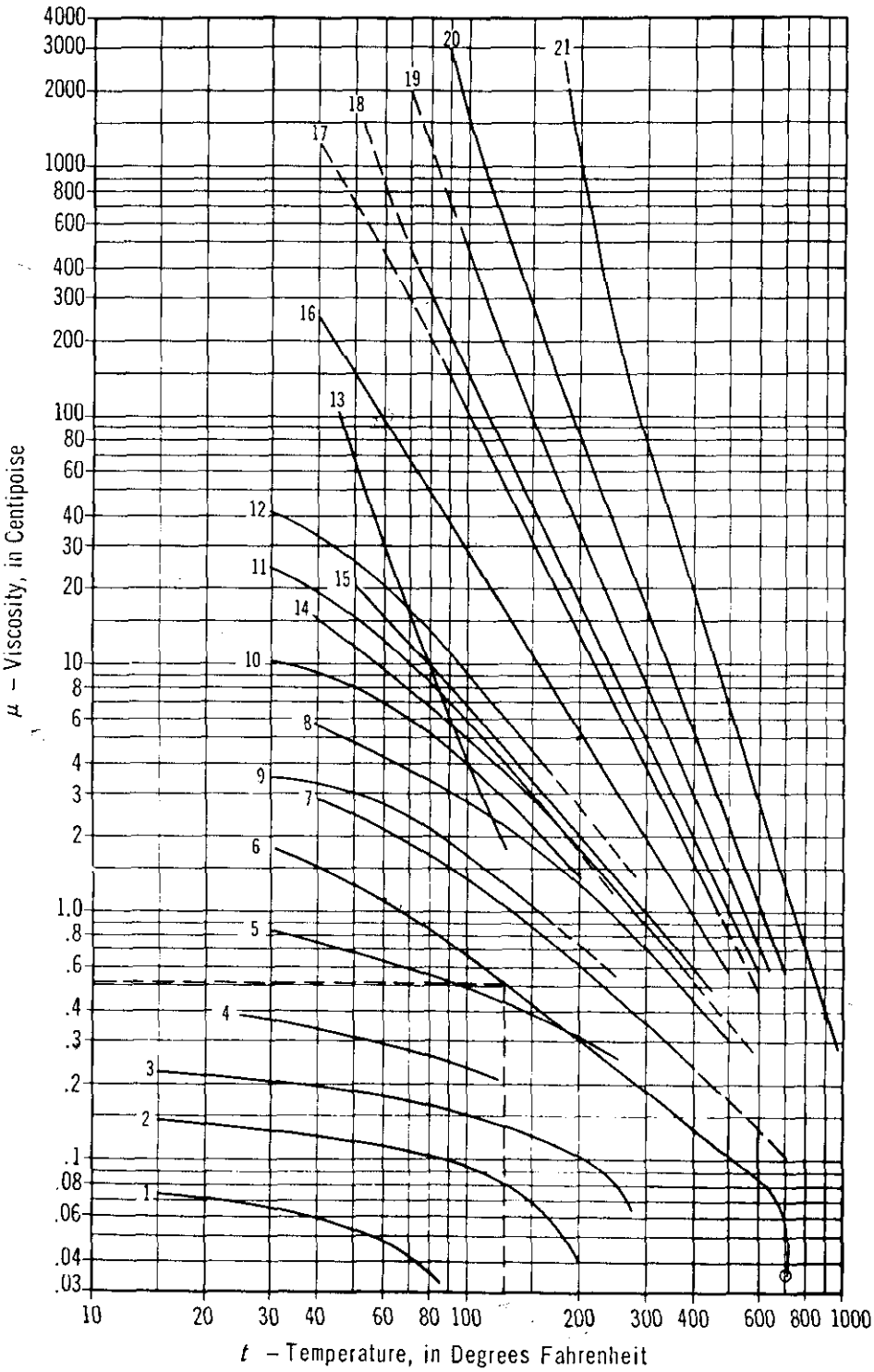
$$q'_m = 678\ Yd^2 \sqrt{\frac{\Delta P\ P'_1}{KT_1\ S_g}} = 412 \frac{Yd^2}{S_g} \sqrt{\frac{\Delta P\ \rho_1}{K}}$$

$$q' = 11.30\ Yd^2 \sqrt{\frac{\Delta P P'_1}{KT_1\ S_g}} = 6.87 \frac{Yd^2}{S_g} \sqrt{\frac{\Delta P \rho_1}{K}}$$

$$w = 0.525\ Yd^2 \sqrt{\frac{\Delta P}{K\overline{V}_1}} \qquad W = 1891\ Yd^2 \sqrt{\frac{\Delta P}{K\overline{V}_1}}$$

Values of $Y$ are shown on page A-22. For $K$, $Y$, and $\Delta P$ determination, see examples on pages 4-13 and 4-14.

# Viscosity of Water and Liquid Petroleum Products[8, 12, 23]




1. Ethane ($C_2H_6$)
2. Propane ($C_3H_8$)
3. Butane ($C_4H_{10}$)
4. Natural Gasoline
5. Gasoline
6. Water
7. Kerosene
8. Distillate
9. 48 Deg. API Crude
10. 40 Deg. API Crude
11. 35.6 Deg. API Crude
12. 32.6 Deg. API Crude
13. Salt Creek Crude
14. Fuel 3 (Max.)
15. Fuel 5 (Min.)
16. SAE 10 Lube (100 V.I.)
17. SAE 30 Lube (100 V.I.)
18. Fuel 5 (Max.) or Fuel 6 (Min.)
19. SAE 70 Lube (100 V.I.)
20. Bunker C Fuel (Max.) and M.C. Residuum
21. Asphalt

Data extracted in part by permission from the Oil and Gas Journal.

**Example:** The viscosity of water at 125 F is 0.52 centipoise (Curve No. 6).

"K" FACTOR TABLE—SHEET 1 of 4

# Representative Resistance Coefficients (K) for Valves and Fittings

*("K" is based on use of schedule pipe as listed on page 2-10)*

## PIPE FRICTION DATA FOR CLEAN COMMERCIAL STEEL PIPE WITH FLOW IN ZONE OF COMPLETE TURBULENCE

| Nominal Size | ½" | ¾" | 1" | 1¼" | 1½" | 2" | 2½, 3" | 4" | 5" | 6" | 8-10" | 12-16" | 18-24" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Friction Factor ($f_T$) | .027 | .025 | .023 | .022 | .021 | .019 | .018 | .017 | .016 | .015 | .014 | .013 | .012 |

## FORMULAS FOR CALCULATING "K" FACTORS* FOR VALVES AND FITTINGS WITH REDUCED PORT

(Ref: Pages 2-11 and 3-4)

- **Formula 1**

$$K_2 = \frac{0.8\left(\sin\frac{\theta}{2}\right)(1-\beta^2)}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 2**

$$K_2 = \frac{0.5\,(1-\beta^2)\sqrt{\sin\frac{\theta}{2}}}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 3**

$$K_2 = \frac{2.6\left(\sin\frac{\theta}{2}\right)(1-\beta^2)^2}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 4**

$$K_2 = \frac{(1-\beta^2)^2}{\beta^4} = \frac{K_1}{\beta^4}$$

- **Formula 5**

$$K_2 = \frac{K_1}{\beta^4} + \text{Formula 1} + \text{Formula 3}$$

$$K_2 = \frac{K_1 + \sin\frac{\theta}{2}\left[0.8\,(1-\beta^2) + 2.6\,(1-\beta^2)^2\right]}{\beta^4}$$

- **Formula 6**

$$K_2 = \frac{K_1}{\beta^4} + \text{Formula 2} + \text{Formula 4}$$

$$K_2 = \frac{K_1 + 0.5\sqrt{\sin\frac{\theta}{2}}\,(1-\beta^2) + (1-\beta^2)^2}{\beta^4}$$

- **Formula 7**

$$K_2 = \frac{K_1}{\beta^4} + \beta\,(\text{Formula 2} + \text{Formula 4}) \text{ when } \theta = 180^\circ$$

$$K_2 = \frac{K_1 + \beta\left[0.5\,(1-\beta^2) + (1-\beta^2)^2\right]}{\beta^4}$$

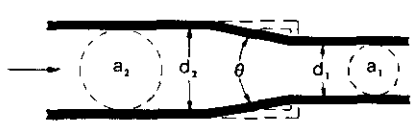
$$\beta = \frac{d_1}{d_2}$$

$$\beta^2 = \left(\frac{d_1}{d_2}\right)^2 = \frac{a_1}{a_2}$$

Subscript 1 defines dimensions and coefficients with reference to the smaller diameter.
Subscript 2 refers to the larger diameter.

***Use "K" furnished by valve or fitting supplier when available.**

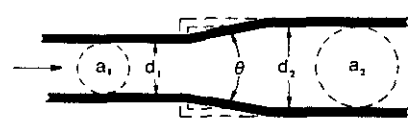
### SUDDEN AND GRADUAL CONTRACTION




If: $\theta \leq 45^\circ$ . . . . . $K_2$ = Formula 1

$45^\circ < \theta \leq 180^\circ$ . . . $K_2$ = Formula 2

### SUDDEN AND GRADUAL ENLARGEMENT




If: $\theta \leq 45^\circ$ . . . . . $K_2$ = Formula 3

$45^\circ < \theta \leq 180^\circ$ . . . $K_2$ = Formula 4

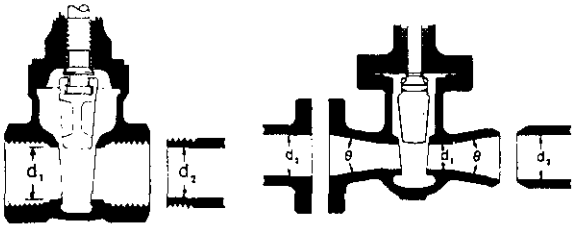
"K" FACTOR TABLE—SHEET 2 of 4

# Representative Resistance Coefficients (K) for Valves and Fittings

*(for formulas and friction data, see page A-26)*

*("K" is based on use of schedule pipe as listed on page 2-10)*

## GATE VALVES
### Wedge Disc, Double Disc, or Plug Type

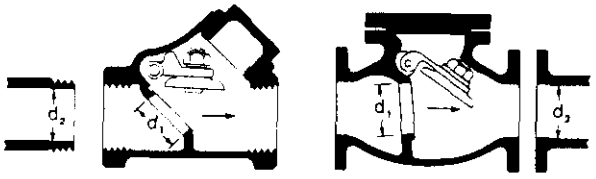



If: $\beta = 1$, $\theta = 0$ . . . . . $K_1 = 8 f_T$

$\beta < 1$ and $\theta \leq 45°$ . . . . . $K_2$ = Formula 5

$\beta < 1$ and $45° < \theta \leq 180°$ . . . $K_2$ = Formula 6

## SWING CHECK VALVES



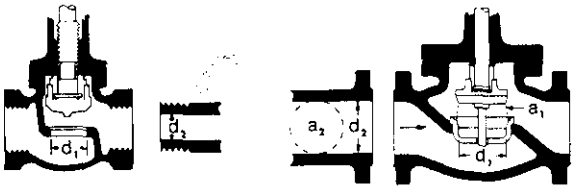

$K = 100 f_T$

Minimum pipe velocity (fps) for full disc lift $= 35 \sqrt{\bar{V}}$

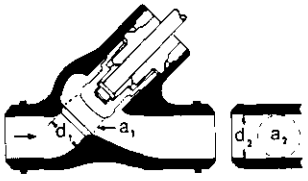
$K = 50 f_T$

Minimum pipe velocity (fps) for full disc lift $= 60 \sqrt{\bar{V}}$ except U/L listed $= 100 \sqrt{\bar{V}}$

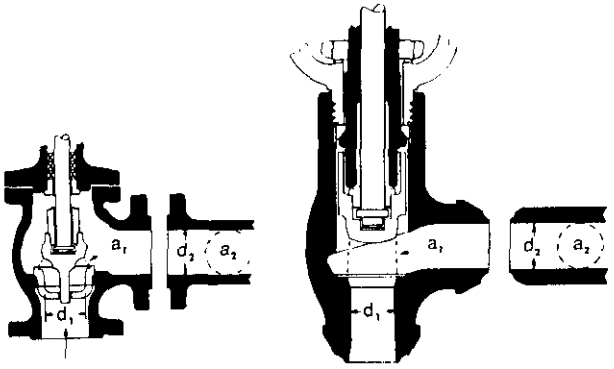
## GLOBE AND ANGLE VALVES




If: $\beta = 1 \ldots K_1 = 340 f_T$




If: $\beta = 1 \ldots K_1 = 55 f_T$

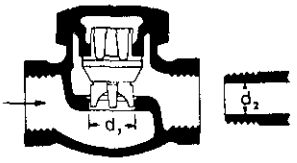



If: $\beta = 1 \ldots K_1 = 150 f_T$ If: $\beta = 1 \ldots K_1 = 55 f_T$

All globe and angle valves, whether reduced seat or throttled,

If: $\beta < 1 \ldots K_2$ = Formula 7

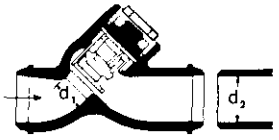
## LIFT CHECK VALVES




If: $\beta = 1 \ldots K_1 = 600 f_T$

$\beta < 1 \ldots K_2$ = Formula 7

Minimum pipe velocity (fps) for full disc lift $= 40 \beta^2 \sqrt{\bar{V}}$

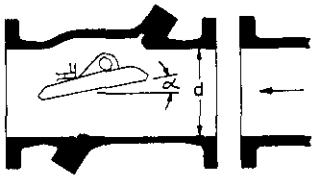



If: $\beta = 1 \ldots K_1 = 55 f_T$

$\beta < 1 \ldots K_2$ = Formula 7

Minimum pipe velocity (fps) for full disc lift $= 140 \beta^2 \sqrt{\bar{V}}$

## TILTING DISC CHECK VALVES




| | $\alpha = 5°$ | $\alpha = 15°$ |
|---|---|---|
| Sizes 2 to 8" . . . K = | $40 f_T$ | $120 f_T$ |
| Sizes 10 to 14" . . . K = | $30 f_T$ | $90 f_T$ |
| Sizes 16 to 48" . . . K = | $20 f_T$ | $60 f_T$ |
| Minimum pipe velocity (fps) for full disc lift = | $80 \sqrt{\bar{V}}$ | $30 \sqrt{\bar{V}}$ |

Calc No. DSTAP-P-005, Rev. 0
Ref. 1 A5 of A9

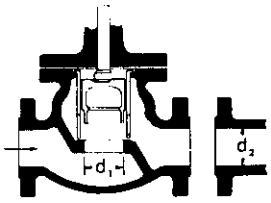
"K" FACTOR TABLE.

# Representative Resistance Coefficients (K) for Valves and Fittings

*(for formulas and friction data, see page A-26)*

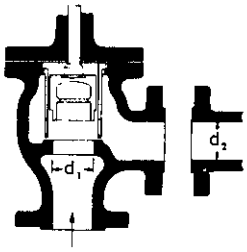
*("K" is based on use of scheduled pipe as listed on page 2-10)*

## STOP-CHECK VALVES (Globe and Angle Types)



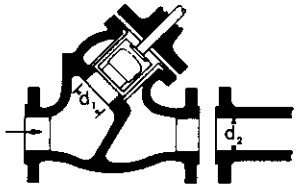

If:
$\beta = 1 \ldots K_1 = 400\, f_T$
$\beta < 1 \ldots K_2 =$ Formula 7

Minimum pipe velocity for full disc lift
$= 55\, \beta^2 \sqrt{\bar{V}}$

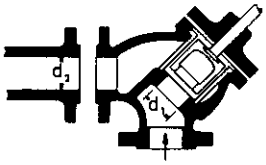



If:
$\beta = 1 \ldots K_1 = 200\, f_T$
$\beta < 1 \ldots K_2 =$ Formula 7

Minimum pipe velocity for full disc lift
$= 75\, \beta^2 \sqrt{\bar{V}}$

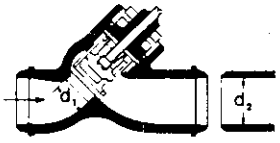



If:
$\beta = 1 \ldots K_1 = 300\, f_T$
$\beta < 1 \ldots K_2 =$ Formula 7

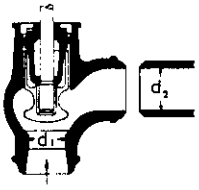



If:
$\beta = 1 \ldots K_1 = 350\, f_T$
$\beta < 1 \ldots K_2 =$ Formula 7

Minimum pipe velocity (fps) for full disc lift
$= 60\, \beta^2 \sqrt{\bar{V}}$




If:
$\beta = 1 \ldots K_1 = 55\, f_T$
$\beta < 1 \ldots K_2 =$ Formula 7




If:
$\beta = 1 \ldots K_1 = 55\, f_T$
$\beta < 1 \ldots K_2 =$ Formula 7

Minimum pipe velocity (fps) for full disc lift
$= 140\, \beta^2 \sqrt{\bar{V}}$

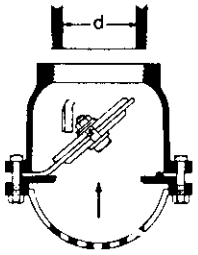
## FOOT VALVES WITH STRAINER

**Poppet Disc**

$K = 420 f_T$

Minimum pipe velocity (fps) for full disc lift
$= 15 \sqrt{\bar{V}}$

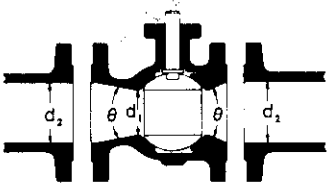
**Hinged Disc**




$K = 75 f_T$

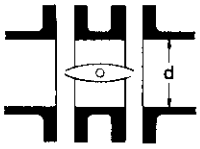
Minimum pipe velocity (fps) for full disc lift
$= 35 \sqrt{\bar{V}}$

## BALL VALVES




If: $\beta = 1,\ \theta = 0 \ldots\ldots\ldots\ldots K_1 = 3\, f_T$
$\beta < 1$ and $\theta \leq 45° \ldots\ldots\ldots K_2 =$ Formula 5
$\beta < 1$ and $45° < \theta \leq 180° \ldots K_2 =$ Formula 6

## BUTTERFLY VALVES




Sizes 2 to 8" . . . $K = 45\, f_T$
Sizes 10 to 14" . . . $K = 35\, f_T$
Sizes 16 to 24" . . . $K = 25\, f_T$

"K" FACTOR TABLE— SHEET 4 of 4

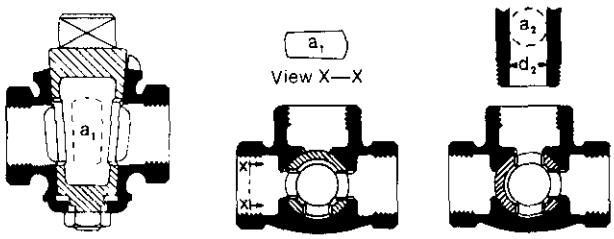
# Representative Resistance Coefficients (K) for Valves and Fittings

*(for formulas and friction data, see page A-26)*

*("K" is based on use of schedule pipe as listed on page 2-10)*

## PLUG VALVES AND COCKS

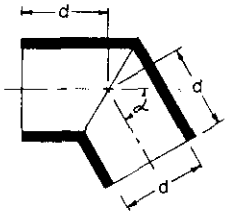
**Straight-Way** **3-Way**




If: $\beta = 1$, $K_1 = 18\, f_T$ | If: $\beta = 1$, $K_1 = 30\, f_T$ | If: $\beta = 1$, $K_1 = 90\, f_T$

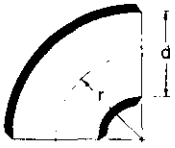
If: $\beta < 1 \ldots K_2$ = Formula 6

## MITRE BENDS




| α | K |
|---|---|
| 0° | 2 $f_T$ |
| 15° | 4 $f_T$ |
| 30° | 8 $f_T$ |
| 45° | 15 $f_T$ |
| 60° | 25 $f_T$ |
| 75° | 40 $f_T$ |
| 90° | 60 $f_T$ |

## 90° PIPE BENDS AND FLANGED OR BUTT-WELDING 90° ELBOWS



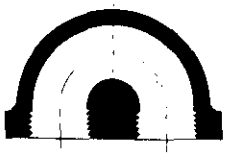

| r/d | K | r/d | K |
|---|---|---|---|
| 1 | 20 $f_T$ | 8 | 24 $f_T$ |
| 1.5 | 14 $f_T$ | 10 | 30 $f_T$ |
| 2 | 12 $f_T$ | 12 | 34 $f_T$ |
| 3 | 12 $f_T$ | 14 | 38 $f_T$ |
| 4 | 14 $f_T$ | 16 | 42 $f_T$ |
| 6 | 17 $f_T$ | 20 | 50 $f_T$ |

The resistance coefficient, $K_B$, for pipe bends other than 90° may be determined as follows:

$$K_B = (n - 1)\left(0.25\,\pi\, f_T \frac{r}{d} + 0.5\,K\right) + K$$

$n$ = number of 90° bends
$K$ = resistance coefficient for one 90° bend (per table)

## CLOSE PATTERN RETURN BENDS



$K = 50\, f_T$

## STANDARD ELBOWS

90° 45°

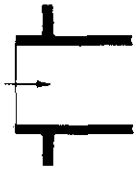
$K = 30\, f_T$ | $K = 16\, f_T$

## STANDARD TEES

Flow thru run. . . . . $K = 20\, f_T$
Flow thru branch. . . . $K = 60\, f_T$

## PIPE ENTRANCE

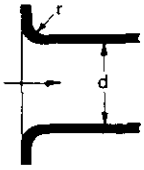
**Inward Projecting** **Flush**



$K = 0.78$

| r/d | K |
|---|---|
| 0.00* | 0.5 |
| 0.02 | 0.28 |
| 0.04 | 0.24 |
| 0.06 | 0.15 |
| 0.10 | 0.09 |
| 0.15 & up | 0.04 |

*Sharp-edged




For $K$, see table

## PIPE EXIT

**Projecting** **Sharp-Edged** **Rounded**

$K = 1.0$ | $K = 1.0$ | $K = 1.0$

Colebrook–White formula, from which the Moody diagram was developed, Swamee and Jain (39) developed explicit formulas relating $f$, $h_f$, $Q$, and $D$. It is reported that their formulas yield results that deviate no more than 3% from those obtained from the Moody diagram for the following ranges of $k_s/D$ and Re: $10^{-5} < k_s/D < 2 \times 10^{-2}$ and $4 \times 10^3 < \text{Re} < 10^8$. The formulas for $f$ and $Q$ are

$$f = \frac{0.25}{\left[\log\left(\frac{k_s}{3.7D} + \frac{5.74}{\text{Re}^{0.9}}\right)\right]^2} \tag{10.26}$$

$$Q = -2.22D^{5/2}\sqrt{gh_f/L}\,\log\left(\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2}\sqrt{gh_f/L}}\right) \tag{10.27}$$

They also developed a formula for the explicit determination of $D$. A modified version of that formula, given by Streeter and Wylie (38), is

$$D = 0.66\left[k_s^{1.25}\left(\frac{LQ^2}{gh_f}\right)^{4.75} + \nu Q^{9.4}\left(\frac{L}{gh_f}\right)^{5.2}\right]^{0.04} \tag{10.28}$$

If you want to solve for head loss given $Q$, $L$, $D$, $k_s$, and $\nu$, simply solve for $f$ by Eq. (10.26) and compute $h_f$ with the Darcy–Weisbach equation, Eq. (10.22). Straightforward calculations for $Q$ and $D$ can also be made if $h_f$ is known. However, for problems involving head losses in addition to $h_f$, an iterative solution is required. For computing $Q$, you can assume an $f$ and solve for $Q$ from the energy equation after substituting $Q/A$ in that equation. Then compute Re and use the result in Eq. (10.26) to get a better estimate of $f$, and so on, until $Q$ converges analogous to the procedure for determining $Q$ using the Moody diagram. In this case, however, Eq. (10.26) is substituted for the Moody diagram. Similarly, you can determine $D$ if you are given $Q$, $\nu$, the change in pressure or head, and the geometric configuration.

**EXAMPLE 10.8** Solve Example 10.5 using Eq. (10.27).

***Solution*** From Fig. 10.8, $k_s$ for asphalted cast-iron pipe is given as $1.2 \times 10^{-4}$ m. From the given conditions, $h_f/L = 0.0122$. Assume $T = 20°\text{C}$, so $\nu = 10^{-6}$ m²/s. Then, using Eq. (10.27), we have

$$Q = -2.22(0.20\text{ m})^{5/2}\sqrt{9.81\text{ m/s}^2 \times 0.0122}$$
$$\times \log\left(\frac{1.2 \times 10^{-4}\text{ m}}{3.7 \times 0.20\text{ m}} + \frac{1.78 \times 10^{-6}\text{ m}^2/\text{s}}{(0.20\text{ m})^{3/2}\sqrt{9.81\text{ m/s}^2 \times 0.0122}}\right)$$
$$= 0.050\text{ m}^3/\text{s}$$

◄

RPP-6485 Rev. 0

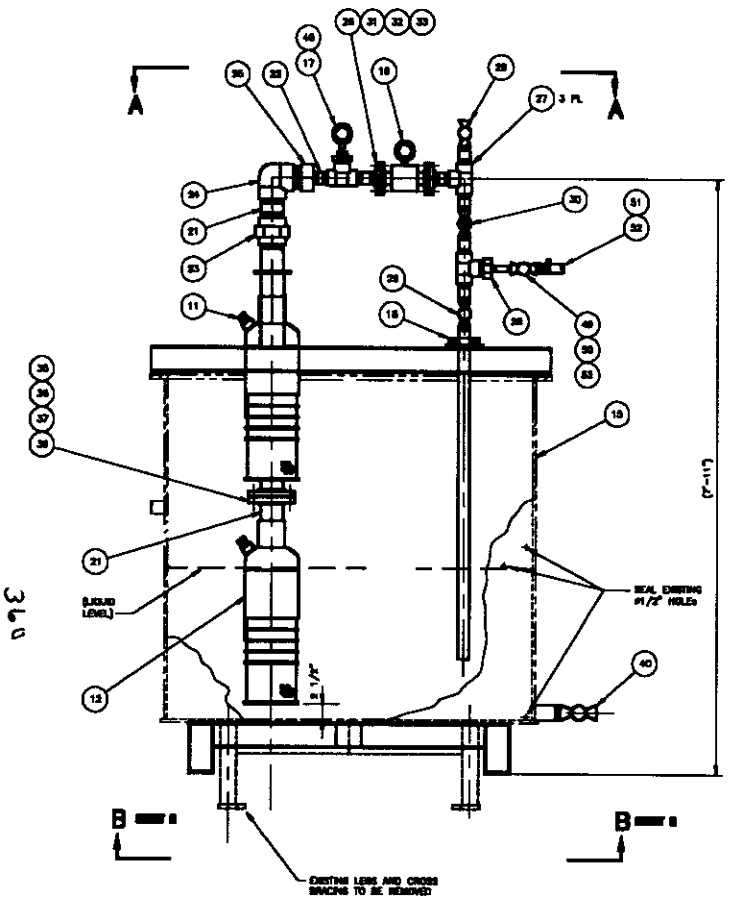


TABLE A.5 APPROXIMATE PHYSICAL PROPERTIES OF WATER* AT ATMOSPHERIC PRESSURE

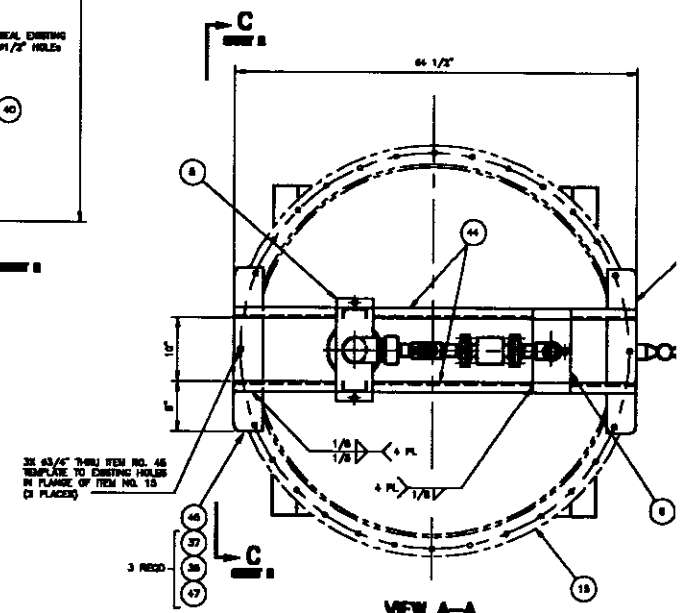
| Temperature | Density | Specific weight | Dynamic viscosity | Kinematic viscosity | Vapor pressure |
|---|---|---|---|---|---|
| | kg/m³ | N/m³ | N • s/m² | m²/s | N/m² abs. |
| 0°C | 1000 | 9810 | $1.79 \times 10^{-3}$ | $1.79 \times 10^{-6}$ | 611 |
| 5°C | 1000 | 9810 | $1.51 \times 10^{-3}$ | $1.51 \times 10^{-6}$ | 872 |
| 10°C | 1000 | 9810 | $1.31 \times 10^{-3}$ | $1.31 \times 10^{-6}$ | 1230 |
| 15°C | 999 | 9800 | $1.14 \times 10^{-3}$ | $1.14 \times 10^{-6}$ | 1700 |
| 20°C | 998 | 9790 | $1.00 \times 10^{-3}$ | $1.00 \times 10^{-6}$ | 2340 |
| 25°C | 997 | 9781 | $8.91 \times 10^{-4}$ | $8.94 \times 10^{-7}$ | 3170 |
| 30°C | 996 | 9771 | $7.97 \times 10^{-4}$ | $8.00 \times 10^{-7}$ | 4250 |
| 35°C | 994 | 9751 | $7.20 \times 10^{-4}$ | $7.24 \times 10^{-7}$ | 5630 |
| 40°C | 992 | 9732 | $6.53 \times 10^{-4}$ | $6.58 \times 10^{-7}$ | 7380 |
| 50°C | 988 | 9693 | $5.47 \times 10^{-4}$ | $5.53 \times 10^{-7}$ | 12,300 |
| 60°C | 983 | 9643 | $4.66 \times 10^{-4}$ | $4.74 \times 10^{-7}$ | 20,000 |
| 70°C | 978 | 9594 | $4.04 \times 10^{-4}$ | $4.13 \times 10^{-7}$ | 31,200 |
| 80°C | 972 | 9535 | $3.54 \times 10^{-4}$ | $3.64 \times 10^{-7}$ | 47,400 |
| 90°C | 965 | 9467 | $3.15 \times 10^{-4}$ | $3.26 \times 10^{-7}$ | 70,100 |
| 100°C | 958 | 9398 | $2.82 \times 10^{-4}$ | $2.94 \times 10^{-7}$ | 101,300 |
| | slugs/ft³ | lbf/ft³ | lbf-s/ft² | ft²/s | psia |
| 40°F | 1.94 | 62.43 | $3.23 \times 10^{-5}$ | $1.66 \times 10^{-5}$ | 0.122 |
| 50°F | 1.94 | 62.40 | $2.73 \times 10^{-5}$ | $1.41 \times 10^{-5}$ | 0.178 |
| 60°F | 1.94 | 62.37 | $2.36 \times 10^{-5}$ | $1.22 \times 10^{-5}$ | 0.256 |
| 70°F | 1.94 | 62.30 | $2.05 \times 10^{-5}$ | $1.06 \times 10^{-5}$ | 0.363 |
| 80°F | 1.93 | 62.22 | $1.80 \times 10^{-5}$ | $0.930 \times 10^{-5}$ | 0.506 |
| 100°F | 1.93 | 62.00 | $1.42 \times 10^{-5}$ | $0.739 \times 10^{-5}$ | 0.949 |
| 120°F | 1.92 | 61.72 | $1.17 \times 10^{-5}$ | $0.609 \times 10^{-5}$ | 1.69 |
| 140°F | 1.91 | 61.38 | $0.981 \times 10^{-5}$ | $0.514 \times 10^{-5}$ | 2.89 |
| 160°F | 1.90 | 61.00 | $0.838 \times 10^{-5}$ | $0.442 \times 10^{-5}$ | 4.74 |
| 180°F | 1.88 | 60.58 | $0.726 \times 10^{-5}$ | $0.385 \times 10^{-5}$ | 7.51 |
| 200°F | 1.87 | 60.12 | $0.637 \times 10^{-5}$ | $0.341 \times 10^{-5}$ | 11.53 |
| 212°F | 1.86 | 59.83 | $0.593 \times 10^{-5}$ | $0.319 \times 10^{-5}$ | 14.70 |

*Notes: (1) Bulk modulus $E_v$ of water is approximately 2.2 G $P_a$ ($3.2 \times 10^5$ psi); (2) Water–air surface tension is approximately $7.3 \times 10^{-2}$ N/m ($5 \times 10^{-3}$ lbf/ft) from 10°C to 50°C.

