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KE BASIN SLUDGE TRANSPORTATION SYSTEM 100% DESIGN REPORT – Project A.16

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Prepared for the U.S. Department of Energy
Fluor Hanford
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL.13200

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Richland, Washington

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1.0 DESIGN ANALYSIS REPORT SUMMARY

1.1 Introduction

The Hanford K Basins have an accumulation of sludge on the basin floors, in canisters, and in the basin pits from operation of the Basins over the past 30 years. The sludge is composed of irradiated nuclear fuel particles, fuel corrosion products, cladding, storage canister corrosion products, structural degradation and corrosion products from features in the basin pools (e.g., racks, pipes, sloughed off concrete, etc.), beads lost from ion exchange modules (IXM), environmental debris (e.g., sand, insects, pieces of vegetation, etc.), and various other materials (e.g., sand, filter media, hardware, plastic, etc.). The KE Basin Sludge Transportation System (STS) will be used for the onsite shipment of KE Basins sludge and water to T Plant for subsequent storage. The STS basically consists of a large diameter sludge container, a shielded shipping cask, and transport trailer.

A Fluor Hanford project team performed a conceptual design study (Ref. 1) during 2001 for the STS. The project team developed a Functional Design Criteria document, SNF-8166 (Ref. 2) and a Performance Specification, SNF-8163 (Ref. 3), which documented the results of this conceptual design study. A Statement of Work (Ref. 4) was then developed that documented those portions of the Performance Specification that were to be accomplished through a design-fabricate contract that Fluor Hanford subsequently awarded to Packaging Technology, Inc. (PacTec) of Tacoma, Washington.

During the execution of this STS design-fabrication contract, certain portions of the Performance Specification were performed by Fluor Hanford. These portions included criticality safety analyses and the safety basis thermal and gas generation analyses.

1.2 Scope

The scope of this 100% Design Report includes all design documentation and supporting information generated by both Fluor Hanford and PacTec. The documentation supplied by PacTec consists of that specified in the Statement of Work. This report addresses design documentation for the STS only. A separate 100% Design Report has been prepared for the K-Basin Sludge Retrieval System (SRS). Together the STS and SRS 100% design reports constitute the KE Basin Sludge Water System 100% design.

1.3 Summary of STS Design

The STS package consists of three major elements: the Cask, the Large Diameter Container (LDC) that is transported inside the cask and which provides storage for the sludge, and the Transport Trailer that transports the cask containing the LDC to T Plant. Each of these elements is described briefly below. More detailed description of the design of the STS is provided in the PacTec Design Analysis Report (PacTec DAR) (Ref. 5) and shown in Figures 1.1 through 1.4.

1.3.1 STS Cask

The STS cask is cylindrical in shape with a diameter of 72.3 inches and a maximum height of 132 inches. It provides containment and biological shielding for the transportation conditions prescribed with in SNF-8163 (Ref. 3). The cask is made of Type 304 austenitic stainless steel. The cask wall consists of inner and outer shells of stainless steel with a 3 1/8-inch thick layer of lead cast between the two shells. The closure lid containment seal is a metallic O-ring. Metallic O-rings are also provided for the vent and drain port containment penetrations. No lifting components are integral to the packaging. The STS Cask components are described more fully below. The maximum permissible gross shipping weight of the STS **Cask** is 85,000 pounds including maximum payload and cask body.

The cask is designed to provide shielding for both neutron and gamma sources. The inner and outer structural steel shells of the cask and the lead shell in between provide shielding between the payload and the exterior surface of the package for the attenuation of gamma radiation. The neutron source term is not of great enough significance to require design specific attenuation.

The cask design includes a seal test port, a vent port and a drain port. The seal test port accesses the cavity between the inner (containment) and outer O-ring bore seals on the closure lid, thereby allowing leak tight verification prior to shipping the loaded package. The vent port permits venting and purging of the cask cavity during loading and unloading of the package. Each port is an integral part **of** the lid, and each port plug is well recessed into the lid for protection. The drain port permits draining of the case, should that be required. There are no receptacles or valves utilized on this package.

The cask serves as the containment boundary for the payload of K East sludge during transportation. The cask components that form the containment boundary are the inner cylindrical shell, the bottom forging, the drain port plug and metallic O-ring, the upper forging, the closure lid, the vent port plugs and metallic O-ring, and the closure lid containment metallic O-ring. The cylindrical cavity formed by these components is **61** inches in diameter and 121 inches in length.

The 1-inch thick cask inner shell is made from ASME SA-240, Type 304 austenitic stainless steel. The inner shell thickness transition *to* the bottom and upper forging is a 3:1 minimum taper. The 1%-inch outer shell is also made from ASME SA-240, Type 304 austenitic stainless steel. Gamma shielding is provided by cast lead. The gamma shield is sealed inside an annular cavity formed between the inner and outer shells and end forgings.

The bottom end closure is made from SA-182, Type F304 austenitic stainless steel. It provides a bottom thickness of 6-inches. A drain port is provided thru the bottom end forging and the penetration to containment is sealed using the drain port plug and metallic O-ring. The upper forging, made **from** SA-182, Type F304 austenitic stainless steel, provides a transition for the inner and outer shells to the sealing region and lid closure.

The closure lid is made from SA-182, Type F304 austenitic stainless steel, provides a thickness of 5-inches and locations for the metallic containment O-ring seal and adjacent elastomeric O-rings used for leak testing, as well as providing a location for the vent, fill, and test ports. The lid is attached to the cask using 24, 1½-10 UNC ASTM A564, 630 (H1100) bolts.

The closure lid is sealed using a single 0.268-inch diameter face-type O-ring Helicoflex seal. **An** O-ring seal made from butyl is located outboard the containment O-ring to facilitate leak testing. The outer O-ring is used to create a cavity, which is evacuated and tested for the presence of helium during leak testing.

1.3.2 Large Diameter Container

The LDC is a 59-inch diameter cylindrical pressure vessel fitted with 2:1 elliptical heads fabricated of Type 316/316L stainless steel. The lower head and cylindrical portions are of nominal %-inch thickness. The upper head has a nominal thickness of ¾ -inches. The overall height of the LDC is 120-inches, including the lower support skirt, top mounted processing flanges and centrally mounted lifting lug. The upper elliptical head together with an integral lifting lug transfers lifting lug loads to the cylindrical side walls of the LDC. The LDC is designed as an ASME Section **VIII,** Division I pressure vessel, with a design pressure rating of 150 psig. The LDC serves as a processing vessel to receive and store sludge wastes and as such is fitted with internal filter components and a variety of penetration ports. The internal volume of the LDC accommodates a maximum payload of 3.0 m^3 (105.9 ft^3) of as-settled sludge covered with a minimum of 25.4 cm (10 in.) of water. The minimum void space above the payload is 1.6 m^3, including void space within the cask cavity.

1.3.3 Transport Trailer

The Trailer is a 4-axle single drop flatbed with an overall length of 35-feet and width of IO-feet. The height of the drop deck is 42-inches and the overall height, including superstructure work platform railings is 181-inches. The trailer is fabricated of welded carbon steel shapes, plates and tubular sections. The materials and fabrication are in accordance with industry accepted standards (ASTM, AISC, ANSI, AWS) and all surfaces are primed and painted with coatings appropriate for use. The superstructure is a welded framework surrounding the cask allowing access to the containers during loading and handling operations. The integral cask tie-down system consists of deck mounted lugs which engage 4 slots at the base of the STS Cask plus a tubular framework which envelopes the top of the cask. A work stand for storage and inspection of the cask lid is located at the Trailer stem. This stand includes features allowing the lid to be rotated 180° for inspections, seal installation and replacement.

1.3.4 Other Components

The STS includes several other significant elements. These include the Process Shield Plate (PSP), the Lid Lift Device and the Cask Lift Device.

The PSP is 84.5 inch in diameter and is fabricated of all carbon steel. It weighs some 14,000 lbs. It provides primary gamma shielding to workers during loading operations. The stepped PSP envelopes the open end of the cask and fits tightly around the several nozzles and fittings located at the top of the Large Container. Appropriate guides and lead-ins are provided to assure that the

PSP properly interfaces with both cask and LDC without endangering the rather fragile nozzles of the LDC.

The Lid Lift Device serves dual functions. The primary function is as simple device that bolts directly to the cask lid using 3 ¾-10UNC A320, Grade LM7 bolts. The secondary function is as an element of the trailer Lid Turning Fixture. In this lid turning application, the fixture serves as the axle of the turning device.

The Cask Lit? Device is also a simple strongback that bolts directly to the cask using four 1-1/2 inch UNC-2A bolts threaded into four lid bolt tapped holes locations. The cask is never lifted during operations and is never lifted loaded. The only occasions when this lift will occur is during initial installation of the cask on the Trailer and for periodic servicing, as required.

1.3.5 Operational Features

The STS Cask normally remains attached to the trailer throughout transport as well as during operations at the KE Basin and T-Plant facilities. At the KE Basin, the cask lid is removed, set-aside, and the PSP is positioned above an empty LDC. Process lines and instrumentation cabling are connected to the LDC and the loading process commences. In this loading process, Basin sludge and water is pumped into the Large Container. The sludge remains in the LDC whereas filtered water is returned to the processing system. Upon completion of loading, excess water is removed from the LDC, the lid is installed and the cask is prepared for shipment. Upon arrival at the T-Plant, the lid is removed and the LDC is lifted and placed into its designated interim storage location. Next, an empty LDC is positioned in the cask, the lid is re-installed and the system is returned to K-Basin for another shipping sortie.

1.4 Summary of Incorporated Documents

This 100% Design Report incorporates the documents listed and briefly described below. The first twelve documents were developed as direct products of the design effort. That is, the first three documents (see Sections 1.41. – 1.4.3) established requirements, specifications and the scope of work for the design-build contract that was let to PacTec. The next six documents (see Sections 1.4.4 – 1.4.7) were produced to document the products of the design efforts that led up to the ultimate fabrication of the hardware for the STS. Section 1.4.4 contains three reports for the design effort (30%, 60%, 90% reviews). The three documents described in Sections 1.4.8 – 1.4.10 document analyses that were performed to confirm that the hardware being designed would be acceptable from the nuclear and criticality safety perspectives. Each of these twelve documents is discussed in the main body of this report.

The last six documents listed below (see Sections 1.4.11-1.4.16) are not discussed in the main body of this report. A brief discussion of the purpose and scope of each of these documents is provided in Section 11.0

1.4.1 Functional Design Criteria

The Functional Design Criteria (Ref. 2) identifies the minimum criteria and requirements that form the authorized baseline for the SWS project. This document is included as Attachment 1.

1.4.2 Performance Specification

The Performance Specification document, SNF-8163 (Ref. 3) specifies the necessary requirements and criteria for procurement of the STS. This document is included as Attachment 2.

1.4.3 Statement of Work

The Statement of Work (Ref. 4) documents those portions of the Performance Specification that were to be accomplished through a design-fabricate contract that Fluor Hanford subsequently awarded to Packaging Technology, Inc. (PacTec) of Tacoma, Washington. This document is included as Attachment 3.

1.4.4 Design Review Report Summaries

Design reviews were conducted on the STS design being developed by PacTec at the points in time when their design efforts were approximately 30%, *60%* and 90% complete. The design review meetings involved SWS project personnel and members of the PacTec design team. The SWS project prepared a Design Review Report following each of these meetings to document the state of the design at that point, comments made by reviewers on the design, and the resolution of these comments are incorporated herein as Refs. 6, 7 and 8. These documents are included as Attachments 4, 5 and 6.

1.4.5 PacTec Design Analysis Report

The PacTec DAR incorporated the comments received at the 90% design review meeting and thus documented the final design that governs fabrication. The PacTec report, ED-073 (Ref.5), is included as Attachment 7. It is referred to hereafter as the PacTec DAR.

1.4.6 PacTec Design Analysis Report Addendum

Following issuance of the Design Analysis Report, PacTec performed some additional design work in closing out the design effort. The additional design documentation prepared by PacTec is presented in a Design Analysis Report addendum, (Ref. 9). The Design Analysis Report addendum is included as Attachment 8.

1.4.7 Fluor Hanford Supplemental Design Information

Flour Hanford performed or supplemented PacTec analyses for the STS. This information has been compiled in a number of position papers, supplemental analysis and updated drawings. Issues addressed consisted of:

- Calculation SWS-A-16-(3-010, Rev. 2 – Sludge container maximum sludge loading
- Position paper – Rising slug plug disruptor
- Position paper – Deflector plate analysis to promote uniform distribution
- Position paper – Radiation hardening of level sensor
- Position paper – Hydrogen flammability
- Analysis – Thermal/gas evaluation for normal and accident conditions for transportation using TI-015, Rev. 9
- Analysis – Shielding analysis for process shield plate well area
- Updated PacTec 100% design drawings (changes after 90% PacTec DAR approval)

This documentation is included as Attachment 9.

1.4.8 SWS Criticality Safety Report

Fluor Hanford performed the criticality safety analyses for the SWS project. The results of these analyses, which demonstrate that an accidental criticality is an incredible event for all normal and credible off-normal conditions, are documented in HNF-8513 (Ref. 10). This report is included as Attachment 10.

1.4.9 Safety Basis Thermal and Gas Generation Analysis

Fluor Hanford performed the safety basis thermal and gas generation analyses for the STS. The results of these analyses are documented in the report SNF-9955 (Ref. 11). This report is included as Attachment 1 1.

1.4.10 Design Basis Thermal and Gas Generation Analysis

Fluor Hanford also performed the thermal and gas generation analyses for the STS for design basis conditions. The results of these analyses are documented in the report SNF-10415 (Ref. 12). This report is included as Attachment 12.

1.4.11 Design Verification and Validation Plan

Fluor Hanford prepared a plan for performing verification and validation of the SWS design completed by PacTec. This plan is documented in SNF-6470 (Ref. 13). This document is included as Attachment 13.

1.4.12 Design Verification and Validation Report

Fluor Hanford will perform a verification and validation of the PacTec design for the SWS. The results of this effort along with the STS FDC compliance matrix will be documented following completion of the Acceptance Test Program.

1.4.13 SWS Human Factors Report

During the course of the design effort for the SWS, analyses were performed and design reviews were conducted that focused on various Human Factors aspects of the design and operation of the system. The results of these efforts are documented in SNF-13144 (Ref. 14). This document is included as Attachment 15.

1.4.14 SWS ALARA Report

During the conceptual design phase of the SWS, ALARA reviews were held frequently to discuss the radiation protection aspects of the evolving design. The results of these efforts are documented in SNF-8509 (Ref. 15). This document is included as Attachment 16.

1.4.15 SWS Hazards Analysis

Fluor Hanford performed a hazards analysis of the entire SWS as an initial step in developing the safety basis for the SWS project. This hazard analysis was updated throughout the SWS design. The hazards analysis is documented in SNF-I0020 (Ref. 16). This document is included as Attachment 17.

1.4.16 K Basins Hazards Analysis

Given the results of the hazards analysis, Fluor Hanford performed a hazards analysis of the entire K Basins operation as the next step in developing the safety basis for the SWS project. This hazards analysis is documented in HNF-3960 (Ref. 17). This document is included as Attachment 18.

1.5 References

References 2, 3, and 4 have subsequently been updated during the execution of the design contract to incorporate all design modifications/changes. All modifications and changes to the referenced documents were incorporated in the presented design and analyses. The references were not updated in the individual chapter write-ups because those revisions (with appropriate contract modifications) were in effect at the time of supporting document generation and the cross link to the supporting analyses refers to the old revision.

1 SNF-8671, Rev. 0, ***Sludge & Water Sys Conceptual Design Studies Project A-16,*** Fluor Hanford, Inc., July 2001

2 SNF-8166, Rev. 2, ***Functional Design Criteria for the K Basins Sludge and Water System – Project A-16,*** Fluor Hanford, Inc., December 2002

3 SNF-8163, Rev. 5, ***Performance Specification for the K East Basin Sludge Transportation System – Project A.16,*** Fluor Hanford, Inc., March 2002

4 ***Statement of Work, Revision 4, For The Sludge Transportation System Project A-16,*** Contract 12329, Attachment 8, Fluor Hanford, Inc., March 13,2002

5 ED-073, *Sludge Transportation System Design Analysis Report*, PacTec, Tacoma, WA, September 2002

6 Fluor Hanford Letter FH-0200181, R.P. Heck, FH to S.J. Veitenheimer, DOE-RL, *Contract Number DE-AC06-96RL13200 – Transmittal of the Sludge Transportation System Thirty Percent Design Review Package*, January 10, 2002

7 SNF-10914, Rev. 0, *K Basins Sludge Transportation System STS 60% Design Review*, Fluor Hanford, Inc., May 2002

8 SNF-12345, Rev. 0, *K Basin Sludge Transportation System 90% Design Report*, Fluor Hanford, Inc., October 2002

9 PacTec Submittal 12329/STS 22, PacTec Final Design Analysis Report, PacTec, Inc., 11/1/02.

10 HNF-8513, Rev. 1, *CSER 01-002: Criticality Safety Evaluation Report for Loading, Transport, and Storage of K Basin Sludge Containers*, Fluor Hanford, Inc., May 2002

11 SNF-9955, Rev. 1, *Safety-Basis Thermal Analysis for KE Basis Sludge Transport and Storage*, Fluor Hanford, Inc., October 2002

12 SNF-10415, Rev. 0, *Design-Basis Thermal and Gas Generation Analysis for KE Basis Sludge in Large Diameter Containers*, Fluor Hanford, Inc., August 2002

13 SNF-6470, Rev. 0, *Design Verification Plan for the K Basins Sludge and Water System, Project A.16*, Fluor Hanford, Inc., June 2001

14 SNF-13143, Rev. 0, *Human Factors Report for the Sludge Water System*, Fluor Hanford, Inc., October 2002

15 SNF-8509, Rev. 0, *ALARA Report – Sludge Water System SNF Project A-16*, Fluor Hanford, *Inc.*, July 2001

16 SNF-10020, Rev. 1, *Hazards Evaluation for KE Sludge & Water Sys Project A-16*, Fluor Hanford, Inc., October 2002

17 HNF-3960, Rev. 5, *K Basin Hazard Analysis*, Fluor Hanford, Inc., October 2002

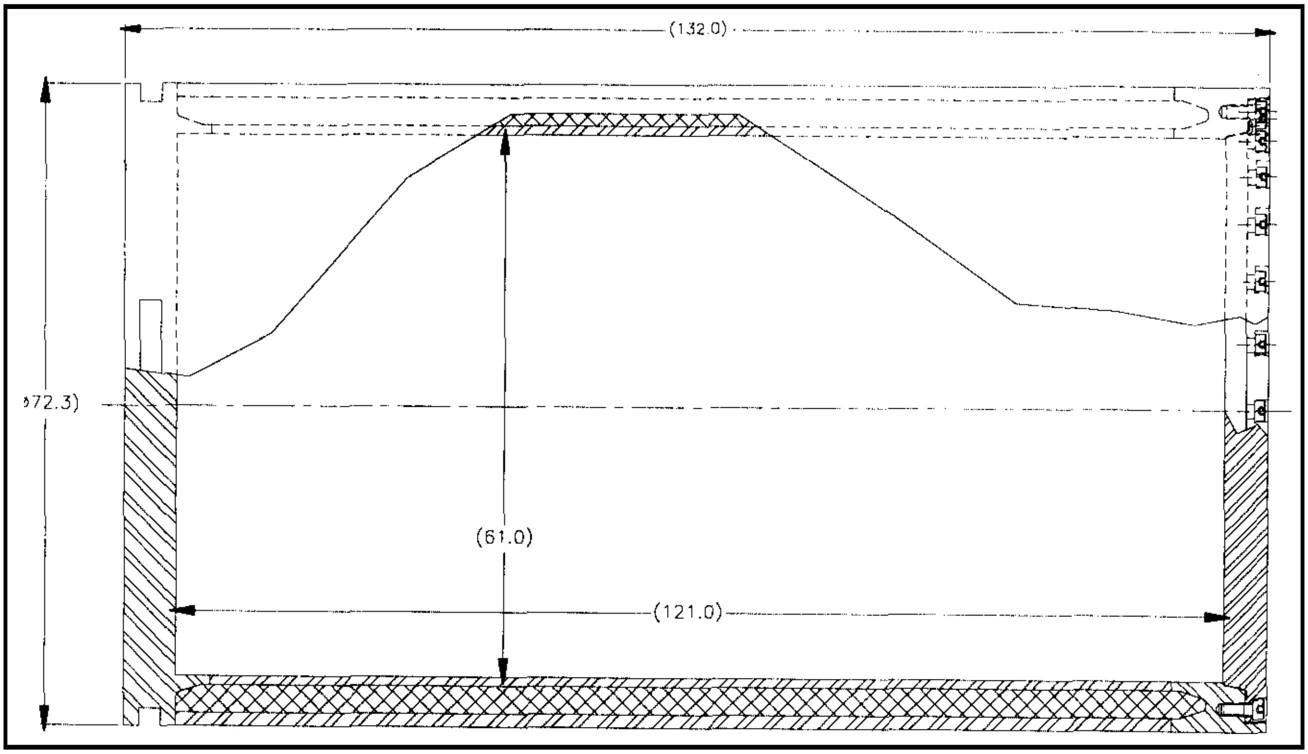

Figure 1-1 – STS Cask Basic Dimensions

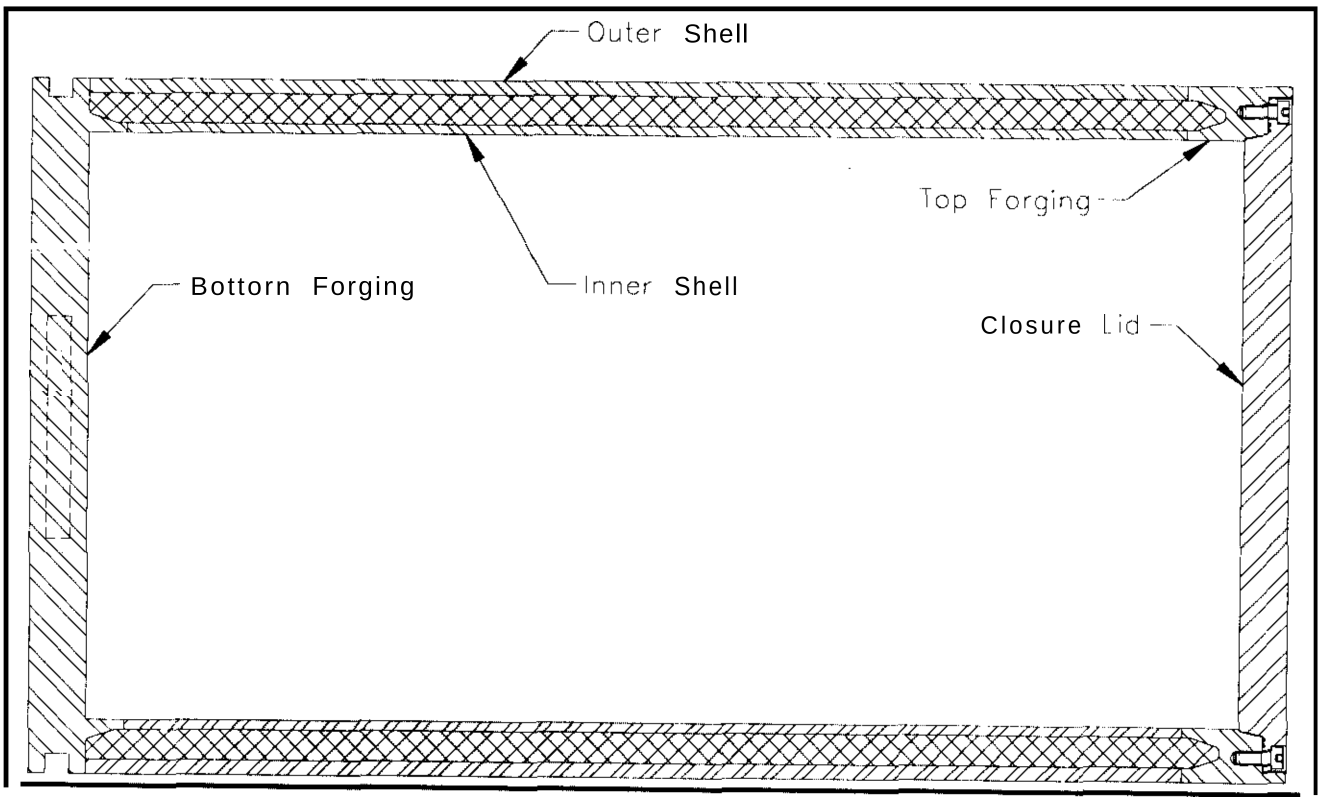

Figure 1-2 – STS Cask Primary Structural Components

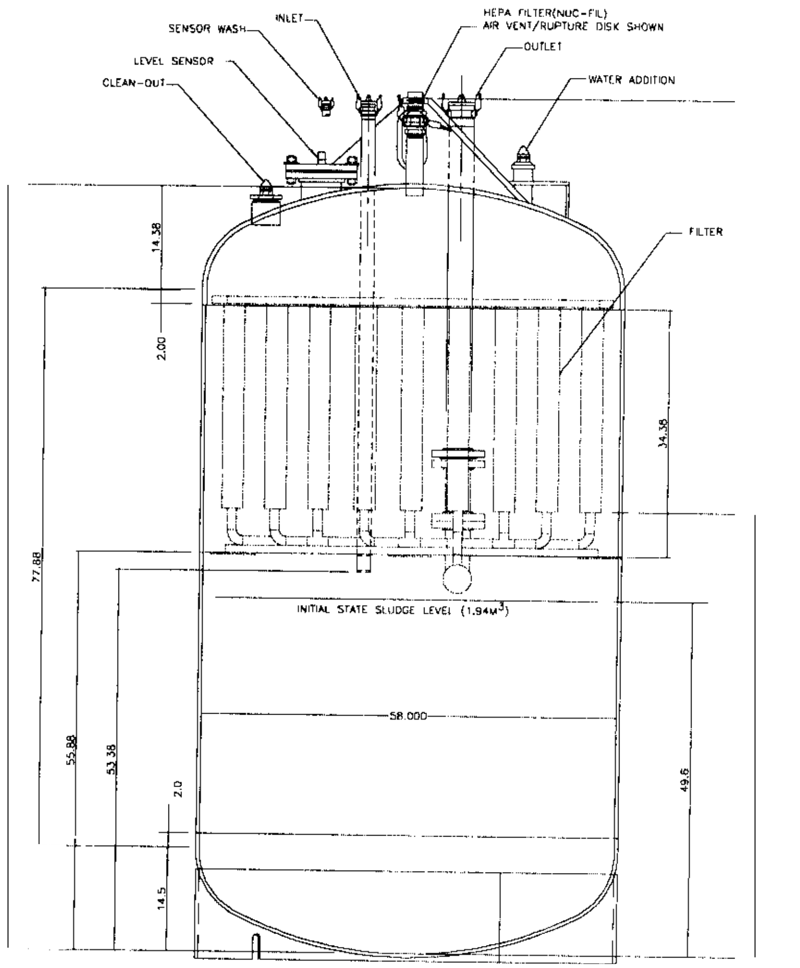

Figure 1-3 STS Container with initial sludge loading of 2.0 m^3

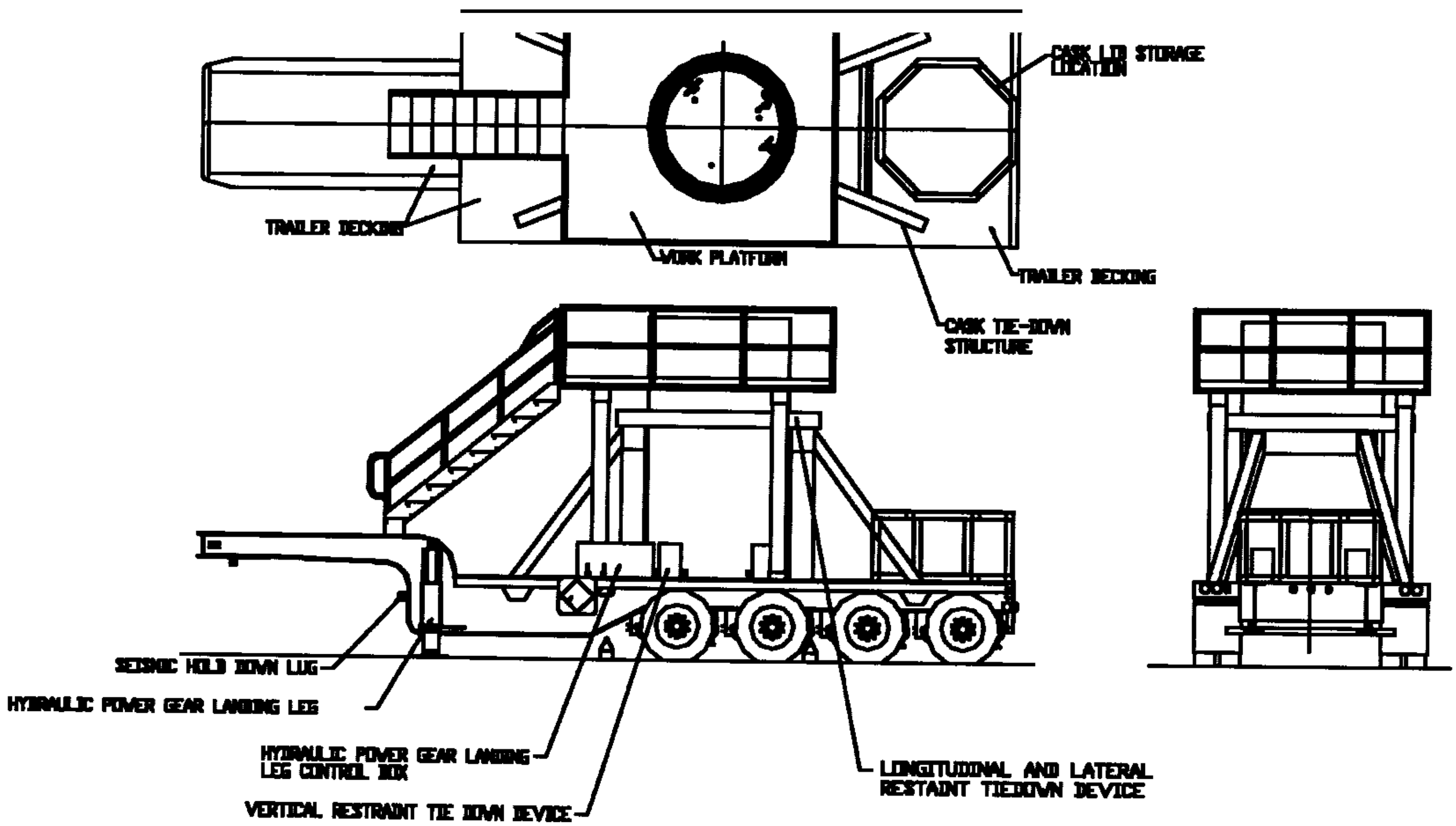

Figure 1-4 STS Trailer Assembly

2.0 STRUCTURAL EVALUATION

2.1 Introduction

This chapter presents the structural design criteria, weights, mechanical properties of materials, and structural evaluations that demonstrate that the STS Cask and Large Diameter Container (LDC) design meets all applicable structural criteria. The package that is designed to transport a single LDC is a cask including the containment (inner) shell, outer shell, lead shielding, bottom forging, and closure lid. Evaluations of Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC) were performed using analytical techniques to address the performance requirements in the SNF-8163 (Ref. 1). **All** events were evaluated analytically.

2.2 Structural Design Criteria

This section defines the allowable stresses and load combinations used to design the STS Cask for the analytical evaluations of the transportation load conditions. These design criteria meet the following safety requirements of 10 CFR §71.51 [Reference 3]:

- For normal conditions of transport, there shall be no **loss** or dispersal of radioactive contents, as demonstrated to a sensitivity of $10^{-6}A_2$ per hour, no significant increase in external radiation levels, and no substantial reduction in the effectiveness of the package.

- For hypothetical accident conditions, there shall be no escape of radioactive material exceeding a total amount A, in one week, and no external radiation dose rate exceeding one rem-per-hour at one meter **from** the external surface of the package.

The acceptance criterion for STS Cask analytical assessments is in accordance **with** Regulatory Guide 7.6 and Section III, the ASME Boiler and Pressure Vessel Code, and the Hanford Sitewide Transportation and Safety Document.

The acceptance criterion for LDC analytical assessments is in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.

2.3 PacTec Structural Evaluations

The scope of the activity was to cover structural and stress analysis for the entire STS package (Cask, container, trailer, lifting devices and tiedown system). Areas analyzed and presented in the reference documentation are:

- Chemical and Galvanic Reactions - The materials from which the STS cask and Large Container is fabricated (i.e., primarily stainless steel, lead) will not cause significant chemical, galvanic, or other reactions in air, helium, or water environments. The lead gamma shield material is enclosed inside sealed (welded closed) cavity. Thus, the requirement of 10 CFR §71.43(d) is satisfied.

- Size of the Package and Cavity - The cask is a right circular cylinder with flat end with a cavity diameter of 61 inches and length of 121 inches. The STS cask has an outer diameter of 72¼ inches and total length of 132 inches. The STS cask is designed to transport one Large Container. The Large Container is a right circular cylinder with standard ellipsoidal heads, 59 inches in diameter, and 120 inches in height.
- Weights and Center of Gravity - The calculated weights of the major components of the STS cask, Large Container, payload and Trailer are tabulated in Table 2-1.
- Tamper-Indicating Features - A lock wire is used on the vent, test and drain ports caps and a minimum of 2 lid closure bolts after installation. Failure of the lock wire indicates deliberate tampering. Once installed, the contents of the package may not be accessed without deliberately removing the lockwire(s). This satisfies the tamper indicating requirement of 10 CFR §71.43(b).
- Positive Closure - Inadvertent opening of the cask closure cannot occur for the STS transportation cask. Upon completion of loading the cask payload, the top closure plate's 24, 1½-6UNC-2A socket head cap screws are tightened to a relatively high torque value thereby eliminating access to the containment cavity. Following containment seal leak testing, the vent, test and drain port caps are installed. Once installed, lock wire. Thus, inadvertent opening of the cask cannot occur, and the requirement of 10 CFR §71.43(c) is satisfied.
- Lifting and Tiedown Features - The Sludge Transportation System (STS) Cask is typically not lifted during any of the loading, unloading, or transportation operations. Installation of the cask onto the trailer is performed by utilizing a sub-set of lifting devices that attach to the cask by means of the cask lid closure boltholes. The sub-set of cask lifting devices are evaluated within Calculation 12099-23. The cask lid is lifted separately via the Lid Lifting Device that interfaces with threads in the top of the cask lid. These Lid Lifting Device threads are analyzed in Calculation 12099-24.

  Two types of tie-down devices secure the cask for transportation. The cask bottom forging has four machined grooves that interface with trailer tie-down bars to prevent motion in the vertical direction. The main device used to prevent motion in the horizontal plane is a trailer tie-down clamp that encompasses the circumference of the cask at approximately 7' 2" (up from the bottom of the cask). In this calculation the grooves of the cask bottom forging are analyzed for a vertical load, and the cask is analyzed for loading in the horizontal plane caused by bearing forces applied by the trailer tie-down clamps. The tie-down components of the STS cask and trailer are evaluated in Chapter 8 of this report.

Component Configuration	Nominal Weight (lbs)
Containment Boundary	
- inner shell	6,720
- lead	31,650
- outer shell	11,503
- lid	4,952
- bottom	[illegible]
Component SubTotal	***63,691***
Large Container	
- large container	4,800
Component SubTotal	***4,800***
Payload	
- sludge (3 m^3)	10,912
Component SubTotal	*10,912*
Trailer	35,000
Component SubTotal	35,000
Loaded Cask Total	***79,403***
Loaded Trailer Total	***114,403***

- <u>Brittle Fracture</u> - With the exception of the cask lid closure bolts lead biological shielding, all structural components of the STS Cask are fabricated of austenitic stainless steels. These materials do not undergo a ductile-to-brittle transition in the temperature range of interest (i.e., down to -27°F), and thus do not need to be evaluated for brittle fracture. Further, Regulatory Guide 7.11 [Reference 8] states, “Since austenitic stainless steels are not susceptible to brittle failure at temperatures encountered in transport. their use in containment vessels is acceptable to the staff and no tests are needed to demonstrate resistance to brittle fracture.”

  The closure lid bolts are fabricated from ASME SA564, Type 630 (HI100), alloy steel bolting material. Per Section 5 of NUREG/CR-1815 [Reference 9], bolts are not considered as fracture-critical components because multiple load paths exist and bolting systems are generally redundant, as is the case with the STS Cask. Therefore brittle fracture is not a failure mode of concern.

- Earthquake and stability - The Performance Specification, SNF 8163, Section 4.3.2.3, requires evaluation of the STS system (cask and trailer) to a performance category 3 (PC3) earthquakes. The detailed evaluation is provided in the PacTec DAR.

2.3 Summary and Conclusions

Four area of analysis were performed for the structural analysis (normal conditions for transfer; hypothetical accident conditions; trailer, lifting devices and tiedown system; and earthquake and stability analysis). **A** summary of each of the structural evaluations is provided below.

2.3.1 Normal Conditions of Transfer (NCT)

Ten normal conditions are defined for K-East Basin, transportation and T Plant structural analyses:

- The maximum heat generation rate based on the limiting payload **as** described in Section 3.0 of SNF-8163, (Ref. **1),** plus maximum normal initial environment conditions, plus maximum solar heat load (see Table 5-2 of SNF-8163, (Ref. 1)) plus maximum air temperature of 46°C (115°F).
- The maximum heat generation rate based **on** the limiting payload as described in Section 3.0 of SNF-8163, (Ref. **1),** plus minimum normal initial environment conditions.
- **A** minimum air temperature -33 °C **(-27** °F) and zero heat generation rate.
- Reduced External Pressure: **An** external pressure **of** 25 kPa (3.5 psi) absolute.
- Increased External Pressure: **An** external pressure of 140 kPa (20 psi) absolute.
- Maximum Internal Pressure: An internal operating pressure of 551.58 kPag (80 psig) is the maximum achievable pressure during transportation.
- Vibration: Vibration normally incident to transport. The cask shall be evaluated per Draft American National Standard Design Basis for Resistance to Shock and Vibration of Radioactive Material Packages Greater Than One Ton in Truck Transport (Reference **1)** ***to*** demonstrate containment when exposed to normal vibration due to the onsite transfers defined herein by the selected transport vehicle. Tiedowns and hold down bolts shall also be evaluated for this scenario.
- Water Spray: The cask shall be evaluated to demonstrate containment through a water spray that simulates exposure to rainfall of approximately 5 cm (2 in.) per hour for at least one hour.
- Penetration: The cask shall be evaluated to demonstrate the impact of the hemispherical end **of** a vertical steel cylinder of 3.2 cm **(1.25** in.) diameter and ***6*** kg (13 Ib.) mass, dropped from a height of 1 m (40 in.) onto the exposed surface of the package that is expected to be most vulnerable **to** puncture. The long axis of the cylinder must be perpendicular to the cask surface.
- Free Drop: The cask shall be evaluated to demonstrate containment subsequent to a 0.3 m (1 ft) free drop onto a 20.3 cm (8 in.) thick concrete surface with a concrete strength of

20,685 kPa (3,000 psi), Grade 60, No. 7 reinforcing bar spaced 30.5 cm (12. in.) apart with 5.1 cm (2 in,) cover, each way, each face, and soil properties in accordance with DOE/RL-2001-0036, Hanford Sitewide Transportation Safety Document [Reference 6]. The cask shall impact in an orientation expected to cause maximum damage. If the worst case orientation does not bound the comer drop accident, additional analysis will be performed.

A summary of the above ten K Basin and NCT analyzed conditions is provided below:

NCT Analyzed Conditions	Criteria
Hot Environment	115°F ambient temperature, maximum insolation, and maximum decay heat per Section 5.1.1 of SNF-8163, (Ref. 1).
Cold Environment	-27°F steady state ambient temperature is utilized per Section 5.1.1 of SNF-8163, (Ref. 1), with both zero insulation and zero decay heat and zero insulation and maximum decay heat.
Reduced External Pressure	3.5 psia, per Section 5.1.2.4 of SNF-8163, (Ref.1) Conservatively assuming a MNOP of 60 psig
Increased Internal Pressure	20 psia, per Section 5.1.2.4 of SNF-8163, (Ref. 1) Consistent with Regulatory Guide 7.6 (Ref. 2) philosophy.
Water Spray	NA - Reg. Guide 7.8 (Ref. 3) exemption for large packages
Vibration	NA - Bounded by NCT Free Drop
Penetrations	NA - Free Drop per Regulatory Guide 7.8 (Ref. 3), the penetration condition of Section 5.1.2.9 of SNF-8163, (Ref. 1) is not considered a general requirement for large packages.
Free Drop	1 foot worst case orientation drop

For these analyzed conditions, several acceptance criteria were defined:

- Containment: The cask shall be designed, constructed, and prepared for shipment so that when subjected to normal conditions, the containment boundary shall remain leak-tight in accordance with the ***Radioactive Materials Leakage Tests on Packages for Shipment*** (Ref. 5) definition of "leak-tight" (leakage less than 10^{-7} std cc/sec air). If the cask design incorporates a venting feature, the leakage rate evaluation shall be made with the vent(s) sealed. For conditions normally incident to transfer, the packaging shall be evaluated by analysis to meet the containment criteria listed above.
- The STS Cask is designed to provide containment for all normal conditions of transport (NCT). The NCT conditions affecting containment capability are fully evaluated in Sections 2.7.1 and 3.6.1.1 and shown to meet the acceptance criteria described in Sections 2.4.2 and 3.4.2. Chapter 4 also provides a discussion of the STS Cask containment.

- Thermal: Maximum accessible outside surface temperature of the cask shall be less than 85 °C (185 °F) in 37.8 °C (100 "F) air temperature and in the shade. The STS design shall ensure the maximum temperature of the payload does not exceed 100°C (212°F) at any time during loading, transportation and storage.
- The STS Cask thermal analysis address all NCT thermal conditions are fully evaluated in Section 3.6.1.1 and shown to meet the acceptance criteria.
- Shielding: Shielding shall meet the DOT requirements for shipments of radioactive materials as defined in ***Shippers General Requirementsfor Shipments and Packaging*** [Reference 8].
- The Cask is shielding analysis is contain in Chapter 5, and conservatively demonstrates that the shielding criteria are met.

When subjected to the Normal Conditions of Transfer (NCT) as specified above, the STS cask meets the performance requirements and the applicable design criteria.

2.3.2 Hypothetical Accident Conditions (HAC)

Three accident conditions are defined for transportation:

- Impact: The worst case failure threshold evaluation for the cask system shall be a free drop of 9.1 m (30 ft) onto an 20.3 cm (8 in.) thick concrete surface with a concrete strength of 20,685 kPa (3,000 psi), Grade 60, No. 7 rebar spaced 30.5 cm (12 in.) apart with 5.1 cm (2 in.) cover, each way, each face, and soil properties in accordance with [Reference 9]. The cask shall impact in an orientation expected to cause maximum damage.
- Puncture: The worst case credible puncture incident is equivalent to a free drop of the cask through a distance of 1 m (40 in.) in a position expected to cause the maximum damage, onto the upper end of a solid, vertical, cylindrical, mild-steel bar. The bar must be 15 cm (6 in.) in diameter, with the top horizontal and its edge rounded to a radius of not more than 6 mm (0.25 in.) and of a length to cause maximum damage to the cask, but not less than 20 cm (8 in.) long. The puncture bar is mounted on a 20.3 cm (8 in.) thick concrete horizontal surface with a concrete strength of 20,685 kPa 3,000 psi, Grade 60, No. 7 rebar spaced 30.5 cm (12 in.) apart with a 5.1 cm (2 in.) cover, each way, each face, and soil properties in accordance with [Reference 9].
- Fire: The worst-case fire that the cask system can be exposed to during transport is a 30-minute, 800 °C (1,475 °F) engulfing fire that has an emissivity coefficient of 0.9. The surface absorptivity of the cask shall be the greater of the anticipated absorptivity or 0.8. Insolation may be assumed to be 'inactive' following the fire. Active cooling of the cask following the 30-minute fire can be assumed. If assumed, the active cooling shall consist of quenching the outer cask surfaces using water spray from a fire hose rated at 473 L/m (125 gal/min.) Flow at this maximum rate shall be assumed to occur for a maximum of 45 minutes. If needed, additional quenching water flow can be assumed for an additional period of 100 minutes at a maximum flow rate of 189 L/m (50 gal/min.). Assume a water

temperature of 29 °C (85 °F) for this procedure. Any active cooling system for the packaging shall be assumed to be inoperative during the fire.

A *summary* of three HAC analyzed conditions is provided below:

HAC Condition	Criteria
Free Drop	30 foot worst case orientation drop.
Crush	NA – The crush test specified in 10 CFR §71.73(c)(2) (Ref. 4) is required only when the specimen has a mass not greater than 1,100 lbs. Because the STS cask weighs much more than 1,100 lbs, no crush test is required.
Puncture	40 inch puncture drop condition preceded by a worst case orientation 30 foot drop.
Thermal & Fire	30 minute fire of 1,475°F (802°C) per Section 5.2.2.3 of SNF-8163 (Ref. 1).

For these conditions, several acceptance criteria are defined below:

- Containment: Subsequent to the conditions described in above, the packaging system shall maintain a single containment barrier for the payload. The system must structurally retain the container and its contents. Gas or radiological material (except Kr 85) leakage past the seals following accident conditions shall limit releases to 1 A2 per week.

  The STS Cask is designed to provide containment for all Hypothetical Accident Conditions (HAC). The HAC conditions affecting containment capability are fully evaluated in Sections 2.7.2 and 3.6.1.2 and shown to meet the acceptance criteria. Chapter 4 also provides a discussion of the STS Cask containment.

- Thermal: The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation, storage and subjected to accident conditions.

  The STS Cask thermal analysis address all NCT thermal conditions are fully evaluated in Section 3.5 and shown to meet the acceptance criteria described in Section 3.4.2.

- Shielding: Subsequent to the conditions described in above, the dose 1 m (3.3 ft) from the surface of the packaging system shall not exceed 1 rem/h. With respect to the thermal condition, there shall be no net loss of lead shielding if lead is used. Lead may melt but cannot be lost.

  The Cask shielding analysis is contained in Chapter 5, and conservatively demonstrates that the shielding criteria are met. Additionally, it should be noted, that although possible lead melt is predicted during the fire, the cask will not loose any gamma shielding. This conclusion is based on a review of the structural analysis:

- o The accident conditions structural acceptance criteria do not allow for rupture of the cask structural components (inner & outer shells, and the forgings, including the welded joints).
- o The accident conditions analyses show positive margin, demonstrating there will be no rupture **of** the cask structural components.
- o Without rupture, there can be not lead leakage path.
- o Therefore, no lead is lost for any normal or accident conditions and shielding is retained.

When subjected to Hypothetical Accident Conditions (HAC) as specified above, the STS cask meets the performance requirements and the applicable design criteria.

2.3.3 Lifting Attachments, Trailer and Tiedown system

As specified in Section **7.5** of SNF-8163, (Ref. 1), the following functional requirements are:

- Lifting attachments are designed per ANSI N14.6 (Ref. ***5).*** Lifting attachments are provided for removing the cask from the trailer, and for removing the lid from the cask.
- The tie-down system is designed to secure the cask system to the trailer. The tie-down system meets the requirements of 10 CFR 71.45(b) (Ref. 6).

Lifting Attachments

The maximum weight of the cask is 85,000 lbs. The weight of the lid, **for** the purpose of this calculation, is bounded by 6,250 lbs. The cask and cask lid are both evaluated for a static vertical lift. The cask lifting analysis is evaluated to the criteria specified for a non-critical lift in ANSI N14.6. ANSI N14.6 specifies that the lifting devices be capable of lifting three times the load without generating a combined shear stress or maximum tensile stress in excess of the minimum yield tensile strength **of** the material of construction. The lifting devices shall also be capable of lifting five times the weight without exceeding the ultimate tensile strength **of** the material. The cask and cask lid are each hoisted vertically, ***so*** only a tension load is applied to the threads. The threaded holes used for hoisting the cask and cask lid are evenly spaced circumferentially.

Two lifts were analyzed: 1) the cask lift and, 2) the lid lift. The cask normal operations did not include a lift and thus there are no lifting devices that are a structural part of the cask. For all normal cask lift operations, the cask is lifted empty. Conservatively, the cask lifting analysis was performed using the maximum loaded weight of the cask of 85,000 lbs.

The lifting attachments, lid lifting device and bolt threads met the acceptance and design criteria.

Trailer and Tiedown System

The following paragraphs summarize the Trailer's structural features and behavior. Details are found PacTec DAR (Ref. 7).

The trailer and tiedown structure were modeled with MSC Nastran. A mid-surface model was generated from the Nelson supplied 2- dimensional drawing files. Plate elements were constructed on the midsurfaces representing the trailer structure. A global mesh size of 2" was used. Beam elements are used to represent the axles, suspension and tires. Rigid elements were used to connect the suspension to the underside of the main beams of the trailer. Beam elements were also used to represent the cask and the structural tubes in the tiedown structure to allow for quick tube sizing. The densities of the cask and trailer were modified so that a cask weight of 85,000 lb and empty trailer weight of 35,000 Ib. was obtained for analysis.

An additional model was created of the tiedown structure only, consisting of all tiedown components located above the trailer deck. Plate elements are used to model all the rectangular tubes, top cask clamp lower tiedown devices, and the cask. Compression only gap elements were added between the cask, tiedown devices and top clamp to simulate contact due to the acceleration loads. A static-nonlinear analysis is used for this model in order to utilize the gap elements.

Four operational and one tiedown load case were analyzed. The operational loadings were evaluated versus, structural safety factors of 2:1. Tiedown loads enveloped past and current DOT criteria and were evaluated versus structural safety factors of 1:1, again consistent with DOT criteria.

The results of the analysis indicated that loads are acceptable:

- The minimum operational factor of safety was found to be +2.05, representing a 1g aft and 1g down loading.
- The minimum tiedown factor of safety was found to be +4.12.

2.3.4 Earthquake Analyses of STS

The seismic analysis model utilized the trailer structural model described above in PacTec DAR (Ref. 7), converting it into a single super-element accurately representing the elastic and inertial properties of the trailer, tiedown structure and cask. To this super element were added discrete models of each element of the suspension system. All modeling properties were derived from manufacturers supplied data. Tire and landing gear model restraints were accurately modeled as gaps to ground surface with lateral friction forces acting when the gap was compressively loaded.

The loading was applied via time history ground motion excitations whose spectral transformations matched the Performance Specification, SNF 8163 (Ref. 1), requirements for a K-basin PC-3 earthquake.

The evaluation demonstrates that the STS Trailer will not overturn during the specified earthquake. Specifically,

- Maximum uplift on either landing leg is 2.43 inches.
- Maximum tire lift is 1.06 inches
- Lateral sway **of** the cask top is 6.12 inches.

Details are provided in the PacTec DAR (Ref. 7).

2.4 References

1 SNF-8163, Rev. **4,** *Performance Specification for the K East Basin Sludge Transportation System – Project A.16,* Fluor *Hanford,* Inc., March 2002

2 Regulatory Guide 7.6, *Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels,* Revision *1,* United States Nuclear Regulatory Commission (USNRC) Office **of** Standards Development, March 1978.

3 Regulatory Guide 7.8, *Load Combinations for the Structural Analysis of Shipping Casks for Radioactive Material,* Revision **1,** United States Nuclear Regulatory Commission (USNRC) **Office** of Standards Development, March 1989.

4 10 CFR 71, *Packaging and Transportation **of** Radioactive Materials,* U S . Nuclear Regulatory Commission, 1999.

5 ANSI N14.5, *American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment,* American National Standards Institute (ANSI) Inc.

6 10 CFR 71.45(b), *Packaging and Transportation of Radioactive Materials,* U.S. Nuclear Regulatory Commission, 1999.

7 ED-073, *Sludge Transportation System Design Analysis Report,* PacTec, Tacoma, WA, September 2002

3.0 THERMAL EVALUATION

3.1 Introduction

Both PacTec and Fluor Hanford performed extensive evaluations of the thermal performance of a loaded LDC sitting in one of the shipping casks. Additionally, Fluor Hanford performed analyses of six LDC sitting in a cell at T-Plant during the storage mission. These evaluations were performed to demonstrate that the STS as designed met the performance criteria established in the Functional Design Criteria document, SNF-8166 (Ref. 1), and the Performance Specification, SNF-8163 (Ref. 2). The thermal evaluations were performed for both normal operating conditions and under postulated accident conditions. This section summarizes the thermal evaluations that were performed and the results that were obtained.

3.2 PacTec Thermal Evaluations

The thermal evaluations performed by PacTec are documented in Chapter 3.0 of the PacTec DAR (Ref. 3). This document is included as Attachment ***6.***

The specific objectives of the PacTec thermal calculations were as follows:

- Evaluate the thermal performance of the STS under normal and accident conditions of transportation and ensure the compliance of the system design with all thermal criteria
- Evaluate the gas generation of the payload and the venting performance of the system to ensure that internal pressures and hydrogen gas concentrations remain within design criteria.

PacTec performed thermal evaluations for a range of payload volumes and compositions. Specifically, PacTec evaluated payloads consisting of both the design basis sludge mixture of **80%** floor sludge and 20% canister sludge (80/20 sludge) and the safety basis mixture of ***60%*** floor sludge and **40%** canister sludge (60/40 sludge). The sludge quantities considered in the PacTec evaluations ranged from a minimum of **2.0** m^3 of as-settled sludge without gas retention (which expanded to **3.08** m' with 35% gas retention) to a maximum of 3.38 m^3 of as-settled sludge without gas retention. The 2.0 m^3 sludge payload was assumed to consist of four “layers” of sludge, each having an initial volume of 0.5 m^3. Each layer was further assumed to consist of an “active” sub-layer occupying the lower 2/3 of the layer and an “inactive” layer forming the upper 1/3 of the layer. The uranium fuel particles were assumed to be spread uniformly throughout the active sub-layer.

The 3.38 m^3 sludge payload was assumed to consist of six “layers” of sludge, each having a volume of 0.55 m^3. These six layers were assumed to be identical in composition to those in the four-layer model. In addition to performing analyses on these layered models, PacTec analyzed a homogeneous payload with no layering within the sludge and no retained gas. The thermal model developed by PacTec included heat sources from radioactive decay, radiolytic decomposition of water, and chemical reaction between the uranium metal fuel particles and water. The model also treated the heating and cooling effect of the external environment during each diurnal cycle.

PacTec's analyses focused on the period of time during which the STS is being moved from the K-Basins to T-Plant. This shipping window was modeled as being 60 hours in duration, which is twice the expected maximum transportation time (defined as the time period from the completion of inerting of the cask/LDC at K-East Basin to start of re-inerting of the cask/L:DC at T-Plant). PacTec analyzed a total of 11 cases that included both normal transportation scenarios and accident conditions. In addition, they performed sensitivity analyses around the conditions developed as the starting point for the postulated accident case (a fire).

The transportation cask and LDC were modeled in axi-symmetric cylindrical geometry in the thermal analysis computer codes used by PacTec for the non-accident cases. A 180° three-dimensional model was used for the accident calculations. In addition to computing transient temperatures within the model, the computer codes calculated the generation and subsequent diffusion of hydrogen from within the sludge to the gas-filled region at the top of the LDC and on into the cask. The gas generation results are discussed in Section **7.0.**

For the safety basis case calculated for non-accident conditions (the safety basis sludge loading under worst-case insolation conditions), the computer model used by PacTec predicted peak temperatures and internal gas pressures that are well within acceptance criteria for the STS. The several parametric cases that were run to examine the effect of additional conservatisms in the modeling also resulted in peak temperatures and pressures that were well within acceptance criteria. The results of these PacTec evaluations are documented in Section 7.1 of PacTec Calculation 12099-05, which is included in Attachment 3.1 of the PacTec DAR. Tables 7-1 through 7-7 from this PacTec calculation summarize key results.

PacTec evaluated three configurations for the hypothetical accident conditions. In all of these cases, the cask and LDC were assumed to be on their sides with a fire burning around them for 30 minutes. The results of these analyses were provided to the Fluor Hanford team that developed the transportation safety documentation for the STS that serves as the safety basis for the STS during transportation from K-Basins to T-Plant.

These hypothetical accident evaluations are presented in Section 7.2 of the PacTec calculation. The results are summarized in Tables 7-8 through 7-10 in the calculation.

3.3 Fluor Hanford Thermal Evaluations

Fluor Hanford personnel performed two sets of thermal evaluations. The first set of evaluations is reported in SNF-9955 (Ref. **4).** This document is included as Attachment 11. This set of evaluations considered a safety basis payload consisting of a mixture of 60/40 sludge. The sludge quantity considered in Fluor Hanford safety basis evaluations was 2.0 m^3 of as-settled sludge that had expanded to 3.08 m^3 with **35%** gas retention. The **2.0** m^3 sludge payload was assumed to consist of four "layers" of sludge, each having an initial volume of 0.5 m^3. Each layer was further assumed to consist of an "active" sub-layer occupying the lower 2/3 of the layer and an "inactive" layer forming the upper 1/3 of the layer. The uranium fuel particles were assumed to be spread uniformly throughout the active sub-layer. This is the same starting point as was used for the baseline safety basis evaluation performed by PacTec.

The Fluor Hanford safety basis thermal evaluations used as their starting point the time when the STS is ready to leave K-East Basis for its trip to T-Plant. The evaluations followed the STS through **30-** and 60-hour transportation windows during maximum insolation conditions for the Hanford site. **As** with the PacTec analyses, the Fluor Hanford safety basis evaluation predict that peak pressures in the cask and LDC would not exceed the **80** psig acceptance criterion during the **30-** and 60-hour transportation windows and that peak temperatures in the sludge would be well below the boiling point of water, indicating that the sludge is thermally stable.

The Fluor Hanford safety basis thermal evaluations also examined the thermal and gas generation response of a safety basis LDC to storage conditions in a T-Plant cell. The thermal model included one LDC with a safety basis loading of sludge and five LDCs with loadings of 75% floor sludge and 25% canister sludge (75/25 sludge) sitting in a single cell in T-Plant. These evaluations predict that even under a **loss** of forced ventilation condition lasting for **30** days at T-Plant, temperatures in the sludge would remain well below 100°C.

The results of the Fluor Hanford safety basis thermal evaluation were used to establish sludge loading process requirements for the LDC at K-East Basis and to establish the safety basis for the sludge-filled LDCs at T-Plant.

The second set of Fluor Hanford thermal evaluations are reported in SNF-10415 (Ref. ***5).*** This report is included as Attachment 12. These evaluations considered a design basis loading of 80/20 sludge, as did the design basis thermal evaluations performed by PacTec. The results from the Fluor Hanford design basis calculations were confirmatory of the PacTec results that the thermal analysis results meet acceptance criteria for K-East Basin and T-Plant and are also acceptable during the 60 hour transport window.

3.4 References

1 SNF-8166, Rev. 2, ***Functional Design Criteria for the K Basins Sludge and Water System – Project A-16,*** Fluor Hanford, Inc., December 2002

2 SNF-8163, Rev. 4, ***Performance Specification for the K East Basin Sludge Transportation System – Project A.16,*** Fluor Hanford, Inc., March 2002

3 PacTec Report ED-073, ***Sludge Transportation System Design Analysis Report,*** PacTec, Tacoma, **WA,** September 2002

4 SNF-9955, Rev. 1, ***Safety-Basis Thermal Analysis for KE Basis Sludge Transport and Storage,*** Fluor Hanford, Inc., October 2002

5 SNF-10415, Rev. 0, ***Design-Basis Thermal and Gas Generation Analysis for KE Basis Sludge in Large Diameter Containers,*** Fluor Hanford, Inc., August 2002

4.0 CONTAINMENT/CONFINEMENT EVALUATION

4.1 Introduction

This section describes the evaluations that were performed to verify that the containment/confinement requirements spelled out in the Functional Design Criteria documents, SNF-8166 (Ref. 1), and the Performance Specification, SNF-8163 (Ref. 2), are met by the STS design.

4.2 Containment/Confinement Description

The STS cask provides a single level of containment for the STS payload. In general, all containment components are fabricated from Type 304 austenitic stainless steel, with exceptions noted in the following description. The containment boundary for the STS cask is identified as the 1.0 inch thick inner shell, the 6.0 inch thick cask bottom, the 5.0 inch thick closure lid, and the cask body upper forging. The non-stainless steel components included in the containment boundary are the metallic inner **O-** ring for the closure lid, the closure bolts, the vent and drain port plugs, and their associated metal O-ring sealing elements.

The drain port, vent **ports,** and closure lid comprise the only penetrations into the containment boundary. Each penetration is designed to demonstrate "leaktight" sealing integrity, **i.e.,** a leak rate not to exceed 1×10^{-7} standard cubic centimeters per second (scc/sec), air, per ANSI N14.5 (Ref. 3). The seals of the containment boundary are comprised of a nominally 0.286 inch diameter, HN200 Helicoflex" O-ring face seal in a groove in the closure lid, and Garlock metallic O-ring sealing elements for the vent and drain port plugs.

Additional details regarding the design of the cask containment system are provided in the PacTec DAR (Ref. 4), which is included **as** Attachment **7.**

4.3 Containment/Confinement Performance Evaluations

4.3.1 Normal Conditions

PacTec performed structural and thermal and gas generation evaluations of the containment/confinement system represented by the STS cask with an LDC containing sludge payloads under normal conditions. The structural evaluations for normal conditions are discussed in Section 2.0 of this report and in more detail in Section 2.4 of the PacTec DAR. The thermal and gas generation calculations are discussed in Section 3.2 of this report and presented in more detail in Section 3.4 of the PacTec DAR.

Fluor Hanford performed extensive thermal and gas generation evaluations of the STS cask and LDC for normal conditions. These are discussed in Section 3.3 of this report and presented in detail in the report SNF-10415 (Ref. 5). This report is included as Attachment 12.

The PacTec structural evaluations and the PacTec and Fluor Hanford thermal and gas generation evaluations demonstrate that the STS cask maintains a leak-tight containment boundary during normal conditions of transport and storage at T-Plant.

4.3.2 Accident Conditions

PacTec performed structural and thermal evaluations **of** the containment/confinement system represented by the STS cask with an LDC containing sludge payloads hypothetical accident conditions. For structural evaluation purposes, each hypothetical accident condition was applied sequentially to determine the maximum cumulative damage in the following order: a 30-foot drop, followed by a 40-inch drop onto a mild steel puncture bar, followed by exposure to a **30** minute, 1,475°F thermal environment. The structural evaluations for hypothetical accident conditions are discussed in Section 2.0 of this report and in more detail in Sections 2.5-2.7 **of** the PacTec DAR. The thermal and gas generation calculations are discussed **in** Section 3.2 of this report and presented in more detail in Sections 6.3 and 7.2-7.3 of Attachment **3.1** of the PacTec DAR.

The PacTec structural evaluations for hypothetical accident conditions demonstrate that the STS cask has adequate design margin to withstand the hypothetical accident conditions without experiencing failure (see Section 2.7.2 of the PacTec DAR).

The PacTec thermal evaluations for hypothetical accident conditions demonstrate that the STS cask with payload also meets the thermal requirements for these conditions. The safety basis case considers the cask and LDC to be on their sides with a minimal amount of water leaked into the annulus between the cask and the LDC. The thermal analyses cover the time period that includes the 30-minute fire, followed by water quenching and a 11.5 hour cool-down period. These same analyses also demonstrate that gas pressures within the cask meet the performance specifications. The results of the thermal and gas generation analyses for hypothetical accident conditions are summarized in Table 7-8 of Attachment 3.1 to the PacTec DAR.

4.4 References

1 SNF-8166, Rev. 2, ***Functional Design Criteria for the K Basins Sludge and Water System – Project A-16,*** Fluor Hanford, Inc., December 2002

2 SNF-8163, Rev. 4, ***Performance Specijication for the K East Basin Sludge Transportation System – Project A.16,*** Fluor Hanford, Inc., March 2002

3 ANSI N14.5, ***American National Standard for Radioactive Materials - Leakage Test on Packages for Shipment,*** American National Standard Institute, Inc. (ANSI)

4 PacTec Report, ED-073, ***Sludge Transportation System Design Analysis Report,*** PacTec, Tacoma, **WA,** September 2002

5 SNF-10415, Rev. 0, ***Design-Basis Thermal and Gas Generation Analysis for KE Basis Sludge in Large Diameter Containers,*** Fluor Hanford, Inc., August 2002

5.0 SHIELDING EVALUATION

5.1 Introduction

This section describes the evaluations that were performed to verify that the radiation shielding requirements spelled out in the Functional Design Criteria documents, SNF-8166 (Ref. 1), and the Performance Specification, SNF-8163 (Ref. 2), are met by the STS design. PacTec performed the shielding evaluations for the complete STS. Avantech performed the shielding evaluations for the LDC with its payload. The latter analyses were performed to assure that requirements for handling and storage of the LDC at T-Plant were met.

5.2 Radiation Source Specification for STS Evaluations

Section 5 of the PacTec DAR (Ref. 3) documents the shielding evaluations performed by PacTec for the cask with a loaded LDC in it. For radiation shielding purposes, PacTec evaluated LDC payloads consisting of the safety basis mixture of 60% by volume floor sludge and 40% by volume canister sludge (60/40 sludge) and the design basis mixture of 80% by volume floor sludge and 20% by volume canister sludge (80/20 sludge). The safety basis payload resulted in higher dose rates because it contained significantly more fuel particles. The radionuclide compositions of both mixtures was obtained from the SNF Project Technical Databook (Ref. 4). The gamma and neutron sources were determined using the ORIGEN-S module of the SCALE code package (Ref. 5).

5.3 STS Shielding Evaluation for Normal Transportation Conditions

For normal conditions, PacTec chose to evaluate a payload consisting of 3.6 m^3 of 80/20 sludge. This quantity was chosen because it represents the maximum amount of sludge that could be loaded into the LDC. Two cases were run, one with the source evenly distributed throughout the entire sludge volume and one with the source evenly distributed throughout the bottom 50% of the sludge volume.. Dose rates were calculated using the MCNP shielding code (Ref. 6). The acceptance criteria for normal conditions were taken from 49 CFR 173. Dose limits of 200 mrem/hr on the cask surfaces and 10 mrem/hr at 2 meters radially were imposed to meet 49 CFR 173 requirements.

The results of the shielding calculations for all four cases considered under nonnal conditions are summarized in Section 5.4.4 of the PacTec DAR. All calculated dose rates were within their respective limits.

5.4 STS Shielding Evaluation for Transportation Accident Conditions

For evaluating STS shielding performance under hypothetical accident conditions, PacTec assumed that the LDC no longer provided either containment or shielding so that it was ignored in the MCNP calculations. Because the cask lid is thinner than the cask bottom, the sludge was assumed to have migrated to the top of the cask with the source compressed into the half of the sludge closest to the top lid. As with the normal conditions analysis, two loadings were analyzed: 3.6 m^3 of 80/20 sludge and 2.0 m^3 of 60/40 sludge. The acceptance criterion used was that the dose rate 1 meter from the surface of the cask not exceed 1000 mrem/hr.

The results of the shielding evaluation for accident conditions are presented in Section 5.5.4 of the PacTec DAR. In both cases analyzed, dose rates were less than the acceptance criterion.

5.5 LDC Shielding Evaluations for Storage

Avantech performed the shielding evaluations for the LDC with its sludge payload. These evaluations are documented in Attachment 1 to Section 5 of the PacTec DAR. For these evaluations, a loading of 3.35 m^3 of 60/40 sludge was assumed. The MicroShield computer code (Ref. 7) was used to was used to calculate gamma dose rates based on a point kernel model. The neutron dose rate was calculated using a one-dimensional model in the SCALE SAS1 computer code (Ref. 8). The acceptance criterion was that the dose rate be less than 500 rad/hr at 1 meter from the surface of the LDC. The results of the evaluations were that the highest contact dose rate was less than 350 rad/hr and the maximum dose rate at 1 meter **was** 121 rad/hr. Therefore, the unshielded LDC was shown to meet applicable performance requirements.

5.6 References

1 SNF-8166, Rev. 2, ***Functional Design Criteria for the K Basins Sludge and Water System – Project A-16,*** Fluor Hanford, Inc., December 2002

2 SNF-8163, Rev. **4,** ***Performance Specification for the K East Basin Sludge Transportation System – Project A.16,*** Fluor Hanford, Inc., March 2002

3 PacTec Report, ED-073, ***Sludge Transportation System Design Analysis Report,*** PacTec, Tacoma, WA, September 2002

4 HNF-SD-SNF-TI-015, Rev. 8, ***Spent Nuclear Fuel Project Technical Databook, Vol. 2, Sludge,*** Fluor Hanford, Inc., 2001

5 SCALE4.3, ***Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation for Workstations and Personal Computers,*** CCC-545, ORNL, March 1997

6 LA-12625, ***MCNP –*** A ***General Monte Carlo N-Particle Transport Code, Version 4B***, Los Alamos National Laboratory.

7 MicroShield Version 5.05, Grove Engineering, Inc., 1992-1998

8 NUREG.CR-0200, Rev. 6 **(ORNL/NUREG/CSD-1/R6),** ***SCALE (CCC-545):*** A ***modular Code System for Performing Standardized Computer Analyses for Licensing Evaluations,*** Volumes I, II and III, September 1998

6.0 CRITICALITY EVALUATION

6.1 Introduction

This section describes the criticality safety evaluations that were performed to demonstrate that a criticality event is incredible for the STS as characterized the Functional Design Criteria document, SNF-8166 (Ref. 1), and the Performance Specification, SNF-8163 (Ref. 2). Fluor Hanford performed the criticality safety evaluations for the STS. These evaluations are documented in HNF-8513 (Ref. 3).

6.2 Criticality Safety Evaluation Model

Fluor Hanford performed the criticality safety evaluations using the MCNP computer code (Ref. 4). Criticality calculations were performed both for a single LDC and cask and for six loaded LDCs stored in a single T-Plant cell. The cask and LDC were modeled based on their nominal dimensions. The fissionable material was modeled as spherical pieces of unirradiated uranium metal in a cubic lattice filled with unirradiated homogeneous UO, sludge in water. The uranium was modeled as enriched to 0.95 wt% U^{235}. The sludge pumped into the LDC was assumed to be canister sludge with an as-settled density of 2.0 g/cm^3. Each LDC was modeled as containing at least 3 m^3 of material consisting of homogeneous sludge and 2,000 kg of 0.95 wt% U^{235} metal (unirradiated). Taken collectively, these modeling assumptions result in a very conservative representation of the LDC loaded with sludge. Table 4-2 of HNF-8513 (Ref. 3) provides a concise summary of these modeling assumptions and conservatisms.

6.3 Criticality Safety Evaluation Results

A number of cases involving a single cask and LDC were run on MCNP. These cases examined various degrees of sludge compaction while holding the mass of uranium metal constant at approximately 2,000 kg. The largest keff calculated for this range of cases was 0.942. The results of all of the cases run on MCNP are shown in Table 4-4 of HNF-8513. These calculations demonstrate that criticality is incredible for a single cask and loaded LDC and therefore that neither a criticality alarm or criticality detection system is required.

6.4 References

1 SNF-8166, Rev. 2, ***Functional Design Criteriafor the K Basins Sludge and WaferSystem – ProjecfA-16,*** Fluor Hanford, Inc., December 2002

2 SNF-8163, Rev. 4, ***Performance Specificationfor fheK East Basin Sludge Transportation System – ProjecfA.16,*** Fluor Hanford, Inc., March 2002

3 HNF-8513, Rev. 1, ***CSER*** 01-002: ***Criticality Safety Evaluation Reporffor Loading, Transport, and Storage of K Basin Sludge Containers,*** Fluor Hanford, Inc., May 2002

4 LA-12625, ***MCNP –*** A ***General Monte Carlo N-Particle Transport Code, Version 4B***, Los Alamos National Laboratory.