SOURCE: Reprinted with permission from R. E. Bolz and G. L. Tuve, *Handbook of Tables for Applied Engineering Science*, CRC Press, Inc., Cleveland, 1973. Copyright 1973 by The Chemical Rubber Co., CRC Press, Inc.




① ARRANGEMENT
SCALE: 1 1/2"=1'-0"




VIEW A–A
SCALE: 1 1/2"=1'-0"

## GENERAL NOTES:

1. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
2. WELDING TO BE PER ANSI D1.1 AND DWG#TR-0013.
3. DIMENSIONS ARE IN INCHES. TOLERANCES: FRACTIONAL = ±1/8" UNLESS OTHERWISE SPECIFIED.

## PARTS LIST/MATERIAL LIST

| | | | | | | |
|---|---|---|---|---|---|---|
| | AR | | TUBING, 6" X 4" X 1/4" WALL | ASTM A 500 GR B | | 41 |
| | AR | | TUBING, 4" X 4" X 1/4" WALL | ASTM A 500 GR B | | 42 |
| | 1 | | PIPE, 2" SCHED 40 X 4" LG. TOE | ASTM A 53 TYPE E GR B | | 43 |
| | AR | | C4 X 5.4 | ASTM A 36 | | 44 |
| | 2 | | PLATE, 6" X 1/2" X 26" LONG | ASTM A 36 | | 45 |
| | 2 | | SCREW, HEX HD, 1/2"-13UNC-2A X 1 1/4" LG | ANSI B18.2.1 CS | | 46 |
| | 6 | | SCREW, HEX HD, 5/8"-11UNC-2A X 2 1/2" LG | ANSI B18.2.1 CS | | 47 |
| | 1 | | BUSHING, REDUCING, 1 1/2" X 1/4", THREADED | ASTM A 197 | | 48 |
| | 1 | | NIPPLE, 3/4" SCHED 40 X 6" L | ASTM A 197 | | 49 |
| | 1 | | HOSE CONNECTOR, MALE NPT, 3/4 NPT 3/4" ID HOSE | SWAGELOK | | 50 |
| | 1 | | CLAMP, HOSE, WORM DRIVE, FOR 3/4" ID HOSE | COMMERCIAL GALV | | 51 |
| | AR | | HOSE, 3/4" ID X 1/8" WALL | COMMERCIAL RUBBER | | 52 |
| | 1 | S-637512 | VALVE, BALL, 3/4", NPT | WHITEY | | 53 |

## PARTS LIST/MATERIAL LIST

| | | | | | | |
|---|---|---|---|---|---|---|
| | | -019 | ARRANGEMENT | | | 1 |
| | | | | | | 2 |
| | | | | | | 3 |
| | | | | | | 4 |
| | 1 | -001 | PLATE, 6" X 1/2" X 18 3/4" L | ASTM A 36 | 2 | 5 |
| | 1 | -002 | PLATE, 6" X 1/2" X 13" L | ASTM A 36 | 2 | 6 |
| | 2 | -003 | ANGLE, 1 1/2" X 1 1/2" X 1/4" X 6" L | ASTM A 36 | 2 | 7 |
| | | | | | | 8 |
| | | | | | | 9 |
| | | | | | | 10 |
| | 1 | H-14-104148-018 | PUMP | | | 11 |
| | 1 | H-14-104148-020 | PUMP | | | 12 |
| | | | | | | 13 |
| | | | | | | 14 |
| | 1 | | TANK (MODIFIED) | (PROVIDED BY OTHERS) | | 15 |
| | 1 | MODEL M50MHS | FLOWMETER, MAGNETIC, INTERNAL TYPE, WITH ANSI 150# FLANGES | YOKOGAWA ELECTRIC CORPORATION | | 16 |
| | 1 | TYPE 1009 | GAUGE, PRESSURE, 0-100# PSI, 4 1/2" DIAL, 1/4" NPT BOTTOM CONNECTION | ASHCROFT | | 17 |
| | 1 | #212 | PIPE CLAMP, 1 1/2" PIPE SIZE | GRINNELL | | 18 |
| | | | | | | 19 |
| | | | | | | 20 |
| | AR | | PIPE, 3" SCHED 40, WELDED | ASTM A 53 TYPE E GR B | | 21 |
| | AR | | PIPE, 1 1/2" SCHED 40, WELDED | ASTM A 53 TYPE E GR B | | 22 |
| | 1 | | UNION, 3", 150#, THREADED | ASTM A 197 | | 23 |
| | 1 | | ELBOW, 90°, 3", 150#, THREADED | ASTM A 197 | | 24 |
| | 1 | | BUSHING, REDUCING, 3" X 1 1/2", THREADED | ASTM A 197 | | 25 |
| | 3 | | FLANGE, 1 1/2", R.F., SCREWED, 150# | ASTM A 105 | | 26 |
| | 3 | | TEE, 1 1/2", 150#, THREADED | ASTM A 197 | | 27 |
| | 1 | | BUSHING, REDUCING, 1 1/2" X 3/4" THREADED | ASTM A 197 | | 28 |
| | 2 | S-671734 | VALVE, BALL, 1 1/2", FNPT | WHITEY | | 29 |
| | 1 | NO. 25-GR | VALVE, GLOBE, 1 1/2", FNPT | CRANE | | 30 |
| | 2 | BLUEGRAD STYLE 3700 | GASKET, 1 1/2" CL 150, R.F. FLANGE 1/8" THK COMPRESSED FIBER | GARLOK | | 31 |
| | 6 | | SCREW, HEX HD, 1/2"-13UNC-2A X 2 1/2" LG | ANSI B18.2.1 CS | | 32 |
| | 10 | | NUT, HEX, 1/2"-13UNC-2B | ANSI B18.2.2 CS | | 33 |
| | 2 | | WASHER, FLAT, 1/2" BOLT SIZE | ANSI B18.21.1 CS | | 34 |
| | 2 | | FLANGE, 3", R.F., SCREWED, 150# | ASTM A 105 | | 35 |
| | 4 | | SCREW, HEX HD, 5/8"-11UNC-2A X 3 1/4" LG | ANSI B18.2.1 CS | | 36 |
| | 16 | | NUT, HEX, 5/8"-11UNC-2B | ANSI B18.2.2 CS | | 37 |
| | 6 | | WASHER, FLAT, 5/8" BOLT SIZE | ANSI B18.21.1 CS | | 38 |
| | 1 | BLUEGRAD STYLE 3700 | GASKET, 3" CL 150, R.F. FLANGE 1/8" THK COMPRESSED FIBER | GARLOK | | 39 |
| | 1 | S-667733 | VALVE, BALL, 2", 150#, THREADED | WHITEY | | 40 |

PRELIMINARY

U.S. DEPARTMENT OF ENERGY
Richland Operations Office

TEST SKID
SUBMERSIBLE PUMP
ARRANGEMENT

ES-259-001 0

DRAWING TRACEABILITY LIST

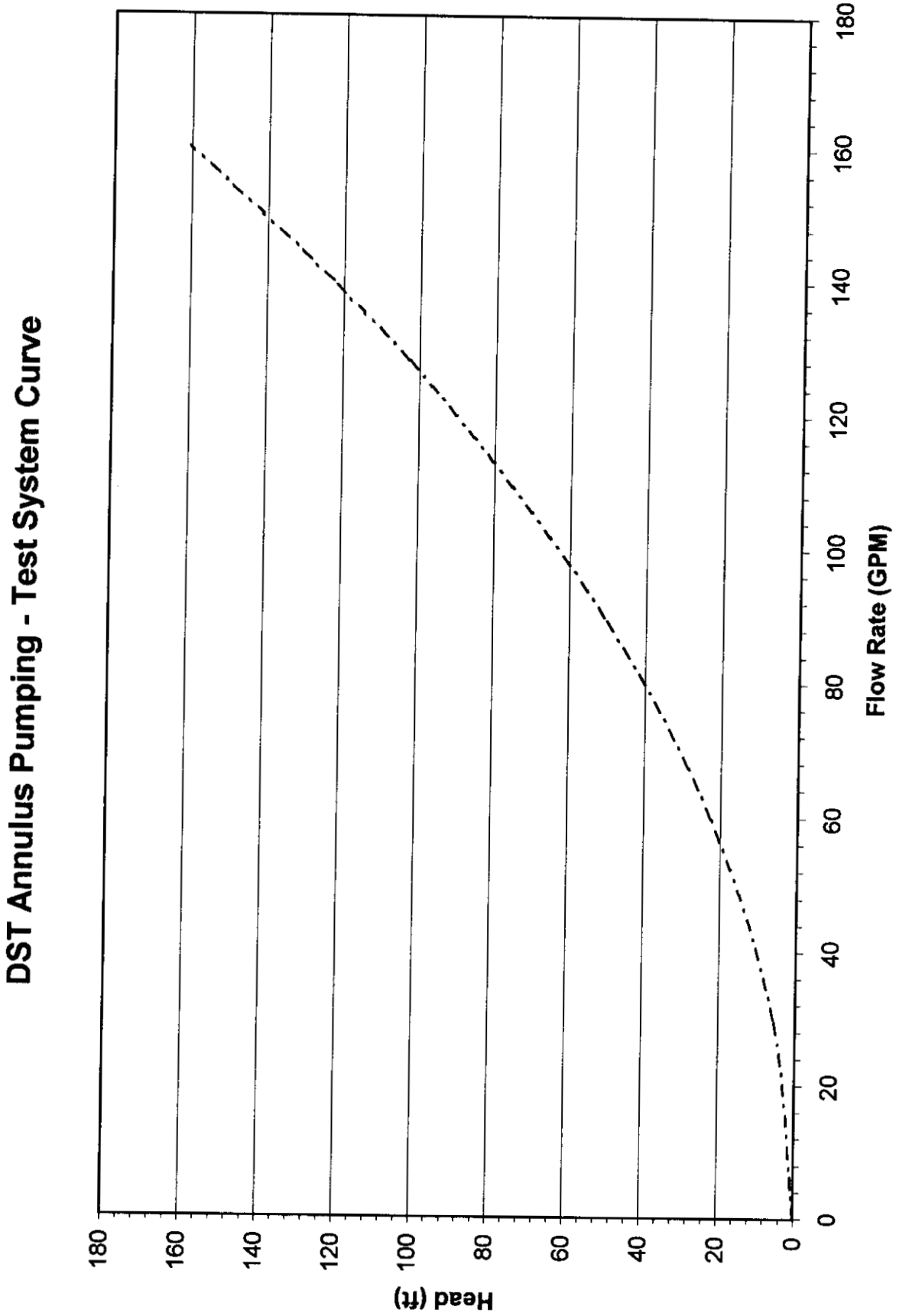
RPP-6485 Rev. 0

Calc No. DSTAP-P-005, Rev. 0
Ref. 3 A9 of A9

36

# CALCULATION NO: DSTAP-P-005, Rev. 0
# APPENDIX B

## Test System Curve


DST Annulus Pumping - Test System Curve
Head (ft)
0
20
40
60
80
100
120
140
160
180
Flow Rate (GPM)
0
20
40
60
80
100
120
140
160
180

| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX | Page: i of i<br>Date: 05/30/00 |
|---|---|---|

This sheet shows the status and description of the attached Design Analysis sheets

Discipline: 454 Project/Area/Unit: 65100541/25/9 Calculation No.: MISC.

Project No. & Name: Double Shell Tank Annulus Pumping

Calculation Item: DST Annulus Pump Miscellaneous Calculations

These calculations apply to:

Drawing No.: N/A Rev. No:

Drawing No.: Rev. No:

Other (Study, CDR): Rev. No.

The status of these calculations is:

[] Preliminary Calculations

[X] Final Calculations

[] Check Calculations (On Calculation Dated )

[] Void Calculation (Reason Voided )

Incorporated in Final Drawings? [] Yes [X] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | | | |
| Checked by | | | |
| Approved by | | | |
| Checked Against Approved Vendor Data | | | |

## INDEX


| Design Analysis Page No. | Description |
|---|---|
| Appendix A | Air Compressor Sizing |
| A1-A2 | Calculation and References |
| Appendix B | Desiccant Filler Replacement |
| B1-B3 | Calculation and References |
| Appendix C | Test Tank Modification Analysis |
| C1-C5 | Calculation and References |
| Appendix D | Test Tank Sizing |
| D1-D4 | Calculation and References |
| Appendix E | Radiation Resistance of Flygt Submersible Pump Elastomers |
| E1-E4 | Calculation and References |

| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX<br>Continuation Sheet | Page ii of ii<br>Date: 05/30/00 |
|---|---|---|

Discipline: 454 | Project/Area/Unit: 65100541/25/9 | Calculation No.: MISC.

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | | | |
| Checked by | | | |

## INDEX


| Design Analysis Page No. | Description |
|---|---|
| Appendix F | Weep Hole Sizing |
| F1-F4 | Calculation and References |
| Appendix G | Annulus Pump Assembly |
| G1-G9 | Calculation and References |


## REVISION

| Revision No. | Description |
|---|---|
| | |

# APPENDIX A

# Air Compressor Sizing

RPP-6485 Rev. 0

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: A1 of A2

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 19 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

## OBJECTIVE:

The objective of this calculation is to determine the air requirements of the Double Shell Tank Annulus air driven pump. The air requirements will be used to properly size and select an air compressor, which will be used to drive the air motor attached to the pump .

## INPUT:

1.) A 2" air motor has been recommended by the manufacturer to operate the air pump.

2.) All other input was obtained from manufacturer's published data on Hydrostar System Air Motors.

## REFERENCES:

1.) Instrumentation Northwest, Inc. Hydrostar System Air Motors

## CALCULATION:

Air Motor Cylinder Size $M := 2.0 \cdot in$

Air Consumption (@ 80 psi) $C := 0.18 \cdot \frac{SCF}{stroke}$ (Ref 1, A1)

Maximum Stroke Rate $V := 60 \cdot \frac{stroke}{min}$ (Ref 1, A1)

Amount of Air Required $A := C \cdot V$ $A = 10.8 \cdot SCFM$

## CONCLUSION:

The air motor attached to the pump will require a flow rate of 10.8 SCFM. This value considers an operation pressure of 80 psi and a maximum stroke rate of 60 strokes per minute. An air compressor with this capability should be chosen. However, according to the manufacturer, a compressor with less performance will not harm anything. The pump will be unable to operate at higher speeds.

RPP-6485 Rev. 0

# Instrumentation Northwest, Inc.

ATTACHMENT A
PAGE A2 OF A2

APPLICATION NOTE:
**Hydrostar System Air Motors**
May 5, 1992

## Introduction

When sizing an air-driven system one must consider the air motor cylinder size being used, the stroke rate desired to produce a certain production rate (GPM) and the air consumption of the air motor.

## Air Cylinder Size

Without going through the formulas, outlined below is a general guideline table for selecting the proper size air motor depending on the installation depth of the HydroStar. For each motor size a range of values is given: the Maximum Full Speed Depth (MFSD) and the Maximum Recommended Depth (MRD). The Maximum Full Speed Depth is the installation depth where some loss in air motor performance will begin to occur. The Maximum Recommended Depth is the deepest installation depth we would recommend using this size air motor.

**Depth Chart (In Feet)**

| Cylinder size (in) | 1.5 | 2.0 | 2.5 | 3.25 | 4 |
|---|---|---|---|---|---|
| MFSD (ft) | 76 | 146 | 240 | 392 | 617 |
| MRD (ft) | 106 | 205 | 337 | 549 | 865 |

## Production Due to Stroke Rate

The HS-8000 and HS-8001 pumps are 1.5" diameter pump cylinders with a stroke rate of 12 inches. If we assume that the pumps operate at 90% efficiency the production factor of the pumps is .082 gallons per stroke. Note: Actual field studies rate the efficiency of the HydroStar pumps better than 90% at their rated operating depth capacity *(see pump curves).*

Example: If your pump is operating at 40 strokes per minute your production rate would be 40 * .082 = 3.29 gallons per minute.

## Air Consumption *(at 80 PSI operation)*

Air consumption is a factor of the cylinder size you use and the stroke rate of the cylinder. The HydroStar system can operate up to 60 strokes per minute down to less than 1 stroke per minute so naturally the air consumption will vary depending on the desired operating speed.

Below is a table of factors one can use to determine the air consumption of your system in Standard Cubic Feet (SCF). (These factors are just guidelines since a number of additional variables can effect air consumption).

| Cylinder Size (in) | 1.5 | 2.0 | 2.5 | 3.25 | 4 |
|---|---|---|---|---|---|
| Air consumption *(SCF per stroke)* | .10 | .18 | .30 | .49 | .76 |

Example: A HydroStar system operating at 40 strokes per minute using a 1.5 inch cylinder would need .1 * 40 = 4 SCFM air.

*(cont.)*

# APPENDIX B

# Desiccant Filler Replacement

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: B1 of B3

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 19 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

## OBJECTIVE:

The objective of this calculation is to determine when the desiccant filter, used to trap moisture in the air line from the compressor to the air motor, should be replaced. The air motor is used to drive the Hydrostar piston pump.

## INPUT:

1.) The total volume of air that can be dried before desiccant must be replaced is 11,000 $ft^3$.

2.) The free air from the air compressor at 40 psi is 11.0 CFM.

## REFERENCES:

1.) Wilkerson Desiccant Dryers cut-sheet, from Grainger 1995 General Catalog No. 386.

2.) Dayton Air Compressor cut-sheet, from Grainger 1995 General Catalog No. 386.

## CALCULATION:

Assume that the air compressor is operating at 40 psi (most conservative)

Capacity of Desiccant Filter $C := 11000 \cdot ft^3$ (Ref. 1, B2)

Free Air at 40 psi $A := 11.0 \cdot CFM$ (Ref. 2, B3)

Operation Life of Filter $L := \frac{C}{A}$ $L = 16.7 \cdot hr$

## CONCLUSION:

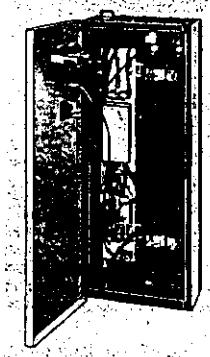
The desiccant filter should be replaced approximately every 16.5 hours of operation. The desiccant material also contains 25% cobalt blue coloring which turns pink to indicate saturation.

RPP-6485 Rev.0

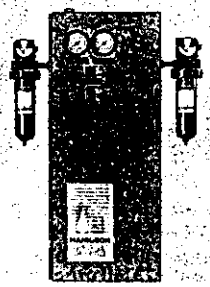


# REGENERATIVE DESICCANT COMPRESSED AIR DRYERS

HANKISON INTERNATIONAL



- For ultra-dry compressed air
- Prefilter and afterfilter included



Prevent liquid water from forming in air systems exposed to temperatures below freezing. Adjustable for −40°F or −100°F pressure dew points.

Applications: Added protection where air is used for air tools, motors, cylinders and valves, logic circuits and instrumentation, cable and antenna pressurization, dust collectors, sand blasting and painting. Ultra-dry compressed air for critical applications such as air agitation, air bearings, air blanketing, air conveying and fluidization, fine grit blasting; nitrogen replacement for electronic chip manufacturing, feedstock for ozone generators.

- **Large desiccant beds provide consistent outlet pressure dew points**
- **Tower repressurization promotes long desiccant life**
- **Bed design minimizes purge air usage**
- **Solid-state timer accurately controls tower cycling**
- **Heavy-duty purge exhaust muffler for quiet operation**
- **Uses easily replaced bulk desiccant—no special cartridges required**
- **Removable, cleanable stainless steel flow diffusers**
- **Non-lubricated, soft seated control valves**
- **Enclosed in durable metal cabinet for easy wall mounting**
- **Front-mounted control panel with Power-On light, tower pressure gauges and On/Off switch**

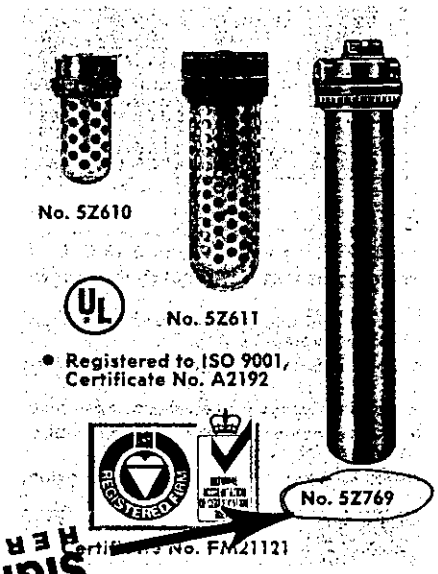
## DESICCANT AIR DRYER ORDERING DATA

| Flow Capacity SCFM @ 100 PSIG (−40°F P.D.P) Inlet | Outlet | In/Out Connection NPTF | Dimensions H | W | D | Hankison Model | Stock No. | List | Each | Shpg. Wt. |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 4 | 1/2" | 30" | 20" | 6" | DHW-5 | 6F569 | $1152.80 | $1095.00 | 83.0 |
| 10 | 8 | 1/2 | 30 | 26 | 6 | DHW-10 | 6F570 | 1302.80 | 1235.00 | 108.0 |
| 15 | 12 | 1/2 | 30 | 26 | 6 | DHW-15 | 6F571 | 1417.80 | 1345.00 | 126.0 |
| 20 | 16 | 1/2 | 30 | 32 | 8 | DHW-20 | 6F572 | 1662.80 | 1575.00 | 163.0 |
| 25 | 20 | 1/2 | 30 | 32 | 8 | DHW-25 | 6F573 | 2027.80 | 1925.00 | 187.0 |

**Note:** Electrical: 115VAC/1Ø/60 Hz, NEMA 1, includes 6' power cord & plug. Minimum/Maximum Operating Pressure: 50/150 PSIG. Maximum Operating Temperature: 120°F (if inlet temp. exceeds 120°F, use aftercooler to precool incoming air—see index under Aftercoolers.

WILKERSON CORPORATION • ENGLEWOOD, CO 80150

# DESICCANT DRYERS




- **Remove harmful moisture from compressed air systems through direct adsorption**
- **Useful for small systems and moisture sensitive point-of-use applications**
- **Used with air tools, instruments, and paint spraying equipment, or where air lines must be protected from freeze-up**

Desiccant dryers provide −45°F atmospheric dewpoint (<0.5% relative humidity at 78°F). Units rated to 150 PSI at 125°F.

**Nos. 5Z610 and 5Z611** have quick-release polycarbonate bowls for easy detection and replacement of saturated desiccant. No. 5Z769 has quick disconnect aluminum bowl with desiccant saturation indicator.

**Silica gel desiccant material** contains 25% cobalt blue coloring which turns pink to indicate saturation. When desiccant becomes saturated, replace with new desiccant, or regenerate at 350°F. Replacement desiccant material also available. See table below. Wilkerson brand.

- Registered to ISO 9001, Certificate No. A2192

Certificate No. FM21121

## DESICCANT DRYER ORDERING DATA

| Max. CFM @ 100 PSI | Total Cap. Cu. Ft* | Overall Dimen. Ht | W | Inlet/Outlet (F)NPT | Bowl Size | Wilkerson Model No. | Stock No. | List | Each | Shpg. Wt. |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 600 | 5½" | 2¾" | 1/4" | 0.25 lbs | X06-02-000 | 5Z610 | $46.50 | $39.50 | 1.0 |
| 10 | 4400 | 13 | 4⅜ | 1/4 | 1.64 lbs | X03-02-000 | 5Z611 | 96.50 | 82.00 | 8.0 |
| 25 | 11,000 | 21 5/16 | 4 13/16 | 1/2 | 4.40 lbs | X25-04-000 | 5Z769 | 230.00 | 195.50 | 13.0 |

(*) Total volume of air that can be dried before desiccant must be replaced or regenerated.