7.0 GAS GENERATION EVALUATION

7.1 Introduction

As discussed in Section 3.1, both PacTec and Fluor Hanford performed extensive evaluations of the thermal performance of a loaded LDC sitting in one of the shipping casks. Additionally, Fluor Hanford performed analyses of six LDCs sitting in a cell at T-Plant during the storage mission. These evaluations were performed to demonstrate that the STS as designed met the thermal and gas generation-related performance criteria established in the Functional Design Criteria document, SNF-8166 (Ref. 1), and the Performance Specification, SNF-8163 (Ref. 2). The results of the thermal evaluations were discussed in Sections 3.2 and 3.3. This Section presents the results of the gas generation evaluations that were performed in conjunction with the thermal evaluations.

7.2 PacTec Gas Generation Evaluations

The PacTec gas generation evaluations are presented in Attachment 3.1 to the PacTec DAR (Ref. 3). The gas generation evaluations were performed in conjunction with the thermal evaluations for both the normal conditions of transport and for hypothetical accident conditions.

7.2.1 Gas Generation for Normal Transportation Conditions

PacTec performed gas generation evaluations for a range of payload volumes and compositions. Specifically, PacTec evaluated payloads consisting of both the design basis sludge mixture of 80% floor sludge and 20% canister sludge (80/20 sludge) and the safety basis mixture of 60% floor sludge and 40% canister sludge (60/40 sludge). The sludge quantities considered in the PacTec evaluations ranged from a minimum of 2.0 m^3 of as-settled sludge without gas retention (which expanded to 3.08 m^3 with 35% gas retention) to a maximum of 3.38 m^3 of as-settled sludge without gas retention. The 2.0 m^3 sludge payload was assumed to consist of four "layers" of sludge, each having an initial volume of 0.5 m^3. Each layer was further assumed to consist of an "active" sub-layer occupying the lower 2/3 of the layer and an "inactive" layer forming the upper 1/3 of the layer. The uranium fuel particles were assumed to be spread uniformly throughout the active sub-layer.

The 3.38 m^3 sludge payload was assumed to consist of six "layers" of sludge, each having a volume of 0.55 m^3. These six layers were assumed to be identical in composition to those in the four-layer model. In addition to performing analyses on these layered models, PacTec analyzed a homogeneous payload with no layering within the sludge and no retained gas.

The thermal model developed by PacTec included heat sources from radioactive decay, radiolytic decomposition of water, and chemical reaction between the uranium metal fuel particles and water. The model also treated the heating and cooling effect of the external environment during each diurnal cycle. The gas generation model that was integrated with the thermal model considered hydrogen and oxygen generation from the radiolytic decomposition of water and hydrogen generation from the chemical reaction between the uranium metal fuel particles and water. The model also treated the diffusion of hydrogen gas from the void space above the water in the LDC through the HEPA filter at the top of the LDC into the void space in the cask.

The results of the gas generation evaluations are presented in Section 7.3 of Attachment 3.1 to the PacTec DAR for both normal transport conditions and hypothetical accident conditions. For the safety basis normal transportation case, the cask pressure at the end of the 60-hour transportation window was predicted to be approximately 29 psia, compared to an acceptance criterion of 95 psia. The predicted gas pressures in the cask at the end of the 60-hour window were also significantly less than the acceptance criterion of the ten other cases considered by PacTec for the transportation window.

Hydrogen gas concentrations are predicted to exceed the lower flammability limit of **4%** during the 60 hour window. However, the void space in the cask and LDC will have been inerted prior to the time when the STS leaves the K-Ease Basin, and only a small quantity of oxygen is generated by radiolysis of water during the 60-hour window. The absence **of** oxygen makes it impossible for the hydrogen to bum.

7.2.2 Gas Generation for Hypothetical Accident Conditions

PacTec evaluated three configurations for the hypothetical accident conditions. In all of these cases, the cask and LDC were assumed to be on their sides with a fire burning around them for 30 minutes, followed by a 11.5 hour post-fire cool down period. The results of these analyses were provided to the Fluor Hanford team that developed the transportation safety documentation for the STS that serves as the safety basis for the STS during transportation from K-Basins to T-Plant.

In each case, the hypothetical accident was assumed to occur at the end of the 60-hour transportation window. Thus, gas pressures in the void space were elevated but were within the acceptance limits. The fire that is assumed to bum for 30 minutes when the accident occurs heats the water that is assumed to have leaked into the annulus between the cask and LDC to the point that the water is predicted to boil after about 20 minutes. The steam produced causes the pressure to increase to about 123 psia. Once the quenching begins after the 30-minute fire, boiling is predicted to cease in about 5 more minutes. PacTec performed structural evaluations or the cask with LDC inside using the temperature distributions and pressures predicted for the accident conditions that demonstrated that the cask would maintain its integrity under these hypothetical accident conditions.

7.3 Fluor Hanford Gas Generation Evaluations

Fluor Hanford performed two sets of thermal evaluations. The first set of evaluations is reported in SNF-9955 (Ref. 4). This document is included as Attachment 11. This set of evaluations considered a safety basis payload consisting of a mixture of 60/40 sludge. The sludge quantity considered in Fluor Hanford safety basis evaluations was 2.0 m^3 of as-settled sludge that had expanded to 3.08 m^3 with 35% gas retention. The **2.0** m^3 sludge payload was assumed to consist of four "layers" of sludge, each having an initial volume of 0.5 m^3. Each layer was further assumed to consist of an "active" sub-layer occupying the lower 2/3 of the layer and an "inactive" layer forming the upper 1/3 of the layer. The uranium fuel particles were assumed to be spread uniformly throughout the active sub-layer. This is the same starting point as was used for the baseline safety basis evaluation performed by PacTec.

The Fluor Hanford safety basis gas generation evaluations used as their starting point the time when the STS is ready to leave K-East Basis for its trip to T-Plant. The evaluations followed the STS through 30- and 60-hour transportation windows during maximum insolation conditions for the Hanford site. As with the PacTec analyses, the Fluor Hanford safety basis evaluation predict that peak pressures in the cask and LDC would not exceed the 80 psig (94.7 psia) acceptance criterion during the 30- and 60-hour transportation windows. At the end of the 30- and 60-hour transportation windows, the analyses predict internal cask pressures of 22.55 psia and 31.36 psia, respectively. Starting with a hydrogen-free environment in the cask following inerting at K-East Basin, the hydrogen concentrations in the cask are predicted to increase to 21.0% at the end of 30 hours and to 41.4% after 60 hours. These hydrogen concentrations necessitate putting the cask through a re-inerting process once it has arrived at T-Plant.

The Fluor Hanford safety basis gas evaluations also examined the gas generation response of a safety basis LDC to storage conditions in a T-Plant cell. The thermal model included one LDC with a safety basis loading of sludge and five LDCs with loadings of 75% floor sludge and 25% canister sludge (75/25 sludge)sludge sitting in a single cell in T-Plant. These evaluations predict that even under a **loss** of forced ventilation condition lasting for 30 days at T-Plant, the maximum hydrogen concentration in the T-Plant cell would be 2.11%..

The results of the Fluor Hanford safety basis gas generation evaluation were used to establish sludge loading process requirements for the LDC at K-East Basis and to establish the safety basis for the sludge-filled LDCs at T-Plant.

The second set of Fluor Hanford thermal evaluations are reported in SNF-10415 (Ref. 5). This report is included as Attachment 12. These evaluations considered a design basis loading of sludge, as did the design basis gas generation evaluations performed by PacTec. The results from the Fluor Hanford design basis calculations were confirmatory of the PacTec results that the gas generation results meet acceptance criteria for K-East Basin and T-Plant and are also acceptable during the 60 hour transport window.

14 References

1 SNF-8166, Rev. 2, ***Functional Design Criteria for the K Basins Sludge and Water System – Project A-16,*** Fluor Hanford, Inc., December 2002

2 SNF-8163, Rev. 4, ***Performance Specifcation for the K East Basin Sludge Transportation System – Project A.16,*** Fluor Hanford, Inc., March 2002

3 PacTec Report, ED-073, ***Sludge Transportation System Design Analysis Report,*** PacTec, Tacoma, WA, September 2002

4 SNF-9955, Rev. 1, ***Safety-Basis Thermal Analysis for** KE **Basis Sludge Transport and Storage,*** Fluor Hanford, Inc., October 2002

5 **SNF-10415,** Rev. *0*, ***Design-Basis Thermal and Gas Generation Analysis for KE Basis Sludge in Large Diameter Containers,*** Fluor **Hanford,** Inc., **August** 2002

8.0 TIEDOWN DEVICES AND SPECIAL TOOLS EVALUATION

8.1 Introduction

Because the STS will be moved across the quasi-public roads while being moved from K-East Basin to T-Plant, its design and fabrication have been subjected to the requirements of 10 CFR 71 (Ref. 1). Specific requirements are imposed upon the cask tiedown system that secures the cask to the trailer 10 CFR 71.45(b). For this reason, the PacTec DAR (Ref. 2) addressed the cask tiedown system as a separate topic. The cask tiedown system is discussed in Section **8.0** of the PacTec DAR.

8.2 Cask Tiedown System

The cask tiedown system is simple in concept. Horizontal loading from the **cask** is resisted by bearing against tiedown clamps mounted on the trailer. Vertical loading is resisted by trailer tiedown bars that engage grooves in the cask bottom forging. For design purposes, the loading conditions that serve as the design basis are taken from 10 CFR 71.45(b). The cask tiedown system must be capable of withstanding a load 10 times the weight of the cask in the horizontal direction or travel, a load five times the cask weight in the transverse horizontal direction, and a load two times the cask weight in the vertical direction. The horizontal loads are combined by taking their vector sum. The stress on the cask that would be generated from loading against the trailer tiedown clamps is calculated by using the bearing area over one-half of the circumference.

Stress calculations presented in Section 8.0 of the PacTec DAR demonstrate that the tiedown system as designed has substantial design margins for all of the required loading cases.

8.3 References

1 10 CFR 71, ***Packaging and Transportation of Radioactive Material,*** Code of Federal Regulations, as amended

2 PacTec Report, ED-073, ***Sludge Transportation System Design Analysis Report,*** PacTec, Tacoma, WA, September 2002

9.0 OPERATING PROCEDURES

9.1 Introduction

PacTec provided a limited set of outlines for operating procedures for the STS in Section 10.0 of the PacTec DAR (Ref. 1). These procedures are described in more detail in PacTec document OM-07 (Ref. 2). In addition, AVANTech provided an Operations and Maintenance (O&M) Manual for the LDC in AVANTech Calculation ER-3C-0126-01 (Ref. 3). The procedure information provided by PacTec and AVANTech is being incorporated into the operations and maintenance procedures under development by the SNF Project.

9.2 Summary of Operating Procedures

The STS cask is to be loaded on the transport trailer before the cask and trailer arrive on the Hanford site. The PacTec DAR provides outlines for procedures for the following activities:

- Load empty LDC into empty cask
- Prepare the cask for start of loading of the LDC
- Remove the loaded LDC from the cask at T-Plant

The AVANTech calculation serves as a vehicle for transmitting the Instruction Manual from Milltronics (Ref. 4) for the level detector that is installed on the LDC. The level detector is the only device on the LDC that requires maintenance and calibration.

9.3 References

1 PacTec Report, ED-073, ***Sludge Transportation Sysfem Design Analysis Report,*** PacTec, Tacoma, **WA,** September ***2002***

2 PacTec Report, OM-07, Rev. **1,** ***Sludge Transportation System Installation, Repair and Maintenance (IORM),*** PacTec, Tacoma, **WA,** September 2002

3 Calculation ID No. ER-3C-0126-01, Rev. 0, ***K-East Sludge Transport System – A-1 70 (Large Container): O&M Manual (90% Final Design),*** AVANTech, Inc.

4 PL-566, ***Instruction Manual for Inferranger DPS 300,*** Siemens Milltronics Process Instruments, Inc., Peterborough, Ontario, Canada, 2001

10.0 ACCEPTANCE TEST AND MAINTENANCE PROGRAM

10.1 Introduction

PacTec developed inspection, testing and maintenance requirements for the cask and its various components. These are documented in Section 11.0 of the PacTec DAR (Ref. 1). These requirements will be incorporated into SNF Project procedures as appropriate.

10.2 Initial Testing Requirements

Several types of tests are required as a part of the acceptance process for the STS cask. These are listed below:

- Lifting Device Load Testing – There are four threaded holes in the cask lid into which bolts are inserted to attach both the cask and the cask lid lifting devices. These lifting points are to be subjected to an initial load test per **ANSI N14.6** (Ref. 2). Additional visual inspections, examination with a thread go/no-go gauge, and liquid penetrant testing are also to be conducted.
- Pressure Testing – The cask containment boundary is to be pressure tested to 150% of the maximum normal operating pressure per 10 CFR 71.85(b) (Ref. **3),** which results in testing to 120 psig. Following the pressure test, accessible welds are to be visually inspected and subjected to dye penetrant testing.
- Leak Testing – Five leak tests are to be conducted on the cask at the completion of fabrication. These include 1) a test to determine the response time for the helium mass spectrometer leak detector; 2) a test to determine the actual leak rate of the metallic containment boundary; **3)** three leak tests to verify containment integrity for *the* vent port bolt, the drain port bolt, and the closure lid.
- Shielding Integrity Testing – Gamma scans are to be conducted to verify the integrity of the lead that **is** cast into the walls **of** the cask.

All of these tests will be performed by PacTec before the STS is delivered to the Hanford site.

10.3 Duty Cycle-Related Inspection, Testing and Maintenance Requirements

Several tests and inspections are required each duty cycle experienced by the **STS.** These are noted below.

- Leak Testing – Three leak tests are to be performed each time the cask lid is placed on the cask following loading of the LDC contained in it. Leak testing is to be performed on *the* vent port bolt, the drain port bolt and the closure lid.
- Containment 0-Ring Seal Replacement – All containment O-ring seals are to be replaced after each use (or when damaged).
- Routine Inspections – Inspections are to be performed during each loading and unloading operation for the following items: 1) condition **of** bolts and seals, 2) indications of

corrosion, and 3) evidence of dents, cracks or other deformations. In addition, surfaces are to be inspected for any sign of containment failure, and the ease of use of removable components is to be observed for signs of wear.

10.4 References

1 PacTec Report, ED-073, ***Sludge Transportation System Design Analysis Reporf,*** PacTec, Tacoma, **WA,** September **2002**

2 **ANSI N14.6,** ***American National Standardfor RadioacfiveMaterials – Special Lifting Devicesfor Shipping Containers Weighing 10,000 Pounds (4,500kg) or More,*** American National Standards Institute

3 Title 10, Code of Federal Regulations, **Part** 71 (10 CFR **71),** ***Packaging and Transportation of Radioactive Materials,*** **1994**

11.0 ANCILLARY DOCUMENTS

The last six documents listed in Section 1.4 were not prepared as part of the design effort required to support the fabrication of the various components of the STS. Rather, their preparation was driven by other requirements and purposes. Each of the documents is described briefly below.

11.1 Design Verification and Validation Plan

Fluor Hanford prepared a plan for performing verification and validation of the **SWS** design completed by PacTec. Preparation and implementation of the verification and validation activity is required by HNF-RD-1819 (Ref 1). This plan is documented in SNF-6470 (Ref. 2). This document is included as Attachment 13.

11.2 Design Verification and Validation Report

Fluor Hanford will perform a verification and validation of the PacTec design for the **SWS.** The results of this effort along with the STS FDC compliance matrix will be documented following completion of the Acceptance Test Program. The verification and validation effort is intended to demonstrate that the design produced by the several vendors who supported the **SWS** Project complies with the requirements and specifications imposed on it.

11.3 SWS Human Factors Report

During the course of the design effort for the **SWS,** analyses were performed and design reviews were conducted for that focuses on various **Human** Factors aspects of the design and operation of the system. The results of these efforts are documented in SNF-13143 (Ref. 3). This document is included as Attachment 15.

11.4 SWS ALARA Report

During the conceptual design phase of the **SWS,** ALARA reviews were held frequently to discuss the radiation protection aspects of the evolving design. The results of these efforts are documented in SNF-8509 (Ref. 4). The ALARA Report identifies a number of design features that should be given attention during the design effort for **SWS** to assure that ALARA goals are achieved. It also identifies aspects of the full cycle of operations activities required to fill and ship an LDC to which attention will need to be given to assure fulfillment of ALARA goals. This document is included as Attachment 16.

11.5 SWS Hazards Analysis

Fluor Hanford performed a hazards analysis of the entire **SWS** as an initial step in developing the safety basis **for** the **SWS** project. This hazards analysis is documented in SNF-I0020 (Ref. *5).* This document is included as Attachment 17.

11.6 K Basins Hazards Analysis

Given the results of the hazards analysis, Fluor Hanford performed a hazards analysis of the entire K Basins operation as the next step in developing the safety basis for the SWS project. This Hazards analysis is documented in HNF-3960 (Ref. 6). This document is included as Attachment **17.**

11.7 References

1 HNF-RD-1819, Rev. 0, ***PHMC Engineering Requirements,*** Fluor Hanford, Inc., August 2002

2 SNF-6470, Rev. 0, ***Design Verification Planfor the K Basins Sludge and Water System, ProjectA.16,*** Fluor Hanford, Inc., June **2001**

3 SNF-13143, Rev. 0, ***Human Factors Reportfor the Sludge WaferSystem,*** Fluor Hanford, Inc., October 2002

4 SNF-8509, Rev. 0, ***ALARA Report – Sludge Water System SNF Project A-16,*** Fluor Hanford, Inc., July 2001

5 SNF-10020, Rev. 1, ***Hazards Evaluationfor KE Sludge and WaferSystem – ProjectA.16,*** Fluor Hanford, Inc., October 2002

6 HNF-3960, Rev. 5, K ***Basins Hazards Analysis,*** Fluor Hanford, Inc., October 2002

12.0 SUPPORTING REFERENCE DOCUMENTS

During the course of developing the functional design criteria and performance specifications for the **STS,** Fluor Hanford consulted a large number of requirements documents, including the Code of Federal Regulations, DOE Orders, the State of Washington's Administrative Code and various consensus national codes and standards. A partial listing of these documents is provided below.

12.1 Code of Federal Regulations

1. 10 CFR 71, *Packaging and Transportation of Radioactive Material.*
2. 10 CFR 820, *General Statement of Enforcement Policy*
3. 10 CFR 830, *Nuclear Safety Management*
4. 10 CFR 830.120, *Quality Assurance*
5. 10 CFR 835, *Occupational Radiation Protection*
6. 29 CFR 1910, *Occupational Safety and Health Standards*
7. 29 CFR 1926, *Safety and Health Regulations for Construction*
8. 40 CFR Part 60, Appendix A, Methods 1, 1A, 2, 2A, 2C, 2D, 4, 5, and 17.
9. 40 CFR 61, *National Emission Standards for Hazardous Air Pollutants*
10. 40 CFR 761, *Toxic Substances Control Act*
11. 49 CFR 173, *Shippers--General Requirements for Shipments and Packaging*

12.2 Department of Energy

1. DOE 1994, *Spent Nuclear Fuel Program Requirements Document*, SNF-RD-PM-001, Rev. 1
2. DOE Order 460.1A, *Packaging and Transportation Safety*
3. DOE Order 474.1, *Control and Accountability of Nuclear Materials*
4. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*
5. DOE Order 5480.24, *Nuclear Criticality Safety*
6. DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*
7. DOE Order 5480.7A, *Fire Protection*
8. DOE Order 5820.2A, *Radioactive Waste Management*
9. DOE Order 6430.1A, *General Design Criteria*

12.3 Washington Administrative Code

1. WAC 173-303, *Dangerous Waste Regulations,* Department of Ecology, Olympia, Washington.

2. WAC 296-104, *Board of Boiler Rules, Substantive,* Washington Administrative Code, State of Washington.
3. WAC 246-247, *Radiation Protection-Air Emissions,* Washington Administrative Code, State of Washington.

12.4 National Consensus Codes and Standards

12.4.1 American National Standards Institute, New York, New York

1. ANSI A13.1, *Scheme for the Identification of Piping Systems*
2. ANSI C50.2, *Alternating-Current Induction Motors, Induction Machines in General, and Universal Motors*
3. ANSI/ANS 57.7, *Design Criteria for an Independent Spent Fuel Storage Installation (Water Pool Type)*
4. ANSI C2, *National Electric Safety Code*
5. ANSI N13.1. *Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities*

12.4.2 American Society of Civil Engineers, New York, New York

1. ASCE 7-93, *Minimum Design Loads for Buildings and Other Structures,* Revision of ASCE 7-88

12.4.3 American Society of Mechanical Engineers, New York, New York

1. ASME B31.1, *Power Piping*
2. ASME Section VIII, *Rules for Construction of Pressure Vessels, Boiler and Pressure Vessel Code*
3. ASME Section IX, *Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators, ASME Boiler and Pressure Vessel Code*
4. ASME N509, *Nuclear Power Plant Air-Cleaning Units and Components*
5. ASME N510, *Testing of Nuclear Air-Treatment Systems*
6. ASME NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications*
7. ASME Y14.5, *Dimensioning and Tolerancing*
8. ASME Y14.5.1, *Mathematical Definition of Dimensioning and Tolerancing Principles*
9. ASME AG-1, *Code on Nuclear Air and Gas Treatment,* American Society of Mechanical Engineers, New York, New York.

12.4.4 American Welding Society, Miami, Florida

1. AWS D1.1, *Structural Welding Code-Steel*
2. AWS D1.2, *Structural Welding Code-Aluminum*

3. AWS D1.4, *Structural Welding Code – Reinforcing Steel.*
4. AWS D14.1, *Specification for Welding of Industrial and Mill Cranes and Other Material Handling Equipment*
5. AWS D9.1, *Structural Welding Code – Sheet Metal*
6. AWS QC-1, *Guide to AWS Welding Inspector Qualifications and Certification*

12.4.5 Institute of Electrical and Electronics Engineers, New York, New York

1. IEEE 829, *IEEE Standard for Software Test Documentation*
2. IEEE 1008, *IEEE Standard for Software Unit Testing*
3. IEEE 1012, *IEEE Standard for Software Verification and Validation Plans*
4. IEEE 1016, *IEEE Recommendation Practice for Software Design Descriptions*
5. IEEE **336,** *Standard Installation, Inspection, and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear Facilities*

12.4.6 Illuminating Engineering Society of North America, New York, New York

1. IES, *Lighting Handbook Reference and Application,* Eighth Edition

12.4.7 International Conference of Building Officials, Whittier, California

1. UBC-97, I997 *Uniform Building Code*

12.4.8 International Society for Measurement and Control, Research Triangle Park, North Carolina

1. ISA S5.1, *Instrument Symbols and Identification*
2. ISA S5.1, *Binary Logic Diagrams for Process Operations,*
3. ISA S5.4, *Instrument Loop Diagrams*
4. ISA S18.1, *Annunciator Sequences and Specifications*
5. ISA S50.1, *Compatibility of Analog Signals for Electronic Industrial Process Instruments*
6. ISA S82.01, *Safety Standard for Electrical and Electronic Test, Measuring, Controlling and Related Equipment – General Requirements*
7. ISA S82.02, *Safety Standard for Electrical and Electronic Test, Measuring, Controlling and Related Equipment – Electrical and Electronic Test and Measuring Equipment*
8. ISA S82.03, *Safety Standard for Electrical and Electronic Test, Measuring, Controlling and Related Equipment – Electrical and Electronic Process Measurement and Control Equipment*

12.4.9 National Electrical Manufacturers Association, Washington, D. C.

1. NEMA AB1, *Molded Case Circuit Breakers and Molded Case Switches*

2. NEMA C84.1, *Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)*
3. NEMA ICS 6, *Industrial Control and Systems: Enclosures*
4. NEMA SG 3, *Low Voltage Power Circuit Breakers*
5. NEMA SG 5, *Power Switch Gear Assemblies*
6. NEMA *SG* 6, *Power Switching Equipment*
7. NEMA TR 1, *Transformers, Regulators, and Reactors*
8. NEMA MG-1, *Motors and Generators*
9. NEMA WC 5/ICEA S 61 402, *Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy*
10. NEMA WC 7/ICEA S 66 524, *Cross Linked Thermosetting Polyethylene Insulated Wire and Cable for Transmission and Distribution of Electrical Energy*
11. NEMA WC 3/ICEA S 19, *Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy*

12.4.10 National Fire Protection Association, Quincy, Massachusetts

1. NFPA 701, *Standard Methods of Fire Test for Flame-Resistant Textiles and Films*
2. NFPA 69, *Standard on Explosion Prevention*
3. NFPA *70*, *National Electric Code*
4. NFPA 101, *Life Safety Code*

12.4.11 Electrical Council of Underwriters Laboratories, Northbrook, Illinois

1. UL 508, *Standard for Safety Industrial Control Equipment*

12.4.12 U.S. Naval Publication and Forms Center, Philadelphia, Penn

1. Mil-C-I7, *Coaxial Cable, Military Specifications*

12.5 Hanford Specific Documents

1. AP CM-6-037, *Process Automation Software and Equipment Configuration Management,* Spent Nuclear Fuel Project, Fluor Hanford, Inc., Richland, Washington.
2. AP CM-6-040, *Verification and Validation of SNF Project Software,* Spent Nuclear Fuel Project, Fluor Hanford, Inc., Richland, Washington.
3. AP EN-6-005, *Engineering Component Identifier and Labeling Control,* Spent Nuclear Fuel Project, Fluor Hanford, Inc., Richland, Washington.
4. AP EN-6-021, *Interface Control Process,* Spent Nuclear Fuel Project, Fluor Hanford, Inc., Richland, Washington.
5. AP MS-1-039, *ISMS Description Configuration Control,* Spent Nuclear Fuel Project, Fluor Hanford, Inc., Richland, Washington.

6. AP OP-7-003, *Project Review Process,* Spent Nuclear Fuel Project, Fluor Hanford, Inc., Richland, Washington.
7. AP RP-12-009, *Radiological Review Process,* Spent Nuclear Fuel Project, Fluor Hanford, Inc., Richland, Washington.
8. HNF-PRO-097, *Engineering Design and Evaluation,* Fluor Hanford, Inc., Richland, Washington.
9. HNF-PRO-I00, *TransportationSafety*, Fluor Hanford, Inc., Richland, Washington.
10. HNF-PRO-102, *Safity Color Coding,* Fluor Hanford, Inc., Richland, Washington.
11. HNF-PRO-154, *Responsibilities and Proceduresfor all Hazardous Material,* Fluor Hanford, Inc., Richland, Washington
12. HNF-PRO-I57, *Radioactive Material/Waste Shipments,* Fluor Hanford, Inc., Richland, Washington
13. HNF-PRO-334, *Criticality Safety: General Requirements,* Fluor Hanford, Inc., Richland, Washington.
14. HNF-PRO-350, *Fire Hazard Analysis Requirements,* Fluor Hanford, Inc., Richland, Washington.
15. HNF-PRO-351, *Fire Protection System Testing/Inspection and Maintenance,* Fluor Hanford, Inc., Richland, Washington.
16. HNF-PRO-450, *Air Quality – Radioactive Emissions,* Fluor Hanford, Inc., Richland, Washington.
17. HNF-PRO-517, *Safety Analysis Program Glossary,* Fluor Hanford, Inc., Richland, Washington.
18. HNF-PRO-539, *Criticality Safity Evaluations,* Fluor Hanford, Inc., Richland, Washington.
19. HNF-PRO-704, *Hazard and Accident Analysis Process,* Fluor Hanford, Inc., Richland, Washington.
20. HNF-PRO-709, *Preparation and Control Standardsfor Engineering Drawings,* Fluor Hanford, Inc., Richland, Washington.
21. HNF-PRO-I621, ***ALARA** Decision-Making Methods,* Fluor Hanford, Inc., Richland, Washington.
22. HNF-PRO-1633, *ALARA Program Records,* Fluor Hanford, Inc., Richland, Washington.
23. HNF-PRO-1819, *PHMC Engineering Requirements,* Fluor Hanford, Inc., Richland, Washington.
24. HNF-PRO-2778, *IRM Application Software System Life Cycle Standards,* Fluor Hanford, Inc., Richland, Washington.
25. HNF-PRO-3152, *Polychlorinated Biphenyl Management,* Fluor Hanford, Inc., Richland, Washington.

26. HNF-PRO-3154, ***Regulated Substance Storage Tanks***, Fluor Hanford, Inc., Richland, Washington.

27. HNF-RD-7085, ***Safety Responsibilities,*** October ***26, 2000,*** Fluor Hanford, Inc., Richland, Washington.

28. WHC-SD-SNF-DRP-002, ***Field Verified Measurements of 30 Ton Bridge Crane Travel in I05 KE and I05 KW Transfer Bay Area,*** Westinghouse Hanford Company, Richland, Washington.

29. WHC-SD-WM-SAR-002, ***Safety Analysis Irradiated N Reactor Fuel,*** Westinghouse Hanford Company, Richland, Washington.

ATTACHMENT 1

SNF-8166, Rev. 2

Functional Design Criteria for the K Basins Sludge and Water System, Rev. 2 – Project A-16

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ATTACHMENT 2

SNF-8163, Rev. 5
Performance Specijication for the K East Basin Sludge Transportation System – Project A.16

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ATTACHMENT 3

Statement of Work, Revision 4, For The Sludge Transportation System Project A-16,
Contract 12329, Attachment 8

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ATTACHMENT 4

Fluor Hanford Letter FH-0200181, R.P. Heck, FH to S.J. Veitenheimer, DOE-RL, *Contract Number DE-AC06-96RL13200 – Transmittal of the Sludge Transportation System Thirty Percent Design Review Package*, January 10,2002

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January 10, 2002 FH-0200181

Mr. S. J. Veitenheimer. Director
Office of Spent Nuclear Fuels
U.S. Department of Energy
Richland Operations Office
Post Office Box 550
Richland. Washington 99352

Dear Mr. Veitenheimer:

CONTRACT NUMBER DE-AC06-96RL13200 – TRANSMITTAL OF THE SLUDGE TRANSPORTATION SYSTEM THIRTY PERCENT DESIGN REVIEW PACKAGE

Attached for your information is the Sludge Transportation System 30% Design Review Package. The attachinent includes Review Meetiiig Minutes, comments for internal and vendor resolution and the submittals from the vendor. Additionally. a submittal log is included that shows what submittals were provided within the 30% design review package.

If you have any questions, please contact Mr. J. E. Crocker on 372-0021.

Very truly yours.

R. P. Heck, Vice President and Project Director
Spent Nuclear Fuel Project

lar

Attachment

cc:	RL -	P. A. Corbin	A4-79
		S. L. Helmann	A4-79
		S. A. Sieracki	A7-80 w/o attachment
		S. J. Veitenheimer	A4-79

ATTACHMENT 5

SNF-10914, Rev. 0
K Basins Sludge Transportation System STS 60% Design Review

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ATTACHMENT 6

SNF-12345, Rev. 0
K Basin Sludge Transportation System 90% Design Report

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ATTACHMENT 7

ED-073
Sludge Transportation System Design Analysis Report

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ATTACHMENT 8

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Final Design Report

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Sludge Transportation System Design Analysis Report
Insert-Remove Instructions for Revision 1

Remove pages	Insert pages
Section 2	
37	37
42 thru 47	42 thy 47
50 to **59** (not including calculation 12099-08)	50 to 60
Section 2.9.8.3 Cover Sheet **and** Contents (Structural Analysis of (A-170) Large Container. EN-3C-0126-04, Revision 1, Aventech Incorporated. **33** pages)	Section 2.9.8.3 Cover Sheet [Structural Analysis **of** (A-170) Large Container, EN-3C-0126-04, Revision **3,** Aventech Incorporated. 37 pages)

Table 2.2-2 - ASME SA564, Type 630 (H1100) Bolt Material Properties

Material Specification	Temp, °F	Yield Strength① (S_y), ksi	Ultimate Strength② (S_u), ksi	Design Stress Intensity③ (S_m), ksi	Elastic Modulus④, ×10^6 psi	Coefficient of Thermal Expansion⑤, ×10^-6 in/in/°F
SA564. Type 630 (H1100)	-40	115.0	140.0	38.3	**29.1**	**5.9**
	-20	115.0	140.0	38.3	**29.0**	**5.9**
	70	115.0	140.0	38.3	28.5	5.9
	100	115.0	140.0	38.3	**28.3**	5.9
	200	106.3	140.0	35.4	27.8	5.9
	300	101.8	140.0	33.9	27.2	5.9
	400	98.3	136.1	32.7	26.6	5.9
	500	95.2	133.4	31.7	26.1	5.9
	600	92.7	131.4	30.9	25.5	5.9
	700	90.3	128.4	30.1	24.9	5.9
	800	86.9	122.5	29.0	24.2	**6.0**

Notes:

① ASME B&PV Code, Section II. Part D, Table Y-1.

② ASME B&PV Code. Section II, Part D, Table U.

③ ASME B&PV Code, Section II, Pan D, Table 4, except for values at 700°F and 800°F, which were calculate by taking one-third of yield at temperature.

④ ASME B&PV Code, Section II, Part D, Table TM-1, S17400.

⑤ ASME B&PV Code, Section II, Part D. Table TE-1. Coefficients for Precipitation Hardened 17Cr-4Ni-4Cu Stainless Steels, Coefficient B (mean from 70°F).

⑥ When necessary. values are linearly interpolated or extrapolated and **given** in bold text.

occur. For this reason. the variable Dlo. closure lid diameter at the outer edge, is identical with Dlb, the closure lid diameter at the bolt circle.

In cases where a moment in the lid is considered (Mf), the formulae developed in Section 2.9.2 are used to determine the bolt bending moment.

2.9.1.3.1 Preload

The closure bolts are prrloaded to 600 ± 100 to a maximum of 800 ft-lb torque.. resulting in a minimum The evaluation include an evaluation of a minimum and maximum preload torque of 500 ft-lb and 700 ft-lb, respectively.

From Subsection 4.2 of NUREG/CR-6007, the maximum non-prying tensile force per bolt, Fa_{max}, is found from

$$Fa_{max} = \frac{Q_{max}}{(K)(Db)}$$

where Q_{max} is the maximum applied closure bolt torque, K is the nut factor (0.186). and Db **is** the closure bolt nominal diameter. The minimum preload force is computed in the same way except for the use of Q_{min} in the place of Q_{max}.

The maximum residual torsional bolt moment is conservatively assumed to be 50% of the maximum applied torque (Reference 12, Page ***662):***

$$Mtr = 0.5(Q_{max})$$

Preload forces on the bolts under each loading condition are given in Table 2.9-6.

2.9.1.3.2 Gasket Loads

From Subsection 4.3 of NUREG/CR-6007, some gasket types can produce loads in the closure bolts. The STS cask seals are relatively small and soft and do not apply a load to the closure bolts.

2.9.1.3.3 Pressure Loads

From Subsection **4.4** of NUREG/CR-6007, utilizing appropriate temperature dependent material properties from Section 2.2.2, the maximum non-prying tensile force per bolt. Fa, shear force, Fs, and moment. Mf. due to pressure loads are based on the following formulae:

$$Fa = \frac{\pi(Dlg)^2(Pli - Plo)}{4Nb}$$

$$Fs = \frac{\pi(El)(tl)(Pci - Pco)(Dlb)^2}{2(Nb)(Ec)(tc)(1 - Nul)}$$

$$Mf = \frac{(Pli - Plo)Dlb^2}{32}$$

where Dlg is the closure lid diameter at ***the*** location of gasket load reaction (i.e., the O-ring seal diameter). Pli is the pressure inside the closure lid, Plo **is** the pressure outside the closure lid, Pci is the pressure inside the cask wall. Pco is the pressure outside the cask wall, Ec is the elastic modulus

Table 2.9-5 - Geometric Parameters Used in Bolt Evaluations

Property	Description	Dimension
Db	Closure bolt nominal diameter. inches	1.50
Dba	Closure bolt diameter for tensile stress calculation. inches	1.34
Dbs	Closure bolt diameter for shear stress calculation. inches	1.34
Dbb	Closure bolt diameter for bending stress calculation, inches	1.34
Dbt	Closure bolt diameter for torsional stress calculation, inches	1.34
Lb	Bolt length between the top and bottom surfaces of the closure lid at the bolt circle. inches	0.94
Nb	Number of closure bolts	24
K	Nut factor	0.186①
Q_{max}	Maximum applied preload torque, ti-lb	800
Q_{min}	Minimum applied preload torque, ti-lb	500
Dlb	Closure lid diameter at the bolt circle, inches	67.00
Dli	Closure lid diameter at the inner edge, inches	62.38
Dlo	Closure lid diameter at the outer edge, inches	67.00
Dlg	Seal diameter, inches	63.10
tc	Cask wall thickness, inches	5.63
tl	Cask Lid thickness, inches	5.00
tlf	Lid flange thickness. inches	2.50
Wl	Weight of closure lid, lb	5.000
Wc	Weight of cask contents, lb	18.500

Notes:

① **For cadmium plated bolts [Reference 7, Table 4.1]**

Table 2.9-6 - Closure Bolt Forces

Load Combination	Pre-Load		Pressure			Temperature			Impact			
	(lbs.)	(lb-in)	(lbs.)	Fs (lbs.)	Mf (lb-in/in)	(lb-in)	(lbs.)	(lbs.)	Fa (lbs.)	Fs (lbs.)	Mf (lb-in/in)	Mbb (lb-in)
1. NCT Cold Operating (-40) {L}. {T}	21.505	3.000	0	0	0	0	-12.633	0	0	0	0	0
NCT Cold Operating (-2' {L}. {P}. {T}	21,505	3.000	11.883	33.546	12.794	4.931	-11.327	0	0	0	0	0
① NCT Cold Impact (End) {L}. {P}. {T}. {I}	34.409	4.800	10.424	29.426	11.223	4.325	-11.327	0	17.057	0	16.288	6.278
① NCT Hot Impact (End) {L}, {P}. IT). {I}	34.409	4.800	10.424	29.436	11.223	4.318	11.309	0	17.057	0	16.288	6.266
① NCT Hot Operating {L}. {P}. {T}	34.409	4,800	11.883	33.546	12.794	4.922	11.309	0			0	0
① HAC H a (Fire) Pressure {L}. {P}. {T}	34.409	4,800	14.372	40.572	15.473	5.931	127.995	0			0	0
① HAC Cold Impact (End) {L}, {P}. {T}. {I}	34.409	4.800	10.424	29.426	11.223	4.325	-1 1.327	0			95.976	36.991
3. HAC Hot Impact (End) {L}. {P}. {T}. {I}	34.409	4.800	10.424	29.426	11.223	5.318	11.309	0	100.506		95,976	36.924
4. HAC Cold Impact (Oblique) {L}. {P}. {T}. {I}	34.409	4.800	10.424	29.426	11.223	4,325	-1 1,327	0	31.921	3.549	30.483	11.749
5. HAC Hot Impact (Oblique) {L}. {P}. {T}. {I}	34.409	4.800	10.424	29.426	11.223	1.318	11.309	0	31.921	3.549	30.483	11,727
6. HAC Cold Impact (Side) {L}. {P}. {T}. {I}	34.409	4.800	10.424	29.426	11.223	1.325	-11.327	0	0	15.083	0	0
7. HAC Hot Impact(Side) {L}. {P}. {T}. {I}	34.409	4.900	10.424	29.426	1 1.223	1.318	11.309	0	0	15.083	0	0

Notes:

① Results of calculations are based on loads, geometric properties, and mechanical properties per NUREG/CR-6007.

{L) = Pre-load

{T} =Thermal load

{P} = Pressure load

{I} = Impact Load

Table 2.9-7 - Normal and Hypothetical Accident Conditions Load Combinations

Load Combination	Identification per Table 4.9 of NUREG/CR-6007					
	Fa_pt① (lbs.)	Fa_al② (lbs.)	Fa_c③ (lbs.)	Fs_c④ (lbs.)	Mbb⑤ (lb-in)	Mtr⑥ (lb-in)
1. NCT Cold Operating (-40) {L}, {T}	8,872	0	8,872	0	0	3,000
2. NCT Cold Operating (-27) {L}, {P}, {T}	10,178	11,883	11,883	33,546	4,931	3,000
1. NCT Cold Impact (End) {L}, {P}, {T}, {I}	23,081	27,481	27,481	29,426	10,603	4,800
2. NCT Hot Impact (End) {L}, {P}, {T}, {I}	45,718	27,481	45,718	29,426	10,584	4,800
3. NCT Hot Operating {L}, {P}, {T}	45,718	11,883	45,718	33,546	4,922	4,800
4. HAC Hot (Fire) Pressure {L}, {P}, {T}	34,409	14,372	34,409	40,572	5,931	4,800
3. HAC Cold Impact (End) {L}, {P}, {T}, {I}	34,409	110,929	110,929	29,426	41,316	4,800
4. HAC Hot Impact (End) {L}, {P}, {T}, {I}	34,409	110,929	110,929	29,426	41,242	4,800
5. HAC Cold Impact (Oblique) {L}, {P}, {T}, {I}	34,409	42,345	42,345	32,975	16,074	4,800
6. HAC Hot Impact (Oblique) {L}, {P}, {T}, {I}	34,409	42,345	42,345	32,975	16,045	4,800
7. HAC Cold Impact (Side) {L}, {P}, {T}, {I}	34,409	10,424	34,409	44,510	4,325	4,800
8. HAC Hot Impact (Side) {L}, {P}, {T}, {I}	34,409	10,424	34,409	44,510	4,318	4,800

Notes:

① Fa_pt is the summation of Fa{L} + Fa{T} for NCT and Fa{L} for HAC, fmrnTable1.9-6.

② Fa_al is the summation of Fa{P} + Fa{I} or Fa{P}, from Table 2.9-6, whichever is the application load combination.

③ Fa-c is the greater of Fa_pt or Fa–al.

④ Fs_c is the summation of Fs{P} + Fs{I}, from Table 2.9-6.

⑤ Mbb is the summation of Mbb{P} + Mbb{I}, from Table 2.9-6.

⑥ Mtr. the closure bolt residual torsional moment (is not used For HAC evaluations).

Table 2.9-8 - Closure Bolt Stress Ana sis Results

Load Combination	Tensile Stress Sba (psi)	Shear Stress Sbs (psi)	Bending Stress Sbb (psi)①	Torsion Stress Sbt (psi) ①
1. NCT Cold Operating (-40) {L}, {T}, {V}	6.313	0	0	6,384
2. NCT Cold Operating (-27) {L}, {P}, {T}, {V}	8.456	23.371	20,986	6,384
1.0 NCT Cold Impact (End) {L}, {P}, {T}, {I}	19,555	20,940	45,128	10,215
2.0 NCT Hot Impact (End) {L}, {P}, {T}, {I}	32,533	20,940	45,046	10,215
3.0 NCT Hot Operating {L}, {P}, {T}, {V}	32,533	23,871	20,948	10,215
3. HAC Hot (Fire) Pressure {L}, {P}, {T}	24,485	28,871		
4. HAC Cold Impact (End) {L}, {P}, {T}, {I}	78.937	20,940		
5. HAC Hot Impact (End) {L}, {P}, {T}, {I}	78.931	20,940		
6. HAC Cold Impact (Olique) {L}, {P}, {T}, {I}	30,133	23,465		
7. HAC Hot Impact (Olique) {L}, {P}, {T}, {I}	30.133	23,465		
8. HAC Cold Impact (Side) {L}, {P}, {T}, {I}	24,483	31,673		
9. HAC Hot Impact (Side) {L}, {P}, {T}, {I}	24,485	31,673		

Notes:

① Bending and torsion stresses are nut limited for HAC and therefore not calculated.

Load Combination	Applied Tensile Stress (psi)	Allowable Tensile Stress (psi)	Tensile Stress Ratio	Applied Shear Stress (psi)	Allowable Shear Stress (psi)	Shear Stress Ratio	Combined Stress Ratio <1.0 ①
1. NCT Cold Operating (-40) {L}, {T}, {V}	6,313	76,667	0.08	0	46,000	0.00	0.08
2. NCT Cold Operating (-27) {L}, {P}, {T}, {V}	8,456	76,667	0.11	23,871	46,000	0.52	0.53
10. NCT Cold Impact (End) {L}, {P}, {T}, {I}	32.533	73,767	0.44	20,940	44,260	0.47	0.65
11. NCT Hot Impact (End) {L}, {P}, {T}, {I}	32,533	73,767	0.44	23,871	44.260	0.54	0.70
12. NCT Hot Operating {L}, {P}, {T}, {V}	24,485	85,750	0.29	28,871	51,450	0.56	0.63
13. HAC Hot (Fire) Pressure {L}, {P}, {T}	78,937	98,000	0.81	20,940	58,800	0.36	0.88
3. HAC Cold Impact (End) {L}, {P}, {T}, {I}	78,937	98.000	0.81	20,940	58,800	0.36	0.88
4. HAC Hot Impact (End) {L}, {P}, {T}, {I}	30.133	98,000	0.31	23,465	58,800	0.40	0.50
5. HAC Cold Impact (Oblique) {L}, {P}, {T}, {I}	30,133	98,000	0.31	23,465	58.800	0.40	0.50
6. HAC Hot Impact (Oblique) {L}, {P}, {T}, {I}	24,485	98,000	0.25	31,673	58.800	0.54	0.59
7. HAC Cold Impact (Side) {L}, {P}, {T}, {I}	24,485	98,000	0.25	31,673	58,800	0.54	0.59
8. HAC Hot Impact (Side) {L}, {P}, {T}, {I}	32,533	73,767	0.44	20,940	44,260	0.47	0.65

Notes:

① The combined tensile and shear stress ratio must be less than 1.0 and is calculated as [(Tensile Stress Ratio)' + (Shear Stress Ratio)'?'

Load Combination	Applied Stress Intensity (psi)	Allowable Stress Intensity (psi)	Stress Intensity Ratio<1.0
5. NCT Cold Operating (-40) {L}, {T}	14,244	103.500	0.14
6. NCT Cold Operating (-27) {L}, {P}, {T}	67.293	103,500	0.65
9. NCT Cold Impact (End) {L}, {P}, {T}, {I}	89.811	103.500	0.87
7. NCT Hot Impact (End) {L}, {P}, {T}, {I}	99.503	99.585	0.9992
8. NCT Hot Operating {L}, {P}, {T}	86,646	99.585	0.87

2.9.3 Main Seal Evaluation

Using the Garlock Helicoflex catalog (See Attachment #1) methods. the Helicoflex seal is evaluated. For a pressure of 123psia (108.3 psig). and at a temperature of 800°F. the applied load is greater than the 'load to be applied'. Therefore the seal design is acceptable. This evaluation only evaluates the Fire case, which bounds all other cases. The Helicoflex seal catalog that contains the seal data and methods used for this evaluation **is** can be found in Chapter 4.

Table **2.9-11-** Helicoflex Seal Evaluation - Input

Definition of Characteristic Values		
Groove Inner Diameter	62.794	D_{j1}, inch
Seal Cross Sectional Diameter	0.268	D_{j2}, inch
Mean Seal Diameter ($D_{j1}+D_{j2}$)	63.167	D_j, inch
Linear Load Corresponding to e_2 compression	2500	Y_2, Ibdinch
Load on the seal to maintain sealing in service at low pressure (=Y_{m1})	457	Y_1, lbs/inch
Intrinsic power of the seal under pressure at 68ºF when the reaction force of the seal is maintained at Y_2, reaardless of the operatinq conditions	23,200	P, psi
Value of P, at temperature θ	7,830	$P_{u\theta}$, psi
Operating or proof pressure	108.3	P, psi
Linear Tightening load on the seal at room temperature to maintain sealing under pressure	11.67	Y_{m2}, lbs/inch
Value of Y_{m2} at temperature θ	3.73	$Y_{m2\theta}$, lbs/inch
Young's modulus of bolt material at 68ºF	28,500,000	E_t, psi
Young's modulus of bolt material at operating pressure (Fire Case, 800ºF)	24,200,000	E_{ts}, psi

Table **2.9-12** - Helicoflex Seal Evaluation - Output

Load Calculations		
Total Tightening load to compress the seal to the operating point (Y_2, e_2)	496,112	F_i, lbs
Total hydrostatic end force	339,390	F_f, lbs
Minimum total load to be maintained on the seal in service to preserve sealing	2,316	F_j lbs
Total load to be applied on the bolts to maintain sealing service	341,706	F_s, lbs
Increased value of **F**, to compensate for Young's modulus at temperature	402,422	F_s^*, lbs
Load to be applied	402,422	F_b, lbs
Applied Load (24 x Individual Bolt Preload)	722,581	lbs

2.9.4 Port Seal Evaluation

The vent/test port O-ring is a U221200875SEB. Per the Garlock Helicoflex catalog, the Y2 compression load is 799 lb/in. The OD of the O-ring is 0.875 inches, therefore the total required load to compress the **seal** is:

$$F_{min} = Y2 \cdot ID \cdot \pi = 2{,}196 \text{ lbs}$$

Assuming a nut factor (K) of 0.25 for an un-lubricated bolt. the required torque on the ¾-10UNC bolt is:

$$T = F_{min} \cdot K \cdot d = 2{,}196 \cdot 0.25 \cdot 0.75 = 411 \text{ in-lb} = 34 \text{ ft-lb}$$

The **groove** design for this **seal** prevents excessive compression and therefore excessive torque will not harm the O-ring. **Assuming** a maximum torque of 50 ft-lb (600 in-lb), the tensile force is:

$$F_{max} = \frac{T}{Kd} = \frac{600}{0.25 \cdot .75} = 3{,}200 \text{ lbs}$$

The tensile area of the bolt is 0.334 in^2. Therefore the tensile stress in the bolt is:

$$\sigma = \frac{F_{max}}{A} = \frac{3{,}200}{0.334} = 9{,}580 \text{ psi}$$

The yield stress of the ASTM A320, Grade L43 bolting material is 105 ksi. Therefore excessive preload is not of concern.

The vent/test tool shaft must be capable of driving a 50 ft-lb torque. The shaft is constructed of ASTM A193, Grade B7 alloy **steel** and the smallest cross sectional diameter is 0.50 inches. The yield strength of the shaft material is 105 ksi and therefore the maximum shear stress allowed is

0.6(105) = 63 ksi. The minimum cross section resisting the torsional stress is the 0.50 hex at the top of the shaft. The torsion stress in the shaft. where b is the width of one flat on the hex, is“’:

$$\tau = \frac{1.09 \cdot T}{b^3} = \frac{1.09.600}{0.29'} = 26.815 \text{ psi}$$

The torsion stress of 26,815 psi is much less than the allowable shear stress of 63,000 psi.

2.9.5 Drain Seal Evaluation

The vent/test port O-ring is a U231801437SEB. Per the Garlock Helicoflex catalog, the Y2 compression load is 1,313 lb/in. The OD of the O-ring is 1.437 inches, therefore the total required load to compress the seal is:

$$F_{min} = Y2 \cdot ID \cdot \pi = 5{,}927 \text{ lbs}$$

Assuming a nut factor (K) of 0.25 for an un-lubricated bolt, the required torque on the 1-¼-7UNC bolt is:

$$T = F_{min} \cdot K \cdot d = 5{,}927 \cdot 0.25 \cdot 1.25 = 1{,}852 \text{ in} - \text{lb} = 154 \text{ft} \cdot \text{lb}$$

The groove design for this seal prevents excessive compression and therefore excessive torque will not harm the O-ring. Assuming a maximum torque of 250 ft-lb (3.000 in-lb), the tensile force is:

$$F_{mu} = \frac{T}{Kd} = \frac{3{,}000}{0.25 \cdot 1.25} = 9{,}600 \text{ lbs}$$

The tensile area of the bolt is 0.969 in’. Therefore the tensile stress in the bolt is:

$$\sigma = \frac{F_{max}}{A} = \frac{9{,}600}{0.969} = 9{,}907 \text{ psi}$$

The yield stress of the ASTM A320, Grade L43 bolting material is 125 **ksi.** Therefore excessive preload is not of concern.

The vent/test tool shaft must **be** capable of driving a 250 ft-lb torque. The shaft **is** constructed of ASTM A193, Grade B7 alloy steel and the smallest cross sectional diameter is 0.75 inches. The yield strength of the shaft material is 105 ksi and therefore the maximum shear stress allowed is 0.6(105) = 63 ksi. The minimum cross section resisting the torsional stress **is** the 0.50 hes at the top of the shaft. The torsion stress in the shaft, where b is the width of one flat on the hex, is‘?’:

$$\tau = \frac{1.09 \cdot T}{b'} = \frac{1.09.3000}{0.43'} = 41.128 \text{ psi}$$

The torsion stress of 41,128 psi **is** much less than the allowable shear stress of 63,000 **psi.**

[1] Eshbach. Ovid W. ***Handbook** of Engineering Fundamentals*. Second Edition, John Wiley & Sons, Inc. 1966

[2] Eshbnch, Ovid W.. ***Handbook** of Engineering Fundamentals*. Second Edition. John Wiley & **Sons. Inc.** 1966

2.9.6 STS Cask Drop Analysis - Calculation Package 12099-08, Revision 2, 199 pages, includes PE Stamp

2.9.7 Summary Evaluations of Ancillary Equipment

None of the STS ancillary components are considered as part of the formal packaging used for transport of the radioactive K-Basin sludge. None are required to survive or function following application of the Hypothetical Accident Conditions, Section 2.5. The design loadings for each component have been developed based upon operational or storage conditions applicable to the equipment.

2.9.7.1 Process Shield Plate

The following paragraphs highlight the Large Container's structural features and behavior. Details are found in Appendix 2.9.8.2

2.9.7.1.1 Geometry

The Process Shield Plate (PSP) is a circular ring structure with a two lifting lug located 180° degrees apart. The PSP is lifted with a double hook lifting device for installation onto the **STS** Cask during routine sludge loading operations. The PSP is shown in PacTec Drawing 12099-400.

2.9.7.1.2 Loading Conditions 8 Analysis

- The PSP is analyzed for being lifted for installation with a bounding weight of 18138 lbs from its double lifting lugs. The PSP lifting components are designed in accordance with **ANSI N14.6.** Load Bearing members are capable of lifting three and five times the total weight without generating a combined shear stress or maximum tensile stress in excessive of the minimum tensile yield and ultimate stress, respectfully.

2.9.7.1.3 Conclusions

The PSP is fully capable of being lifted for installation onto the STS Cask in accordance with the design criteria. Design Margins include:

- Double Lifting Lug Pin +0.60
- Double Lifting Lug +?.18

2.9.7.2 Lifting Devices

2.9.7.2.1 Cask Lift Device

The following paragraphs highlight the Cask Lift Device's structural features and behavior. Details are found in Appendix 2.9.8.1

2.9.7.2.1.1 Geometry

The Cask Lift Device is an I-beam structure that is a separate component from the cask. The cask is lifted for initial placement onto the transport trailer. and does not require lifting during routine operation. The Cask Lift Device attaches to the cask using four bolts (1 ½-6UNC-2B) that thread into existing cask lid bolt holes. The Cask Lift Device is shown in PacTec Drawing 12099-510.

2.9.7.2.1.2 Loading Conditions & Analysis

The Cask Lifi Device is analyzed for two load cases. being lifting with a single crane hook from the center lifting lug. and being lifted with a double hook device from the double lifting lugs. The Cask Lift Device is analyzed to lift the gross cask weight of 85,000 Ibs. which is extremely conservative because the cask is not loaded when lifted for initial placement onto the transport trailer.

The Cask Lift Device is designed in accordance with ANSI N14.6. Load Bearing members **are** capable of lifting three and five times the total weight without generating a combined shear stress or maximum tensile stress in excessive of the minimum tensile yield and ultimate stress, respectfully.

2.9.7.2.1.3 Conclusions

The Cask Lift Device is fully capable of lifting the STS Cask with a gross weight of 85.000 Ibs in accordance with the design criteria. Design Margins include:

- Center Lifting Lug +1.11
- Double Lifting Lug +0.99
- Main Beam minimum required section modulus = 229.32 in^3. Supplied = 232 in'
- Attachment Bolts ' +0.66

2.9.7.2.2 Cask Lid Device

The following paragraphs highlight the Cask Lid Device's structural features and behavior. Details *are* found in Appendix 2.9.8.2

2.9.7.2.2.1 Geometry

The Lid Lift Device is a circular plate structure that is a separate component from the cask. The cask lid is lifted during routine operation. The Lid Lift Device attaches to the cask lid using three bolts (3/4-10UNC-2B) spaced 120° apart, which thread into cask lid lifting bolt holes. The Lid Lift Device is shown in PacTec Drawing 12099-500.

2.9.7.2.2.2 Loading Conditions & Analysis

The Lid Lift Device is analyzed for lifting 6250 lbs by a single crane hook from the center lifting lug. The Lid Lift Device is designed in accordance with ANSI N14.6. Load Bearing members are capable of lifting three and five times the total weight without generating a combined shear stress or maximum tensile stress in excessive of the minimum tensile yield and ultimate stress, respectfully.

2.9.7.2.2.3 Conclusions

- The Lid Lift Device is fully capable of lifting the STS Cask Lid with a bounding weight of 5,280 Ibs in accordance with the design criteria.

2.9.7.2.3 Double Hook Adapter Lift Device

The following paragraphs highlight the Large Container's structural features and behavior. Details are found in Appendix 2.9.8.1 & 2.9.8.3.

2.9.7.2.3.1 Geometry

The Container Lifting Adapter is an I-beam structure with a lifting lug on each end and a center lug bolt for attaching a standard lifting hook. The container is lifted during routine operation. The Container Lifting Adapter attaches to the container using a single Crosby lifting hook. The Container Lifting Adapter is shown in PacTec Drawing 12099-520.

2.9.7.2.3.2 Loading Conditions & Analysis

The Container Lifting Adapter is analyzed for lifting a bounding load of 19,500 lbs with a double hook device from the double lifting lugs. The Container Lifting Adapter is designed in accordance with ANSI N14.6. Load Bearing members are capable of lifting three and five times the total weight without generating a combined shear stress or maximum tensile stress in excessive of the minimum tensile yield and ultimate stress. respectfully.

2.9.7.2.3.3 Conclusions

The Container Lifting Adapter is fully capable of lifting the **STS** Container with a gross weight of 19,500 lbs in accordance with the design criteria. Design Margins include:

- Center Lifting Lug Bolt +0.21
- Double Lifting Lug +0.91
- Main Beam minimum required section modulus = 44.5 in', Supplied = 52.0 in'

2.9.7.3 Large Container

The following paragraphs highlight the Large Container's structural features and behavior. Details **are** found in Appendix 2.9.8.3

2.9.7.3.1 Geometry

The Large Container (LC) vessel structure is a 5' diameter, 10' tall, ASME (Section VIII Division 1) **pressure** vessel having a working design pressure of 150 psig. The vessel is of welded **316** stainless steel construction fabricated from ¾ inch thick upper head, 1% inch thick lift lug. and ½ inch thick shell, lower head, and lower skirt. Commercially available 2:1 formed ellipsoidal heads are used in the assembly. The shell is rolled from plate material for fabrication. Nozzles are installed in accordance with the Code requirements as applicable.

The LC is vented during transport and storage activities. During filling and storage. it is operated as a pressure vessel. The design operating temperature range is **-33** to 60°C. The LC design life is 30 **years,** and all non-serviceable components are designed to perform during that time. Corrosion allowance is provided to maintain its' pressure rating during its' lifetime. The Performance Specification. SNF 8163, limits mavimum weight with maximum payload to less than or equal to 8.390 kg (18,500 lbs). In fact. the maximum loaded weight of the Large Container is **7,773** kg (17,100 Ibs). assuming a **3** m^3 60/40 sludge load and 10 inches of cover water.

2.9.7.3.2 Loading Conditions 8 Analysis

The Large Container is designed and fabricated in complete conformance with ASME Section VIII. Division 1 rules. The upper head was initially sized for the pressure (@200°F) load case with 150-psig pressure to determine the head thickness. A finite element model (with upper head penetrations) considers these pressure and lift conditions to confirm the ¾ inch upper head thickness. The Pressure (hot) case is considered more critical than the cold case (-27°F) since the hot condition allowable stress value is less than the cold case value.

The upper head requires **8** total penetrations. which vary from 1 to 4 inches diameter (nominal) for LC loading and storage operations. The head penetrations are spaced to meet code guidelines conservatively neglecting connecting pipe reinforcements. Verification of the upper head hole penetrations has been confirmed by finite element analysis for Lift and Pressure case conditions.

Three sets of analyses have been performed:

- Section VIII code calculations for thickness requirements, nozzle reinforcement requirements, and lifting requirements.
- An FEM analysis of the upper half of the Large Container to verify structural integrity of the composite structure considering the close proximity of lifting lugs and process nozzles. Allowable stresses are governed by **ANSI N14.6** requirements.
- An FEM analysis of the lower half of the Large Container to verify structural integrity at the lower head to shell and skirt junctures.

The 1st FEM model **is** representative of a ½ symmetric (fixed perimeter) arrangement of the upper head and cylindrical shell. The model utilizes **4** node quadrilateral shell elements located at mean geometry (wall thickness mid-plane) to recover peak stress intensity in the structural assembly. The **1-1/4** inch thick lift lug incorporates a 5" wide **x** 8-1/2" tall oval slot for single lift operations. The lug cross section is 12" in height at vessel center gradually decreasing to ½ inch tall at **49.5"** diameter (lug width). For each load condition displacement boundary conditions **are** applied at the model cylindrical shell mid-span.

The 2nd finite element model. is an axisymmetric representation of the lower and upper heads, **skirt** and shell only. This model uses *3* node quadrilateral 2 dimensional solid elements. The Pressure case steady state temperatures are applied to the model to determine thermal stresses. Mechanical pressure loading are applied to the vessel interior in a separate load case. Results from the two load cases are superimposed to recover the combined stress state.

The Performance Specification, SNF 8163, Section 6.5.2.4, requires that the Large Container be evaluated to demonstrate consequences of an object impact. The demonstration is provided in Appendix 2.9.8.4. In summary, the demonstration analysis concludes that penetration and rupture of the Large Container is bounded (by and order of magnitude) by existing T-Plant Preliminary Accident Analyses.

2.9.7.3.3 Conclusions

- Code calculations for required shell thicknesses to resist pressure show generous margins. The minimum corrosion allowance for any of the shell components exceeds the Performance Specification. SNF 8163, requirements by 63%.

- FEM analyses show the minimum Factor of Safety in the upper head for lift conditions is +2.13. In the 1-1/4 inch thick lift lug itself the minimum Factor of Safety is +1.034 based on a peak stress intensity of 8.05 ksi. This peak stress is highly localized and on the inner surface of the **lug** cutout at the two upper radiused comers. Notably both hand analyses and FEM analyses predict average (primary membrane) stresses of about **3** ksi in the main body of the lift lug.
- FEM analyses show the minimum Factor of Safety for pressure and temperature effects is **+1.33**.
- The FEM results all assume nominal material thicknesses with no corrosion allowance applied. Should a corrosion allowance of 1/8 inch be applied per the requirements of the Performance Specification. SNF 8163, adjusted minimum Factor of Safety would be as follows:
  - ✓ Lift Load, Upper Head +1.78
  - ✓ Lift Load. Lug (unchanged) +1.034
  - ✓ Pressure & Temperature, Upper Mead +1.11
  - ✓ Pressure &Temperature. Shell +1.25

2.9.7.4 STS Transport Trailer Including Tiedown Structure

The following paragraphs highlight the Trailer's structural features and behavior. Details are found in Appendix 2.9.8.5

2.9.7.4.1 Description and Geometry

The Trailer is a 4-axle single drop flatbed with an overall length of 35-feet and width of IO-feet. The height of the drop deck is 42-inches and the overall height, including superstructure work platform railings is 181-inches(15'-1"). The trailer is fabricated of welded carbon steel shapes, plates and tubular sections. The materials and fabrication are in accordance with industry accepted standards **(ASTM, AISC,** ANSI, AWS) and all surfaces are primed and painted with coatings appropriate for **use.** The superstructure is a welded framework surrounding the cask allowing access to the containers during loading and handling operations. The integral cask tie-down system consists of deck mounted lugs which engage 4 slots at the base of the STS Cask plus a tubular framework which envelopes the top of the cask. **A** work stand for storage of the cask lid is located at the Trailer stem..

2.9.7.4.2 Loading Conditions & Analysis

The trailer and tiedown structure were modeled with **MSC** Nastran. A mid-surface model was generated from the Nelson supplied 2- dimensional drawing tiles. Plate elements were constructed on the midsurfaces representing the trailer structure. A global mesh size of 2" was used. Beam elements **are** used to represent the axles. suspension and tires. Rigid elements were used to connect the suspension to the underside of the main beams of the trailer. Beam elements were also used to represent the cask and the structural tubes in the tiedown structure to allow for quick tube sizing. The densities of the cask and trailer were modified so that a cask weight of 85,000 lb and empty trailer weight of 35,000 Ib. was obtained for analysis.

An additional model was created of the tiedown structure only. consisting of all tiedown components located above the trailer deck. Plate elements are used to model all the rectangular tubes. top cask clamp lower tiedown devices, and the cask. Compression only gap elements were added between the cask. tiedown devices and top clamp to simulate contact due to the acceleration loads. A static-nonlinear analysis is used for this model in order to utilize the gap elements.

Four operational and one tiedown load case were analyzed. The operational loadings were evaluated versus structural safety factors of 2:1. Tiedown loads enveloped past and current **DOT** criteria and were evaluated versus structural,safety factors of **1**:1, again consistent with **DOT** criteria.

2.9.7.4.3 Conclusions

- The minimum operational factor of safety was found to be +2.05, representing a 1g **aft** and 1g down loading.
- The minimum tiedown factor of safety was found to be +4.12.

2.9.7.5 Earthquake Analyses *of* STS

The Performance Specification, SNF 8163, Section 4.3.2.3, requires evaluation of the STS system (cask and trailer) to a performance category **3** (PC3) earthquakes. The detailed evaluation is provided as Attachment 2.9.8.6

2.9.7.5.1 Description & Geometry

The seismic analysis model utilized the trailer structural model described above in Appendix 2.9.7.4, converting it into a single super-element accurately representing the elastic and inertial properties of the trailer, tiedown structure and cask. To this super element were added discrete models of each element of the suspension system. All modeling properties were derived from manufacturers supplied data. Tire and landing gear model restraints were accurately modeled **as** gaps to ground surface with lateral friction forces acting when the gap was compressively loaded.

2.9.7.5.2 Loading Conditions & Analysis

The loading was applied via time history ground motion excitations whose spectral transformations matched the Performance Specification. SNF 8163, requirements for a K-basin PC-3 earthquake.

2.9.7.5.3 Conclusions

- The evaluation demonstrates that the **STS** Trailer will not overturn during the specified earthquake.
- Maximum uplift on either landing leg is 2.43 inches.
- Maximum tire lift is 1.06 inches
- Lateral sway of the cask top is 6.12 inches.

2.9.8 Supporting Ancillary Equipment Calculation Packages

The following structural calculations are attached:

- Sludge Transfer Cask Lifting Devices Analysis. PacTec Calculation Number 12099-23, Revision 0, 32 Pages + PE Stamp cover sheets for calculation packages 12099-23, Revision 0, 2 pages
- Installation/Removal & Maintenance Devices. PacTec Calculation Number 12099-24, Revision 2.40 Pages + PE Stamp cover sheets for calculation packages 12099-24, Revision 2, 2 pages
- Structural Analysis of (A-170) **Large** Container. EN-3C-0126-04. Revision 1, Avantech Incorporated, **33** Pages.
- Accident Analysis of (A-170) Large Container. EN-3C-0126-06, Revision 1, Avantech Incorporated. 8 Pages.
- Finite Element Analysis (of STS Trailer & Tiedown Frame), J152-01, Revision 0, **Sun** Engineering, **20** Pages.
- Seismic Analysis of the STS Trailer, PacTec Calculation Number 12099-30. Revision 0, 66 Pages + PE Stamp cover **sheets** for calculation packages 12099-30, Revision 0, 1 pages
- Stress Analysis of STS Trailer Lid Inspection Fixture, PacTec Calculation Number 12099-**25,** Revision 1, 35 Pages.

2.9.8.3 Structural Analysis of (A-170) Large Container, EN-3C-0126-04. Revision 3, Avantech Incorporated, 37 Pages.

AVANTech
INCORPORATED

CALCULATION ID NUMBER	EN-3C-0126-04
REVISION NUMBER	3
JOB NUMBER	0126

TITLE	K-East Basin Sludge Transport System – A-170 (Large Container): Structural Analysis

PROBLEM STATEMENT OR OBJECTIVE OF THE CALCULATION:

Provide structural analyses for evaluation of the K-East Basin Sludge Transport System Large Container (LC) considering the following conditions:

- 150 psig Internal LC Pressure combined with maximum 200°F temperature
- Lift (no internal pressure) combined with LC maximum 200°F temperature at 17,100 lbs weight
- internal pressure and payload weight combined with maximum steady state thermal loads

Note: The LC thermal response is developed in a separate calcuiation. see EN-3C-0126-02 Rev.C.

PREPARED	WBC	10-17-02
Title	Principal Engineer	[illegible]
REVIEWED	KBM	10-21-02
Title	Project Engineer	KBM

REVISION NOTES	Revision 3: Revise reinforcement calculation Table 7-2. Revision 2: Incorporates analysis for skin redesign with additional holes and sludge growth affect on filter cage (stability analysis of sleeves). Revision 1: Incorporates code calculation and further engineering analysis to consider 1/8th inch loss of material due to corrosion for pressurization and lifl conditions. Penetration reinforcement analysis has been revised to consider corrosion and area exceeding required vessel thickness and takes FEA results into consideration. Owner comments to Rev.0 have been incorporated. Revision 0: Incorporates an axisymetric finite element model lo supplement evaluation and for corroboration of the LC design / analysis. The model provides evaluation of skirt to lower head juncture under Pressure case temperatures with pressure. Minor notes are added for clarification. **ASME** penetration reinforcement calculation /notes are provided.

Title	*A-170 Structural Analysis*	*Calculation Number EN-3C-0126-04 Rev 3 (CON-11)*
Project Name	*Sludge Transportation System*	***Job Number*** *0126*

APPENDIX B -CALCULATION REVIEW CHECKLIST

REVISION NUMBER	3

Item	Yes	N/A*
1. Design Inputs such as design bases, regulatory requirements, codes, and standards are identified and documented.	✓	
2. Effect of design package on compliance with the Safety Analysis Report or Certificate of Compliance identified and documented.		✓
3. Revision numbers correct on the list of drawinas?	✓	
4. Assumptions reasonable?	✓	
5. Appropriate analysis method used?	✓	
6. Correct values used from drawinas?	✓	
7. Answers and units correct?	✓	
8. Summary of results matches calculations?	✓	
9. Material properties properly taken from credible references?	✓	
10. Figures match design drawings?	✓	
11. Computer input complete and properly identified?	✓	
12. Documentation of all hand calculations attached?	✓	
13. Meeting minutes of the Design Review?		✓

* N/A, Comments	2. SAR or CofC evaluation not included in work scope

REVIEWED	[signature]	10-21-02

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1 Introduction

The K Basin Sludge Transportation System includes a Large Container (LC) and a Transport Cask [Reference 9.1]. The scope of work requires the design and evaluation of the Large Container and Transport Cask. and the construction of a working prototype of the Large Container. The Large Container pressure boundary and level sensor are classified as Quality Level 2 and the internals are classified as Quality Level 3. Evaluations are to be submitted in four phases: 30% completion, 60% completion, 90% completion, and the final submittal. The information provided in this document represents the Final Design completion submittal for the Large Container Structural (and Lifting Attachment) Evaluation including analysis of design modifications, as noted.

2 Design Input

2.1 Geometry

The K-Basin Large Container (LC) vessel structure is a 59" diameter, 10' tall, ASME (Section VIII Division 1) pressure vessel having a working design pressure of 150 psig. Note that this analysis considers a 60 diameter vessel with all other parameters consistent with the design being verified – the larger diameter offers conservatism to the results. The vessel is of welded 316 stainless steel construction fabricated from ¾ inch thick upper head, 1¼ inch thick lift lug, and ½ inch thick shell, lower head, and lower skirt. Commercially available 2:1 formed ellipsoidal heads are used in the assembly. The shell is rolled from plate material for fabrication. Nozzles are installed in accordance with the Code requirements and intent, as applicable.

2.2 Design

The LC is vented during transport and storage activities. During filling and storage, it is operated as a pressure vessel. The design operating temperature range is –33 to 60°C. The LC storage design life is 30 years, and all non-serviceable components are designed to perform during that time. Corrosion allowance is defined as 1/8" maximum (by the Owner) and excess material provided to maintain pressure rating during the defined lifetime. The LC maximum weight with maximum payload is less than 8,390 kg (18,500 lbs). Support for the analytical weight is provided in section 4.