## REPLACEMENT DESICCANT

| For Dryer Stock No. | Qty. Per Bag | Bags Per Pkg | Refills Per Pkg | Wilkerson Model No. | Stock No. | List | Pkg. Each | Shpg. Wt. |
|---|---|---|---|---|---|---|---|---|
| 5Z610 | 0.25 lbs | 3 | 3 | DRP-95-303 | 5Z613 | $21.50 | $20.40 | 1.0 |
| 5Z611 | 0.88 lbs | 8 | 4 | DRP-85-059 | 5Z612 | 90.00 | 85.50 | 7.0 |
| 5Z769 | 0.88 lbs | 15 | 3 | DRP-85-280 | 5Z770 | 180.00 | 171.00 | 14.0 |

*WHOLESALE PRICES—GRAINGER*

RPP-6485 Rev. 0

ATTACHMENT B
PAGE B3 OF B3

NEW ITEM ON THIS PAGE

AIR COMPRESSORS

# STATIONARY TANK MOUNTED AND BASE PLATE AIR COMPRESSORS

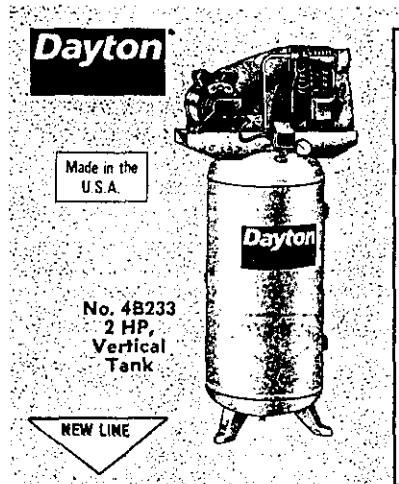
**EXCLUSIVE DAYTON DESIGN RELIABLY POWERS AIR TOOLS, PAINT SPRAYERS, SANDBLAST EQUIPMENT, AIR CYLINDERS, AND SMALL MACHINES**

**THE DAYTON CAST IRON DIFFERENCE**

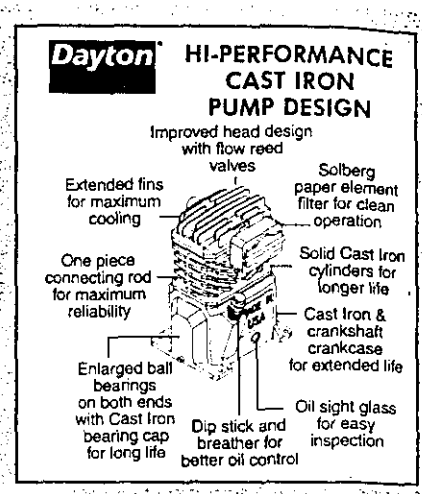
- Longer life—up to 100% longer pump life than comparable air compressors
- Higher Air Flow—Up to 10% more CFM than comparable models
- Higher Pressure—Maximum 135 PSI for a broader range of applications
- Higher Duty Cycle—Runs up to a 65% duty cycle vs. the standard 50/50 duty cycle

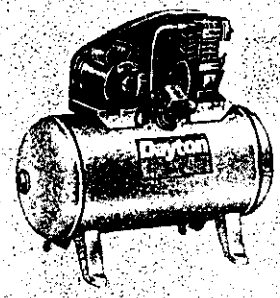
**TANK MOUNT MODELS INCLUDE**

- High flow air cooling system reduces pump temperature
- Copper discharge tube for improved durability and cooling
- Single and 3-phase open dripproof motors with thermal protection
- NEMA 1 enclosure pressure switch with gauge
- 30 gallon stationary ASME air tank
- Pressure switch setting 95 PSI On and 135 PSI Off (Except Base Plate Nos. 4B242 and 4B243)
- Comply with State of California code 462 (L) (2)
- Charcoal gray metallic finish



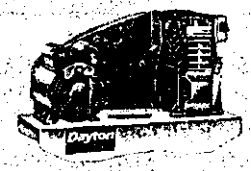

No. 4B233
2 HP,
Vertical
Tank




No. 4B234
2 HP,
Horizontal
Tank

Except
Nos. 4B242
& 4B243




No. 4B243
Base Plate

## PUMP SPECIFICATIONS

| Free Air CFM @ PSI 40 | 90 | Displ. CFM | Max. PSI | Rated Pump Life (Hrs)† | Max. Duty Cycle | RPM | Cyls. | Bore (In.) | Stroke (In.) | Oil Cap. | Repl. Pump Stock No. | Compressor Stock No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.9 | 5.7 | 8.8 | 100 | 5000 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 oz. | 4B246 | 4B232 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B233 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B234 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B235 |
| 11.0 | 9.4 | 13.7 | 135 | 4200 | 65/35 | 1000 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B237 |
| 11.2 | — | 13.7 | 40 | 5000 | 65/35 | 1000 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B242 |
| 14.1 | — | 16.8 | 40 | 5000 | 65/35 | 1225 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B243 |

**BASE PLATE MODELS Nos. 4B242 and 4B243**

- Suitable for fire sprinkler applications (verify local codes and regulations for compliance)
- Prewired (240V) with pneumatic control package
- Pressure switch setting 30 PSI On and 40 PSI Off

SIGN HERE

## ORDERING DATA

| Peak Developed HP* | Running Motor HP* | Gal. | Tank Type | Volts, 60 Hz | Phase | Amp Draw | NPT Outlet, In. | Dimensions, In. L | W | H | Stock No. | List | Each | Shpg. Wt. | With Magnetic Starter# Volts, 60 Hz | Stock No. | List | Each | Shpg. Wt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 30‡ | Horizontal | 120/240 | 1 | 17.8/8.9 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B232▲ | $748.75 | $585.00▲ | 177.0 | 120<br>240 | 7Z021▲<br>7Z022▲ | $915.00<br>910.00 | $729.00▲<br>715.00▲ | 184.2<br>184.2 |
| 2 | 2.00 | 30‡ | Vertical | 120/240 | 1 | 24.0/12.0 | 1/4(F) | 26¼ | 19 | 52 | 4B233▲ | 798.75 | 599.00▲ | 170.0 | 120<br>240 | 7Z023▲<br>7Z024▲ | 939.00<br>915.00 | 750.00▲<br>729.00▲ | 177.3<br>177.2 |
| 2 | 2.00 | 30‡ | Horizontal | 120/240 | 1 | 24.0/12.0 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B234▲ | 798.75 | 599.00▲ | 179.0 | 120<br>240 | 7Z025▲<br>7Z026▲ | 939.00<br>915.00 | 750.00▲<br>729.00▲ | 186.3<br>186.2 |
| 2 | 2.00 | 30‡ | Vertical | 208/240/480 | 3 | 5.6/2.8 | 1/4(F) | 26¼ | 19 | 52 | 4B235▲ | 836.25 | 639.00▲ | 170.0 | 208/240<br>480 | 7Z027▲<br>7Z028▲ | 960.00<br>960.00 | 765.00▲<br>765.00▲ | 172.8<br>177.5 |
| 3 | 3.00 | 30‡ | Horizontal | 208/240/480 | 3 | 8.0/4.0 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B237▲ | 873.75 | 675.00▲ | 180.0 | 208/240<br>480 | 7Z029▲<br>7Z030▲ | 870.00<br>870.00 | 695.00▲<br>695.00▲ | 182.5<br>187.5 |
| 2 | 2.00 | | Base Plate | 120/240 | 1 | 15.0/7.5 | 1/2(F) | 22½ | 15½ | 14¾ | 4B242▲ | 581.25 | 465.00▲ | 89.0 | 120<br>240 | 7Z048▲<br>7Z049▲ | 769.00<br>750.00 | 615.00▲<br>599.00▲ | 96.3<br>96.2 |
| 3 | 3.00 | | Base Plate | 208/240/480 | 3 | 8.0/4.0 | 1/2(F) | 22½ | 15½ | 14¾ | 4B243▲ | 645.00 | 515.00▲ | 90.0 | 240<br>480 | 7Z100▲<br>7Z101▲ | 799.00<br>859.00 | 639.00▲<br>685.00▲ | 92.8<br>97.5 |

(*) For specific HP rating explanations, see page 2214. (‡) ASME code air tanks. (†) As rated by the standard B-10 bearing life of the pump. Individual compressor life will vary depending on duty cycle, ambient temperature, maintenance performed, air intake quality, and manufacturing part tolerances. (#) Magnetic starters not mounted and wired; provided separately.



▲Net Prices, Not Subject To Discounts

# APPENDIX C

# Test Tank Modification Analysis

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: C1 of C5

**DESIGN ANALYSIS**

| | | | | | |
|---|---|---|---|---|---|
| Client: | CH2M HILL Hanford Group | Project/Area/Unit: | 65100541 / 25 / 9 | | |
| Subject: | DOUBLE SHELL TANK ANNULUS PUMPING | Date: | 04 / 21 / 00 | By: | P. M. DORSH |
| | DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS | Checked: | / / | By: | |
| Location: | 200 E AREA HANFORD | Revised: | | By: | |

**OBJECTIVE:**

The objective of this calculation is to do a "quick check" on the adequacy of the testing equipment and the legs used on the DST Annulus Pumping Test Tank.

**DESIGN INPUT:**

1.) Test Skid Submersible Pump Sketch, ES-259-001, Rev. 0

2.) Stress allowables are based on the *Allowable Stress Design, Ninth Edition.*

**ASSUMPTIONS:**

As stated in the calculation.

**REFERENCES:**

1.) Pump Sketch, ES-259-001, Rev. 0

2.) *Allowable Stress Design, Ninth Edition.*

**CONCLUSION:**

The tank and its components are more than adequate for use.

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: C2 of C5

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 21 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

---

Inside Diameter of Tank $D_i := 59 \cdot in$

Depth of Tank $L := 55 \cdot in$

Volume of Tank $V := \left(\frac{\pi}{4} \cdot D_i^2\right) \cdot L$ $V = 87.019 \cdot ft^3$

Density of Water @ 50 F $\rho := 62.4 \cdot \frac{lb}{ft^3}$

Weight of Water $W_w := V \cdot \rho$ $W_w = 5430 \cdot lb$

Weight of Equipment $W_e := 300 \cdot lb$

Total Weight $W := W_w + W_e$ $W = 5730 \cdot lb$

<u>Check 4" x 4" x 1/4" Tubing Leg Bracing</u>

Assume that only one center beam takes the load and the ends are fixed. (Ultra conservative)

Area of Tubing $A := 3.59 \cdot in^2$

Section Modulus $S := 4.11 \cdot in^3$

Moment of Inertia $I := 8.22 \cdot in^4$

Yield Strength $S_y := 36000 \cdot psi$

Allowable Shear $\tau_{all} := 0.4 \cdot S_y$ $\tau_{all} = 14400 \cdot psi$

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: C3 of C5

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 21 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

| | | |
|---|---|---|
| Shear Stress | $\tau := \frac{W}{A}$ | $\tau = 1596.1 \cdot psi$ |
| Factor of Safety | $FS := \frac{\tau_{all}}{\tau}$ | $FS = 9.022$ |
| Allowable Bending | $\sigma_{all} := 0.6 \cdot S_y$ | $\sigma_{all} = 21600 \cdot psi$ |
| Bending Moment | $M := \frac{W \cdot 44 \cdot in}{8}$ | $M = 2626.2 \cdot lb \cdot ft$ |
| Bending Stress | $\sigma := \frac{M}{S}$ | $\sigma = 7667.8 \cdot psi$ |
| Factor of Safety | $FS := \frac{\sigma_{all}}{\sigma}$ | $FS = 2.817$ |

Welds

Assume only the 1/4" fillet weld on the end of one of the center beams takes the load. This is ultra conservative.

| | | |
|---|---|---|
| Dimensions of Weld | $b := 4 \cdot in$ | $d := 4 \cdot in$ |
| Line Area | $A_w := 2 \cdot d$ | $A_w = 8 \cdot in$ |
| Bending Area | $S_w := \frac{d^2}{3}$ | $S_w = 5.333 \cdot in^2$ |
| Force on Weld | $f := \frac{W}{A_w} + \frac{M}{2 \cdot S_w}$ | $f = 3670.8 \cdot \frac{lb}{in}$ |
| Allowable Weld Stress (assume E60 electrode) | $S := 0.3 \cdot 60000 \cdot psi$ | $S = 18000 \cdot psi$ |
| Required Weld Size | $w := \frac{f}{0.707 \cdot S}$ | $w = 0.288 \cdot in$ |

1/4" fillet welds are used. There is another welded cross beam under the tank, which will distribute the load and greatly stiffen the bracing. Therefore, by judgment, the welds are more than adequate for the load.

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: C4 of C5

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 21 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

---

Pump Support Channel - C4 x 5.4

| | | |
|---|---|---|
| Area of Channel | $A := 1.59 \cdot in^2$ | |
| Moment of Inertia | $I := 3.85 \cdot in^4$ | |
| Section Modulus | $S := 1.93 \cdot in^3$ | |
| Length | $L := 5 \cdot ft + 4.5 \cdot in$ | $L = 5.375 \cdot ft$ |
| Moment | $M := \frac{W_e \cdot L}{2 \cdot 8}$ | $M = 100.8 \cdot lb \cdot ft$ |
| Shear Stress | $\tau := \frac{W_e}{2 \cdot A}$ | $\tau = 94.3 \cdot psi$ |
| Factor of Safety | $FS := \frac{\tau_{all}}{\tau}$ | $FS = 152.6$ |
| Bending Stress | $\sigma := \frac{M}{S}$ | $\sigma = 626.6 \cdot psi$ |
| Factor of Safety | $FS := \frac{\sigma_{all}}{\sigma}$ | $FS = 34.471$ |

Pump Plate

| | | |
|---|---|---|
| Width | $w := 6 \cdot in$ | |
| Length | $l := 16.1875 \cdot in$ | |
| Thickness | $t := 0.5 \cdot in$ | |
| Shear Stress | $\tau := \frac{W_e}{t \cdot w}$ | $\tau = 100 \cdot psi$ |
| Factor of Safety | $FS := \frac{\tau_{all}}{\tau}$ | $FS = 144$ |
| Bending Stress | $\sigma := \frac{12 \cdot W_e \cdot L}{(8 \cdot w \cdot t^2)}$ | $\sigma = 19350 \cdot psi$ |
| Factor of Safety | $FS := \frac{\sigma_{all}}{\sigma}$ | $FS = 1.116$ |

# APPENDIX D

# Test Tank Sizing

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: D1 of D4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 19 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

## OBJECTIVE:

The objective of this calculation is to size a test tank that will be used to perform run-in and maintenance tests on the DST submersible annulus pumps.

## INPUT:

1.) The submersible pump has a rating of 3.6 HP. (Ref 1, D2)

## ASSUMPTIONS:

1.) A 20 degree rise in temperature over an 8 hour test period is acceptable.

2.) Tandem pumps (2 pumps in series) will be tested. Therefore, assume that 7.2 HP is dissipated as heat into the test water.

## REFERENCES:

1.) Performance data of Flygt BS-2060 submersible pump.

## CALCULATION:

The Flygt submersible pump to be used for annulus pumping has a power rating of 3.6 HP. Two pumps will be tested in tandem. Therefore, assume that 7.2 HP is lost to heat which is dissipated into the test tank. Also, assume that the test will last a period of 8 consecutive hours, 20 degrees F rise in temperature is acceptable, and the initial temperature of the water is 50 degrees F.

By the First Law of Thermodynamics, $Q - W = \Delta U$, where Q is heat transferred into the system, W is work out of the system and $\Delta U$ is the change of internal energy. In this case, no work is going into or out of the system, thus $W = 0$. For solids and incompressible liquids, the change in internal energy can by determined by the relation $\Delta U = mC(T_2 - T_1)$, where m is the mass, C is the specific heat, $T_1$ is the initial temperature, and $T_2$ is the final temperature. Thus, the First Law equation becomes $Q = mC(T_2 - T_1)$, or $m = Q/(\Delta T^{*}C)$.

Heat Transfer to Water $Q := 7.2 \cdot hp$ $\quad Q = 18319.49 \cdot \frac{BTU}{hr}$

Density of Water @ 50 F $\rho := 62.4 \cdot \frac{lb}{ft^3}$

Specific Heat of Water $C := 1 \cdot \frac{BTU}{(lb \cdot F)}$

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: D2 of D4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 19 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

---

Change in Temperature $\Delta T := 20 \cdot \frac{F}{8 \cdot hr}$ $\Delta T = 2.5 \cdot \frac{F}{hr}$

Required Mass of Water $m := \frac{Q}{\Delta T \cdot C}$ $m = 7.328 \cdot 10^3 \cdot lb$

Volume of Water for Given Mass $V := \frac{m}{\rho}$ $V = 117.43 \cdot ft^3$ $V = 878.5 \cdot gal$

**Tank Sizing**

| Volume (ft^3) | Depth (ft) | Diameter (ft) | Length (ft) |
|---|---|---|---|
| 117.5 | 1 | 12.23 | 10.84 |
| | 2 | 8.65 | 7.66 |
| | 3 | 7.06 | 6.26 |
| | 4 | 6.12 | 5.42 |
| | 5 | 5.47 | 4.85 |
| | 6 | 4.99 | 4.43 |
| | 7 | 4.62 | 4.10 |
| | 8 | 4.32 | 3.83 |
| | 9 | 4.08 | 3.61 |
| | 10 | 3.87 | 3.43 |
| | 11 | 3.69 | 3.27 |
| | 12 | 3.53 | 3.13 |
| | 13 | 3.39 | 3.01 |
| | 14 | 3.27 | 2.90 |
| | 15 | 3.16 | 2.80 |

**FLUOR FEDERAL SERVICES**

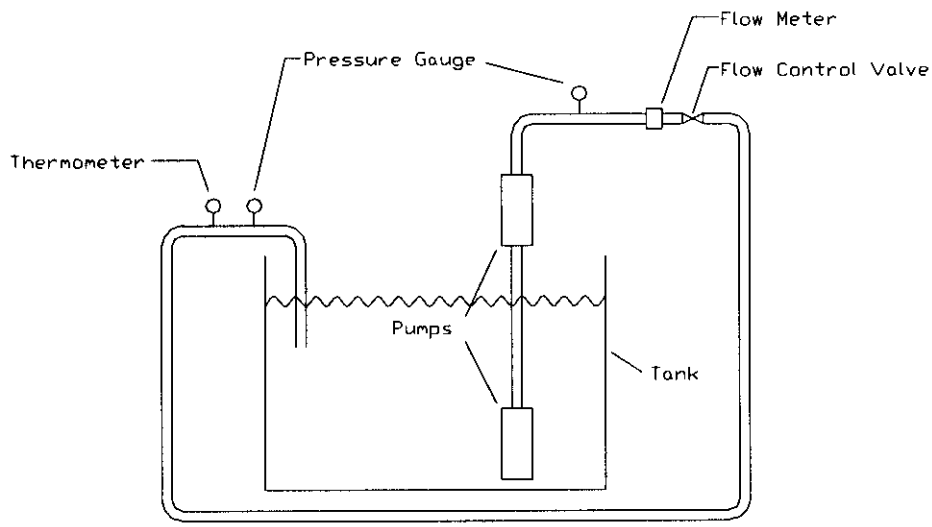
Calc. No.: MISC.
Revision No.: 0
Page No.: D3 of D4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 04 / 19 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

**Submersible Pump Run-In Test**




**CONCLUSION:**

Considering that 7.2 HP is lost to heat, an allowable temperature increase of 20° over an eight hour period, 117.5 $ft^3$ of 880 gallons of water is required. This number is conservative since it is unlikely that all power will be dissipated as heat into the water. A chart showing relative tank sizes for a the required volume is seen in the chart above.

From Flygt BS-2060.390 Performance Data, per the Imp. Code of 232, the pump is rated at 3.6 HP.

# APPENDIX E

# Radiation Resistance of Flygt Submersible Pump Elastomers

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: E1 of E4

**DESIGN ANALYSIS**

| | | | |
|---|---|---|---|
| Client: | CH2M HILL Hanford Group | Project/Area/Unit: | 65100541 / 25 / 9 |
| Subject: | DOUBLE SHELL TANK ANNULUS PUMPING | Date: | 04 / 20 / 00 By: P. M. DORSH |
| | DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS | Checked: | / / By: |
| Location: | 200 E AREA HANFORD | Revised: | By: |

**OBJECTIVE:**

The objective of this calculation is to explore the elastomers used in the Flygt submersible pump and verify their adequacy in the radiation environment.

**INPUT:**

1.) The expected radiation dose is $8.8 \times 10^6$ Rad. (Ref. 1, E3)

2.) The maximum temperature is 140° F. (Ref. 1, E3)

**REFERENCES:**

1.) Annulus Pump Submersible Pump Specification 4975-59-P1, Rev. 0

2.) Flygt Pump Material/Component List

**CALCULATION:**

See table on next page (E2).

**CONCLUSION:**

The radiation resistance of the elastomers used in the Flygt submersible pump are higher than the expected radiation dose. Therefore, the elastomers used in the Flygt pump will be sufficient for use in the design life of the pump.

## Pump Elastomers

| Pump Component | Trade Name | Material | Radiation Exposure (Rad) | Radiation Resistence (Rad) | Maximum Service Temperature | Acceptable? |
|---|---|---|---|---|---|---|
| Fluorocarbon Rubber, FPM | Viton | O-ring | 8.8 x 10^6 | 1 x 10^8 | +90 C / +194 F | Yes |
| | | Seal Sleeve | 8.8 x 10^6 | 1 x 10^8 | +90 C / +194 F | Yes |
| Nitrile Rubber, NBR | BUNA-N | Diffuser Coating | 8.8 x 10^6 | 8 x 10^8 | +90 C / +194 F | Yes |
| | | O-ring | 8.8 x 10^6 | 9 x 10^8 | +70 C / +158 F | Yes |
| | | Oil Housing Coating | 8.8 x 10^6 | 10 x 10^8 | +90 C / +194 F | Yes |
| Chloroprene Rubber, CR | Neoprene | Motor Cable | 8.8 x 10^6 | 3.5 x 10^7 | +70 C / +158 F | Yes |
| | | Seal Sleeve | 8.8 x 10^6 | 3.5 x 10^7 | +70 C / +158 F | Yes |

3.1.5 These pumps will be stored in a warehouse and installed only in the case of a leak into the tank annulus. During the time in storage it is anticipated that they will be periodically performance tested to ensure the availability of reliable pumps should there be a leak.

3.1.6 The maximum weight of the pump assembly, including motor and water, shall not exceed 1,000 lbs. *The Seller shall specify both wet and dry weights of the equipment* furnished.



3.2 Environmental Conditions

3.2.1 The transfer pump shall be able to withstand the following conditions inside the pump pit and in the annulus area:

| LOCATION | TEMPERATURE | % RELATIVE HUMIDITY | RADIATION EXPOSURE IN RAD | |
|---|---|---|---|---|
| | | | PER HOUR | 2 YEARS ACCUMULATION |
| PUMP PIT | 15 to 150 °F | 0 to 100 | 50 | $8.8 \times 10^5$ |
| TANK VAPOR SPACE | 50 to 140 °F | 0 to 100 | 400 | $6.8 \times 10^6$ |
| ANNULUS LIQUID | 65 to 140 °F | N/A | 500 | $8.8 \times 10^6$ |

3.3 Fluid Pumped

3.3.1 The radioactive sludge settled in the tanks consists mainly of insoluble oxides and/or hydroxides of aluminum, iron, manganese, and zirconium.

3.3.2 Fluid Properties

| | |
|---|---|
| Specific Gravity | 1.47 |
| Absolute Viscosity, Centipoise | 1.0 to 30 cP |
| Solids Content (vol.%) | 0 to 20.0 |
| Particle Size, Micron | 0.5 to 4000* |
| Abrasiveness, Miller Number (ASTM G75-82) | less than 100 |
| Temperature (transfer) | 65 to 140 °F |
| Temperature (flush or dilution) | 35 to 150 °F |
| PH | 7 – 14 |

- Although 50-micron particle size is the nominal design point, the pump must be fully capable of operating with the full range of particle sizes. The number of larger (500 to 4000 micron) particles will be relatively small (less than 1% of the total particles). Particles in the range of 50 to 500 micron will constitute less than 5% of the total particles. Particles ranging in size from 0.5 to 50 micron will constitute approximately 95% of the total particles.

# mical Resistance Table

oduct: 2060 390 Stainless Steel

Liquid: ALUMINIUM HYDROXIDE

Concentration: ALL Chemical Denomination: Al(OH)3 or AlO(OH)

ATTACHMENT E
PAGE E4 OF E4

| Material | Component | °F<br>°C | 50<br>10 | 68<br>20 | 86<br>30 | 104<br>40 | 122<br>50 | 140<br>60 | 158<br>70 | 176<br>80 | 194<br>90 | 212<br>100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STAINLESS STEEL, AISI 316L | Bearing Cover | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Connection Housing | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Cover | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Data Plate | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Diffuser Uncoated | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Entrance Cover | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Gland Screw | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Jacket | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Lifting Handle | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Metal Hose | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Nipple Pipe | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Oil Housing | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Outer Casing | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Screw | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Sleeve | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Stator Housing | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Strainer Bottom | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STAINLESS STEEL, AISI 329 | Impeller | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Shaft | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SINTERED ALUMINIUM OXIDE | Mechanical Seal | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Seal Ring | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CEMENTED CARBIDE, WCCR | Seal Ring | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ~~SILICON CARBIDE, RSiC~~ | ~~Mechanical Seal~~ | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ~~FLUOR. ETHYLENE PROPYLENE, FEP~~ | ~~Motor Cable~~ | | - | - | - | - | - | - | - | - | - | - |
| FLUOROCARBON RUBBER, FPM | O-ring | | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Seal Sleeve | | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| NITRILE RUBBER, NBR | Diffuser Coat. | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| | O-ring | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| | Oil Housing Coated | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| ARAMID FIBRE, RUBBER BONDED | Pipe | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| CHLOROPRENE RUBBER, CR | Motor Cable | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 |
| | Seal Sleeve | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 |

# APPENDIX F

# Weep Hole Sizing

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: F1 of F4

**DESIGN ANALYSIS**

| | | | |
|---|---|---|---|
| Client: | CH2M HILL Hanford Group | Project/Area/Unit: | 65100541 / 25 / 9 |
| Subject: | DOUBLE SHELL TANK ANNULUS PUMPING | Date: | 05 / 03 / 00 By: P. M. DORSH |
| | DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS | Checked: | / / By: |
| Location: | 200 E AREA HANFORD | Revised: | By: |

## OBJECTIVE:

The objective of this calculation is to determine the effects of placing a "weep hole" in the discharge piping of the air pump. A 1/16" weep hole will be drilled into the 3/4" discharge piping just after the pump discharge. The hole will allow the discharge column to drain once pumping is complete.

## INPUT:

1.) The pump piston is 1.5" in diameter and has a stroke of 12". (Ref. 1, F4)

2.) The pump displaces fluid at a maximum rate of 60 strokes/min. (Ref. 1, F4)

## METHODS:

1.) Calculations are performed using Mathcad 6.0, MathSoft Inc.

2.) Bernoulli's equation is used to determine the velocity of fluid at the weep hole.

For ease of calculation, the velocity at the weep hole is determined by considering a constant elevation head and neglecting the effects of the pump discharge.

## ASSUMPTIONS:

1.) The highest elevation of the discharge fluid is 50 feet above the elevation of the weep hole.

2.) The air pump is operating at its maximum speed of 60 fluid displacement strokes/min.

3.) Losses due to friction are negligible.

4.) The pump is 88% efficient.

5.) The entrance of the weep hole has a resistance coefficient of K = 0.5.

## REFERENCES:

1.) Instrumentation Northwest, Inc. Hydrostar System Air Motors

## CONCLUSIONS:

A 1/16" weep hole placed near the pump discharge will have a flow rate of 0.362 gal/min. Since the pump displaces 4.86 gal/min, this is a minor loss. A weep hole of this size would effectively drain the air pump discharge piping and would not greatly effect the pumping flow rate.

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: F2 of F4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 05 / 03 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

| | | | |
|---|---|---|---|
| Length of Pump Stroke | $L := 12 \cdot in$ | | (Ref. 1, F4) |
| Pump Piston Diameter | $D := 1.5 \cdot in$ | | (Ref. 1, F4) |
| Pump Piston Surface Area | $A := \frac{\pi}{4} \cdot D^2$ | | |
| Pump Efficiency | $e := 0.88$ | | (Assumption 4) |
| Volume of Fluid Displaced by Pump | $V := A \cdot L \cdot e$ | $V = 18.661 \cdot in^3$ | |
| Maximum Stroke Rate | $R := 60 \cdot \frac{stroke}{min}$ | | (Ref. 1, F4) |
| Pump Flow Rate | $Q_p := 18.7 \cdot \frac{in^3}{stroke} \cdot R$ | $Q_p = 18.7 \cdot \frac{in^3}{sec}$ | |
| | $Q_p = 4.857 \cdot \frac{gal}{min}$ | | |
| Weep Hole Diameter | $D_w := \frac{1}{16} \cdot in$ | | |
| Weep Hole Area | $A_w := \frac{\pi}{4} \cdot D_w^2$ | $A_w = 0.003 \cdot in^2$ | |
| Highest Elevation of Discharge Fluid | $z_a := 50 \cdot ft$ | | (Assumption 1) |
| Elevation of Weep Hole | $z_b := 0 \cdot ft$ | | |

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: F3 of F4

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 05 / 03 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

Considering Bernoulli's equation, $P_a/\gamma + V_a^2/2g + z_a = P_b/\gamma + V_b^2/2g + z_b + h_L$, with position "a" located at the highest elevation point and position "b" located at the weep hole, we find the velocity at the weep hole to be:

$$V_b^2/2g = (P_a/\gamma - P_b/\gamma) + (V_a^2/2g) + (z_a - z_b) - h_L$$

or, with zero terms canceled out (both pressures are atmospheric and $V_a = 0$) and $h_L = KV_b^2/2g$ (assuming K = 0.5):

$$1.5V_b^2/2g = z_a$$

Velocity of Fluid Exiting Weep Hole $\quad V := \frac{\sqrt{z_a \cdot (2 \cdot g)}}{1.5} \quad V = 37.815 \cdot \frac{ft}{sec}$

Flow Rate of Fluid at Weep Hole $\quad Q_w := V \cdot A_w \quad Q_w = 1.392 \cdot \frac{in^3}{sec}$

$$Q_w = 0.362 \cdot \frac{gal}{min}$$

Flow Rate $\quad Q := Q_p - Q_w \quad Q = 4.496 \cdot \frac{gal}{min}$

Efficiency $\quad e := \frac{Q}{Q_p} \quad e = 0.926$

# Instrumentation Northwest, Inc.

APPLICATION NOTE:
**Hydrostar System Air Motors**
May 5, 1992



## Introduction

When sizing an air-driven system one must consider the air motor cylinder size being used, the stroke rate desired to produce a certain production rate (GPM) and the air consumption of the air motor.

## Air Cylinder Size

Without going through the formulas, outlined below is a general guideline table for selecting the proper size air motor depending on the installation depth of the HydroStar. For each motor size a range of values is given: the Maximum Full Speed Depth (MFSD) and the Maximum Recommended Depth (MRD). The Maximum Full Speed Depth is the installation depth where some loss in air motor performance will begin to occur. The Maximum Recommended Depth is the deepest installation depth we would recommend using this size air motor.

**Depth Chart (In Feet)**

| Cylinder size (in) | 1.5 | 2.0 | 2.5 | 3.25 | 4 |
|---|---|---|---|---|---|
| MFSD (ft) | 76 | 146 | 240 | 392 | 617 |
| MRD (ft) | 106 | 205 | 337 | 549 | 865 |

## ›ı ›uction Due to Stroke Rate

he HS-8000 and HS-8001 pumps are 1.5" diameter pump cylinders with a stroke rate of 12 inches. If we assume that the umps operate at 90% efficiency the production factor of the pumps is .082 gallons per stroke. Note: Actual field studies ıte the efficiency of the HydroStar pumps better than 90% at their rated operating depth capacity *(see pump curves)*.

xample: If your pump is operating at 40 strokes per minute your production rate would be 40 * .082 = 3.29 gallons per inute.