The upper head was initially sized for the pressure (@200°F) load case with 150-psig internal pressure to determine the head thickness. A finite element model (with upper head penetrations) considers pressure and lift conditions to confirm the ¾ inch upper head thickness. The Pressure (hot) case is considered more critical than the cold case (-27°F) since the hot condition allowable stress value is less than the cold case value.

The upper head requires 8 total penetrations, which vary from 1 to 5-1/2 inches diameter (nominal) for LC loading and storage operations. Verification of the upper head hole penetrations is confirmed by finite element analysis stress recovery for Lift and Pressure case conditions. The model for these analyses also conservatively ignores any pipe reinforcements. The finite element model without consideration of nozzle, weld or reinforcing pads does not show any stress intensity above those allowed. Accordingly, the construction meets with Code intent of controlling stress at these zones.

The upper head incorporates gentle 3:1 minimum angular transition between shell and head flange required by the Code. Both head to shell welds require wall beveling (30" to

45' from the horizon) for full weld penetration. The upper weld will be single side welded with backing strip to prevent damage to the filters. The final weld group design configuration is presented to meet applicable code welding requirements for (SA-240 Type 316 is P No.8) materials in the given thickness. Consideration for various weld configurations and examinations are observed for the joint efficiency factor of 0.9 assuming full radiography in the standard pressure case code calculations for the head and shell. Two different Finite element models are used to corroborate stress levels at the weld seams and are shown within allowable stress intensities. After fabrication the vessel requires no special Postweld Heat Treatment for code compliance (Ref 9.2, Table UHA-32, Page 216 - P No 8 Gr1).

2.3 Analysis Considerations

The lower ellipsoidal head analysis conservatively considers the pressure case (150-psig @200°F temperature) combined with the maximum 17,100 pound (Reference Section 4) gross weight distributed, as a uniform interior pressure using required code internal pressure formulas.

The maximum possible increase in vessel length is determined considering a conservative classical evaluation of the elevated temperature change of the entire assembly from 50°F to 200°F at fabrication and in operations respectiveiy. Since the thermal growth is observed by adequate design clearance there are no resulting compression forces occurring between the cask and the LC. Accordingly, the lower skirt is considered in axial compression by transfer of 17,100 pound gross payload weight to the bottom of the cask at l g gravity load conditions. An axisymmetric finite element model has also been considered to recover stress intensities due to thermal and pressure loading from the pressure case steady state condition for the vessel. The evaluation determines the stress intensities at the juncture of the skirt to lower head and in the local areas of head bending under these conditions. Since the temperature difference across each section of the vessel wall is nearly constant the thermal stress due to the wall temperature differences were found negligible (634-psi maximum).

Two finite element models (FEM) results were provided to 1) confirm classical analysis and results from code calculations and 2) to ensure code compliance through stress recovery / comparison to allowable stresses. The **1st** FEM model is representative of a **½** symmetric (fixed perimeter) arrangement of the upper head and cylindrical shell. The model utilizes 4 node quadrilateral shell elements located at mean geometry (wall thickness mid-plane) to recover peak stress intensity in the structural assembly. For analysis the 1-1/4 inch thick lift lug incorporates a *5*" wide x 8-1/2" tali oval slot for single lift operations. Tne lug cross section is 12" in height at vessel center gradually decreasing to ½ inch tall at 49.5" diameter (lug width). The lug is groove and fillet welded from both sides to the ¾" head forming an integral arrangement. The lifting loads are uniformly applied on the oval upper slot surface corresponding with the hook engagement. Subsequent to analysis revision 1 the lift lug slot was modified to remove the lug material under the slot. This modification was assessed for impact to design and determined to have no adverse affect. The model also recovers stress results for the pressure case by applying **150** psig pressure over the interior shell surfaces. For each load condition displacement boundary conditions are applied at the model cylindrical shell mid-span using a cylindrical coordinate system at the center of the section (X=R is radial, Y=Theta coordinate, Z is oriented toward lift lug).

The 2nd finite element model representation considers the lower and upper heads, skirt and shell only. This model uses 4 node quadrilateral 2 dimensional solid elements modeled in the positive quadrant of the X-Y plane. The centerline of the model resides along X=0 representing a symmetric solid body of revolution about the Y-axis. The Pressure case steady state temperatures performed by separate heat transfer calculations (Reference 9.7) are applied to the model to determine the thermal stress. Mechanical pressure loading is applied to the vessel interior in a separate load case. Results from the two load cases are superimposed to recover the combined stress state.

The LC geometry is shown (Reference 9.4) in Drawing 3C40-0126-D. Analysis plots and information concerning the model, loads, structural response, boundary conditions (free body diagrams, etc) are included in the Appendix.

3 Material Properties

The LC vessel and lift lug structural materials of fabrication are composed from SA-240 316 stainless steel. Temperature dependent material properties are obtained from Section II, Part D, of the ASME Code Reference 9.5. Table 3-1 provides summary of the LC temperature dependant mechanical properties.

Table 3-1 - Type 316 Stainless Steel Material Properties

Material Specification	Temperature, °F	Yield Strength① (S_y) psi	Ultimate Strength① (S_u) psi	Design Stress Intensity① (S_m) psi	Elastic Modulus① $\times 10^6$ psi	Coefficient of Thermal Expansion① 10^{-6} in/in/°F
SA-240 Type 316 UNS Designation 531600 P No 8 Gr 1 16Cr-12Ni-2Mo	-20	30,000	75,000	20,000	28.7	8.2
	100	30,000	75,000	20,000	26.1	8.6
	200	25,900	75,000	17,300	27.6	8.9

Table 3-2 outlines the stainless steel, sludge, and water densities used in Section 4 vessel gross weight calculations.

Table 3-2 - Regional Material Density

Material	Density (g/cc)	Density (lb / inch³)

Sludge	1.55	0.048
Steel	8.00	0.290

4 Conditions Analyzed

The Large Container is analyzed using *ASME* Code pressure vessel design and manufacturers requirements and for T-Plant lift lug design parameters. Based on the Large Container (LC) 60% Thermal Analysis (Reference 9.7) and to conservatively envelop the LC thermal conditions, the Large Container materials are assumed to be at a constant temperature of 200°F throughout the Container combined 30-year process and storage lives for Code calculations. However, the LC axisymmetric finite element model analysis has also considered thermal stress affects using the Steady State Temperatures developed in Reference 9.7. Stress intensities from this analysis are generally compared to the material allowable stress intensities at 200°F.

The Large Container lift members and load paths are analyzed assuming a maximum 17,100 pound gross weight including payload. The weight breakdown is outlined below.

Component	Design Weight (Pounds)	
½ inch thick Shell	2,025	
¾ inch thick Upper Elliptical Head	980	
%inch thick Lower Elliptical Head	603	
½ vessel skirt	385	
Miscellaneous Vessel Components	673	(4.666 *lbs. empty wt.)*
Payload:		
Sludge (3 m^3 max fill)	10,248	
Water (IO-inch column height)	988	
Conservatism Factor (7.5%)	1,198	
Totals	**17,100**	

5 Acceptance Criteria

5.1 ASME Code Vessel Conditions (Pressure case)

The **ASME** Boiler and Pressure **Vessel** Code (References 9.2 and 9.5) provides the acceptance criteria, material properties, and allowable stresses for the 150-psig (200°F Pressure Case) design pressure input parameter specified by Specification SNF-8163 Rev.4, Reference 9.1. Section 3 Table 3-1 - Type 316 Stainless **Steel** Material Properties outlines the allowable **stress** intensity depending on temperature. Consistent with classical strength of materials (Reference 9.6 page 169, maximum shear stress theory for linear elastic response of isotropic materials) the allowable shear stress is conservatively taken at **50%** of the allowable stress intensities.[1]

[1] **The allowable shear strength may be taken as 57.7% (0.577Sy) of the allowable Stress intensity limit using Mises-Hencky (distortion energy) theory when compared with Von-Mises stress (Ref: 9.6 P 170).**

5.2 Lift Conditions

ANSI 14.6 Lift requirements, reference 9.3, outline safety factors for the Lift conditions. The allowable stress intensity consistent with this standard is the lower of **1/3rd** yield or **1/5th** ultimate strengths. Material Properties Section 3 Table 3-1 - Type 316 Stainless Steel Material Properties provides Sy and Sult strengths dependency on temperature for evaluation of the allowable stress. This results in the following lowest possible allowable stress values for the Lift using 200°F maximum service temperature.

1/3 Sy = 1/3 (25,000)= **8,333** psi or **1/5** Sult=1/5 (75,000)≈15,000 psi

The allowable stress intensity is the lower 8,333-psi limit.
The allowable shear strength is 50% of this value (4,166-psi).

6 Assumptions

The material is a linear elastic isotropic medium. Stresses recovered are in the linear elastic region and qualify the design by comparison to the allowable stresses outlined in Section 5. All construction details, fabrication processes, and operational loads will be in accordance with assumptions and Code requirements.

Following revision 0, the specification defining the LC maximum outside diameter was reduced from 60-inches to 59-inches. The structural analysis continues to use the 60-inch maximum OD generally providing a level of conservatism to the analysis

Section 7 provides particular assumptions concerning each calculation.

7 Calculations

The classical calculations were performed using MathCad 2000 with results spot-checked by hand. The FEM analyses were performed using Cosmos/m ver.1.71a and were benchmarked using theoretical classical results for similar analytical configurations and conditions. The Benchmark report is maintained on file.

7.1 Upper Ellipsoidal Head - Notes & Assumption

Reference **9.2, UG-32,** Mandatory Appendix1

- Basis: **2:1** Ellipsoidal head assuming full penetration welding from outer side with multi-pass welds and use of an interior un-reinforced backing strip. The backing strip is required for protection of filters located near this region.
- Category **B** (Location) Type 2 (c) assumed for connection of Upper Ellipsoidal Head to Main Body Shell
- Variables:
  - ✓ **D** = 59 inch inside head Diameter

- ✓ $S = Sm$ = 17.3 Ksi for SA240 Type 316 material at 200°F
- ✓ P=150 psig internal design pressure
- ✓ h = 14.75 inch inside head depth to start of straight formed skirt
- ✓ k = factor for ellipsoidal heads formulation depends on head proportion D / 2h generally taken as 1.0 for 2:1 heads
- ✓ t_{actual} = 3/4 (inch) for the desired upper head construction

- Thermal stress is considered negligible
- Full radiography joint efficiency factor, E = 0.9
- Calculate maximum corrosion rates the design can sustain in service (IPY – inches / year) conservatively based on 150 psig internal pressure during full 30 Year Life.

Variable Declaration:

$D := 59.0$

$S := 17300$

$P := 150$

$h := 14.75$

$E := 0.9$

$t_{actual} := 0.75$

$$k := \frac{1}{6}\cdot\left[2+\left(\frac{D}{2\cdot h}\right)^2\right] \qquad k = 1.00000$$

K factor used in thickness calculation Appendix 1, ASME Code Section VIII - Div 1

$t := \frac{(P\cdot D\cdot k)}{(2\cdot S\cdot E - 0.2\cdot P)}$	$t = 0.284$	Required Code thickness - inch
$FI := 0.385\cdot S\cdot E$	$FI = 5994.450$	> P (pressure. psi) therefore valid by code
$t_{allowance} := t_{actual} - t$	$t_{allowance} = 0.466$	corrosion allowance (inch) exceeding the required head thickness to retain pressure
$IPY_{corrosion} := \frac{t_{allowance}}{30}$		allowable corrosion rate inches per year
$IPY_{corrosion} = 0.01552$	allowable corrosion rate inches per year	

Considering the geometry with D equal to 59.25 inch (i.e., loss of 1/8th inch wall thickness) the upper head thickness is required to be a minimum of 0.286 inches in the above formula. Accordingly, the wall thickness of 0.625 inch (0.75-0.125) in the fully corroded condition is adequate.

7.2 Evaluation of Cylindrical Shell Section under Pressure

Ref Part UG-Section 27 Requirements Circumferential requirements for Longitudinal weld joints

Assumptions and Notes:

- Longitudinal seam(s) in the right circular cylinder must be full penetration butt weld complying with requirements of Table UW-12, Figure UW-13.1, and Section uw-35.
- Category A - Single Side Welding, Type 2(c) with full radiographs Ej= 0.90
- t_{shell} = 0.50 inch (Desired Shell Thickness)
- 200°F service temperature conditions
- SA-240 Type 316 shell material

Variable Declaration:

Joint Efficiency and allowable stress (psi) at 200°F

$Ej := 0.90$

$S := 17300$

$t_{shell} := 0.50$ **shell thickness [inch)**

$R_{shell} := \frac{D}{2}$ $R_{shell} = 29.50$ **interior shell radius** (**inch**)

$FI := 0.385 \cdot Ej \cdot S$ $FI = 5994.450$ **OK -exceeds 150 pressure** (**psi**)

$t_{shellrequired} := \frac{P \cdot (R_{shell})}{S \cdot Ej - 0.60P}$ $t_{shellrequired} = 0.286$ **required shell thickness (inch**)

$t_{allowance} := t_{shell} - t_{shellrequired}$ $t_{allowance} = 0.214$ corrosion **allowance** (**inch**)

$IPY_{corrosion} := \frac{t_{allowance}}{30}$ $IPY_{corrosion} = 0.00714$ **allowable corrosion** rate **inches per year**

Considering geometry with D equal to 59.25 inch (i.e., loss of 1/8th inch wall thickness) the cylindrical shell thickness is required to be a minimum of 0.287 inch by the above formula. Accordingly, the wall thickness of **0.375** inch (0.5-0.125) in the fully corroded condition is adequate.

7.3 Evaluation of Lower Ellipsoidal Head - Notes & Assumption

Ref: 9.2, UG-32, Mandatory Appendix1

- Basis: 2:1 Ellipsoidal head assuming full penetration welding from either side with multi-pass welds
- Full radiograph inspection
- Category B (Location) Type 1 (c) assumed for connection of Ellipsoidal Head to Main Body Shell
- Variables:
  - ✓ t_{actual} = 1/2 (inch) for the desired lower head construction
  - ✓ Use other Section 7.1 geometry data
- Combine **6.25** psi uniform pressure with the 150 psi Pressure case internal design pressure to account for 17,100 pounds gross weight supported by lower head

$Wg := 17100$ LC Gross weight (pounds)

$Pg := \frac{4 \cdot Wg}{\pi \cdot D^2}$ $Pg = 6.15$ Pressure due to LC 17,100 pound Gross weight

Variable Declaration:

$D := 59.0$

$S := 17300$

$P = 156.25$

$h := 14.75$

$E := 0.90$ (UW-12 allows E = 1.00)

$t_{actual} := 0.5$

$k := \frac{1}{6} \cdot \left[2 + \left(\frac{D}{2 \cdot h}\right)^2\right]$ $k = 1.00000$

K factor used in thickness calculation Appendix 1, ASME Code Section VIII - Div 1

$t := \frac{(P \cdot D \cdot k)}{(2 \cdot S \cdot E - 0.2 \cdot P)}$ $t = 0.296$

$FI := 0.385 \cdot S \cdot E$ $FI = 5994.450$ > P (pressure - psi) therefore valid by code

$t_{allowance} := t_{actual} - t$ $t_{allowance} = 0.204$ corrosion allowance (inch)exceeding the required head thickness to retain pressure

$IPY_{corrosion} := \frac{t_{allowance}}{30}$ allowable corrosion rate inches per year

$IPY_{corrosion} = 0.00679$ allowable corrosion rate inches per year

Considering geometry with D equal to 59.25 inch (i.e., loss of 1/8th inch wall thickness) the lower head thickness is required to be a minimum of 0.298 inch by the above formula. Accordingly, the lower head wall thickness of 0.375 inch (0.5-0.125) in the fully corroded condition is adequate.

7.4 Alternate Evaluation of Cylindrical Shell Section under Pressure

Ref: Pari UG-Section 27 Requirements Longitudinal Stress requirements for Circumferential weld Joints

UG-27 Longitudinal stress requirements imposed on shell circumferential welds are bounded by weld joint requirements previously developed for the upper heads. This is demonstrated by assuming a joint efficiency (Ej=0.90) for weld achieved by welding from one side with full radiographs and 200°F service temperatures.

$Ej := 0.90$ $S := 17300$

$t_{shellrequired} := \frac{P \cdot (R_{shell})}{2 \cdot S \cdot Ej + 0.40P}$ $t_{shellrequired} = 0.15$

7.5 Thermal Growth

$a := 8.9 \cdot 10^{-06}$		Max Coefficient of thermal expansion inchlinch-F
$L_{LC} := 108$		Vessel Length subjected to elevated temperature
$TI := 200$ $T2 := 50$		Elevated and Fabrication Temperatures - degrees F
$AT := TI - T2$	$AT = 150.00$	Overall Temperature Difference (degrees F)
$AL := L_{LC} \cdot \alpha \cdot AT$	$AL = 0.144$	Maximum Axial Growth (inch)

Adequate clearance of %inch minimum is observed in the design to accommodate axial growth in LC length under maximum elevated temperatures. Since the diameter is less than the LC length the radial expansion will be less critical due to the spacing of ½-inch minimum observed between the Cask and LC radii.

7.6 Lower Skirt Compression

$A_{skirt} := \pi \cdot \left[(R_{shell})^2 - (R_{shell} - t_{shell})^2 \right]$

$A_{skirt} = 91.89$		skirt area - square inch
$wg = 1.71 \times 10^{4}$		Maximum LC wieght and payload-pounds
$\sigma_{skirt} := \frac{Wg}{A_{skirt}}$	$\sigma_{skirt} = 186.09$	Nominal Skirt Stress - psi
$\sigma_{skirtpeak} := 3.5 \cdot \sigma_{skirt}$		Skirt Stress near lower holes
$\sigma_{skirtpeak} = 651.31$		Peak Skirt Compressive Stress - psi

Initial skirt design **(i.e.** revision 0 and 1 designs) included holes located at the lower zone of the skirt. Even with Consideration of a stress concentration factor near **3.5** at the holes this location does not pose a concern for compressive stress intensity. Accordingly, the lower skirt depicts a large factor of safety **on** compressive stresses.

Additional holes were added to the skirt to promote purge gas circulation and heat transfer. This modified skirt design was analyzed via FEA. Refer to Section 7.9.

7.7 Container Lift Analysis & Pressure (Hot) Case Confirmation

7.7.1 Classical and ½ Symmetric Finite Element Model

Input:	Max gross weight	17,100 lbs. maximum
	Lift lug dimensions	1-1/4" thick, 12" H with Lift slot
	LC Upper head	3/4" thick w/ nozzle penetrations
	Cylindrical Shell	½ inch thick

Classical Analysis
Lift Lug transfer Lift loads from the lug to large container

$Sy_{Lift} := 8313$		Allowable Stress Intensity -psi
$\tau_{weldallowable} := Sy_{Lift} \cdot 0.50$		Allowable Weld Shear Stress -psi
$\tau_{weldallowable} = 4166.50$		
$W_{lift} := 17100$		Lift Weight - Pounds
$V_{lug} := W_{lift}$	$V_{lug} = 17100.00$	Lug Tensile Loading - Pounds
$B_{lug} := 49.5$		Lug Length - inch
$t_{Glugweld} := 0.375$		Groove Weld Size Lug to Head- inch
$t_{Flugweld} := 0.375$		Outer Weld Size Lug to Head- inch
$A_{lugweld} := 2 \cdot (t_{Glugweld} + t_{Flugweld}) \cdot 0.707 \cdot B_{lug}$		Total weld area in shear - sq inch
$\tau_{weld} := \dfrac{V_{lug}}{A_{lugweld}}$	$\tau_{weld} = 325.75$	Lug Fillet Weld Shear Stress -psi
$FS_{Lugweld} := \dfrac{\tau_{weldallowable}}{\tau_{weld}}$	$FS_{Lugweld} = 12.79$	Factor of Safety - Lug to Head attachment

Lug Shear

Loads are applied at the upper slot. The crane hook must shear through two Lug cross-sections in order to fail the Lug

$\tau_{allowable} := Sy_{Lift} \cdot 0.50$	$\tau_{allowable} = 4166.50$	lug allowable shear stress - psi
$t_{lug} := 1.25$		Lug thickness - inch
$h_{lug} := 1.5$		Minimum lug height in shear - inch
$A_{lug} := t_{lug} \cdot h_{lug}$	$A_{lug} = 3.13$	Lug shear Area - sq. inch
$t_{luy} := \dfrac{V_{lug}}{2A_{lug}}$	$t_{luy} = 2716.00$	Lug Shear Stress - psi
$FS_{Lug} := \dfrac{\tau_{allowable}}{t_{luy}}$	$FS_{Lug} = 1.52$	Factor of Safety - Lug

Finite Element Analysis

Afinite element model was developed based on the **LC** design found in Reference 9.4 to address the lift condition and confirm code calculations. The lift lug is used to distribute vertical loads into the **¾ inch** thick head and shell. The lug incorporates a central **5"** x 8-1/2" oval hole to ensure the crane hook can be engaged for remote lift. The 360-degree shell model considers **8** penetrations to evaluate peak stress intensities.

The stiffened head is expected to be compliant for ASME Section VIII internal pressure requirements since the previous calculations determined the 314' thick 2:1 elliptical head is sufficient for the design pressure. The finite element model simulates a ½ symmetric arrangement by application of shell elements at the center of vessel wall thickness (mid plane). The 17,100-pound lift load was applied to the upper oval cutout and the structural response was recovered.

The lug cross section is 12" in height at vessel center gradually decreasing to ½ inch tall at 49.5" diameter (lug width). It is groove and fillet welded from both sides to the ¾" upper head forming an integral arrangement. The lift loads are uniformly applied on the oval upper slot surface corresponding with the hook engagement.

The model recovers stress results for the pressure case by application of 150-psi pressure over the interior shell surfaces. For each load case the displacement boundary conditions are applied at the model cylindrical shell mid-span using a cylindrical coordinate system at the center of the section (X=R is radial, Y=Theta coordinate, Z is oriented toward lift lug).

Results from the finite element analysis for the lift condition are as follows (ref: Section 10 FEM plots):

Lifl Case

Component	Peak Stress Intensity (ksi)
%inch thick Elliptical Head	3.91 (outer surface under lift lug)
%inch thick Elliptical Head	1.20 (near outer shell weld)
%inch thick Elliptical head	2.70 (Near Penetrations)
1-1/4" thick Lift Lug	**8.05** (near upper slot)
Shell	0.60 (away from weld joint)

The allowable stress intensity at the outer surface is 8.33 **ksi.** Accordingly, the Factors of Safety at these **zones** are:

$FS_{Head} = 8.33 / 3.91 = 2.13$	Head Factor of Safety
$FS_{Lug} = 8.33 / 8.05 = 1.034$	Lift Lug Factor of Safety
$FS_{shell} = 8.33 / 1.20 = 6.94$	Shell Factor of Safety at weld joint

Note the stresses under the analysis slot oval are extremely low and the attachment points in this region are also low. Removal of the lug material below the slot has no adverse affect on the lug and head attachment design, as analyzed.

Corroded Geometry Considerations

The lift Lug is not subject to corrosion from the contents or the process or storage environments. The factor of safety for the head in the head is extremely large. The increment in stress intensity for the head is proportional to the inverse oft' where t is the head wall thickness. The increment in head stress intensity increases 44% from 3.91 to 5.63 ksi due to ratio of thickness squared (0.75^2 / 0.625^2) from the new to fully corroded condition. The minimum factor *of* safety for this condition is at the Lift Lug which remains greater than 1.

Results from the finite element analysis for the Pressure Case (200°F and 150-psig) condition are as follows (reference Appendix Section 10.1 FEM plots):

Pressure **(Hot)** Case

Component	Peak Stress Intensitv (ksi)
¾ inch thick Elliptical Head	12.30 (outer surface under lift lug)
¾ inch thick Elliptical Head	6.14 (near outer shell weld)
¾ inch thick Elliptical head	13.00 (Near Penetrations)
Shell	10.40 (away from weld joint)

The allowable stress intensity at the outer surface is 17.3 ksi (Table 3-1). Accordingly, the Factors *of* Safety at these zones are:

FS_{Head} = 17.3 / 13.00 = 1.33 Head Factor of Safety
FS_{shell} = 17.3/ 10.40 = 1.66 Shell Factor of Safety

Please refer to the Appendix (Section 10.1) figures (eight total) for more information.

Corroded Geometry Considerations

The Stress Intensity will increase for internal pressure imposed on the corroded geometry. The critical design region is the upper head due to thickness reduction from ¾-inch (corroded) to 518-inch (new). The design stress intensity increment is controlled by membrane stresses occurring in the region. Accordingly, the stress intensity at un-reinforced penetrations for this condition increases 20% from 13 to 15.6 ksi (0.75/0.625 =0.20). The cylindrical shell stress intensity will also increase 20% from 10.4 to 12.48 ksi due to 20% increase in hoop and longitudinal stress components. The limiting factor of safety for the fully corroded head condition remains acceptable as shown by:

FS_{Head} = 17.3 / 15.6 = 1.11 Corroded Head Factor of Safety

7.7.2 Axisymmetric Finite Element Model

A separate model was developed to recover stress intensity in the upper and lower head, skirt and cylindrical shell considering steady state thermal and mechanical loading. The model considers ½" thick lower head, ½" thick shell and ¾" thick upper

Zone of Stress Recoverv	Thermal Loadlng Stress **Intensity (Psi)**	Pressure Loading Stress Intensity **(Psi)**	Combined Loading Stress Intensity (Psi)	Allowable Stress Intensity **(Psi)**	Factor of Safety
Upper **Head**	<634	9,980	9,980	17,300	**1.73**
Lower Head	<634	13,200	**13,300**	17,300	**1.30**
Shell	<634	<9,980	9,980	17,300	**1.73**
Skirt Weld at Lower Head Juncture	<634	12,291	<12,000	17,300	**>1.44**

7.8 Reinforcements for Nozzle Penetrations

In consideration of reinforcement pads for nozzle penetrations, this evaluation **uses** vessel head area removed (A) by the penetration, pad reinforcement thickness (t_e), if required, excessive vessel area (A_{shell}) above the required 0.286 inch head thickness (corroded condition), and associated weld areas. Weld areas consider fillet type equal to the pad or nozzle. Weld areas are considered only when the penetration is reinforced.

Excessive vessel areas are shown to exceed the head area removed (A). The calculation does not consider excessive reinforcing shell area beyond D_p although it can be as large as twice the nozzle inner diameter. Accordingly, the calculation considers adjacent reinforcements not overlapping or exceeding ligament spacing between any two penetrations.

The head stresses are within stress intensity requirements without reinforcements as shown by the shell model. The level sensor nozzle has Increased with respect to the model (i.e. 5.563 versus 4.5) yet is expected to result in reduced stress concentration (and therefore reduced stress intensity) at its' edge since design ligament spacing belween holes are not changed from original assumptions of the model.

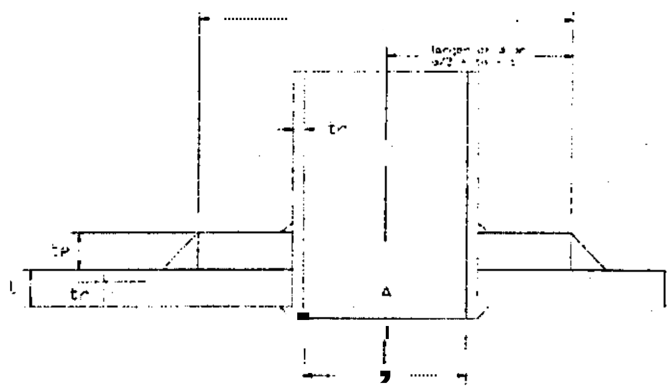


Table 7-2 - Penetration Re-Pad Assessment - Fully Corroded Head Condition

Pipe Nozzle	d	tr	A	Dp	tn	te	Apad	Awelds	t	Ashell	Areinf't
5" Sch 10 Level Sensor	5.295	0.286	1.514	7.5	0.258	0	0	0	0.625	1.795	1.795
3" Schedule 40 Outlet	3.06	0.286	0.875	NA	0.216	0	0	0	0.625	1.037	1.037
3"- 3000# Coupling Clean-Out	3.5	0.286	1.001	NA	0.357	0	0	0	0.625	1.187	1.187
2" Schedule 40 Vents	2.067	0.286	0.591	NA	0.154	0	0	0	0.625	0.701	0.701

With consideration of excess head area and the FEM analysis, no reinforcement pads are needed.

7.9 *Skirt Design with Additional Holes*

Evaluation is provided to determine stress intensities for skirt redesign with additional holes. The modification includes holes near the upper portion of the skirt attachment to the vessel, ½ shaped slots in the lower skirt support surface, and mid skirt section holes. The mid section holes are aligned with the upper holes. Stress intensities are low in magnitude near the lower support skirt support surface. Accordingly, an alignment slot feature (comparable slot size) to engage the cask orientation key can be safely provided with negligible effect on the evaluation. The construction and full penetration continuous skirt weld to shell is comparable to that forjacketed vessels as shown in Reference 9.2.

A single one-fourth symmetric shell model is provided to evaluate the structural response of the lower skirt area, lower head, and attaching cylindrical shell for internal pressure (150 psig) when combined with hot case temperatures (see axisymetric model thermal load description and appendix figures) and 1G design weight (17,100 lbs) static analysis conditions. The model considers fully corroded uniform upper head (5/8 inch thick), uniform shell (3/8 inch thick), uniform lower head (3/8 inch thick), and the skirt (1/2 inch thick) assembly configuration.

Displacement boundary conditions (restraints) are applied along the model at symmetric free edges and the lower skirt surface. Nodes along X=O have restraints Ux = Roty = Rotz =0 for translations and rotations. Similarly, nodes located along Z=O have Uz = Rotx = Roty = 0 restraints. Vertical supports (Uy=0) are applied at nodes along the lower skirt surface.

The results from this evaluation are as follows:

Zone of Stress Recovery	Combined Loading Stress Intensity (Psi)	Allowable Stress Intensity (Psi)	Factor of Safetv
Lower Head	**16,500**	17,300	**I.0S**
Shell	14,400	17,300	**1.20**
Skirt (Hole			

area within the grating boundary is 22.2% for a total of 404 square inches of metal area for the sludge to apply loads upwards.

Between the upper and lower grating, fourteen ½" sch.40 pipes are installed (not fastened) as sleeves surrounding each of the all-thread tie rods. Mechanical stops are included to retain the sleeves between the upper and lower support grids (grating).

The total upward grating load is a maximum of 606 pounds (1.5 psi x 404).

The average compressive force on each pipe is 43.3 pounds

Pipe column stability evaluation

½ inch schedule 40 pipe properties	
Inside Diameter	0.622 inch
Outside Diameter	0.840 inch
Cross Sectional Area	0.250 square inches
Moment of Inertia	0.026 inch ^{4}

The average pipe column stress is low (43.3 / 0.250 = 173.1 psi).

The allowable most conservative pipe load for stability assuming pinned ends is:

$P_{critical} = 3.14\ E\ I / L^2$ [Reference 9.61

For L = 32 inch, E = 28 million psi, I = 0.026 inch ^{4}

$P_{critical}$ = 2,233 pounds FS = 2233 / 606 = 3.68

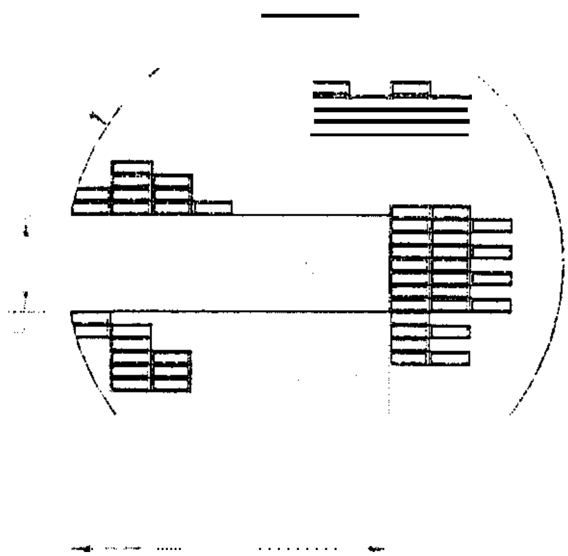
Since the critical load exceeds the applied load the pipes remain stable. Note this analysis does not consider the additional restraint (opposing the upward load) provided by the flex connection behveen the outlet header and the outlet nozzle.

The assembly is subject to 1G static loads downward.

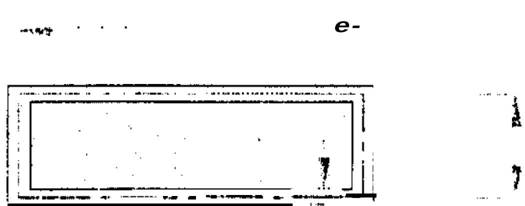
Total Filter Assembly weight acting onto the lower grate are as follows:

top grating with support bars:	130 lbs
bottom grating	94 lbs
all-thread and fasteners	20 lbs
filters	70 lbs
piping	125 lbs
sleeves and stops	35 lbs
The total Filter Assembly total weight:	474 **lbs**

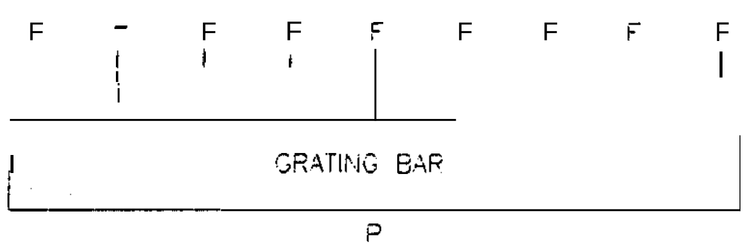
This exceeds the net force (difference of sludge growth force and weight) acting on the lower grate. Accordingly, 1G static tests will be used to qualify the assembly.



Lower Grid Overall Geometry



Individual Grating **Cell**



Lower Grid Free Body Diagram

8 Summary

8.1 ASME Code Vessel

The ellipsoidal head, shell and skirt thickness are shown to provide adequate safety factor beyond the allowable stress intensities for design. The design exhibits the desired corrosion allowance under all code vessel requirements imposed at longitudinal and circumferential weld seams.

The Specification (Reference 9.1) Section 7.3 requires the LC corrosion allowance of no greater than 3-5 millyr or 1/8" over a 30 year service life. The design exhibits excess material thickness far exceeding the specified corrosion allowance.

8.2 Lifting – Lug & Vessel

The analysis demonstrates that the lift lug and vessel design provides adequate margin beyond the allowable stress intensities based on ANSI 14.6 (ref. 9.3) criteria. The classical analysis develops proper weld and preparation to attach the lug to the upper head.

9 References

9.1 SNF-8163 Rev. 4, Performance Specification for the K Basin Sludge Transportation System – Project A-16, Fluor Hanford (Richland, Washington) for US DOE, March, 2002.

9.2 ASME Boiler and Pressure Vessel Code, Section VIII Division 1, 1998 Edition w/ Addenda.

9.3 ANSI N14.6, Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4,500 kg) or More

9.4 Large Container;drawing 3C40-0126-D Rev.1, K-East Basin STS Large Container Assembly.

9.5 ASME Boiler and Pressure Vessel Code, Section II, Part D, 1998 Edition w/ Addenda

9.6 Mechanical Engineering Design – Shigley, J. -Third Edition – McGraw Hill – Copyright 1977, 1972. 1963 ISBN 0-07-056881-2.

9.7 EN-3C-0126-03 Rev. C (full text not submitted to Fluor Hanford), K-East Basin Sludge Transport System, Large Container Thermal Analysis (60% Preliminary Design), February 2002.

9.8 Large Container drawing 3C42-0126-D Rev.1, K-East Basin STS Large Container Filter Assembly.

9.9 Email from Gary Sly to Mike Brubaker, "Change Order #3 GS to SS for LDC", dated August 8, 2002.

10 Appendix (Figures)

10.1 Half Symmetric FEM

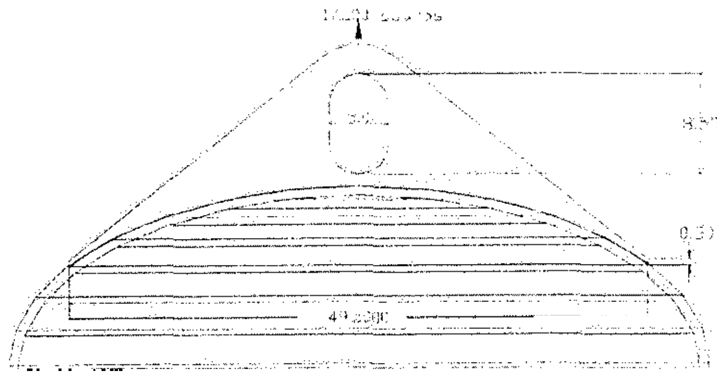


Figure 10.1-1 Free Body Diagram (Container Lift)

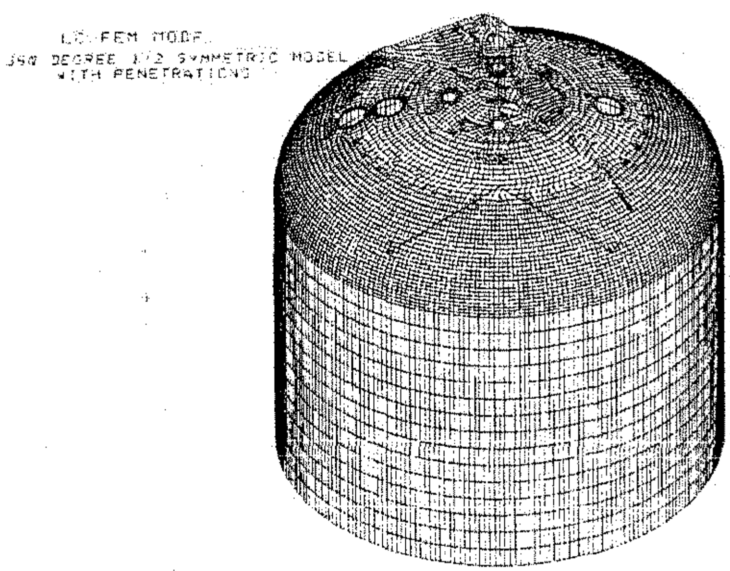


Figure 10.1-2 Large Container Finite Element Model

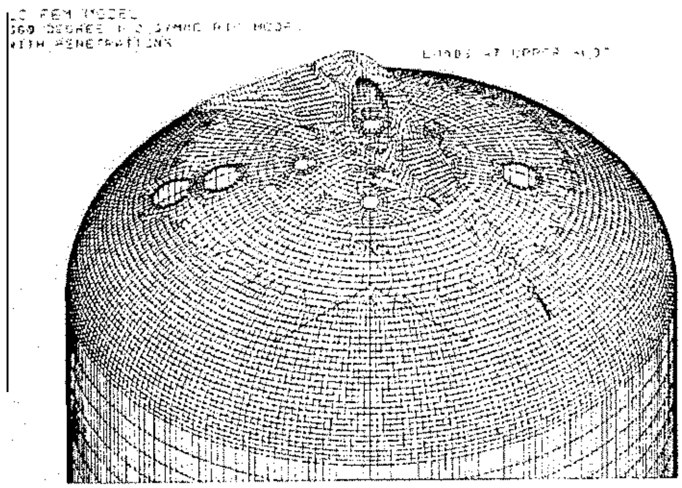


Figure 10.1-3 Large Container Finite Element Model
(Local View *of* Head with Applied Lift Loads)

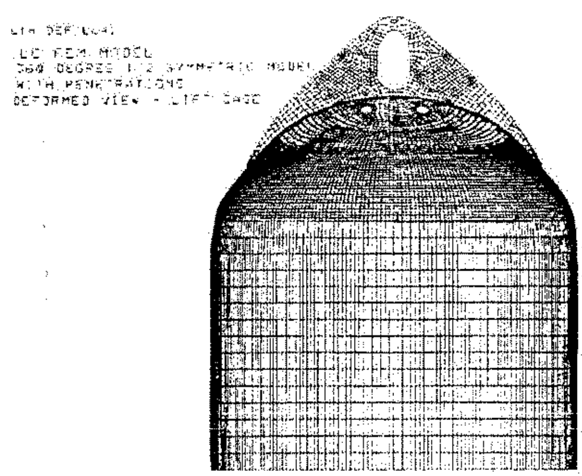


Figure 10.14 **Large Container under Lifting Loads**
(Deformed View- Pressure - "Lift Case")

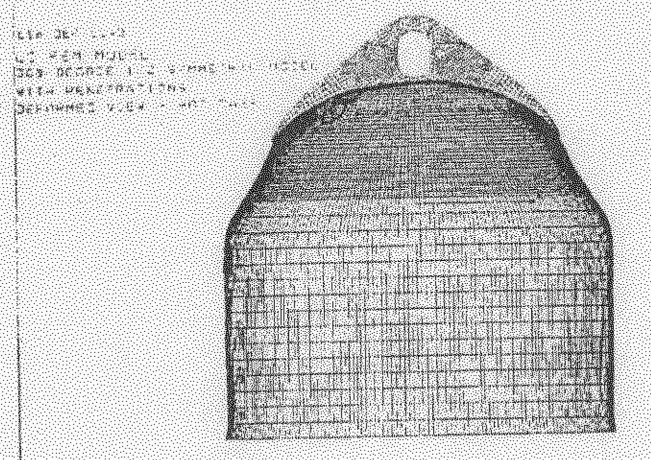


Figure 10.1-5 Large Container under Internal Pressure
(Deformed View- Pressure – "Pressure Case")

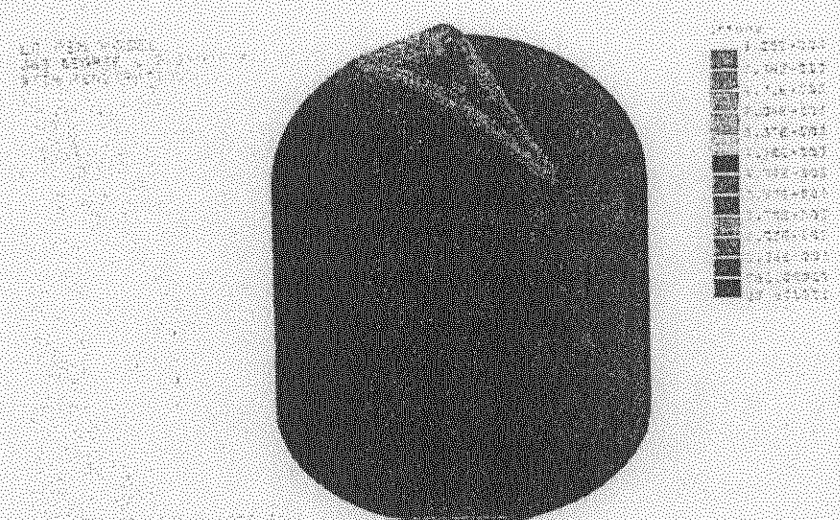


Figure 10.1-6 Large Container Finite Element Model
(Lift Case - Stress Intensity - psi)

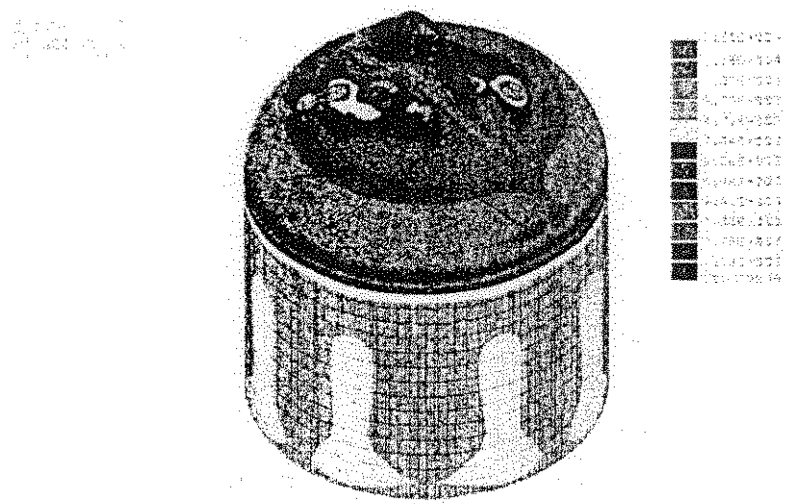


Figure 10.1-7 Large Container Finite Element Model
(Pressure Case . Stress Intensity – psi)

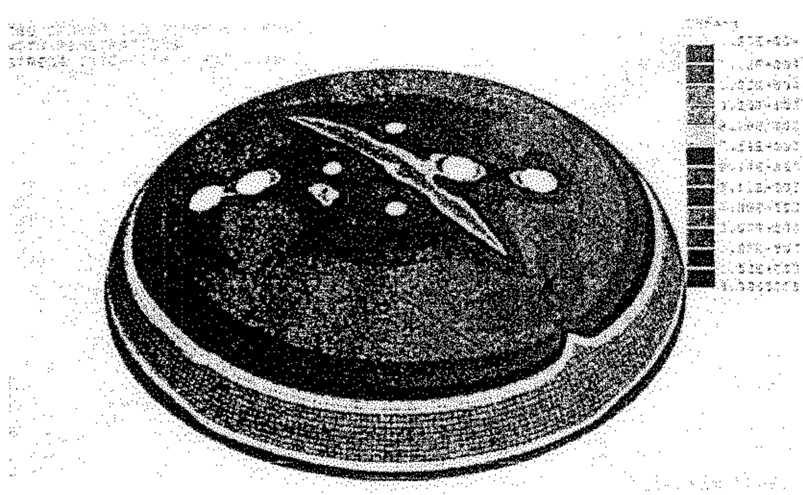


Figure 10.1-8 Large **Container Finite Element Model** Head **Local View**
(Pressure **Case - Stress Intensity – psi)**

10.2 Axisymmetric FEM

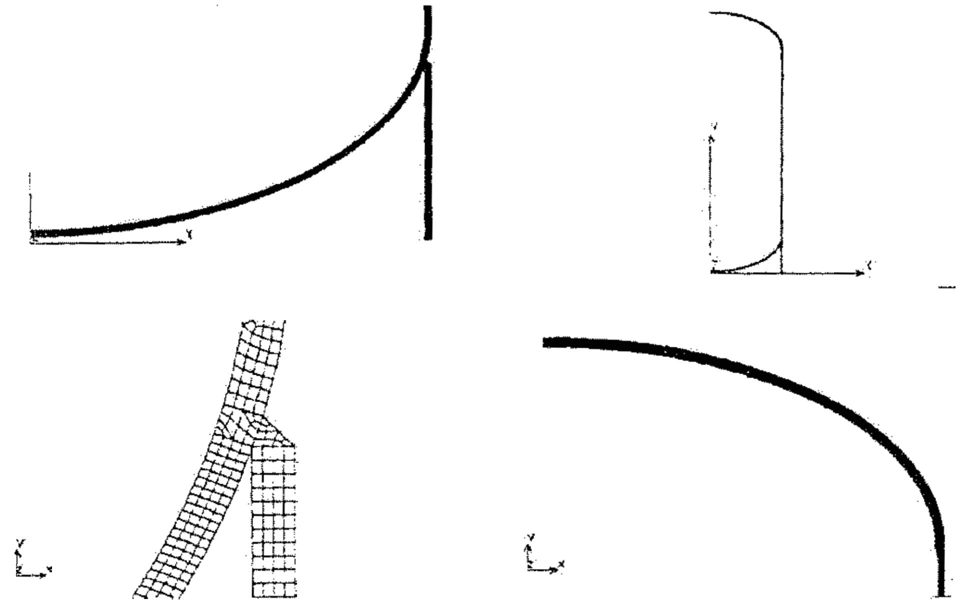


Figure 10.2-1 Axisymmetric Finite Element Model

(Views: Overall Model (Upper Right), Skirt to Lower Head, Upper Head to Shell)

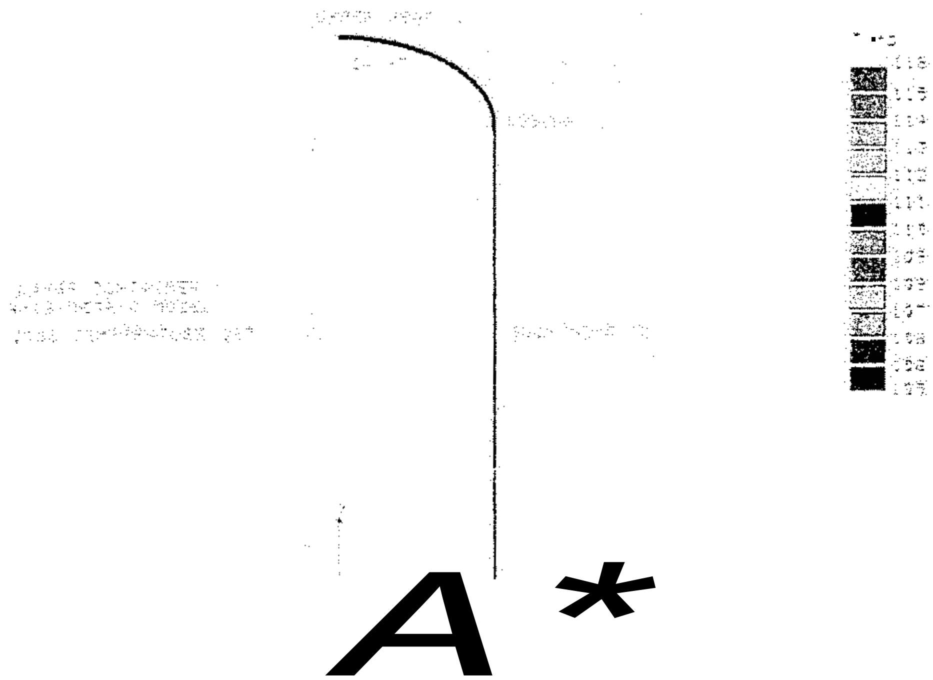


Figure 10.2-2 Axisymmetric Finite Element Model

(Isotherms: Pressure Case Steady State Temperature Field Loading)

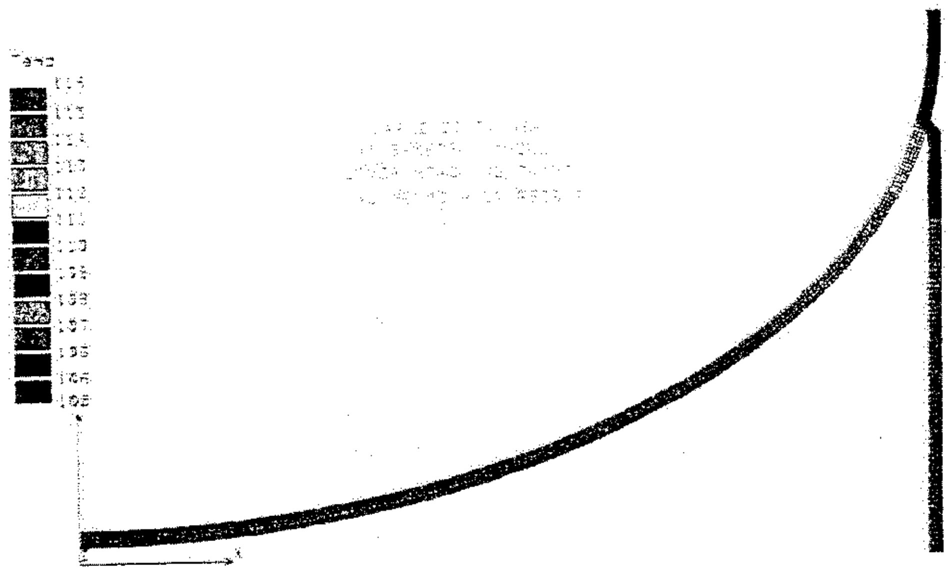


Figure 10.2-3 Axisymetric Finite Element Model

(Isotherms: Temperature Field Loading at Lower Head and Skirt)

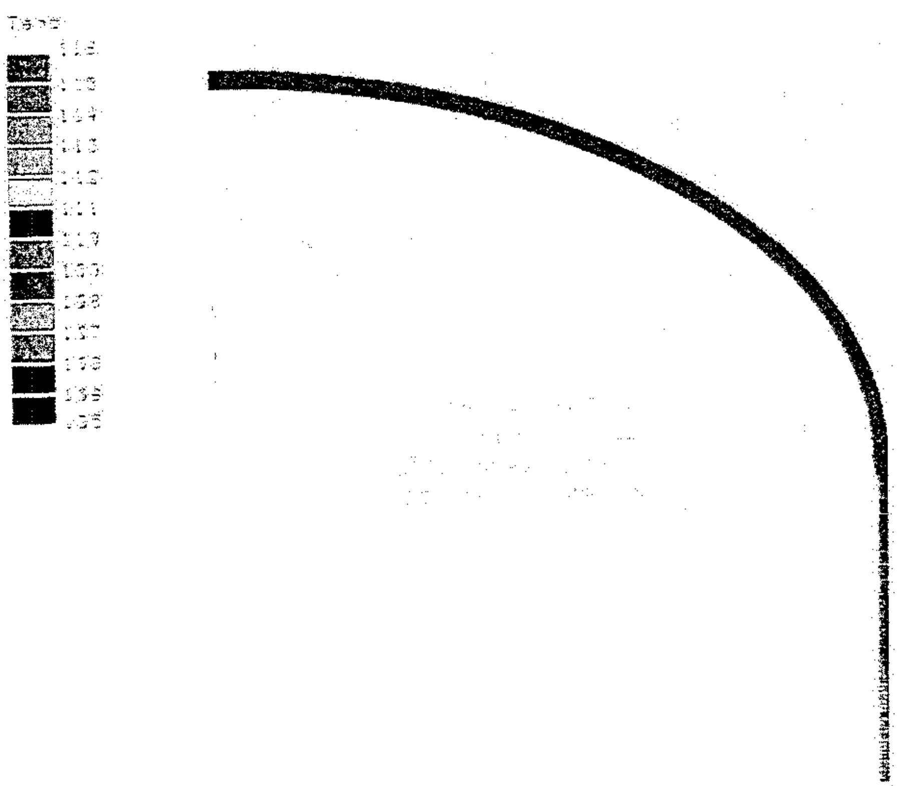


Figure 10.24 Axisvmetric Finite Element Model

(Isotherms: Temperature Field Loading at Upper Head to Shell)

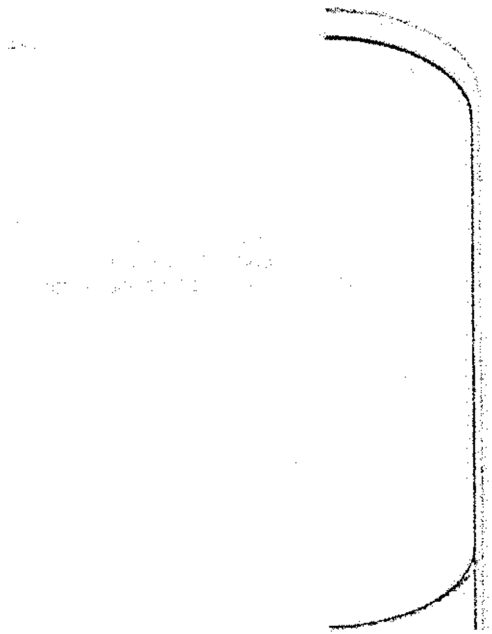


Figure 10.2-5 Axisymmetric Finite Element Model

(Thermal Loading: Deformed Shape)

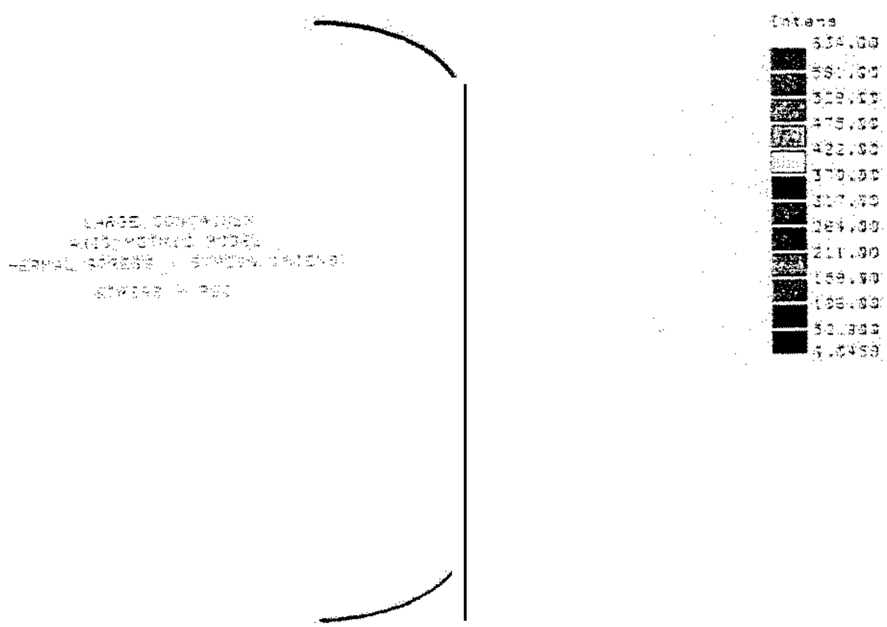


Figure 10.2-6 Axisymmetric Finite Element Model

(Thermal Stress: Stress Intensity - Psi)

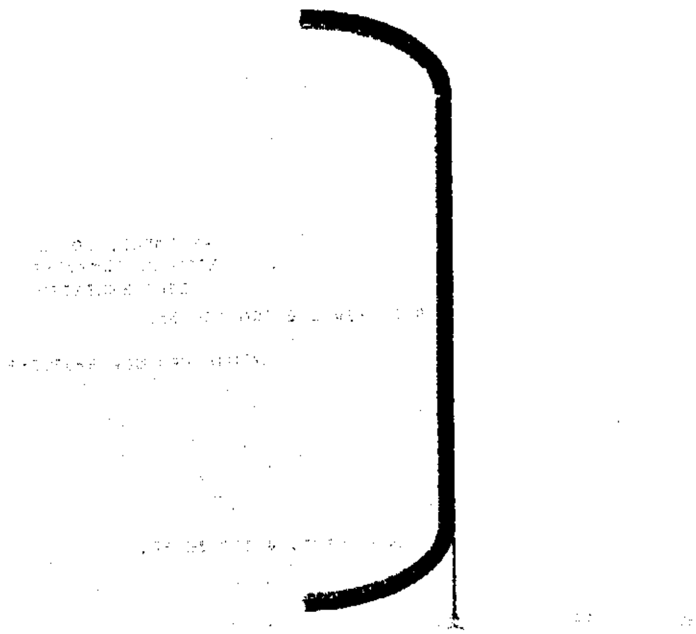


Figure 10.2-7 Axisymetric Finite Element Model
(Mechanical Pressure Load Vectors at Interior Surfaces, Vertical Restraint at Skirt)

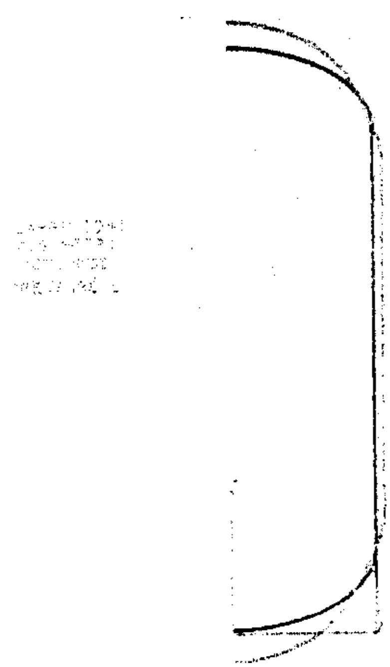


Figure 10.2-8 Axisvmetric Finite Element Model
(Mechanical Pressure Loading: Deformed Shape)

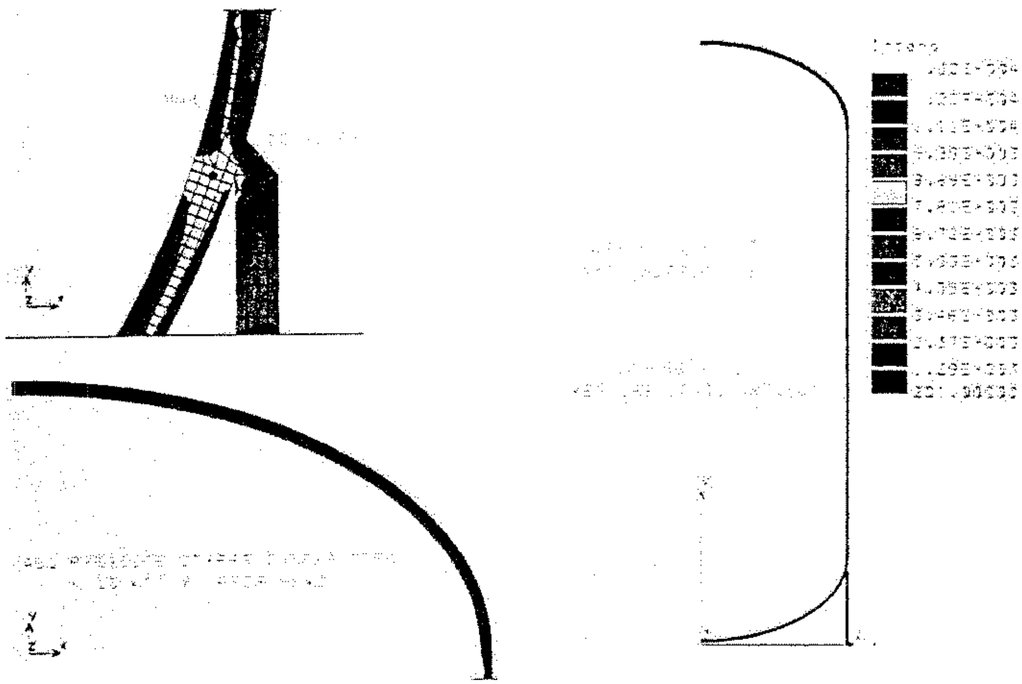


Figure 10.2-9 Axisvmetric Finite Element Model

(Mechanical Pressure Loading: Stress Intensity - Psi)

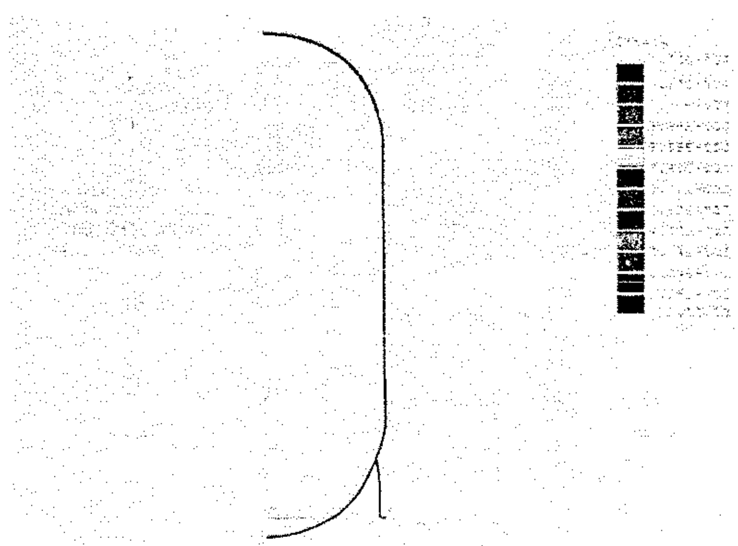


Figure 10.2-10 Axisvmetric Finite Element Model

(Combined Loading Stress Intensity & Deformed Shape - Psi)

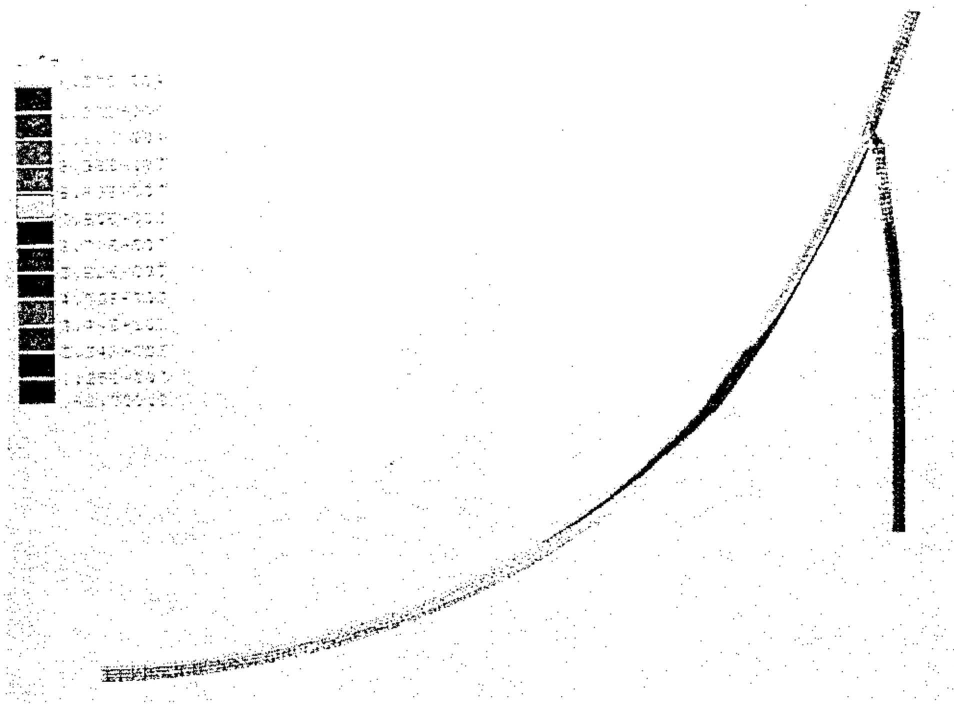


Figure 10.2-11 Axisvmetric Finite Element Model

(Combined Loading: Stress Intensity Deformed Shape @ Skirt / Head Juncture- Psi)

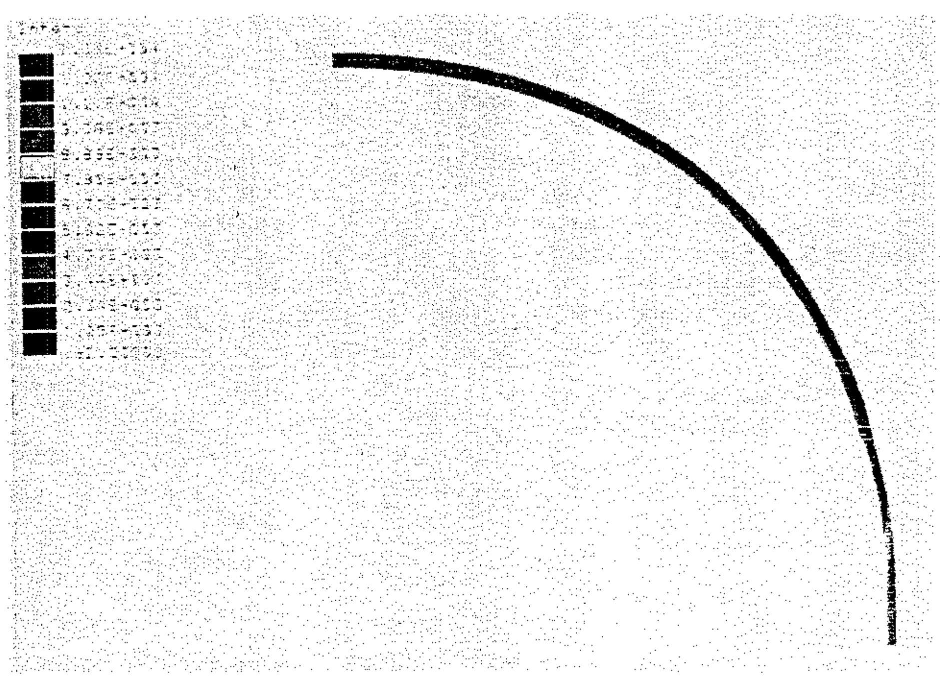


Figure 10.2-12 Axisvmetric Finite Element Model

(Combine Loading Stress Intensity Deformed Shape Upper Head / Shell- Psi)

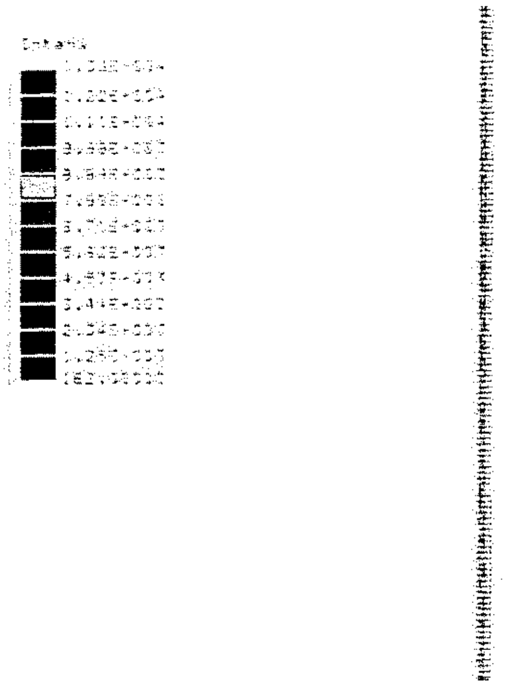


Figure 10.2-13 Axisvmetric Finite Element Model

(Combined Loading: Stress Intensity@Mid Shell Section- Psi)

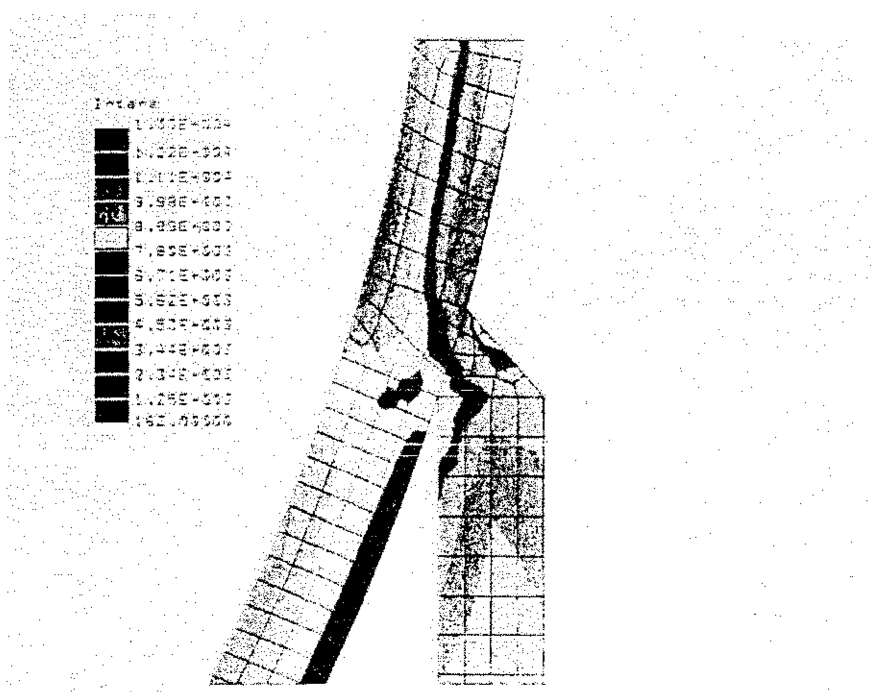


Figure 10.2-14Axisymetric Finite Element Model

(Combined Loading. Stress Intensity @Skirt Juncture- Psi)

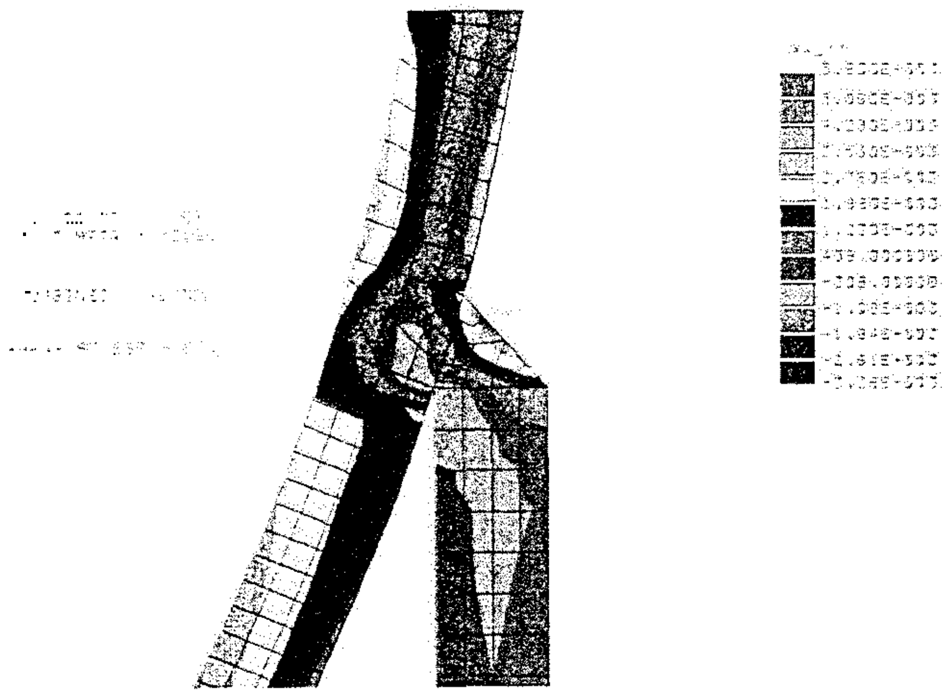


Figure 10.2-15 Axisvmetric Finite Element Model

(Combined Loading: Shear Stress @Skirt Juncture- Psi)

10.3 Skirt Quarter Symmetric FEM

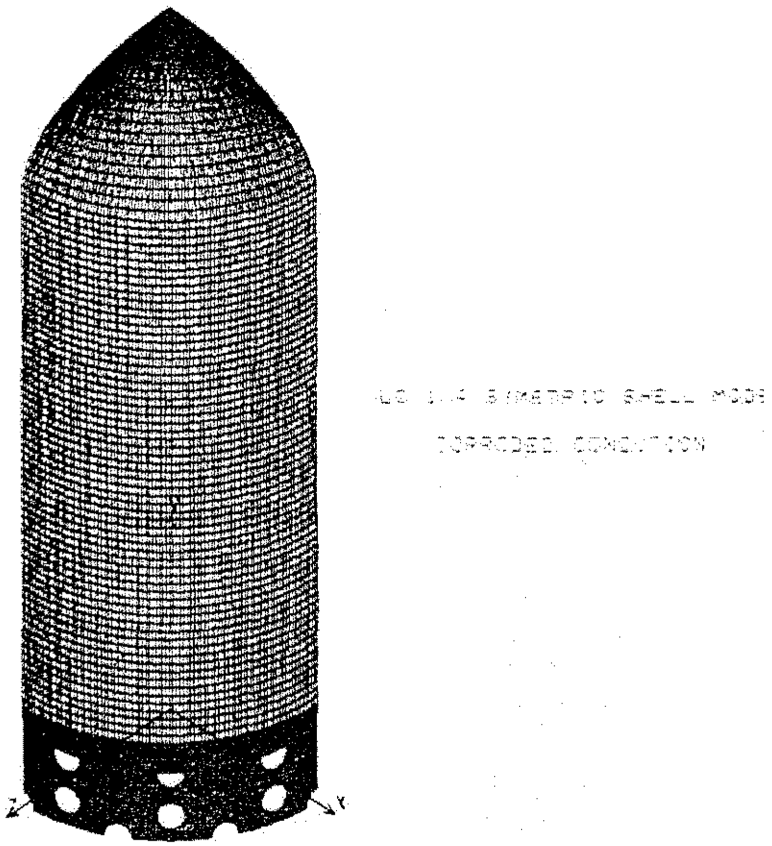


Figure 10.3-1 – ¼ Symmetric Skirt Shell Model

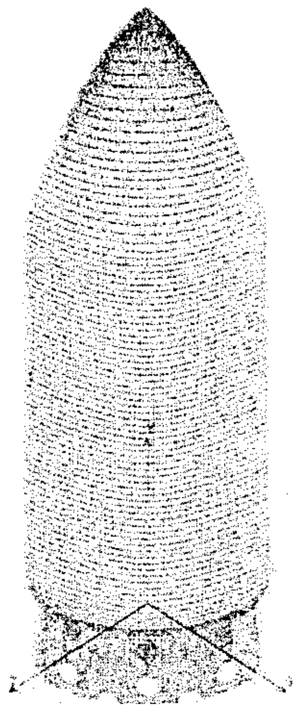


Figure 10.3-2 – Skirt Shell Model – Deformed Shape

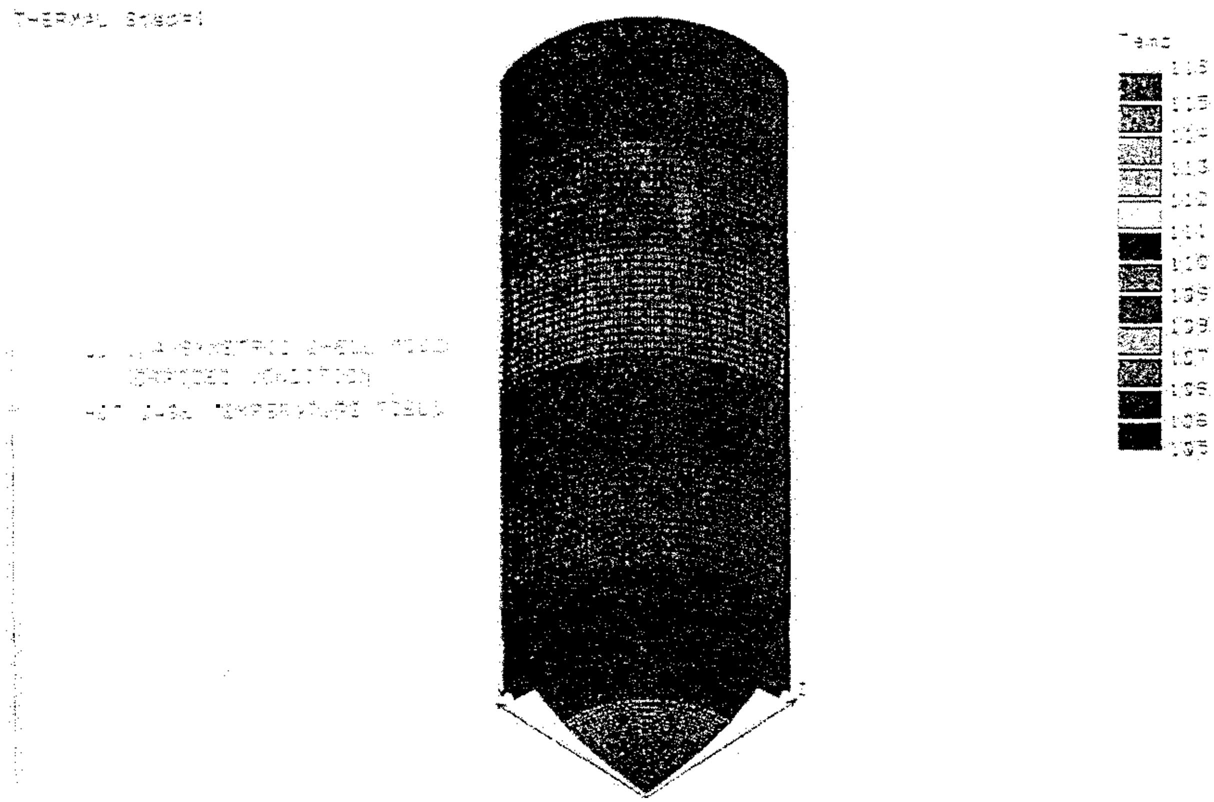


Figure 10.3-3 – Skirt **Shell** Model – Isotherms – **Hot Case**

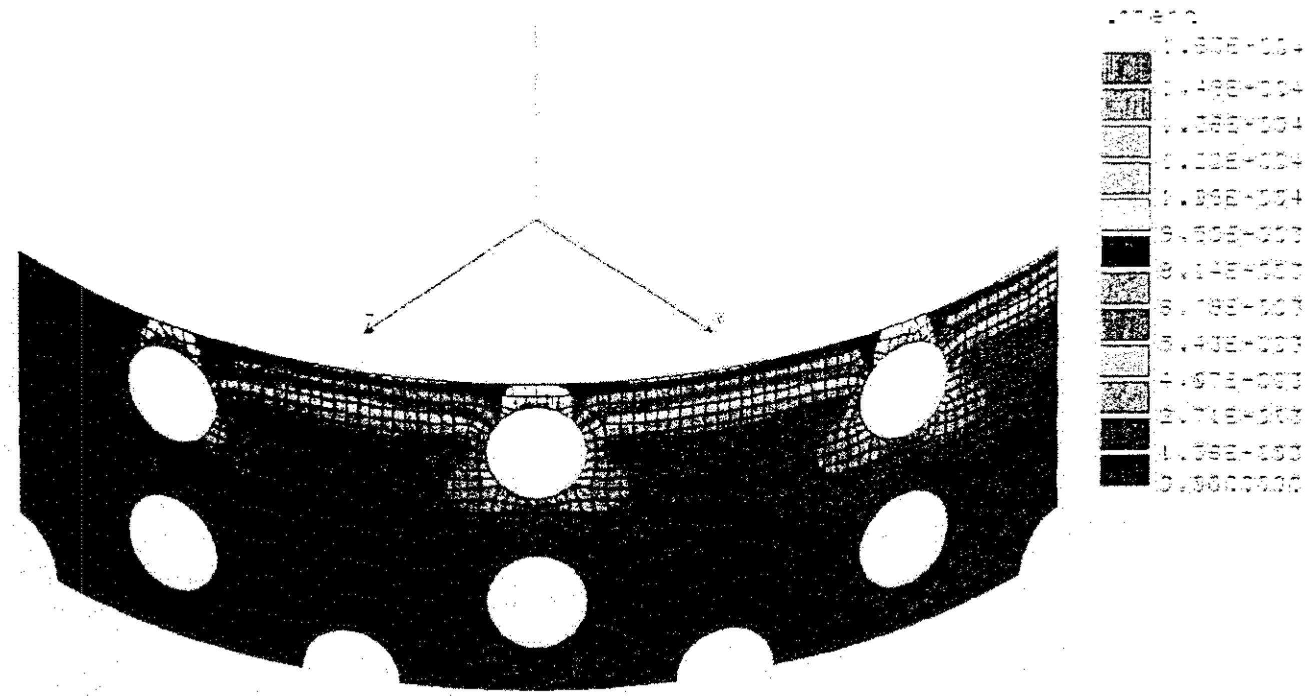


Figure 10.3-4 – Skirt Shell Model – Skirt Stress Intensity – psi

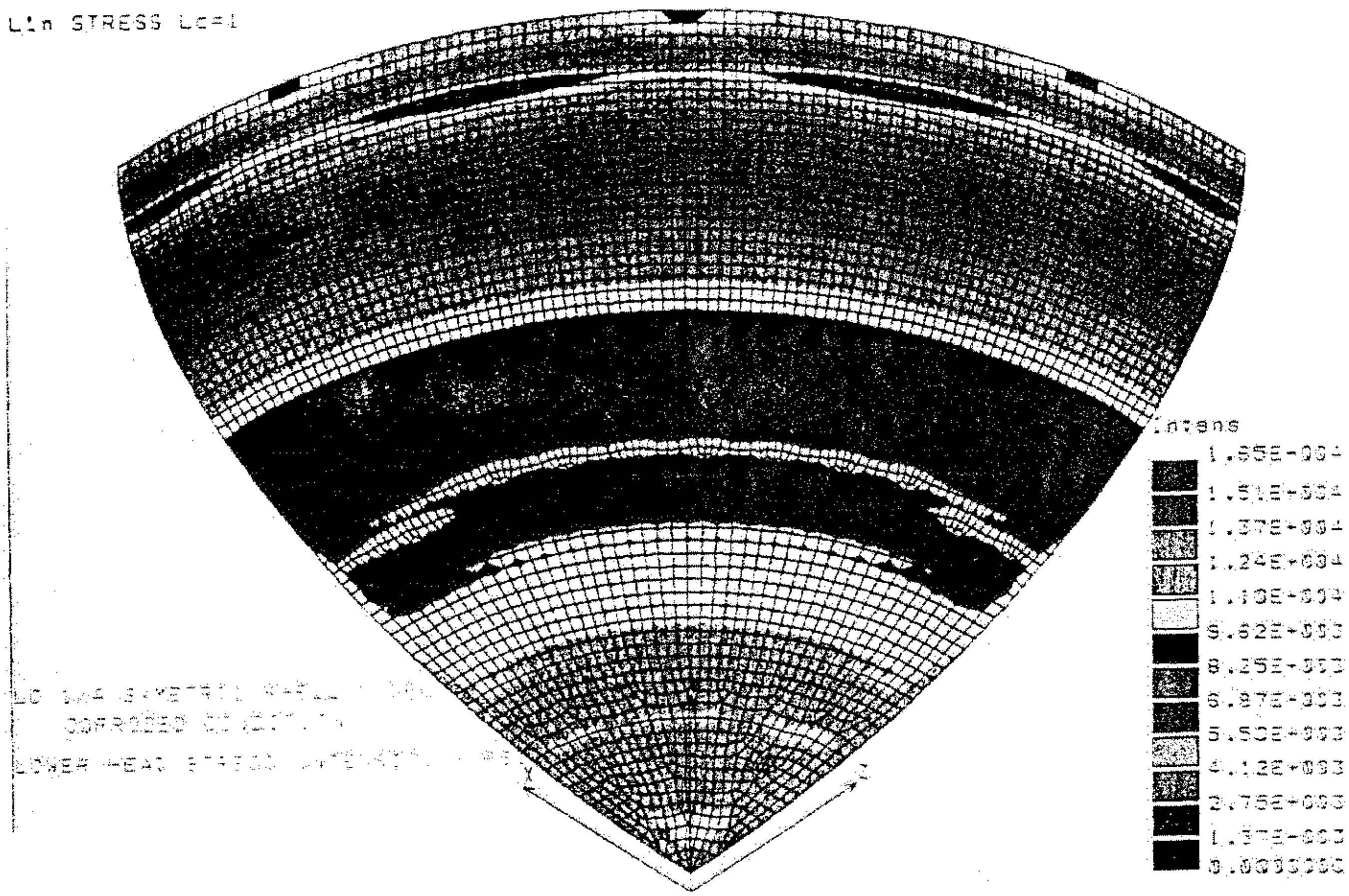


Figure 10.3-5 - Skirt Shell Model – Lower Head Stress Intensity – psi

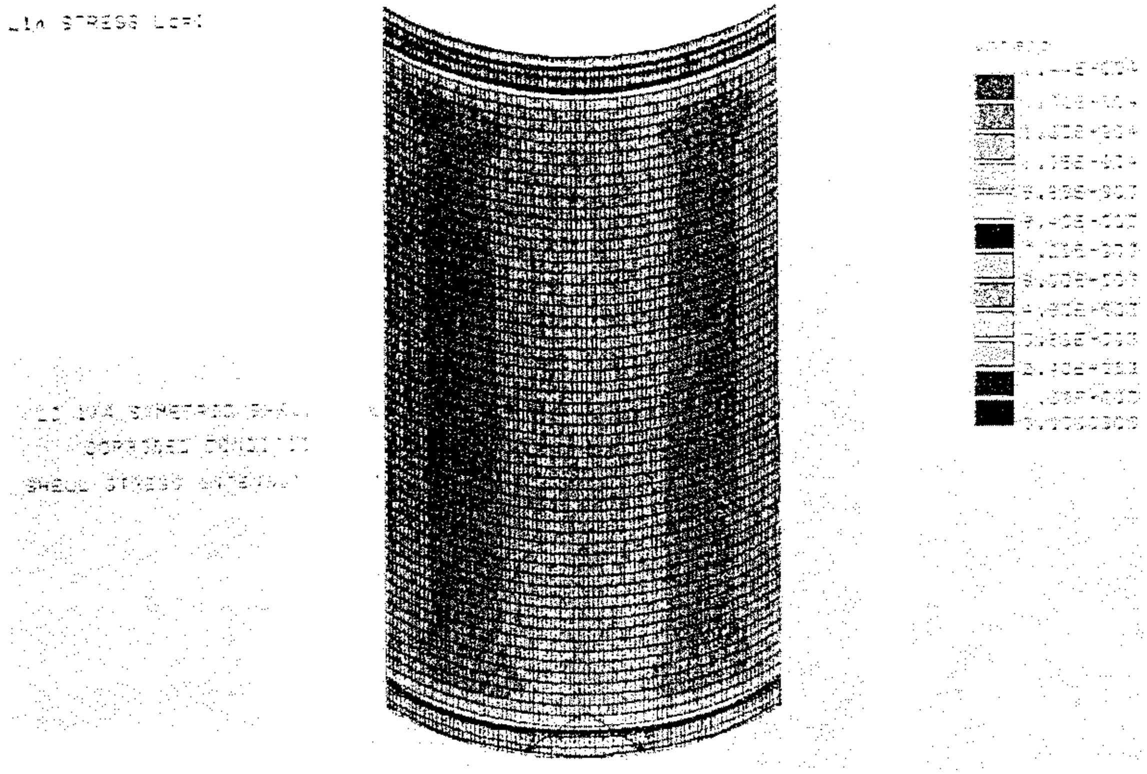


Figure 10.3-6 – Skirt **Shell Model – Circumferential Shell Stress Intensity – psi**

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A - Conforms to the Contract Requirements
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PACTEC	CALCULATION PACKAGE	Calc. No: 12099-21 Rev. 3 Page 1 of 23

Title: STS Process Shield Plate Analysis

Customer: Fluor Hanford Project No.: 12099

Prepared by: Jim Livingston Date: November 1, 2002

Checked by: Rick Migliore Date: 11/1/02

Approved by: Fred Yapuncich Date: 11/1/02

Summary Description:

This analysis evaluates the dose rates at the top of the Process Shield Plate (PSP) for 1) an off normal condition of the container completely filled with 60% KE floor sludge+40% KE canister sludge and 2) a 2.0 m^3 of revised activity waste composed of 60% KE floor sludge+40% KE canister sludge.

The 2.0 m^3 payload is modeled with 10" of water covering the sludge mix.

The specification dose limits are 20 mrem/hr at 30 cm above the shield for normal operations and 80 mrem/hr for the off-normal condition.

The average dose 30 cm above the shield plate for the current source term and shield design is calculated to be 20% above the limit at 24.3±0.5 mrem/hr. This dose rate is sensitive to the cover water thickness and source distribution. Calculated doses adjacent to the shield plate (in areas were operators are likely to be standing) meet the 20 mrem/hr dose limit for the normal operations and the 80 mrem/hr limit under off-normal condition. The off-normal dose limit is calculated to be exceeded directly over the penetrations when the tank is overfilled.

Document Revision	Affected Pages	Revision Description	Approved by: Name/Date	Names of Preparers & Verifiers
0	All	Initial issue	Fred Yapuncich/ 5/13/02	JV Livingston RJ Migliore
1	All	Revised Source Term	Joe Nichols/ September 2002	JV Livingston RJ Migliore
2	All	Revised and Additional penetrations	Joe Nichols/ September 2002	JV Livingston RJ Migliore
3	9-23	Revised penetrations and puck locations	Fred Yapuncich / November 2002	JV Livingston RJ Migliore

DESIGN REVIEW SUBMITTAL
30% ☐ 60% ☐ 90% ☒ DRFT ☐
(X) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: Date: 11-1-02

11/1/02

TABLE OF CONTENTS

1.0 Introduction

The K Basins, built in the early 1950's, have been used to store irradiated N Reactor SNF underwater starting in 1975 for K East (KE) Basin, 1981 for K West (KW) Basin, and much earlier for Single Pass Reactor SNF. In 1992, the decision to deactivate the Plutonium Uranium Reduction Extraction (PUREX) Facility precluded processing the approximately 2,100 metric tons (2,3 15 tons) of heavy metal from the SNF left in the K Basins, where it has remained. The SNF in the KE Basin is stored in'open-top canisters; some have closed bottoms while others have screened bottoms. The SNF in the KW Basin is stored in canisters that have closed tops and bottoms; therefore, most of the corrosion products are retained within the canisters. A significant fraction of the SNF in the K Basins has become degraded due to cladding breaches during reactor discharge. Corrosion has continued during underwater storage.

Associated with this SNF is an accumulation of particulate-layered material that is generally called sludge. Sludge is found on the basin floors, in canisters, and in the basin pits. As defined by the SNF Project and used herein, the term “sludge” refers to particulate matter that shall pass through a screen with 0.64 cm (0.25 in.) openings. The sludge is composed of irradiated nuclear fuel, fuel corrosion products, cladding, storage canister corrosion products, structural degradation, and corrosion products from features in the basin pools (e.g., racks, pipes, sloughed off concrete, etc.), beads lost from Ion Exchange Modules (IXM beads), environmental debris (e.g., wind blown sand, insects, pieces of vegetation, etc.), and various materials accumulated through the operation (e.g., sand filter media, hardware, plastic, etc.) of the basins over the past 30 years [Reference 6]. The estimated total sludge volume in the KE Basin is nominally 43.8 m^3 (1 1,572 gal) [Ref. 9]. The total sludge volume in the KW Basin is estimated to be nominally 6.66 m^3 (1,759 gal) [Ref. 9].

The SNF Project mission includes safe removal and transportation of all sludge from these storage basins to a more secure storage state in the 200 West Area (currently identified as T Plant). This calculation estimates the dose rates in the vicinity of the process shield plate for the prescribed source term. Sludge transferred from KW in the “small” container is beyond the scope of this calculation.

2.0 Design Input

2.1 *Discussion*

The “as-settled sludge” is a radioactive mi› re of solids and interstiti ısin w: r (approximately 30 vol% solids). The solids consist of windblown sand, vegetation, and insects; spalled concrete from the basin walls, iron and aluminum corrosion products, ion exchange resin beads, uranium oxides, uranium fuel particles and other debris that may have fallen into the basin. The basin process water is radioactive and provides the covering to the sludge. The process water comes from loading and flushing operations. Table 2-1 lists some of the basic design properties used for the sludge.

Table 2-1 Design Basis As-Settled Sludge Properties

	Large Container Sludge Sources	
	KE Floor	KE Canister
Density	1.4 g/cm³	1.9 g/cm³
Percent Water (Vol%)	65%	70%
Total U (1)	0.060 gU/cm³	0.77 gU/cm³

References 1 and 8 provide a description of "floor" and "canister" sludge characteristics that are required to be used. The canister sludge has a larger radionuclide inventory. A homogeneous mixture, i.e., payload, of floor and canister sludge is modeled. The payload configurations considered for the large container:

1) the off normal condition of a container completely filled (maximum payload of 4.15 m^3) with 60% floor and 40% canister sludge and;

2) 71 ft^3 (2.0 m^3) of KE 60% floor and KE 40% canister sludge with a nominal cover of 10 inch (25.4 cm) of basin process water.

2.2 Geometry

As discussed above, the large container will consist of 2.0 to 4.15 m^3 of settled sludge, with a nominal cover of 10 inches (25.4 cm) of basin process water when possible. The large container wall thickness is ½ inches (1.27 cm) thick, has an outer diameter of 59 inches (149.86 cm) and is elliptical on each end. The processes shield plate is 5.5 inches thick with several strait access penetrations. See Figure 2-1 for a visual *summary* of the geometry and Section 6.0 for a discussion of the shielding assumptions.

Each source of sludge is a unique, non-homogeneous mixture, possibly containing irradiated fuel, fuel corrosion products, and/or fission products in addition to non-radioactive debris. The KE floor, KW floor, and KW Canister inventories given in reference 8 (HNF-SD-SNF-TI-015, Rev. 9, Spent Nuclear ***Fuel Project Technical Databook,*** Volume 2, Sludge, Fluor Hanford, Richland, Washington, 2002) are design basis values and do not necessarily represent an individual shipment payload.

PACTEC CALCULATION SHEET

Title	*STS Process Shield Plate Analysis*	*Calculation Number* 12099-21	*Revision* 3
Project Name	*Sludge Transportation System*	*Project Number* 12099	*Page* 5 of 23

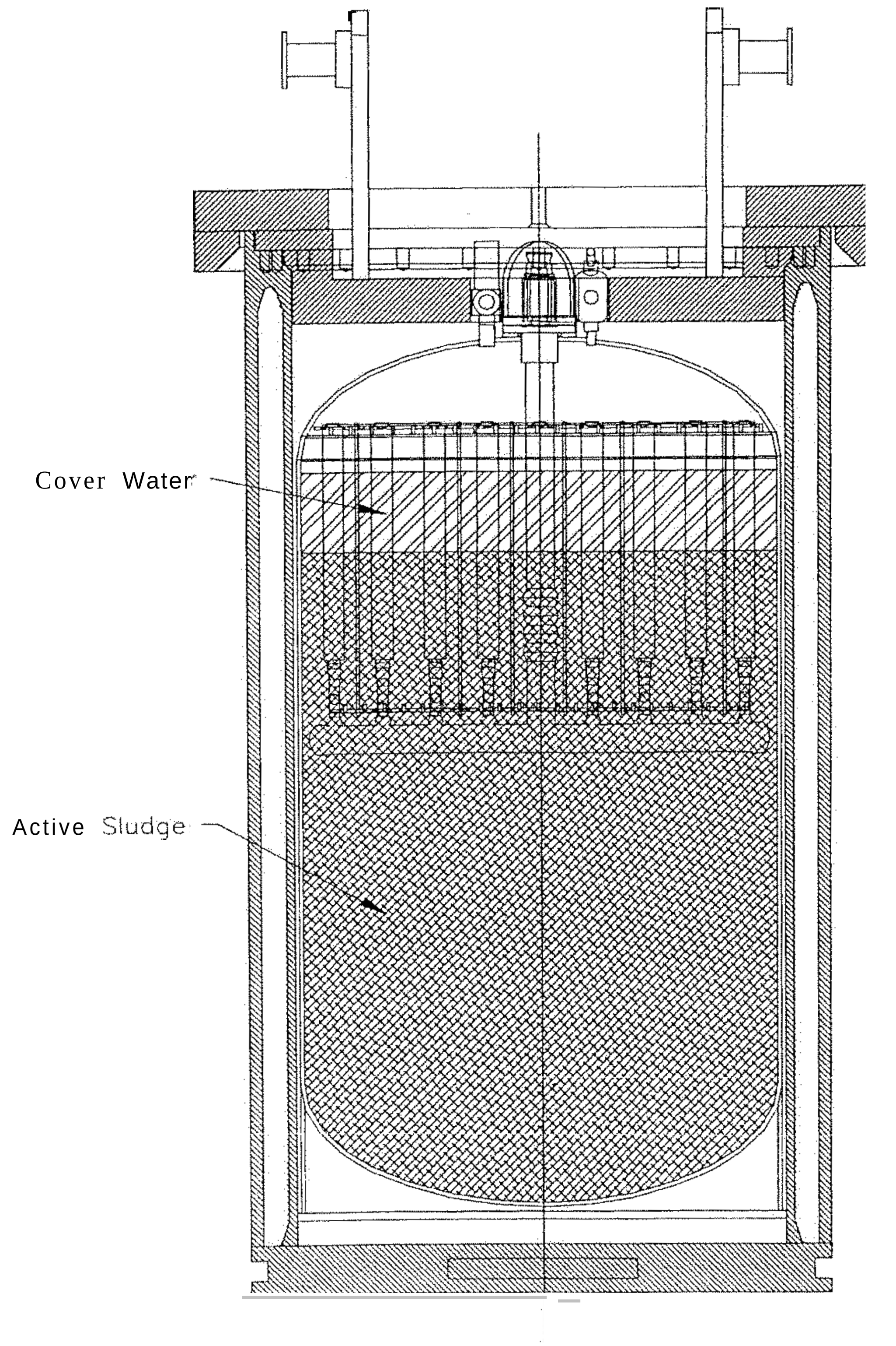

Figure 2-1 Source Term Geometry

11/01/02

2.3 Functional Requirements

Section 10 of [Ref. 1], specify the following functional requirements for the Process Shield Plate:

- Shielding thickness shall be designed based on the highest specific-activity sludge, with the sludge settled to the bottom of the large container. Individual large containers (in the cask with the process shield plate on) shall be < 20 mrem/hr at 30 cm. The design shall mitigate radiation streaming from the penetrations. If lead is used, it shall be isolated from contact with radioactive material.
- Process shield plates shall be designed per 10 CFR 835, subpart K and shall be documented per 10 CFR 835, Section 704(b).
- The off-noma1 and/or accident conditions shielding evaluation shall be with the sludge filling the canister volume. The off-normal conditions dose above the Process shield Plate shall be limited to <80 mrem/hr at 30 cm.

2.4 Source Term

The design payload for the large container is as 80-vol% KE floor and 20-vol% KE canister sludge (80/20) and the worst case ratio is 60/40 (reference 1) is used. HNF-SD-SNF-TI-015 (reference 8) provides the shielding design basis source term and Table *2-2* lists the revised source term based on Revision 9 of TI-015. The source inventories for the large container are based on a mixture of the floor sludge and the KE canister sludge. The curie inventory for the large container is assumed decayed to May 2000 (time at which the last samples collected from the KE Basin were analyzed). HNF-SD-SNF-TI-015 lists the mass and activity of the basin process water. This activity is considered for the interstitial, cover water and filter loading. Details of the source term development are presented in reference 10. The revised source term for this calculation was processed using ORIGEN-S to generate a new and lower photon spectrum following the same process as presented in reference 10.

The radioisotopes given in the tables include only those reported in the project specification [Ref. 8]. Other unlisted isotopes of importance include ^{208}Tl and ^{212}Bi, which are decay products of ^{236}Pu and contribute to the high-energy gamma-ray source; and ^{144}Pr, ^{106}Rh, and ^{125}Sb, which also make major contributions to the gamma ray source term. As part of the design analysis, further evaluations (e.g., ORIGEN decay calculations) will be conducted by the buyer (Fluor Hanford) to ensure the design is bounded and shall meet the performance requirements prescribed herein.

Table 2-2 - Large Container Shielding Design Basis Revised Source Terms

Isotope	Rev 9 of TI-015 Sludge Reference Data		Bounding Sludge (60% floor, 40% canister)	Water
	Floor	Canister		
	Ci/m³	Ci/m³	Ci/m³	Ci/m³
^{241}Am	1.22E+01	1.12E+02	52.12	5.3E-03
^{237}Np	3.67E-03	1.54E-02	0.008362	(1)
^{238}Pu	2.05E+00	2.31E+01	10.47	(1)
^{239}Pu	8.26E+00	8.91E+01	40.596	(1)
^{240}Pu	4.54E+00	4.89E+01	22.284	(1)
^{241}Pu	2.44E+02	2.63E+03	1198.4	(1)
^{242}Pu	2.19E-03	2.36E-02	0.010754	(1)
^{60}Co	9.98E-01	9.44E-01	0.9764	6.4E-04
^{137}Cs	2.52E+02	1.02E+03	559.2	3.3E-02
^{134}Cs	6.03E-02	2.84E-01	0.14978	5.8E-06
^{152}Eu	1.09E-01	(1)	0.0654	(1)
^{154}Eu	1.92E+00	1.40E+01	6.752	6.9E-04
^{155}Eu	9.44E-01	7.91E+00	3.7304	5.0E-04
^{90}Sr	1.88E+02	1.82E+03	840.8	1.5E-02
^{99}Tc	(1)	1.54E+01	6.16	(1)

Notes:

(1) No data reported.

3.0 Material Properties

The important material properties of the cask are given in Table 3-1. A lower steel density of 7.82 g/cm³ was conservatively used in the calculations, rather than a more nominal value of 8.02 g/cm³. A single sludge composition is used, with a density of 1.41 g/cm³ for the 60140 sludge.

Table 3-1: Material Densities and Material Compositions Used in Calculation Models.

Material	Density (g/cm³)	Density (a/b-cm)	Composition Isotope	Composition Mass fraction
Sludge -[30 vol% SiO_2, 70 vol% Water)	1.41	0.09452	H	0.05890
			O	0.71969
Lead	11.35	0.03298	Pb	1.000000
SS-304	7.81	0.08634	C	0.00080
			N	0.00100
			Si	0.00750
			P	0.00045
			S	0.00030
			Cr	0.19000
			Mn	0.02000
			Fe	0.68745
			Ni	0.09250
Water/filter	1.00	0.10032	H	0.11193
			O	0.88807
Air	0.00123	0.0000513	N	0.75633
			O	0.24367

4.0 Conditions Analyzed

The source terms identified in Section 2.4 are analyzed with the shield plate in place and all transfer connections (e.g., fill and vent pipes) removed. Each source term is evaluated with the shield plate and penetrations. Average dose rates are calculated above the shield plate and in adjacent areas that may be accessible.

5.0 Acceptance Criteria

Shielding thickness shall be designed based on the highest specific-activity sludge, with the sludge settled to the bottom of the large container. Average doses from individual large containers (in the cask with the process shield plate on) shall be < 20 mrem/hr at 30 cm in the areas that are typically accessible to the operators. The design shall mitigate radiation streaming to the extent possible given that the penetrations will be straight through the shield. Lead will be isolated from contact from the radioactive material.

Shielding shall meet the requirements set forth in 10 CFR 835, subpart K, for loading and cask lid operations and shall be documented per 10 CFR 835, Section 704(b).

6.0 Assumptions

The density assumed for the sludge is **1.41** g/cm^3 with composition mix of 30 vol% solid (assumed to be SiO_2) and 70 vol% water for the 60/40 sludge **source.** Because the payload region is large, this material provides significant internal attenuation

Isotopes not listed in the reference source term are ignored. The source term is assumed to be homogenous within the sludge volume.

The filters are analyzed assuming a 275 gram loading of sludge material. Due to the vertical orientation of the filters and radiation streaming concerns, attenuation by the filters is ignored. The filter source is uniformly distributed over 28 vertical inches from the hemispherical head joint down to **just** above the 10" water layer.

7.0 Calculations

The source term and geometry model is based on the "STS Cask Shielding Analysis" (Reference 10) and changed for this STS Process Shield Plate Analysis. The main differences are: the sludge volumes; sludge radionuclide inventory; the lid of the cask is replaced with a steel process shield plate; and dose rates *are* tallied at 30 cm intervals above the top of the process shield plate.

7.1 Source Terms

The "STS Cask Shielding Analysis" (Reference 10) concluded that the dose from the neutron sources was inconsequential and the doses are dominated by the photons from the waste. Consequently, this STS Process Shield Plate Analysis considers only photons from the waste.

"STS Cask Shielding Analysis" (Reference 10) used ORIGEN-S to obtain the neutron and photon source terms in the sludge. The inventory was revised from the reference to that listed in Table 2-2. Using this radioisotope inventory an energy dependent photon source spectra calculated with **ORIGEN-S** is obtained **as** given in Table 7-2 for the sludge mixtures and the water. ORIGEN-S determines the photon intensity at discrete photon energies to exactly conserve energy **so** these discrete energies are used **to** specify the photon source in MCNP.

The photon source intensity for each energy group is orders of magnitude less in the water than in the sludge **so** the activated water is negligible within the sludge.

The filter loading was assumed to be 275 grams of sludge mix (60/40 mix) over a 28 inch vertical volume (above the 10 inches of cover water). The filter loading source term was found by multiplying the sludge source by the ratio ***of*** the densities. For the 60/40 sludge at a density of **1.41** g/cm^3 the density the filter **source** is 1.258×10^9 p/s.

The source strengths and spectra are listed in Table 7-1 and Table 7-2. These source calculations are performed in the 'Source Term" sheet of the Excel file "Working3".

Table 7-1 Photon Source Strength for Shielding Calculations

Source Region	Source Volume (m^3)	Source Strength (PhotonsIs)
Sludge, nominal	2.0	1.2885e14
10” Water	0.4330	1.0226e9
Filter	1.21	1.258e10
Total-nominal	3.64	1.2886e14
Sludge, Accident	4.15	2.673e14

Mean Photon Energy (MeV)	Rev 9 of TI-015 60/40 Sludge (Photons/m^3/s)	Rev 9 of TI-015 Water (Photons/m^3/s)
0.01	2.30E+13	5.35E+08
0.03	8.63E+12	2.53E+08
0.055	5.52E+12	1.83E+08
0.085	2.66E+12	5.91E+07
0.12	1.91E+12	4.95E+07
0.17	1.76E+12	3.41E+07
0.3	1.86E+12	3.58E+07
1.13	3.44E+11	7.16E+07
1.58	1.90E+10	8.49E+05
2	7.45E+08	1.39E+04
2.4	4.62E+06	8.72E+00
	[illegible]	
3.25	9.79E+03	2.37E-02
3.75	5.63E+03	1.19E-02
4.25	3.24E+03	5.97E-03
4.75	1.87E+03	3.00E-03
5.5	1.68E+03	2.23E-03
Total	6.442E+13	2.36E+09

7.2 MCNP Model Specification

The dimensions utilized in the MCNP calculation models for NCT are summarized in Table 7-6. An axial view of the MCNP model is shown in Figure 7-1 with expanded views of the process shield plate vicinity shown in Figure 7-2 and Figure 7-3. The cask steel and lead are divided into additional regions for optimization. Five MCNP geometry models were utilized, as listed in Table 7-3, where they differ by the treatment of the source strength and dimension. The photon source strength ($p/m^3/s$) in HNF-SD-SNF-TI-015 is multiplied by the volume of the source. The photon sludge source is uniformly distributed over the 2.0 cubic meters of sludge. The water source is uniformly distributed over 10 inches of water. and the filter source is distributed over 28 inches of air. The analysis assumes there is 275 g of sludge in the filter volume. The total source strengths of these MCNP models are listed in Table 7-3:

Table 7-3: MCNP Case Identification

Case	Shield Penetrations	Source	Source Volume	Total Source Strength
Psp5zi	na	Rev 9 of TI-015 60/40 sludge and water	$2.0 m^3$ sludge +10" water and 275 g filter	1.2886×10^{14} (p/s)
Psp70zi	Open	Psp5zi tape	Uses Psp5zi	1.2886×10^{14} (p/s)
Psp71zi	Plugged	Psp5zi tape	Uses Psp5zi	1.2886×10^{14} (p/s)
Psp72zi	Open	Rev 9 of TI-015 60/40 sludge	$4.15 m^3$	2.673×10^{14} (p/s)
Psp73zi	Plugged	Rev 9 of TI-015 60/40 sludge	$4.15 m^3$	2.673×10^{14} (p/s)

The [ANSI/ANS-6.1.1-1977] flyx-to-dose conversion factors are used for the photons and the neutrons as given in Appendix H of the MCNP manual.

The material densities and material compositions used in the MCNP models are given in Table 3-1. Sludge was assumed to be 70 vol% water and the remainder SiO_2 with a total mix density of 1.41 g/cm^3. SiO_2 was used for the solid portion since it is more conservative to use silicon with its low neutron absorption cross-section and small atomic number (for photons) than a more representative mix that might be non-conservative.

The dimensions for the shield plate and penetrations were obtained from the drawings listed in Table 7-4. Shield collars are modeled around penetrations. Dimensions from the drawing were used to define the shield plate penetrations and collars (aka pucks). The collars were assumed tight to the penetration piping and have a top surface elevation at 110.13" above the bottom of the *tank* (i.e., 0.13 inches into the bottom of the shield plate). The penetration (piping) plugs are a solid steel section extending from the bottom of the collars to the top of the lower shield plate.

The penetration and counter bore dimensions provided are listed in Table 7-5. The model uses a uniform 0.75 inch counter bore (the increase in radii and depth of the hole for the collars) for all penetrations except for the outlet pipe (uses a 0.80 inch counter bore). The bottom of the PSP was set at 19.0" above the head body joint. The lifting lug penetration is a square shape 31.50 inches long and 1.60 inches wide.

Title	Number	Revision
K-East Basin STS A-170 Assembly	3C40-0126-D	1
Cask Assembly Cask Sludge Transportation System	12099-200	2
Sludge Transport Sys Process Shield Plate Assembly	12099-400	4, DCN 1
Sludge Transport Sys Process Shield Plate Shield Cap and Pucks	12099-401	3

Penetration	Penetration Diameter (in)	Counter bore depth (in)	Counter bore Diameter (in)	Collar/Puck Diameter (in)	Collar/Puck thickness (in)	Plug Diameter (in) [a]
Rupture/ Air Vent	5.35	0.75	6.5	5.92	2.0	1.652
HEPA	5.35	0.75	6.5	5.92	2.0	1.652
inlet	4.96	0.75	6.12	5.50	2.0	1.25
outlet	6.86	0.80	8.15	7.44	2.0	2.625
Sensor wash	4.42	0.75	7.5	5.90	2.0	0.625 Not modeled
Water addition	5.29	Not modeled	Not modeled	5.29	2.75" cap 1.75" used	5.25, 5.29 used
level sensor [c]	3.13	1.63	11.5	10.	0.5" for plate and sensor	none

[b] The water addition penetration and cap were simplified to include just the inserted portion of the cap with no counter bore or gap.

[c] Details of the level sensor penetration were not included; instead a 0.5 inch thick disk was modeled.

Table 7-6– Dimensions Used in Calculation Models

Radial Dimensions			
Region	**Material**	**Inner Radius (cm)**	**Outer Radius (cm)**
Source	Sludge	10.00	73.66, or to inner ellipse of lower IC
Water/filter Zone	Water	0.00	73.66
Inner Container – side	SS-304	73.66	74.93
Inner Container – bottom	SS-304	Bounded by ellipses	Thickness=1.27
Inner Container – top	SS-304	Bounded by ellipses	Thickness=1.905
Inner Cask Steel – side	SS-304	77.47	80.01
Middle Cask Lead – side	Lead	80.01	87.9475
Outer Cask Steel – side	SS-304	87.9475	91.7575
Bottom Cask Steel	ss-304	0.00	91.7575
Process Shield Plate	ss-304	0.00	91.7575
Inside Air	Air	Above water/filter and below top of IC	Also beyond IC and inside cask
Outside Air	Air	Beyond cask	
Region	**Material**	**Bottom of region, z(cm)**	**Thickness of Region (cm)**
Source	Sludge	1.27	130.8787
Water Zone(10")	Water	130.8787	25.4
Inner Container – side	SS-304	38.735	196.85
Inner Container – bottom	SS-304	0.00, outside ellipse	Outer ellipse-z half-height ≈36.83, thickness=1.27
Inner Container – top	SS-304	235.585, outside ellipse	Outer ellipse-z half-height ≈36.83, thickness=1.905
Cask – side	SS-304 with lead in center	0.00	1307.34
Cask – bottom	SS-304	-15.24	15.24
Process SP (recessed)	SS-304	1279.4	13.97

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Source Geometries

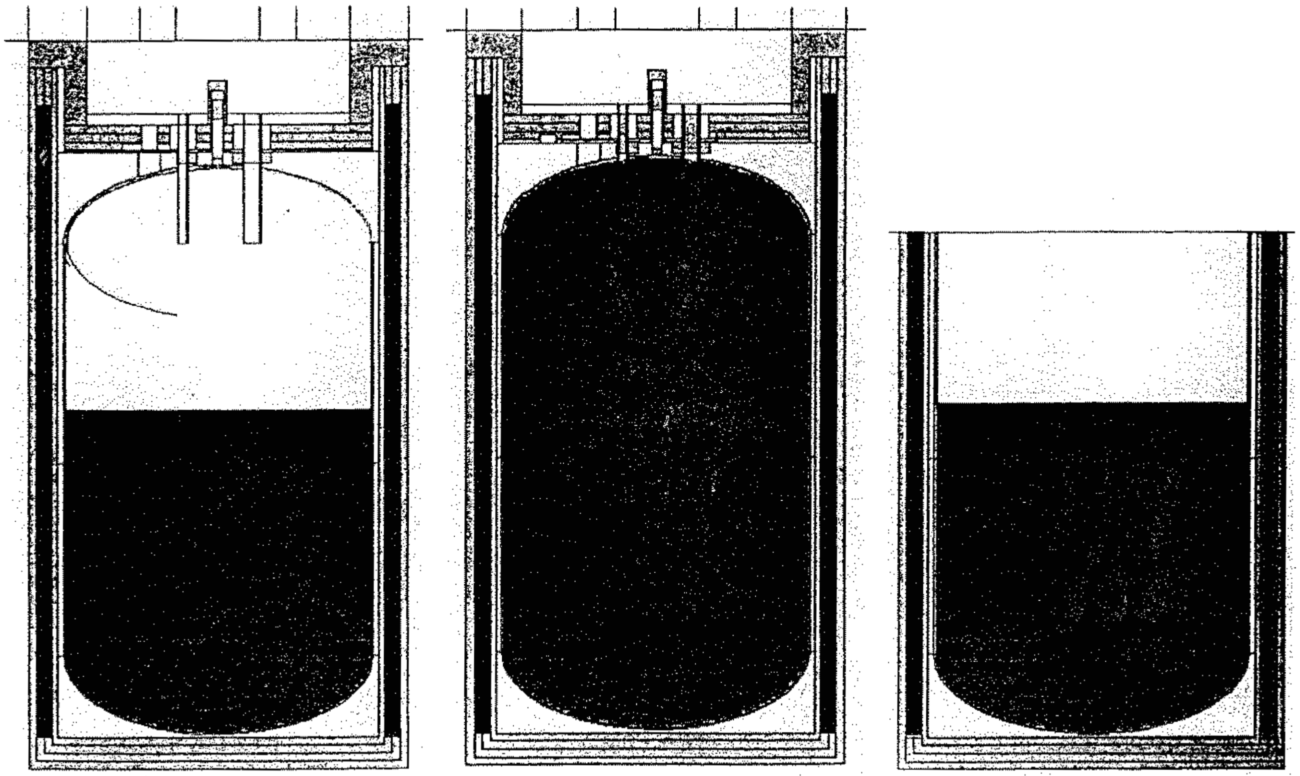
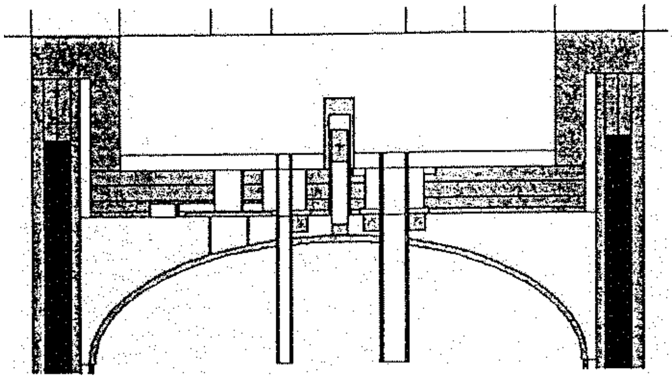
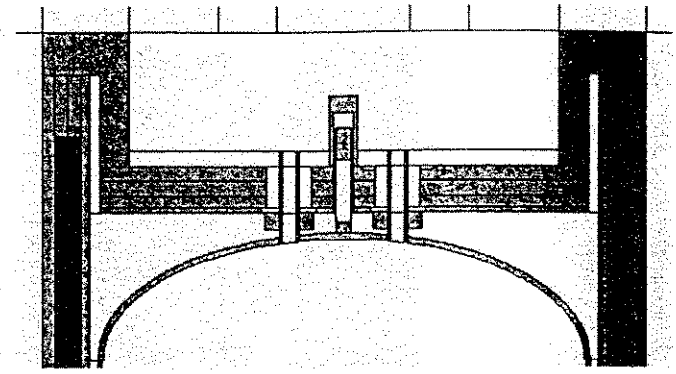


Figure 7-1: Axial 0 Degree View of the MCNP 2.0, 4.15 m^3 and source tape sludge Models.

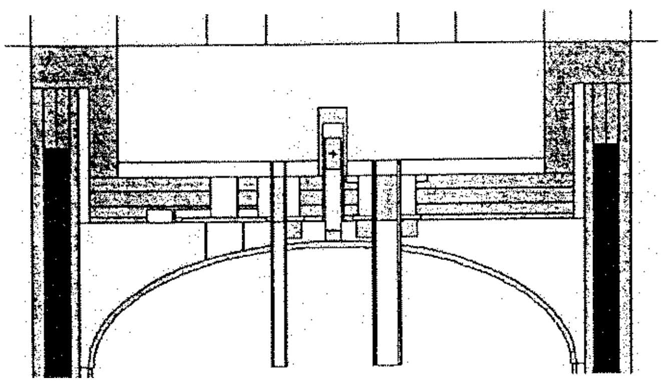
Un-plugged level, inlet and outlet penetrations



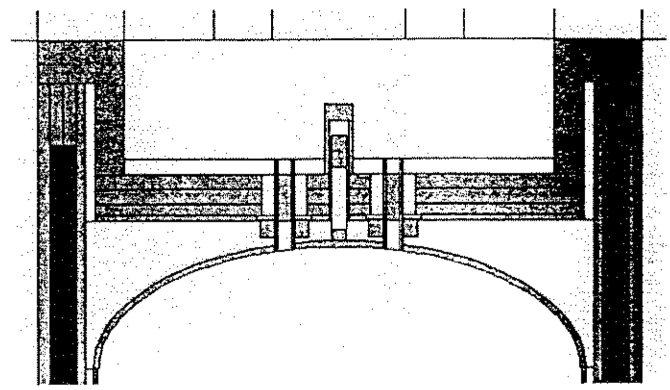
Un-plugged HEPA Vent and Rupture penetrations



Plugged level, inlet and outlet penetrations



Plugged HEPA Vent and Rupture penetrations



Lifting Lug (both cases)

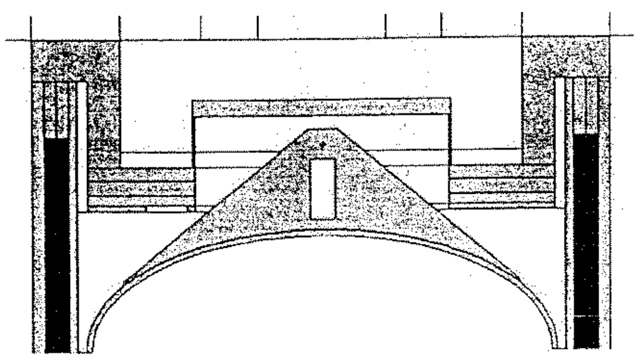


Figure 7-2 - Expanded Axial Views of MCNP Model Process Shield Plate Penetrations and Lifting Lug.

PACTEC CALCULATION SHEET

Title	*STS Process Shield Plate Analysis*	*Calculation Number* **12099-21**	*Revision* 3
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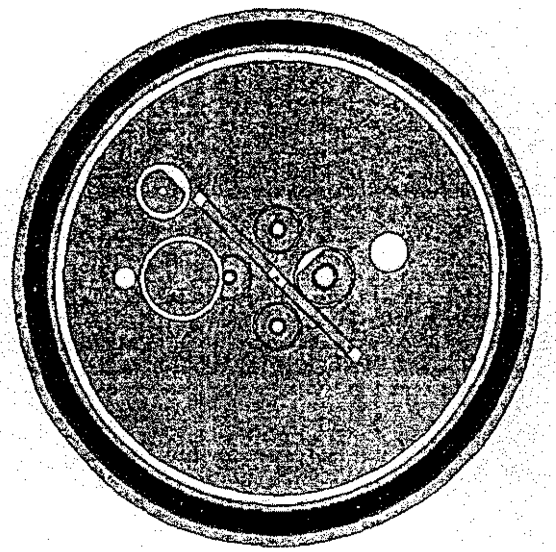
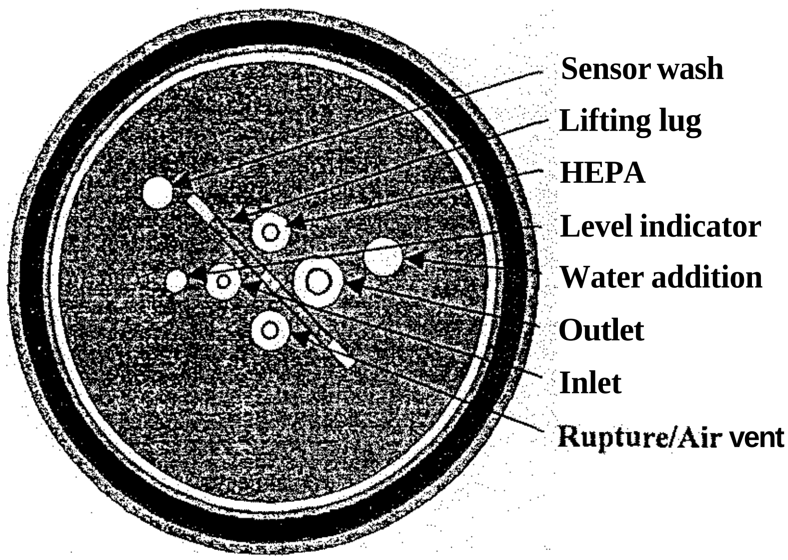
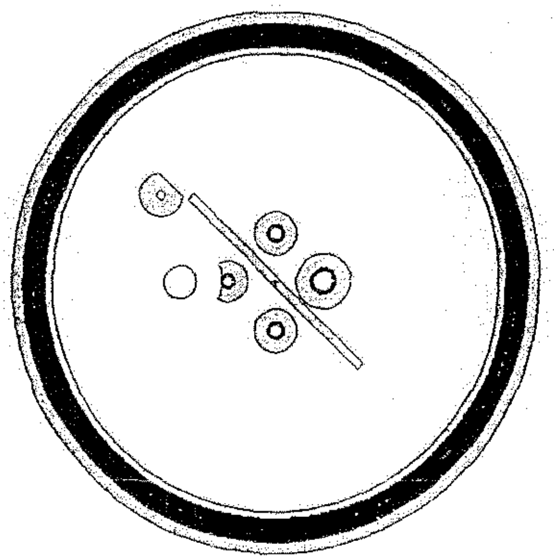
Unplugged Shield plate at 279.5 **cm** elevation



Unplugged Shield plate at 285 cm **elevation**



Unplugged Shield plate at 275 cm elevation



Unplugged Shield plate at 293 cm elevation

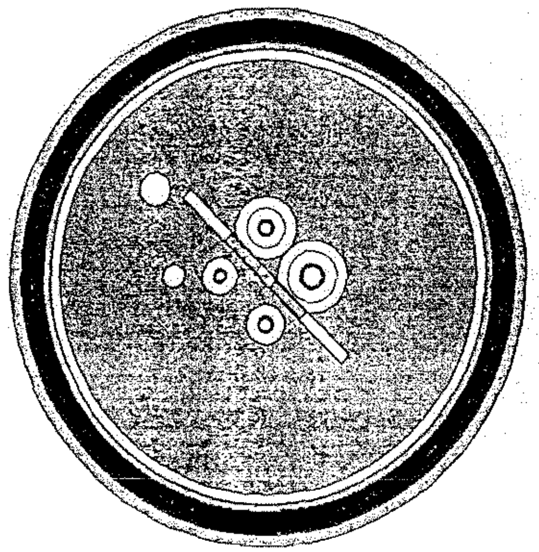


Figure 7-3 Horizontal Views of the MCNP Model in the Vicinity of the Process Shield Plate

7.3 Results

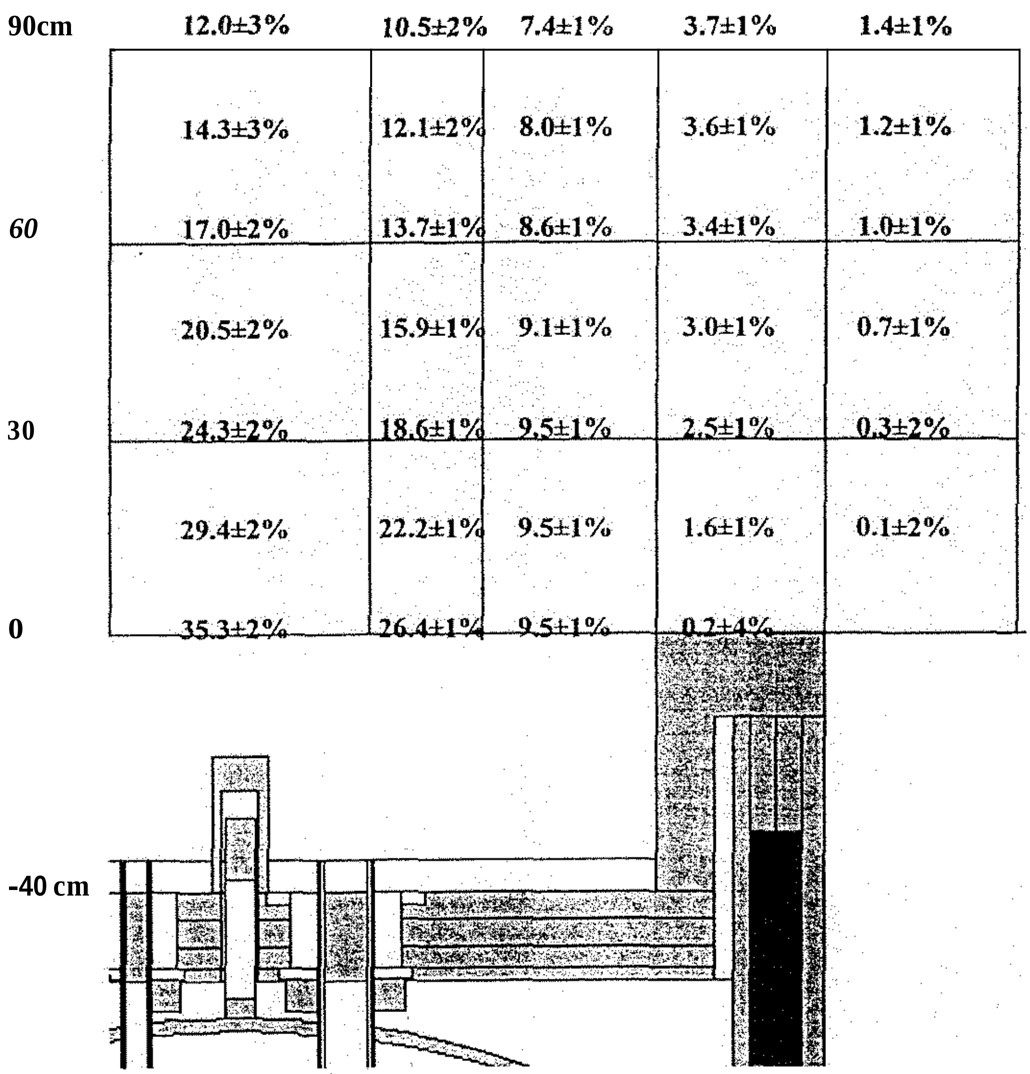
The calculated dose rates at 30 cm intervals above the top of the process shield plate are summarized in Figure 7-4 through Figure 7-7. The dose rates include the contribution from the photon source uniformly in the sludge volume and from the photon source in the water/filter volume. The dose rates represent volume and surface averages over a 360 degree annulus. Local dose rates above the penetrations were also calculated. The one standard deviation statistical uncertainties in the Monte Carlo calculations are expressed as a percent of the dose rate. Dose rate for both plugged and open shield penetrations are listed.

The average dose rate 30 cm above the shield plate lip and centered over the penetrations was calculated to be 24.3i0.5 mRem/hr. Although the dose rates over some of the plugged penetrations are larger, they have large statistical uncertainties and thus are not considered sufficiently converged for use. Due to the complexity of the shield and high dependency on the source distribution, determining the maximum dose is problematic. The presence of local hot particles in the waste at inopportune locations could significantly increase the actual dose above the shield. Conversely, the use of a thicker cover water layer will significantly reduce the dose rates.

Dose rates above the open penetrations are expected to be near the local maxima with the larger openings having the higher dose rates. The dose rates directly above the open penetrations are comparable to the average dose rates with a moderate peaking above open penetrations. For plugged penetrations there is no discernable peaking calculated directly above the penetrations. When the penetrations are plugged, the location of the maximum dose rate can not be readily identified, thus average values are reported.

The dose rates above the shield are sensitive to the cover water depth, sludge volume and sludge composition. Since these properties will vary during filling, the dose rates above the shield plate can be expected to significantly vary as well. The maximum dose rate can readily change location and magnitude based on waste concentrations and distribution. The dose rate calculated here use the "worse case" source term and anticipated maximum sludge volume.

The accident condition, with the canister filled with waste, represents the bounding limit for waste geometry. The calculated dose rates are likewise bounding for the worst case source term.



Penetration	**HEPA**	*rupture disk*	*inlet*	*outlet*
30 cm Dose rate Centered (mrem/hr)	17±14%	21±17%	44±21%	21±8%
30 cm Dose rate *Annulus*				

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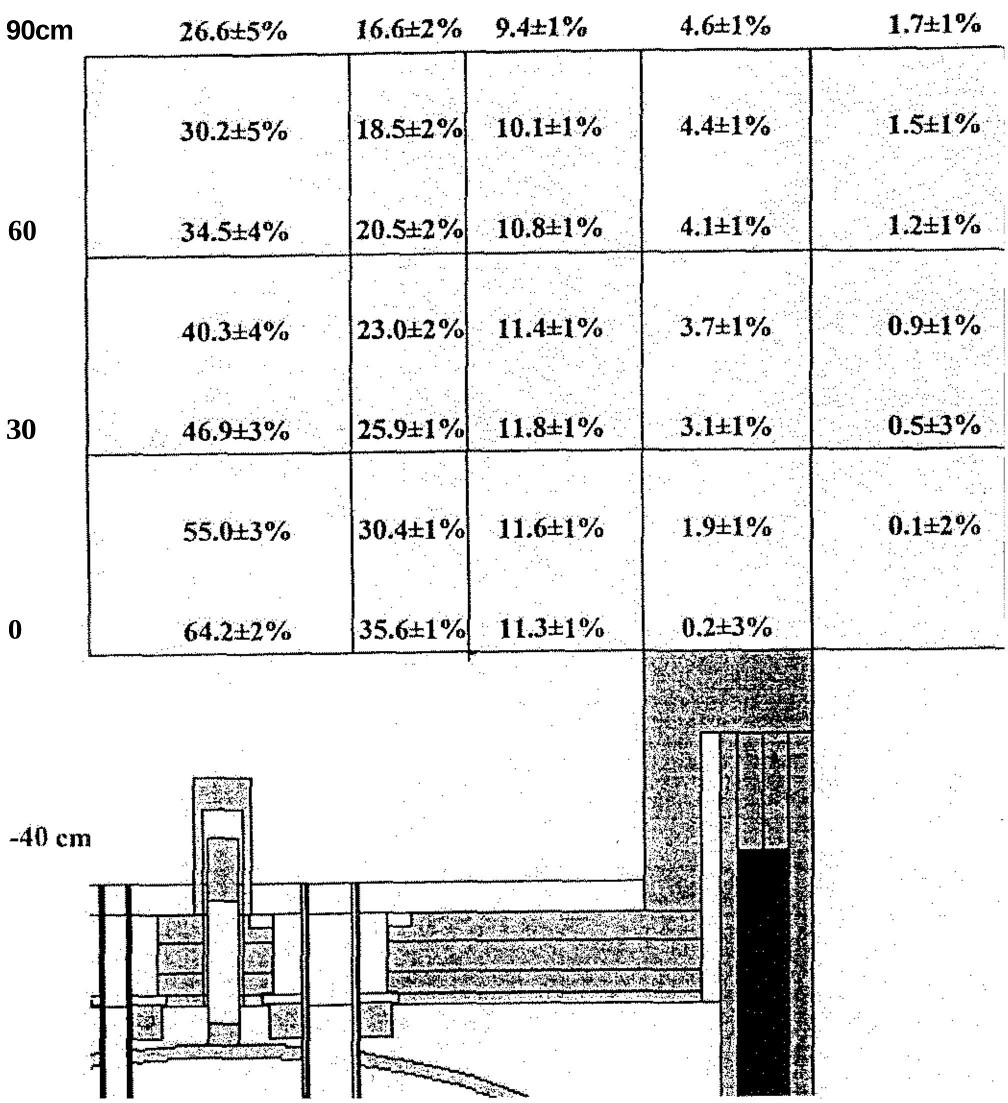

Penetration	HEPA	rupture disk	inlet	outlet
30 cm Dose rate Centered (mremihr)	38±16%	51±17%	63±20%	64±12%
30 cm Dose rate *Annulus* (rnremihr)	47±8%	56±10%	43±7%	53±6%

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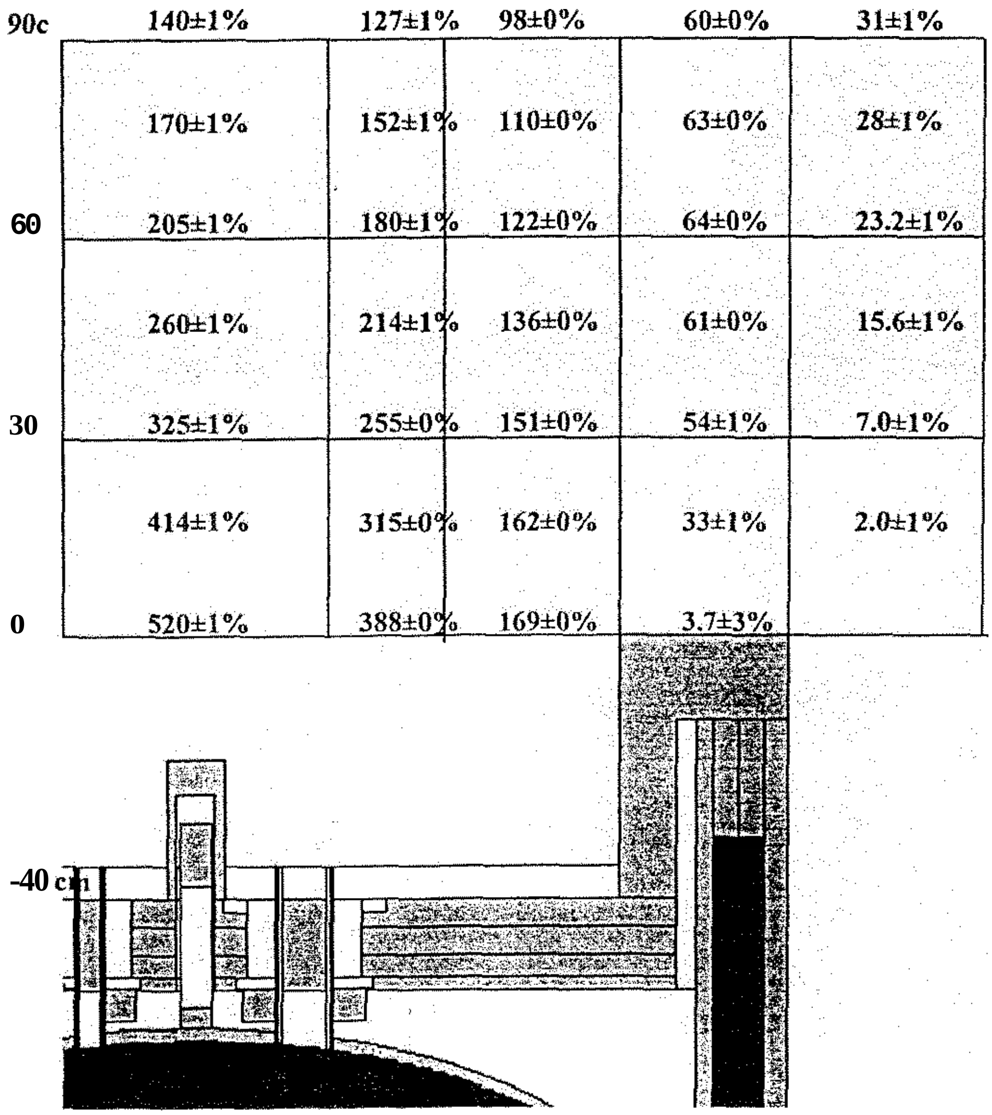

Penetration	*HEPA*	*rupture* disk	*inlet*	outlet
30 cm Dose *rate Centered* (mrem/hr)	311±5%	291±5%	331±7%	318±4%
30 cm Dose *rate Penetration Annulus* (mrem/hr)	297±2%	295±3%	342±2%	306±2%

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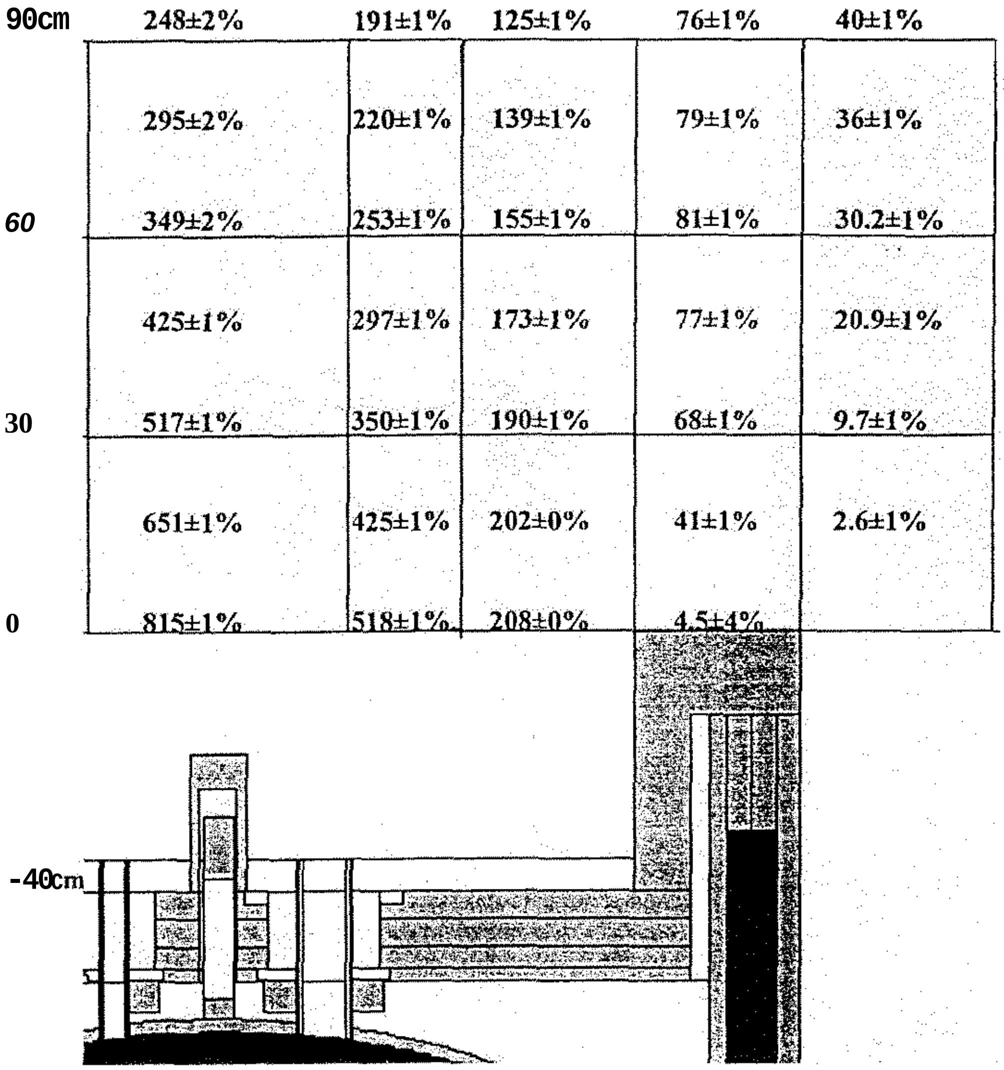

Penetration	HEPA	rupture disk	inlet	outlet
30 cm Dose rate Centered (rnremihr)	535±7%	467±7%	445±16%	626±5%
30 cm Dose rate Penetration Annulus (rnremihr)	493±4%	462±5%	451±3%	632±4%

8.0 Summary

Calculations show that the average annular dose rates around the case perimeter will meet the 20 mrem/hr dose specification for normal operations and the 80 mrem/hr for the off-normal conditions. Average doses over plugged penetrations are 20% above the specification using the revised source term in revision 9 of HNF-SD-SNF-TI-015. The 20 mrem/hr dose rate will be exceeded above open penetrations and in the PSP well. The dose rates for the off-normal condition also exceed the specification above the PSP, but are within the specification at the perimeter of the PSP.