## .ir Consumption *(at 80 PSI operation)*

ir consumption is a factor of the cylinder size you use and the stroke rate of the cylinder. The HydroStar system can ›erate up to 60 strokes per minute down to less than 1 stroke per minute so naturally the air consumption will vary pending on the desired operating speed.

›low is a table of factors one can use to determine the air consumption of your system in Standard Cubic Feet (SCF). hese factors are just guidelines since a number of additional variables can effect air consumption).

| Cylinder Size (in) | 1.5 | 2.0 | 2.5 | 3.25 | 4 |
|---|---|---|---|---|---|
| Air consumption *(SCF per stroke)* | .10 | .18 | .30 | .49 | .76 |

ample: A HydroStar system operating at 40 strokes per minute using a 1.5 inch cylinder would need .1 * 40 = 4 SCFM air.

*(cont.)*

# APPENDIX G

# Annulus Pump Assembly

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: G1 of G9

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 05 / 30 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

## OBJECTIVE:

The objective of this calculation is to verify the addequacy of a typical annulus pump assembly flange and lifting bails. A typical balance of the entire pump assembly is also included.

## INPUT:

1.) The weigth of the pump assembly is 1300 lbs. (Ref. 2, G9)

## METHODS:

1.) Calculations are performed using Mathcad 6.0, MathSoft Inc.

2.) Standard engineering practices are used to calculate stresses in the components and welds.

## ASSUMPTIONS:

1.) As stated in the calculation.

## REFERENCES:

1.) Drawing H-2-90161, Standard Rigid Lifting Bails.

2.) Drawing H-14-104134, Rev. 0, Pumps Assembly Annulus Pump Pit 241-AN-01B Thru -07B (typical).

## CONCLUSIONS:

The bails and associated components are adequate for vertical lifts. However, in a worst case sinerio, the capacity of the bails for lateral lifts are exceeded. The bending stresses in the bail created by a lateral lift surpasses the allowable stress, but are still below the yield stress for the material. It is unknown how the assembly will actually be lifted from the horizontal position. Any additional bracing or lifting points will lower the bending stresses to the allowable level.

Pump Assembly Balance Calculation performed by Roger Schroeder is located on page G6.

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: G2 of G9

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 05 / 30 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

Lifting Bail Capacity

Lifting Bail Capacity (vertical capacity) = 795 lbs*2 = 1590 lbs (per H-2-90161-15) (Ref. 1, G7)

Assembly Weight = 1300 lbs

Lifting Bail Support Welds

| | | |
|---|---|---|
| Weight of Assembly | $W := 1300 \cdot lb$ | |
| Diameter of Weld | $D := 3.068 \cdot in$ | |
| Length of Weld | $L := \pi \cdot D \cdot 2$ | $L = 19.277 \cdot in$ |
| Strength of Weld (Assuming E60 electrodes) | $S_w := 60000 \cdot psi$ | |
| Allowable Weld Force | $f_{all} := 0.3 \cdot S_w$ | $f_{all} = 1.8 \cdot 10^4 \cdot psi$ |
| Horizontal Shear on Weld | $f_w := \frac{W}{L}$ | $f_w = 67.439 \cdot \frac{lb}{in}$ |
| Minimum Allowable Fillet Weld Required by Design | $t := \frac{f_w}{0.707 \cdot f_{all}}$ | $t = 0.005 \cdot in$ |
| Factor of Safety | $FS := \frac{.1875 \cdot in}{t}$ | $FS = 35.382$ |

Lifting the Pump Assembly

It is assumed that the pump assembly will be lifted from a horizontal position to the vertical position (for insertion into the annulus riser) via the 2 lifting bails. The stresses in the bail will be checked for this lift. Note: only half the weight of the pump assembly will be lifted since one end is still in contact with the ground.

| | | |
|---|---|---|
| Weight of Assembly on each bail | $W := \frac{650 \cdot lb}{2}$ | $W = 325 \cdot lb$ |

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: G3 of G9

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 05 / 30 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

| | | |
|---|---|---|
| Moment on Weld on each Bail | $M := W \cdot 10 \cdot in$ | $M = 3.25 \cdot 10^3 \cdot lb \cdot in$ |
| Diameter of Weld | $D := 0.875 \cdot in$ | |
| Length of Weld | $L := \pi \cdot D \cdot 2$ | $L = 5.498 \cdot in$ |
| Bending | $S_w := \left(\frac{\pi \cdot D^2}{4}\right) \cdot 2$ | $S_w = 1.203 \cdot in^2$ |
| Force on Weld | $f_w := \frac{W}{L} + \frac{M}{S_w}$ | $f_w = 2.762 \cdot 10^3 \cdot \frac{lb}{in}$ |
| Strength of Weld (Assuming E60 electrodes) | $S_w := 60000 \cdot psi$ | |
| Allowable Weld Force | $f_{all} := 0.3 \cdot S_w$ | $f_{all} = 1.8 \cdot 10^4 \cdot psi$ |
| Minimum Allowable Fillet Weld Required by Design | $t := \frac{f_w}{0.707 \cdot f_{all}}$ | $t = 0.217 \cdot in$ |
| Factor of Safety | $FS := \frac{.3125 \cdot in}{t}$ | $FS = 1.44$ |

<u>Bending Stress in Bail</u>

| | | |
|---|---|---|
| Moment of Inertia | $I := \left(\frac{\pi}{64} \cdot D^4\right) \cdot 2$ | $I = 0.058 \cdot in^4$ |
| Radius | $c := \frac{7}{16} \cdot in$ | |
| Bending Stress | $\sigma := \frac{M \cdot c}{I}$ | $\sigma = 24707.5 \cdot psi$ |
| Yield Stress | $S_y := 36000 \cdot psi$ | |
| Allowable Bending Stress | $S_\sigma := S_y \cdot 0.6$ | $S_\sigma = 21600 \cdot psi$ |

The bending stress of the lifting bail is slightly higher than the allowable stress, but is much lower than yield stress.

Bending Stress in Bail Support

| | | |
|---|---|---|
| Diameter | $D := 3.068 \cdot in$ | |
| Moment of Inertia | $I := \left(\frac{\pi}{64} \cdot D^4\right) \cdot 2$ | $I = 8.698 \cdot in^4$ |
| Radius | $c := \frac{D}{2}$ | $c = 1.534 \cdot in$ |
| Bending Moment | $M := W \cdot 22 \cdot in$ | |
| Bending Stress | $\sigma := \frac{M \cdot c}{I}$ | $\sigma = 1261 \cdot psi$ |
| Yield Stress | $S_y := 25000 \cdot psi$ | |
| Allowable Bending Stress | $S_\sigma := S_y \cdot 0.6$ | $S_\sigma = 15000 \cdot psi$ |

Based on the low stresses in the bail support pipe, the support welds are still acceptable.

Pump Flange

The Pump Flange is under the most stress during installation. For conservatism and ease of calculation assume that the plate is 8" wide, and simply supported at the lifting bails.

| | | |
|---|---|---|
| Width of Plate | $w := 8 \cdot in$ | |
| Thickness of Plate | $t := .875 \cdot in$ | |
| Moment of Inertia | $I := \frac{w \cdot t^3}{12}$ | $I = 0.447 \cdot in^4$ |
| Length of Plate | $L := \sqrt{(7.375 \cdot 2)^2 + (6.75 \cdot 2)^2} \cdot in$ | $L = 19.995 \cdot in$ |

**FLUOR FEDERAL SERVICES**

Calc. No.: MISC.
Revision No.: 0
Page No.: G5 of G9

**DESIGN ANALYSIS**

Client: CH2M HILL Hanford Group
Subject: DOUBLE SHELL TANK ANNULUS PUMPING
DST ANNULUS PUMP MISCELLANEOUS CALCULATIONS
Location: 200 E AREA HANFORD

Project/Area/Unit: 65100541 / 25 / 9
Date: 05 / 30 / 00 By: P. M. DORSH
Checked: / / By:
Revised: By:

| | | |
|---|---|---|
| Modulus of Elasticity | $E := 30 \cdot 10^6 \cdot psi$ | |
| Weight of Assembly | $W := 1300 \cdot lb$ | |
| Plate Deflection | $\delta := \frac{W \cdot L^3}{48 \cdot E \cdot I}$ | $\delta = 0.016 \cdot in$ |
| Moment | $M := \frac{W \cdot L}{2}$ | $M = 1083.1 \cdot lb \cdot ft$ |
| Bending Stress | $\sigma := \frac{M \cdot t}{I \cdot 2}$ | $\sigma = 12731.7 \cdot psi$ |
| Shear Stress | $\tau := \frac{W}{w \cdot t}$ | $\tau = 185.714 \cdot psi$ |
| Yield Stress | $S_y := 25000 \cdot psi$ | |
| Allowable Bending Stress | $S_\sigma := S_y \cdot 0.6$ | $S_\sigma = 15000 \cdot psi$ |
| Allowable Shear Stress | $S_\tau := S_y \cdot 0.4$ | $S_\tau = 10000 \cdot psi$ |

Both stresses are well below the allowable. Therefore, the plate is acceptable.

RPP-6485 Rev. 0

KAISER ENGINEERS HANFORD

# JUMPER CALCULATION



| JOB NO. | DWG. NO. | DATE 5/8/00 | PAGE |
|---|---|---|---|
| BLDG. NO. AZ FARM | H-14-104138 | BY RWS / CHKD. | |

| PART | DESCRIPTION | WEIGHT LBS. | X - X AXIS MOM. ARM IN. | X - X AXIS MOMENT IN. LBS. | Y - Y AXIS MOM. ARM IN. | Y - Y AXIS MOMENT IN. LBS. |
|---|---|---|---|---|---|---|
| A | R 7/8" THK & TRUNN | 288 | 16.75 | 4489 | 16.75 | 4489 |
| B | NOZZ 'A' | 7 | 4.06 | 28.42 | 16 | 112 |
| C | NOZZ 'B' | 6.5 | 20.5 | 133.25 | 20.5 | 198.25 |
| D | 'A' PL | 13 | 4.06 | 52.78 | 16 | 208 |
| E | 'B' PL 3.25 | | 18.06 | 58.7 | 30.63 | 99.55 |
| F | R PL | 3.25 | 15.75 | 51.2 | 30.5 | 99.13 |
| G | 3" PIPE | 3.23 | 9.38 | 30.3 | 16 | 51.7 |
| H | 3/4" PIPE | 1.4 | 20.5 | 28.7 | 23.25 | 32.55 |
| J | BIG PUMP | 140 | 14.69 | 2056.6 | 16 | 2240 |
| K | 3" PIPE & FLGS | 440 | 14.69 | 6463.6 | 16 | 7040 |
| L | SM PUMP ET. AL. | 320 | 20.5 | 6560 | 16 | 5120 |
| M | 3/4" FLUSH | 48 | 18.5 | 888 | 23.7 | 1137.6 |
| N | 1/2 FLUSH | 3 | 18.5 | 55.5 | 28.2 | 84.6 |
| P | CABLE | 6 | 14.69 | 161.6 | 16 | 176 |
| Q | | 1267.63 | | 21,057.65 | | 21088.38 |
| R | | | 16.612 | | | 16.636 |
| S | | | | | | |
| T | | | | | | |
| U | | | | | | |
| V | | | | | | |

$\Sigma W =$ $\Sigma Mx =$ $\Sigma My =$

$\bar{x} = \frac{\Sigma Mx}{\Sigma W} =$ $\bar{y} = \frac{\Sigma My}{\Sigma W} =$ 1'-4 5/8

| | COEFF. OF. EXP. / °F | Δt °F | ΔX EXPANDING LENGTH | ΔX EXPANSION | ΔY EXPANDING LENGTH | ΔY EXPANSION | ΔZ EXPANDING LENGTH | ΔZ EXPANSION |
|---|---|---|---|---|---|---|---|---|
| JUMPER | | | | | | | | |
| VESSEL | | | | | | | | |
| DUNNAGE | | | | | | | | |
| TOLERANCE | | | | | | | | |
| Δ | | | | | | | | |

Post-it® Fax Note 7671 Date 5-22-00 # of pages ▶ 1
To Paul Dorsch From Roger Schlaberg
Co./Dept. FPS Co. FPS
Phone # 372-0289 Phone # 373-3060
Fax # 373-5712 Fax # 373-4115
(2-82) 63-H

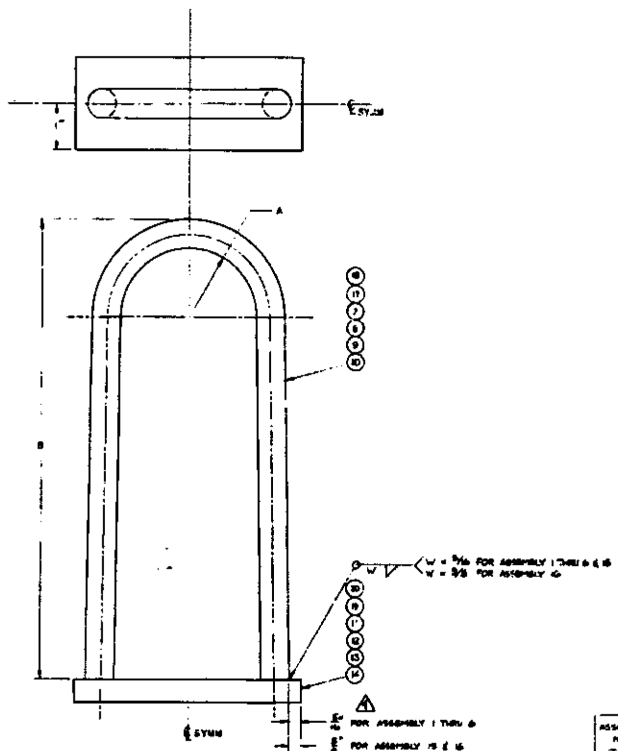


05/22/00 MON 07:34 FAX 1 509 373 4115 86 TWRS CHARACTERIZATION 001

| QUANTITY | | | | | | | | PT NO | DESCRIPTION | | MAT'L./REF. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | X | 1 | ASSEMBLY | 8" CS | |
| | | | | | | X | | 2 | ASSEMBLY | 8" SST | |
| | | | | | X | | | 3 | ASSEMBLY | 10" CS | |
| | | | | X | | | | 4 | ASSEMBLY | 10" SST | |
| | | | X | | | | | 5 | ASSEMBLY | 14" CS | |
| | | X | | | | | | 6 | ASSEMBLY | 14" SST | |
| | | | | | 1 | | 1 | 7 | BAR ⌀ $\frac{1}{2}$" X LG A/R | | ASTM A36 CS |
| | | | 1 | | | | | 8 | BAR ⌀ $\frac{1}{2}$" X LG A/R | | ASTM A36 CS |
| | | | | 1 | | 1 | | 9 | BAR ⌀ $\frac{1}{2}$" X LG A/R | | ASTM-A276 304L SST |
| | | 1 | | | | | | 10 | BAR ⌀ $\frac{1}{2}$" X LG A/R | | ASTM-A276 304L SST |
| | | | | | 1 | | 1 | 11 | BAR, FLAT 2 X $\frac{1}{2}$ X 5 | | ASTM-A36 CS |
| | | | 1 | | | | | 12 | BAR, FLAT 2 X $\frac{1}{2}$ X 7 | | ASTM-A36 CS |
| | | | | 1 | | 1 | | 13 | BAR, FLAT 2 X $\frac{1}{2}$ X 5 | | ASTM-A276 304L SST |
| | | 1 | | | | | | 14 | BAR, FLAT 2 X $\frac{1}{2}$ X 7 | | ASTM-A276 304L SST |
| | X | | | | | | | 15 | ASSEMBLY | 10" CS | |
| X | | | | | | | | 16 | ASSEMBLY | 14" CS | |
| | 1 | | | | | | | 17 | BAR ⌀ $\frac{3}{4}$" X L A/R | | ASTM A36 CS |
| 1 | | | | | | | | 18 | BAR ⌀ $1\frac{1}{8}$" X L A/R | | ASTM A36 CS |
| | 1 | | | | | | | 19 | BAR, FLAT 2 X $\frac{1}{2}$ X 6 | | ASTM A36 CS |
| 1 | | | | | | | | 20 | BAR, FLAT 2 X $\frac{3}{4}$ X $8\frac{1}{2}$ | | ASTM A36 CS |

## GENERAL NOTES

1. BREAK ALL SHARP EDGES AND CORNERS.
2. WELD AND INSPECT:
   a) ALL CARBON STEEL BAIL ASSEMBLIES (PARTS # 1, 3, 5, 15, & 16) PER AWS D1.1. VT WELDS AT FINAL PASS. MT ALL WELDS ON FINAL PASS.
   b) ALL STAINLESS STEEL BAIL ASSEMBLIES (PARTS # 2, 4, & 6) PER HS-V-6-005. VT WELDS AT FINAL PASS. PT ALL WELDS ON FINAL PASS.
3. IDENTIFY ALL ASSEMBLIES PER HS-86-005, TYPE 10, WITH DWG NO, PART NO, & DWG REV NO USING $\frac{1}{8}$" HIGH CHARACTERS.
4. IDENTIFY PARTS, IN PARTS LIST, AS FOLLOWS:
   a) IMPACT LEVEL 3 - PARTS 1 THRU 6 AND PARTS 15 & 16.
   b) IMPACT LEVEL 4 - PARTS 7 THRU 14 AND PARTS 17 THRU 20.




(1) ASSEMBLY
(2) ASSEMBLY
(3) ASSEMBLY
(4) ASSEMBLY
(5) ASSEMBLY
(6) ASSEMBLY
(15) ASSEMBLY
(16) ASSEMBLY

SCALE: NONE

SUMMARY OF BAIL CAPACITY
PER WHC-SD-WM-DA-085

| ASSEMBLY NO. | BAIL CAPACITY AT | |
|---|---|---|
| | VERTICAL LIFT (LBS.) | LATERAL LIFT (LBS) |
| 1 | 410 | 70 |
| 2 | 395 | 60 |
| 3 | 390 | 56 |
| 4 | 360 | 40 |
| 5 | 475 | 68 |
| 6 | 340 | 49 |
| 15 | 795 | 135 |
| 16 | 1490 | 260 |

TABLE OF DIMENSIONS

| ASSEMBLY NO | 1 | 2 | 3 | 4 | 5 | 6 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|
| DIM A | $1\frac{1}{2}$ | $1\frac{1}{2}$ | $1\frac{1}{2}$ | $1\frac{1}{2}$ | 2 | 2 | $1\frac{3}{4}$ | $2\frac{1}{8}$ |
| DIM B | 8 | 8 | 10 | 10 | 14 | 14 | 10 | 14 |
| MAT'L | CS | SST | CS | SST | CS | SST | CS | CS |
| WEIGHT | 2.9# | 2.9# | 3.7# | 3.7# | 5.7# | 5.7# | 5.4# | 14.2# |

CROSS REFERENCE INFORMATION

| ASSEMBLY NO | REPLACES |
|---|---|
| 1 | H-2-37676-2 |
| 2 | H-2-37670-1 |
| 3 | H-2-8571<br>H-2-30777 |
| 4 | H-2-34850 |
| 5 | H-2-2510<br>H-2-3245<br>H-2-40603<br>H-2-40604<br>H-2-40602<br>H-2-42806<br>H-2-53563<br>H-2-53564<br>H-2-53562<br>H-2-53560 |
| 6 | H-2-34850 |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON:
DECIMALS ANGLES FRACTIONS
± $\frac{1}{8}$
DO NOT SCALE PRINT

STANDARD PART

U.S. Department of Energy
Rockwell Hanford Operations

STANDARD RIGID LIFTING BAILS

SIZE E | 300 GEN | H-2-90161 | SHEET 1 OF 1

AS ALLOCATED

RPP-6485 REV. 0

| FLUOR FEDERAL SERVICES | CALCULATION IDENTIFICATION AND INDEX | Page i of i<br>Date |
|---|---|---|

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline STRUCTURAL WO/Job No. _____ Calculation No. DST-C-001

Project No. & Name DST TANK ANNULUS PUMP SYSTEM

Calculation Item PORTABLE DST TANK SKID

These calculations apply to:

Dwg. No. H-14-104141 SH 1 Rev. No. 0

Dwg. No. _____ Rev. No. _____

Other (Study, CDR) _____

_____ Rev. No. _____

The status of these calculations is:

- ☐ Preliminary Calculations
- ☒ Final Calculations
- ☐ Check Calculations (On Calculation Dated _____)
- ☐ Void Calculation (Reason Voided _____)

Incorporated in Final Drawings? ☒ Yes ☐ No

This calculation verified by independent "check" calculations? ☐ Yes ☒ No

Original and Revised Calculation Approvals:

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | D Chou 4/18/00 | | |
| Checked by | G.A. Lisle 4/21/00 | | |
| Approved by | | | |
| Checked Against Approved Vendor Data | | | |

INDEX

| Design Analysis Page No. | Description |
|---|---|
| 1-5 | GENERAL & CALC BODY |
| ATTACH. | A-1 THRU A-4 EQUIP CUT SHEETS |



KEH 0378.00 (06/92)

Fluor Federal Services

DESIGN ANALYSIS

Calc. No. DST-C-001
Revision 0
Page No. 1 of

Client | Contract/Job No.

Subject PORTABLE DST TANK SKID | Originated By DTC | Date 4/18/00

Checked By G.A. Lisle | Date 4/21/00

Location | Revised By | Date

OBJECTIVE: TO CHECK THE PORTABLE SKID STRUCTURE. SEE NEXT PG FOR LAYOUT.

CRITERIA: THE SKID IS A GENERAL SERVICE CLASSIFICATION.

REFERENCES: USE HNF-PRO-97, UNISTRUT GENERAL ENGINEERING CATALOG NO. 12.

DESIGN INPUT: SEE THE ATTACHMENT A FOR ELECTRICAL PANEL & AIR COMPRESSOR (TANK) DATA.

WIND LOAD: ASCE 7-95, EXPOSURE C, PC 2.

$F = q_z G C_f A_f$ (TABLE 6-1, OTHER STRUCTURES)

(6.6.1)

$= 16.82 \times 0.85 \times 1.2 A_f$ (TABLE 6-8)

$= 17.2 A_f$

$q_z = .00256 K_z K_{zt} V^2 I$

$= .00256 \times 0.85 \times 1.0 \times 85^2 \times 1.07$

$= 16.82$ PSF

SEISMIC LOAD: PC 2, UBC 97, ZONE 2B, FOR ESSENTIAL FACILITY (1632.2, FORMULA 32.2, w/ $h_x = 0$)

$F_p = \frac{a_p C_a I_p}{R_p} W_p$

$= \frac{2.5 \times 0.28 \times 1.5}{3.0} W_p = 0.35 W_p$

ASSUME $S_D$ SOIL PROFILE

USE SIGNS & BILLBOARD TYPE



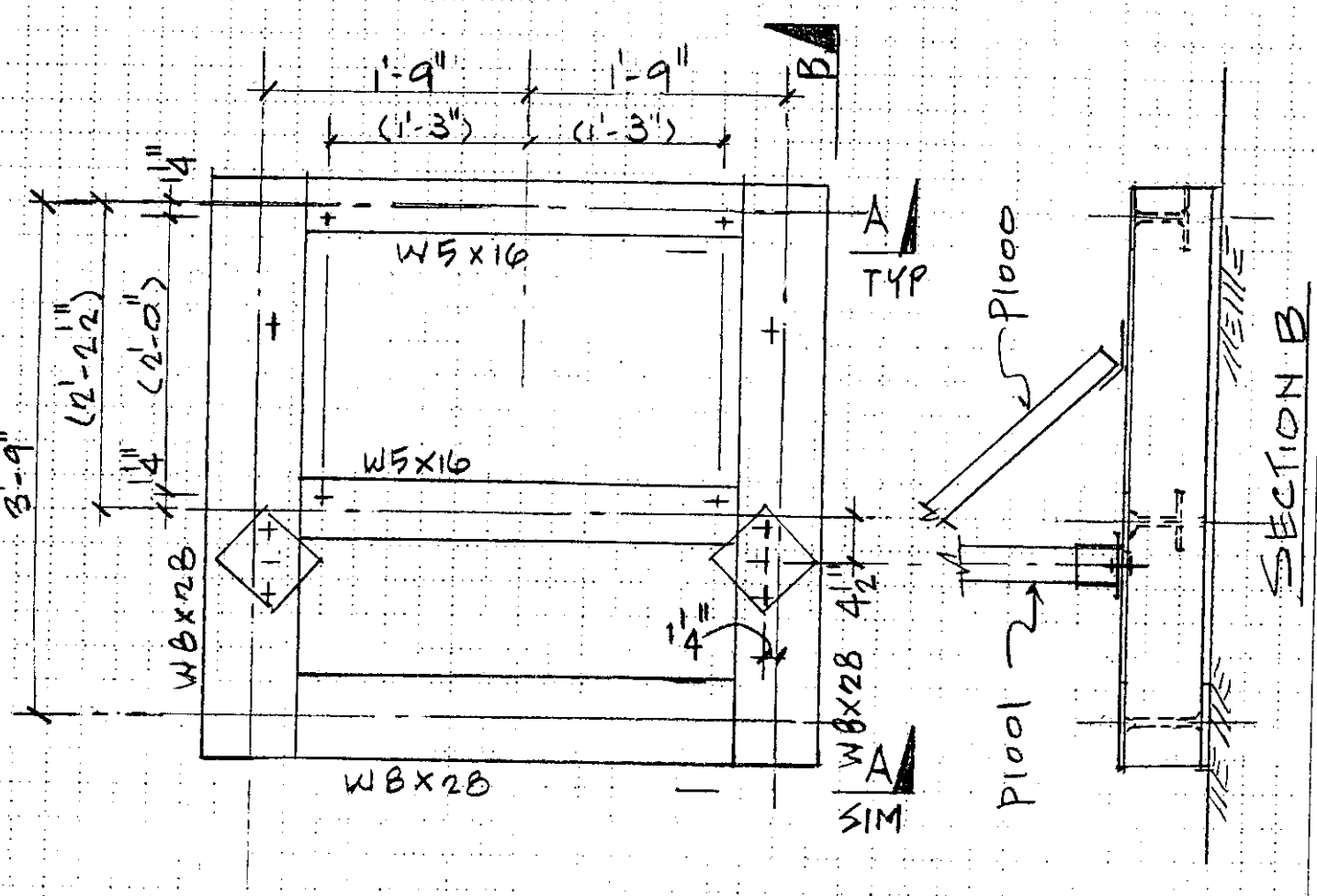
E-NW-123A (5/98)

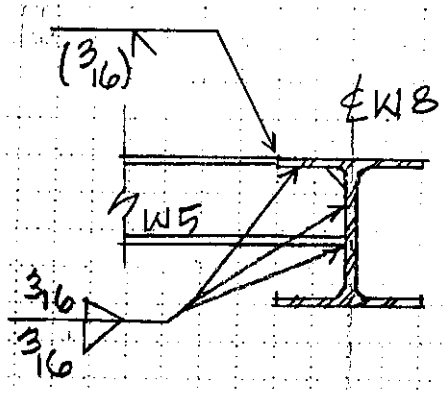
Fluor Federal Services

DESIGN ANALYSIS

Calc. No. DST-C-001
Revision 0
Page No. 2 of

Client
Contract/Job No.
Subject PORTABLE DST TANK SKID
Originated By DTC Date 4/18/00
Checked By GR Lisle Date 4/21/00
Location
Revised By Date




SECTION A



E-NW-123A (5/98

Fluor Federal Services

DESIGN ANALYSIS

Calc. No. DST-C-001
Revision 0
Page No. 3 of

Client
Contract/Job No.
Subject PORTABLE DST TANK SKID
Originated By DTC Date 4/18/00
Checked By GA Lisle Date 4/21/00
Location
Revised By Date

DEAD LOADS

AIR COMPRESSOR (40 5/8 x 21 5/8 x 38) DL = 180 LBS
L W H

ELEC. PANEL (30 x 25.4 x 8.0) ASSUME 100 LBS

BASE FRAME

| | | | |
|---|---|---|---|
| W8 X 28 | 28 PLF (4.3 x 2 EA + 3.5') | = 339 | |
| W5 X 16 | 16 x 3.5' x 2 EA | = 112 | |
| | | | 451 |
| UNISTRUT | 3.8 PLF x 5' x 2 EA | = 38 | |
| | 2.0 PLF x 4' x 3 | = 24 | |
| | CONNECTION & MISC | = 7 | |
| | | | 69 |

TOTAL = 830 LBS

STABILITY ANALYSIS

WIND LOAD

| | | | $M_o$ |
|---|---|---|---|
| 17.2 PSF x (34" x 30"/144) | = 122 LBS | x (3.8' + 0.7') | = 549 |
| " x 2.5' x 3.5' | = 151 | x (1.3 + 0.7) | = 302 |
| | 273 | | 851 |

SEISMIC $F_p = 0.35 \times 800 = 280$ LBS



E-NW-123A (5/98

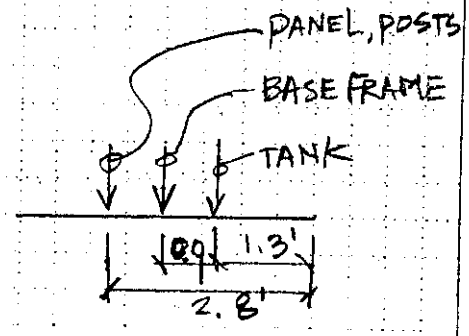
Fluor Federal Services

DESIGN ANALYSIS

Calc. No. DST-C-001
Revision 0
Page No. 4 of

Client
Contract/Job No.
Subject PORTABLE DST TANK SKID
Originated By DTC
Date 4/18/00
Checked By G.A. Lisle
Date 4/21/00
Location
Revised By
Date

OVERTURNING




$M_R = 180^{LBS} \times 1.3 + 451 \times 2.2 + (100 + 69) \times 2.8$

$= 1700$ #-1

$F.S. = M_R / M_O = 2.0 > 1.1$ OK

↑ WIND GOVERNS

SLIDING

ASSUME FRICTION COEFFICIENT STEEL/SOIL = 0.35

RESISTANCE $= 800^{LBS} \times 0.35 = 280^{LBS}$

$F.S. = 280 / 280 = 1.0$ SAY OK

↑ SEISMIC GOVERNS

(AN IMPORTANCE FACTOR OF 1.5 APPLIED TO THE SEISMIC LOAD)



E-NW-123A (5/98)

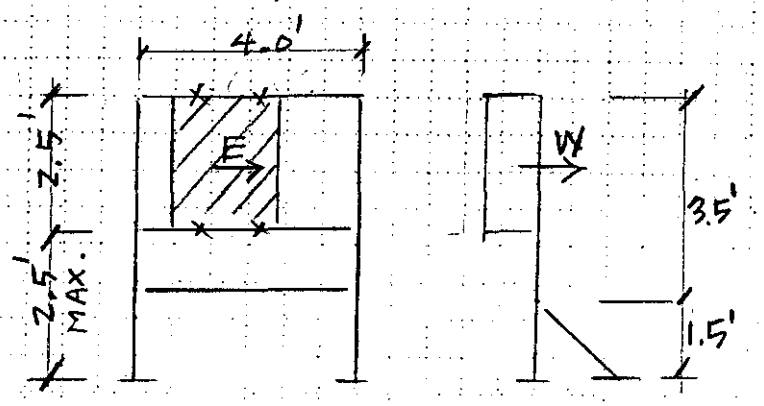
Fluor Federal Services

DESIGN ANALYSIS

Calc. No. DST-C-001
Revision 0
Page No. 5 of

Client
Contract/Job No.
Subject PORTABLE DST TANK SKID
Originated By DTC
Date 4/18/00.
Checked By G.A. Lisle
Date 4/21/00
Location
Revised By
Date

ELECTRICAL PANEL RACK.




E (SEISMIC) = (100 LBS + 71 LBS) (0.35) = 60 #

W (WIND) = 122 # (PG 3)

BY INSPECTION.

VERT COLS USE P1001.

HORIZ BM USE P1000

VERT BRACE USE P1000.

DESIGN MANUAL / SOIL MECHANICS, FOUNDATIONS, AND EARTH STRUCTURES NAVFAC DM-7

TABLE 10-1

**Friction Factors and Adhesion for Dissimilar Materials**

| Interface materials | Friction factor, tan $\delta$ | Friction angle, $\delta$, degrees | Adhesion $C_A$, psf |
|---|---|---|---|
| Mass concrete on the following foundation materials: | | | |
| Clean sound rock | 0.70 | 35 | ..... |
| Clean gravel, gravel-sand mixtures, coarse sand | 0.55 to 0.60 | 29 to 31 | ..... |
| Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel. | 0.45 to 0.55 | 24 to 29 | ..... |
| Clean fine sand, silty or clayey fine to medium sand | 0.35 to 0.45 | 19 to 24 | ..... |
| Fine sandy silt, nonplastic silt | 0.30 to 0.35 | 17 to 19 | ..... |
| Very stiff and hard residual or preconsolidated clay | 0.40 to 0.50 | 22 to 26 | ..... |
| Medium stiff and stiff clay and silty clay | 0.30 to 0.35 | 17 to 19 | ..... |
| (Masonry on foundation materials has same friction factors.) | | | |
| Steel sheet piles against the following soils: | | | |
| Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls. | 0.40 | 22 | ..... |
| Clean sand, silty sand-gravel mixture, single size hard rock fill | 0.30 | 17 | ..... |
| Silty sand, gravel or sand mixed with silt or clay | 0.25 | 14 | ..... |
| Fine sandy silt, nonplastic silt | 0.20 | 11 | ..... |
| Soft clay and clayey silt | ..... | ..... | 100 to 600 |
| Stiff and hard clay and clayey silt | ..... | ..... | 600 to 1,200 |
| Formed concrete or concrete sheet piling against the following soils: | | | |
| Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls. | 0.40 to 0.50 | 22 to 26 | ..... |
| Clean sand, silty sand-gravel mixture, single size hard rock fill | 0.30 to 0.40 | 17 to 22 | ..... |
| Silty sand, gravel or sand mixed with silt or clay | 0.30 | 17 | ..... |
| Fine sandy silt, nonplastic silt | 0.25 | 14 | ..... |
| Soft clay and clayey silt | ..... | ..... | 200 to 700 |
| Stiff and hard clay and clayey silt | ..... | ..... | 700 to 1,200 |
| Various structural materials: | | | |
| Masonry on masonry, igneous and metamorphic rocks: | | | |
| Dressed soft rock on dressed soft rock | 0.70 | 35 | ..... |
| Dressed hard rock on dressed soft rock | 0.65 | 33 | ..... |
| Dressed hard rock on dressed hard rock | 0.55 | 29 | ..... |
| Masonry on wood (cross grain) | 0.50 | 26 | ..... |
| Steel on steel at sheet pile interlocks | 0.30 | 17 | ..... |

Note: Numbers shown are ultimate values and require sufficient movement for failure to occur.
Where friction factor only is shown, the effect of adhesion is included in the friction factor.
For data on adhesion on bearing piles, see Chapter 13.

of resultant uplift force on failure wedge for various inclinations of failure plane to be used in analysis of the active wedge.

d. **Seepage Beneath Wall.** See bottom panel of Figure 10-5 for correction to be applied to active and passive pressures in cohesionless material for steady seepage beneath a wall.

e. **Consolidation Pore Pressures.** Where impervious clay behind a wall is loaded by backfill, hydrostatic excess pore pressures can develop in the clay. Estimate such pore pressures by methods of Chapter 6 and include them in uplift on the failure surface.

5. **SURCHARGE LOADING.** For the effect of surcharge loading, see Figures 10-1 and 10-2.

a. **Area Loads.** Where surcharge behind a wall consists of area load, include the weight of surcharge with forces acting on the trial failure wedges.



CALC DST-C-001
ATTACH A-1

For Type 4 and Type 12 Enclosures for Flange-Mounted Disconnects, the electrical Engineer called the supplier, Hoffman Engineering Company, for the WT:

Enclosure = 61#
Panel = 18#
Switches, etc=21# (assumed)
---
100# DTC 4/17/00

These enclosures are designed to house Square D Class 9422 disconnect switches with flange mounted variable depth operating mechanisms or cable mechanisms.

RPP-6485 Rev. 6



For Sealing

**Furnished with enclosures:**

1. Bracket welded to door for attaching disconnect door catch (interlock)
2. Instructions to locate and install disconnect switches, circuit breakers, and operating mechanisms

**Ordering a Disconnect?**

*Disconnect switch (or circuit breakers), operating handle, and operating mechanism are not furnished with enclosure. Disconnect ordering information is located on page 5.15.*

## Standard Sizes Type 4 and Type 12 Enclosures for Flange-Mounted Disconnects

| Enclosure Catalog Number | Enclosure Size A x B x C | * Panel Catalog Number | Panel Size D x E | Data Pocket | Number of Clamps | Stiffener Door/Body | |
|---|---|---|---|---|---|---|---|
| A-24HS2108LP | 24.00 x 21.38 x 8.00 (610 x 543 x 203) | A-24P20 | 21.00 x 17.00 (533 x 432) | Small | 5 | 0 | 0 |
| A-24HS2508LP | 24.00 x 25.38 x 8.00 (610 x 645 x 203) | A-24P24 | 21.00 x 21.00 (533 x 533) | Small | 5 | 0 | 0 |
| A-30HS2508LP | 30.00 x 25.38 x 8.00 (762 x 645 x 203) | A-30P24 | 27.00 x 21.00 (686 x 533) | Large | 5 | 0 | 0 |
| A-36HS2508LP | 36.00 x 25.38 x 8.00 (914 x 645 x 203) | A-36P24 | 33.00 x 21.00 (838 x 533) | Large | 5 | 0 | 0 |
| A-36HS3108LP | 36.00 x 31.38 x 8.00 (914 x 797 x 203) | A-36P30 | 33.00 x 27.00 (838 x 686) | Large | 7 | 0 | 1 |
| A-42HS3112LP | 42.00 x 31.38 x 12.00 (1067 x 797 x 305) | A-42P30 | 39.00 x 27.00 (991 x 686) | Small | 10 | 0 | 1 |
| A-42HS3712LP | 42.00 x 37.38 x 12.00 (1067 x 949 x 305) | A-42P36 | 39.00 x 33.00 (991 x 838) | Large | 10 | 0 | 1 |
| A-48HS3712LP | 48.00 x 37.38 x 12.00 (1219 x 949 x 305) | A-48P36 | 45.00 x 33.00 (1143 x 838) | Large | 10 | 0 | 1 |
| A-60HS3712LP | 60.00 x 37.38 x 12.00 (1524 x 949 x 305) | A-60P36 | 57.00 x 33.00 (1448 x 838) | Large | 11 | 0 | 1 |

Millimeter dimensions ( ) are for reference only; do not convert metric dimensions to inch.

* Panels must be ordered separately. Optional stainless steel or aluminum panels are available. See General Accessories.

### Accessories

Blank Adapter Plate page 5.49

See also *General Accessories index page 9.00*

Corrosion Inhibitors
Electric Heater
Electrical Interlocks
Floor Stand Kit
Lighting Kit
Panels (See table)
Terminal Kit Assembly
Touch-Up Paint (A-TPPY61)
Window Kit

*Air conditioners and heat exchangers for this enclosure can be found in Hoffman's Specifier's Guide for Thermal Management Products.*

*Product also available in stainless steel.*

*Contact your local Hoffman Sales Representative for information on modifications to this product.*

### Cross Reference

Stainless Steel Type 4X Enclosures for Flange-Mounted Disconnects (page 6.26)

CONCEPT™ Stainless Steel Disconnect Wall-Mount Enclosures (page 6.22)

Type 12 and Type 13 Enclosures for Flange-Mounted Disconnects (page 5.02)

CALC DST-C-001
ATTACH A-3





410

CALC DST-C-001, ATTACH A-4

NEW ITEM ON THIS PAGE

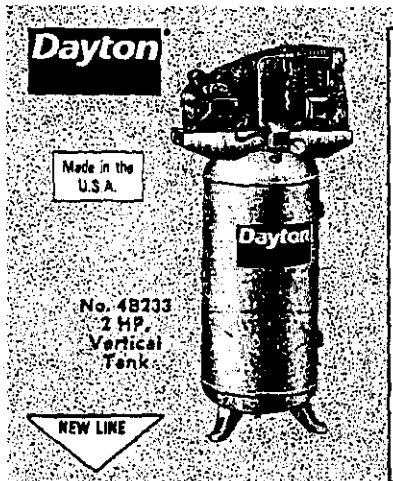
**AIR COMPRESSORS**

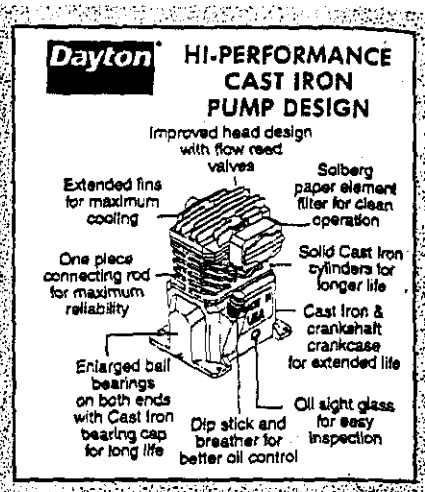
# STATIONARY TANK MOUNTED AND BASE PLATE AIR COMPRESSORS

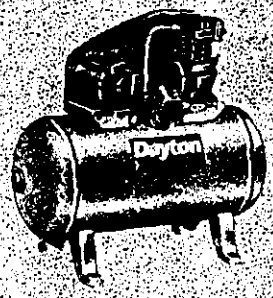
**EXCLUSIVE DAYTON DESIGN RELIABLY POWERS AIR TOOLS, PAINT SPRAYERS, SANDBLAST EQUIPMENT, AIR CYLINDERS, AND SMALL MACHINES**

**THE DAYTON CAST IRON DIFFERENCE**

- Longer life—up to 100% longer pump life than comparable air compressors
- Higher Air Flow—Up to 10% more CFM than comparable models
- Higher Pressure—Maximum 135 PSI for a broader range of applications
- Higher Duty Cycle—Runs up to a 65% duty cycle vs. the standard 50/50 duty cycle

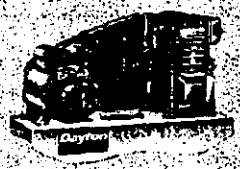



No. 4B234
2 HP,
Horizontal
Tank

Except Nos. 4B242 & 4B243



No. 4B243
Base Plate

**TANK MOUNT MODELS INCLUDE**

- High flow air cooling system reduces pump temperature
- Copper discharge tube for improved durability and cooling
- Single and 3-phase open dripproof motors with thermal protection
- NEMA 1 enclosure pressure switch with gauge
- 30 gallon stationary ASME air tank
- Pressure switch setting 95 PSI On and 135 PSI Off (Except Base Plate Nos. 4B242 and 4B243)
- Comply with State of California code 462 (L) (2)
- Charcoal gray metallic finish

**BASE PLATE MODELS Nos. 4B242 and 4B243**

- Suitable for fire sprinkler applications (verify local codes and regulations for compliance)
- Prewired (240V) with pneumatic control package
- Pressure switch setting 30 PSI On and 40 PSI Off

## PUMP SPECIFICATIONS

| Free Air CFM @ PSI 40 | 90 | Displ. CFM | Max. PSI | Rated Pump Life (Hrs)† | Max. Duty Cycle | RPM | Cyls. | Bore (in.) | Stroke (in.) | Oil Cap. | Repl. Pump Stock No. | Compressor Stock No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.9 | 5.7 | 8.8 | 100 | 5000 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 oz. | 4B246 | 4B232 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B233 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B234 |
| 6.9 | 5.7 | 8.8 | 135 | 3600 | 65/35 | 850 | 2 | 2¾ | 1½ | 11.5 | 4B246 | 4B235 |
| 11.0 | 9.4 | 13.7 | 135 | 4200 | 65/35 | 1000 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B237 |
| 11.2 | — | 13.7 | 40 | 5000 | 65/35 | 1000 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B242 |
| 14.1 | — | 16.8 | 40 | 5000 | 65/35 | 1225 | 2 | 2¾ | 2 | 16.0 | 4B247 | 4B243 |

## ORDERING DATA

| Peak Developed HP* | Running Motor HP* | Gal. | Tank Type | Volts, 60 Hz | Phase | Amp Draw | NPT Outlet, In. | Dimensions, In. L | W | H | Stock No. | List | Each | Shpg. Wt. | With Magnetic Starter# Volts, 60 Hz | Stock No. | List | Each | Shpg. Wt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00 | 30‡ | Horizontal | 120/240 | 1 | 17.8/8.9 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B232▲ | $748.75 | $585.00▲ | 177.0 | 120<br>240 | 7Z021▲<br>7Z022▲ | $915.00<br>910.00 | $729.00▲<br>715.00▲ | 184.2<br>184.2 |
| 2 | 2.00 | 30‡ | Vertical | 120/240 | 1 | 24.0/12.0 | 1/4(F) | 26¼ | 19 | 52 | 4B233▲ | 798.75 | 599.00▲ | 170.0 | 120<br>240 | 7Z023▲<br>7Z024▲ | 939.00<br>915.00 | 750.00▲<br>729.00▲ | 177.3<br>177.2 |
| 2 | 2.00 | 30‡ | Horizontal | 120/240 | 1 | 24.0/12.0 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B234▲ | 798.75 | 599.00▲ | 179.0 | 120<br>240 | 7Z025▲<br>7Z026▲ | 939.00<br>915.00 | 750.00▲<br>729.00▲ | 186.3<br>186.2 |
| 2 | 2.00 | 30‡ | Vertical | 208/240/480 | 3 | 5.6/2.8 | 1/4(F) | 26¼ | 19 | 52 | 4B235▲ | 838.25 | 639.00▲ | 170.0 | 208/240<br>480 | 7Z027▲<br>7Z028▲ | 960.00<br>960.00 | 765.00▲<br>765.00▲ | 172.8<br>177.5 |
| 3 | 3.00 | 30‡ | Horizontal | 208/240/480 | 3 | 8.0/4.0 | 1/4(F) | 40⅝ | 21⅝ | 38 | 4B237▲ | 873.75 | 675.00▲ | 180.0 | 208/240<br>480 | 7Z029▲<br>7Z030▲ | 870.00<br>870.00 | 695.00▲<br>695.00▲ | 182.5<br>187.5 |
| 2 | 2.00 | | Base Plate | 120/240 | 1 | 15.0/7.5 | 1/2(F) | 22½ | 15½ | 14¾ | 4B242▲ | 581.25 | 465.00▲ | 89.0 | 120<br>240 | 7Z048▲<br>7Z049▲ | 769.00<br>750.00 | 615.00▲<br>599.00▲ | 96.3<br>96.2 |
| 3 | 3.00 | | Base Plate | 208/240/480 | 3 | 8.0/4.0 | 1/2(F) | 22½ | 15½ | 14¾ | 4B243▲ | 645.00 | 515.00▲ | 90.0 | 240<br>480 | 7Z100▲<br>7Z101▲ | 799.00<br>850.00 | 639.00▲<br>885.00▲ | 92.8<br>97.5 |

(*) For specific HP rating explanations, see page 2214. (‡) ASME code air tanks. (†) As rated by the standard B-10 bearing life of the pump. Individual compressor life will vary depending on duty cycle, ambient temperature, maintenance performed, air intake quality, and manufacturing part tolerances. (#) Magnetic starters not mounted and wired; provided separately.



▲Net Prices, Not Subject To Discounts

411

| Fluor Federal Services | CALCULATION IDENTIFICATION AND INDEX | Calc. No.: DST-C-002<br>T.O./Job No.: b5100541-26X<br>Date: 6/20/00 |
|---|---|---|

Status and description of the attached Calculation Sheets.

Discipline: STRUCTURAL

Project No. & Title: DST ANNULUS DUMP SYSTEM

Calculations: FUSED DISCONNECT SKID

These calculations apply to:

Drawing No. H-14-104120 SH 1 Rev. No. 0

Drawing No. _____ Rev. No. _____

Other (Study, CDR) _____

_____ Rev. No. _____

The status of these calculations is:

☒ Final Calculations

☐ Void Calculations (reason voided): _____

Were calculations incorporated into the final drawings? ☒ Yes ☐ No

Were calculations verified by independent "check" calculations? ☐ Yes ☒ No

**Original and Revised Calculation Approvals**

| | Rev. 0 Signature/Date | Rev. 1 Signature/Date | Rev. 2 Signature/Date |
|---|---|---|---|
| Originator | Sumit T Chou 6/20/00 | | |
| Checked By | Greg Fish 6/21/00 | | |
| Approved By | | | |
| Checked Against Approved Vendor Data | | | |

INDEX

| Calculation Sheet Page No. | Description |
|---|---|
| 1 - 4 | GENERAL, CALCULATIONS, ATTACHMENTS |

E-NW-128 (03/00)

**Fluor Federal Services**

**DESIGN ANALYSIS**

Calc. No. DST-C-002
Revision 0
Page No. 1 of 2

Client
T.O./Job No.
Subject FUSED DISCONNECT SKID
Originated By DTC
Date 6/20/00
Location HANFORD
CHKD G.A. Lisk
6/21/00

OBJECTIVE CHECK THE SKID STRUCTURE

SEE FOLLOWING PG FOR SKID LAYOUT.

CRITERIA GENERAL SERVICE.

REFERENCES
- HNF-PRO-97.
- UNISTRUT GENERAL ENGINEERING CATALOG NO. 12.
- CALC DST-C-001, DST TANK SKID.

WIND LOAD. ASCE-7-95. EXPOSURE C, PC 2

USE P = 20 PSF (CONSERVATIVE)

SEISMIC LOAD. SKID LESS THAN 400 LBS (SEE p. 2) DO NOT NEED ANALYSIS. (PRO-97).

STABILITY ANALYSIS.

WIND = 20 PSF × 18" × (10" + 2" × 2) / 144 = 35 # SMALL.
(UNISTRUT)

BY INSPECTION. SKID OVERTURNING & SLIDING IS ADEQUATE.

ELECTRICAL PANEL RACK

THE RACK & UNISTRUTS IS SIMILAR TO THE DST TANK SKID.

THE RACK IS ADEQUATE.

E-NW-123A (03-2

**Fluor Federal Services**

**DESIGN ANALYSIS**

Calc. No. DST-C-002
Revision 0
Page No. 2 of

Client | T.O./Job No.

Subject: FUSED DISCONNECT SKID | Originated By: DTC | Date: 6/20/00

Location: HANFORD | CHK'D: G.A Lisle | 6/21/00

SKID WEIGHT

ELEC PANEL . (17.5" x 9" x 6.4") (SEE P. 4) . 30# (ASSUMED)

UNISTRUT . P1001 3.8 PLF x 4' x 2 = 30
P1000 2.0 x 2' x (2 + 2) = 16
CONNECTIONS = 4
50

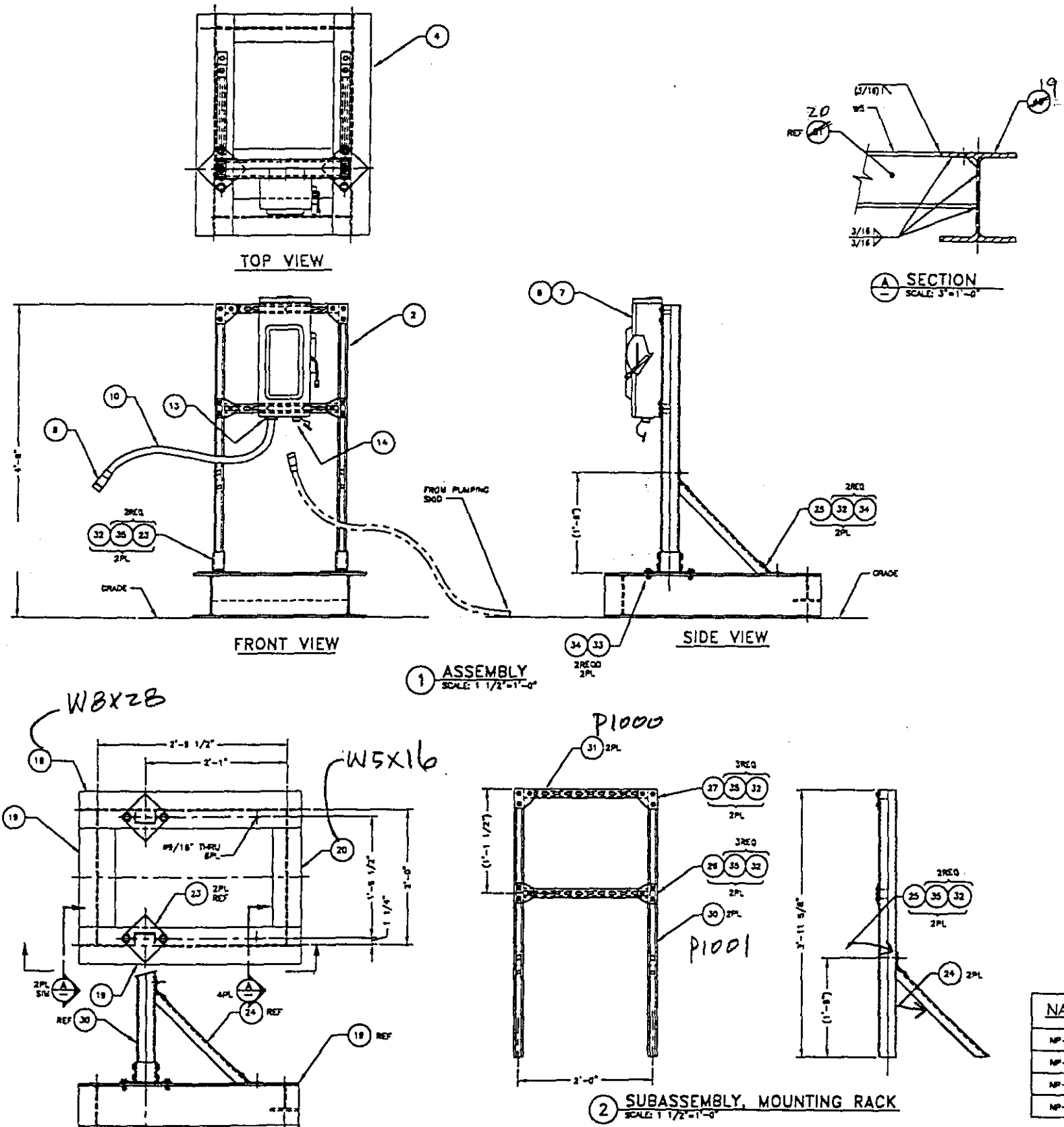
BASE FRAME . W8x28 28 PLF x (3.3' x 2 + 1.5') = 227
W5x16 16 x 2.0' = 32
~ 260

ELEC. CORD 4 - #4 AWG 1.4 PLF x 30' ~ 45
385

E-NW-123A (03/00)

RPP-6485 REV. 0

CALC. DST-C-002
PG. 3



Heavy Duty Safety Switches:

Typical NEMA Type 3R

Catalog # H362NRB,RB Series F5:

Height = 17.50 inches
Width = 9.00 inches
Depth = 6.38 inches
W/H =10.50 inches

# APPENDIX I
# ANNULUS PUMP CRITERIA LETTERS

RPP-6485 Rev. 0

**MEMORANDUM** **CH2MHILL**

ANNULUS PUMP DESIGN CRITERIA

| | | | |
|---|---|---|---|
| TO: | M. J. Sutey | S5-07 | 74100-00-005 |
| COPIES: | D. G. Baide | S5-05 | |
| FROM: | DST Engineering | | |
| DATE: | February 8, 2000 | | |

References:
(1) HNF-4241, Rev. 0, "Double-Shell Tank Annulus Pumping Alternative Evaluation," dated March 1999.
(2) HNF-2728, Rev. 0, "Flow Velocity Analysis for Avoidance of Solids Deposition During Transport of Hanford Tank Waste Slurries," dated October 8, 1999.
(3) HNF-1939, Rev. 0c, "Waste Feed Delivery Technical Basis, Volume II, Waste Feed Delivery Flowsheet for 241-AN-104," dated June 9, 1999.
(4) Letter, D. A. Reynolds, WHC to M. C. Teats, WHC, "Viscosity of Evaporator Slurries," 13314-88-105, dated June 30, 1988.

Criteria is required to support the design of a new style of Annulus Pumps for the Double –Shell Tank System. Reference 1 recommended a change in design from the deep-well turbines to a smaller submersible style pump. Significantly lower maintenance and disposal costs were several of the factors that made the submersible pump attractive. The following is a discussion of the factors that influence the pumping of the DST waste, and used to derive the pump criteria. Attached in Table 1 is a compilation of the design criteria developed for the new annulus pump.

The old style annulus turbine pumps were designed to handle flowrates of 100 gpm at a head of 150 feet in the normal DST's to 100 gpm at a head of 80 feet in the aging waste tank farms. The submersible pumps will approach similar flowrates, approximately 40 gpm at a head of 160 feet. The 40 gpm @ 160 feet equates to approximately 85 gpm at a head of 100 feet. The fewer stages and size constraints are partially compensated for by using two pumps in series, as dictated by piping pressure drop between farms. The reduced flow is due to fewer stages and size constraints, but the pumps are still capable of performing the transfers required, as discussed in more detail below.

## New Generation Pump Considerations

The new generation transfer pump is a submersible two-stage design. This pump could be used for the annulus pumping. Its compact design allows it to fit down a twelve-inch riser, the same size as the annulus riser. The pump is a two-stage pump and delivers a flow of 140

the same size as the annulus riser. The pump is a two-stage pump and delivers a flow of 140 gpm at a head of 450 feet. The pump is designed for an extended service life. The cost of the new generation pump approaches one million dollars. An annulus pump would not be required for an extended period of operation. Nor are the pumping distances for which the new generation pump was designed, such as Cross-Site, required for annulus pumping. So a new generation pump style is not warranted for the annulus service.

**Flow Vs Solids Suspension Considerations**

The amount of solids reaching the suction of an annulus pump is not expected to be significant. Solids entrainment into the annulus from a leak in the primary would depend on the leak location. The settling and accumulation of solids, which would occur on the path around the perimeter of the annulus, would limit the amount reaching the pump. Reference 2 provides the basis for evaluating flow rates required to suspend solids through transfer lines. The reference states that "much of the available characterization data for Hanford particulate solids indicate mass distributions typically in a range less than 50 microns". The reference also states that "typical insoluble solids in Hanford waste are identified as aluminum hydroxide, iron hydroxides and phosphate salts. The solid density of these particles range from 2.5 to 3.5kg/L". Correlation's sited in the reference were used to calculate the flow velocities required to overcome solids settling tendencies. The following is an extremely conservative example:

> Assuming a 50 micron mean particle diameter, 3.0kg/L particle density, 1.0 kg/L liquid phase density, 1.0 centi-poise liquid phase viscosity – a velocity of 3.0 ft/sec or a flow of 70 gpm in a 3-inch pipe would be required to suspend the solids.
>
> If some of the conservatism is removed by assuming a 50 micron mean particle diameter, 3.0kg/L particle density, 1.35 kg/L liquid phase density, 15 centi-poise liquid phase viscosity – a velocity of 2.4 ft/sec or a flow of 55 gpm in a 3-inch pipe would be required to suspend the solids.