The use of collars and penetration plugs in the design reduces the radiation streaming through and around the penetrations and reduces the dose in the normally occupied areas, thus along with adequate operational controls the ALARA objective can be met.

9.0 References

1. SNF-8163 Rev. 4, *Performance Specification for the* K *Basin Sludge Transportation System – Project A.16*, Fluor Hanford Inc., Richland, WA, March 2002
2. 10 CFR 71, "Packaging and Transportation of Radioactive Material," *Code of Federal Regulations*, as amended.
3. 10 CFR Part 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.
4. LA-I2625-M, *MCNP--A General Monte Carlo Code N-Particle Transport Code, Version 4C,* Breismeister, J. F., Editor, Los **Alamos** National Laboratory, Los Alamos, New Mexico, 1997.
5. SCALE4.3, "Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation for Workstations and Personal Computers," CCC-545, ORNL, March 1997.
6. HNF-6705, Revision 0, *Observations of K Basins Sludge Behavior in Relation to Sludge Container Design and Storage at T Plant,* Baker, R.B., B. J. Makenas, and J. A. Pottmeyer, Fluor Hanford, Richland, Washington, 2000
7. HNF-SD-SNF-TI-009, Volume *2,* Rev. 4,105-K *Basin Material Design Basis Feed Description For Spent Nuclear Fuel Project Facilities, Volume 2, Sludge,* Pearce, K.L., Fluor Hanford, Richland, Washington, 2001
8. HNF-SD-SNF-TI-OI*5*, Rev. 9, *Spent Nuclear Fuel Project Technical Databook. Volume 2, Sludge,* Fluor Hanford, Richland, Washington, 2002
9. HNF-SD-SNF-TI-009, Volume I, Rev. 3,105-K *Basin Material Design Basis Feed Description for Spent Nuclear Fuel Project Facilities, Volume I, Fuel,* Packer, *M.J.,* Numatec Hanford, Inc., Richland, Washington, 1999
10. 12099-04 Rev 0, *"Sludge Transportation System Cask Shielding Analysis"*, L Carter, Pactec-TN, Tacoma Washington, 2002.

PACTEC CALCULATION SHEET

Title	*STS* Process Shield Plate Analysis	Calculation Number 12099-21	Revision 3
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10.0 Appendices

PACTEC	COMPUTER RUN RECORD		
Computer Run Number	Revision 3		
Analysis Software	MCNP, SCALE4.4, MCNP4c2L		
Hardware Description	Dell Pentium 4, Windows XP- Serial Number 6GSN911, AMD DURON processor running Windows 98 (no serial number)		
Disk Storage Description	CD labeled "Process Shield Plate"		
Disk File Storage	File Description	File Name	Creator
	Input files	Psp5zi, Psp70zi, Psp71zi, Psp72zi, Psp73zi or6040.in, or8020.in	Jim Livingston
	Cross sections	XSDIR, cross-section files	LANL
	Output files	Psp5zio, psp5ziw Psp70zio, Psp71zio, Psp72zio, Psp73zio, Psp70zim, Psp71zim, Psp72zim, Psp73zim OR6040.in.out, OR8020.in.out	CNP d SCALE lculation results
	Excel Spreadsheet	Working3	Jim Livingston
Printed Attachments	Description: none		

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ATTACHMENT 9

FH Supplemental Design Information

Consisting of 182 Pages
Including this cover page.

Position Paper

Expected Behavior of Sludge Due to Hydrogen Generation And Adequacy of Filter Array Assembly Design for SWS Large Diameter Container (LDC)

Issue/Concern

The sludge currently accumulated at the bottom of the K-East Basin contains an unknown but significant quantity of irradiated metallic uranium fuel particles. In their current undisturbed state, the irradiated metallic fuel particles are expected to be largely coated with a protective layer of oxide material that formed when the metallic fuel reacted with water. This reaction would have created a relatively stable coating of metal oxide on the surface and generated heat and hydrogen gas in the process. Once the oxide layer formed, further oxidation of the fuel occurs at a significantly slower rate, generally when a crack forms in the oxide layer and water is able to come in contact with freshly exposed metal underneath the oxide layer. Support for this hypothesis that the fuel particles are currently experiencing only very limited further oxidation comes from the fact that bubbles (presumably hydrogen gas) can be currently observed to be emerging from the surface of the sludge at a relatively low rate.

As the sludge/water slurry is being pumped into the Large Diameter Container (LDC) during the loading phase in the K-East Basin, it is expected that the protective oxide layer coating on the metallic fuel particles will be disturbed and possibly knocked off many of the particles, leaving a large surface area of fresh metallic fuel exposed to the surrounding water. This is expected to lead to a significant increase in the rate of hydrogen generation from the renewed oxidation of exposed metallic fuel particles once they settle out of the sludge/water slurry in the LDC. Eventually, it is expected that the rate of hydrogen generation will once again diminish significantly as a relatively stable oxide coating again forms on the fuel particles. However, there are substantial uncertainties associated with 1) how rapidly hydrogen gas will be generated in the freshly settled sludge in the LDC, 2) how long it will be before rate of hydrogen generation slows either because of the oxide layer formation phenomenon or because the fuel particles have been consumed and 3) how the sludge will respond to the expected increased rate of hydrogen gas generation.

Two possible modes of gross sludge behavior (with variations) have been proposed, based on laboratory scale observations, gross behavior of similar materials experiencing internal hydrogen gas generation, and various analyses. One predicted mode of behavior is predicated on the expectation that the fuel particles will settle out of the sludge/water slurry mixture so that they are distributed more or less homogeneously in the axial dimension at any particular radius in the LDC. This mode, which is the anticipated mode, would lead to hydrogen gas bubbles forming sufficiently close together that the bubbles will ultimately join in the axial direction to provide flow paths for the hydrogen to escape up through the sludge. In this scenario, the overall height of the sludge in the LDC would change very little as the fuel particles continue to oxidize until (and if) the rate of hydrogen generation slows as discussed above.

A proposed variation on this first mode of behavior would result from some portion of the growing quantity of hydrogen gas being generated remaining trapped in small bubbles throughout the sludge. These trapped bubbles would slowly grow in volume, causing the sludge mass to grow in volume as its internal structure becomes "Swiss cheese-like" in appearance. This mode of behavior was postulated based on observations of the behavior of the caustic waste that is being stored in the Hanford Tank Farms. The caustic waste consists of the radioactive fission products recovered from the reprocessing of spent fuel from the plutonium production reactors at the Hanford site. The radiation field leads to the production of hydrogen gas from the radiolytic decomposition of water and any other hydrogenous material present in the waste. In at least some of the large tanks, sufficient hydrogen has remained trapped in the interstitial volume of the waste material to cause it to become somewhat porous and thus increase significantly in volume.

The second postulated mode of sludge behavior in the LDC would result from the metallic fuel particles settling preferentially toward the bottom of the sludge. As the fuel particles oxidize to produce hydrogen gas, the sludge is postulated to be sufficiently impervious that the hydrogen gas cannot escape upward through the sludge. When the hydrogen gas pressure in the growing volume below the bottom of the sludge increases sufficiently to levitate the sludge, it would slowly drive a slug of sludge upward. If the sludge slug were to be lifted sufficiently high, it would strike the bottom of the Filter Array Assembly. Beyond this point in the scenario, various outcomes have been postulated, including the Filter Array Assembly being partially collapsed by the upward force from the slug or the sludge in the slug being forced up into the Filter Array Assembly so that water and perhaps even sludge would be pushed into the filtered vent system on the LDC. If sludge were forced into the vent system, it could effectively plug the vents, thus allowing the pressure in the LDC to continue to grow.

This range of postulated behavior modes for the metallic fuel particle-bearing sludge has given rise to several concerns that have been addressed during the design and safety analysis efforts for the LDC. These concerns are as follows:

Concern 1: Given the spatial distribution of metallic fuel particles that settle out in the sludge as it is pumped into the LDC,

1) Will the hydrogen gas that will be generated from oxidation of the particles be able to escape the sludge so that the sludge volume remains relatively unchanged, or

2) Will the bubbles be trapped throughout the sludge so that the sludge becomes more and more porous as its overall volume increases, or

3) Will the hydrogen gas be generated preferentially in the bottom of the LDC and not escape the sludge so that it could ultimately drive a slug of sludge upward into the Filter Array Assembly?

Concern 2: If the sludge were indeed to be driven upward as an intact slug by the expanding hydrogen gas volume below it, would the Filter Array Assembly be capable of arresting the slug such that water is not forced out of the LDC and the LDC vent system remains effective?

Background Discussion

The LDCs in which the sludge is to be stored at T-Plant are required to provide for the safe storage of the sludge for a period of up to 30 years, including the various configurations and operating environments in which they will exist from the start of pumping the sludge/water slurry into each LDC at K-East Basin through to storage in a cell at T-Plant. As noted above, the metallic fuel particles present in the sludge are expected to experience more rapid oxidation once they have been disturbed as a result of being vacuumed from the bottom of the Basin into the LDC. This more rapid oxidation will generate both heat and hydrogen gas. In addition, fission product isotopes present in the metallic fuel particles will continue to undergo radioactive decay, resulting in the production of additional heat.

Extensive analyses have been performed to demonstrate that the design of the LDC is such that it will accommodate the consequences of the heat and hydrogen generation during the required 30-year storage mission. The specific functional and design requirements imposed on LDC that address the heat and hydrogen generation phenomena are as follows:

SNF-8166, Rev. 0, *Functional Design Criteria for the K Basins Sludge and Water System – Project A-16.* (Ref. 1)

Section 3.2.3 – Vessel Performance Requirement – ...

- Tank/vessel design shall preclude the possibility of accumulating either more than 25 percent of the lower flammability limit of hydrogen, per the National Fire Protection Association (NFPA™[1]) 69, *Explosion Prevention Systems,* or a problematic quantity of hydrogen as determined by the fire hazards analysis.
- Tank/Vessel design shall provide for the removal of heat from radiolytic decay and uranium chemical reaction to prevent the hulk sludge temperatures from exceeding 60°C (140°F). The preferred bulk sludge storage temperature is below 20°C (68°F).

SNF 8163, Rev. 4, *Performance Specfor the K-East **Basin** Sludge Transportation System for Project A-16.* (Ref. 2)

Section 4.2 – Normal Conditions of KE Operations:

- 4.2.3.2 Thermal [Acceptance Criteria]: The STS [Sludge Transportation System] design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.
- 4.2.3.5 Gas Generation: The hydrogen gas generation shall be evaluated to show that during sludge loading and preparation for transportation no accumulation of hydrogen gas exceeds one quarter of the lower flammability limit assuming normal operation of the KE Basin ventilation.

[1] NFPA™ is a registered trademark of National Fire Protection Association, Inc., Quincy, Massachusetts

Section 4.3 – Accident Conditions of KE Operations:

- 4.3.3.2 Thermal [Acceptance Criteria]: The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.
- 4.3.3.5 Gas Generation: The hydrogen gas generation shall be evaluated to show that within the KE Basin no accumulation of hydrogen gas exceeds one-quarter of the lower flammability limit assuming off-normal operation of the KE Basin ventilation.

Section 5.1 – Normal Conditions of Transport:

- 5.1.3.2 Thermal [Acceptance Criteria]: Maximum accessible outside surface temperature of the cask shall be less than 85°C (185°F) in 37.8°C (100°F) air temperature and in the shade. The STS design shall ensure the maximum temperature of the payload does not exceed 100°C (212°F) at any time during loading, transportation and storage.

Section 5.2 – Hypothetical Accident Conditions:

- 5.2.3.3 Thermal [Acceptance Criteria]: The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage and subjected to the accident conditions.

Section 6.2 – Normal Conditions of T Plant Unloading Operations:

- 6.2.3.2 Thermal [Acceptance Criteria]: The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.
- 6.2.3.5 Gas Generation: The hydrogen gas generation shall be evaluated to show that within the T Plant no accumulation of hydrogen gas exceeds one-quarter of the lower flammability limit assuming off-normal operation of the T Plant ventilation.

Section 6.3 – Accident Conditions of T Plant Unloading Operations:

- 6.3.3.2 Thermal [Acceptance Criteria]: The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.
- 6.3.3.5 Gas Generation: The hydrogen gas generation shall be evaluated to show that within the T Plant canyon or tunnel no accumulation of hydrogen gas exceeds one-quarter of the lower flammability limit assuming off-normal operation of the T Plant ventilation.

Section 6.4 – Normal Conditions of T Plant Storage Operations:

- 6.4.3.2 Thermal [Acceptance Criteria]: The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.
- 6.4.3.5 Gas Generation: The hydrogen gas generation shall be evaluated to show that within the T Plant no accumulation of hydrogen gas exceeds one quarter of the lower flammability limit assuming off-normal operation of the T Plant ventilation.

Section 6.5 – Accident Conditions of T Plant Storage Operations:

- 6.5.3.2 Thermal [Acceptance Criteria]: The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.
- 6.5.3.5 Gas Generation: The hydrogen gas generation shall be evaluated to show that within the T Plant no accumulation of hydrogen gas exceeds quarter of the lower flammability limit assuming normal operation of the T Plant ventilation.

Section 7.5 – General Design and Interface Requirements:

- 7.5.6 The Large Container shall be capable of receiving 30 to 90 gpm of sludge slurry transferred to the Large Container. The slurry flow of 30 gpm shall be considered the minimum. The normal flow for which the Large Container is designed shall be identified and be capable of up to **60** gpm continuously. Slurry flow up to 90 gpm shall be acceptable for short duration transfers of high-density material, as needed to ensure adequate transfer velocities are attained. The inlet flow shall be designed to promote uniform mixing of fluid above the settling sludge. The inlet piping shall not penetrate the uniform mixing layer. For example, consider a flat plate with a diameter twice the inlet pipe diameter separated large of one-quarter the pipe diameter or ½ in. from the exit of the inlet pipe.

<u>Consideration of Heat and Hydrogen Generation in LDC Design</u>

For a variety of mission-related considerations, it was decided to size the LDC to be approximately 5 ft in diameter and approximately **9** ft in height. Given the thermal and hydrogen gas requirements cited above, the early thermal analyses focused on demonstrating that a payload of 3 m^3 of a so-called safety basis mixture of sludge (which was postulated to contain a relatively high proportion of the fuel particle-rich canister sludge) would experience peak temperatures that would remain below the maximum temperatures established in the requirements cited above throughout the various loading, transportation and storage phases. These initial thermal analyses raised concern that if the metallic fuel particles in this safety basis sludge mixture were permitted to concentrate preferentially in the lower portion of the sludge. temperatures that exceeded the requirements could be reached in some configurations.

The LDC was designed to operate in a mode such that it will initially be filled with water, into which the sludge/water slurry will be pumped once sludge pumping has begun. Because the LDC will be completely filled with water when sludge pumping begins, water will be forced through the internal Filter Array Assembly and out through the LDC outlet piping, where it will be discharged back into the K-East Basin. The end of the inlet pipe was located below the Filter Array Assembly lower support grid, and a flat deflector plate was placed below the end of the inlet pipe to deflect the incoming slurry in the radial direction. This was done 1) to minimize the extent to which the sludge that settled out at the bottom of the LDC could become re-suspended by the incoming stream and 2) to deflect the heavy fuel particles in the radial direction to prevent the particles from settling preferentially in the radial center of the LDC. Had the particles been permitted to concentrate in the radial center of the LDC, peak temperatures in the sludge would have been higher and could have exceeded the requirements under some conditions.

Given the concern about the possibility of the metal particles settling preferentially to the lower portion of the sludge, studies were performed to understand the settling characteristics of the sludge (Ref.3). These studies demonstrated that, once the pumping of the sludge/water slurry into the LDC was stopped, the sludge pumped into the LDC during the period of continuous pumping settled out rather quickly. This led to establishment of an operational requirement that, after each period of continuous pumping, pumping would have to be suspended for a period of time to let most of the lighter particles in the sludge settle out on top of the already-settled sludge. This limit was ultimately expressed in a requirement that no more that 0.5 m^3 can be pumped without pausing the pumping, and that the subsequent pause would have to be of sufficient duration to permit settling to occur. Imposition of the "0.5 m^3 pumped in/ pause" operational requirement would guarantee that the sludge would be formed in several distinct layers (Ref. 3). Within each layer, it was expected that fuel particles would be concentrated in the lower portion of that layer. In actual fact, given the current operational sludge retrieval philosophy, it is anticipated that it will take far more than four pumping sessions to place the required quantity of sludge in a LDC, thus assuring that there will be relatively more layers of sludge, each with the fuel particles settled preferentially toward its lower portion.

The initial scoping thermal analyses assumed that any hydrogen generated in the settled sludge would escape the sludge as it was generated so that the volume occupied by the sludge would not increase perceptibly. Given this assumption, the LDC was designed to store **3** m^3 of settled sludge with approximately 10 in of water covering it. As the thermal and hydrogen gas generation studies proceeded, concerns were raised that some of the hydrogen gas that could be generated would be retained in the interstitial volume of the sludge, causing the sludge to increase slowly in volume. These concerns were raised based on surveys of the behavior of analogous materials that also experienced internal hydrogen generation.

Specifically, this mode of behavior was postulated based on observations of the behavior of the caustic waste that is being stored in the Hanford Tank Farms (Ref. 4). The caustic waste consists of the radioactive fission products recovered from the reprocessing of spent fuel from the plutonium production reactors at the Hanford site. The radiation field leads to the production of hydrogen gas from the radiolytic decomposition of water and any other hydrogenous material present in the waste. In at least some of the large tanks, sufficient hydrogen has remained trapped in the waste material to cause it to become somewhat porous and to increase significantly in volume. Extrapolating on this observed behavior, it was suggested that this phenomena could lead to a volume increase of up to 54% for the K-East sludge stored in a LDC,

At this point in the ongoing design effort for the LDC, it was decided to limit the volume of sludge in a LDC so as to accommodate this potential volume increase. Reference **5** demonstrates that 2 m^3 of as-settled sludge can be accommodated in a LDC under the assumption **of** this **54%** limiting volume increase as well as the volume changes that would occur from complete oxidation of the metallic uranium particles. Thus, the design payload for a LDC became **2** m^3 of as-settled sludge. Given a payload of 2 m^3 of as-settled sludge, imposition of the "0.5 m^3 pumped in/pause" operational requirement would result in a minimum of four distinct layers of sludge in a LDC.

At the same time that the concern regarding the potential significant volumetric expansion of the sludge due to retention of hydrogen gas was being raised and addressed, observations of the behavior of a small sample of actual Basin sludge in a test beaker led to concern being raised regarding another possible mode of behavior. This behavior was observed in a sample of sludge that had been placed in glass graduated cylinders some **3** inches in diameter and thoroughly mixed with a helium sparging hose (Ref. *6)***.** As a result of the mixing, the sludge in the cylinders settled into a stratified layer where the denser fuel particles remained predominately at the bottom of the layer. Approximately 10 days after the sludge was sparged with helium, a gas bubble began to form at the bottom of one of the cylinders. In time, the bubble spanned the diameter of the cylinder, and the pressure buildup was enough to move the sludge layer upward.

After due consideration, it was decided to proceed with an approach in which the adequacy **of** the LDC design would be based on a design payload of 2 m^3 of as-settled sludge that had expanded uniformly to a volume of over **3** m^3 (the 54 % plus volume change due to oxidation discussed above). Furthermore, it was decided to address the opposite possibility that a vessel-spanning slug of sludge could be levitated upward into the filter bank by demonstrating that such behavior would be very unlikely to occur. As a second "line of defense" to this improbability argument, it was decided to perform analyses to demonstrate that the Filter Array Assembly would "bust" the slug to permit the gas below it to escape before water or sludge could be forced out through the vent or rupture disc.

The sections that follow document the basis that has been used to demonstrate **1)** that an acceptable radial and axial distribution of metallic fuel particles will be obtained in the as-settled sludge in the LDC, 2) that the maximum temperatures that would be experienced in the volumetrically expanded 2 m^3 of sludge are acceptable in all required modes of operation, and **3)** that the "levitating slug" mode of behavior is both very unlikely to occur and, if it did occur, could be accommodated by the design of the LDC and its internal structures.

Basis for Resolution of Concerns

Radial and Axial Distribution of Fuel Particles

As noted above, it was understood at the inception of the design effort for the LDC that it would be necessary to demonstrate that the fuel particles would settle out of the sludge/water slurry such that acceptable thermal behavior could be demonstrated. This led to the inclusion of a baffle plate with a diameter of 2 in located approximately 1.5 in below the end of the inlet pipe. Both experimental and analytical evidence now exist to demonstrate that an acceptable axial and radial distribution of fuel particles will result.

Fauske & Associates, Inc. (FAI) was commissioned to perform analyses to establish acceptable ranges for these parameters of baffle plate diameter and distanced below the inlet pipe end. The results of the FAI study are documented in Ref. **7.** The analyses documented in Ref. **7** assume that the suspended fuel particles behave as a continuum fluid that is blended with the carrier feed liquid. This assumption permits application of the extensive literature that is available on jet mixing in tanks to determine the maximum particle size that will remain well stirred by the LDC inlet pipe flow. Particles remaining well stirred by the liquid feed flow would be deposited in a relatively homogeneous fashion. Particles larger in diameter than this maximum particle size would not remain well stirred.

The FAI analyses lead to the conclusion that the metal fuel particles will not remain well stirred as the particle-bearing slurry strikes the baffle plate, resulting in fuel particles leaving the flowing fluid streamlines and undergoing inertial deposition on the surface of the already-settled sludge. However, since the initial flow of the slurry is radial once it has encountered the baffle plate, the settled sludge will most probably consist of an outer annular region with a higher concentration of metal particles surrounding an inner cylindrical region containing relatively few fuel particles.

The FAI report notes that such a deposition pattern of metal particles should not be a cause for concern. If the sludge is loaded in a number of discrete pumping sessions, each of which is followed by a pause in pumping, the annular region will form a stratified morphology of alternating metal-rich and metal-poor sub-layers, with each pair of sub-layers being formed during a particular loading period. The distance between stratified metal layers should be small enough so that the hydrogen bubbles that form in one layer connect with hydrogen bubbles in an adjacent layer, thereby forming paths for gas to flow to the surface of the sludge. In this respect, annular deposits are not necessarily different from sludge-wide homogeneous deposits. In both cases, vessel-spanning bubbles are not likely to form as long as the discrete metal layers are close to one another.

A Proof of Principle (POP) test (referred to as POP2) was performed on a prototype container in June 2002 by the firm that completed the detailed design of and is fabricating the LDC. including its internals (Ref. 8). This test used surrogate materials to simulate the metallic fuel particle-bearing sludge. Particles of a tungsten/cobalt alloy were used to simulate the metallic fuel particles. The POP2 test was designed to demonstrate that the surrogate material could be pumped into the prototype container at planned flow rates, that the surrogate sludge material would distribute itself as anticipated as it settled out in the container, and that the Filter Array Assembly would function as designed to filter out at least 98% of the particles in the sludge with diameters larger than five microns.

During the POP2 test, 2.1 m^3 of sludge surrogate was loaded into the prototype container at flow rates of 60 and 90 gpm. Pumping was periodically ceased for various purposes. After pumping was ceased for the final time and the sludge surrogate was allowed to settle, the top head of the prototype container was removed and a diaphragm pump was used to remove water and sludge surrogate from the container in a layer-by-layer manner. Visual observations were made and pictures taken during the surrogate sludge offload to evaluate how evenly the sludge was distributed.

Observations during the offload showed that the tungsten/cobalt alloy particles and other surrogate materials were relatively evenly distributed in the radial direction. It was noted that, as the layers of the sludge were removed, a thin layer of fine sludge would periodically be present. This was likely a result of settling that took place while pumping operations were halted overnight and during other test iterations that did not require pumping.

In summary, the combination of the FAI analyses of settling behavior and performance of the baffle plate on the inlet pipe end and the experimental results from the POP2 test strongly support the conclusion that the metallic fuel particles will be distributed throughout the sludge following settling of the sludge particles in the LDC. The distribution of fuel particles in the axial direction will consist of a number of relatively discrete deposition layers, with each layer being the result of a period of continuous pumping of sludge into the LDC followed by a period of several hours of no pumping. With each deposited layer, the fuel particles will be located preferentially toward the bottom of the layer, with the density of fuel particles continuously decreasing at successively higher elevations in the layer and with a fuel particle-free zone of very light particulate material at the top of the layer.

As noted above, the FAI analysis predicted that the distribution of fuel particles in the radial direction at any elevation would be expected to reach a maximum density of particles in an annular region some distance away from the end of the inlet pipe, with the density of fuel particles decreasing to a relatively fuel particle-free zone directly below the baffle plate on the end of the inlet pipe. The POP2 test results suggest that there would be less variation in the radial direction than predicted by the FAI analyses.

These results have provided confirmation that the thermal analyses discussed below have been performed using a conservative approach and the conditions that could possible give rise to the levitating sludge slug scenario are very unlikely to exist.

Summary of Thermal Analysis Results

Extensive thermal analyses have been performed on the LDC and the STS in the various conditions cited above to establish that the payload (sludge/water mixture with fuel particles distributed in it) would not experience maximum temperatures that exceed those established in the requirements. These thermal analyses are documented in Ref. **9.** The analyses were performed using the conservative safety basis sludge mixture consisting of 40% of fuel particle-rich canister sludge and 60% of floor sludge, which generally has a much lower density of fuel particles. The payload in these analyses was assumed to be 2 m^3 of as-settled sludge that had subsequently expanded by **54%** in volume because of hydrogen gas bubble formation in the interstitial volume of the sludge. The sludge payload was assumed to have been deposited in four pumping sessions, each followed by a period of no pumping to allow the sludge to settle.

As noted above, this assumption gives rise to the four discrete layers of sludge, with the fuel particles in each being concentrated in the lower portion of the layer.

Reference 9 documents that this payload would not experience temperatures that exceed the requirements. Thus, these analyses establish that the LDC and cask as designed meet the thermal performance criteria cited above for both the case where little hydrogen is retained within the interstitial volume (the sludge expands very little in volume as a result of hydrogen gas generation) and the case where the sludge has expanded in volume due to gas entrainment by 54% (which is the more conservative of the two from a heat transfer perspective and was the configuration actually analyzed).

Unlikelihood of Formation of a Vessel-Spanning Bubble

Both analyses and experiments have been performed to address the related issues of likelihood for formation of a hydrogen gas bubble that would span the LDC and the behavior of the sludge above the bubble as it formed and expanded. Fauske & Associates performed analyses both of the conditions that could give rise to a vessel-spanning bubble and how a sludge slug driven by an expanding vessel spanning bubble would behave (Ref. 10). Regarding the possibility of a vessel-spanning bubble, the FAI report concludes that if the metallic fuel particles on which the hydrogen is being produced are uniformly distributed throughout the sludge column, they are close enough together to enable the product-gas bubbles to connect and form a continuous path to the surface. This same conclusion is stated in the FAI report on baffle plate performance (Ref. 7). Reference 10 goes on to state that the actual sludge morphology is likely to be a stratified one involving many thin horizontal layers of metallic particle-rich sludge "sandwiched" between relatively thick layers of inert material. The stratified morphology is likely to be similar to the uniform metallic uranium particle distribution in that the bubbles that form in one layer are close enough to connect with bubbles in an adjacent layer, thereby forming paths for gas to flow to the surface of the plug. The report notes, however, that this conjecture should be checked by experiment.

The FAI report further states that at least three failure mechanisms could play a role in causing a sludge plug located above a growing hydrogen gas bubble to be disrupted so that the gas below it would escape. The first failure mode examined would result from a spatial variation in plug thickness so that one side of the plug is heavier than the other, leading to a mass imbalance. The report concludes that plug failure by this mass imbalance mechanism is predicted only for very thin plugs as the yield stress of the sludge increases beyond 1,000 Pa.

The second mechanism examined is the well-known Taylor instability. This mechanism results from the fact that the development of buoyancy forces due to the presence of the underlying light gas layer can render the sludge layer laterally unstable to infinitesimal disturbances at the gas/sludge layer interface. Unstable disturbances will grow into gas spikes that penetrate the overlying sludge layer and result in the disintegration of the sludge layer. The report shows that a rising sludge plug would fail by the Taylor instability mechanism if the sludge yield strength is less than about 1,600 Pa. As the sludge shear strength increases above 1,600 Pa, it is possible for a bubble to form and expand radially and axially that could at some point start pushing the sludge plug upward.

The third failure mechanism that would disrupt a rising sludge plug (if it had not already been disrupted by one of the first two mechanisms) would come into play when the sludge plug struck the lower support structure of the Filter Array Assembly. This failure mechanism is addressed in the next section.

The FAI report highlights the fact that sludge behavior will depend upon the shear strength of the sludge material, among other parameters. All else being equal, sludge mixtures with lower shear strengths are more susceptible to failure by both the mass imbalance and Taylor instability mechanisms. The physical parameters of thermal conductivity and shear strength of the K Basin sludge were studied at PNNL and reported in Ref. 11. Reference 11 reports shear stress values that range from 100 to 8,200 Pa., with most samples having shear strength values in the range of 100 to 500 Pa. The analyses reported in Ref. 10 suggest that a sludge plug comprised of sludge with shear strength in this range would be prone to failure by either ofthe first two mechanisms. However, for reasons that are not apparent to the authors of Ref. 11, some few samples included in the Ref. 11 study had measured shear strength values that were significantly higher than the 1,600 Pa cited in Ref. 10 as the upper bound on shear strength values that would lead to sludge plug failure by the Taylor instability mechanism.

This rising sludge plug phenomenon could only occur if sufficient uranium fuel particles were initially concentrated at the bottom of the LDC. This was the case in the laboratory experiment cited in Ref. **6,** where the helium sparging resulted in the heavy metallic uranium particles settling to the bottom of the container, with the remaining sludge above being relatively free of metallic particles. Thus, in this experimental situation, the hydrogen gas source was located almost exclusively at the bottom of the container.

The sludge loading process planned for the LDC virtually guarantees, in contrast, that the metallic fuel particles will be distributed axially in the “sawtooth” pattern discussed above and observed in the POP2 test (Ref. 8). This distribution of fuel particles, in and of itself, practically precludes this postulated plug-like behavior from occurring in the LDC because, if any significant amount of uranium metal is oxidized, the oxidation process would be occurring throughout the axial extent of the sludge and not concentrated at the bottom of the LDC.

In summary, whereas both analyses and experiments have demonstrated that it would not be physically impossible for a vessel-spanning hydrogen bubble to form that would drive a sludge plug upward as the bubble expands, there is substantial evidence available to suggest that it is beyond extremely unlikely that such a phenomenon would be observed in the LDCs loaded with 2 m^3 of K-East Basin sludge using the planned loading process. Factors that, taken together, lead to this conclusion of extremely low probability include, most prominently, 1) the fact that the planned loading sequence will lead to many relatively thin layers of settled sludge and 2) the fact that the bulk of the sludge samples whose shear strength was measured were found to have values well within the range where the Taylor instability mechanism would result in sludge plug failure.

Adequacy of Filter Array Assembly to Disrupt Sludge Slug

As noted above, the third sludge plug failure mechanism would come into play if a vessel-spanning hydrogen bubble were indeed to form and drive a sludge plug upward until the plug came into contact with the lower support grid for the Filter Array Assembly. Fauske & Associates studied these phenomena both analytically and experimentally (Ref. 10). Reference 10 reports on a series of experiments in which mixtures of water and kaolin were used to represent sludge plugs. The starting condition for these experiments was a Plexiglas column in which a gas column was initially trapped under a simulated sludge plug of the water/kaolin mixture. When the pressure in this gas column was increased, the clay slug was driven upward. Various structures were placed at the top of the column above the clay slug. As the clay slug was driven upward, it ultimately came in contact with these structures and was driven through (extruded) whatever opening(s) existed in the structure.

In each experiment, the clay was initially extruded through whatever opening(s) existed. At some point in each experiment, a loud pop signaled the end of the extrusion process. At this point, the underlying gas had penetrated the remaining vertical thickness of the clay plug, which resulted in the rapid depressurization of the driver gas column. In each case, a significant fraction of the clay plug was left behind in the Plexiglas column, pressed up against the lower surface of the structure through which it was being extruded. This same phenomenon occurred when the opening was a simple 1-in diameter hole in a flat plate placed over the top of the column and when the upper structural element was designed to simulate the Filter Array Assembly with its slot.

In this latter case, the structure consisted of a circular grate of diameter equal to the inside **of** the test column. The grate was suspended from a lid placed on the test section by eight steel rods. A rectangular opening was cut into the grate to represent the actual slot in the lower support grid for the Filter Array Assembly in a LDC. When driven upward by gas pressure below it, the clay extruded through the slot. Gas break-through occurred after about 35% of the clay was extruded through the slot. The failure mechanism was the same as that observed in the initial experiment where the opening was a simple round hole in the lid of the test assembly.

Reference 10 presents an analytical model of slug flow that can be used to predict when failure by gas break-through will occur. The model treats the clay plug as a viscous non-Newtonian fluid. It can be used to predict the thickness (denoted H_{cr}) of the remaining clay plug (that has not yet been extruded through the opening) at which gas break-through would occur. In this model, the higher the shear strength of the sludge, the sooner that failure by gas break-through will occur. For example, while the model predicts that a sludge plug with shear strength of 1,500 Pa would fail when the sludge plug had been reduced to a thickness of .21 m by extrusion through the slot in the lower support grid. For sludge with shear strength of 10,000 Pa, the critical thickness at which the sludge plug would fail is 0.8 m.

Two issues were identified when these results were used to predict how **the** Filter Array Assembly would respond to a sludge plug being driven upwards against its lower support grid, with the sludge subsequently being extruded through the slot (which is 10 in wide and stretches from the outer periphery to the centerline of the support grid). The first issue regards the structural response of the Filter Array Assembly to the sludge plug being driven up against it. The second issue regards the volume that is available above the lower support grid, including volume around the cylindrical filters and the LDC head above the filters. It would be into this volume that the water and extruded sludge would be driven.

Regarding the first issue, it was decided to increase the structural capability of the Filter Array Assembly to resist the upward force of the postulated hydrogen bubble-driven sludge plug. To this end, a design change was implemented to add stainless steel pipe segments around the 14 all-thread tie rods that hold the Filter Array Assembly together. Reference 12 presents a calculation which shows that the re-designed Filter Array Assembly is capable of resisting the force of the sludge plug with a factor of safety of 1.45. This calculation assumed sludge with very high shear strength of 8,200 Pa. If the sludge that formed the plug had lower shear strength, the factor of safety would be correspondingly higher (since the upward force exerted by the sludge plug is directly proportional to its shear strength).

Based on the model presented in Ref. 10, a sludge plug with such high shear strength would fail by gas break-through while the plug was still relatively thick. In this case, relatively little sludge would be extruded through the slot into the volume around the filters. A separate calculation is reported in Ref. 13 that examines the amount of volume that would be displaced in the case where the sludge being extruded had much lower shear strength. This calculation started with a sludge plug some 35 in thick with shear strength of 1,500 Pa (to correspond to the low end of the shear strength range where the sludge plug would not be likely to fail by Taylor instability). In the case of this lower shear strength sludge, the calculation shows that the sludge plug would extrude down to a thickness of **6.7** in before gas break-through would occur. At this point in time, some 45 ft^3 of sludge and 32 ft^3 of water would have been pushed up into the Filter Array Assembly. Given that the volume around the filters and in the upper head above the Filter Array Assembly is 63 ft^3, some of this water would have been forced through the filters and into the exit manifold piping. Because the outlet pipe through which filtered water flowed when the LDC was being loaded in the K-East Basin will have been capped, this outlet piping will contain only a limited amount of water. If this large volume of sludge and water were indeed to be forced into the volume above the Filter Array Assembly lower support grid, excess water in the LDC would be forced out of the LDC onto the floor of the cell in T-Plant. Water would be preferentially expelled because it is lighter that the underlying sludge and would be pushed ahead of the sludge.

The cells in T-Plant have been lined with stainless steel liners with leak detection available. Thus, the ultimate (and very improbable) outcome of the vessel-spanning sludge plug event described here would be that some quantity of contaminated water from the LDC would be forced out of the LDC and into the lined cell, where its presence would be alarmed by the leak detection system. The accident consequences of such a scenario are clearly bounded by the various scenarios analyzed in the T-Plant Documented Safety Analyses that provide a safety basis for the project.

However, it must be kept in mind that the likelihood of formation of a vessel-spanning sludge plug is judged to be a beyond extremely unlikely event for all of the reasons cited above. Therefore, the fact that such an event could possibly lead to a small quantity of water being expelled from an LDC into a lined cell at T-Plant should not be viewed with any alarm whatsoever.

Conclusions

The following conclusions are documented and supported in this White Paper:

1. Radial and Axial Distribution of Fuel Particles in LDC Two factors in the design of the LDC and planned sludge-gathering operations combine to provide a high degree of assurance that the radial and axial distribution of metallic fuel particles in the settled sludge is such that heat generated within the sludge can be transported out without exceeding the maximum temperature requirements and hydrogen gas generated in the sludge will "percolate" through the sludge and escape. The design of the LDC inlet pipe, with its attached baffle plate, results in the fuel particles being distributed in an acceptable radial pattern. The operational limitation of requiring a significant pause after each successive 0.5 m^3 of sludge is loaded assures an acceptable axial distribution of fuel particles from a heat transfer perspective. The actual expected operation of the sludge retrieval system, which will consist of a large number of pumping sessions, each followed by a pause of sufficient duration to permit the sludge to settle out of the sludge/water slurry, would result in numerous layers of settled sludge, each with a somewhat richer concentration of fuel particles toward the bottom of the layer. This expected configuration is such that hydrogen gas bubbles formed from the oxidation of fuel would be likely to link up vertically such that paths would form through the sludge that would permit the hydrogen to escape the sludge.

2. Thermal Response of STS Given the radial distribution of fuel particles assured by the baffle plate and the minimum of four layers of sludge, thermal analyses cited in this white paper demonstrate that the maximum temperature requirements are satisfied in all configurations.

3. Response of Sludge to Hydrogen Generation As noted in 1 above, it is expected that hydrogen gas bubbles will link vertically to form escape paths for hydrogen gas generated in the sludge. At most, some gas may be trapped in the interstitial volume of the sludge such that the sludge would expand in volume by some 10% to 15%. The payload of sludge has been limited to 2 m^3 in order to accommodate an increase in volume of up to 54 percent.

4. Potential for Formation of Vessel-Spanning Hydrogen Bubble As cited above, the metallic uranium fuel particles will be distributed throughout the sludge volume in a large number of relatively thin layers of heavy particles alternating with layers of lighter sludge particles. If any significant oxidation of the fuel particles were to occur, hydrogen would be generated throughout the volume of sludge and not preferentially at the bottom of LDC. This fact leads to the conclusion that the formation of a vessel-spanning sludge plug must be viewed as a beyond extremely unlikely event. Furthermore, analyses and experiments cited in this white paper lead to the conclusion that, unless the sludge collected in a LDC has shear strength significantly in excess of that expected for the sludge, any sludge plug that might (however improbably) form above an expanding

hydrogen gas bubble would break up before it could be driven upward to any significant extent.

5. Response of LDC to Hydrogen Bubble-Driven Sludge Plug In the beyond extremely unlikely case where a vessel-spanning hydrogen gas bubble were to form and drive a sludge plug upward, this white paper cites analyses and experiments that show that the consequences of this event could be tolerated by the LDC with at most some water being ejected from the open ports on the LDC as it sits in storage in a T-Plant cell. Such a consequence is judged to be acceptable for such a beyond extremely unlikely event.

References

1 SNF-8166, *Rev. 0, Functional Design Criteria for the K Basins Sludge and Water System – Project A-16*, Fluor Hanford, Inc., July 2001.

2 SNF 8163, Rev. 4, *Performance Specification for the K-East Basin Sludge Transportation System for Project A-16*, Fluor Hanford, Inc., March 2002.

3 FAI Memo, M. Plys to D. Duncan and J. Sloughter, Fluor Hanford, *Sludge Settling & Segregation During Loading, Draft* **3,** January 21,2002.

4 PNNL-13893, *Estimated Maximum Gas Retention From Uniformly Dispersed Bubbles in K Basin Sludge Stored in Large-Diameter Containers*, P. Gauglitz and G. Terrones, Pacific Northwest National Laboratory, May 2002.

5 SWS-A-16-G-010, Rev. 2, *Sludge Container Maximum Sludge Loading Calculation*, Fluor Hanford, Inc., *(This is the calc. that needs to be reissued Sly did the necessary editing before he left.}*

6 PNNL-13805, *Vessel-Spanning Bubble Formation in K-Basin Sludge Stored in Large-Diameter Containers*, G. Terrones and P.A. Gauglitz, Pacific Northwest National Laboratory, March 2002.

7 FAI Memo ME071202a, M. Esptein to M. Plys and R. Crawford, *Mixing of Sludge Feed During Loading and the Role of the Baffle Plate*, Fauske & Associates, July 12,2002.

8 Calculation ER-3C-0126-04, Rev. A, *K-East Sludge Transport System – Large Diameter Container: Proof of Principle Test #2 Report*, AVANTech, Inc., June 14,2002.

9 SNF-9955, Rev. 0, *Safety-Basis Thermal Analysis for KE Basin Sludge Transport and Storage*, Fluor Hanford, Inc., June 2002.

10 FAI/02-39, *Hydrodynamic and Thermal Behavior of Reactive Sludge in Storage Containers*, M. Epstein and M. Plys, Fauske & Associates, May 2002.

11 PNNL-13911, *Thermal Conductivity and Shear Strength of K Basin Sludge*, Pacific Northwest National Laboratory, June 2002.

12 Project A.16 Calculation, *Strength of Filter Cage*, Rev. 1, R. Bromm, Fluor Hanford, Inc., July 10, 2002.

13 Memorandum, *Evaluation of the "Sludge Buster,"*, R. Bromm to G. Sly, Fluor Hanford, Inc., July 15,2002.

Position Paper

Adequacy of Inlet Deflector Plate Design To Assure Acceptable Fuel Particle Distribution in SWS Large Diameter Container (LDC)

Issue/Concern

As the sludge/water slurry is being pumped into the Large Diameter Container (LDC) during the loading phase in the K-East Basin, it is desirable to achieve a distribution of fuel particles that is as close to homogeneous as possible throughout the sludge. The more homogeneous the distribution of particles, the less likely it is that a “hot spot” could develop in the sludge where a relatively high concentration of fuel particles gives rise to excessive heat generation from fuel oxidation. Once the LDC has been filled with water, the inlet pipe will discharge the sludge/water slurry under several feet or water at an elevation slightly below the bottom of the lower filter support grating. **A** deflector place that will deflect the slurry will be attached to the discharge end ***of*** the inlet piping some distance below the end of the pipe. The ability of the deflector plate to deflect the incoming slurry ***so*** as to achieve an acceptable distribution of fuel particles in the sludge has given rise to the following concern:

Concern 1: Is the planned size (diameter) and installation location (distance below the end of the inlet pipe) of the deflector plate adequate to assure an acceptable distribution of the fuel particles throughout the sludge?

Background Discussion

It is expected that a substantial amount of heat will be generated throughout the sludge once it has been pumped into the LDC due to the oxidation of the fuel particle that have lost their protective oxide coating during the pumping process. Extensive calculations have been performed to establish that, if the fuel particles are distributed reasonably homogeneously throughout the sludge, maximum temperatures reached would not lead to local boiling in the sludge even under the extremely conservative assumption that complete oxidation of the fuel particles would occur based on an enhanced reaction rate (by a factor of three).

It was recognized that, if the inlet pipe were permitted to discharge the sludge/water slurry without a deflector plate directly down onto the top of the growing pile of sludge mixture on the bottom of the LDC, sludge located directly below the inlet pipe would continue to be disturbed enhancing the potential for oxidation. In addition, the relatively heavy fuel particles would be less likely to be transported to the periphery of the LDC and could concentrate in a pile below the inlet pipe. These considerations led to the inclusion of a deflector plate to be affixed to the end of the inlet pipe that would deflect the inlet sludge/water slurry in the radial direction.

The requirements to design the inlet piping system to achieve an acceptable distribution of fuel particles in the sludge are established in the following documents:

SNF-8166, Rev. 0, *Functional Design Criteria for the K Basins Sludge and Water System – Project A-16.* (Ref. 1)

Section 3.2.3 – Vessel Performance Requirement –

- Tank/Vessel design shall provide for the removal of heat from radiolytic decay and uranium chemical reaction to prevent the bulk sludge temperatures from exceeding 60°C (140°F). The preferred bulk sludge storage temperature is below 20°C (68°F).

SNF 8163, Rev. 4, *Performance Specification for the K-East Basin Sludge Transportation System for Project A-16.* (Ref. 2)

Section 4.2 – Normal Conditions of KE Operations:

- 4.2.3.2 Thermal (Acceptance Criteria): The STS [Sludge Transportation System] design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.

Section 4.3 – Accident Conditions of KE Operations:

- 4.3.3.2 Thermal (Acceptance Criteria): The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.

Section 5.1 – Normal Conditions of Transport:

- 5.1.3.2 Thermal (Acceptance Criteria): Maximum accessible outside surface temperature of the cask shall be less than 85°C (185°F) in 37.8°C (100°F) air temperature and in the shade. The STS design shall ensure the maximum temperature of the payload does not exceed 100°C (212°F) at any time during loading, transportation and storage.

Section 5.2 – Hypothetical Accident Conditions:

- 5.2.3.3 Thermal (Acceptance Criteria): The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage and subjected to the accident conditions.

Section 6.2 – Normal Conditions of T Plant Unloading Operations:

- 6.2.3.2 Thermal (Acceptance Criteria): The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.

Section 6.3 – Accident Conditions of T Plant Unloading Operations:

- 6.3.3.2 Thermal (Acceptance Criteria): The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.

Section 6.4 – Normal Conditions of T Plant Storage Operations:

- 6.4.3.2 Thermal (Acceptance Criteria): The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.

Section 6.3 – Accident Conditions of T Plant Storage Operations:

- 6.5.3.2 Thermal (Acceptance Criteria): The STS design shall ensure the maximum temperature of the payload does not reach 100°C (212°F) at any time during loading, transportation and storage.

Section 7.5 – General Design and Interface Requirements:

- 7.5.6 The Large Container shall be capable of receiving **30** to 90 gpm of sludge slurry transferred to the Large Container. The **slurry flow** of 30 gpm shall be considered the minimum. The normal flow for which the Large Container is designed shall be identified and be capable of up to ***60*** gpm continuously. Slurry **flow** up to 90 gpm shall be acceptable for short duration transfers of high-density material, as needed to ensure adequate transfer velocities are attained. The inlet flow shall be designed to promote uniform mixing of fluid above the settling sludge. The inlet piping shall not penetrate the uniform mixing layer. For example, consider a flat plate with a diameter twice the inlet pipe diameter separated large of one-quarter the pipe diameter or ½ in. from the exit of the inlet pipe.

Extensive thermal analyses have been performed on the STS in the various conditions cited above to establish that the payload (sludge/water mixture with fuel particles distributed in it) would not experience maximum temperatures established in the requirements. These thermal analyses are documented in Ref. **3.**

These thermal analyses assume that the fuel particles will settle in a reasonably homogeneous distribution radially and into a number of layers axially, where each layer results from a period of continuous pumping followed by a to be specified time of no pumping. Within each layer, the fuel particles are assumed to be concentrated more heavily in the lower regions of the layer due to the different rates of settling of the heavy fuel particles and the other lighter constituents of the sludge during the pumping phase that created that layer.

Basis for Resolution of Concern

Given the concern raised regarding deflector plate design parameters, Fauske & Associates, Inc. **(FAI)** was commissioned to perform analyses to establish acceptable ranges for these parameters (deflector plate diameter and distanced below the inlet pipe end). The results of the FAI study are documented in Ref. 4.

The analyses documented in Ref. **4** assume that the suspended fuel particles behave as a continuum fluid that is blended with the carrier feed liquid. This assumption permits application of the extensive literature that is available on jet mixing in tanks to determine the maximum particle size that will remain well stirred by the LDC inlet pipe flow. Particles remaining well stirred by the liquid feed flow would be deposited in a relatively homogeneous fashion. Particles larger in diameter than this maximum particle size would not remain well stirred.

The FAI analyses lead to the conclusion that the metal fuel particles will not remain well stirred as the particle-bearing slurry strikes the deflector plate, leading to fuel particles leaving the flowing fluid streamlines and undergoing inertial / gravitational deposition on the surface of the already-settled sludge. However, since the initial flow of the slurry is radial once it has encountered the deflector plate, the settled sludge will probably consist of an outer annular region with a higher concentration of metal particles surrounding an inner cylindrical region containing relatively few fuel particles.

The FAI report notes that an annular deposit of metal particles should not be a cause for concern. If the sludge is loaded in a number of discrete operations the annular region will form a stratified morphology of alternating metal-rich and metal-poor sublayers, each pair of sublayers formed during a particular loading period. The distance between stratified metal layers should be small enough so that the hydrogen bubbles that form in one layer would connect with hydrogen bubbles in an adjacent layer, thereby forming paths for gas to flow to the surface of the sludge. In this respect, annular deposits are not necessarily different from sludge-wide homogeneous deposits. In both cases, vessel-spanning bubbles are not likely to form as long as in both cases the discrete metal layers are close to one another.

The FAI report provides a formula for calculating the size of the deflector plate that will accomplish the redirection of the fuel particles in the radial direction. It concludes that a deflector plate with a diameter of 2 in. and placed 1.5 **in.** below the end of the inlet pipe would satisfy the criteria established by application of this formula. That is, it will deflect the incoming feed mixture in the radial direction, preventing the inlet flow from re-suspending the already-deposited sludge below the inlet pipe and causing the fuel particles to be deposited in the annular fashion discussed above.

Conclusions

The current design of the deflector plate is adequate to accomplish its function

References

1. SNF-8166, Rev. 0, *Functional Design Criteriafor the K Basins Sludge and Water System – Project A-16,* Fluor Hanford, Inc., July 2001.

2. SNF 8163, Rev. 4, ***Performance Specificationfor the K-East Basin Sludge Transportation Sys for Project A-16,*** Fluor Hanford, Inc., March 2002.

3. SNF-9955, **Rev.** 0, ***Sufety-Basis Thermal Analysis for KE Basin Sludge Transport and Storage,*** Fluor Hanford, Inc., June 2002.

4. FAI Memo ME071202a, M. Esptein to M. Plys and R. Crawford, ***Mixing of Sludge Feed During Loading and the Role ofthe Deflector Plate,*** July 12,2002.

Position Paper

Radiation Hardening For SWS Sludge Containers Filters

Issue/Concern

The Filter Array Assembly in the Large Diameter Container (LDC) includes over 50 filters, each some 30 inches in length. These filters will exist in a relatively high radiation field once loading of sludge has begun for an LDC. The concern has been expressed regarding the effect that the radiation could have on the filter media and filter assembly

Specifically, the following comments were made at the STS 60% Design Review:

1. The filter assembly appears to not be in compliance with the specification in a number of areas. First the materials (PVC, polypropylene) may not meet the 30 year design life requirement for all container components. Radiation degradation over time will most likely lead to the breakdown of the items. (60-CAP-023)

2. Do PVC and Polypropylene meet the design requirement that all container components be compatible with a 30-year service life (SNF-8163, Section 5.4.1). It would seem PVC and Poly might degrade **due** to radiation exposure. What is the life expectancy of the PVC and Poly filters? Will this degrade over the 30-year storage life? (60-EGE-005C)

Background Discussion

The driving requirements were identified in the Functional Design Criteria and the STS Performance Specification.

SNF-8166, Rev. 0, ***Functional Design Criteria for the** K **Basins Sludge and Water System** – **Project** A-16.*

Section 2.2.8 – The equipment associated with sludge handling, removal, and sludge transport shall have a minimum design life of five (5) years.

Section 3.2.1 - . . . The storage containers shall provide long-term (30 years) storage of sludge.

Section 3.2.3 – Vessels shall be compatible with K Basin water and sludge.

Section 2.2.8 addresses shelf life and storage **of** the LDC and equipment associated with K Basin sludge retrieval operations. Section 3.2.1 requires that LDC maintain its containment boundary for 30 years. Section 3.2.3 also implies that the vessel and all vessel components are compatible with K Basin conditions. This implies all chemical, thermal, and radiological conditions.

SNF 8163, Rev. 4, *Performance Specificationfor the K-East Basin Sludge Transportation System - Project A-16.*

> Section 7.6.1 – Process Service: The Large Container during normal KE Basin operations shall he capable of not less than 6 months of full operations within the KE Basin operation segment as defined in Section 4.0. The operation begins once filling of the Large Container begins and ends once the containment boundary of the Cask has been established.
>
> Section 7.6.2 – Storage Service: ... The Large Container internal filter has two service life requirements. The first being five (5) years during loading in K Basin (functional). The second being thirty (30) years is related to the decomposition and corrosion of the filter media and assembly (filter physical integrity).

The intent of SNF-8163, Rev. 4, Section 7.6.1 was to ensure that the LDC filter media was capable of performing its intended function in the K Basin. Once the LDC was full and prepared for shipment, this mission was complete.

The intent of SNF-8163, Rev. 4, Section 7.6.2 was to address the pre-filling shelf life of the LDC filter media prior to the loading of any sludge. During this time, the LDC filter media is not exposed to a radiation field. Lastly, the reference to the 30-year life is to ensure that the filter media and assembly dose not degrade to the point that it would impact the removal of sludge in the future.

Defensible/Defendable Support

PacTec provided as a response to 60-EGE-005C as follows: "The PVC and poly are used only during the loading of the Large Container. Upon the completion of loading their service life may come to an end. ..."

PacTec provided as a response to 60-CAP-023 as follows: "First – the PVC and polypropylene will not degrade significantly during the 30 year design life (90% submittal will include a polymer degradation analysis.)"

In PacTec Con 15, Rev. 2 – Using Sections 6.2 (Table 6-1) and 7.2, and for a 6 month campaign, the expected radiation field is approximately 1.5E+6 Rad. Using this value and comparing it to Figure 7-1 in Section 7.2 the break point from "Usually always usable" to "Often satisfactory" is approximately 8 E+6. Therefore the value for a 6-month campaign is about a factor of 5 below the limit of minimal concern.

Resolution / Conclusions

From the above requirements and discussion, it can be deduced that the LDC filter media only need to remain functional for a maximum period of six months. During this time, the radiation field will not be sufficiently large or the duration long enough for the radiation to have a significant and damaging effect upon the LDC filter media.

Secondly, in actual operations, the expected K Basin filling mission time is approximately 1 month. If this value were to be used, the expected radiation field would be even less.

Finally, the LDC design was modified between the 60 and 90% design points to eliminate any use of PVC components. This change left polypropylene (filter media and filter housing) as the only component of concern. **(If** the filter media is changed to the 90% design polyester filter media the radiation hardening values are higher by a factor of 100 greater then a polypropylene filter media).

In either case, polypropylene or polyester filter media is acceptable for the K Basin filling operation. As for long-term storage, the filter media may experience some limited radiation hardening, but at that time it is no longer necessary to perform the filtration function. And any degradation would not change the waste classification or hamper sludge removal.

References

1. 60% STS Design Review Comment – 60-CAP-023 and 60-EGE-005C.

2. SNF-8166, Rev. 0, *Functional Design Criteria for the K Basins Sludge and Water System – Project A-16.*

3. SNF 8163, Rev. 4, *Performance Specification for the K-East Basin Sludge Transportation System for Project A-16.*

4. PacTec Con 15, Rev. 2 – *K-East Sludge Transport System – Large Container: Fire Hazard Analysis.*

5. NASA SP-8053, *Nuclear and Space Radiation Effects on Materials*, June 1970.

Position Paper
Prevention of Ignition and Burning of Hydrogen Gas
In
SWS Sludge Container (LDC)

Issue/Concern

Two processes that will produce hydrogen gas will occur in the sludge/water mixture in the Large Diameter Container (LDC) once it is loaded. These processes are 1) oxidation of metal fuel particles (composed predominately **of** uranium metal) and 2) radiolysis of water in the radiation field that will exist in the LDC. Oxidation of metal fuel particles will be the dominant source of hydrogen gas. The presence of this hydrogen gas gives rise to the following concern:

Concern 1: Could the hydrogen gas concentration in the free space above the liquid/air interface in the LDC build up to the point that it exceeds ¼ of the Lower Flammability Limit (LFL) of 4% at the same time that the oxygen gas concentration in the free space lies within the range that would support burning of the hydrogen gas, given an ignition source?

This White Paper examines this concern during the period in time extending from the start of loading the LDC in KE Basin until the LDC is ready to be placed in a storage cell at T-Plant.

Background Discussion

The potential for hydrogen gas building up in the free space at the top of the LDC was recognized during the development of the requirements for the SWS equipment. The driving requirements are identified in the Functional Design Criteria and the STS Performance Specification.

SNF-8166, Rev. 0, ***Functional Design Criteriafor the K Basins Sludge and Water System – Project A-16.***

Section 3.2.3 – Vessel Performance Requirement – ...

- Tank/Vessel design shall preclude the possibility of accumulating either more than *25* percent of the lower flammability limit of hydrogen, per the National Fire Protection Association (NFPA™1) **69, *Explosion Prevention Systems,*** or a problematic quantity of hydrogen as determined by the fire hazards analysis.

SNF **8**163, Rev. 4, ***Performance Spec for the K-East Basin Sludge Transportation*** *System for* ***Project A-I*** 6.

Section 4.2.3.5 – Gas Generation: The hydrogen gas generation shall be evaluated to show that during sludge loading and preparation for transportation no accumulation of hydrogen gas exceeds one quarter of the lower flammability limit assuming normal operation of the KE Basin ventilation.

Section 4.3.3.5 – Gas Generation: The hydrogen gas generation shall be evaluated to show within the KE Basin no accumulation of hydrogen gas exceeds one quarter of the lower flammability limit assuming off-normal operation of the KE Basin ventilation.

Section 6.2.3.5 – Gas Generation: The hydrogen gas generation shall be evaluated to show within T Plant no accumulation of hydrogen gas exceeds one quarter of the lower flammability limit assuming off-normal operation of the T Plant ventilation.

Section 6.3.3.5 – Gas Generation: The hydrogen gas generation shall he evaluated to show within T Plant no accumulation of hydrogen gas exceeds one quarter of the lower flammability limit assuming off-normal operation of the T Plant ventilation.

These requirements regarding limits on accumulation of hydrogen gas in the LDC under various conditions are more succinctly summarized in the following table:

Condition 1: LFL Hydrogen

Location	Requirement	Ventilation	Requirement Section
KE Basin – Normal	1/4th LFL during loading and staging for transportation or fire hazard analysis	Normal	SNF-8163, Section 4.2.3.5
KE Basin – Off-Normal	1/4th LFL during loading and staging for transportation or fire hazard analysis	Off-Normal	SNF-8163, Section 4.3.3.5
Transporation – Normal	Less than 80 psig internal cask Pressure	NA	SNF-8163, Section 5.1.2.6
Transporation – Off Normal	Less than 80 psig internal cask pressure	NA	SNF-8163, Section 5.2.3.2
T Plant – Unloading (Normal)	114'" LFL during receipt and LDC unloading	Off-Normal	SNF-8163, Section 6.2.3.5
T Plant – Unloading (Off-Normal)	1/4th LFL during receipt and LDC unloading	Off-Normal	SNF-8163, Section 6.3.3.5

Basis for Resolution of Concern

The following table summarizes the passive conditions, design features and administrative controls that exist or will be imposed at the various locations and corresponding operational phases and configurations that will work in concert to prevent the concentration of hydrogen gas from reaching ¼ of LFL in the free space at the top of the LDC:

Location/Operational Phase	Configuration	Design Feature/Control	Resulting Condition in LDC
K-East/LDC Filling	Pumps On	Venting through outlet piping	Venting continuously sweeps H_2 from the LDC back to the basin through the outlet piping. Any H_2 generated is entrained in water in the form of small bubbles and is not flammable. H_2 accumulation is not a concern.
K-East/LDC Filling	Pumps Off – LDC Solid	Venting through outlet piping	Passive venting purges H_2 from the LDC back to the basin through the outlet piping. Any H_2 remaining is entrained in water in the form of small bubbles and is not flammable. H_2 accumulation is not a concern.
K-East/LDC Staging	Pumps Off	He Purge to remove excess liquid from LDC	Helium gas is introduced into the LDC to lower the water level in the LDC to the desired point. This results in a cover gas of helium existing in the free space above the liquid level in the LDC. Any H_2 generated during this period cannot be ignited because of the lack of oxygen.
K-East/LDC Staging	Pumps Off / Excessive Delay in Shipping	Re-initiation of He purge if necessary	If something occurs such that the LDC cannot be readied for shipment in expected time frame (**~8** hrs), provisions have been made in the design to enable the He purge lines to be reconnected to the LDC. Additional purging of the free space in the LDC can be performed as necessary to limit H_2 buildup.
LDC During Transportation to T-Plant	LDC with Helium cover gas/ LDC vented into STS cask	LDC vented to cask that encloses it; Cask has undergone He purge.	Both the cask and the free space in the top of the LDC will be filled with He gas with very low oxygen concentrations. Any H_2 generated during this period cannot be ignited because of the lack of oxygen.

Location/Operational Phase	Configuration	Design Feature/Control	Resulting Condition in LDC
T Plant/LDC Receipt	Cask Lid on	He Purge of cask to reestablish He atmosphere in cask and LDC prior to removal of cask lid	The cask containing the LDC is purged with He to re-establish **an** inert environment prior to removing the cask lid.
T Plant/LDC Receipt / Time period following initial purge of STS cask and LDC	Cask Lid on	He Purge of free space in LDC to reestablish He atmosphere in LDC prior to placing it in T-Plant cell	Following the initial He purge of the cask and LDC, the cask and its contents will be monitored for some time to assure that conditions have stabilized before the cask lid is removed and the LDC removed for placement in a T-Plant cell. The cask will be repurged with He periodically to assure that H_2 is not allowed to build up to unacceptable levels.
T Plant/LDC Receipt	Cask Lid off	Cask lid will not be removed until it has been established that a sufficient window of time will be available to place the LDC in storage and vented before H2 could build to unacceptable levels.	When it has been confirmed that the H_2 generation rate is sufficiently low that adequate time will be available to remove the cask lid and "pluck and place" the LDC in storage, that activity can begin with confidence the H2 will not build up to concentrations greater than the LFL while the LDC is being handled.

Conclusions

Information provided in the table above provides the basis for concluding that a combination of design features, modes of operation and administrative controls will preclude the buildup of H_2 in the free space at the top of the LDC to the point that the H_2 could ignite and burn.

References

1. 60% **STS** Design Review Comment – 60-CAP-023 and 60-EGE-005C.

2. SNF-8166, Rev. 0, Functional Design Criteria for the K Basins Sludge and Water System – Project A-16.

3. SNF 8163, Rev. 4, Performance Spec for the K-East Basin Sludge Transportation Sys for Project A-16.

4. PacTec Con 15, Rev. 2 – K-East Sludge Transport System – Large Container: Fire Hazard Analysis.

Metrics	CALCULATION PACKAGE COVER SHEET	File No: L035N-Sludge Calc. No: L035N-Sludge-01 Revision: 0

CALCULATION TITLE:

Extended Thermal Analysis Of Sludge Transport System

PROJECT/CLIENT:

STS / Duratek Federal Services, Inc.

PROBLEM STATEMENT OR OBJECTIVE OF THE CALCULATION:

The K East Basin sludge properties and the initial cask pressure have changed since the safety basis analysis for the Sludge Transport System (STS) Thermal Analysis [3.1] was issued. The intent of this calculation is to extend the safety basis calculation provided in the [3.1] calculation by evaluating the thermal performance of the Sludge Transport System for the revised sludge properties and initial cask pressure. The evaluation is conducted as a sensitivity analysis using the bounding safety basis load cases for normal and accident conditions of transportation.

Since this calculation extends the analysis conducted under the Reference [3.1] calculation to new sludge properties and revised operational conditions, it is to be View as an addendum to the Reference [3.1] calculation.

Document Revision	Affected Pages	Revision Description	Project Engineer Approval/Date	Name of Preparer & Checker
0	All	Initial Release	G. J. Banken (seal: Gregory J. Banken) Expires: 8/12/2004	Preparer: G. J. Banken 10/21/02 Checker: L. H. Nielsen 10/22/02

RECORD OF VERIFICATION

	Circle:		
[a] The objective is clear and consistent with the analysis.	YES	NO	
(b) The inputs are correctly selected and incorporated into the design.	YES	NO	NIA
(c) References are complete, accurate, and retrievable.	YES	NO	N/A
(d) Basis for engineering judgments is adequately documented.	YES	NO	N/A
(e) The assumptions necessary to perform the design activity are adequately described and reasonable.	YES	NO	N/A
(f) Assumptions and references, which are preliminary, are noted as being preliminary.	YES	NO	NIA
(g) Methods and units are clearly identified.	YES	NO	NIA
(h) Any limits of applicability are identified.	YES	NO	NIA
(i) Computer calculations are properly identified.	YES	NO	NIA
(j) Computer codes used are under configuration control.	YES	NO	N/A
(k) Computer codes used are applicable to the calculation.	YES	NO	NIA
(l) Input parameters and boundary conditions are appropriate and correct.	YES	NO	
(m) An appropriate design method is used.	YES	NO	
(n) The output is reasonable compared to the inputs.	YES	NO	
(o) Conclusions are clear and consistent with analysis results.	YES	NO	

COMMENTS:

Verifier: Larry H. Nielsen [signature] 10/22/02

Name/Signature/Date

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1. INTRODUCTION

Objectives:

The K East Basin sludge properties and the initial cask pressure have changed since the safety basis analysis for the Sludge Transport System (STS) Thermal Analysis [3.1] was issued. **The** intent of this calculation is to extend the safety basis calculation provided in the Reference [3.1] calculation by evaluating the thermal performance of the Sludge Transport System for the revised sludge properties and initial cask pressure. The evaluation is conducted as a sensitivity analysis using the bounding safety basis load cases for normal and accident conditions of transportation developed under the Reference [3.1] calculation.

Purpose:

The purpose of this calculation is to **ensure** that the safety basis evaluation provided in the STS Thermal Analysis [3.1] is either bounding for the revised sludge properties and initial cask pressure or to provide the bounding thermal and gas generation evaluations within this document. This calculation extends the analysis conducted under the Reference [3.1] calculation to these new sludge properties and revised operational conditions. As such, it is to be viewed as an addendum to the Reference [3.1] calculation.

Scope:

This calculation applies to the Sludge Transportation System during the transportation between the K Basins and T Plant.

2. DESIGN REQUIREMENTS

With the exception of the sludge property revisions provided in Reference [3.5], the design requirements for this calculation are the same as those presented in the Reference [3.1] calculation. The References [3.2] and [3.3] documents are the basis for the design requirements.

3. REFERENCES

3.1. PacTec Calculation **No.** 12099-05, Rev. 2, ***STS Thermal Analysis,*** September 2002, Packaging Technology, Inc., Tacoma, Washington.

3.2. SOW for the Sludge Transportation System - Contract 12329, Attachment **8,** Rev. 3, March 2002, Fluor Hanford Inc., Richland, WA.

3.3. **SNF-8**163, ***Performance Specification For The K Basin Sludge Transportation System - Project A.16,*** Rev. **4,** March 2002, Fluor Hanford, Richland, WA.

3.4. SNF-9955, ***Safety-Basis Thermal Analysis For KE Basin Sludge Transport System And Storage At T Plant*****,** Rev. 1, September, 2002, Fluor Hanford, Richland, **WA.**

3.5. HNF-SD-SNF-TI-015, Volume 2, Rev. 9, ***Spent Nuclear Fuel Projecf Technical Data Book, Volume 2, Sludge,*** August 2002, Fluor Hanford, Inc., Richland, Washington.

3.6. SINDA/FLUINT™, Systems Improved Numerical Differencing Analyzer and Fluid Integrator, Version 4.4, prepared for NASA, Johnson Spacecraft Center, Contract NAS9-19365, prepared by Cullimore & Ring Technologies, Inc., Littleton, CO, 2001.

3.7. Thermal Desktop™, Version 4.4, Cullimore & Ring Technologies, Inc., Littleton, CO, 2001.

3.8. Q-Metrics QA Record #QMI. 1000.002, ***Computer Program V&V Document: Thermal Desktop™ & SINDA/FLUINT™, V4.4,*** September 2002, Q-Metrics, Inc., Woodinville, WA.

4. THERMAL SOURCE TERM

The thermal source term for the packaging is determined by a combination of assumptions for 1) the thermal properties of the various sludge streams to be loaded, **2)** the mixture ratio of the various sludge types, 3) the quantity of sludge to be loaded during the fill process, and 4) the assumed settling pattern. **The** KE Basin sludge stream is comprised of a mixture of sludge released from the fuel canisters holding the spent nuclear fuel (SNF) and from the sludge on **the** floor or in the basin loadout pit. Each of these sources of sludge represents a non-homogeneous mixture of debris, possibly including some uranium fuel particles. The following sections present the thermal properties and payload configuration assumptions used in this analysis.

4.1. Sludge Thermal Properties

The thermal properties of the sludge are based upon the best available data as documented in Volume 2 of the Spent Fuel Project Technical Databook [3.5]. The Technical Databook provides values for the bounding (i.e., safety basis) and the nominal (i.e., design basis) sludge compositions for the canister and floor sludge sources. Since the issuance of the reference [3.1] thermal analysis, the radiolytic decay heat and **the** thermal conductivities for the safety and design bases sludge payloads and the composition of the design basis sludge payload have changed. The following paragraphs document the values used in this calculation.

Per the project specification [3.3], the safety basis payload for the Large Container will be comprised of 60% by volume of floor sludge and 40% by volume of KE canister sludge, while the design basis payload will consist of 80% floor sludge and 20% KE canister sludge. The reference [3.4] analysis also assumed a 60%/40% mixture for the safety basis sludge payload, but increased the mixture composition to 75%/25% for the design basis payload. This revised design basis payload mixture is considered in this analysis.

Table 4-1 presents a selection of critical sludge thermal parameters **for** the safety basis and design basis sludge payloads based on the properties for the individual sludge streams. The blended sludge properties assume a homogeneous mixture on a volumetric basis. For example, the blended density of the safety basis sludge of 1.9 g/cm^3 is computed using the volumetric mix ratio of the sludge and the individual mass density of the sludge streams or 40% x 2.5 g/cm^3 +

60% x 1.5 g/cm^3. However, those properties that are expressed on a unit mass basis (i.e., reactive surface area, specific heat, etc.) require the **use** of a mass weighted averaging approach.

The thermal conductivity of the sludge is based on a porous media modeling approach, while **the** specific heat for the sludge is computed using a mass weighted average of the constituents making up the sludge. Rather than repeat the calculation of these thermal properties within this document, the reader is directed to [3.4] for a discussion of the calculation methodology used to arrive at these thermal property values.

The transient calculation of the consumption of the metallic uranium due to chemical reaction requires several assumptions. These assumptions are: 1) the initial mass of the metallic uranium present, **2)** a relationship between mass and surface area, and 3) that the reaction rate is a function of the local environment. The initial mass is taken from the data in Spent Fuel Project Technical Databook [3.5] and is equal to 0.0638 g U/cm^3 for the safety basis sludge and 0.013 g U/cm^3 for the design basis sludge (without allowance for gas retention). **The** relationship between the mass of the metallic uranium and the reaction surface area is provided by the Reference [3.5] assumption that the uranium metal exists in the form of uniform spherical particles with a diameter of 500 microns. This assumption permits the calculation **of** the initial number of reacting particles based on **the** initial mass and the determination of an extinction rate by computing the change in particle diameter with the change in mass as the uranium reacts with the surrounding water.

The chemical reaction rate between **the** metallic uranium in the sludge is the same as that assumed in the Reference [3.1] safety analysis. **The** reaction rate is conservatively assumed to be unaffected by previous chemical reactions, whereas logic would indicate that the majority of **the** metallic uranium is covered by a protective layer of oxide layer since the material has existed for years in the KE pool without being consumed by continuing chemical reaction.

4.2. Quantity Of Sludge To Be Loaded

The quantity of as-settled sludge that can be loaded into the Large Container was determined in the Reference [3.1] calculation and this **quantity remains** bounding for this calculation. **The** safety basis sludge quantity considered within this calculation is 2 m^3 of as-settled sludge without gas retention. The **2** m^3 sludge quantity equates to 3.08 m^3 after allowance for 35% gas retention. **The** mass of the sludge remains constant.