It should be recognized that solids accumulations in piping would tend to be a self-correcting problem. As the solids accumulate in a location in the pipe the fluid velocity would increase and tend to re-suspend the particles. Due to the relatively low quantity of insoluble solids in the DST system, the favorable solids characteristics for suspension in solutions, and the unlikely distribution of a significant quantity in the annulus, lower flowrates are considered acceptable for annulus pumping.

**Dilution vs. Solution Density & Viscosity Considerations**

The solutions in the double shell tank system are very fluid and pumpable. Most of the DST wastes were never concentrated to the final stage originally planned. Tank 103-AN contains the only dilute waste that went through the final stage of evaporation to reach the classification of Double-Shell Slurry. The rest of the dilute wastes were concentrated less through the evaporator and are classified as Double-Shell Slurry Feed. Tank 101-SY was the

only complex waste tank concentrated to such a high level and is atypical as can be seen from table 2. Viscosity of the supernate rarely exceeds 30 centi-poise.
The capability to dilute the DST waste with water however is felt to be a prudent design consideration to ensure the waste is well below the saturation point The quantity of dilution water is a hard design criteria to establish. Saltwell operations are currently using a range of 2:1 to a 1:1 dilution ratio for saturated solutions.

The initial 101-SY transfer in December 1999 was diluted in a 1:1 ratio with water. One factor influencing this high dilution ratio was the dissolved gases, which were desired to be kept in solution.

Flowsheets are being developed for the pumping of the more concentrated wastes in AN Farm to the Vitrification Plant. The Reference 3 flowsheet dilutes the DST waste in AN-104 to a density of 1.30, which represents a 2:1 waste to water dilution. Discussions with the author indicate that a 1.35 density was determined to be adequate (3:1 dilution) but further conservatism was added. Reference 4 also supports the 1.35 density. The 1.35 density is used as a pluggage criteria in the Waste Compatibility Program. Reference 4 compiled several years of evaporator slurry data and no solids were ever noted above a 1.35 density.

Table 2 shows that not many waste tanks are above the 1.30 density and current waste concentration practices require a density of < 1.40 in the evaporator product to prevent flammable gas accumulations.

Dilution of the more concentrated DST wastes by a 2:1 waste to water ratio is definitely adequate to prevent transfer line pluggage, a 3:1 ratio is determined to be sufficiently adequate however. Diluting the highest DSSF waste from a 1.47 density to a 1.35 requires a 3:1 ratio. Diluting a 1.47 density to a 1.30 requires a 2:1 ratio. Diluting a 1.40 density to a 1.30 requires a 3:1 ratio.

The design criteria for the annulus dilution system will be specified as a 2:1 waste to water ratio for conservatism.

## Flammable Gas Considerations

The Tank Farms Final Safety Analysis Report (FSAR) for Double-Shell Tanks contains an Administrative Control – 5.10 Ignition Controls, that applies to annulus pump operation. Annulus pumping is considered Waste Intrusive and therefore for all DST's Ignition Source Control Set # 1 applies at all times.

## Service Life Considerations

The service life for an annulus pump is expected to be short. A readily available commercial grade pump is desirable. The service life specified allows the use of normal elastomers used in the pump industry, to meet the radiation resistance requirement. The radiation field data used was developed for the W-211 project.

## Table 1 – Pump Design Criteria

Submersible Centrifugal

| | |
|---|---|
| Total Flow | 40 - 140 gpm (300* gpm maximum) |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centi-poise |
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$F |
| Discharge Pressure | 230 psig maximum** |
| Flammable Gas Controls | Ignition Source Control Set #1 (Class 1 Division 1 Group B or equivalent)*** |
| Waste Flow | 26 - 93 gpm**** |
| Dilution water Flow | 14 - 47 gpm**** |
| Chemical Resistance | All parts exposed to liquids must be resistant to the basic solutions (pH of 13) found in the DST Tanks |
| Life Expectancy | 2,000 hours in a 2 year period |

* The allowable envelope of operation for flow is specified as 40 to 140 gpm. However higher flowrates are acceptable for the shorter distance transfers as long as 300 gpm is not exceeded. The maximum flow rate of 300 gpm is based on an accident in the Tank Farm FSAR 3.4.2.7 Surface Leak Resulting in a Pool.

** Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

*** Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

**** The dilution water flow may be required to be as high as 50% of the waste flow. It's recognized that design constraints may prevent reaching dilution water flows above 40 gpm. In this case throttling existing waste line valves will be used to set the proper dilution. The design constraints anticipated are water supply pressure, pressure drop through hose connections, and the limiting pipe diameter that can be coupled with the pump assemblies.

## Table 1 - Pump Design Criteria (Continued)

Heel Pump

| | |
|---|---|
| Total Flow | 2 - 5 gpm |
| SpG | 1.0 - 1.47 |
| Viscosity | 1.0 - 30 centi-poise |
| Solids | 0 - 20 Volume % |
| Temperature | 65 - 140$^0$F |
| Discharge Pressure | 230 psig maximum* |
| Flammable Gas Controls | Ignition Source Control Set #1 (Class 1 Division 1 Group B or equivalent)** |
| Dilution water Flow | None Required |
| Chemical Resistance | All parts exposed to liquids must be resistant to the basic solutions (pH of 13) found in the DST Tanks |
| Life Expectancy | 2,000 hours in a 2 year period |

Note: It is assumed that the heel pump will be used just to remove the last few inches of liquid from the annulus. Repeated water flushes of the annulus may be performed to remove the residual radioactive components. So it is anticipated that the actual solution SpG will probably be significantly lower than the maximum stated above.

*Maximum design pressure for transfer lines in SY Farm (Spec B-101-C3) and A & AX Farms (Spec B-102-C1)

**Mineral insulated Cable meets requirements for equivalency. Series 300 stainless is acceptable as non-sparking.

## Table 2 – Double-Shell Tank Contents

| Tank | Waste Type | Sludge | Salt Cake | SpG |
|---|---|---|---|---|
| AN-101 | DN | 0 | 12" | 1.23 |
| AN-102 | CC | 0 | 32" | 1.39 |
| AN-103 | DSS | 0 | 0" | 1.46 |
| AN-104 | DSSF | 0 | 163" | 1.40 |
| AN-105 | DSSF | 0 | 178" | 1.43 |
| AN-106 | CC | 0 | 6" | 1.18 |
| AN-107 | CC | 0 | 90" | 1.37 |
| AP-101 | DSSF | 0 | 0 | 1.28 |
| AP-102 | CP | 0 | 0 | 1.20 |
| AP-103 | DSSF | 0 | 0 | 1.25 |
| AP-104 | DSSF | 0 | 0 | 1.29 |
| AP-105 | DSSF | 0 | 32" | 1.34 |
| AP-106 | DC | 0 | 0 | 1.06 |
| AP-107 | DN | 0 | 0 | 1.01 |
| AP-108 | DN | 0 | 0 | 1.15 |
| AW-101 | DSSF | 0 | 111" | 1.45 |
| AW-102 | DC | 0 | 13" | 1.19 |
| AW-103 | DN | 115" | 17" | 1.01 |
| AW-104 | DN | 0 | 84" | 1.00 |
| AW-105 | DN | 93" | 0 | 1.02 |
| AW-106 | CC | 0 | 82" | 1.30 |
| AY-101 | DC | 34" | 0 | 1.08 |
| AY-102 | DN | 80" | 0 | 1.00 |
| AZ-101 | Aging | 17" | 0 | 1.21 |
| AZ-102 | Aging | 32" | 0 | 1.11 |
| SY-101 | CC | 0 | 0 | 1.62 |
| SY-102 | DN | 0 | 26" | 1.30 |
| SY-103 | CC | 0 | 0 | 1.47 |

References: HNF-IP-0482-140 Waste Tank Summary Report for Month Ending November 30,1999
Letter 74650-97-013 Double-Shell Tank Composition Status – Quarterly Report, September 2,1997

Should you have any questions regarding the above information please contact me on 373-3926.

D. W. Reberger
DST Engineering

RPP-6485 Rev. 0

Fluor Federal Services
1200 Jadwin, PO Box 1050
Richland, WA 99352-1050

509 372-2000 phone
509 372-3000 fax

**FLUOR** GLOBAL SERVICES

March 23, 2000

LMHC96WO-0006
CO-00-RPP-237

Ms. L. N. Cortez
CH2M HILL Hanford Group, Inc.
P. O. Box 1500
Richland, Washington 99352-1505

Dear Ms. Cortez:

CONTRACT NO. 4975, RELEASE NO. 59, DST ANNULUS PUMPING (L-02)

Response Requested By: N/A

Responds To: N/A

One of the deliverables Fluor Federal Services (FFS) has for this task is to prepare procurement specifications for a submersible and an air operated pump that will be used for pumping the Double Shell Tank (DST) Annulus. During the course of preparing the specifications, we researched different pump manufacturers and conducted telephone discussions with more than six different manufacturers reviewing at least seven different designs.

Taking the various design criteria into account, transfer routes, riser diameter, material etc., FFS engineering has concluded that the best choice for the submersible pump is the Flygt Model BS-2060.390, operated in tandem. Operation in tandem means, where necessary, there will be two pumps in series in the same line. This model pump has already been approved by the Hanford Flammable Gas Review Board (Report No: FGEAB-00-002, Rev. 0) for use in this application.

The Flygt pump has materials that are compatible with the waste characteristics for the relatively short mission of this project (2000 hours of operation over a two-year period) and will provide the operating characteristics necessary to pump waste from the annulus to other DSTs.

This submersible pump is commercially available for approximately $6,500 a piece. It will have a side discharge as received from the vendor. The discharge will be modified to a top discharge at the Hanford site in accordance with existing Hanford drawings prepared specifically for this pump (H-2-72507), after the dimensions on the Hanford drawing are checked against the latest drawings of the pump.

The air driven pump that should be used is a Hydrostar positive displacement pump that can be installed alongside the submersible pump. This pump will be used to remove the heel down to the last three inches in the Annulus. This is the only pump identified to meet all criteria identified for this operating condition. It has a Teflon seal that may be affected by radiation, however conservative calculations show that it will exceed the needed design life.

Thus, the ultimate life of this pump will be a function of the exposure the pump has to radiation. It may be as low as 500 hours in a very high radiation field. This pump has been reviewed and approved by the Board also at the same meeting as the submersible pump. This pump is also commercially available.

FFS originally prepared specifications for both pumps, with one (#4975-59-P1) transmitted to CH2M HILL Hanford Group, Inc. (CHG) via letter No. CO-00-RPP-228, dated February 22, 2000. The second specification (#4975-59-P2) has been completed and was signed off by both FFS and CHG personnel as of February 28, 2000, and was transmitted to CHG via letter No. CO-00-RPP-250, dated March 14, 2000. FFS received an e-mail from Mr. Dan Reberger, the Technical Representative on this task, stating that the classification of these pumps is "General Service." Because both pumps are commercially available, they may be purchased without a specification by identifying the model number desired. Therefore, the specifications prepared for this task are not required. FFS Quality Assurance (QA) (Mr. Lanny Hall) has reviewed the information above, and agrees that since the pumps are commercially available and they are classified as "General Service," a specification is not required, and we do not need to review the QA plan of the selected vendors. In addition, the only receipt inspection required is to verify that what was shipped matches the requisition and enclosed paperwork is for the requested pump. (Check for shipping damage, also).

Procurement of these pumps was originally a part of the FFS scope. On, or about February 3, 2000, Mr. Reberger notified Mr. Rarig that Mr. Shipler stated that CHG would perform the procurement using the specifications for the submersible and air driven pump. Procurement was discussed at each weekly status meeting thereafter and we were told that CHG would perform the procurement in order to save money, since funding had been cut. FFS continued to offer to do the procurement, but the offer was declined.

Therefore, in order for CHG to do the procurement, we are providing here the following information on the Flygt Submersible Pump and the Hydrostar Pump, which meet the requirements contained in the specifications. The specifications were given to CHG on February 8, 2000 for review and approval.

Finally, here is the information and quantities needed to procure the pumps for DST Annulus Pumping:

| Quantity | Description | Address | Phone |
|---|---|---|---|
| 4 | ITT Flygt Small Dewatering pump-<br>Stainless Steel<br>Product Code - BS-2060.390/232 460 V with 100 feet electrical cable | Whitney Equipment Company<br>14636 N. E. 95th Street<br>Redmond, WA 98052 | (425) 556-1750 |
| 2 | ITT Flygt Small Dewatering Pump<br>Tandem Connection Stainless Steel<br>Product Code - 377-26-01 | | |
| 2 | INW HYDROSTAR Pump HS8001-1<br>Part Number 3A001 | Instrumentation Northwest, Inc.<br>Attn: Engineering Dept -<br>HYDROSTAR System<br>14972 N. E. 31st Circle<br>Redmond, WA 98052<br>(800) 776-9355 | |

RPP-6485 Rev. 0



| Quantity | Description | Address | Phone |
|---|---|---|---|
| 2 | 2" Air Motor<br>Part Number 3B020 | | |
| 2 | 2" Well Completion Assembly<br>Part Number 3E502 | | |
| 20* | Actuating rod (5 ft. sections<br>w/coupling and nut)<br>Part Number 2B095 | | |

*Subject to further engineering review to determine the exact discharge column configuration

Procurement of 50' of discharge pipe must come from a source other than the pump vendors.

On March 6, 2000, Mr. Dan Reberger, CHG, Technical Representative, requested that FFS review the compatibility of a Gorman Rupp submersible pump to the requirements in the specification. This pump has a mine Safety and Health Approved rating. After extensive review and numerous discussions with the vendor, the pump was presented to the Flammable Gas Review Board for consideration on March 14, 2000. On March 21, 2000, Mr. Reberger notified FFS that the Board did not approve the Gorman Rupp pump due to the lack of a UL rating or equivalent. Therefore, we have reverted back to the Flygt pump as the only viable submersible pump for this application. However, the Board added a stipulation to the approval of the Flygt pump. That is: it must have a Class 1, Division 1, Group B power cable. Mr. Ray Merriman, FFS, is currently evaluating cables to satisfy this requirement. Ray has suggested using a conduct for the power cable and intrinsically safe thermal sensor circuit as a possible option for the cable.

FFS has been told that CHG will procure the pumps. However, FFS is offering to procure these pumps. The formal hold placed on FFS procurement activities by CHG applies only to Safety Class components. These pumps, as mentioned earlier, are General Services and therefore are not affected by this HOLD. Should CHG desire FFS procurement support, please notify us via e-mail from CHG Contract Administration (Ms. Kathy McLerran) and we will immediately proceed with procurement activities.

All other activities in support of Release No. 59 are proceeding as identified in weekly status meetings. If there are any questions regarding this information, please contact Mr. Bradley Rarig at 373-2673 or Mr. Marshall Hauck at 376-9339.

Sincerely,

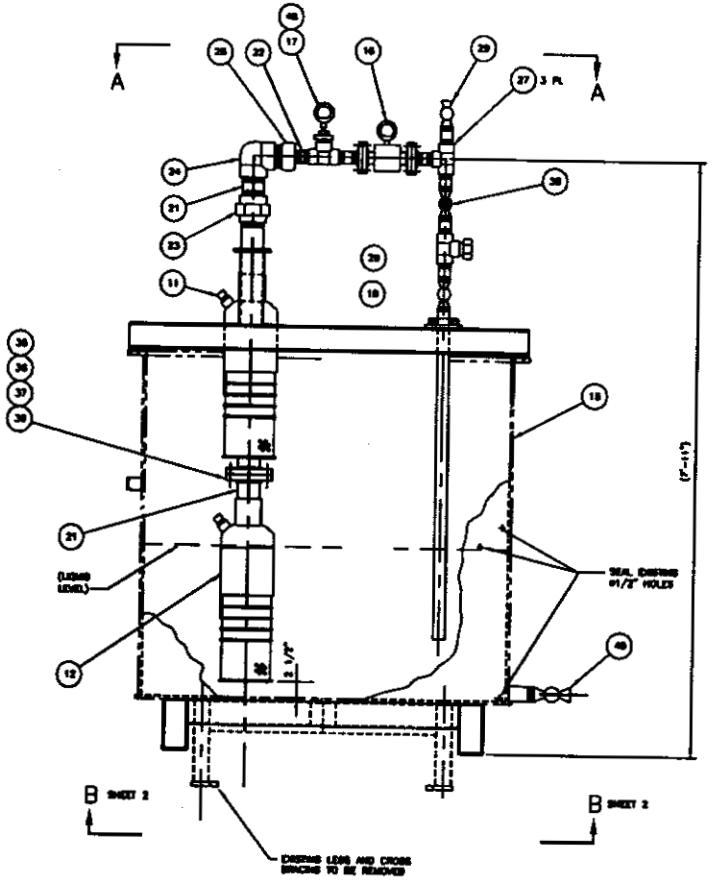
Bradley Rarig

Bradley R. Rarig
Project Manager

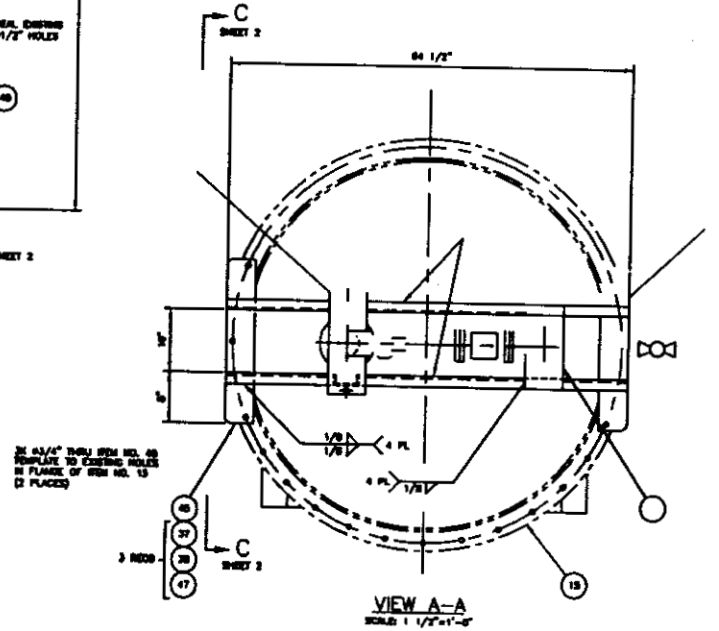
BKR:rdp

c: D. W. Reberger, CHG, w/attachments

# APPENDIX J
# SKETCHES FOR PUMP TEST TANK




1 ARRANGEMENT
SCALE: 1 1/2"=1'-0"




VIEW A-A
SCALE: 1 1/2"=1'-0"

## GENERAL NOTES:

1. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
2. WELDING TO BE PER ANSI B1.1 AND DWG#TR-0013.

## PARTS LIST/MATERIAL LIST

| | | | | | | |
|---|---|---|---|---|---|---|
| | AR | | TUBING, 8" X 4" X 1/4" WALL | ASTM A 500 GR B | | 41 |
| | AR | | TUBING, 4" X 4" X 1/4" WALL | ASTM A 500 GR B | | 42 |
| | 1 | | PIPE, 2" SCHED 40 X 4" LG, TOE | ASTM A 53 TYPE E GR B | | 43 |
| | AR | | C4 X 5.4 | ASTM A 36 | | 44 |
| | 2 | | PLATE, 8" X 1/2" X 36" LONG | ASTM A 36 | | 45 |
| | 2 | | SCREW, HEX HD, 1/2"-13UNC-2A X 1 1/4" LG | ANSI B18.2.1 CS | | 46 |
| | 6 | | SCREW, HEX HD, 5/8"-11UNC-2A X 2 1/2" LG | ANSI B18.2.1 CS | | 47 |
| | 1 | | BUSHING, REDUCING, 1 1/2" X 1/4", THREADED | ASTM A 197 | | 48 |
| | | | | | | 49 |
| | | | | | | 50 |

## PARTS LIST/MATERIAL LIST

| | | | | | | |
|---|---|---|---|---|---|---|
| | | -010 | ARRANGEMENT | | | 1 |
| | | | | | | 2 |
| | | | | | | 3 |
| | | | | | | 4 |
| | 2 | -001 | PLATE, 6" X 1/2" X 19 3/4" L | ASTM A 36 | 2 | 5 |
| | 1 | -002 | PLATE, 6" X 1/2" X 13" L | ASTM A 36 | 2 | 6 |
| | 2 | -003 | ANGLE, 1 1/2" X 1 1/2" X 1/4" X 6" L | ASTM A 36 | 2 | 7 |
| | | | | | | 8 |
| | | | | | | 9 |
| | | | | | | 10 |
| | 1 | N-14-101140-010 | PUMP | | | 11 |
| | 1 | N-14-101140-020 | PUMP | | | 12 |
| | | | | | | 13 |
| | | | | | | 14 |
| | 1 | | TANK (MODIFIED) | (PROVIDED BY OTHERS) | | 15 |
| | 1 | MODEL AE30-N40 | FLOWMETER, MAGNETIC, INTEGRAL TYPE, 150# ANSI FLANGES | YOKOGAWA ELECTRIC CORPORATION | | 16 |
| | 1 | TYPE 1009 | GAUGE, PRESSURE, 0-100# PSI, 4 1/2" DIAL, 1/4" NPT BOTTOM CONNECTION | ASHCROFT | | 17 |
| | 1 | /8112 | PIPE CLAMP, 1 1/2" PIPE SIZE | GRINNELL | | 18 |
| | | | | | | 19 |
| | | | | | | 20 |
| | AR | | PIPE, 3" SCHED 40, WELDED | ASTM A 53 TYPE E GR B | | 21 |
| | AR | | PIPE, 1 1/2" SCHED 40, WELDED | ASTM A 53 TYPE E GR B | | 22 |
| | 1 | | UNION, 3", 150#, THREADED | ASTM A 197 | | 23 |
| | 1 | | ELBOW, 90°, 3", 150#, THREADED | ASTM A 197 | | 24 |
| | 1 | | BUSHING, REDUCING, 3" X 1 1/2", THREADED | ASTM A 197 | | 25 |
| | 3 | | FLANGE, 1 1/2", R.F., SCREWED, 150# | ASTM A 105 | | 26 |
| | 3 | | TEE, 1 1/2", 150#, THREADED | ASTM A 197 | | 27 |
| | 1 | | BUSHING, REDUCING, 1 1/2" X 3/4" | ASTM A 197 | | 28 |
| | 2 | S-87W34 | VALVE, BALL, 1 1/2", FNPT | WHITEY | | 29 |
| | 1 | NO. 254NR | VALVE, GLOBE, 1 1/2", FNPT | CRANE | | 30 |
| | 2 | BLUEGARD STYLE 3700 | GASKET, 1 1/2" CL 150, R.F. FLANGE 1/8" THK COMPRESSED FIBER | GARLOK | | 31 |
| | 8 | | SCREW, HEX HD, 1/2"-13UNC-2A X 2 1/2" LG | ANSI B18.2.1 CS | | 32 |
| | 10 | | NUT, HEX, 1/2"-13UNC-2B | ANSI B18.2.2 CS | | 33 |
| | 2 | | WASHER, PLAIN, 1/2" BOLT SIZE | ANSI B18.21.1 CS | | 34 |
| | 2 | | FLANGE, 3", R.F., SCREWED, 150# | ASTM A 105 | | 35 |
| | 6 | | SCREW, HEX HD, 5/8"-11UNC-2A X 3 1/4" LG | ANSI B18.2.1 CS | | 36 |
| | 10 | | NUT, HEX, 5/8"-11UNC-2B | ANSI B18.2.2 CS | | 37 |
| | 5 | | WASHER, PLAIN, 5/8" BOLT SIZE | ANSI B18.21.1 CS | | 38 |
| | 1 | BLUEGARD STYLE 3700 | GASKET, 3" CL 150, R.F. FLANGE 1/8" THK COMPRESSED FIBER | GARLOK | | 39 |
| | 1 | S-88W32 | VALVE, BALL, 3", 150#, THREADED | WHITEY | | 40 |

RPP-6415 REV. 0

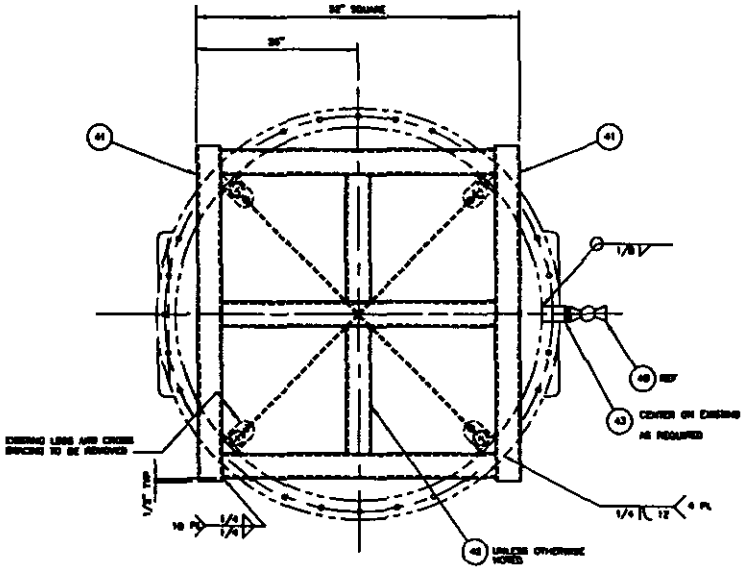
429

FLUOR FEDERAL SERVICES

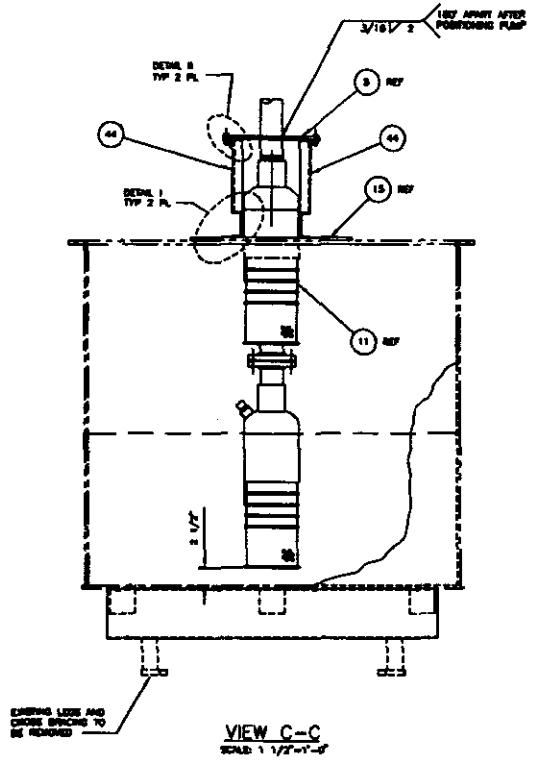
U.S. DEPARTMENT OF ENERGY
National Operations Office

TEST SKID
SUBMERSIBLE PUMP
ARRANGEMENT

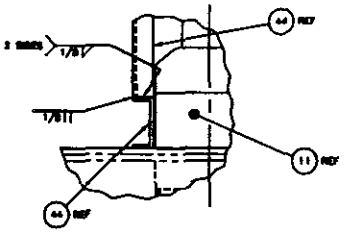
F | ES-259-0010



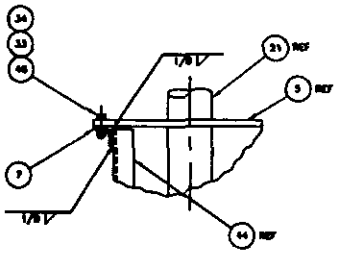

VIEW B-B
SCALE: 1 1/2"=1'-0"



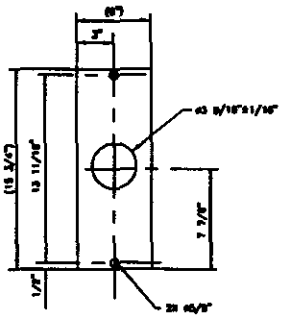

VIEW C-C
SCALE: 1 1/2"=1'-0"



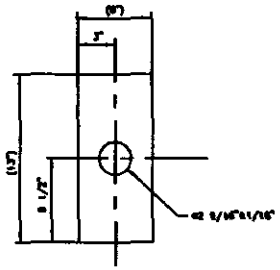

DETAIL I
SCALE: 3"=1'-0"



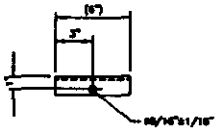

DETAIL II
SCALE: 3"=1'-0"