4.3. Assumed Sludge Layering

Layering within the sludge payload assumed for this calculation is the same as that evaluated for the safety basis calculations in the Reference [3.1] and for the Reference [3.4] calculation. A total of four (4) active and four (4) inactive sludge layers are assumed within **the** sludge container (see Figure 4-1). The chemical reaction between the metallic uranium and **the** water is considered to occur only within the active sludge layers, while the radiolytic decay heat is distributed equally **on** a volumetric basis between the active and the inactive sludge layers. **The** sludge volumes within each active layer are equal to each other and are twice as large as **the** sludge volumes within each inactive layer.

Table 4-2 and Table 4-3 present the material properties of safety and design basis sludge payloads assuming a sludge layering with 66.7% of the sludge volume in an 'active' sludge layer and 33.3% of the sludge volume in an 'inactive' sludge layer and with a retention of hydrogen gas equal to 35% by volume.

4.4. Thermal Heat Load

The heat loading from the sludge will arise from a combination of radiolytic decay and chemical reaction heat sources. **Per** the Reference [3.5] databook, the safety basis decay heat loading is 118 watts per m^3 of KE canister sludge and 37 watts perm' of floor sludge. Based on a sludge mixture of 60% by volume of floor sludge and 40% by volume of KE canister sludge, the safety basis decay heat loading is 69.4 watts per m^3. The design basis decay heat loading is 25.9 watts per m^3 of KE canister sludge and 3.34 watts per m^3 of floor sludge. Based on a sludge mixture of 75% by volume of floor sludge and 25% by volume of KE canister sludge, the design basis decay heat loading is 8.98 watts per m^3. The decay heat loading are assumed to be constant throughout the sludge volume.

These radiolytic decay heat loads are 91.3% and 60.7%, respectively, of the safety and design basis decay heat loadings used in the Reference [3.1] calculation.

The heat generation resulting from chemical reactions within the sludge container is a function of the temperature and the reacting surface area. The safety basis for reaction rate and the amount and the distribution of the reacting surface area within the sludge payload is the same as that used in the Reference [3.1] and [3.4] thermal analyses. **Due** to a change in the mixture ratio for the design basis sludge composition from 80% floor/20% canister to 75% floor/25% canister, the design basis reaction area increases from the 0.0689 cm^2/cm^3 of gassy sludge assumed for **the** Reference [3.1] thermal analysis to 0.0800 cm^2/cm^3 of gassy sludge (see Table 4-3). **As** such, the change in the composition of the design basis sludge results in a 16% increase in the reaction area over that assumed in the Reference [3.1] thermal analysis.

4.5. Radiolysis of Water

The methodology used to compute the hydrogen and oxygen generation due to radiolysis of the water is the same as that used in the Reference [3.1] and [3.4] thermal analyses. However, based on the latest radioisotopic inventory for the sludge presented in the Reference [3.5] databook, the computed values of $f_\alpha, f_\beta, f_\gamma$ (i.e., alpha, beta, and gamma fractions, respectively, of the decay heat power absorbed by the water) are 0.3217, 0.5146, and 0.1637, respectively. See Reference [3.4] for the development of these factors.

Table 4-1 - Homogeneous Sludge Parameters w/o Gas Retention

Sludge Parameter	Safetv Basis	Design Basis
% Floor Sludge / % Canister Sludge	60-vol% / 40-vol%[A]	75-vol% / 25-vol%[C] (80-vol% / 20-vol%)[A, D]
KE Canister Sludge Density (w/ water)[B]	2.5 g/cm^3	1.9 g/cm^3
Floor Sludge Density (w/ water)[B]	1.5 g/cm^3	1.4 g/cm^3
Blended Density of Wet Sludge	1.9 g/cm^3	1.525 g/cm^3 (1.5 g/cm^3)[D]
KE Canister Sludge U Metal Fraction'	0.125 g/cm^3	0.040 g/cm^3
Floor Sludge U Metal Fraction'	0.023 g/cm^3	0.004 g/cm^3
Metallic U Concentration'	0.0638 gm U/cm^3	0.013 gm U/ cm^3 (0.0112 gm U/ cm^3)[D]
Reaction Area Based On Metallic U Concentration And 500 micron Spherical Particles'	0.403 cm^2/cm^3	0.0821 cm^2/ cm^3 (0.0707 cm^2/ cm^3)[D]
Reaction Enhancement Factor'	3	1
%Water In KE Canister Sludge'	75%	75% (70%)'
% Water In Floor Sludge'	75%	75% *(65%)'*
Thermal Conductivity of Sludge'	0.70 W/m-K (0.82 W/m-K)[D]	0.70 W/m-K (0.88 W/m-K)[D]
Specific Heat of Sludge'	1.852 J/g-K (1.923 J/g-K)[D]	2.319 J/g-K (2.186 J/g-K)[D]
Total U Content In Sludge[B]	0.74 gm U/cm^3 (0.69 gm U/cm^3)[D]	0.238 gm U/cm^3 (0.202 gm U/cm^3)[D]
KE Canister Sludge Radiolytic Decay Heat[B]	118 W/m^3 (117 W/MTU)[D]	25.9 W/m^3 (73.3 W/MTU)[D]
Floor Sludge Sludge Radiolytic Decay Heat[B]	37.0 W/m^3 (117 W/MTU)[D]	3.34 W/m^3 (73.3 W/MTU)[D]

Table Notes: **A) Based on values in the project specification [3.3]**
B) Based on values in the Spent Fuel Project Technical Databook [3.5]
C) Based on values in SNF-9955 [3.4].
D) Value assumed for the reference 3.1 safety analysis.

Table 4-2 - Layered Sludge Parameters For Safety Basis (60:40 Mix) w/ 35% Gas Retention

Sludge Parameter	Homogeneous Sludge w/o Gas Retention	Active Layer (66.7% of volume)	In-Active Layer (33.3% of volume)
Blended Density of Wet Sludge	1.9 g/cm^3	1.235 g/cm^3	1.235 g/cm^3
Metallic U concentration	0.0638 gm U/cm^3	0.0622 gm U/cm^3	0 gm U/cm^3
Reaction Area Based On Metallic U Concentration And 500 micron Spherical Particles	0.403 cm^2/cm^3	0.393 cm^2/cm^3	0 cm^2/cm^3
Reaction Enhancement Factor	3	3	3
Thermal Conductivity of Sludge	0.70 W/m-K	0.512 W/m-K	0.512 W/m-K
Specific Heat of Sludge	1.852 J/g-K	1.852 J/g-K	1.852 J/g-K
Total U Content In Sludge	0.74 gm U/cm^3	0.481 gm U/cm^3	0.481 gm U/cm^3
Sludge Radiolytic Decay Heat	69.4 W/m^3	45.11 W/m^3	45.11 W/m^3

Sludge Parameter	Homogeneous Sludge w/o Gas Retention	Active Layer (66.7% of volume)	in-Active Layer (33.3% of volume)
Blended Density of Wet Slydge	1.525 g/cm^3	0.991 g/cm^3	0.991 g/cm^3
Metallic U concentration	0.013 gm U/ cm^3	0.0127 gm U/cm^3	0 gm U/cm^3
Reaction Area Based On Metallic U Concentration And 500 micron Spherical Particles	0.0821 cm^2/ cm^3	0.0800 cm^2/cm^3	0 cm^2/cm^3
Reaction Enhancement Factor	1	1	1
Thermal Conductivity of Sludge'	0.70 W/m-K	0.512 W/m-K	0.512 W/m-K
Specific Heat of Sludge'	2.319 J/g-K	2.319 J/g-K	2.319 J/g-K
Total U Content In Sludge	0.238 gm U/cm^3	0.154 gm U/cm^3	0.154 gm U/cm^3
Sludge Radiolytic Decay Heat	8.98 W/m^3	5.837 W/m^3	5.837 W/m^3

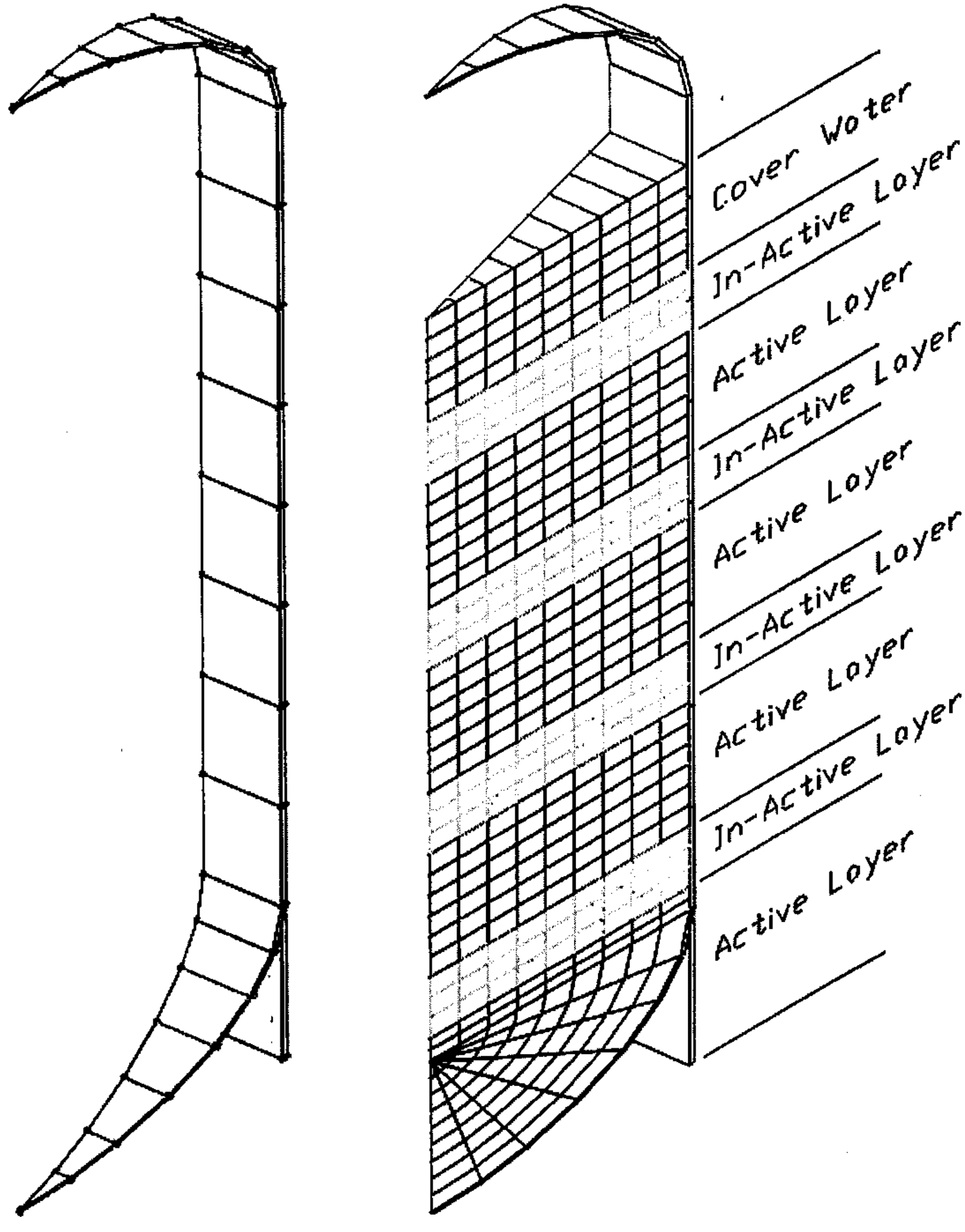


Figure 4-1 - Thermal Model Layout For Large Contalner (Shell & 'Gassy' Sludge)

5. SUMMARY OF MATERIAL THERMAL PROPERTIES

The material properties for the Sludge Transportation Cask and the Large Diameter Container (LDC) are the same as those presented in the Reference [3.1] analysis. As such, this information will not be repeated within this calculation.

6. CONDITIONS ANALYZED

The conditions considered in this sensitivity analysis are a subset of those evaluated in the Reference [3.1] analysis. Specifically, Load Case 1 (i.e., safety basis NCT), Load Case 3 (i.e., safety basis for NCT cold), and Load Case 4 (i.e., safety basis HAC with minimal water leakage) are used to evaluate the effect of the changes in the sludge properties and the initial cask pressure on the thermal performance of the cask.

The following paragraphs summarizes the principle parameters associated with each of these load cases. See the Reference [3.1] analysis for additional discussion on the development of these load cases.

1. ***Safety Basis NCT:*** A transient condition consisting of the safety basis diurnal cycle for ambient temperature and insolation, with safety basis source terms for decay and chemical reaction heat. The sludge payload is 2 m^3 of as-settled sludge, plus 35-vol% of retained hydrogen gas, and 10 inches of water cover. The total decay heat load is 138.8 watts. The transport condition begins with the sludge, the cover water, the container, and the transportation cask at an initial temperature of 77°F. This temperature is equal to the maximum K Basin pool water temperature per [3.5]. The transient is evaluated over a 60 hour shipping window (i.e., twice the expected transportation time).

2. ***Design Basis NCT:*** Same as Case #1, except with design basis source terms for decay and chemical reaction heat. This load condition provides the basis for assessing the expected thermal performance for the system with a nominal payload. The total decay heat load for the sludge payload is 17.96 watts.

3. ***NCT Cold:*** A transient analysis assuming a -27°F steady state ambient temperature with **zero** decay and chemical reaction heat and zero insolation. The transport condition begins with the 3.08 m^3 of 'gassy' sludge, the cover water, the container, and the transportation cask at **an** initial temperature of 50°F. This temperature is equal to the minimum K Basin pool water temperature per [3.5]. The intent of this load condition is to assess the possibility for freezing the water in the payload during the 60 hour shipping window under the worst case Hanford cold day conditions. By assuming a zero heat load, the need to verify the heat loading for each sludge shipment is avoided.

4. **HAC Fire** Event (hot): The peak system temperature obtained from the Safety Basis NCT (i.e., the Load Case **#1)** transient analysis serves as the starting condition for the **fire** event. The fire event consists of a thirty minute transient with an ambient temperature of 1,475°F and the maximum decay heat, and then back to a diurnal cycle in ambient air temperature. Active cooling of the packaging, using water flow from fire hoses, is permitted after the 30 minute **fire.** This load case evaluates the peak temperature achieved for the various cask components under the HAC fire event and the associated thermal gradients. The packaging

configuration prior to the initiation of the hypothetical fire is the bounding package configuration from the Reference [3.1] analysis (i.e., on its side with the leakage of 0.03 m^3 of water into the cask-LDC annulus).

7. ACCEPTANCE CRITERIA

The thermal acceptance criteria for the Sludge Transportation Cask and the Large Diameter Container (LDC) are the same as those presented in the Reference [3.1] analysis. Table **7-1** summarizes the acceptance criteria applied in this calculation. ***See*** the Reference [3.1] analysis for the basis for these values.

Table 7-1 Acceptance Criteria Summary

Parameter	Acceptance Criteria
Bulk Sludge Temperature	≤ 212°F ≥ 32°F
Cask Accessible Surface Temperature	≤ 185°F for NCT w/o Solar
Cask Pressure	- structural calc. to demonstrate a positive design margin[1]
Helicoflex™ Metallic Seals - closure lid - vent & drain ports	 -40°F to 932°F -40°F to 700°F
Butyl-N Rubber Seals[2]	-40°F to 285°F
NucFil™ Filter[2]	-40°F to 180°F
Betafine® XL Cartridge Filters[2]	-40°F to 175°F < 60 psid @ 77°F[3] < 40 psid @ 77°F[4]
Copperized Lead[5]	-40°F to 620°F
Type 304 Stainless Steel[6]	-40°F to 800°F for NCT -40°F to 1000°F for HAC

1) No direct limit on HAC pressure is provided by the **SNF-8163** performance specification [3.3]. Instead. the **STS** Cask structural calculations must demonstrate that the cask design provides a positive design margin in relation to the peak **HAC** pressure.
2) **NITS** - Not Important To Safery
3) Maximum forward differential pressure (psid) across filter in pounds per square inch
4) Maximum reverse differential pressure (psid) across filter in pounds per square inch
5) Per the **SNF-8163** performance specification [3.3], lead melt can occur, but no net **loss** of lead can occur.
6) The temperature limitations apply only to structural components. The applicable limit for the non-structural components is the melting poinl (i.e., approximately 2600°F).

8. CALCULATION METHODOLOGY

The calculation methodology used for this analysis is the same as that described in the Reference [3.1] analysis. The thermal analysis is conducted using the SINDA/FLUINT™ and Thermal Desktop™ computer programs (see [3.6] and [3.7]). These programs are designed to function together to build, exercise, and post-process a thermal model. The codes provide the capability to simulate steady-state and transient temperatures using temperature dependent material properties and heat transfer via conduction, convection, and radiation. Complex algorithms may be programmed into the solution process for the purposes of computing variations to the thermal model as a function of various parameters. Examples include computing the heat transfer coefficients as a function of the local geometry, the heat generation due to the chemical reaction of uranium and water, the decrease in metallic uranium content as it is converted to oxide form, etc. The Thermal Desktop™ and the SINDA/FLUINT™ codes have been validated for use in simulating the thermal response of transportation packages [3.8].

Although the void volume in the STS cask interior and within the LDC will be filled with a combination of helium, hydrogen, oxygen, water vapor, and residual air from the backfill operation, the thermal modeling assumed that the gas mixture in these void volumes can be thermally characterized using the thermophysical properties of helium only. This modeling approach (the same as used in the Reference [3.1] analysis) is justified because of the relative quantities of gas constituents involved, the time frame for the calculations, and the distribution of the gas constituents within the packaging. *See* Appendix C for the justification of this modeling approach.

9. CALCULATIONS

9.1. Sensitivity Analysis For Normal Conditions

The effect of the sludge thermal property changes and the initial cask pressurization on the thermal performance of the system under normal conditions of transportation (NCT) is evaluated in a series of steps using the' Load Case #1 scenario. The first step is to increase the initial cask pressurization from atmospheric to 2 psig, while keeping the thermal sludge properties at the values used in the Reference [3.1] analysis. The second step involved switching to the revised sludge thermal properties presented in Section 4, while assuming the same atmospheric initial cask pressure assumed in the Reference [3.1] analysis. The third and fourth steps involved analyzing the system for the combination of the revised sludge thermal properties presented in Section 4, plus an initial cask pressurization of 2 and 4 psig, respectively. By evaluating the thermal performance in this manner, the sensitivity of the design to these changes can be seen individually and in combination with one another.

Table 9-1 presents the comparison between the thermal performance of the Sludge Transport Cask with an initial pressure of 2 psig and the results obtained from the Reference [3.1] analysis with an initial atmospheric cask pressure. As seen from the table, with the exception of cask pressure, the measured performance parameters after 30 and 60 hours of simulated transport conditions are essentially identical. This is to be expected since cask pressure has no effect on the internal heat source loading and only a minor effect on the internal heat transfer rates. The only noted difference in thermal performance is the increase in cask pressure throughout the transport period by the approximately the initial 2 psig differential. The difference is not exactly 2 psig because of the fact there are two gas volumes considered (i.e., one inside the sludge container and one for the annulus between the container and the cask) and because of the difference in the amount of heat added to each gas volume during the simulated transportation period.

Table 9-2 presents the comparison between the thermal performance of the Sludge Transport Cask with the revised sludge thermal properties and the results obtained from the Reference [3.1] analysis. Again, as seen from the table, the measured performance parameters after 30 and 60 hours of simulated transport conditions are essentially identical. The primary difference noted is a slight (i.e., approximately 0.4°F) increase in the maximum container wall/sludge payload temperature. This temperature increase is attributed to the decrease in the sludge conductivity, which decreases the thermal connection between the relatively cool mass of the sludge interior and the container wall. As a result, the relative influence of the hotter inner shell of the cask on the container wall temperature increases slightly and drives the temperature up.

The combination of the reduction in radiolytic decay heat from 152.1 to 138.8 watts and the reduced conductivity with the container wall causes a slight drop in the bulk average temperature in the sludge and a lower level of radiolysis. As such, a slight decrease in the hydrogen and oxygen gas generation occurs due to the reduced chemical reaction (as seen by the noted lower chemical reaction heat) and radiolysis. The slight magnitude of the effect of the revised sludge thermal properties over the simulated 60-hour transportation process is reflected in the predicted 0.06 psi reduction in the maximum cask pressure. A greater effect would be seen had the simulation been carried through to steady-state conditions, as would exist at the T-Plant.

Table 9-3 presents the comparison between the thermal performance of the Sludge Transport Cask with a combination of a 2 psig initial cask pressure and the revised sludge thermal properties versus the results obtained from the Reference [3.1] analysis. The results seen for this combination are essentially those from Table 9-2, with the maximum pressure from Table 9-1. Overall, with the exceptionof the cask pressure, there **is** very little impact from this combination. Again, the slight decrease in the hydrogen and oxygen generation is associated with the reduction in the total payload radiolytic heat from 152 to 138.8 watts and the reduced conductivity with the container wall. The change in the cask pressure from that predicted using the Reference [3.1] analysis asssumptions reflects the impact of the initial 2 psig cask pressurization. A similar set of results was obtained from the independent analysis presented in Reference [3.4].

The results for the combination of a 4 psig initial cask pressurization and the revised sludge thermal properties presented in Table 9-4 show similar results to those seen with the ***2*** psig initial pressurization. The only real difference is the higher cask pressure due to the difference in the initial cask pressurization. Again, the difference is not exactly 2 psig or 4 psig because of the fact there are two gas volumes considered (i.e., one inside the sludge container and one for the annulus between the container and the cask) and because the difference in the heating of these two gas volumes during the simulated transportation period.

Since all of the sensitivity cases evaluated herein yield essentially the same cask and sludge temperatures and similar gas generation levels, the transient trends for all of the sensitivity cases can be illustrated using a single case. The transient temperatures, cask pressure and gas constituents, and the heat source loadings for the sensitivity case with an initial 4 psig cask pressurization and with the revised sludge thermal properties are illustrated in Figure 9-1, Figure 9-2, and Figure 9-3, respectively. The 4 psig initial pressurization case bounds the results seen for the 0 and 2 psig initial pressure cases.

9.2. Sensitivity Analysis For NCT Cold

The bounding NCT Cold condition analysis was evaluated in Reference [3.1] as Load Case #3. That analysis conservatively assumed that package transport begins at a uniform package temperature of **50°F** and is exposed for 60 **hours** to a constant ambient temperature of -27°F without insolation. For additional conservatism under bounding cold conditions, the analysis assumes no heat loading from radioactive decay or chemical reaction in the sludge, and therefore no hydrogen gas generation by radiolysis or uranium oxidation (chemical reaction).

Reference [3.1] indicated that negative cask gage pressures down to -1.8 psig at 30 hours and -2.2 psig at 60 hours were theoretically possible under the evaluated NCT Cold conditions. Negative cask gage pressure was not identified as a safety issue in Reference [3.1] for the following reasons:

- First, oxygen levels remain low throughout the 60-hour safety-basis shipping window. Assuming (a) the upper bound of 1% oxygen after the pre-transport helium purge operation and (b) the bounding radiolytic oxygen contribution of **0.515** g-moles from column 2 of Table 9-1 (even though radiolysis is assumed not to occur), and taking the 65.4 g-moles of helium backfill from footnote (2) of Table 9-1, the oxygen level at the end of 60 hours is conservatively estimated as:

$$0.01 + \frac{0.515\ g-mole}{65.4\ g-mole} = 0.018 = 1.8\%$$

  Combustion would not occur at this low oxygen concentration, particularly since the NCT cold conditions will dramatically limit hydrogen generation.

- Second, the NCT Cold case in Reference [3.1] conservatively assumed an initial package fill gas temperature of 77°F, with no time to reach equilibrium with the **50°F** overall package temperature prior to sealing the cask. As a result, the package pressure rapidly dropped to -0.7 psig as the fill gas cooled to 50°F, then continued downward under the effect of the extreme cold ambient conditions. **An** additional 3.3 g-moles of fill gas over the 65.4 g-moles assumed for the Reference [3.1] analysis would be required to achieve an initial 0 psig pressure within the sealed cask at **50°F.** This additional fill gas would not affect the overall oxygen concentration since it would be conservatively assumed to contain the same minimum 1% oxygen as the base fill gas quantity. However, initiating the shipping window at true equilibrium atmospheric pressure for the evaluated temperature conditions would limit the minimum package pressure to -1.5 psig at the end of 60 hours, rather than the -2.2 psig as predicted in the Reference [3.1] analysis.

- Third, the STS cask is designed and fabricated to meet the leaktight criteria (leakage less than 1 x 10^{-7} standard cubic centimeters per second [scc/s] for air) of ANSI N14.5-1997, Leakage Tests *on* Packages *for* Shipment. Given the maximum differential pressure across the seal at cold conditions of –2.2 psig, the potential ingress of air is negligible over 60 hours at a bounding negative pressure of -1.5 psig.

Therefore, initial pressurization of the cask above 0 psig with helium gas only further enhances the safety margin against flammability due to oxygen buildup during NCT Cold conditions.

The revisions to the sludge thermal properties will have a negligible effect on the predicted temperatures under the NCT cold conditions. Since the Reference [3.1] analysis assumed zero decay heat and no radiolysis, the changes in the sludge properties affected these parameters will not affect the evaluation. The lower sludge thermal conductivity will tend to reduce the heat loss from the sludge to the cold packaging and make the temperature levels presented in Reference [3.1] conservatively low. Therefore, the safety basis for NCT Cold conditions are bounded by the Reference [3.1] results for Load Case #3 (see Table *9-5).* The table includes the predicted cask pressure based on the quantity of helium backfill assumed for the Reference [3.1] analysis and estimated pressure if the quantity of helium required to achieve atmospheric conditions at the assumed payload temperature of 50°F had been used instead.

The recommendation of the Reference [3.1] analysis is to limit cask exposure to freezing weather to 24 hours or less when the ambient temperature is below 0°F is still valid. Given the limited number of days at the Hanford site that meet this temperature criteria, the impact of such an administrative control on operations is expected to be minimal.

9.3. Sensitivity Analysis For Accident Conditions *Of* Transportation

Three packaging configurations were evaluated for the Load Case #4 hypothetical accident condition (HAC) under the Reference [3.1] analysis. These configurations were: 1) the cask and container on their sides and with a minimal amount (i.e., 0.03 m^3) of cover water required to over-pressurize the cask being leaked into the annulus between the cask and the container, 2) the cask and container on their sides and with the entire cover water volume (i.e., 0.43 m^3) leaked into the annulus, and 3) the' cask and container upright and the entire cover water volume leaked into the annulus. In addition, the potential impact of a mixture of sludge and water being leaked into the annulus was addressed.

The Reference [3.1] results demonstrated that the first accident configuration produced the bounding cask pressure results and that the situation where the leakage consisted of pure water bounded the situation where a mixture of water and sludge were leaked. The peak pressure reached during the 30-minute fire and subsequent 11.5 hour cool down period was 123 psia (108.3 psig). *As* such, the accident configuration with the cask and container on their sides and with 0.03 m^3 of cover water leaked into the annulus between the cask and the container was selected to assess the sensitivity of the HAC simulation to the revised sludge properties and initial cask pressurization.

The thermal model described in Reference [3.1] for this calculation was modified for the revised sludge thermal properties and the system component temperatures and gas constituents were set equal to those values existing at the end of the 60 hour transient with an initial 4 psig cask backfill *(see* Table 9-4). This starting point bounds the results for either the 0 or 2 psig backfill conditions.

Table 9-6 presents a comparison of the peak cask parameters noted between the Reference [3.1] analysis and this HAC simulation based on the revised sludge thermal properties and a 4 psig initial cask pressurization. As seen from the table, with the exception of a peak surface temperature (reached at the cask's fork lift pockets at the bottom of the cask), the temperatures achieved for the various cask components are equal or lower than those reached under the Reference [3.1] analysis. Given the location of the peak surface temperature, the relatively slight 9°F increase in maximum temperature noted in this analysis is not seen as significant as even a slight change in the thermal conductors associated with this low mass region of the cask could produce the noted temperature difference in a 1500°F fire event.

Although the peak lead temperature noted during the fire of 672°F is 52°F above the melting point for lead, the analysis does not account for the heat of fusion for lead. As such, some **of** the heat energy would have been absorbed in melting the lead. The heat of fusion for lead is approximately 11.3 Btu/lbm, while the specific heat for lead at its melting point is 0.036 Btu/lbm-°F. As such, the heat required to melt a pound of lead is over 300 times greater than the heat required to raise the temperature of a pound of lead 1°F. Given this fact, the temperature gradient through the lead shield *(see* the curves for the lead and the inner shell in Figure ***9-5),*** and the fact that the peak lead temperature occurs at the end of the fire, it can be safely stated that if any lead melt does occur, it will be limited to a very short time period and to a thin layer at the outer diameter of the lead shield and that the lead will quickly re-solidify during the water quench operation. Therefore, no net lead **loss** is predicted. It should again be noted that lead melt is permitted for this condition per the [3.3] performance specification.

Figure 9-4 to Figure 9-5 present the transient temperature plots for the HAC event and the post-fire cool down. The effectiveness ***of*** the water quench operation at the end of the fire can readily be seen from the plotted data. Figure 9-6 presents the pressure and gas generation transients over the same time period. As seen from the plotted data for cask pressure, the internal pressure rises quickly once boiling begins, reaches a peak point shortly after the fire is over, reduces in level as the water quench operation, drops the cask temperatures (and hence the internal gas temperatures), and then drops dramatically once the cask inner surface temperatures fall below the condensation temperature.

The peak chemical reaction heat noted during the transient is 1,739 watts, while the radiolytic decay heat remains constant at its safety basis value of 138.8 watts. The peak chemical reaction heat lasts **less** than 5 minutes before **the** quenching operation reduces the sludge temperatures and brings the chemical reaction heat level down to a level that is approximately 25% higher than that seen for the pre-fire conditions. As demonstrated by the system temperatures, the cask design is adequate to handle this elevated heat generation rate and maintain the packaging in **a** safe condition. As seen from Table 9-6, the maximum source terms for both the radiolytic decay and chemical reaction heat are **lower** than those seen for the Reference [3.1] calculation. While a portion of the lower chemical reaction heat is due to the cooler sludge temperatures achieved as a result of the revised sludge properties, the majority of the change in the source terms **is** due to the removal of excessive conservatism in the [3.1] calculation HAC routines that compute the volumetric heating rates for radiolyitic decay heat and chemical reaction heat. Since the conservatism resulted in over-estimating the heat loads, the results in the [3.1] calculation are valid for safety analysis purposes.

To assess the sensitivity of the HAC results to the radiolytic and chemical reaction heat loads and in the interest of correctness, this modeling conservatism was removed for the HAC modeling for this calculation. The fact that similar peak cask pressures are achieved demonstrates that, as is expected, the system's thermal performance under HAC conditions is driven primarily by the heating from the fire and not from the sludge payload.

Boiling of the water within the annulus is predicted to begin approximately **21.5** minutes after the start of the fire. At that point in time the steam saturation pressure exceeds the **33 psia** pressure existing in the cask cavity due to the presence of gas generation from the assumed 60 hours of NCT transportation that precedes the fire accident event. The **4** psi higher cask pressure at the start of the HAC event raises the saturation temperature of the leaked water by **7°F,** and thus delays the onset of boiling by an estimated **1.5** minutes beyond the onset **of** boiling seen in the Reference **[3.1]** analysis. Analysis of the temperature of the water in the annulus vs. time indicates that if the initial cask backfill pressurization was atmospheric, boiling would begin at about **17** minutes after the initiation of the fire. As such, no boiling is expected if the fire event lasts **15** minutes or **less.** Boiling is predicted to cease approximately ***5*** minutes after the start of the cask quench operations, with a shorter fire exhibiting a corresponding shorter period of boiling within the cask. The analysis further predicts that after approximately **35** minutes of water quenching, the interior surfaces of the cask will have dropped in temperature sufficiently to allow the steam to re-condense, with an associated rapid decrease in the cask pressure.

The increase in cask pressure is due to a combination of mechanisms. First, boiling within the cask is a self-arresting process since the increased cask pressure associated with the conversion of the liquid water to vapor also raises the saturation temperature of the remaining liquid water. As such, an ever-increasing temperature level is required to create boiling conditions within the remaining water. Second, the heat of fusion for water (i.e., the change in enthalpy from a liquid to a vapor state) is approximately 1000 times greater than the sensible heat required to raise the water temperature **1°F**. Thus, a significant amount of heat energy can be absorbed with little change in the local temperatures. The third mechanism acting to control the cask pressure is the presence of the relatively cold thermal mass of the sludge payload. Not only does the sludge act as a heat sink, the container's walls remain below the saturation temperature during the fire transient. Therefore, a portion of the water that is boiled off will re-condense on the surfaces of the container and act to moderate the pressure increase with the level of this concurrent condensation process being a complex function of the interior geometry and local temperatures. For simplicity and to avoid the need to justify the configuration of the sludge container following the drop and puncture events that are assumed to precede the fire event, this calculation ignores the potential for concurrent condensation during the boiling phase. This approach will result in a conservative over-prediction of the peak pressures for the HAC event and the rate of condensation during the post-fire cool-down.

The resulting peak pressure seen for this packaging configuration is **124.7** psia (1**10** psig). The saturated steam temperature associated with this pressure is approximately **345°F,** which is indicative of the level of the cask sidewall temperatures reached in the vicinity of the leaked water (the actual sidewall temperature will be approximately **40** to **60°F** hotter due to a combination of the heating rate and the heat transfer coefficient between the sidewall and the water). **The** 124.7 psia (110 psig) peak cask pressure predicted under this calculation is 1.4% higher than the 123 psia (108.3 psig) peak pressure predicted under the [3.1] calculation and that pressure level was shown to yield a positive structural margin with respect to the cask structural design criteria.

The Figure 9-7 color-flooded plot illustrates the temperature distribution in the cask shells (lead shield omitted for clarity), and for the bottom and lid plates at the end of the 30-minute fire event. Since the cask is assumed to be horizontal for this simulation, the 'new bottom' of the cask is on the right side of the plot. The cooler temperatures seen on the right side of the plot are indicative of the presence of the 4" water depth along the side, plus the contact between the container and the cask. The relatively cool inner surface of the cask bottom (or end plate) results from the nearby presence of the lower elliptical head of the container and the convection and radiative exchange between it and the cask end plate. Although peak cask temperatures in the range of 1130°F are seen at the end of the fire, the Figure 9-7 temperature distribution clearly illustrates that this temperature level is only attained at the comers of the cask lid flange and the cask base where the exposed surface area per unit mass is the greatest.

The Figure 9-8 color-flooded plot illustrates the temperature distribution in the lead shield at the end of the 30-minute fire. Again, the cooler temperatures seen on the right side of the plot are the result of the presence of water along that side (i.e., the bottom of the horizontally oriented cask during the fire event), plus the contact between the container and the cask. Further, as discussed above, the portion of the lead that exceeds the lead's 620°F melting point is limited to the outer surface of the lead away from the location of the water in the annulus. The conservative assumption of no gap between the lead and the outer shell of the cask also contributes to a conservative estimate of the lead temperatures during the HAC event.

Figure 9-9 illustrates the temperature distribution in the container and sludge payload via a color flooded plot at the time point of peak temperatures within the cask interior (approximately 3 minutes after the end of the fire). The right hand side of the plot represents the portion of the container that is in contact with the cask inner shell and with the leaked water. As seen from the figure, the localized peak temperature (approximately 390°F) is limited to a small volume adjacent to the section of the container wall that is in contact with the inner shell of the cask. As such, any localized boiling within the sludge is of no consequence as it will re-condense by the sludge mass above these areas and no net steam vapor production is expected. It should be noted that the thermal model does capture the accelerated chemical reaction heat, gas generation, and the depletion of the metallic uranium metal associated with these areas of the elevated sludge temperatures. Since sludge temperatures everywhere else are well below **212°F,** the bulk sludge temperature is clearly demonstrated as remaining within the temperature limit for the sludge payload.

Water quenching of the cask exterior will induce thermal stresses in the cask walls. The color flooded plot presented in Figure 9-10 and the line plot in Figure 9-5 illustrate the predicted temperature gradient between the inner and outer walls of the cask 3 minutes after the start of the quench. At this point, the exterior surface temperatures of the cask have dropped below the boiling point for water used to quench the cask, while the inner shell temperatures are still near their maximum temperature point. Additional information regarding the temperature distribution in the cask shells and at the bottom forging are presented in Appendix B.

The conclusion drawn from this analysis is that the STS cask design is adequate to maintain the system's safety basis for a regulatory 30-minute **fire** event. The **use** of a post-fire quenching operation **is** critical to this safety basis and must be made part of any recovery response where the fire event has lasted 15 minutes or longer. Further, with the exception of peak pressure, the Reference [3.1] analysis of the **HAC** conditions remain valid. An extension to this conclusion is that the sensitivity analyses presented in [3.1] as to the cask and sludge container configuration, the amount of water leakage, and the composition of the leakage into the cask annulus also remain valid and the configuration used in this calculation is the bounding configuration. Finally, the fact that the **4** psig initial cask pressurization yields a slightly higher peak pressure than seen for the [3.1] analysis with **an** initial atmospheric pressure demonstrates that the **4** psig results will bound those **seen** for either **a 2** psig or atmospheric backfill condition.

Table 9-1 - Sensitivity Of NCT Results To Initial Cask Pressure

Parameter	Ref. [3.1] Analysis		Initial 2psig Cask Pressure	
	@ 30 Hours [4]	@ 60 Hours [4]	@ 30 Hours [4]	@ 60 Hours [4]
Max. Lid Temperature, °F	127.9	137.3	127.9	137.2
Max. Outer Shell Temperature, °F	118.4	126.7	118.4	126.7
Max. Lead Temperature, °F	117.0	129.2	117.0	129.2
Max. Inner Shell Temperature, °F	113.3	127.5	113.3	127.5
Seal Temperatures				
- Cask Closure Seal	122.6	131.7	122.5	131.6
- Lid Vent Port	123.2	132.8	123.2	132.8
- Cask Drain Port	107.2	119.5	107.2	119.5
Max. Container Wall / Sludge Temperature, °F	99.0	114.5	99.0	114.5
Metallic U Consumed, kg	2.33	6.17	2.33	6.17
Water Consumed, kg	0.367	0.963	0.367	0.964
Hydrogen Generated, g-moles [1]	20.397	53.482	20.410	53.533
Oxygen Generated, g-moles	0.257	0.515	0.258	0.516
Cask Pressure, psia	20.40 [2]	29.02 [2]	22.56 [3]	31.26 [3]
Gas Generation Rate, g-moles/hr [5]	0.86	1.38	0.86	1.38
Radiolytic Decay Heat, watts	152.1	152.1	152.1	152.1
Chemical Reaction Heat, watts	60.7	99.3	60.7	99.3
Oxygen Mole Fraction [6]	1.06%	0.98%	1.05%	0.98%

Table Notes: 1) Includes hydrogen from radiolysis.

2) Assumes an initial atmospheric cask pressure (i.e., 65.4 g-moles of helium backfill).

3) Assumes an initial 2 psig cask pressure (i.e., 74.5 g-moles of helium backfill).

4) Results for 30 and 60 hours taken from time points of 37 and 67 hours, respectively, in the computer simulation since the analysis conservatively assumes transportation process starts at 7am and 0 hours would represent mid-night far the diurnal cycle of ambient air temperature/solar loading vs. time.

5) Gas generation rate includes 0.0365 g-moles/hr from radiolysis.

6) Assumes an initial 1% oxygen mole fraction at the completion of the cask vent and purge cycle.

Table 9-2 - Sensitivity Of NCT Results To Revised Sludge Thermal Properties

Parameter	Ref. [3.1] Analysis		Revised Sludge Thermal Properties	
	@ 30 Hours [4]	@ 60 Hours [4]	@ 30 Hours [4]	@ 60 Hours [4]
Max. Lid Temperature, °F	127.9	137.3	128.0	137.3
Max. Outer Shell Temperature, °F	118.4	126.7	118.4	126.8
Max. Lead Temperature, °F	117.0	129.2	117.0	129.2
Max. Inner Shell Temperature, °F	113.3	127.5	113.4	127.6
Seal Temperatures - Cask Closure Seal - Lid Vent Port - Cask Drain Port	 122.6 123.2 107.2	 131.7 132.8 119.5	 122.6 123.3 107.3	 131.7 132.8 119.6
Max. Container Wall / Sludge Temperature, °F	99.0	114.5	99.3	114.9
Metallic U Consumed, kg	2.33	6.17	2.32	6.13
Water Consumed, kg	0.367	0.963	0.364	0.953
Hydrogen Generated, g-moles [1]	20.397	53.482	20.235	52.956
Oxygen Generated, g-moles	0.257	0.515	0.254	0.509
Cask Pressure, psia	20.40 [2]	29.02 [2]	20.40 [3]	28.96 [3]
Gas Generation Rate, g-moles/hr	0.86 [5]	1.38 [5]	0.85 [6]	1.36 [6]
Radiolytic Decay Heat, watts	152.1	152.1	138.8	138.8
Chemical Reaction Heat, watts	60.7	99.3	60.8	99.4
Oxygen Mole Fraction [7]	1.06%	0.98%	1.06%	0.98%

Table Notes: 1) Includes hydrogen from radiolysis.

2) Assumes an initial atmospheric cask pressure (i.e., 65.4 g-moles of initial helium backfill).

3) Assumes an initial atmospheric cask pressure.

4) Results for 30 and 60 hours taken from time points of 37 and 67 hours, respectively, in the computer simulation since the analysis conservatively assumes transportation process starts at 7am and 0 hours would represent mid-night for the diurnal cycle of ambient air temperature/solar loading vs. time.

5) Gas generation rate includes 0.0365 g-moles/hr fmm radiolysis.

6) Gas generation rate includes 0.0328 g-moles/hr fmm radiolysis.

7) Assumes an initial 1% oxygen mole fraction at the completion of the cask vent and purge cycle

Table 9-3 -Sensitivity Of NCT Results To 2 psig Initial Cask Pressure And Revised Sludge Thermal Properties

	Ref. [3.1] Analysis		2 psig Cask Fill + Revised Sludge Thermal Properties	
	@ 30 Hours [4]	@ 60 Hours [4]	@ 30 Hours [4]	@ 60 Hours [4]
Max. Lid Temperature, °F	127.9	137.3	127.9	137.3
Max. Outer Shell Temperature, °F	118.4	126.7	118.4	126.8
Max. Lead Temperature, °F	117.0	129.2	117.0	129.2
Max. Inner Shell Temperature, °F	113.3	127.5	113.4	127.6
Seal Temperatures -Cask Closure Seal -Lid Vent Port - Cask Drain Port	 122.6 123.2 107.2	 131.7 132.8 119.5	 122.6 123.3 107.3	 131.7 132.8 119.6
Max. Container Wall /Sludge Temperature, °F	99.0	114.5	99.0	114.9
Metallic U Consumed, kg	2.33	6.17	2.32	6.13
Water Consumed, kg	0.367	0.963	0.364	0.954
Hydrogen Generated, g-moles [1]	20.397	53.482	20.243	52.992
Oxygen Generated, g-moles	0.257	0.515	0.254	0.509
Cask Pressure, psia	20.40 [2]	29.02 [2]	22.53 [3]	31.13 [3]
Gas Generation Rate, g-moles/hr	0.86 [5]	1.38 [5]	0.85 [6]	1.36 [6]
Radiolytic Decay Heat, watts	152.1	152.1	138.8	138.8
Chemical Reaction Heat, watts	60.7	99.3	60.4	98.3
Oxygen Mole Fraction [7]	1.06%	0.98%	1.05%	0.98%

Table Notes: 1) Includes hydrogen from radiolysis.

2) Assumes an initial atmospheric cask pressure (i.e., 65.4 g-moles of initial helium backfill).

3) Assumes an initial 2 psig cask pressure (i.e., 74.5 g-moles of initial helium backfill).

4) Results for 30 and 60 hours taken from time points of 37 and 67 hours, respectively. in the computer simulation since the analysis conservatively assumes transportation process starts at 7am and 0 houn would represent mid-night for the diurnal cycle of ambient air temperature/solar loading vs. time.

5) Gas generation rate includes 0.0365 g-moles/hr fmm radiolysis.

6) Gar generation rate includes 0.0328 g-moles/hr fmm radiolysis.

7) Assumes an initial 1% oxygen mole fraction at the completion of the cask vent and purge cycle.

Table 9-4 - Sensitivity Of NCT Results To 4 psig Initial Cask Pressure And Revised Sludge Thermal Properties

Parameter	Ref. [3.1] Analysis		4 psig Cask Fill + Revised Sludge Thermal Properties	
	@ 30 Hours [4]	@ 60 Hours [4]	@ 30 Hours [4]	@ 60 Hours [4]
Max. Lid Temperature, °F	127.9	137.3	127.9	137.2
Max. Outer Shell Temperature, °F	118.4	126.7	118.4	126.8
Max. Lead Temperature, °F	117.0	129.2	117.0	129.2
Max. Inner Shell Temperature, °F	113.3	127.5	113.4	127.6
Seal Temperatures - Cask Closure Seal - Lid Vent Port - Cask Drain Port	 122.6 123.2 107.2	 131.7 132.8 119.5	 122.6 123.2 107.2	 131.7 132.8 119.6
Max. Container Wall / Sludge Temperature, °F	99.0	114.5	99.3	114.9
Metallic U Consumed, kg	2.33	6.17	2.32	6.14
Water Consumed, kg	0.367	0.963	0.365	0.954
Hydrogen Generated, g-moles [1]	20.397	53.482	20.251	53.025
Oxygen Generated, g-moles	0.257	0.515	0.254	0.509
Cask Pressure, psia	20.40 [2]	29.02 [2]	24.64 [3]	33.31 [3]
Gas Generation Rate, g-moles/hr	0.86 [5]	1.38 [5]	0.85 [6]	1.36 [6]
Radiolytic Decay Heat, watts	152.1	152.1	138.8	138.8
Chemical Reaction Heat, watts	60.7	99.3	60.4	98.4
Oxygen Mole Fraction [7]	1.06%	0.98%	1.05%	0.98%

Table Notes: 1) Includes hydrogen from radiolysis.

2) Assumes an initial atmospheric cask pressure (i.e., 65.4 g-moles of initial helium backfill).

3) Assumes an initial 4 psig cask pressure (i.e., 83.5 g-moles of initial helium backfill).

4) Results for 30 and 60 houn taken from time points of 37 and 67 hours. respectively, in the computer simulation since the analysis conservatively assumes transportation process starts at 7am and 0 houn would represent mid-night far the diurnal cycle of ambient air temperature/solar loading vs. time.

5) Gar generation rate includes 0.0365 g-moles/hr from radiolysis

6) Gas generation rate includes 0.0328 g-moles/hr from radiolysis.

7) Assumes an initial 1% oxygen mole fraction at the completion of the cask vent and purge cycle

Table 9-5 - Bounding Results For NCT Cold (Load Case #3)

Parameter	Results At 30 Hours [1,5]	Results At 60 Hours [1,5]
Lid Temperature, °F	-5.4	-14.6
Outer Shell Temperature, °F	-3.3	-12.4
Lead Temperature, °F	-2.0	-11.9
Inner Shell Temperature, °F	-0.5	-10.8
Seal Temperatures - Cask Closure Seal - Lid Vent Port - Cask Drain Port	 -4.4 -4.5 5.1	 -13.5 -13.6 -7.8
Container Wall / Sludge Temperature, °F	18.0	3.3
Sludge Centerline Temperature, °F	49.8	46.2
Metallic U Consumed, kg	0	0
Water Consumed, kg	0	0
Hydrogen Generated, g-moles [2]	0	0
Oxygen Generated, g-moles	0	0
Cask Pressure, psia	12.86 [3] 13.6 [4]	12.51 [3] [4]
Gas Generation Rate, g-moles/hr [6]	0	0
Radiolytic Decay Heat, watts	0	0
Chemical Reaction Heat, watts	0	0
Oxygen Mole Fraction [7]	1%	1%

2) Includes hydrogen from radiolysis

3) Assumes initial backfill of 65.4 g-moles of helium at 77°F temperature.

4) Estimated cask pressure had the initial backfill quantity been 68.1 g-moles of helium at 50°F temperature.

5) Results for 30 and 60 hours taken from time points of 37 and 67 houn. respectively, in the computer simulation since the analysis conservatively assumes transportation process starts at 7am and 0 houn would represent mid-night for the diurnal cycle of ambient air temperature/solar loading vs. time.

6) Since decay heat is assumed to be zero, gas generation rate from radiolysis is also zero.

7) Assumes an initial 1% oxygen mole fraction at the completion of the cask vent and purge cycle.

Table 9-6 -Sensitivity Results For HAC Load Case #4 (Horizontal Package Configuration w/ 0.03 m^3 Water Leakage)

Parameter	Peak From Ref. [3.1] Analysis [4]	Peak For 4 psig Cask Fill + Revised Sludge Thermal Properties [4]
Max. Exterior Temperature, °F	1124	1133
Max. Outer Shell Temoerature. °F	828	823
Max. Lead Temoerature. °F	675	669
Max. Inner Shell Temperature, °F	555	551
Seal Temperatures - Cask Closure Seal - Lid Vent Port - Cask Drain Port	 624 545 691	 623 544 690
Max. / Min LDC Wall Temnerature. °F	370 / 114 [8]	368 / 115 [8]
Bulk Sludge Temoerature. °F	107	105
Metallic U Consumed, kg	6.639	3.844
Water Consumed, kg	1.011	0.588
Hydrogen Generated, g-moles [1]	56.19	32.67
Oxygen Generated, g-moles	0.12	0.10
Cask Pressure. osia	123 [2]	124.1 [3]
Gas Generation Rate, g-moles/hr [5]	39.90	23.50
Radiolytic Decay Heat, watts	176.6 [6]	138.8
Cl[illegible]ic Reaction Heat, watts	2951 [6]	1739
Time Between Start of Fire & Boiling	[illegible]0 [illegible]	21.5 minutes
Duration of Boiling Conditions [7]	15 minutes	13.5 minutes

able Notes: 1) Includes hydrogen from radiolysis.

2) Includes 65.4 g-moles of initial helium backfill & 102.57 g-moles of hydrogen equivalent assumed trapped in the predrop accident 'gassy' sludge.

3) Includes 83.5 g-moles of initial helium backfill, 53.025 g-moles of hydrogen from preceding 60 hours of NCT transport, and 123.78 g-moles of hydrogen equivalent assumed trapped in the pre-drop accident 'gassy' sludge

4) Results for temperatures and pressure are the maximums noted during the 12 hour transient and do not necessarily occur at coincident times. Results for generated gas quantities, etc. are at the end of the 12 hour transient. Initial conditions for the transient are taken from end of 60 hour shipping window for Load Case #1.

5) Gas generation rate includes 0.036 g-moles/hr from radiolysis for the Ref. 3.1 analysis and 0.0328 g-moles for current analysis, but does not include the steam generation rate.

6) Values for Ref. 3.1 analysis are conservatively high due to the existence of a known error/conservatism in the routines that computed the volumetric heating rates for radiolyitic decay heat and chemical reaction heat.

7) Tabulated value presents the time period over which potential boiling conditions exist, but not necessarily the actual length of time boiling occurs.

8) Minimum LDC wall temperature taken at time coincident with the noted maximum temperature and is provided to illustrate the circumferential temperature variation.

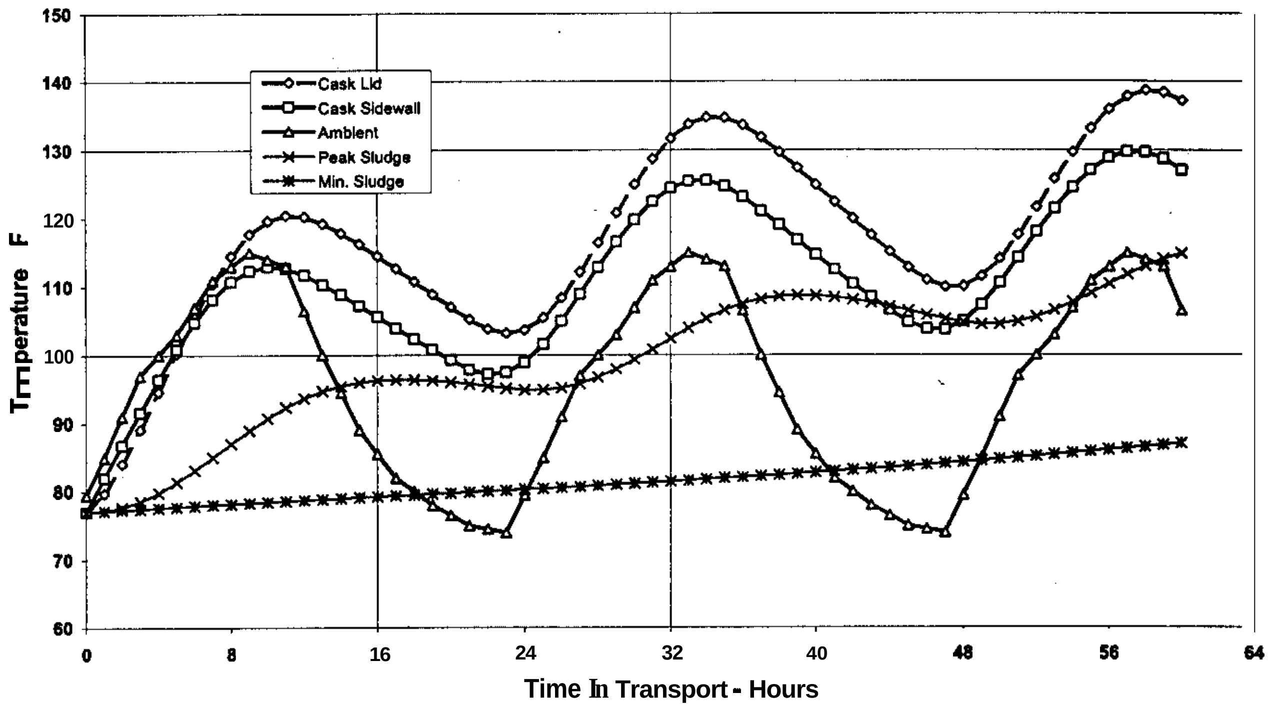


Figure 9-1 -Temperature Profiles For Safety Basis NCT 60-Hour Shipping Window

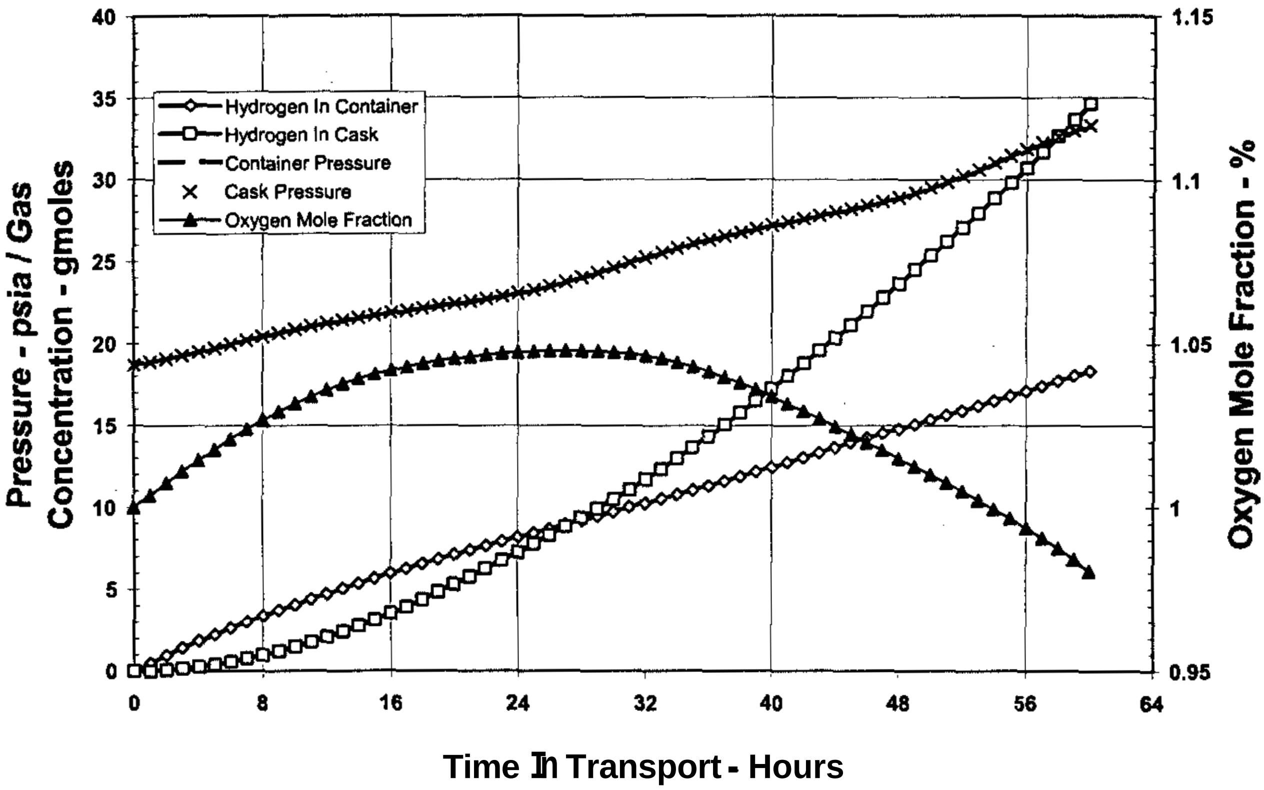


Figure 9-2 - Pressure/Gas Profiles For Safety Basis 60-Hour Shipping Window w/ Initial 4 psig Cask Pressure

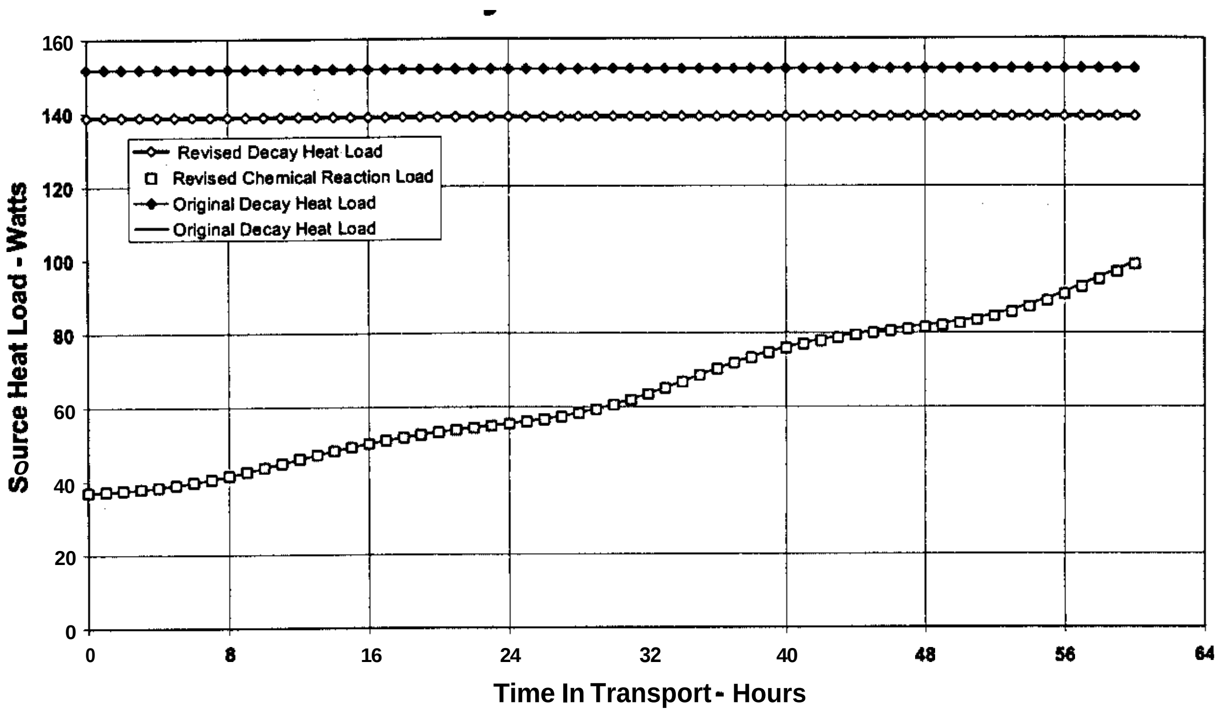


Figure 9-3 - Heat Source Cornparision Between Original And Revised Sludge Payload Properties Over 60-Hour Shipping Window

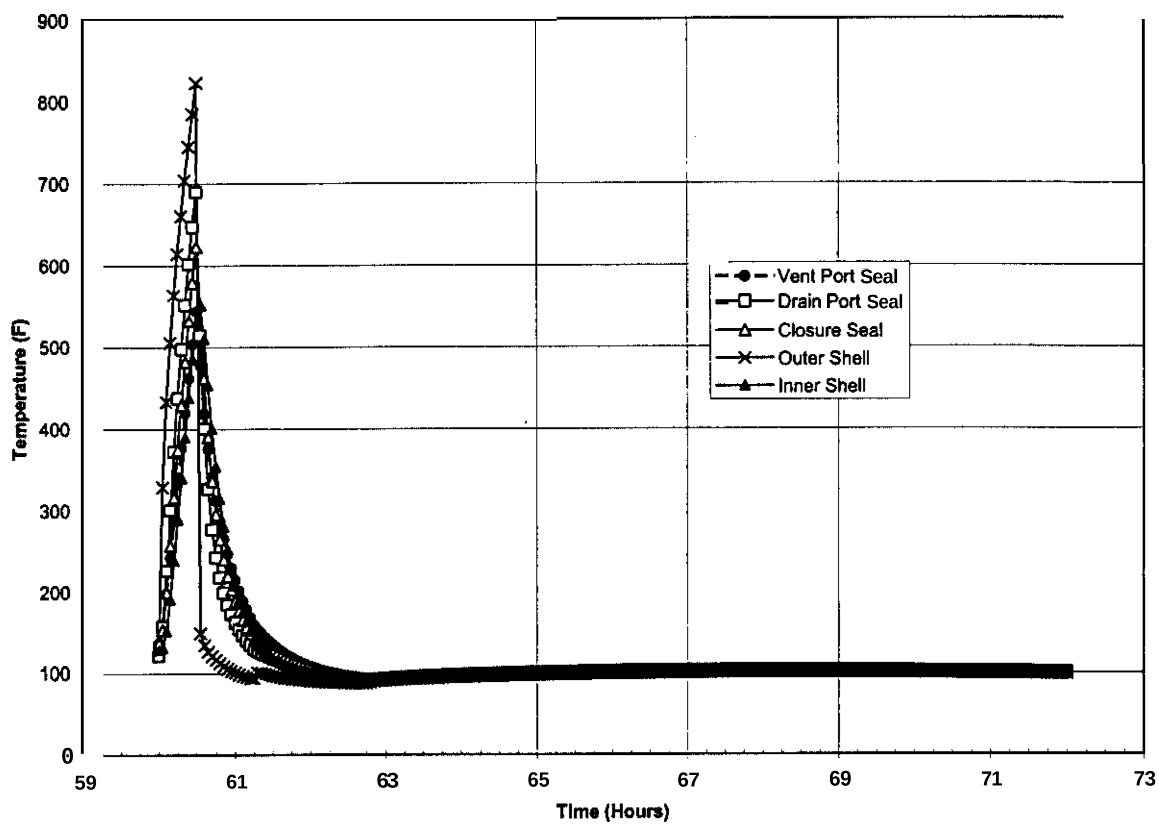


Figure 9-4 - HAC Cask Component Temperatures For The Bounding Package Configuration

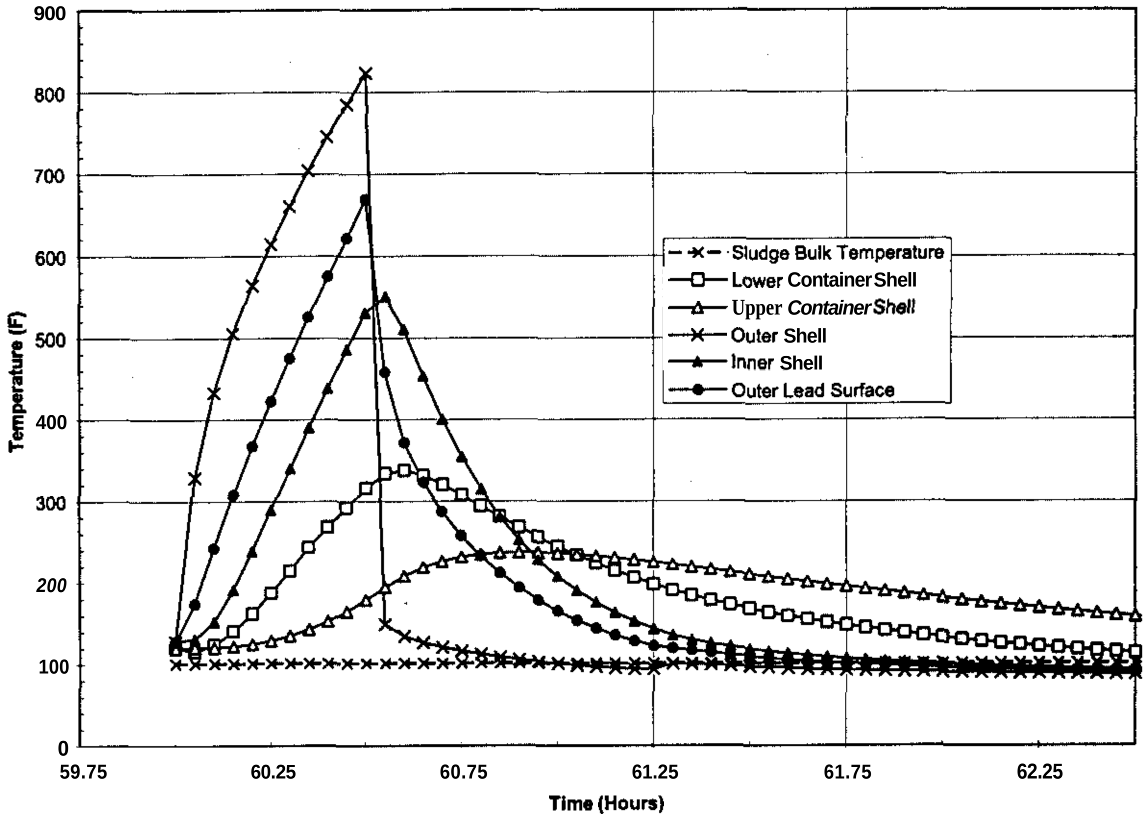


Figure 9-5 - HAC Cask Component Temperatures For The Bounding Package Configuration (Enlarged View)

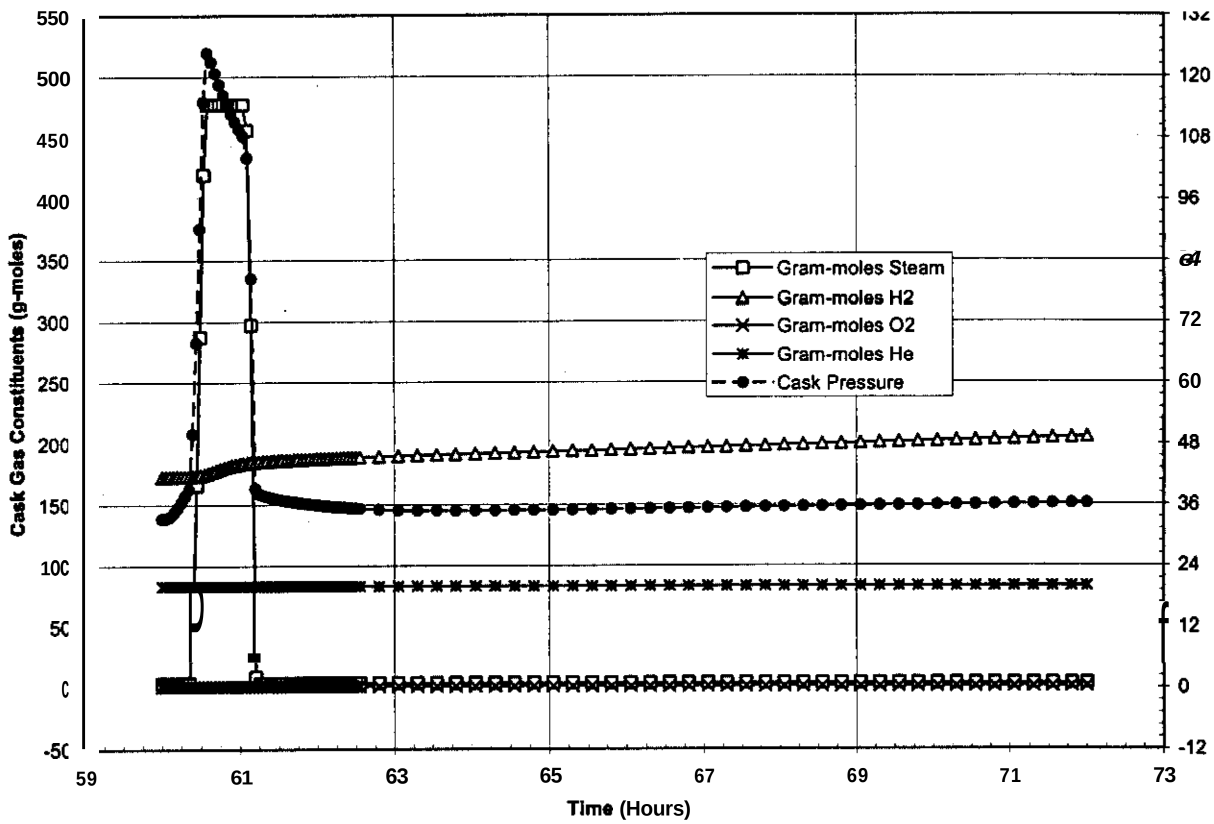


Figure 9-6 - HAC Gas/Pressure Transient For The Bounding Package Configuration

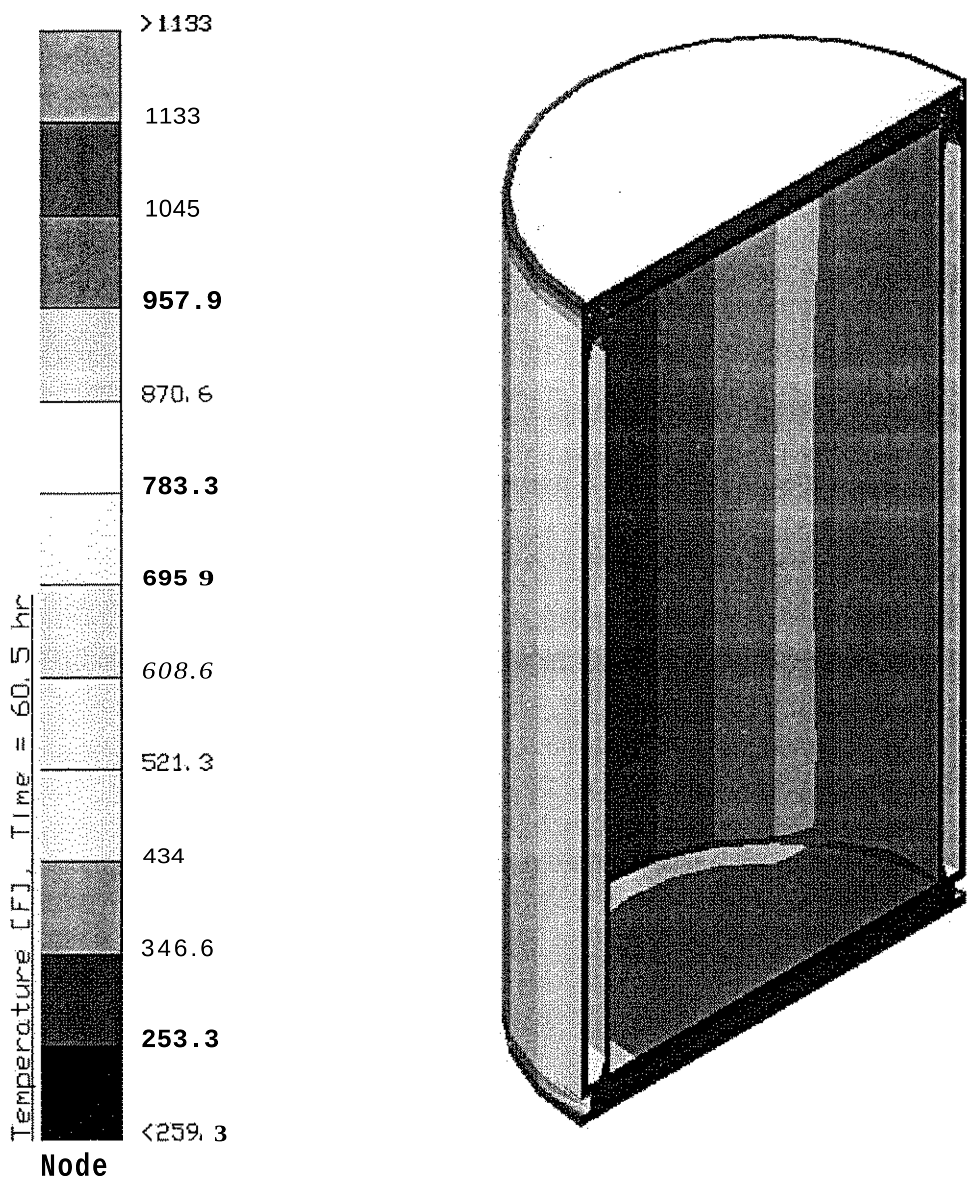


Figure 9-7 -Temperature Distribution In Cask Shells At End Of Fire For The Bounding Package Configuration

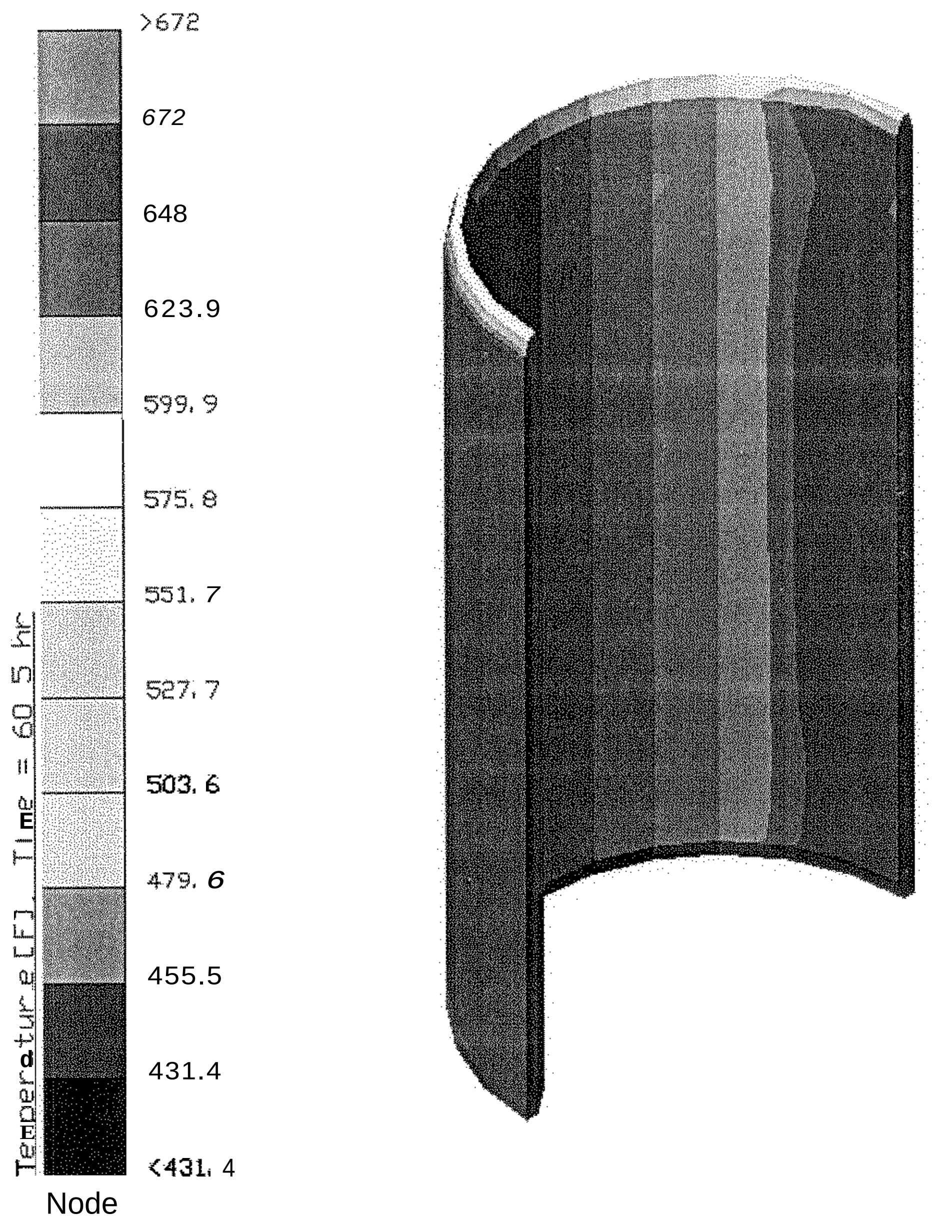


Figure 9-8 - Temperature Distribution In Lead At End Of Fire For The Bounding Package Configuration

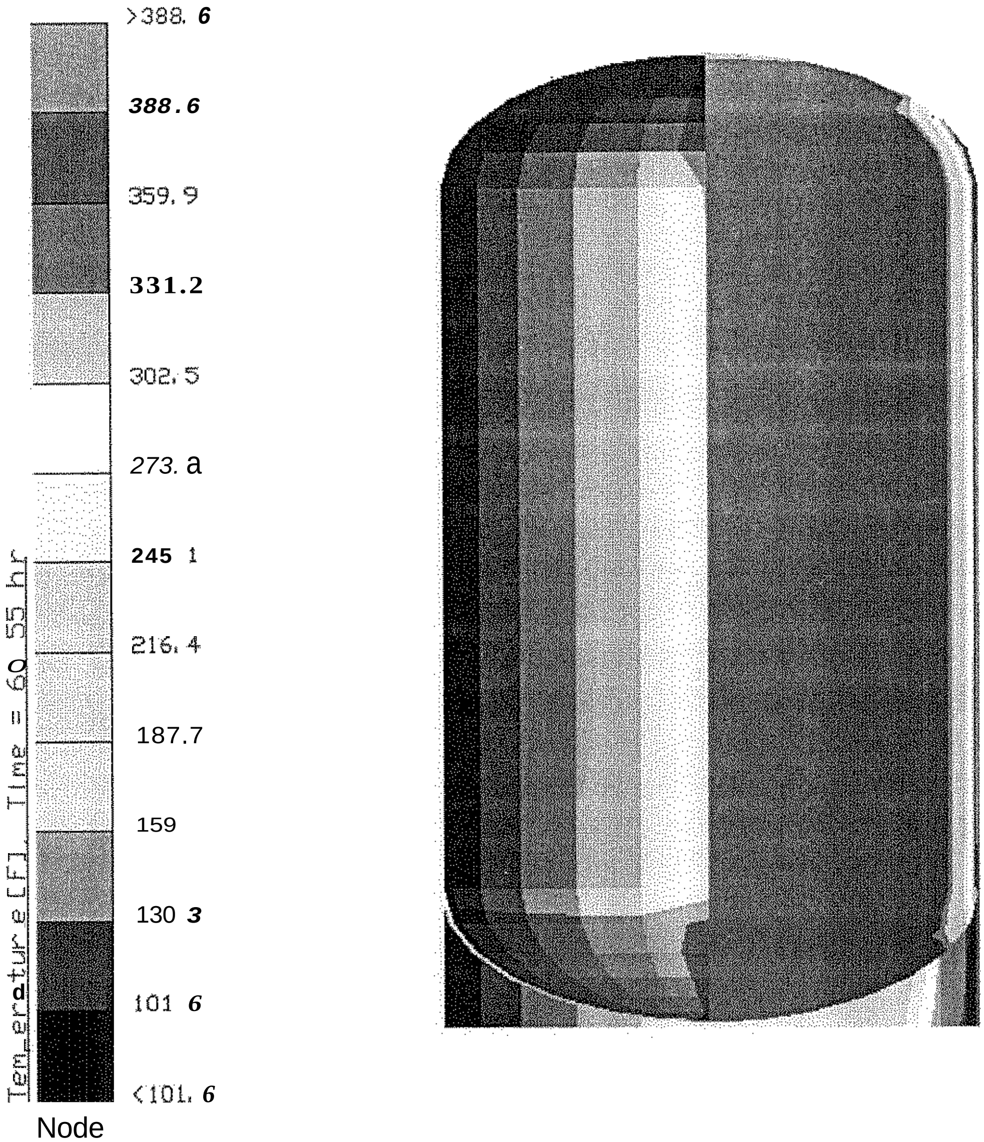


Figure 9-9 - Temperature Distribution In Container & Sludge 3 Minutes After End Of Fire For The Bounding Package Configuration

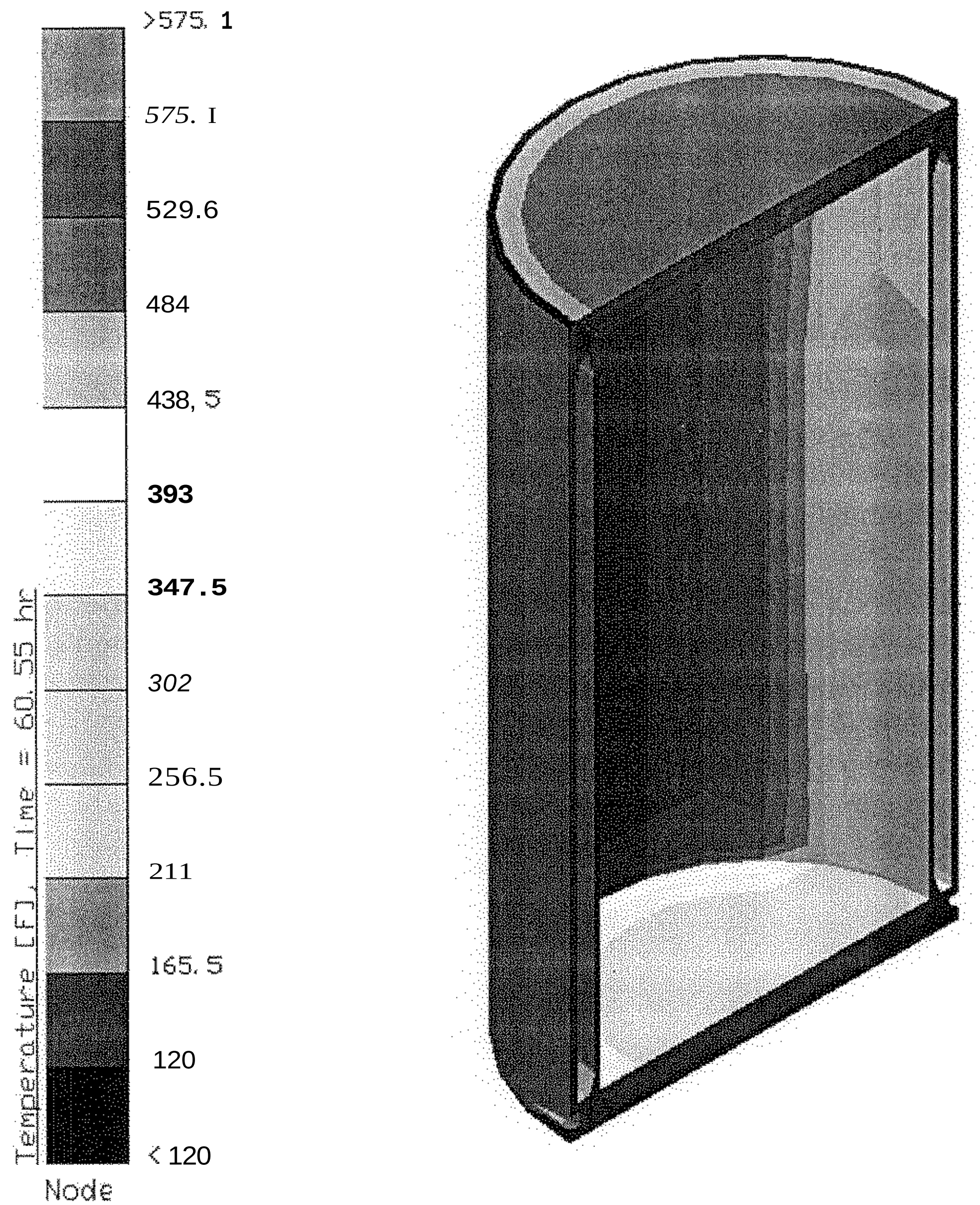


Figure 9-10 - Temperature Distribution In Cask Shells 3 Minutes After Start Of Water Quench For The Bounding Package Gonfiguration

10. CONCLUSIONS

The K East Basin sludge properties and the initial cask pressure have been changed since the Sludge Transport System (STS) Thermal Analysis [3.1] was issued. This calculation extends the safety basis calculation provided in the Reference [3.1] calculation to cover these changes in sludge properties and operating conditions. The evaluation is conducted as a series of sensitivity analyses using the bounding safety basis load cases for normal and accident conditions of transportation developed under the Reference [3.1] calculation.

The results presented in Section 9 demonstrate that the system's design complies with all thermal and pressure criteria in the performance specification [3.3] and as summarized in Table 7-1. Specifically, all packaging components are shown to remain within their allowable temperature limits for both NCT and HAC conditions. The sludge payload is demonstrated to remain thermally stable throughout the 60-hour simulated period (and is expected to remain stable for an indefinite period -- see the extended analysis presented in the Reference [3.4]). The NCT analyses also demonstrate that, even with insolation applied, the system complies with ¶5.1.3.2 of [3.3] in that no accessible surface of the package will exceed 185°F.

Analysis of the Load Case #3 results presented in Table *9-5*, indicates that freezing along the outer edges of the container can be expected to begin after approximately 16 hours of exposure to the -27°F ambient condition. While the results in Table *9-5* indicates that the edges of the sludge container will below 32°F, the center of the sludge payload is seen as being only marginally decreased from its initial 50°F starting temperature. Further, since the analysis does not account for the latent heat required to freeze water, the predicted minimum sludge temperatures are conservatively low. In reality, the combination of a higher sludge density due to the absence of retained gases, and the latent heat removal required to freeze water will tend to limit the portion of the sludge payload which would actually freeze below that predicted in this analysis. For conservatism, it is recommended that exposure of the cask to ambient conditions of 0°F or less should be limited to 24 hours or less to avoid freezing in the sludge payload.

The maximum normal operating pressure (MNOP) of 33.31 psia (18.6 psig) arises with a 4 psig initial cask pressurization. This peak pressure is well within the 94.7 psia (80 psig) pressure criterion for the cask under normal operating conditions. The maximum oxygen gas mole fraction remains well below 2% (i.e., 50% of the lower flammability limit) throughout the 60-hour simulated period (i.e., twice the expected transportation time) and for cask backfill conditions of 0 psig and higher.

The peak packaging component temperatures noted during the simulated fire event remain within the allowable limits specified in Table 7-1. Although the maximum package temperature of 1133°F is above the 1000°F limit for Type 304 stainless steel under accident conditions specified in Table 7-1, this temperature occurs at the upper and lower comers of the cask and not at the cask's pressure boundary. Temperatures over other portions of the cask remain below the short term limit of 1000°F. Although the peak lead temperature is predicted to exceed 620°F, this occurs only for a thin layer, for a short time period, and only under a conservative set of assumptions. As such, no lead melt is actually expected and no net lead loss will occur.

The peak cask pressure under **HAC** conditions is conservatively estimated at **124.7** psia **(110** psig). This pressure is only **1.3%** above the level predicted in the Reference [3.1] calculation, with the difference being primarily related to the increase from 0 to **4** psig in the assumed initial cask pressurization. No boiling is expected within the cask unless the accident condition involves a drop event that damages the LDC container allowing the cover water to escape and unless the fire event lasts more than **15** minutes. The use of the post-fire quench process (see **75.2.2.3** of the performance specification [3.3]) is seen as a critical element in controlling the peak temperatures and gas generation within the sludge payload. As such, any recovery procedure for the **HAC** event involving a fire should incorporate the quench operation.

Finally, the results of this analysis demonstrate that the conclusions drawn in the Reference [3.1] calculation remain valid for the revised sludge thermal properties. The primary difference between the results presented in this calculation and those presented in the [3.1] calculation is the higher cask pressures predicted due to the assumption of a **2** and **4** psig initial cask pressurization **vs.** the atmospheric condition assumed in the [3.1] calculation. **As** such, the conclusion reached in the [3.1] calculation as to the sensitivity to various assumptions, the selection of the bounding HAC configuration, etc. remains valid.

11. APPENDIX A - ELECTRONIC FILE LOGS

The following tables provide a listing of the input and output files used in the thermal simulations for this calculation. All of the computer runs were performed on a Pentium III computer (S/N 1317327-001) running Windows 2000. The spread sheets are generated using Microsoft's **EXCEL** 2000 program.

Metrics	COMPUTER RUN RECORD		
Computer Run Number	Case1_2psig		
Analysis Software	Thermal Desktop™ & SINDA/FLUINT™		
Hardware Description	**Pentium III** PC, Windows 2000 operating system		
Disk Storage Description	CD-ROM		
Disk File Storage	File Description	File Name	Creator
	ASCII Input	'Case1_2psig.inp' 'Sludge_SBgassy.inc' 'Sludge_SBgassy.rad' 'start–mass–SBgassy.f' 'cumass_SBgassy.f' 'total_SBgassy.f' 'frcvv.f', 'frcvhd.f' **'frcvhu.f'**	Gregory J Banken
	Binary Database	'Sludge_Sbgassy_TI015R9.dwg' 'Sludge_Sbgassy_Materials.tdp' **'Sludge_Sbgassy_Materials.rco'**	Gregory J Banken
	ASCII Output	'Case1_2psig.out' 'Case1_2psig_usr1.dat' 'Case1_2psig_usr2.dat'	Gregory J Banken
	Binary Results	'Case1_2psig.sav'	Gregory J Banken
Printed Attachments			
- none -			

Analysis Descriotion:

Analysis represents a repeat of Load Case **#1 as** describe in Reference [3.1], except with **a** 2 psig initial cask pressurization instead of atmospheric pressure.

Metrics	COMPUTER RUN RECORD		
Computer Run Number	Case1_TI015R9		
Analysis Software	Thermal Desktop™ & SINDA/FLUINT™		
Hardware Description	Pentium III PC, Windows 2000 operating system		
Disk Storage Description	CD-ROM		
Disk File Storage	**File Description**	**File Name**	**Creator**
	ASCII Input	'Case1_TI015R9.inp' 'Sludge–Sbgassy–TI015R9.inc' 'Sludge_SBgassy.rad' 'start_mass_SBgassy.f' 'cumass_SBgassy.f' 'total_SBgassy.f' 'frcvv.f', 'frcvhd.f' 'frcvhu.f'	Gregory J Banken
	Binary Database	'Sludge_Sbgassy_TI015R9.dwg' 'Sludge_Sbgassy_Materials_TI015R9.tdp' 'Sludge_Sbgassy_Materials.rco'	Gregory J Banken
	ASCII Output	'Case1_TI015R9.out' 'Case1–TI015R9_usr1.dat' 'Case1_TI015R9_usr2.dat'	Gregory J Banken
	Binary Results	'Case1_TI015R9.sav'	Gregory J Banken
Printed Attachments	**Description**		
-none-			

Analysis represents a repeat of Load Case #1 as describe in Reference [3.1], except with the revised sludge thermal properties.

Metrics	COMPUTER RUN RECORD		
Computer Run Number	Case1_2psig_TI015R9		
Analysis Software	Thermal Desktop™ & SINDA/FLUINT™		
Hardware Description	Pentium III PC, Windows 2000 operating system		
Disk Storage Description	CD-ROM		
Disk File Storage	File Description	File Name	Creator
	ASCII Input	'Case1_2psig_TI015R9.inp' 'Sludge–Sbgassy–TI015R9.inc' 'Sludge_SBgassy.rad' 'start_mass_SBgassy.f' 'cumass_SBgassy.f' 'total_SBgassy.f' 'frcvv.f', 'frcvhd.f' frcvhu.f'	Gregory J Banken
	Binary Database	'Sludge_Sbgassy_TI015R9.dwg' 'Sludge_Sbgassy_Materials_TI015R9.tdp' 'Sludge_Sbgassy_Materials.rco'	Gregory J Banken
	ASCII Output	'Case1_2psig_TI015R9.out' 'Case1_2psig_TI015R9_usr1.dat' 'Case1_2psig_TI015R9_usr2.dat'	Gregory J Banken
	Binary Results	'Case1_2psig_TI015R9.sav'	Gregory J Banken
Printed Attachments	Description		
-none-			

Analysis Description:

Analysis represents a repeat of Case1_TI015R9, except with a 2 psig initial cask pressurization instead of atmospheric pressure.

Metrics	COMPUTER RUN **RECORD**		
Computer Run Number	Case1_4psig_TI015R9		
Analysis Software	Thermal Desktop™ & SINDA/FLUINT™		
Hardware Description	Pentium III PC, Windows 2000 operating system		
Disk Storage Description	CD-ROM		
Disk File Storage	**File Description**	**File Name**	**Creator**
	ASCII Input	'Case1_4psig_TI015R9.inp' 'Sludge–Sbgassy–TI015R9.inc' 'Sludge_SBgassy.rad' 'start_mass_SBgassy.f' 'cumass_SBgassy.f' 'total_SBgassy.f' 'frcvv.f', 'frcvhd.f' 'frcvhu.f'	Gregory J Banken
	Binary Database	'Sludge_Sbgassy_TI015R9.dwg' 'Sludge_Sbgassy_Materials_TI015R9.tdp'	Gregory J Banken
	ASCII Output	'Case1_4psig_TI015R9.out' 'Case1_4psig_TI015R9_usr1.dat' 'Case1_4psig_TI015R9_usr2.dat'	Gregory J Banken
	Binary Results	'Case1–4psig_TI015R9.sav' 'Case1_4psig_TI015R9.xls'	Gregory J Banken
Printed Attachments	**Description**		
- none -			

Analysis Description:

Analysis represents a repeat of Case1_TI015R9, except with a 4 psig initial cask pressurization instead of atmospheric pressure.

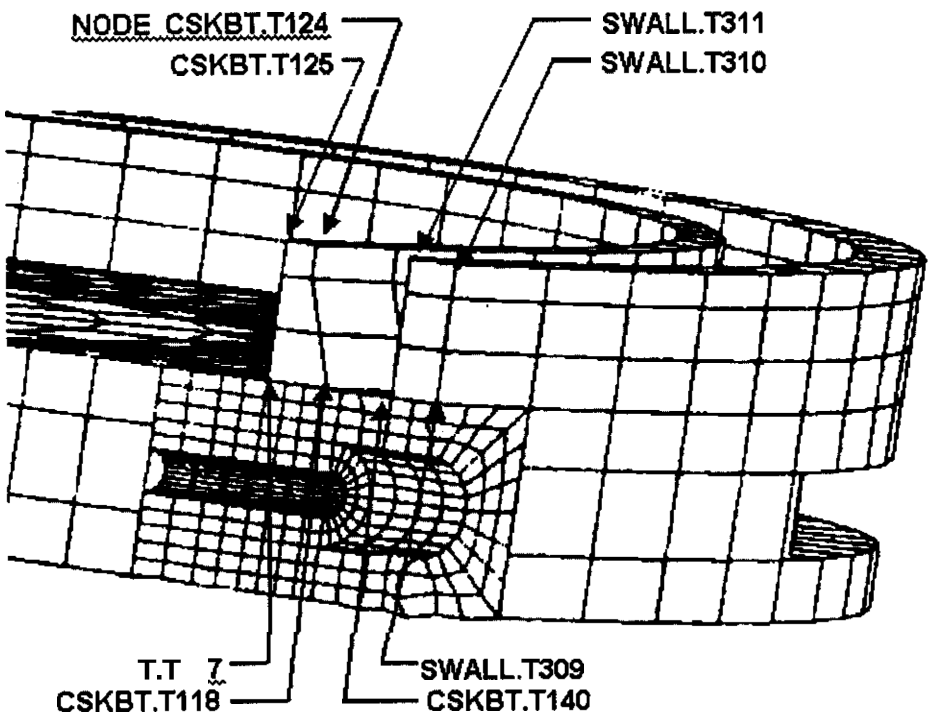
Metrics	COMPUTER RUN RECORD		
Computer Run Number	Case4b_4psig_TI015R9		
Analysis Software	Thermal Desktop™ & SINDA/FLUINT™		
Hardware Description	Pentium III PC. Windows 2000 operating system		
Disk Storage Description	CD-ROM		
Disk File Storage	File DescriDtion	File Name	Creator
	ASCII Input	'Case4b_4psig_TI015R9.inp' 'Sludge–Sbgassy–TI015R9.inc' 'Sludge–HAC–TI015R9.rad' 'start_mass_HAC.f' 'cumass_HAC.f' 'total_HAC.f' 'frcvv.f', 'frcvhd.f' 'frcvhu.f', 'forexcv.f'	Gregory J Banken
	Binary Database	'Sludge_HAC_minH2O.dwg' 'Sludge–HAC–Materials–TI015R9 tdp' 'Sludge_Sbgassy_Materials.rco'	Gregory J Banken
	ASCII Output	'Case4b_4psig_TI015R9.out' 'Case4b_4psig_TI015R9_usr1.dat' 'Case4b_4psig_TI015R9_usr2.dat'	Gregory J Banken
	Binary Results	'Case4b_4psig_TI015R9.sav' 'Case4b_4psig_TI015R9.xls'	Gregory J Banken
Printed Attachments	Description		
- none -			

Analvsis Descriotion:

Analysis represents a repeat of the bounding Load Case #4 package configuration as describe in Reference [3.1], except with the revised sludge thermal properties and with a 4 psig initial cask pressurization instead of atmospheric pressure.

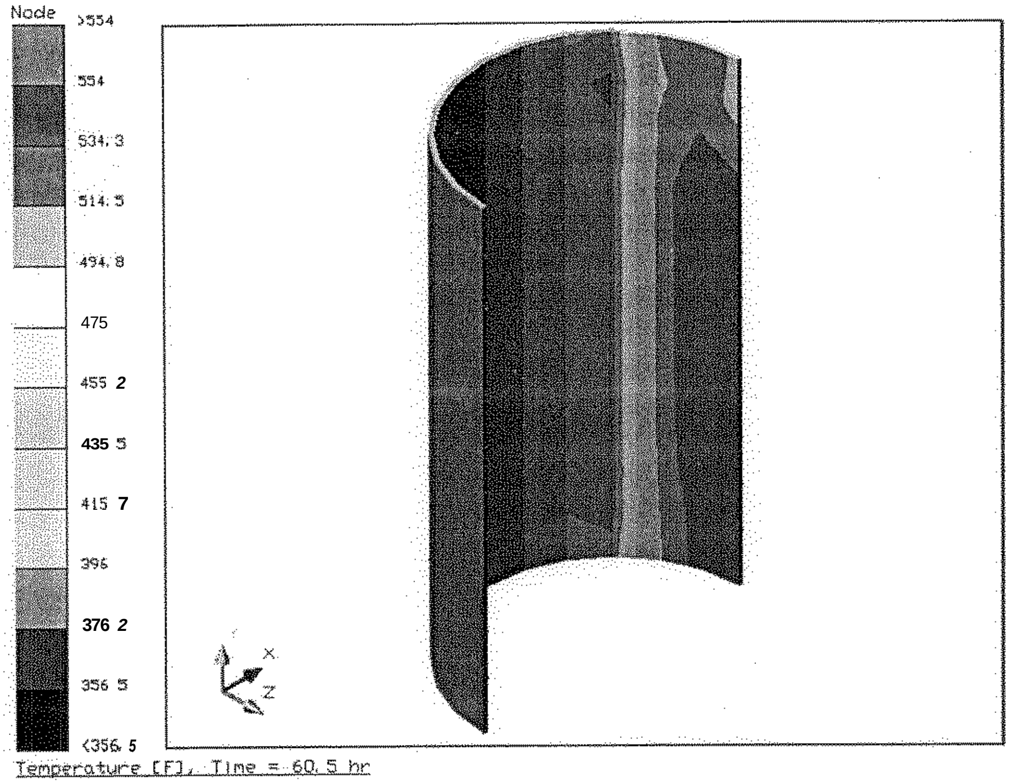
12. APPENDIX B - TEMPERATURE GRADIENT INFORMATION

To support the structural analysis of the thermal stresses for the fire and the post-fire quench operation, temperatures for **8** points on the bottom forging were extracted from the model. The figure below illustrates the specific thermal model node numbers and the location associated with selected 8 points. **As** seen from the figure, the temperature points capture the temperature distribution at the end of the inner and outer shells in the vicinity of the drain port. **For** conservatism, the thermal model assumes that the drain port is oriented towards the top of the horizontal cask (i.e., the left side of Figure **9-7).**

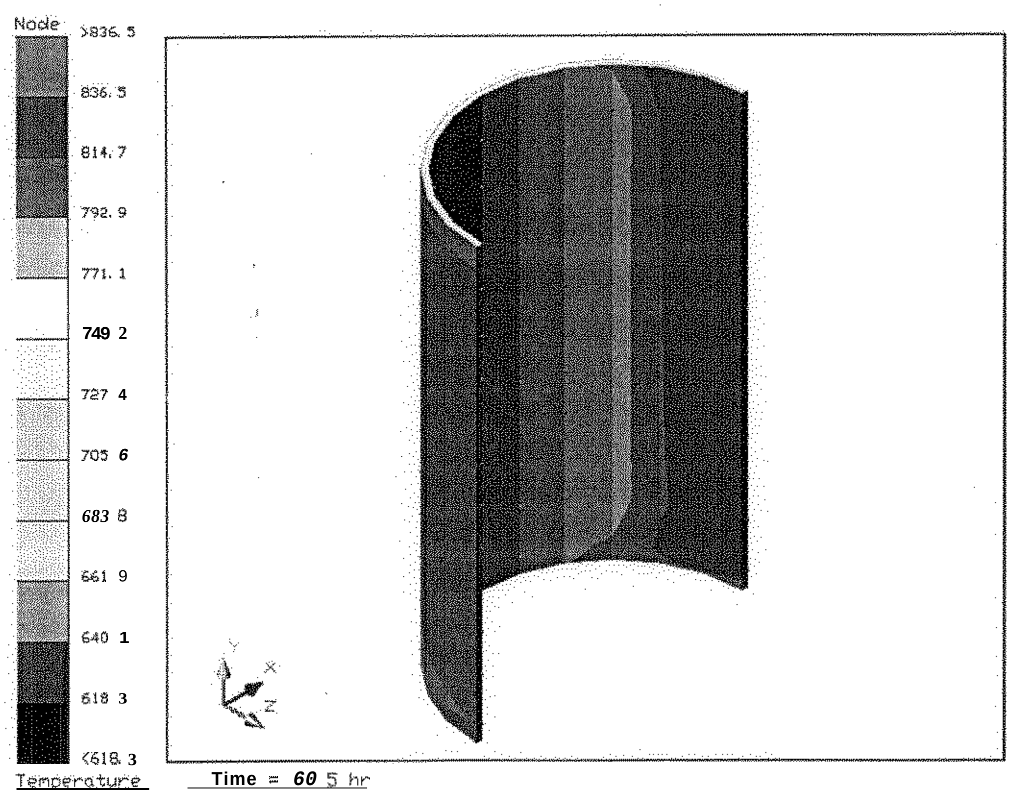


Time	SWALL Submodel			CSKBT Submodel				
	T309	T310	T311	T117	T118	T124	T125	T140
End of Fire	811.7°F	807.9°F	666.8°F	388.0°F	514.7°F	529.5°F	506.5°F	663.2°F
3 Minutes Into Quench	152.0°F	147.7°F	418.7°F	423.4°F	506.6°F	525.2°F	525.3°F	439.7°F

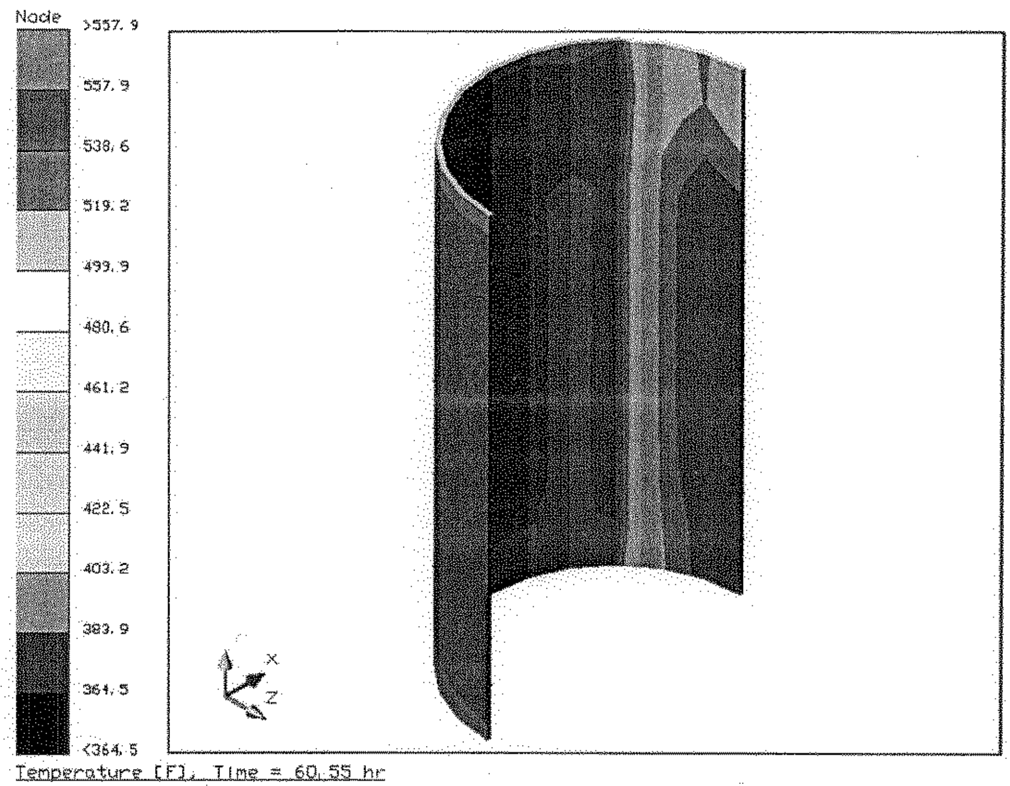
The following color flooded plots provide additional information regarding the temperature distribution in the inner and outer shells for the same time points.



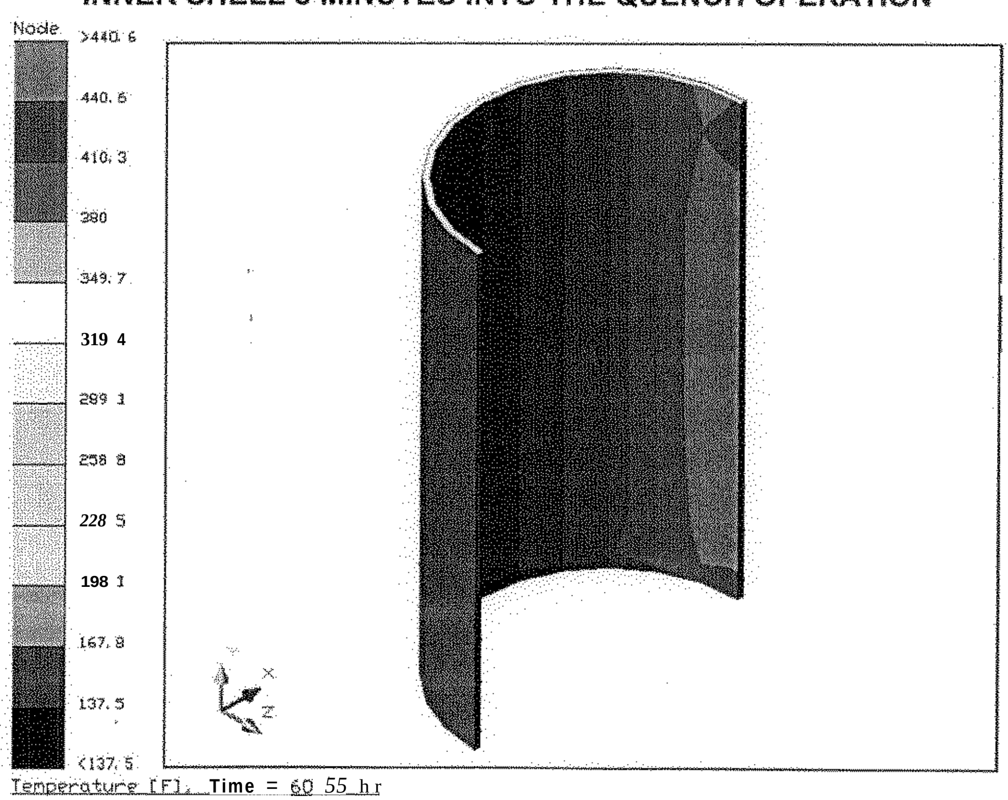
INNER SHELL AT **END OF FIRE**



OUTER SHELL AT **END OF FIRE**



INNER SHELL 3 MINUTES INTO THE QUENCH OPERATION



OUTER SWELL 3 MINUTES INTO THE QUENCH OPERATION

13. APPENDIX C - JUSTIFICATION OF THERMOPHYSICAL PROPERTIES ASSUMED *FOR* VOID VOLUMES WITHIN THE STS CASK

Although the void volumes within the STS cask and the Large Diameter Container (LDC) will be filled with a combination of helium, hydrogen, oxygen, water vapor, and residual air from the backfill operation, the thermal modeling assumed that the gases in these void volumes can be characterized using the thermophysical properties of helium. This modeling approach is justified because of the relative quantities of gas constituents involved, the time frame for the calculation, and the distribution of the gas constituents within the packaging.

The cask and LDC void volumes are to be filled with helium gas prior to the start of transportation. The purge and vent cycle to be used has a criteria that the oxygen concentration at the start of transportation must be ≤1%. Since this oxygen content will result from the residual air left within the packaging, the minimum helium content will be 100% -1%/21% = 95.2%, where the 21% factor represents the relative portion of oxygen in air. Pressurization of the packaging with helium above atmospheric pressure will also increase the relative helium content. Since the thermal conductivity of air is only about 1/5 of that of helium, the thermal conductivity of the gas mixture will also be reduced, with the amount of reduction ranging from about 8% for conduction, to less than 2% for heat transfer via convection. The lower impact on convection heat transfer is due the associated changes in gas density, viscosity, and specific heat which tend to increase the buoyancy driven convection forces.

The addition of hydrogen gas to the void volumes from chemical reactions and/or radioylsis will increase the thermal conductivity of the gas mixture. Since the amount of increase is a function of the mole fraction of the gas constituents, the thermal conductivity of the gas mixtures will increase as longer transportation periods result in larger amounts of generated hydrogen gas. Using the gas constituents for the case with a 4 psig initial backfill condition (see Table 9-4), the thermal conductivity of the gas mixture will be approximately 3% higher than that for pure helium environment after 60 hours of transportation, while the associated convection rate will be approximately 8% higher.

Given that the sludge payload is assumed to begin the safety basis transportation conditions colder than the ambient, the general flow of heat is from the cask into the sludge container. As such, the use of a pure helium environment will tend to over-estimate this heat transfer rate between the cask sidewall and the container during the initial portion of the simulated 60-hour transportation period. Since this would result in higher sludge temperatures and greater gas generation from chemical reactions, it is conservative to ignore the presence of air in the gas mixture. While the opposite effect is true at the end of the 60-hour period where the thermal conductivity of the gas mixture could be 3% higher than a pure helium environment, the effect is small and more than offset by the demonstrated conservatisms during the initial portion of the transportation process. Further, the 3% increase in gas conductivity due to the presence of hydrogen is predicated on a safety basis rate of hydrogen gas generation and the assumption that the initial quantity of helium gas is that for a sludge payload with gas retention (i.e., a greater helium quantity will be required if the gas retention within the sludge is less than 35% by volume). Per the Reference [3.1] analysis, the design basis sludge will generate less than 6% of the hydrogen gas generated under *the* safety basis sludge assumptions. Therefore, overall, the use of a pure helium environment for the NCT analyses will yield conservative results for sludge temperature and gas generation rates.

The same logic applies to the HAC analysis since, of the 32.7 g-moles of hydrogen gas estimated to be generated during the simulated 30-minute fire and 11.5-hour post-fire cool down period *(see* Table 9-6 and Figure 9-6), less than ***6*** g-moles are generated during the **first 45-minutes,** whereas up to **477** g-moles of steam are generated during the same time frame. **As** such, the thermal conductivity of the gas mixture during this critical time frame can be expected to be decreased substantially from that of a pure helium environment due to the presence of water vapor with its associated relatively low thermal conductivity. Only after the quench operation has re-condensed the water vapor will the thermal conductivity of the gas mixture rise above that for a pure helium environment. Therefore, the use of a pure helium environment **will** conservatively increase the heat transfer into the sludge container during the fire event and conservatively restrict the heat flow out of the container during the post fire cool-down period.

Fluor Federal Services	CALCULATION IDENTIFICATION AND INDEX	Calc No.: A16-N-002 T.O./Job No.: 65400851.115916 Date: I1104102

Status and description of the attached Calculation Sheets.

Discipline: Criticality & Shielding

Project No. & Title: K East Basin Sludge and Water System - Project A-16

Calculations: Supplemental Report to the STS Process Shield Plate Analysis of PacTec Calc. 12099-21 Rev. 3

Check applicable box: (when required by project) Safety Class ☐ Safety Significant ☐ General Service ☐ Not Determined ☐

These calculations apply to:

Drawing No. ______ Rel. No ______

Drawing No. ______ Rel. 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

Wrre calculations verilied by independent "check" calculations? ☒ Yes ☐ No

Original and Revised Calculation Approvals

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	J. S. Lan [signature] 12/05/02		
Checked By	J. V. Nelson [signature] 12/5/02		
Approved By	H. Toffer & L. C. Johnson [signatures] 12/5/02		
Checked Against Approved Vendor Data			

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1.0 INTRODUCTION

This report simply extends the average dose rate tallies above the process shield plate provided by PacTec (12099-21, Rev.3) to the well area where information was not reported. This task began with a PacTec delivered (11/7/02) CD, which has nearly 1.6 gigabytes of digital records regarding the STS Process Shield Plate (PSP) Analysis. The package included the input and output files for source generation and Monte Carlo geometric model, source tape, restart files, post processing excel data spread sheets, PacTec calculation package (23 pages, Calc. No.12099-21 Rev.3) and LDC cask shielding analysis records. The FFS extended analysis started with two cases best described by the Table 7-3 of the PacTec report. For the purpose of clarification and continuation of work, this table is shown below:

Table 7-3. MCNP Case Identification

Case	Shield Penetrations	Source	Source Volume	Total Source Strength
Psp5zi	NA	Rev 9 of TI-015 60/40 sludge and water	$2.0m^3$ sludge +10" water and 275 g filter	$1.2886x10^{14}$ (p/s)
Psp70zi	Open	Psp5zi tape	Uses Psp5zi	$1.2886x10^{14}$ (p/s)
Psp71zi	Plugged	Psp5zi tape	Uses Psp5zi	$1.2886x10^{14}$ (p/s)
Psp72zi	Open	Rev 9 of TI-015 60/40 sludge	4.15 m^3	$2.673x10^{14}$ (p/s)
Psp73zi	Plugged	Rev 9 of TI-015 60/40 sludge	4.15 m^3	$2.673x10^{14}$ (p/s)

Sections 2.0 through 6.0 (Design Inputs, Material Properties, Condition Analyzed, Acceptance Criteria and Assumptions) are all omitted from this report because they are the same as in the referenced PacTec report. Also Sections 7.1 (Source Terms) and 7.2 (MCNP™ Model Specification), along with associated tables and figures, are omitted for the same reason.

7.0 CALCULATIONS

The calculation preserved all the assumed parameters including the source terms, material densities, material compositions, penetrations and shield plate dimensions. The analysis also retained the source tape and the STS configuration. The only changes to the models were that tally points and the associated problem cells were added. Case psp5zi models only the partial container where the sludge rises and was used to generate the surface source file called rssa (referenced to as "tape" in Table 7-3), which was repeatedly utilized by the follow up calculations. A surface source file allows records of particles crossing a surface in one problem to be used as the source for subsequent problems. The de-coupling of a calculation into several parts allows detailed design or analysis of certain geometrical regions without having to rerun the entire problem from the beginning each time. Consequently, the input files psp70zi and psp71zi, represent the model that starts with a boundary where psp5zi left off.

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7.3 Results

The extended results in the well area, shown in Figure 7-4' and Figure 7-5, were computed using MCNP4C (Johnson, 2002). Cases psp70zi and psp71zi simulate the unplugged and plugged conditions for the inlet/outlet penetrations subject to normal source intensity. Cases psp72zi and psp73zi are the corresponding input files for the accident source condition, which is only a factor of –2 different from that of the normal condition (see the Total Source Strength column of Table 7-3) and was not re-analyzed.

Table 7-7 and Table 7-8 have also been adjusted. The previous dose rates values in those two tables are due to the particle streaming through the penetrations projected at +30 cm vertical location (shown in the figures). The new values reflect the streaming at the plate surface (– -35 cm surface mark), the deepest reachable position.

There are many ways of averaging flux distributions over reasonably divided regions. To further simplify the matter, extra tallies in the well area are made on existing surfaces and their extended volumes to prevent any discontinuity from the original dose chart.

8.0 CONCLUSION

It is a common practice to bend penetration paths through a shield such as the ones designed five years ago for the MCO lid (WHC-SD-SNF-CAVR-001) for the SNF project. Straight openings such as the ones in the current design do not attenuate the peak dose rates axially regardless of the thickness of cover material. Since the process shield plate of STS has already been manufactured, it is too late to address design options to reduce the dose rates. Using time-motion analysis to control the access occasions to the high radiation zone with the help of lead blankets is the only alternative to minimize cumulative exposures at this point. The extended well area dose map provided here will assist the crucial ALARA analysis to help minimize the effect of operators' contact doses.

9.0 REFERENCES

Johnson, L. E., 2002, *MCNP Version 4C Approval for Use Documentation, and Authorized User List,* FFS-LEI-02-002, February 18, 2002, Fluor Federal Services, Richland, Washington.

PACTEC Calc. No. 12099-21, STS *Process Shield Plate Analysis*, Rev. 3, 11/01/02.

WHC-SD-SNF-CAVR-001, *Recent Dose Rate Calculational Summary for N-Reactor Fuel Handling and Shipping from K-Basin*, Rev. 0, Westinghouse Hanford Company, Richland, Washington, December 1996.

1 Note that the Figure and Table numbers are taken from the original PacTec report.

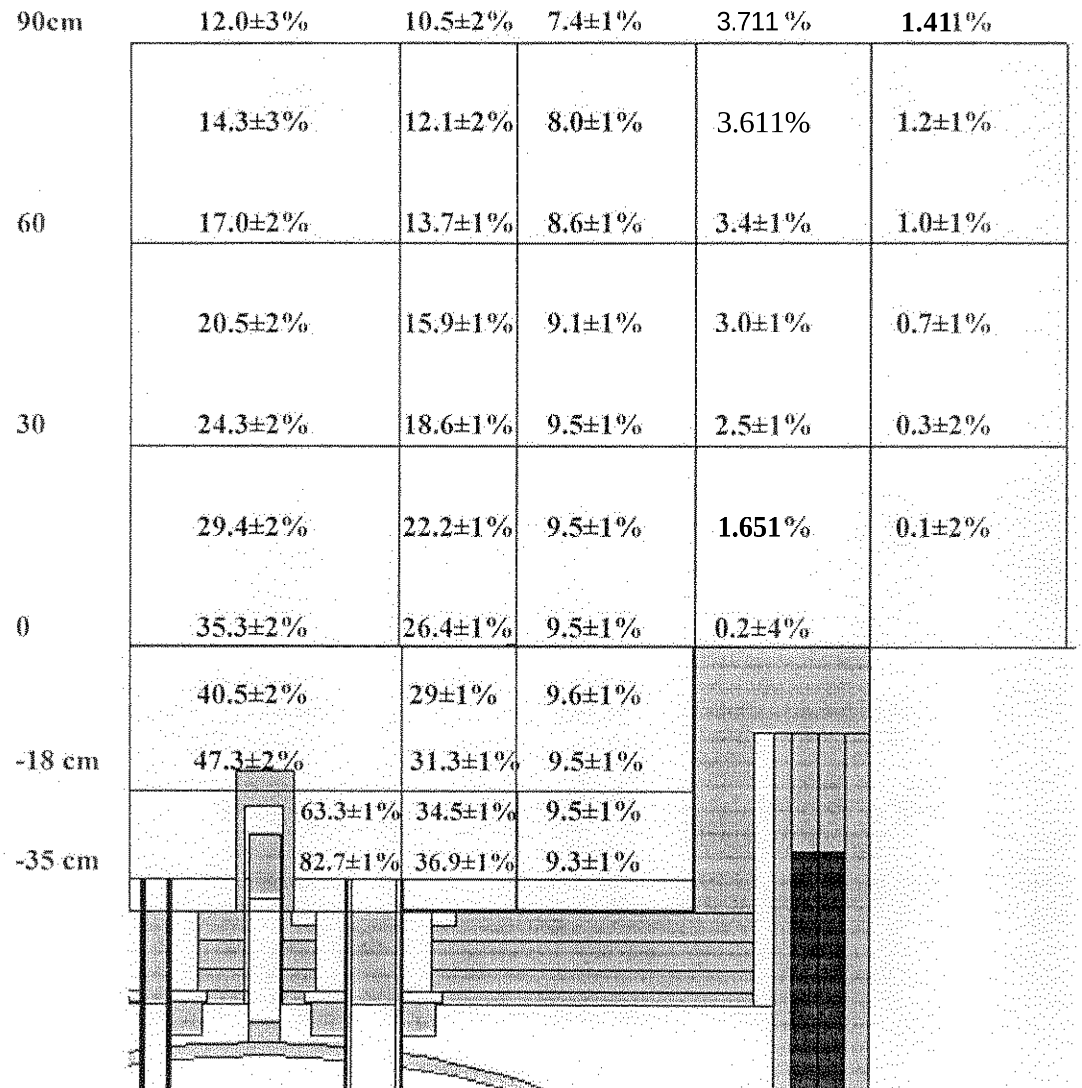

Figure 7-4. Average Dose Rates (in mrem/hr) for 2.0 m^3 of TI-015 Rev 9- 60/40 Sludge–Plugged Penetrations

Table 7-7. Dose Rates above Penetrations for 2.0 m^3 of TI-015 Rev 9- 60/40 Sludge–Plugged Penetrations

Penetration	HEPA	Rupture Disk	Inlet	Outlet
-35 cm Dose rate Centered (mrem/hr)	94±7%	122±7%	141±5%	75±6%
-35 cm Dose rate Annulus (mrem/hr)	123±3%	122±3%	216±2%	110±2%

"Centered" refers to the area immediately above the pipe inner diameter (ID) projected upward to the elevation of interest. "Annulus" is the annular area between the PSP penetration ID and the pipe ID.

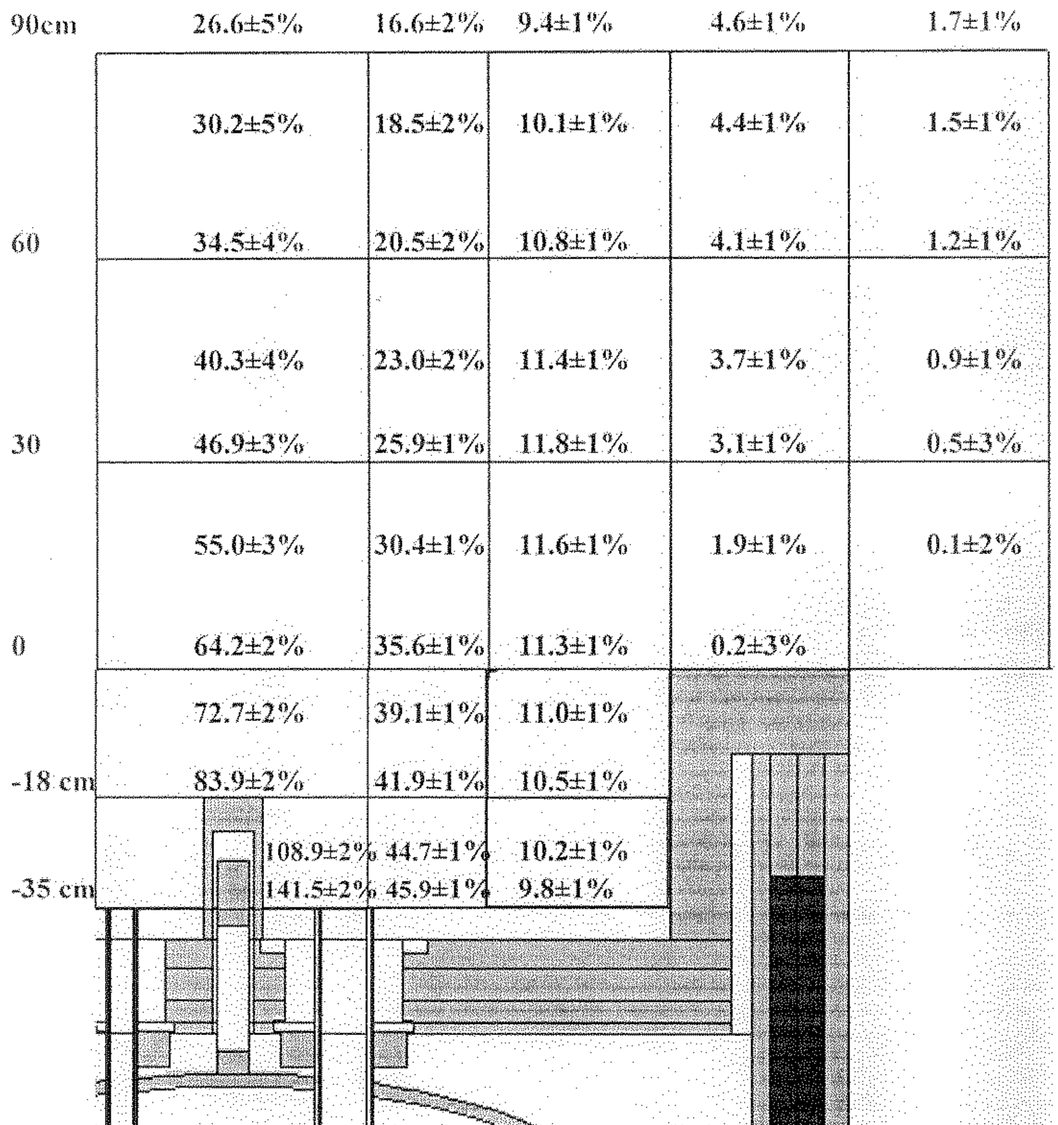

Figure 7-5. Average Dose Rates (in mrem/hr) for 2.0 m^3 of TI-015 Rev 9- 60/40 Sludge– Open Penetrations

Table 7-8. Dose Rates above Penetrations for 2.0 m^3 of TI-015 Rev 9- 60/40 Sludge– Open Penetrations

Penetration	HEPA	Rupture Disk	Inlet	Outlet
-35 cm Dose rate Centered (mrem/hr)	593±12%	622±7%	297±8%	401±4%
-35 cm Dose rate Annulus (mrem/hr)	195±3%	195±3%	245±2%	172±2%

"Centered" refers to the area immediately above the pipe inner diameter (ID) projected upward to the elevation of interest. "Annulus" is the annular area between the PSP penetration ID and the pipe ID.

10.0 INPUT/OUTPUT FILES

The input files PSP80z.i and PSP81z.i listed here were created from the PacTec files PSP70z.i and PSP71z.i referenced in Table 7-3. Due to their large volumes, output files will be stored in a CD and delivered to be contained in the **A-16** Project files.

Input file for Case PSP80z.i

```
PSP plate, 2.0m**3 photon 60/40 sludge source, 10"cover w/0 plugs
c     cask with extra cells for optimization
    1     6  -7.82      -12 -10 4  (11 :-5 ) $ inner zone
    2    51  -11.35     -13 -6 5 12 $ radial lead
    3    51  -11.35     -14 -6 5 13 $ radial lead
    4     6  -7.82      -15 -10 1  114  :-2 ) $ outer zone
    6     6  -7.82      -13 -5 3  (12 :-4 ) $ 2nd axial SS bottom
    7     6  -7.82      -13 -10 6 12 $ 2nd axial SS top ring
    8     6  -7.82      -14 -5 2  (13 :-3 ) $ 3rd axail SS bottom
    9     6  -7.82      -14 -10 6 13 $ 3rd axial SS top ring
c     inside cask
   11    71  -1.41      1-31 -22 21 ):(-33 -21 ) $ sludge-source 1.33 or 1.41
   12     4  -1         1-31 22 -23 ) $ water
   14    77  -0.00123   (-31 23 -24 ):(-35 24 63 64 ) $ air above water
   15     6  -7.82      -34 -21 33 $ lower IC
   16     6  -7.82      -32 -24 31 21 $ middle IC
   17     6  -7.82      -36 24 35 61 62 63 64 $ top IC
   20    77  -0.00123   -11 -21 5 34 $ lower air beyond IC
   21    77  -0.00123   -11 -22 21 32 $ mid radial air beyond IC
   22    77  -0.00123   -11 -24 22 32 $ upper radl air beyond IC
   23    77  -0.00123   -11 -43 24 36 61 62 63 64  #140 #47 #49 #50 #146 $ air above
IC
c     PSP plate
   31     6  -7.82      -42 47 -15 41 (10  :-48 ) $ side and top
   32     6  -7.82      (-44 43 -48 81 82 83 84 85 151 152 153 55 155 $ bottom 1st
layer
           (56  :57 :58 :59 )):(-153 152 -44 43 154)
   33     6  -7.82      (-45 44 -48 51 52 53 84 55 151 152 85 155 $ bottom 2nd layer
           (56  :57 :58 :59 )):(-85 185 -45 55 53):(-155 185 -45):
           (-84 54 -45 144 57)
   34     6  -7.82      -46 45 -48 51 52 53 54 55 151 152 $ bottom 3rd layer
           (56  :57 :58 :59 )
   35     6  -7.82      1-47 46 -48 51 52 53 54 55 152 111 113 $ bottom 4th layer
           (56 :57 :58 :59 )):(-112 46 -111 51 57):(-114 46 -113 54 57)
   37    77  -0.00123   (-60 47 -41 61 62 63 64) #47 #49 #150 $ air above
   38    77  -0.00123   -11 48 -10 43 $ air gap at annulus
c  39    77  -0.00123   (-42 60 -41) #47 #49 #150 $ air above
c     Gaps around Penetration top of shield
   40    77  -0.00123   1-47 44 ((-51 61 ):(-52 62 ):(-53 63 ): $annulus air
           1-54 64 ):(-55 105) )):(43 -46 -151):(-47 -152 87):
           143 -87 -86):(44 -144 -84 54 57)
   41    77  -0.00123   -47 44 -56 -57 -58 -59  $  annulus around lug
           166 :67 :68 :69 )
c     Penetration pipes
   42     6  -7.82      35 24 -70  ((-61 71 ):(-62 72 )) $ Vent pipes
   43    77  -0.00121   35 24 -70  ((-71 101):(-72 102)) $ Vent pipes
```

```
   44     6  -7.82      24 -70 ((-63 73 ):(-64 74 )) $ Inlet, outlet pipes
   45    77  -0.00123   24 -70 ((-73 103):(-74 104)) $ Inlet, Outlet pipes
   47     6  -7.82      36 24 -49 -50 (-66 -67 -68 -69 ) #49 $ lifting Lug
   48     6  -7.82      70 -60  (-61 :-62 :-63 :-64 ) $ Pipe caps
   49    77  -0.00123   79 -78 -76 -77 -66 -67  $ lug hole
   50     6  -7.82      (36 24 -43 -65 75):(-95 43 -186) $ Level pipe and flange
c     Pipe plugs and Air
   52    71  -0.00123   ((-47 43)) (-101 :-102) $ Vent pipes interior
   53    77  -0.00123   (35 24 -70 (-101:-102))  #52 $ Vent pipes void
   54    77  -0.00123   ((-47 43)) (-103:-104) $ Inlet, outlet pipes
   55    77  -0.00123    (24 -70 (-103:-104)) #54 $ Inlet, outlet pipes
   56    71  -0.00123   -47 44 -105  $ level pen
c     Pipe collars in shield plate
c     Gaps around Penetration Bottom of shield
  130    77  -0.00123   (-80 43 ((-81 91 ):(-82 92 ):(-83 93 ): $annulus air
          (-84 94 ):(184 -94):(-85 95 63))) #140 #131 #47 #49 #50
  131    77  -0.00123   -44 43 -56 -57 -58 -59  $  annulus around lug
          (66 :67 :68 :69 )
  132    77  -0.00123   (-154 87 152 -153):(-87 43 -153 #146 861 $ sensor gap
  133    77  -0.00123    (44 -185 -85 55 531 :(-155 43 -185) $ level gap
  134    77  -0.00123    (-47 112 -111 51 57):(-47 114 -113 54 571 $ top air counter
bore
c     Penetration pipes
  140     6  -7.82      (-80 24 36 100 ((-91 61 ):(-92 62 ): $Collars in plate
          (-93 63 ):(-94 64 -184))) #131 #47 #49 85
  145    77  -0.00123   -44 80 ((-81 61 ):(-82 62 ):(-83 63 ): $ gap above col
          (-84 64 ):(-85 63)) #131 #47 #49 #50
  146     6  -7.82      97 -87 86 -96 56 $sensor puck
  150     6  -7.82      (((56 -156 -58 -59):(57 -157 -58 -59):
                          (58 -158 -157 -1561 :
                          (59 -159 -157 -156)) (47 -160)):
                          (-156 -157 -158 -159 160 -161)    $ lug cap
c
c     air beyond cask
  160    77  -0.00123   -400  42     -406                 $ Volume centered over p
  181    77  -0.00123   -400  42 406 -407                 $ 8-15" annulus
  162    77  -0.00123   -400  42 407  -41                 $ 15"-cask ID
  163    77  -0.00123   -400  42  41  -15                 $ Cask ID-OD
  184    77  -0.00123   -400  42  15 -408                 $ OD-OD+30 cm
  280    77  -0.00123   -401 400     -406                 $ Volume centered over p
  281    77  -0.00123   -401 400 406 -407                 $ 8-15" annulus
  262    77  -0.00123   -401 400 407  -41                 $ 15"-cask ID
  283    77  -0.00123   -401 400  41  -15                 $ Cask ID-OD
  284    77  -0.00123   -401 400  15 -408                 $ OD-OD+30 cm
  360    77  -0.00123   -402 401     -406                 $ Volume centered over p
  381    77  -0.00123   -402 401 406 -407                 $ 8-15" annulus
  382    77  -0.00123   -402 401 407  -41                 $ 15"-cask ID
  383    77  -0.00123   -402 401  41  -15                 $ Cask ID-OD
  384    77  -0.00123   -402 401  15 -408                 $ OD-OD+30 cm
c
  480    77  -0.00123    -42 161     -406                 $ added for tally well area
  461    77  -0.00123    -42 161 406 -407                 $ added for tally well area
  482    77  -0.00123    -42 161 407  -41                 $ added for tally well area
  560    77  -0.00123   -161  60     -406 #47 #49 #150   $ added for tally well area
  581    77  -0.00123   -161  60 406 -407 #47 #49 #150   $ added for tally well area
  582    77  -0.00123   -161  60 407  -41 #47 #49 #150   $ added for tally well area
c
  191    77  -0.00123   -262 -266 42 (408 :402 )        $ one meter above shield
  192    77  -0.00123   -262 -266 263 -42 (15  :-1 )     $ one meter, 30 cm
```

```
  193     77  -0.00123    -362 -366 363  (262 :266  :-263 ) $ two meter
  194     77  -0.00123    -399 (362 :366  :-363 )          $ beyond two m
  199      0  399 $ outside world

   1          pz      -15.24 $ bottom outside of cask, 6"  thick
   2          pz      -11.43
   3          pz       -7.62
   4          pz       -3.81
   5          pz      -0.001 $ bottom inside of cask
   6          pz      302.26 $ top of cask Pb (119"  estimated)
c     7   pz  304.8
c     8   pz  309.88
c     8   pz  309.88
   10         pz      320.04 $ top outside of cask, 5" thick
   11         cz       77.47 $ cask inside (61" ID)
   12         cz       80.01 $ 1.00" SS
   13         cz    83.97875
   14         cz     87.9475 $ 3.125" Pb
   15         cz     91.7575 $ 1.500" SS,  cask outside
   21         pz      38.735 $ top of lower ellipses for IC
   22         pz    130.8787 $ to top of sludge  2.0m3
   23         pz    156.2787 $ 2.0m3+10" to top of water
   24         pz      236.22 $ bottom of upper ellipses, 91+2" elevation
   31         cz       73.66 $ ID of IC
   32         cz       74.93 $ OD of IC
   33         sq 0.000184305 0.000184305 0.000737219  0   Sinner botm ell
                       0           0          -1          0          0     38.735
   34         sq 0.00017811 0.00017811 0.00071244     0   $ outer botm ell
                       0           0          -1          0          0     38.735
   35         sq 0.000187524 0.000187524 0.000790818  0   $ inner top ell
                       0           0          -1          0          0     236.22
   36         sq 0.00017811 0.00017811 0.00071244     0   $ outer top ell 93"
                       0           0          -1          0          0     236.22
   41         cz      65.151 $ PSP inner rad - 51.3"OD
   42         pz      332.74 $ top of PSP collar 131"
   43    1    pz      0.0    $ bottom of lower PSP
   44    1    pz      1.905  $ top of 1st layer and counter bores +0.75"
  144    1    pz      2.032  $ top of               counter bores +0.80" outlet
   45    1    pz      5.08   $ top of 2nd layer +2"
   46    1    pz      9.525  $ top of 3rd layer +3.75"
   47    1    pz      13.716 $ top of lower PSP +5.4"=115.15"
   48         cz      74.168 $ bottom plate OR (ie 58.4"OD)
   49         cz      62.865 $ Maximum radi of lift lug
   50         pz      304.8   $  Top of lift lug 120" el
c  shield holes
   51        C/Z      0.0       16.51      6.7945  $ Hepa Vent
   52        c/z      0.0      -16.51      6.7945  $ Rupture Disk
   53        c/z      -16.51          0       6.2992 $ Inlet
   54        c/z       16.51          0       8.7122 $ Outlet
   55        c/z      -33.02          0       3.9751 $ Level
  151        c/z       38.81     8.18548    6.7183  $ water addition
  152        c/z       -39.5564 29.8079     5.6134  $ sensor wash penetration
  153        c/z       -39.5564 29.8079     9.525   $ sensor wash counter bore 7.5"
  154    1    pz       1.905     $  sensor wash bore depth
  155        c/z      -52.705        0        3.81   $  3" hole at 41.5 od
   56          P         -1         -1          0      2.87368 $ Lift Lug
   57          P          1          1          0      2.87368 $ Lift Lug
   58          P         -1          1          0     56.5685 $ Lift Lug
   59          P          1         -1          0     56.5685 $ Lift Lug
```

```
 156        P        -1        -1        0     4.22072 $ Lift Lug cover
 157        P         1         1        0     4.22072 $ Lift Lug cover
 158        P        -1         1        0     57.9155 $ Lift Lug cover
 159        P         1        -1        0     57.9155 $ Lift Lug cover
 160   1    pz    29.591 $ +6.25" above top of plate
 161   1    pz    34.671 $  +2" more
c
  60        pz       298 $ Top of pipe caps 119"
  70        pz    298. $ bottom of caps --none
c    pipes
  61       c/z    0.0      16.51     3.01625 $ Hepa Vent
  71       c/z    0.0      16.51     2.6251  $ Hepa Vent
  62       c/z    0.0     -16.51     3.01625 $ Rupture Disk
  72       c/z    0.0     -16.51     2.6251  $ Rupture Disk
  63       C/Z    -16.51          0      2.413 $ Inlet
  73       c/z    -16.51          0     2.0447 $ Inlet
  64       c/z     16.51          0      4.445 $ Outlet
  74       c/z     16.51          0     3.8964 $ Outlet
  65       c/z    -33.02          0     5.715  $ Level
  75       c/z    -33.02          0     5.4102 $ Level
  66        P        -1        -1        0      2.245 $ Lift Lug
  67        P         1         1        0      2.245 $ Lift Lug
  68        P     0.18525  0.18525  0.3242  100.0  $ Lift Lug
  69        P     0.18525 -0.18525  0.3242  100.0  $ Lift Lug
  76        P        -1         1        0  5.388 $ Lift Lug hole
  77        P         1        -1        0  5.388 $ Lift Lug hole
  78        pz     295.275  $  top of lug hole
  79        pz     276.86   $  bottom of lug hole
c    collar and hole OR
  80    1   pz    0.3302    $ top of collars 0.13" inset
  91       c/z    0.0      16.51    7.5184  5 Hepa Vent 5.92" dia
  81       c/z    0.0      16.51    8.255   $ Hepa Vent 6.5"
 111       c/z    0.0      16.51    10.795  $ Hepa Vent 8.5" od top cb
 112    1   pz    12.7635     $ top counter bore inset 5.4-3/8"
  92       c/z    0.0     -16.51    7.5184  $ Rupture Disk 5.92" dia
  82       c/z    0.0     -16.51    8.255   $ Rupture Disk 6.5"
  93       c/z    -16.51          0     6.985 $ Inlet  5.5" dia
  83       c/z    -16.51          0     7.7724 $ Inlet  3.06 R
  94       c/z     16.51          0     9.4488 $ Outlet 7.44 dia
  84       c/z     16.51          0    10.3505 $ Outlet 8.15
 184        P     -0.00257163  0.00257163 0.00363683 1.0 $45 de9 notch in outlet puck
110.13" el
 113       c/z     16.51     0.0      12.3825  $ outlet 9.75" od top cb
 114   1    pz    11.811    $ top counter bore inset 5.4-.75"
  95       c/z    -33.02          0    12.7    $ Level
  85       c/z    -33.02          0    14.605  $ Level  11.5" OD
 185   1    pz     4.1402                       $ level counter bore depth
 186   1    pz     1.27                         $ level plate thickness
  86       c/z     -39.5564 29.8079    1.3843  $ sensor wash puck hole
  87   1    pz    0.3302                        $ top of sensor puck  (.13")
  96       C/Z     -39.5564 29.8079     7.493  $ sensor wash puck OR
  97   1    pz    -4.7498                       $ bottom sensor puck (0.13-2")
c   Pipe plugs
 100   1    pz    -4.7498  $ Bottom elevation of pipe plugs and collars 0.13-2"
 101       c/z    0.0      16.51     2.06375   $ Hepa Vent 1-5/8"
 102       c/z    0.0     -16.51     2.06375  $ Rupture Disk 1-5/8"
 103       c/z    -16.51          0     1.5875 $ Inlet 1.25"
 104       c/z     16.51          0     3.33375 $ Outlet 2-5/8"
 105       c/z    -33.02          0     3.816 $ Level
```

```
c     air
c  162        cz    92.7575
c  163        pz     -16.24
c  163        pz     -16.24
   262        cz   191.7575
   263        pz    -115.24
   266        pz     432.74
   362        cz   231.7575
   363        pz    -215.24
   366        pz     520.04
   399        so       2000 $ outside world
   400        pz     362.74 $ 30 cm Above top of shield
   401        pz     392.74 $ 60 cm Above top of shield
   402        pz     422.74 $ 90 cm Above top of shield
   406        cz      20.32 $   8" radius
   407        cz       38.1 $  15" radius
   408        cz   121.7575 $  30 cm beyond outer radius

mode   p
tr1    0.0  0.0  279.4 $ bottom of lower PSP 91+19.0" el
m4     1000.            0.6667 $MAT
       8000.            0.3333
c      SS-304
m6     6000.          -0.0008 $MAT
       25055.            -0.02 15000.        -0.00045 28000.          -0.0925
       24000.            -0.19 26000.        -0.68745 16000.          -0.0003
       14000.          -0.0075 7000.           -0.001
m51    82000.               -1 $ lead
c      sludge, assumed to be 30 vol% si02 and 70 vol% water,
m71    1000.         -0.07833 $MAT
       8000.         -0.95719 14000.        -0.29448
c  $  40/60 sludge actinides
c      95241. -3.62E-05  93237. -1.21E-05  94238.  -1.04E-06
c      94239. -1.21E-03  94240. -1.98E-04  94241.  -1.53E-05
c      94242. -4.18E-06  92235. -0.00204   92238.  -0.213
c      air
m77    8000.              0.22 $MAT
       7000.              0.78
imp:p  128          32          8           2           32          $ 1, 6
       128          2           128         16          32          $ 7, 12
       64           16          512         1r          16          $ 14, 20
       1r           512         1024        2048        1024        $ 21, 32
c      2048         4r          8048        2048        19r         $ 33, 134
       2048         4r                      2048        19r         $ 33, 134
       1024         2048        1r          8048        15r         $ 140, 384
       8048         5r                                              $ 480, 582
       1024         8           2r          0           $ 191, 139
prdmp    j j 1 2
print
phys:p  j 1
ctme   800
c
ssr  old=24  new=24
c
c      water dose response
c      ansi/ans-6.1.1-1977 fluence-to-dose, photons(mrem/hr/(p/cm**2/s)
de0        0.01   0.03   0.05   0.07   0.10   0.15   0.20   0.25   0.30
           0.35   0.40   0.45   0.50   0.55   0.60   0.65   0.70   0.80
           1.00   1.40   1.80   2.20   2.60   2.80   3.25   3.75   4.25
```

```
          4.75   5.00   5.25   5.75   6.25   6.75   7.50   3.00   11.0
          13.0   15.0
df0       3.96-3 5.82-4 2.90-4 2.58-4 2.83-4 3.79-4 5.01-4 6.31-4 7.59-4
          8.78-4 9.85-4 1.08-3 1.17-3 1.27-3 1.36-3 1.44-3 1.52-3 1.68-3
          1.98-3 2.51-3 2.99-3 3.42-3 3.82-3 4.01-3 4.41-3 4.83-3 5.23-3
          5.60-3 5.80-3 6.01-3 6.37-3 6.74-3 7.11-3 7.66-3 8.77-3 1.03-2
          1.18-2 1.33-2
c
fc312   surface 42 axial p dose rate (mrem/hr) at top of PSP
f312:p   42
fs312   -406    -407    -41     -15     -408
sd312  1297.17 3263.2 8774.603 13115.48 20123.3   68945.5
c
fc322   surface 400 axial p dose rate (mrem/hr) at 30 above PSP
f322:p   400
fs322   -406    -407    -41     -15     -408
sd322  1297.17 3263.2 8774.603 13115.48 20123.3   0.01
c
fc332   surface 401 axial p dose rate (mrem/hr) at 60 above PSP
f332:p   401
fs332   -406    -407    -41     -15     -408
sd332  1297.17 3263.2 8774.603 13115.48 20123.3    0.01
c
fc342   surface 402 axial p dose rate (mrem/hr) at 30 above PSP
f342:p   402
fs342   -406    -407    -41     -15     -408
sd342  1297.17 3263.2 8774.603 13115.48 20123.3    0.01
c      ------------------------------------------------------------
fc352   surface  60 axial p dose rate (mrem/hr) at -60 above PSP (added)
f352:p    60
fs352   -406    -407    -41
sd352  1297.17 3263.2 8774.603                     0.01
c
fc362   surface 161 axial p dose rate (mrem/hr) at -30 above PSP (added)
f362:p   161
fs362   -406    -407    -41
sd362  1297.17 3263.2 8774.603                     0.01
c      ------------------------------------------------------------
fc412   surface 42 axial p dose rate (mrem/hr) HEPA at top of PSP (changed)
f412:p   60
fs412   -71    -51    -81
sd412  21.649  123.3832   63.05156   115181.
c
fc422   surface 400 axial p dose rate (mrem/hr) Hepa at 30 above PSP
f422:p   400
fs422   -71    -51    -81
sd422  21.649  123.3832   69.05156   46235.
c
fc432   surface 401 axial p dose rate (mrem/hr) Hepa at 60 above PSP
f432:p   401
fs432   -71    -51    -81
sd432  21.649  123.3832   69.05156   46235.
c
fc442   surface 402 axial p dose rate (mrem/hr) Hepa at 90 above PSP
f442:p   402
fs442   -71    -51    -81
sd442  21.649  123.3832   69.05156   46235.
c
fc512   surface 42 axial p dose rate (mrem/hr) Rupture dk top of PSP (changed)
```

```
f512:p   60
fs512   -72    -52    -82
sd512  21.649  123.3832   69.05156   115181.
c
fc522   surface 400 axial p dose rate (mrem/hr) Rupture dk at 30 above PSP
f522:p   400
fs522   -72    -52    -82
sd522  21.649  123.3832   69.05156   46235.
c
fc532   surface 401 axial p dose rate (mrem/hr) Rupture dk at 60 above PSP
f532:p   401
fs532   -72    -52    -82
sd532  21.649  123.3832   69.05156   46235.
c
fc542   surface 402 axial p dose rate (mrem/hr) Rupture dk at 90 above PSP
f542:p   402
fs542   -72    -52    -82
sd542  21.649  123.3832   69.05156   46235.
c
fc612   surface 42 axial p dose rate (mrem/hr)  Inlet top of PSP  (changed)
f612:p   60
fs612   -73    -53    -83
sd612  13.1344  111.5238  65.1261  115181.
c
fc622   surface 400 axial p dose rate (mrem/hr)  Inlet at 30 above PSP
f622:p   400
fs622   -73    -53    -83
sd622  13.1344  111.5238  65.1261   46235.
c
fc632   surface 401 axial p dose rate (mrem/hr)  Inlet at 60 above PSP
f632:p   401
fs632   -73    -53    -83
sd632  13.1344  111.5238  65.1261   46235.
c
fc642   surface 402 axial p dose rate (mrem/hr)  Inlet at 90 above PSP
f642:p   402
fs642   -73    -53    -83
sd642  13.1344  111.5238  65.1261   46235.
c
fc712   surface 42 axial p dose rate (mrem/hr)  Outlet top of PSP  (changed)
f712:p   60
fs712   -74    -54    -84
sd712  47.6954  190.7591  98.1133  115181.
c
fc722   surface 400 axial p dose rate (mrem/hr)  Outlet at 30 above PSP
f722:p   400
fs722   -74    -54    -84
sd722  47.6954  190.7591  98.1133  46235.
C
fc732   surface 401 axial p dose rate (mrem/hr)  Outlet at 60 above PSP
f732:p   401
fs732   -74    -54    -84
sd732  47.6954  190.7591   98.1133  46235.
c
fc742   surface 402 axial p dose rate (mrem/hr)  Outlet at 90 above PSP
f742:p   402
fs742   -74    -54    -84
sd742  47.6954  190.7591   98.1133  46235.
c
```

```
c  Cell doses
fc114   Cell p dose rate (mrem/hr)   0 to  30 above top of PSP
f114:p  180 181 182 183 184
fc124   Cell p dose rate (mrem/hr)  30 to  60 above top of PSP
f124:p  280 281 282 283 284
fc134   Cell p dose rate (mrem/hr)  60 to  90 above top of PSP
f134:p  380 381 382 383 384
c      -----------------------------------------------------------
fc144   Cell p dose rate (mrem/hr)   0 to -30 below top of PSP (added)
f144:p  480 481 482
fc154   Cell p dose rate (mrem/hr) -30 to -60 below top of PSP (added)
f154:p  580 581 582
sd154   20845.54  52439.56  141007.87
```