5 PLATE
SCALE: 3"=1'-0"




6 PLATE
SCALE: 3"=1'-0"




7 ANGLE
SCALE: 3"=1'-0"

FLUOR FEDERAL SERVICES

U.S. DEPARTMENT OF ENERGY

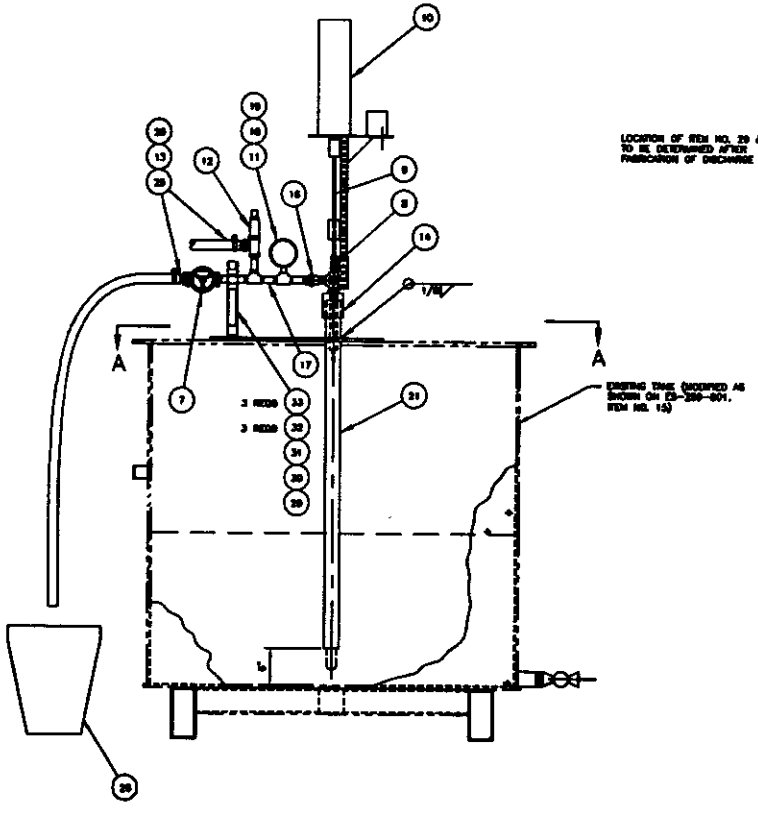
TEST SKID
SUBMERSIBLE PUMP
VIEWS & DETAILS

ES-259-0010

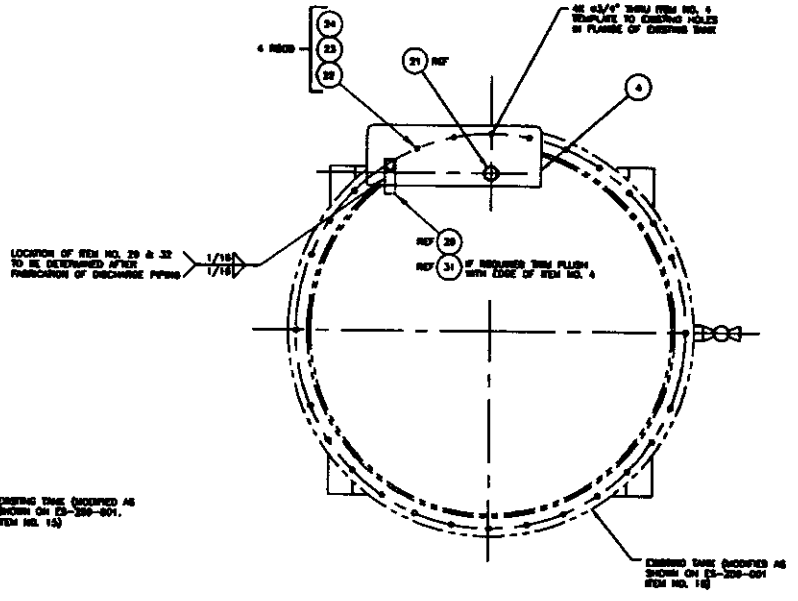
REF DRAWING | TITLE | REFERENCES
DRAWING TRACEABILITY LIST | NEXT USED ON SHEET 1 | REVISIONS

RLP-6495 Rev. 0

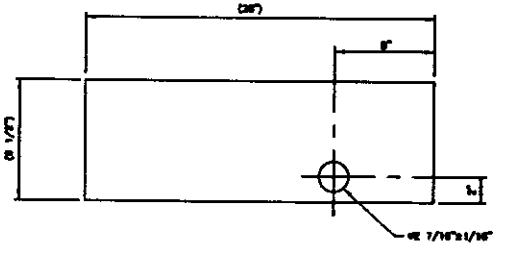
430




1 ARRANGEMENT
SCALE: 1 1/2"=1'-0"




VIEW A-A
SCALE: 1 1/2"=1'-0"




4 PLATE
SCALE: 3"=1'-0"

## PARTS LIST/MATERIAL LIST

| QTY -010 | PART NO. | DESCRIPTION | MATERIAL | CAT | ITEM NO. |
|---|---|---|---|---|---|
| X | -010 | ARRANGEMENT | | | 1 |
| | | | | | 2 |
| | | | | | 3 |
| 1 | -001 | PLATE, 8 1/2" X 1/2" X 36" L | ASTM A 36 | | 4 |
| | | | | | 5 |
| | | | | | 6 |
| 1 | ([illegible]) | VALVE, GLOBE, 3/4", FNPT | (McMASTER-CARR) | | 7 |
| 1 | 32392 | 2" WELL HEAD COMPLETION ASSEMBLY | INSTRUMENTATION NW INC | | 8 |
| 1 | 29895 | ACTUATING ROD (9" SECTIONS W/ COUPLING NUT | INSTRUMENTATION NW INC | | 9 |
| 1 | 38920 | AIR MOTOR, 2" | INSTRUMENTATION NW INC | | 10 |
| 1 | TYPE 1009 | GAUGE, PRESSURE, 0-100# PSI, 4 1/2" DIA, 1/4" NPT BOTTOM CONNECTION | ASHCROFT | | 11 |
| 1 | TYPE K10 | VALVE, RELIEF, ADJUSTABLE, 15-75 PSI ADJUSTABLE RANGE, 3/4" FNPT INLET AND OUTLET | NO CASH VALVE INC. | | 12 |
| 2 | S-12-HC-1-12 | HOSE CONNECTOR, MALE NPT, 3/4" NPT X 3/4" ID HOSE | SWAGELOK | | 13 |
| 1 | ES-259-004 -010 OR -020 | AIR DRIVEN PUMP ADAPTER | | | 14 |
| | | | | | 15 |
| 1 | | COUPLING, 3/4", 150#, FNPT | ASTM A 197 | | 16 |
| AR | | PIPE, 3/4" SCHED 40 X L AR, TBE | ASTM A 197 | | 17 |
| 1 | | BUSHING, REDUCING 3/4" X 1/4", THREADED | ASTM A 197 | | 18 |
| 1 | | TEE, 3/4", 150#, THREADED | ASTM A 197 | | 19 |
| 2 | ([illegible]) | CLAMP, HOSE, WORM GEAR, 1/2" BAND WIDTH, 13/16"-1 1/2" DIA RANGE | (McMASTER-CARR) | | 20 |
| AR | | PIPE, 2" SCHED 40, WELDED | ASTM A 53 TYPE E OR B | | 21 |
| 4 | | SCREW, HEX HD, 5/8"-11UNC-2A X 2 1/2" LG | ANSI B18.2.1 CS | | 22 |
| 4 | | NUT, HEX, 5/8"-11UNC-2B | ANSI B18.2.2 CS | | 23 |
| 4 | | WASHER, PLAIN, 5/8" BOLT SIZE | ANSI B18.21.1 CS | | 24 |
| AR | ([illegible]) | HOSE, POLYESTER REINFORCED, 3/4" ID X 1 1/16" OD, 300 PSI WORKING PRESSURE | (McMASTER-CARR) | | 25 |
| 1 | ([illegible]) | PAIL, STORAGE, 5 GALLON CAPACITY | (McMASTER-CARR) | | 26 |
| | | | | | 27 |
| 1 | | SCREW, HEX, 5/16-18UNC-2A X 1" L | COMMERCIAL, CS | | 28 |
| 1 | P1000 | CHANNEL, 12" L | UNISTRUT | | 29 |
| 1 | P2000-07 | PIPE CLAMP, 3/4" SIZE | UNISTRUT | | 30 |
| 1 | P1326 A | ANGLE FITTING, 90° (3 1/8" X 1 7/8") | UNISTRUT | | 31 |
| 3 | P1000-1420 | CHANNEL, NUT W/SPRING (1/4-20UNC-2B) | UNISTRUT | | 32 |
| 3 | HHCS0250-1420 | SCREW, HEX CAP (1/4" X 7/16" SIZE) | UNISTRUT | | 33 |
| | | | | | 34 |
| | | | | | 35 |

## GENERAL NOTES:

1. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
2. WELDING TO BE PER AWS D1.1 AND SNA-SNR-6013.
3. DIMENSIONS ARE IN INCHES. TOLERANCES: FRACTIONAL = ±1/8" UNLESS OTHERWISE SPECIFIED.

FLUOR FEDERAL SERVICES

U.S. DEPARTMENT OF ENERGY

AIR PUMP IN TEST TANK ARRANGEMENT

ES-259-002 0

ES-259-004 AIR DRIVEN PUMP ADAPTER ASSEMBLIES

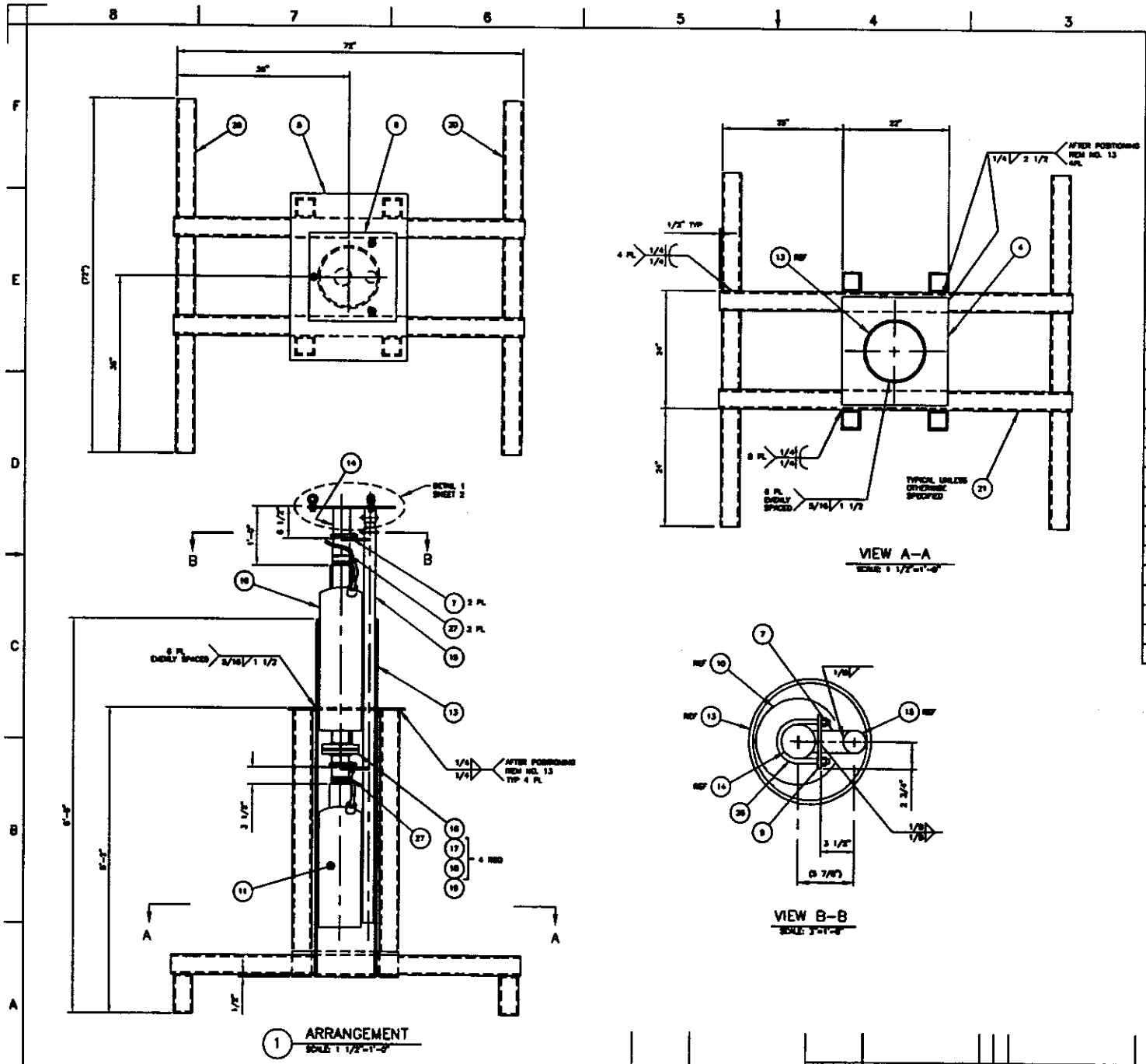
DRAWING MACHINABILITY UNIT

NEXT USED ON DWG NUM

REVISIONS

RPP-14495 REV. 0

431




## PARTS LIST/MATERIAL LIST

| | | | | | | |
|---|---|---|---|---|---|---|
| | | -010 | ARRANGEMENT | | | 1 |
| | | | | | | 2 |
| | | | | | | 3 |
| | 1 | -001 | PLATE, 22" W X 3/8" | ASTM A 36 | 2 | 4 |
| | 1 | -002 | PLATE, 24" X 3/8" X 34" L | ASTM A 36 | 2 | 5 |
| | 1 | -003 | PLATE, 16" W X 3/8" | ASTM A 36 | | 6 |
| | 2 | -004 | PLATE, 2" X 1/2" X 3 13/16" L | ASTM A 36 | 2 | 7 |
| | | -004 | BAR, 1" X 1/4" X 3 1/2" L | ASTM A 36 | | 8 |
| | | | | | | 9 |
| | 1 | 9-14-104140-010 | PUMP | | | 10 |
| | 1 | 9-14-104140-020 | PUMP | | | 11 |
| | | | | | | 12 |
| | AR | | PIPE, 12" SCHED 40 X 72 1/2" L, WELDED | ASTM A 53 TYPE E OR B | | 13 |
| | AR | | PIPE, 3" SCHED 40, WELDED | ASTM A 53 TYPE E OR B | | 14 |
| | AR | | PIPE, 2" SCHED 40 X 84" L, WELDED | ASTM A 53 TYPE E OR B | | 15 |
| | 1 | | FLANGE, 3", R.F., SCREWED, 150# | ASTM A 105 CS | | 16 |
| | 4 | | SCREW, HEX HD, 5/8"-11UNC-2A X 3 1/4" LG | COMMERCIAL CS | | 17 |
| | 4 | | NUT, HEX, 5/8" BOLT SIZE | COMMERCIAL CS | | 18 |
| | 1 | BLUEGUARD STYLE 3700 | GASKET, 3" CL 150, R.F., FLANGE 1/8" THK COMPRESSED FIBER | GARLOK | | 19 |
| | 2 | | TUBING, 6" X 4" X 1/4" WALL X 72" L | ASTM A 500 GR B | | 20 |
| | AR | | TUBING, 4" SQ X 1/4" WALL | ASTM A 500 GR B | | 21 |
| | 2 | (J3014T401) | CHANNEL, SHOULDER, 1/2"-13UNC-2A X 1 1/2" THREAD LENGTH, 01.00" DIA | (MANNER-CHAN) | 2 | 22 |
| | 3 | | NUT, HEX, 1/2" BOLT SIZE | COMMERCIAL CS | 2 | 23 |
| | 3 | | WASHER, FLAT, 1/2" SIZE | COMMERCIAL CS | 2 | 24 |
| | 3 | | WASHER, LOCK, HLX, SPRING, 1/2" NOM, SQUR | COMMERCIAL CS | 2 | 25 |
| | 2 | (J0000F30) | U-BOLT, DOUBLE LENGTH, 3" PIPE SIZE, 1/2-13UNC-2A THREADS, 6 HEX NUTS | (MANNER-CHAN) | | 26 |
| | AR | | WIRE-TIE, LENGTH AR | COMMERCIAL | | 27 |
| | 1 | | PIPE, 1 1/2" SCHED 40 X L AR, WELDED | ASTM A 53 TYPE E OR B | 2 | 28 |
| | 2 | | NUT, HEX, 5/16" BOLT SIZE | COMMERCIAL CS | 2 | 29 |
| | 2 | | SCREW, HEX HD, 5/16"-18UNC-2A X L AR | COMMERCIAL CS | 2 | 30 |

## GENERAL NOTES:

1. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
2. WELDING TO BE PER AWS D1.1 AND SWSER-0013.
3. DIMENSIONS ARE IN INCHES. TOLERANCES: FRACTIONAL = ±1/16" UNLESS OTHERWISE SPECIFIED.

FLUOR FEDERAL SERVICES

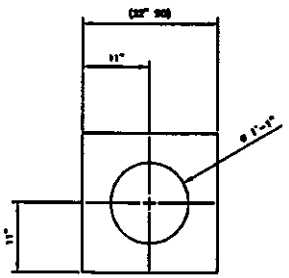
U.S. DEPARTMENT OF ENERGY

MOCK ANNULUS RISER AND LOWER PUMP ARRANGEMENT

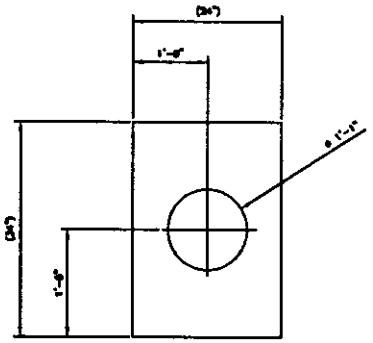
ES-259-003 0

RPP-WS85 Rev. 0

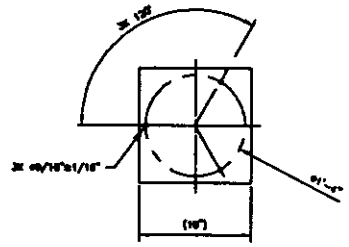
432



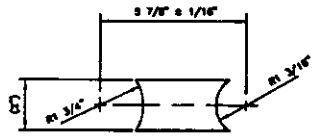
4 PLATE
SCALE: 1 1/2"=1'-0"



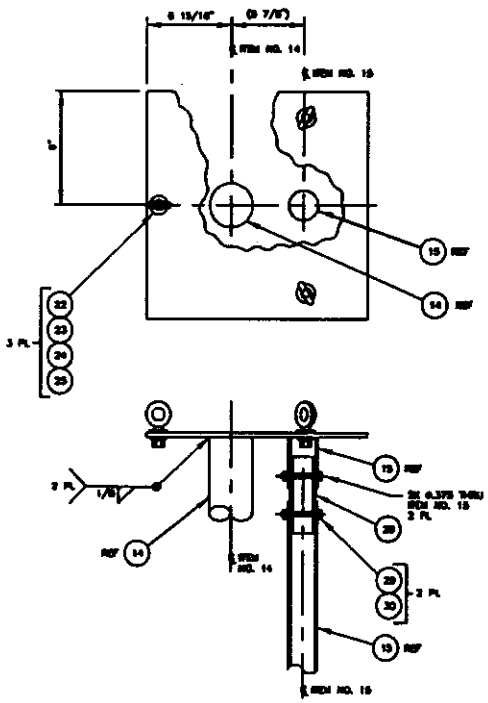
5 PLATE
SCALE: 1 1/2"=1'-0"



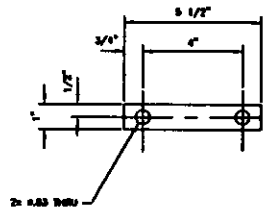
6 PLATE
SCALE: 1 1/2"=1'-0"



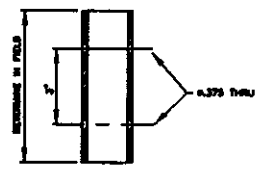
7 PLATE
SCALE: 3"=1'-0"



DETAIL I
SCALE: 3"=1'-0"



9 PLATE
SCALE: 3"=1'-0"



28 PIPE
SCALE: 6"=1'-0"

RPP-6495 REV. 0

FLUOR FEDERAL SERVICES

U.S. DEPARTMENT OF ENERGY

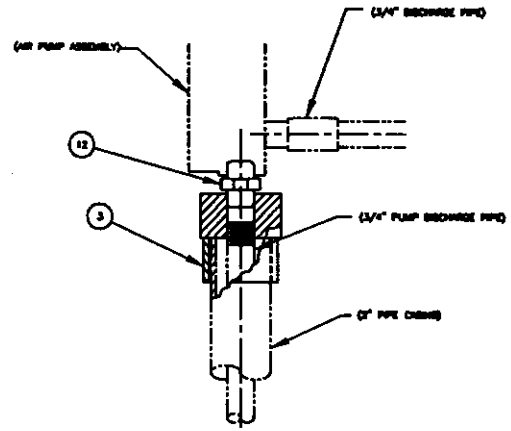
MOCK ANNULUS RISER AND LOWER PUMP DETAILS

ES-259-003 0

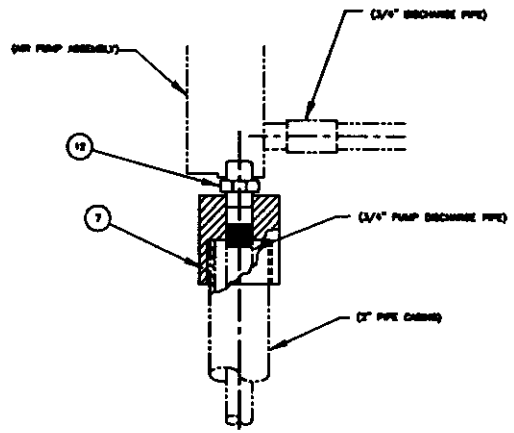
433

## PARTS LIST/MATERIAL LIST

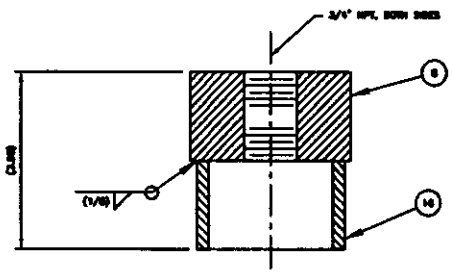
| QTY REQD | | | PART/ITEM NUMBER | DESCRIPTION | MATERIAL/REFERENCE | UNIT | ITEM NO. |
|---|---|---|---|---|---|---|---|
| | | X | -010 | ARRANGEMENT | | | 1 |
| | X | | -020 | ARRANGEMENT | | | 2 |
| X | | 1 | -030 | ASSEMBLY | | | 3 |
| | | | | | | | 4 |
| | | | | | | | 5 |
| | | | | | | | 6 |
| | 1 | | -001 | BAR, ø3.25 X 3.30 L | ASTM A240 TYPE 304L | | 7 |
| 1 | | | -002 | BAR, ø3.25 X 1.30 L | ASTM A240 TYPE 304L | | 8 |
| | | | | | | | 9 |
| | | | | | | | 10 |
| | | | | | | | 11 |
| | 1 | 1 | SS-12-HN | HEX NIPPLE, 3/4 NNPT | CHON | | 12 |
| | | | | | | | 13 |
| | | | | | | | 14 |
| | | | | | | | 15 |
| 1 | | | | PIPE, 2 1/2 SCHED 40 X 1.75 L | ASTM A312 GR TP 304L (SMLS) | | 16 |



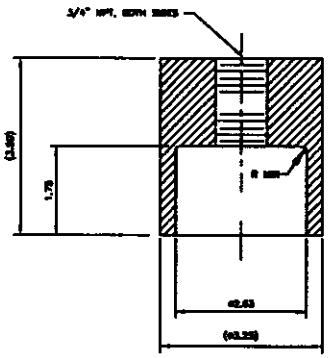

1 ARRANGEMENT
SCALE: HALF




2 ARRANGEMENT
SCALE: HALF




3 ADAPTER ASSEMBLY
SCALE: FULL




7 ADAPTER
SCALE: FULL

### GENERAL NOTES:

1. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
2. WELDING TO BE PER ANSI B31.1 AND SVH-SPR-0013.
3. DIMENSIONS ARE IN INCHES. TOLERANCES: DECIMAL ± 0.03" UNLESS OTHERWISE SPECIFIED.

FLUOR FEDERAL SERVICES

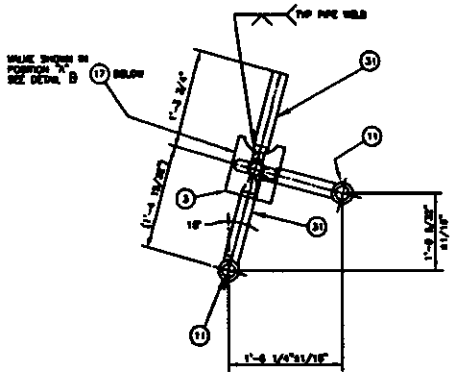
U.S. DEPARTMENT OF ENERGY

AIR DRIVEN PUMP
ADAPTER
ARRANGEMENTS & ASSEMBLY

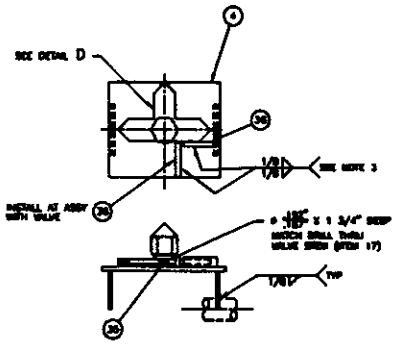
F | ES-259-004 | 0

RPP-6985 Rev. 0

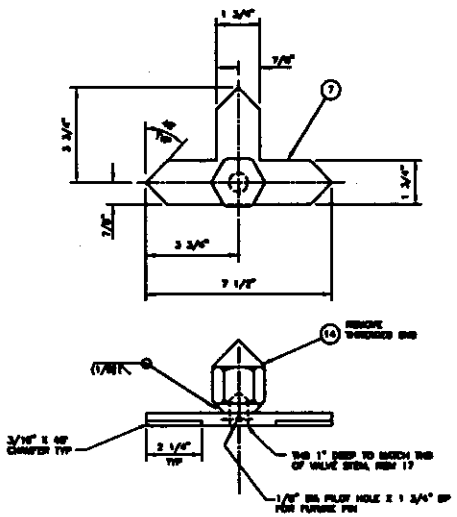
934



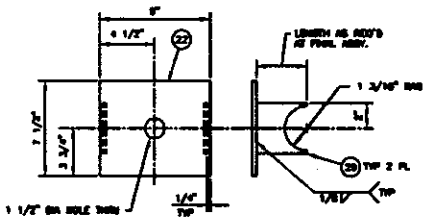

1 ASSEMBLY
SCALE 1 1/2"=1'-0"




3 POSITION INDICATOR
SCALE 3"=1'-0"




DETAIL D
SCALE 6"=1'-0"




4 INDICATOR BRACKET
SCALE 3"=1'-0"

PARTS/MATERIAL LIST

| | | | | | PART/DASH NUMBER | NOMENCLATURE/DESCRIPTION | MATERIAL/REFERENCE | SHT | ITEM NO. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | X | -010 | ASSEMBLY | | | 1 |
| | | | | | | | | | 2 |
| | X | | | 1 | -030 | SUBASSEMBLY POSITION INDICATOR | | | 3 |
| X | 1 | | | | -040 | SUBASSEMBLY INDICATOR BRACKET | | | 4 |
| | | | | | | | | | 5 |
| | | | | | | | | | 6 |
| | 1 | | | | -001 | INDICATOR, 3/8" THK | ASTM A240 304L | | 7 |
| | | | | | | | | | 8 |
| | | | | | | | | | 9 |
| | | | | | | | | | 10 |
| | | | | 2 | H-2-38430-2 | CONNECTOR 2" VERTICAL | | | 11 |
| | | | | | | | | | 12 |
| | | | | | | | | | 13 |
| | 1 | | | | H-2-32421-6 | OPERATING SCREW (MODIFIED) | | | 14 |
| | | | | | | | | | 15 |
| | | | | | | | | | 16 |
| | | | | 1 | | VALVE, 2" 3-WAY | SEE NOTE 2 | | 17 |
| | | | | | | | | | 18 |
| | | | | | | | | | 19 |
| | | | | | | | | | 20 |
| | | | | | | | | | 21 |
| 1 | | | | | -003 | PLATE, 3/8" THK | ASTM A240 304L | | 22 |
| | | | | | | | | | 23 |
| | | | | | | | | | 24 |
| | | | | | | | | | 25 |
| | | | | | | | | | 26 |
| | | | | | | | | | 27 |
| | | | | | | | | | 28 |
| 2 | | | | | | BAR, 4" x 1/4" x L AR | ASTM A240 304L | | 29 |
| | | | | | | | | | 30 |
| | | | | AR | | PIPE, 2" SCHED 40S SMLS | ASTM A312 OR TP 304L | | 31 |
| | | | | | | | | | 32 |
| | | | | | | | | | 33 |
| | | | | | | | | | 34 |
| | 1 | | | | | PIN, GROOVED, TYPE F 3/16" DIA X 2" L | ASTM B16.8.2 ALLOY STEEL | | 35 |
| | 2 | | | | | BAR 3/4" x 3/8" x 2 1/2" L | ASTM A276 304/304L | | 36 |

NOTES:

1. FABRICATION AND TESTING SHALL BE IN ACCORDANCE WITH SWICORP SPECIFICATION SPS-08-107. THE SERVICE REQUIREMENT FOR WELDING WILL BE FOR RADIOACTIVE WASTE SERVICE.
2. 2" BALL VALVE, 3-WAY SER. 6M ,3-PORT, SIDE ENTRY, 90° ROTATION, FLOW PATTERN #2, PER MODEL NO. MPH-MHB-HOE.
3. POSITION STOP BARS (PN 36) SO THAT VALVE IS CENTERED ON PORT OPENINGS.
4. POSITION BRACKET (ITEM 4) SO THAT THERE IS NO INTERFERENCE OR FRICTION BETWEEN RELATED PARTS PRIOR TO WELDING. POSITION ITEM 7 IN THE SAME ORIENTATION AS THE 1-PORT OF THE 3-WAY VALVE.

REFERENCE DRAWINGS:
H-14-104128
THRU
H-14-104133

RPP-6495 REV. 0

FLUOR FEDERAL SERVICES

U.S. DEPARTMENT OF ENERGY
Richland Operations Office

JUMPER ASSEMBLY
ANNULUS PUMP PITS
PRELIMINARY FABRICATION

F ES-259-005-1 0

DRAWING TRACEABILITY LIST

REVISIONS

7435

# APPENDIX K
# FABRICATION

# SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

**FOR SFS USE ONLY** — 1. Servicing Task No: 2H- 00047061F

| 2. Originator Tracking Number: | 3. CACN or Charge No. (Required): | 4. COA (Required): | 5. Issuing Organization Code: |
|---|---|---|---|
| DWR-002 | 111273 | EL10 | 74100 |

6. Deliver to: Contact Dan Rehberger @ 3-3926 for location

7. Delivery Location:

| 8. Requested Completion Date: | 9. Quality Level of Component (Check one only) | 10. Identify Facility Service Use For Fabrication (Check one only): | 11. SSC Designation (Check one only) | 12. Approval Designator (Check required approvals needed) |
|---|---|---|---|---|
| 5/31/00 | 1 [ ] 2 [ ] 3 [X] 0 [ ] | [X] Nuclear [ ] Non-Nuclear | GS [X] SS [ ] SC [ ] | E [ ] S [ ] Q [X] N/A [ ] |

| 13. Equipment Identification No: | 14. Application/Project: | 15. Authorized Amount: |
|---|---|---|
| | Annulus pumping | $5,000 |

| 16. Originator: | MSIN: | Date: | Phone: | 17. Funding Approval: |
|---|---|---|---|---|
| Todd Black | 55-13 | 5/10/00 | 3-3880 | C E Shipler |

18. Title/Description of Work – List all required drawings, ECNs, and specifications required for fabrication:

Assemble 2inch & 3inch connector assemblies. Cross spare & for salvaged parts per drawings H-2-32420 & H-2-32430. The following assemblies are required. Per H-2-32420, (2) #1 and (2) #2 assemblies are necessary. Per H-2-32430, (1) #1 assembly is required. Paint connector operating screw nuts yellow per section 4.5.6.a. of procedure SFS #05-107.

Intended Use for Item Fabricated: _____

19. Check "Q" for inspection planning attributes desired below (Q = QUALITY CONTROL). Check "N/A" if not required (see NOTE below).

| | Q | N/A | | | Q | N/A | |
|---|---|---|---|---|---|---|---|
| 1. | X | | Welding inspection/examination | 4. | | X | Functional tests / acceptance test / operational |
| 2. | | X | Dimensional inspection/verification | 5. | X | | QC acceptance tag (QL 1, 2, or 3) |
| 3. | X | | Component Identification | 6. | | X | Verification tag (QL 0) |

**NOTE: All items above marked N/A will default to General Shop Standard (SFS 05-101 – Copy available at SFS Planner/Scheduler Superintendent Office).**

NEC INSPECTION REQUIRED ON ALL ELECTRICAL FABRICATION

MATERIAL PROCUREMENT REQUIREMENTS

20. For material (part/item) purchases, select from the following Safety Class/Quality Level designations for this fabrication request:

| Check applicable Safety Class/Quality Levels | | LIST EXCEPTIONS BELOW: |
|---|---|---|
| | P-Card GS/NA – QL-0 | |
| | Passport GS/N – QL-0 | |
| X | GS (Procurement/Receiving QC Inspection) – QL-3 | |
| | SS (CGI Dedication) QL-2 | |
| | SC (CGI Dedication) QL-1 | |
| | SS (ESL Procurement) QL-2 | |
| | SC (ESL Procurement) QL-1 | |

**All SFS supported procurement services for identified materials (parts/items) required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approvals by all required customer Facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of the following HNF-PROs: 123, 259, 268, 301, 335, 1819, and 3144. The review approval signatures shall be documented below.**

****NOTE**: All customer-supplied materials (parts/items) must be identified with a minimum of Safety Classification, Quality Level, and material grade/type. All potential suspect/counterfeit items (i.e. fasteners, circuit breakers, flanges) supplied shall meet HNF-PRO-301 requirements.**

**Customer approval signatures according to MRP 5.43 – PLEASE PRINT OR TYPE NAME, SIGN AND DATE.**

| | Date: | Phone: | | Date: | Phone: |
|---|---|---|---|---|---|
| 21. Cog/Responsible Engineer: Todd Black | 5/10/00 | 3-3880 | 24. Design/Technical Engineer: | | |
| 22. Cog/Responsible Engineer's Manager: Dan Rehberger for DeBaide | 5/10/00 | 3-3926 | 25. Health and Safety Assurance: | | |
| 23. Quality Assurance: W L Adams | 5/11/00 | 2-3053 | 26. Environmental Assurance: | | |

1 3" HORIZONTAL } Central PP
1 2" HORIZONTAL }

1 2" HORIZONTAL } ANNULUS PP
2 2" VERTICAL }

JUMPER HEADS

# DynCorp

## SITE FABRICATION SERVICES
## FABRICATION ESTIMATE

Tracking No: 2H-0004706 (Use this Tracking # in all Correspondence) CACN/COA 111273 EL10
Job Title: FAB/ASSEMBLE CONNECTORS PER H-2-32420/30 & J-10 GS QL 3
Drawing(s)/Rev.: Estimator: PARSONS Date: 05/22/00
Customer: Todd BLAAK Signature: M Parsons

| | MATERIALS/ CONTRACTS | CONSUMABLES | LABOR | TOTALS |
|---|---|---|---|---|
| SITE FAB SERVICES LABOR AND MATERIALS | | | | |
| FAB SERVICES PROVIDED MATERIALS | 62 | 10 | | 72 |
| SITE FAB SERVICES LABOR | | | 3,554 | 3,554 |
| OTHER FAB SERVICES SUPPORT | | | 432 | 432 |
| TOTAL S.F.S. SUPPORT | 62 | 10 | 3,986 | 4,057 |
| NON FAB SERVICES REQUIRED SUPPORT | | | | |
| OTHER REQUIRED ONSITE SUPPORT | | 0 | 108 | 108 |
| OFFSITE FAB SUPPORT | 0 | | | 0 |
| CONTRACT SUPPORT | 0 | | | 0 |
| TOTAL NON S.F.S. SUPPORT | 0 | 0 | 108 | 108 |
| | | | **GRAND TOTAL** | **4,166** |

10 ASSUMPTIONS & REMARKS

1. This Estimate represents the estimated costs for the on-site E/C 'Site Fabrication Services" and associated support personnel or services to perform the task set forth in the reference documents. Included are all known costs identifiable at this time with the exception of FH adders (G&A/SS) which is not included in this estimate.

2. All documents and drawings are assumed to be correct and to current site standards unless otherwise noted. No fabrication engineering time has been included for changes or revisions to the fabrication documents. Three complete sets of full size drawings shall be provided by the Customer with the Work Request. Incomplete design's, ECN's, changes to design, materials, requirements, or other alterations to the original design, work scope, or fabrication process may result in increased costs or schedule delays.

3. It is assumed that the work scope (including schedule) will remain the same for the duration of the effort. Any modifications to the work scope or agreed upon schedule could result in re-estimating and/or rescheduling of the activity.

4. Scheduled dates provided at the time of this estimate are for estimating purposes only. A firm schedule will be agreed to at the time the order is issued.

5. This estimate assumes all costs for this effort to be identified and approved by the requester and that sufficient funding will be provided within five working days of the initial request for work. No activities related to this fabrication effort will begin until full (or negotiated partial) funding has been provided.

6. F.O.B. point will be the appropriate Site Fabrication facility unless otherwise specified.

7. This is only an Estimate of the fabrication cost, actual fabrication or material costs may be more or less than the estimate.

SUPERVISOR APPROVAL: C B Stiff DATE: 5/22/00

RPP-6495 Rev. 0

# SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

**FOR SFS USE ONLY** — 1. Servicing Task No: 2H- 0004768/F

| 2. Originator Tracking Number: | 3. CACN or Charge No. (Required): | 4. COA (Required): | 5. Issuing Organization Code: |
|---|---|---|---|
| DWR-003 | 111273 | EL10 | 74100 |

| 6. Deliver to: | 7. Delivery Location: |
|---|---|
| Contact Dan Reberger @ 373-3926 for location | Contact Dan Reberger @ 373-3926 for location |

| 8. Requested Completion Date | 9. Quality Level of Component (Check one only) | | | | 10. Identify Facility Service Use For Fabrication (Check one only): | | 11. SSC Designation (Check one only) | | | 12. Approval Designator (Check required approvals needed) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 5,2000 | 1 | 2 | 3 | 0 | X | Nuclear | GS | SS | SC | E | S | Q | N/A |
| | | | X | | | Non-Nuclear | X | | | | | X | |

| 13. Equipment Identification No: | 14. Application/Project: | 15. Authorized Amount: |
|---|---|---|
| | Annulus Pumping | $20,000 |

| 16. Originator: | MSIN: | Date: | Phone: | 17. Funding Approval: |
|---|---|---|---|---|
| Dan Reberger | S5-13 | 5/25/2000 | 373-3926 | C E Shipler |

18. Title/Description of Work -- List all required drawings, ECNs, and specifications required for fabrication: Assemble jumper parts identified on drawing H-14-104132 as directed by CHG Engineering. Note that the three connector assemblies (parts #'s 10 & 11) are already being assembled per 2H-0004706/F. Steps should be taken to purchase the 2-inch 3-way valve (part #17) ASAP as it will take approximately 6 to 8 weeks before the item is received. Perform fabrication per SFS 03-101 Redline Procedure. DRR

Intended Use for Item Fabricated: _____

19. Check "Q" for inspection planning attributes desired below (Q = QUALITY CONTROL). Check "N/A" if not required (see NOTE below).

| | Q | N/A | | | Q | N/A | |
|---|---|---|---|---|---|---|---|
| 1. | X | | Welding inspection/examination | 4. | X | | Functional tests / acceptance test / operational |
| 2. | X | | Dimensional inspection/verification | 5. | X | | QC acceptance tag (QL 1, 2, or 3) |
| 3. | X | | Component Identification | 6. | | X | Verification tag (QL 0) |

NOTE: All items above marked N/A will default to General Shop Standard (SFS 05-101 -- Copy available at SFS Planner/Scheduler Superintendent Office).

NEC INSPECTION REQUIRED ON ALL ELECTRICAL FABRICATION

MATERIAL PROCUREMENT REQUIREMENTS

20. For material (part/item) purchases, select from the following Safety Class/Quality Level designations for this fabrication request:

| | Check applicable Safety Class/Quality Levels: | LIST EXCEPTIONS BELOW: |
|---|---|---|
| | P-Card GS/NA -- QL-0 | |
| | Passport GS/N -- QL-0 | |
| X | GS (Procurement/Receiving QC Inspection) -- QL-3 | |
| | SS (CGI Dedication) QL-2 | |
| | SC (CGI Dedication) QL-1 | |
| | SS (ESL Procurement) QL-2 | |
| | SC (ESL Procurement) QL-1 | |

**All SFS supported procurement services for identified materials (parts/items) required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approvals by all required customer Facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of HNF-MD-4635. The review approval signatures shall be documented below.**

**NOTE**: All customer-supplied materials (parts/items) must be identified with a minimum of Safety Classification, Quality Level, and material grade/type. All potential suspect/counterfeit items (i.e., fasteners, circuit breakers, flanges) supplied shall meet HNF-PRO-301 requirements.

Customer approval signatures according to MRP 5.43 -- PLEASE PRINT OR TYPE NAME, SIGN AND DATE.

| | | | | | |
|---|---|---|---|---|---|
| 21. Cog/Responsible Engineer: Todd Blaak | Date: 5/25/00 | Phone: 3-3880 | 24. Technical/Engineer -- Core Evaluator: [illegible] | Date: 5/25/00 | Phone: |
| 22. Cog/Responsible Engineer's Manager: Dan Reberger | Date: 5/25/00 | Phone: 3-3929 | 25. Health and Safety Assurance: | Date: | Phone: |
| 23. Cog/Responsible Engineer's Manager: W R Adams | Date: 5/31/00 | Phone: 2-3053 | 26. Environmental Assurance: | Date: | Phone: |

RPP-6485 Rev. 0

# SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

**FOR SFS USE ONLY** — 1. Servicing Task No: 2H-0004769/F

| 2. Originator Tracking Number: | 3. CACN or Charge No. (Required): | 4. COA (Required): | 5. Issuing Organization Code: |
|---|---|---|---|
| ANNPUMP-002 | 111273 | ELIO | 79800 |

| 6. Deliver to: | 7. Delivery Location: |
|---|---|
| DAn Reberger | 272-AW |

| 8. Requested Completion Date: | 9. Quality Level of Component (Check one only) | | | | 10. Identify Facility Service Use For Fabrication (Check one only): | | 11. SSC Designation (Check one only) | | | 12. Approval Designator (Check required approvals needed) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 0 | | | GS | SS | SC | E | S | Q | N/A |
| 7/5/00 | | | X | | X | Nuclear | | | | | | | |
| | | | | | | Non-Nuclear | X | | | | | X | |

| 13. Equipment Identification No: | 14. Application/Project: | 15. Authorized Amount: |
|---|---|---|
| P2-AY/AZ | DST Annulus Pumping | $20,000 |

| 16. Originator: | MSIN: | Date: | Phone: | 17. Funding Approval: |
|---|---|---|---|---|
| G.A. Leshikar | S0-08 | 5/25/00 | 373-4434 | C E Shipler |

18. Title/Description of Work – List all required drawings, ECNs, and specifications required for fabrication:

Fabricate (2) annulus pump mounting flange assemblies and associated piping per H-14-104138, sh. 1 & 2. (Encompasses partial fabrication of entire pump assembly)
See continuation sheet for special instructions.

Intended Use for Item Fabricated: _____

19. Check "Q" for inspection planning attributes desired below (Q = QUALITY CONTROL). Check "N/A" if not required (see NOTE below).

| | Q | N/A | | | Q | N/A | |
|---|---|---|---|---|---|---|---|
| 1. | X | | Welding inspection/examination | 4. | | X | Functional tests / acceptance test / operational |
| 2. | X | | Dimensional inspection/verification | 5. | X | | QC acceptance tag (QL 1, 2, or 3) |
| 3. | X | | Component Identification | 6. | | X | Verification tag (QL 0) |

**NOTE: All items above marked N/A will default to General Shop Standard (SFS 05-101 – Copy available at SFS Planner/Scheduler Superintendent Office).**

NEC INSPECTION REQUIRED ON ALL ELECTRICAL FABRICATION

MATERIAL PROCUREMENT REQUIREMENTS

20. For material (part/item) purchases, select from the following Safety Class/Quality Level designations for this fabrication request:

| | Check applicable Safety Class/Quality Levels: | LIST EXCEPTIONS BELOW: |
|---|---|---|
| | P-Card GS/NA – QL-0 | |
| | Passport GS/N – QL-0 | |
| X | GS (Procurement/Receiving QC Inspection) – QL-3 | |
| | SS (CGI Dedication) QL-2 | |
| | SC (CGI Dedication) QL-1 | |
| | SS (ESL Procurement) QL-2 | |
| | SC (ESL Procurement) QL-1 | |

**All SFS supported procurement services for identified materials (parts/items) required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approvals by all required customer Facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of the following HNF-PROs: 123, 259, 268, 301, 335, 1819, and 3144. The review approval signatures shall be documented below.**

**NOTE**: All customer-supplied materials (parts/items) must be identified with a minimum of Safety Classification, Quality Level, and material grade/type. All potential suspect/counterfeit items (i.e., fasteners, circuit breakers, flanges) supplied shall meet HNF-PRO-301 requirements.

Customer approval signatures according to MRP 5.43 -- PLEASE PRINT OR TYPE NAME, SIGN AND DATE.

| | Date: | Phone: | | Date: | Phone: |
|---|---|---|---|---|---|
| 21. Cog/Responsible Engineer: Dan Reberger | 5/25/00 | 3-3926 | 24. Design/Technical Engineer: GA Leshikar | 5/25/00 | |
| 22. Cog/Responsible Engineer's Manager: mm Hardy | 5/25/2000 | 376-4985 | 25. Health and Safety Assurance: | | |
| 23. Quality Assurance: WK Adams | 5/31/00 | 2-3053 | 26. Environmental Assurance: | | |

# SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

| FOR SFS USE ONLY | 1. Servicing Task No: 2H- 00 A769/F |
|---|---|

## CONTINUATION PAGE

Procure All components on H-14-104138, sh. 1 & 2, for quantity of (2) assemblies except for Items 12, 13, And 45-48.

Perform fabrication per SFS 03-101 Redline Procedure
Customer Design Authority designee - G. A. Leshikar

Fabrication is of "above the flange" components, the lower portion of the dilution line assembly, and the flange connection piece to the lower pump, with the following considerations:

- Cut 3" pipe for centrifugal pump discharge and 2" wellcasing pipe for Hydrostar sample pump approximately 1 foot below the mounting flange.
  * Screw CGB fittings (item #19) into top of flange as shown (ready to accept electrical cables.) Do not install top portion of dilution line (items 25, 30, 51 & 53) to mounting flange at this time.
- Do not install (item #57) on end of trunion at this time. [for interchangeabity with AY farm configuration]
- Customer to supply items 46 and 47, required for fit-up of 3/4" discharge pipe to Hydrostar Air motor/wellhead assembly. These items may be removed prior to shipment at customer's discretion.
- General Note #7 is not applicable at this time.
- Perform dimensional verification of nozzles A & B (x, y, z), trunions, and location of pump discharge pipe holes (2") on mounting flange.
- Fabricate lower portion of dilution line assembly from Item 31 (tee) downward, including spacer, to length specified by customer. Quantity (2)
- Fabricate quantity (14) of item 42 (spacer).

RPP-6485 Rev. 0

# SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

**FOR SFS USE ONLY** — 1. Servicing Task No: 2H- 0004777/F

| 2. Originator Tracking Number: | 3. CACN or Charge No. (Required): | 4. COA (Required): | 5. Issuing Organization Code: |
|---|---|---|---|
| ANN-003 | 111273 | EL10 | 79800 |

| 6. Deliver to: | 7. Delivery Location: |
|---|---|
| Dan Reberger @ 373-3926 | 272-AW |

| 8. Requested Completion Date: | 9. Quality Level of Component Check one only | | | | 10. Identify Facility Service Use For Fabrication (Check one only): | | 11. SSC Designation Check one only | | | 12. Approval Designator Check required approvals needed | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 5, 2000 | 1 | 2 | 3 | 0 | X | Nuclear | GS | SS | SC | E | S | Q | N/A |
| | | | X | | | Non-Nuclear | X | | | | | X | |

| 13. Equipment Identification No: | 14. Application/Project: | 15. Authorized Amount: |
|---|---|---|
| P2 – AN/AP/AW/SY | DST Annulus Pumping | $ 20,000 |

| 16. Originator: | MSIN: | Date: | Phone: | 17. Funding Approval: |
|---|---|---|---|---|
| G. A. Leshikar | S0-08 | 6/1/00 | 373-4434 | Loren Martin |

18. Title/Description of Work – List all required drawings, ECNs, and specifications required for fabrication:

Fabricate (2) annulus pump mounting flange assemblies and associated piping per H-14-104134, Sh. 1 and 2. (Encompasses partial fabrication of entire pump assembly). See continuation sheet for special instructions.

Intended Use for Item Fabricated: *DST Annulus Emergency Pumping*

19. Check "Q" for inspection planning attributes desired below (Q = QUALITY CONTROL). Check "N/A" if not required (see NOTE below).

| | Q | N/A | | | Q | N/A | |
|---|---|---|---|---|---|---|---|
| 1. | X | | Welding inspection/examination | 4. | | X | Functional tests / acceptance test / operational |
| 2. | X | | Dimensional inspection/verification | 5. | X | | QC acceptance tag (QL 1, 2, or 3) |
| 3. | X | | Component Identification | 6. | | X | Verification tag (QL 0) |

NOTE: All items above marked N/A will default to General Shop Standard (SFS 05-101 – Copy available at SFS Planner/Scheduler Superintendent Office).

NEC INSPECTION REQUIRED ON ALL ELECTRICAL FABRICATION

MATERIAL PROCUREMENT REQUIREMENTS

20. For material (part/item) purchases, select from the following Safety Class/Quality Level designations for this fabrication request:

| | Check applicable Safety Class/Quality Levels: | LIST EXCEPTIONS BELOW: |
|---|---|---|
| | P-Card GS/NA – QL-0 | |
| | Passport GS/N – QL-0 | |
| X | GS (Procurement/Receiving QC Inspection) – QL-3 | |
| | SS (CGI Dedication) QL-2 | |
| | SC (CGI Dedication) QL-1 | |
| | SS (ESL Procurement) QL-2 | |
| | SC (ESL Procurement) QL-1 | |

**All SFS supported procurement services for identified materials (parts/items) required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approvals by all required customer Facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of the following HNF-PROs: 123, 259, 268, 301, 335, 1819, and 3144. The review approval signatures shall be documented below.**

**NOTE**: All customer-supplied materials (parts/items) must be identified with a minimum of Safety Classification, Quality Level, and material grade/type. All potential suspect/counterfeit items (i.e., fasteners, circuit breakers, flanges) supplied shall meet HNF-PRO-301 requirements.

Customer approval signatures according to MRP 5.43 -- PLEASE PRINT OR TYPE NAME, SIGN AND DATE.

| | Date: | Phone: | | Date: | Phone: |
|---|---|---|---|---|---|
| 21. Cog/Responsible Engineer: Dan Reberger | 6/1/00 | 3-3926 | 24. Design/Technical Engineer: G A Leshikar | 6/1/00 | |
| 22. Cog/Responsible Engineer's Manager: Mr Hanty J | 6/1/2000 | | 25. Health and Safety Assurance: | | |
| 23. Quality Assurance: WK Adams | 6/2/00 | 2-3053 | 26. Environmental Assurance: | | |

Rev. 1445 rev. 0

# SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

SFS USE ONLY | #1. Servicing Task No: 2H- 0004777/R

## CONTINUATION PAGE

Procure all components on H-14-104134, sh. 1 & 2, for quantity of (2) of Assembly 2, except for Items 12, 13, and 45-48.

Perform fabrication per SFS 03-101 Redline Procedure. Customer Design Authority designee – G. A. Leshikar.

Fabrication is of "above the flange" components, the lower portion of the dilution line assembly, and the flange connection piece to the lower pump, with the following considerations:

- Cut 3" pipe for centrifugal pump discharge and 2" well casing pipe for Hydrostar sample pump approximately 1 foot below the mounting flange. Screw CGB fittings (item 19) into top of flange as shown (ready to accept electrical cables). Do not install top portion of dilution line (items 25, 30, 51 and 53) to mounting flange at this time.
- Customer to supply Hydrostar air motor/wellhead assembly (items 46 and 47), required for fit-up of ¾" discharge pipe. These items may be removed prior to shipment at customer's discretion.
- General Note #7 is not applicable at this time.
- Perform dimensional verification of nozzles ~~A~~ C and ~~B~~ D (x,y,z), dowel pin holes on mounting flange, and location of pump discharge pipe holes (2") on mounting flange. T+B 6/01/00
- Fabricate lower portion of dilution line assembly from tee (item #31) downward, including spacer, to length specified by customer.
- Fabricate quantity (14) of spacers (item #42).

I concur

6/1/00

RPP-6485 Rev. 0

# SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

**FOR SFS USE ONLY** — 1. Servicing Task No: 2H-00004824/F

| 2. Originator Tracking Number: | 3. CACN or Charge No. (Required): | 4. COA (Required): | 5. Issuing Organization Code: |
|---|---|---|---|
| DWR-004 | 111273 | EL10 | 74100 |

| 6. Deliver to: | 7. Delivery Location: |
|---|---|
| Contact Dan Reberger @ 373-3926 for location | Contact Dan Reberger @ 373-3926 for location |

| 8. Requested Completion Date: | 9. Quality Level of Component (Check one only) | | | | 10. Identify Facility Service Use For Fabrication (Check one only): | | 11. SSC Designation (Check one only) | | | 12. Approval Designator (Check required approvals needed) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 0 | | | GS | SS | SC | E | S | Q | N/A |
| July 19,2000 | | | X | | X | Nuclear | X | | | | | X | |
| | | | | | | Non-Nuclear | | | | | | | |

| 13. Equipment Identification No: | 14. Application/Project: | 15. Authorized Amount: |
|---|---|---|
| | Annulus Pumping | $4,999 |

| 16. Originator: | MSIN: | Date: | Phone: | 17. Funding Approval: |
|---|---|---|---|---|
| Dan Reberger | S5-13 | 6/26/2000 | 373-3926 | C E Shipler |

18. Title/Description of Work – List all required drawings, ECNs, and specifications required for fabrication: Assemble jumper parts identified on continuation page.

Intended Use for Item Fabricated: _____

19. Check "Q" for inspection planning attributes desired below (Q = QUALITY CONTROL). Check "N/A" if not required (see NOTE below).

| | Q | N/A | | | Q | N/A | |
|---|---|---|---|---|---|---|---|
| 1. | X | | Welding inspection/examination | 4. | X | | Functional tests / acceptance test / operational |
| 2. | X | | Dimensional inspection/verification | 5. | X | | QC acceptance tag (QL 1, 2, or 3) |
| 3. | X | | Component Identification | 6. | | X | Verification tag (QL 0) |

**NOTE: All items above marked N/A will default to General Shop Standard (SFS 05-101 – Copy available at SFS Planner/Scheduler Superintendent Office).**

**NEC INSPECTION REQUIRED ON ALL ELECTRICAL FABRICATION**

MATERIAL PROCUREMENT REQUIREMENTS

20. For material (part/item) purchases, select from the following Safety Class/Quality Level designations for this fabrication request:

| | Check applicable Safety Class/Quality Levels | LIST EXCEPTIONS BELOW: |
|---|---|---|
| | P-Card GS/NA – QL-0 | |
| | Passport GS/N – QL-0 | |
| X | GS (Procurement/Receiving QC Inspection) – QL-3 | |
| | SS (CGI Dedication) QL-2 | |
| | SC (CGI Dedication) QL-1 | |
| | SS (ESL Procurement) QL-2 | |
| | SC (ESL Procurement) QL-1 | |

**All SFS supported procurement services for identified materials (parts/items) required for this fabrication require pre-acquisition reviews, identification of safety classifications and quality levels, and approvals by all required customer Facility managers and core evaluators responsible for this fabrication. All pre-acquisition reviews and approvals shall meet requirements of HNF-MD-4635. The review approval signatures shall be documented below.**

**NOTE** – All customer-supplied materials (parts/items) must be identified with a minimum of Safety Classification, Quality Level, and material grade/type. All potential suspect/counterfeit items (i.e., fasteners, circuit breakers, flanges) supplied shall meet HNF-PRO-301 requirements.

**Customer approval signatures according to MRP 5.43 – PLEASE PRINT OR TYPE NAME, SIGN AND DATE.**

| | Date: | Phone: | | Date: | Phone: |
|---|---|---|---|---|---|
| 21. Cog/Responsible Engineer: Todd Blade | 6/26/00 | 3-3880 | 24. Technical/Engineer – Core Evaluator: | | |
| 22. Cog/Responsible Engineer's Manager: Dan Reberger | 6/26/00 | 3-3926 | 25. Health and Safety Assurance: | | |
| 23. Quality Assurance – Core Evaluator: W L Adams | 6/26/00 | 2-3053 | 26. Environmental Assurance: | | |

# SITE FABRICATION SERVICES (SFS) FABRICATION REQUEST

**FOR SFS USE ONLY** | 1. Servicing Task No: 2H-

## CONTINUATION PAGE

| Description | Drawings/ECN | Quantity |
|---|---|---|
| 2" Gasket, Type III | H-2-3997, Part # 6 | 1 |
| 3" Gasket, Type III | H-2-3997, Part # 7 | 1 |
| Lifting Bail | H-2-90161 | 1 |
| 2" Horizontal Lifting Bail | H-2-90162-2 | 1 |
| 3" Horizontal Lifting Bail | H-2-90162-3 | 1 |
| 2" Sched 40 SR 90 Degree Elbow (ASTM A403 304-L SST) | H-2-64457, Part # 8 | 2 |
| 2" Sched 40 LR 90 Degree Elbow (ASTM A403 304-L SST) | H-2-64457, Part # 7 | 2 |
| 2" Sched 40 LR 90 Degree Elbow (ASTM A234 GR WPB CS) | H-2-37800, Part # 7 | 2 |
| 2" Sched 40 Pipe (ASTM A312 304-L SST) | H-2-64457, Part # 6 | 1 (10'– 0") |
| 2" Sched 40 Pipe (ASTM A53 Type S GR B CS) | H-2-37800, Part # 6 | 1 (10'– 0") |
| 2" Flex Hose | H-2-57901, Part # 5 | 1 (10'– 0") |

NOTE: Jumper parts listed above are essential parts for assembling jumper in the following central pump pits: AN Farm (H-2-72025), AP Farm (H-2-90726), AW Farm (H-2-70444), AY/AZ Farm (H-2-64457) and SY Farm (H-2-37800). The jumper head connector assemblies have already been assembled per 2H-0004706/F