Input file for Case PSP81z.i

```
PSP plate, 2.0m**3 photon 60/40 sludge source, 10"cover w/5 5.5 plugs
c     cask with extra cells for optimization
    1     6  -7.82      -12 -10 4 (11 :-5 ) $ inner zone
    2    51  -11.35     -13 -6 5 12 $ radial lead
    3    51  -11.35     -14 -6 5 13 $ radial lead
    4     6  -7.82      -15 -10 1 (14 :-2 ) $ outer zone
    6     6  -7.82      -13 -5 3 (12 :-4 ) $ 2nd axial SS bottom
    7     6  -7.82      -13 -10 6 12 $ 2nd axial SS top ring
    8     6  -7.82      -14 -5 2 (13 :-3 ) $ 3rd axail SS bottom
    9     6  -7.82      -14 -10 6 13 $ 3rd axial SS top ring
c     inside cask
   11    71  -1.41      (-31 -22 21 ):(-33 -21 ) $ sludge-source 1.33 or 1.41
   12     4  -1         (-31 22 -23 ) $ water
   14    77  -0.00123   (-31 23 -24 ):(-35 24 63 64 ) $ air above water
   15     6  -7.82      -34 -21 33 $ lower IC
   16     6  -7.82      -32 -24 31 21 $ middle IC
   17     6  -7.82      -36 24 35 61 62 63 64 $ top IC
   20    77  -0.00123   -11 -21 5 34 $ lower air beyond IC
   21    77  -0.00123   -11 -22 21 32 $ mid radial air beyond IC
   22    77  -0.00123   -11 -24 22 32 $ upper radl air beyond IC
   23    77  -0.00123   -11 -43 24 36 61 62 63 64  #140 #47 #49 #50 #146 S air above
IC
c     PSP plate
   31     6  -7.82      -42 47 -15 41 (10  :-48 ) $ side and top
   32     6  -7.82      (-44 43 -48 81 82 83 84 85 151 152 153 55 155 $ bottom 1st
layer
          (56 :57 :58 :59 )):(-153 152 -44 43 154)
   33     6  -7.82      (-45 44 -48 51 52 53 84 55 151 152 85 155 $ bottom 2nd layer
          (56 :57 :58 :59 )):(-85 185 -45 55 531:(-155 185 -45):
          (-84 54 -45 144 57)
   34     6  -7.82      -46 45 -48 51 52 53 54 55 151 152 $ bottom 3rd layer
          (56  :57 :58 :59 )
   35     6  -7.82      (-47 46 -48 51 52 53 54 55 152 111 113 $ bottom 4th layer
          (56  :57 :58 :59 )):(-112 46 -111 51 57):(-114 46 -113 54 57)
   37    77  -0.00123   (-60 47 -41 61 62 63 64) #47 #49 #150 $ air above
   38    77  -0.00123   -11 48 -10 43 $ air gap at annulus
c  39    77  -0.00123   (-42 60 -411 #47 #49 #150 $ air above
c     Gaps around Penetration top of shield
   40    77  -0.00123   (-47 44 ((-51 61 ):(-52 62 ):(-53 63 ): $annulus air
          (-54 64 ):(-55 1051 11:(43 -46 -151):(-47 -152 87):
          (43 -87 -86):144 -144 -84 54 57)
   41    77  -0.00123   -47 44 -56 -57 -58 -59  $  annulus around lug
          (66 :67 :68 :69 )
```

```
c      Penetration pipes
   42     6  -7.82       35 24 -70 ((-61 71 ):(-62 72 )) $ Vent pipes
   43    77  -0.00123    35 24 -70 ((-71 101):(-72 102)) $ Vent pipes
   44     6  -7.82       24 -70 ((-63 73 ):(-64 74 )) $ Inlet, outlet pipes
   45    77  -0.00123    24 -70 ((-73 103):(-74 104)) $ Inlet, outlet pipes
   47     6  -7.82       36 24 -49 -50 (-66 -67 -68 -69 ) #49 $ lifting Lug
   48     6  -7.82       70 -60 (-61 :-62 :-63 :-64 ) $ Pipe caps
   49    77  -0.00123    79 -78 -76 -77 -66 -67  $ lug hole
   50     6  -7.82       (36 24 -43 -65 75):(-95 43 -1861 $ Level pipe and flange
c      Pipe plugs and Air
   52     6  -7.82       ((-47 43)) (-101 :-102) $ Vent pipes interior
   53    77  -0.00123    135 24 -70 (-101:-102))  #52 $ Vent pipes void
   54     6  -7.82       ((-47 43)) (-103:-104) $ Inlet, outlet pipes
   55    77  -0.00123    (24 -70 (-103:-104)) #54 $ Inlet, outlet pipes
   56    77  -0.00123    -47 44 -105  $ level pen
c      Pipe collars in shield plate
c      Gaps around Penetration Bottom of shield
  130    77  -0.00123    (-80 43 ((-81 91 ):(-82 92 ):(-83 93 ): $annulus air
            (-84 94 ):(184 -94):(-85 95 63))) #140 #131 #47 #49 #50
  131    77  -0.00123    -44 43 -56 -57 -58 -59  $  annulus around lug
            166 :67 :68 :69 )
  132    77  -0.00123     (-154 87 152 -153):(-87 43 -153 #146 86) $ sensor gap
  133    77  -0.00123      (44 -185 -85 55 53):(-155 43 -1851 $ level gap
  134    77  -0.00123      (-47 112 -111 51 57):(-47 114 -113 54 57) $ top air counter
bore
c      Penetration pipes
  140     6  -7.82       (-80 24 36 100 ((-91 61 ):(-92 62 ): $Collars in plate
            1-93 63 ): (-94 64 -184))) #131 #47 #49 85
  145    77  -0.00123    -44 80 ((-81 61 ):(-82 62 ):(-83 63 ): $ gap above col
            (-84 64 ):(-85 63)) #131 #47 #49 #50
  146     6  -7.82       97 -87 86 -96 56 $sensor puck
  150     6  -7.82       (((56 -156 -58 -59):(57 -157 -58 -59):
                           (58 -158 -157 -156):
                           (59 -159 -157 -156)) (47 -160)):
                           (-156 -157 -158 -159 160 -1611    $ lug cap
c
c      air beyond cask
  180    77  -0.00123    -400 42 -406 $ Volume centered over p
  181    77  -0.00123    -400 42 406 -407 $ 8-15" annulus
  182    77  -0.00123    -400 42 407 -41 $ 15"-cask ID
  183    77  -0.00123    -400 42 41 -15 $ Cask ID-OD
  184    77  -0.00123    -400 42 15 -408 $ OD-OD+30 cm
  280    77  -0.00123    -401 400 -406 $ Volume centered over p
  281    77  -0.00123    -401 400 406 -407 $ 8-15" annulus
  282    77  -0.00123    -401 400 407 -41 $ 15"-cask ID
  283    77  -0.00123    -401 400 41 -15 $ Cask ID-OD
  284    77  -0.00123    -401 400 15 -408 $ OD-OD+30 cm
  380    77  -0.00123    -402 401 -406 $ Volume centered over p
  381    77  -0.00123    -402 401 406 -407 $ 8-15" annulus
  382    77  -0.00123    -402 401 407 -41 $ 15"-cask ID
  383    77  -0.00123    -402 401 41 -15 $ Cask ID-OD
  384    77  -0.00123    -402 401 15 -408 $ OD-OD+30 cm
c
  480    77  -0.00123     -42 161     -406                $ added for tally well area
  481    77  -0.00123     -42 161 406 -407                $ added for tally well area
  482    77  -0.00123     -42 161 407  -41                $ added for tally well area
  580    77  -0.00123    -161  60     -406 #47 #49 #150   $ added for tally well area
  581    77  -0.00123    -161  60 406 -407 #47 #49 #150   $ added for tally well area
  582    77  -0.00123    -161  60 407  -41 #47 #49 #150   $ added for tally well area
```

```
c
  191    77  -0.00123   -262 -266 42 (408 :402 ) $ one meter above shield
  192    77  -0.00123   -262 -266 263 -42 (15 :-1 ) $ one meter, 30 cm
  193    77  -0.00123   -362 -366 363 (262 :266  :-263 ) $ two meter
  194    77  -0.00123   -399 (362 :366  :-363 ) $ beyond two m
  199     0  399 $ outside world

   1        pz     -15.24 $ bottom outside of cask, 6" thick
   2        pz     -11.43
   3        pz      -7.62
   4        pz      -3.81
   5        pz     -0.001 $ bottom inside of cask
   6        pz     302.26 $ top of cask Pb (119" estimated)
c   7   pz  304.8
c   8   pz  309.88
c   8   pz  309.88
  10        pz     320.04 $ top outside of cask, 5" thick
  11        cz      77.47 $ cask inside (61" ID)
  12        cz      80.01 $ 1.00" SS
  13        cz   83.97875
  14        cz    87.9475 $ 3.125" Pb
  15        cz    91.7575 $ 1.500" SS,  cask outside
  21        pz     38.735 $ top of lower ellipses for IC
  22        pz   130.8787 $ to top of sludge  2.0m3
  23        pz   156.2787 $ 2.0m3+10" to top of water
  24        pz     236.22 $ bottom of upper ellipses, 91+2" elevation
  31        cz      73.66 $ ID of IC
  32        cz      74.93 $ OD of IC
  33        sq 0.000184305 0.000184305 0.000737219  0   $inner botm ell
                 0           0           -1         0          0    38.735
  34        sq 0.00017811 0.00017811 0.00071244     0   $ outer botm ell
                 0           0           -1         0          0    38.735
  35        sq 0.000187524 0.000187524 0.000790818  0   $ inner top ell
                 0           0           -1         0          0    236.22
  36        sq 0.00017811 0.00017811 0.00071244     0   $ outer top ell 93"
                 0           0           -1         0          0    236.22
  41        cz     65.151 $ PSP inner rad - 51.3"OD
  42        pz     332.74 $ top of PSP collar 131"
  43   1    pz     0.0    $ bottom of lower PSP
  44   1    pz     1.905  $ top of 1st layer and counter bores +0.75"
 144   1    pz     2.032  $ top of              counter bores +0.80" outlet
  45   1    pz     5.08   $ top of 2nd layer +2"
  46   1    pz     9.525  $ top of 3rd layer +3.75"
  47   1    pz     13.716 $ top of lower PSP +5.4"=115.15"
  48        cz      74.168 $ bottom plate OR (ie 58.4"OD)
  49        cz      62.865 $ Maximum radi of lift lug
  50        pz     304.8   $  Top of lift lug 120" el
c  shield holes
  51       c/z     0.0      16.51     6.7945  $ Hepa Vent
  52       c/z     0.0     -16.51     6.7945  $ Rupture Disk
  53       c/z     -16.51         0     6.2992 $ Inlet
  54       c/z      16.51         0     8.7122 $ Outlet
  55       c/z     -33.02         0     3.9751 $ Level
 151       c/z      38.81    8.18548    6.7183  $ water addition
 152       C/Z      -39.5564 29.8079     5.6134  $ sensor wash penetration
 153       c/z      -39.5564 29.8079     9.525   $ sensor wash counter bore 7.5"
 154   1    pz      1.905     $  sensor wash bore depth
 155       c/z     -52.705        0       3.81    $  3" hole at 41.5 od
  56        P          -1         -1         0     2.87368 $ Lift Lug
```

```
  57         P         1          1          0     2.87368 $ Lift Lug
  58         P        -1          1          0     56.5685 $ Lift Lug
  59         P         1         -1          0     56.5685 $ Lift Lug
 156         P        -1         -1          0     4.22072 $ Lift Lug cover
 157         P         1          1          0     4.22072 $ Lift Lug cover
 158         P        -1          1          0     57.9155 $ Lift Lug cover
 159         P         1         -1          0     57.9155 $ Lift Lug cover
 160   1     pz     29.591 $ +6.25" above top of plate
 161   1     pz     34.671 $  +2" more
c
  60         pz        298 $ Top of pipe caps 119"
  70         pz     298. $ bottom of caps --none
c     pipes
  61        c/z     0.0       16.51     3.01625 $ Hepa Vent
  71        c/z     0.0       16.51     2.6251  $ Hepa Vent
  62        c/z     0.0      -16.51     3.01625 $ Rupture Disk
  72        c/z     0.0      -16.51     2.6251  $ Rupture Disk
  63        c/z     -16.51          0      2.413 $ Inlet
  73        c/z     -16.51          0     2.0447 $ Inlet
  64        C/Z      16.51          0      4.445 $ Outlet
  74        c/z      16.51          0     3.8964 $ Outlet
  65        C/Z     -33.02          0     5.715  $ Level
  75        c/z     -33.02          0     5.4102 $ Level
  66         P        -1         -1          0      2.245 $ Lift Lug
  67         P         1          1          0      2.245 $ Lift Lug
  68         P      0.18525  0.18525  0.3242  100.0  $ Lift Lug
  69         P      0.18525 -0.18525  0.3242  100.0  $ Lift Lug
  76         P        -1          1          0   5.388 $ Lift Lug hole
  77         P         1         -1          0   5.388 $ Lift Lug hole
  78         pz      295.275  $  top of lug hole
  79         pz      276.86   $  bottom of lug hole
c     collar and hole OR
  80    1    pz     0.3302    $ top of collars 0.13" inset
  91        c/z     0.0       16.51    7.5184   $ Hepa Vent 5.92" dia
  81        c/z     0.0       16.51    8.255    $ Hepa Vent 6.5"
 111        c/z     0.0       16.51    10.795   $ Hepa Vent 8.5" od top cb
 112    1    pz     12.7635     $ top counter bore inset 5.4-3/8"
  92        c/z     0.0      -16.51    7.5184   $ Rupture Disk 5.92" dia
  82        c/z     0.0      -16.51    8.255    $ Rupture Disk 6.5"
  93        c/z     -16.51          0     6.985 $ Inlet  5.5" dia
  83        c/z     -16.51          0     7.7724 $ Inlet  3.06 R
  94        c/z      16.51          0     9.4488 $ Outlet 7.44 dia
  84        c/z      16.51          0    10.3505 $ Outlet 8.15
 184         P      -0.00257163 0.00257163 0.00363683 1.0 $45 deg notch in outlet puck
110.13" el
 113        C/Z      16.51     0.0      12.3825  $ outlet 9.75" od top cb
 114    1    pz     11.811    $ top counter bore inset 5.4-.75"
  95        C/Z     -33.02          0    12.7    $ Level
  85        C/Z     -33.02          0    14.605  $ Level  11.5" OD
 185    1    pz      4.1402                      $ level counter bore depth
 186    1    pz      1.27                        $ level plate thickness
  86        c/z      -39.5564 29.8079    1.3843  $ sensor wash puck hole
  87    1    pz     0.3302                       $ top of sensor puck  (.13")
  96        c/z      -39.5564 29.8079     7.493  $ sensor wash puck OR
  97    1    pz     -4.7498                      $ bottom sensor puck (0.13-2")
c    Pipe plugs
 100    1    pz     -4.7498  $ Bottom elevation of pipe plugs and collars 0.13-2"
 101        c/z     0.0       16.51     2.06375   $ Hepa Vent 1-5/8"
 102        c/z     0.0      -16.51     2.06375  $ Rupture Disk 1-5/8"
```

```
  103       c/z     -16.51          0     1.5875 $ Inlet 1.25"
  104       c/z      16.51          0     3.33375 $ Outlet 2-5/8"
  105       c/z     -33.02          0     3.816 $ Level
c      air
c  162        cz    92.7575
c  163        pz     -16.24
c  163        pz     -16.24
  262        cz   191.7575
  263        pz    -115.24
  266        pz     432.74
  362        cz   291.7575
  363        pz    -215.24
  366        pz     520.04
  399        so       2000 $ outside world
  400        pz     362.74 $ 30 cm Above top of shield
  401        pz     392.74 $ 60 cm Above top of shield
  402        pz     422.74 $ 90 cm Above top of shield
  406        cz      20.32 $   8" radius
  401        cz       38.1 $  15" radius
  408        cz   121.7575 $  30 cm beyond outer radius

mode  p
tr1   0.0  0.0  279.4 $ bottom of lower PSP 91+19.0" el
m4    1000.            0.6667 $MAT
      8000.            0.3333
c      SS-304
m6    6000.           -0.0008 $MAT
      25055.            -0.02 15000.        -0.00045 28000.        -0.0925
      24000.            -0.19 26000.        -0.68745 16000.        -0.0003
      14000.          -0.0075 7000.           -0.001
m51   82000.               -1 $ lead
c      sludge, assumed to be 30 vol% si02 and 70 vol% water,
m71   1000.          -0.07833 $MAT
      8000.          -0.95719 14000.        -0.29448
c  $  40/60 sludge actinides
c     95241. -3.62E-05  93237. -1.21E-05  94238.  -1.04E-06
c     94239. -1.21E-03  94240. -1.98E-04  94241.  -1.53E-05
c     94242. -4.18E-06  92235. -0.00204   92238.  -0.213
c      air
m77   8000.              0.22 $MAT
      7000.              0.78
imp:p  128         32          8           2           32          $ 1, 6
       128         2           128         16          32          $ 7, 12
       64          16          512         lr          16          $ 14, 20
       1r          512         1024        2048        1024        $ 21, 32
c      2048        4r          8048        2048        19r         $ 33, 134
       2048        4r                      2048        19r         $ 33, 134
       1024        2048        1r          8048        15r         $ 140, 384
       8048        5r                                              $ 480, 582
       1024        8           2r          0           $ 191, 199
prdmp    j j 1 2
print
phys:p   j 1
ctme   800
c
ssr  old=24  new=24
c
c      water dose response
c      ansi/ans-6.1.1-1977 fluence-to-dose, photons(mrem/hr/(p/cm**2/s)
```

```
de0     0.01   0.03   0.05   0.07   0.10   0.15   0.20   0.25   0.30
        0.35   0.40   0.45   0.50   0.55   0.60   0.65   0.70   0.80
        1.00   1.40   1.80   2.20   2.60   2.80   3.25   3.75   4.25
        4.75   5.00   5.25   5.75   6.25   6.75   7.50   9.00   11.0
        13.0   15.0
df0     3.96-3 5.82-4 2.90-4 2.58-4 2.83-4 3.79-4 5.01-4 6.31-4 7.59-4
        8.78-4 9.85-4 1.08-3 1.17-3 1.27-3 1.36-3 1.44-3 1.52-3 1.68-3
        1.98-3 2.51-3 2.99-3 3.42-3 3.82-3 4.01-3 4.41-3 4.83-3 5.23-3
        5.60-3 5.80-3 6.01-3 6.37-3 6.74-3 7.11-3 7.66-3 8.77-3 1.03-2
        1.18-2 1.33-2
c
fc312   surface 42 axial p dose rate (mrem/hr) at top of PSP
f312:p   42
fs312   -406    -407    -41     -15     -408
sd312  1297.17 3263.2 8774.603 13115.48 20123.3   68945.5
c
fc322   surface 400 axial p dose rate (mrem/hr) at 30 above PSP
f322:p   400
fs322   -406    -407    -41     -15     -408
sd322  1297.17 3263.2 8774.603 13115.48 20123.3   0.01
c
fc332   surface 401 axial p dose rate (mrem/hr) at 60 above PSP
f332:p   401
fs332   -406    -407    -41     -15     -408
sd332  1297.17 3263.2 8774.603 13115.48 20123.3    0.01
c
fc342   surface 402 axial p dose rate (mrem/hr) at 90 above PSP
f342:p   402
fs342   -406    -407    -41     -15     -408
sd342  1297.17 3263.2 8774.603 13115.48 20123.3    0.01
c    ------------------------------------------------------------
fc352   surface  60 axial p dose rate (mrem/hr) at -60 above PSP (added)
f352:p    60
fs352   -406    -407    -41
sd352  1297.17 3263.2 8774.603                     0.01
c
fc362   surface 161 axial p dose rate (mrem/hr) at -30 above PSP (added)
f362:p   161
fs362   -406    -407    -41
sd362  1297.17 3263.2 8774.603                     0.01
c    -----------------------------------------------------------------
fc412   surface 42 axial p dose rate (mrem/hr) HEPA at top of PS? (changed)
f412:p   60
fs412   -71    -51    -81
sd412  21.649   123.3832   69.05156   115181.
c
fc422   surface 400 axial p dose rate (mrem/hr) Hepa at 30 above PSP
f422:p   400
fs422   -71    -51    -81
sd422  21.649   123.3832   69.05156   46235.
c
fc432   surface 401 axial p dose rate (mrem/hr) Hepa at 60 above PSP
f432:p   401
fs432   -71    -51    -81
sd432  21.649   123.3832   69.05156   46235.
c
fc442   surface 402 axial p dose rate (mrem/hr) Hepa at 90 above PSP
f442:p   402
fs442   -71    -51    -81
```

```
sd442  21.649  123.3832   69.05156   46235.
c
fc512   surface 42 axial p dose rate (mrem/hr) Rupture dk top of PSP (changed)
f512:p   60
fs512   -72    -52    -82
sd512  21.649  123.3832   69.05156   115181.
c
fc522   surface 400 axial p dose rate (mrem/hr) Rupture dk at 30 above PSP
f522:p   400
fs522   -72    -52    -82
sd522  21.649  123.3832   69.05156   46235.
c
fc532   surface 401 axial p dose rate (mrem/hr) Rupture dk at 60 above PSP
f532:p   401
fs532   -72    -52    -82
sd532  21.649  123.3832   69.05156   46235.
c
fc542   surface 402 axial p dose rate (mrem/hr) Rupture dk at 90 above PSP
f542:p   402
fs542   -72    -52    -82
sd542  21.649  123.3832   69.05156   46235.
c
fc612   surface 42 axial p dose rate (mrem/hr) Inlet top of PSP (changed1
f612:p   60
fs612   -73    -53    -83
sd612  13.1344  111.5238  65.1261  115181.
c
fc622   surface 400 axial p dose rate (mrem/hr) Inlet at 30 above PSP
f622:p   400
fs622   -73    -53    -83
sd622  13.1344  111.5238  65.1261   46235.
c
fc632   surface 401 axial p dose rate (mrem/hr) Inlet at 60 above PSP
f632:p   401
fs632   -73    -53    -83
sd632  13.1344  111.5238  65.1261   46235.
c
fc642   surface 402 axial p dose rate (mrem/hr) Inlet at 90 above PSP
f642:p   402
fs642   -73    -53    -83
sd642  13.1344  111.5238  65.1261   46235.
c
fc712   surface 42 axial p dose rate (mrem/hr) Outlet top of PSP (changed)
f712:p   60
fs712   -74    -54    -84
sd712  47.6954  190.7591  98.1133  115181.
c
fc722   surface 400 axial p dose rate (mrem/hr) Outlet at 30 above PSP
f722:p   400
fs722   -74    -54    -84
sd722  47.6954  190.7591  98.1133  46235.
c
fc732   surface 401 axial p dose rate (mrem/hr) Outlet at 60 above PSP
f732:p   401
fs732   -74    -54    -84
sd732  47.6954  190.7591  98.1133  46235.
c
fc742   surface 402 axial p dose rate (mrem/hr) Outlet at 90 above PSP
f742:p   402
```

```
fs742   -74    -54    -84
sd742  47.6954  190.7591  98.1133  46235.
c
c  Cell doses
fc114   Cell p dose rate (mrem/hr) 0 to 30 above top of PSP
f114:p  180 181 182 183 184
fc124   Cell p dose rate (mrem/hr) 30 to 60 above top of PSP
f124:p  280 281 282 283 284
fc134   Cell p dose rate (mrem/hr) 60 to 90 above top of PSP
f134:p  380 381 382 383 384
c      -------------------------------------------------------------
fc144   Cell p dose rate (mrem/hr)   0 to -30 below top of PSP (added)
f144:p  480 481 482
fc154   Cell p dose rate (mrem/hr) -30 to -60 below top of PSP (added)
f154:p  580 581 582
sd154   20845.54  52439.56  141007.87
```

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CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed - A16-N-002, Rev. 0

Title: Supplemental Report to the STS Process Shield Plate Analysis of PacTec Calc. 12099-21 Rev. 3

Author: J. S. Lan

Date: December 2002

Yes	No*	NA	
[✓]	[ ]	[ ]	Referenced analyses appropriate.
[✓]	[ ]	[ ]	Problem completely defined and all potential configurations considered.
[ ]	[ ]	[✓]	Accident scenarios developed in a clear and logical manner.
[✓]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[✓]	[ ]	[ ]	Computer codes and data files documented.
[✓]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[✓]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[ ]	[ ]	[✓]	Mathematical derivations checked including dimensional consistency of results
[✓]	[ ]	[ ]	Models appropriate and used within range of validity, or use outside range of established validity justified.
[ ]	[ ]	[✓]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[✓]	[ ]	[ ]	Software input correct and consistent with document reviewed.
[✓]	[ ]	[ ]	Software output consistent with input and with results reported in document reviewed.
[ ]	[ ]	[✓]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[ ]	[ ]	[✓]	Safety margins consistent with good engineering practices.
[✓]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[✓]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[✓]	[ ]	[ ]	Format consistent with applicable guides or other standards.
[ ]	[ ]	[✓] **	Review calculations, comments, and/or notes are attached.
[✓]	[ ]	[ ]	Document approved (for example, the reviewer affirms the technical accuracy of the document).

J. V. Nelson *JV Nelson* 12/5/02

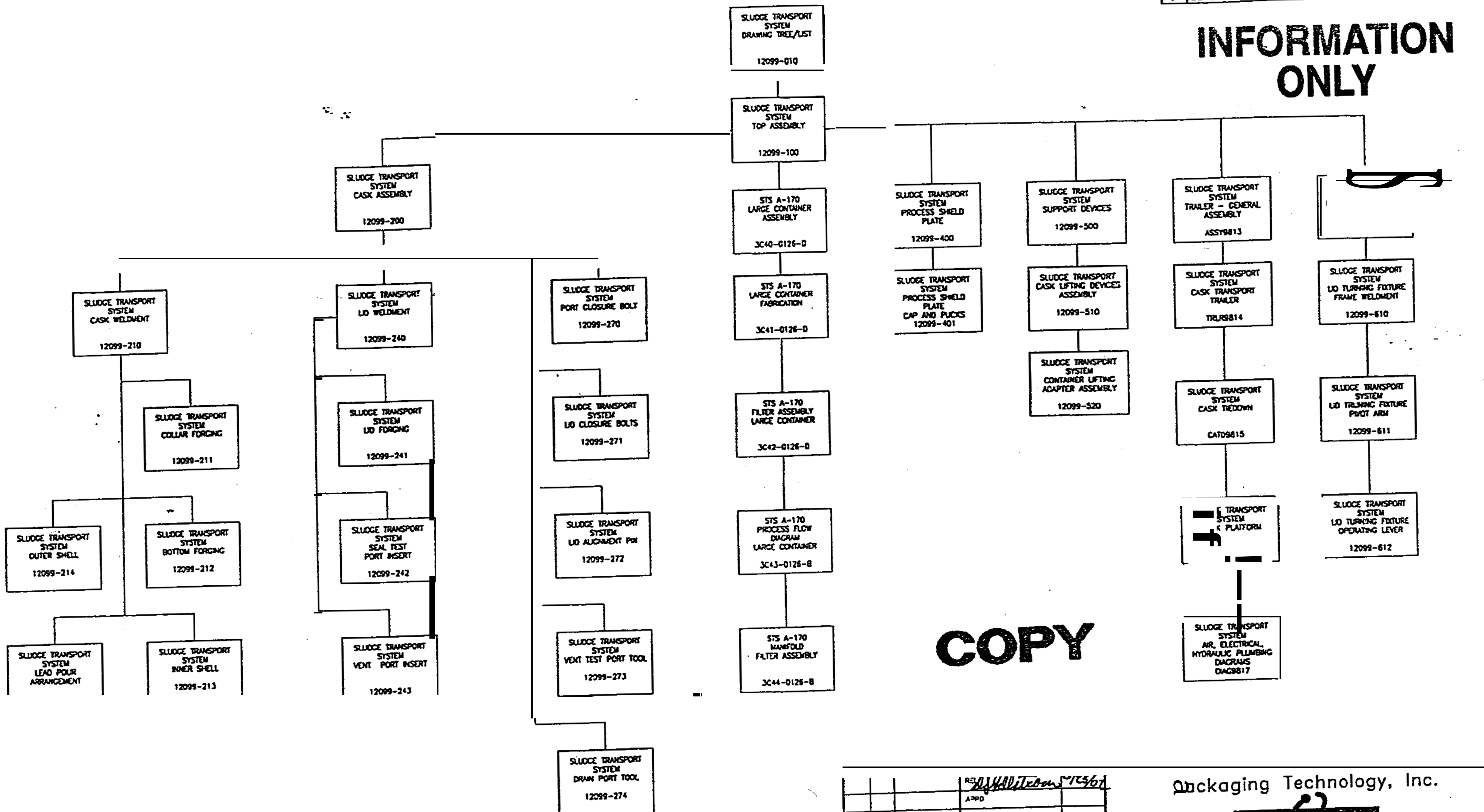
Technical Peer Reviewer (printed name and signature.) Date

* All "no" responses must be explained below or on an additional sheet.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. The material should be labeled and recorded in such a manner as to be understandable to a technically qualified third party.

REV			
0	INITIAL RELEASE	BH	4/17/02
1	GENERAL UPDATE OF TREE		8/9/02

INFORMATION ONLY



COPY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(X) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 8/30/2002

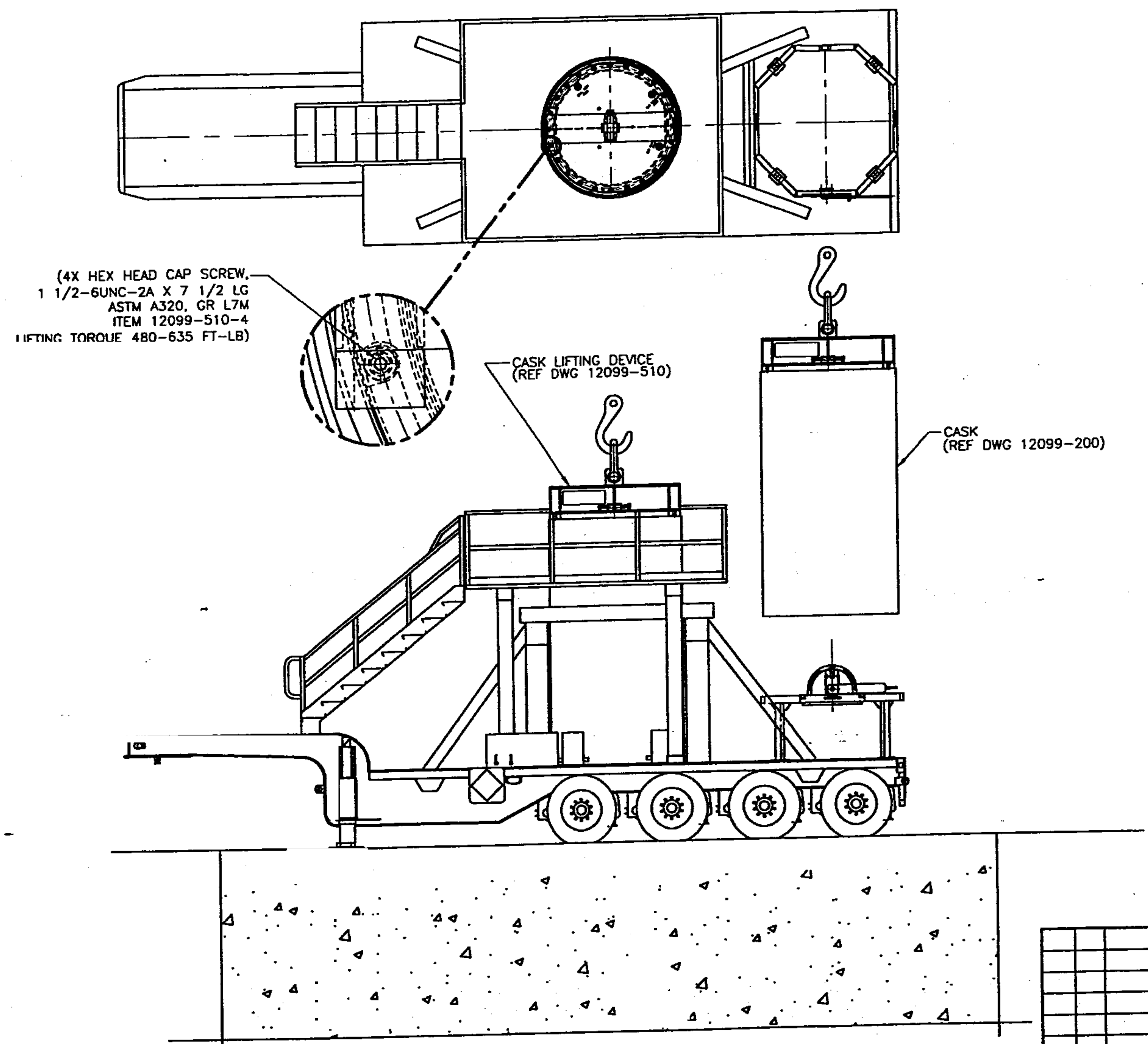
Packaging Technology, Inc.
A Transnuclear Company

DRAWING TREE
SLUDGE TRANSPORTATION SYSTEM

ITEM	QTY	NEXT ASSY	
		REL [signature]	7/25/02
		APPD	
		APPD	
		APPD [signature]	8/23/02
		ENGR [signature]	8/23/02
		QA [signature]	8/23/02
		CHECK [signature]	8/23/02
		DRAWN T. VAAGAN	10/18/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± N/A
3 PLACE DECIMALS ± N/A
2 PLACE DECIMALS ± N/A

SCALE: NONE WT. N/A
REV: 1 SHEET 1 OF 1
DWG SIZE B DWG NO. 12099-010
CADFILE: F:12099010I1.DWG



STS CASK-TRAILER GENERAL ARRANGEMENT

(THE CASK LIFTING DEVICE INSTALLED)

12099-100 | 2 | 2

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	09/16/02
1	REVISION PER CUSTOMER COMMENTS	BH	9/20/02
2	SEE DCN 1/1	BH	11/11/02

FABRICATION/CONSTRUCTION SUBMITTAL
AFC [x] INF/REC [ ] VI [ ]
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/12/02

			REL B. HARGIS	9/20/02
			APPD	
			APPD	
			APPD F.L. YAPUNCICH	9/20/02
			ENGR J. NICHOLS	9/20/02
			QA B. COUNTERMAN	9/20/02
			CHECK D.S.HILLSTROM	9/20/02
ITEM	QTY	NEXT ASSY	DRAWN RI VAN LE	9/19/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

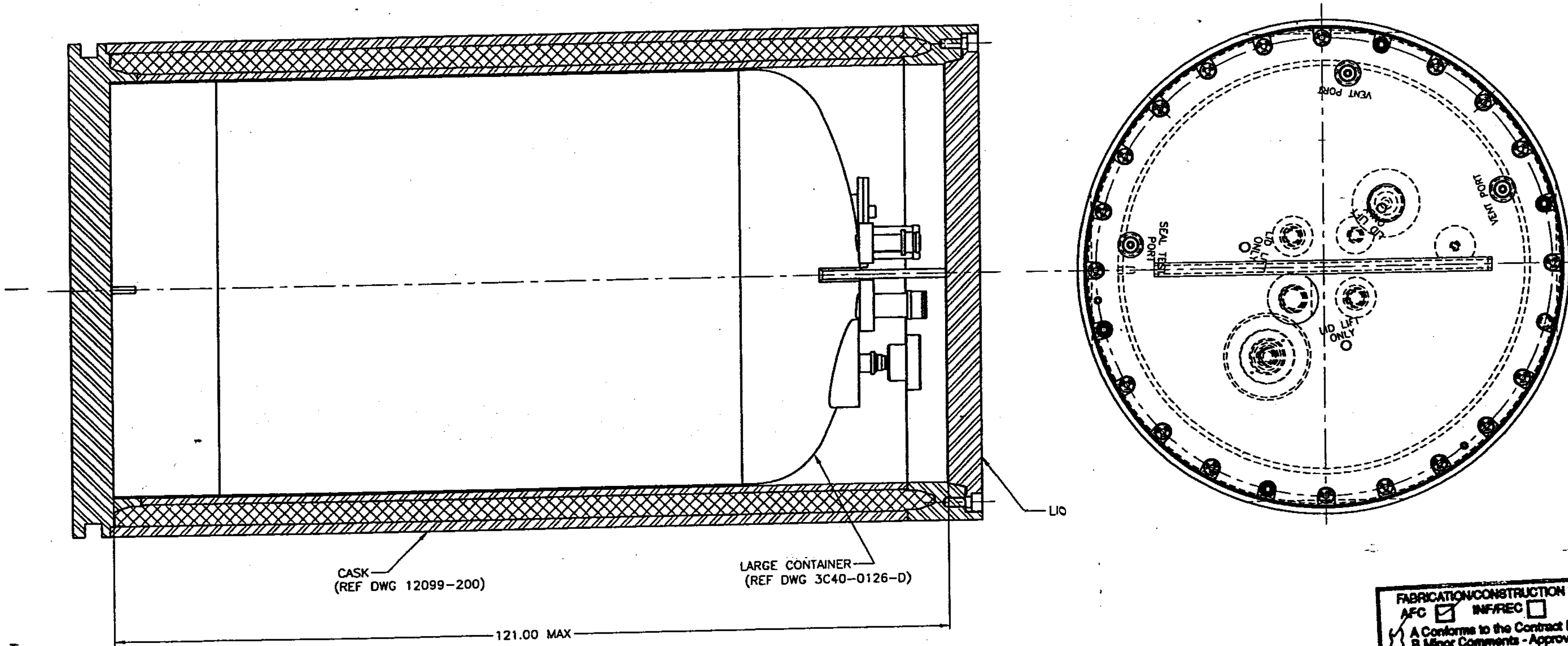
TOLERANCES:
FRACTIONS ±
ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±

Packaging Technology, Inc.
A Transnuclear Company

GENERAL ARRANGEMENT
SLUDGE CASK ASSEMBLY
SLUDGE TRANSPORTATION SYSTEM

SCALE: 1/32 | WT. N/A
REV: 2 | SHEET 2 OF 7
DWG SIZE D | DWG NO. 12099-100
CADFILE: 1209910022.DWG

12099-100	3	2	
REVISION HISTORY			
REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	08/16/02
1	REVISION PER CUSTOMER COMMENTS	BH	9/20/02
2	SEE DCN 1/1	BH	11/11/02



STS CASK-LARGE CONTAINER GENERAL ASSEMBLY

(LID INSTALLED)

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/12/02

ITEM	QTY	NEXT ASSY		
			REL B. HARGIS	9/20/02
			APPD	
			APPD	
			APPD F.L. YAPUNCICH	9/20/02
			ENGR J. NICHOLS	9/20/02
			QA B. COUNTERMAN	9/20/02
			CHECK D.S.HILLSTROM	9/20/02
			DRAWN RI VAN LE	9/19/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ±
ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±

Packaging Technology, Inc.
A Transnuclear Company

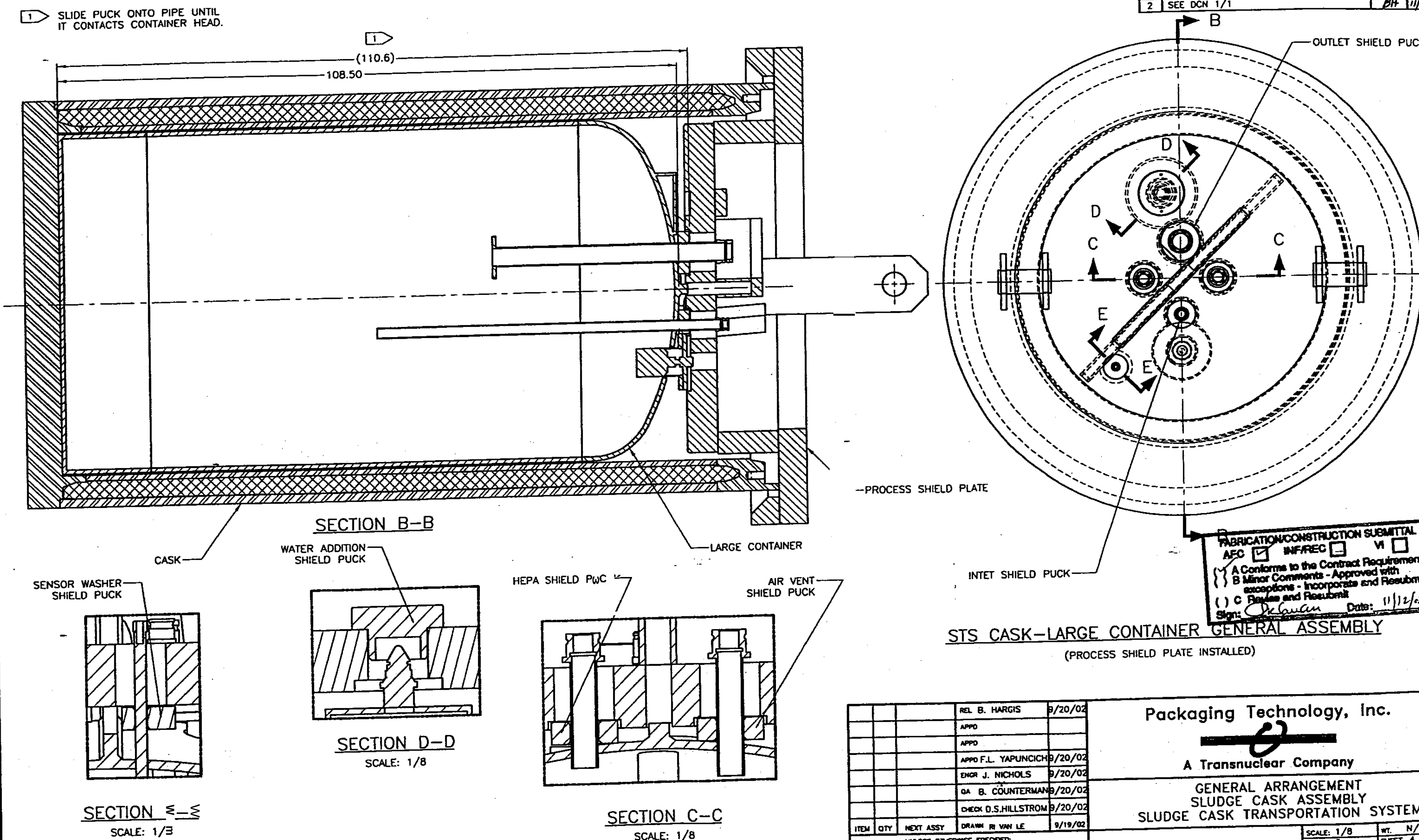
GENERAL ARRANGEMENT
SLUDGE CASK ASSEMBLY
SLUDGE CASK TRANSPORTATION SYSTEM

SCALE: 1/8 | WT. N/A
REV: 2 | SHEET 3 OF 7
DWG SIZE D | DWG NO. 12099-100
CADFILE: 1209910032.DWG

12099-100	4	2

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	09/16/02
1	REVISION PER CUSTOMER COMMENTS	BH	9/20/02
2	SEE DCN 1/1	BH	11/11/02



FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/12/02

STS CASK-LARGE CONTAINER GENERAL ASSEMBLY
(PROCESS SHIELD PLATE INSTALLED)

ITEM	QTY	NEXT ASSY		
			REL B. HARGIS	9/20/02
			APPD	
			APPD	
			APPD F.L. YAPUNCICH	9/20/02
			ENGR J. NICHOLS	9/20/02
			QA B. COUNTERMAN	9/20/02
			CHECK D.S.HILLSTROM	9/20/02
			DRAWN RI VAN LE	9/19/02

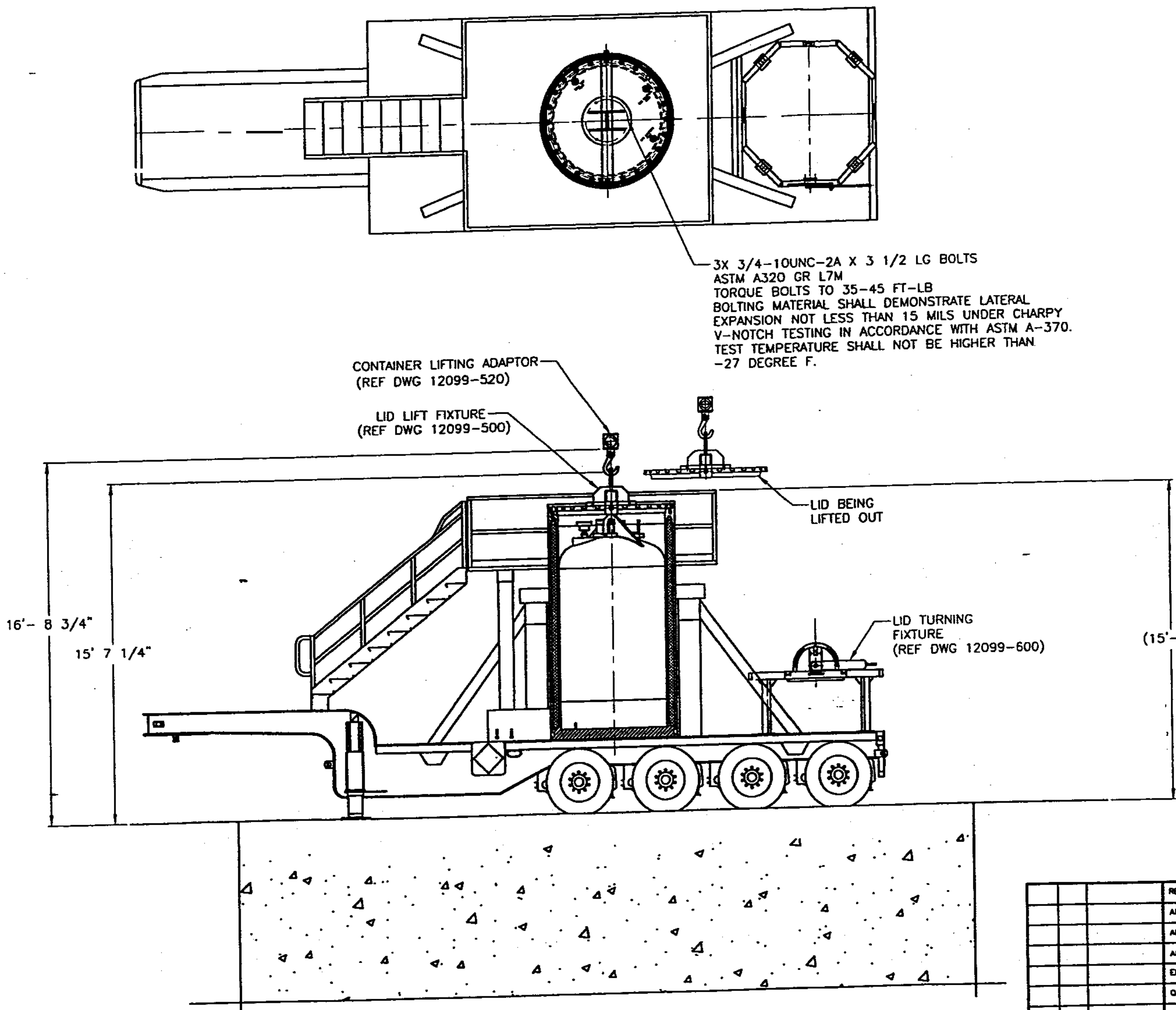
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±

Packaging Technology, Inc.
A Transnuclear Company

GENERAL ARRANGEMENT
SLUDGE CASK ASSEMBLY
SLUDGE CASK TRANSPORTATION SYSTEM

SCALE: 1/8 | WT. N/A
REV: 2 | SHEET 4 OF 7
DWG SIZE D | DWG NO. 12099-100
CADFILE: 1209910042.DWG

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	09/16/02
1	REVISION PER CUSTOMER COMMENTS	BH	9/20/02
2	SEE DCN 1/1	BH	11/11/02



STS CASK-TRAILER GENERAL ARRANGEMENT

(TYPICAL K BASIN POSITION DURING LID REMOVAL)

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/12/02

ITEM	QTY	NEXT ASSY		
			REL B. HARGIS	9/20/02
			APPD	
			APPD	
			APPD F.L. YAPUNCICH	9/20/02
			ENGR J. NICHOLS	9/20/02
			QA B. COUNTERMAN	9/20/02
			CHECK D.S.HILLSTROM	9/20/02
			DRAWN RI VAN LE	9/19/02

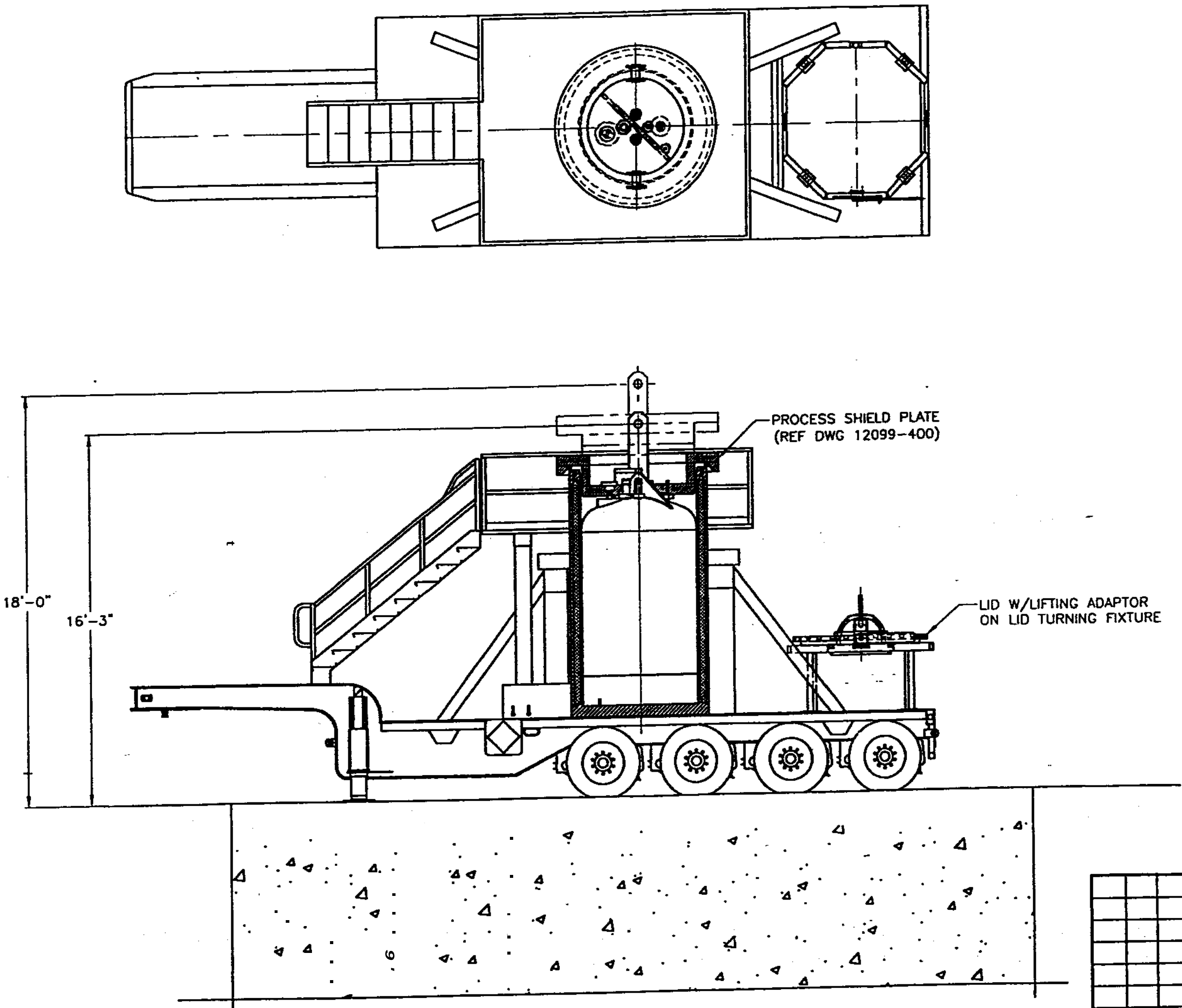
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±

Packaging Technology, Inc.
A Transnuclear Company

GENERAL ARRANGEMENT
SLUDGE TRANSPORTATION SYSTEM
K BASIN INSTALLATION REQUIREMENTS

SCALE: 1/32 | WT. N/A
REV: 2 | SHEET 5 OF 7
DWG SIZE D | DWG NO. 12099-100
CADFILE: 1209910052.DWG

12099-100	6	2	
REVISION HISTORY			
REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	08/16/02
1	REVISION PER CUSTOMER COMMENTS	BH	9/20/02
2	SEE DCN 1/1	BH	11/11/02



STS CASK-TRAILER GENERAL ASSEMBLY

(TYPICAL K BASIN ASSEMBLY DURING LOADING)

ITEM	QTY	NEXT ASSY		
			REL B. HARGIS	9/20/02
			APPD	
			APPD	
			APPD F.L. YAPUNICH	9/20/02
			ENGR J. NICHOLS	9/20/02
			QA B. COUNTERMAN	9/20/02
			CHECK D.S.HILLSTROM	9/20/02
			DRAWN RI VAN LE	9/19/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ±
ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±

Packaging Technology, Inc.

A Transnuclear Company

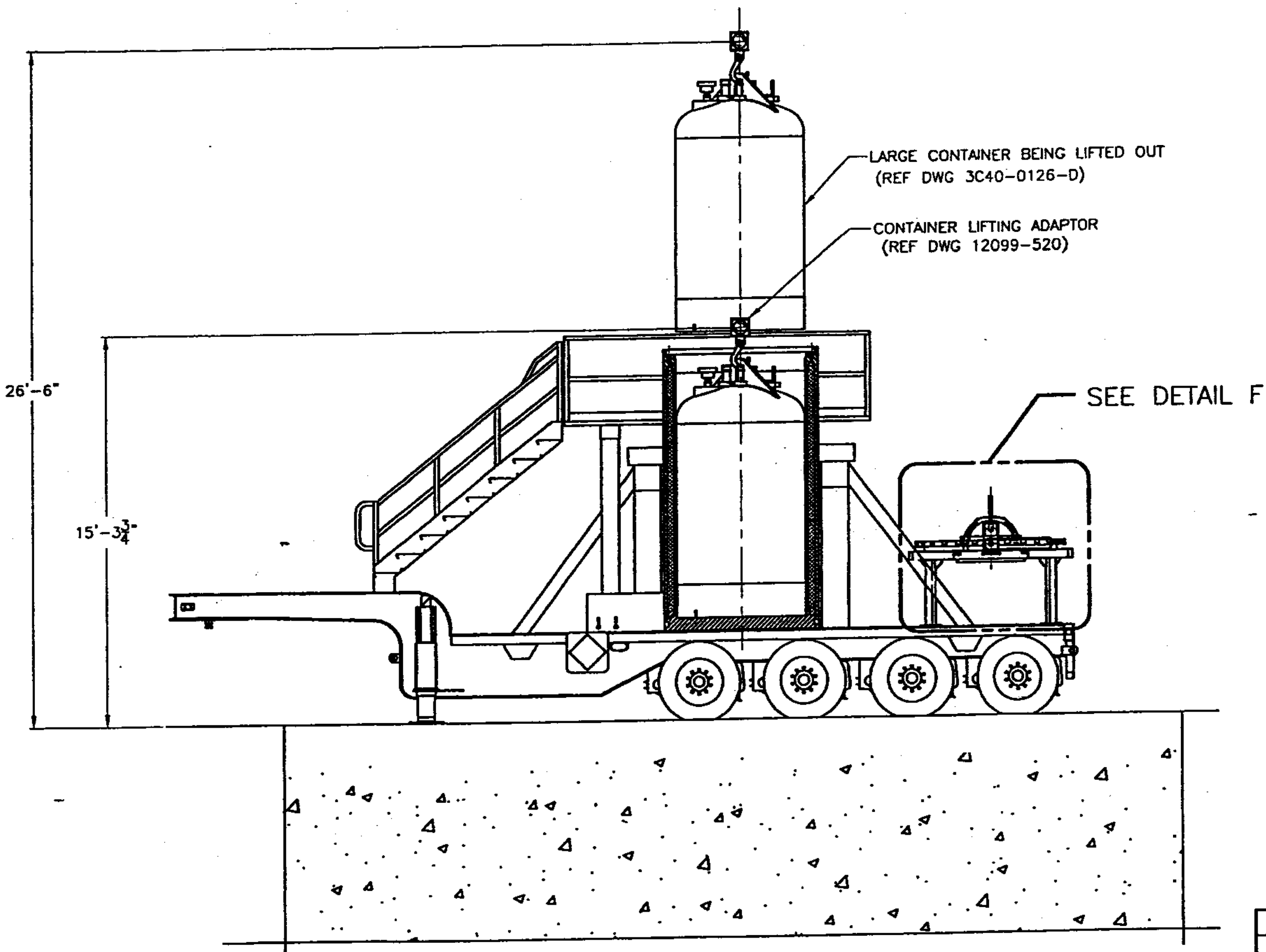
GENERAL ARRANGEMENT
SLUDGE TRANSPORTATION SYSTEM
K BASIN INSTALLATION REQUIREMENTS

SCALE: 1/32	WT. N/A
REV: 2	SHEET 6 OF 7
DWG SIZE D	DWG NO. 12099-100
	CADFILE: 1209910062.DWG

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	08/16/02
1	REVISION PER CUSTOMER COMMENTS	BH	9/20/02
2	SEE DCN 1/1	BH	11/11/02

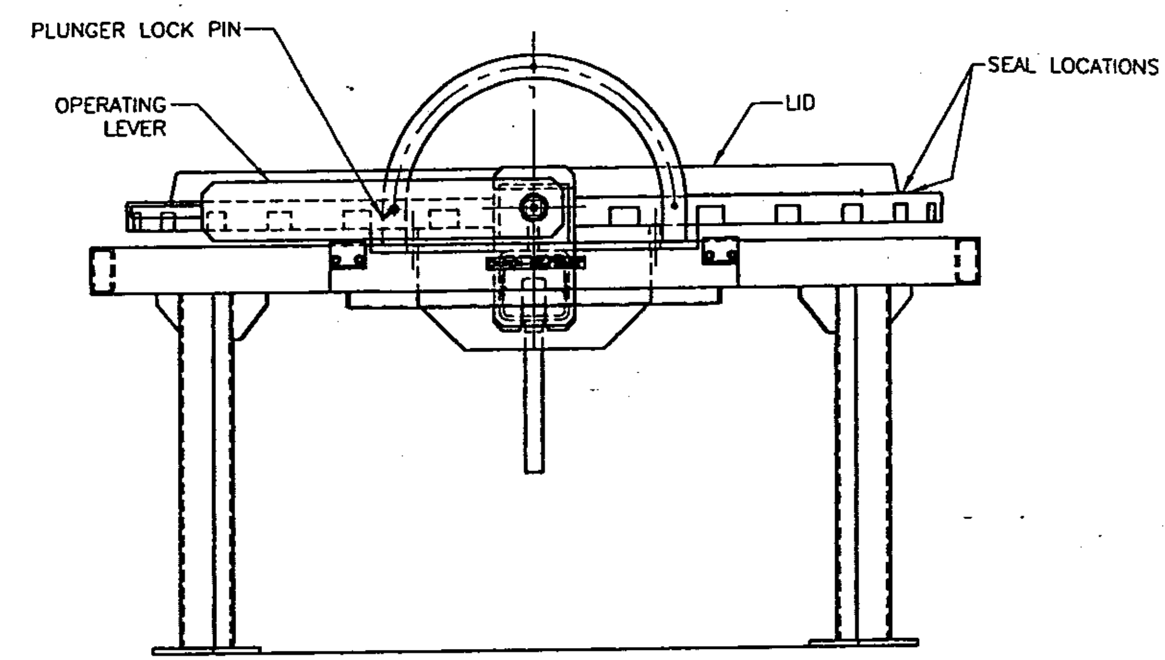
12099-100 7 2

REVISION HISTORY



STS CASK-TRAILER GENERAL ARRANGEMENT

(TYPICAL T PLANT POSITION DURING CANISTER REMOVAL)



DETAIL F

(LID ROTATED FOR SEAL INSPECTION AND REPLACEMENT)
SCALE: 1/8

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
{ } A Conforms to the Contract Requirements
{ } B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/14/02

ITEM	QTY	NEXT ASSY		
			REL B. HARGIS	9/20/02
			APPD	
			APPD	
			APPD F.L. YAPUNCICH	9/20/02
			ENGR J. NICHOLS	9/20/02
			QA B. COUNTERMAN	9/20/02
			CHECK D.S.HILLSTROM	9/20/02
			DRAWN RI VAN LE	9/19/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMAL ±

Packaging Technology, Inc.
A Transnuclear Company

GENERAL ARRANGEMENT
SLUDGE TRANSPORTATION SYSTEM
K BASIN INSTALLATION REQUIREMENTS

SCALE: 1/32 | WT. N/A
REV: 2 | SHEET 7 OF 7
DWG SIZE D | DWG NO. 12099-100
CADFILE: 12099100072.DWG

12099-200	1	3

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	1/30/02
1	SEE DCN 1/0 THRU 8/0	BH	8/14/02
2	SEE DCN 1/1	BH	9/10/02
3	SEE DCN 1/2 THRU 4/2	BH	11/26/02

NOTES, UNLESS OTHERWISE SPECIFIED:

Per submittal STS 22, the torque value was revised to min 500 FT-lb & Max. 800 FT. lb. Correct the torque values.

1. FABRICATE IN ACCORDANCE WITH ~~PACTEC SPEC~~ GF-006.
2. TORQUE TO 500-700 FT-LB. TORQUE WITH OR WITHOUT LUBRICATION. PLACE A WASHER (ITEM 16) UNDER EACH BOLT HEAD.
3. O-RING AND SEAL SURFACES SHALL BE LIGHTLY COATED WITH VACUUM GREASE PRIOR TO ASSEMBLY.
4. TORQUE TO 35-50 FT-LB. CLEAN PORT AND BOLT OF DIRT AND DEBRIS PRIOR TO INSTALLATION. USE NO LUBRICATION.
5. CONTAMINATION BOUNDARY SHALL BE HELIUM LEAK TESTED TO DEMONSTRATE A LEAKAGE RATE NOT TO EXCEED 1 X 10 ATMOSPHERE CUBIC CENTIMETERS PER SECOND AIR IN ACCORDANCE WITH ANSI N14.5. AND GF-006.
6. CASK ASSEMBLY SHALL BE HYDROSTATICALLY PRESSURE TESTED IN ACCORDANCE WITH GF-006.
7. LID LIFTING POINTS SHALL BE EACH LOAD TESTED TO 2,750 LBS (+100 -0 LBS). USING A CALIBRATED SCALE, AND HELD FOR 10 MINUTES. INSPECT THREADS PRIOR TO AND AFTER LOAD TEST. VERIFY THAT NO PERMANENT THREAD DEFORMATION OCCURS BY THREADING A CALIBRATED 3/4-10UNC-2B THREAD GAUGE INTO AND OUT OF THE LIFT POINT. LOAD TEST PROCEDURE SHALL BE SUBMITTED TO PACTEC ENGINEERING FOR APPROVAL.
8. CASK LIFTING POINTS SHALL BE EACH LOAD TESTED TO 31875 LBS (+500 -0 LBS). USING A CALIBRATED SCALE, AND HELD FOR 10 MINUTES. INSPECT THREADS PRIOR TO AND AFTER THE LOAD TEST. VERIFY THAT NO PERMANENT THREAD DEFORMATION OCCURS BY THREADING A CALIBRATED 1-1/2-6UNC-2B THREAD GAUGE INTO AND OUT OF THE LIFT POINT. LOAD TEST PROCEDURE SHALL BE SUBMITTED TO PACTEC ENGINEERING FOR APPROVAL.
9. BUTYL RUBBER SEAL MATERIAL PER RR-0405-70, RAINIER RUBBER COMPANY, SEATTLE WA.
10. TORQUE TO 250-200 FT-LB. CLEAN PORT AND BOLT OF DIRT AND DEBRIS PRIOR TO INSTALLATION. USE NO LUBRICATION.
11. TAMPER INDICATING SEAL SHALL BE INSTALLED AT EACH PORT LOCATION.
12. PAINT A 1" X 12" LG STRIPE AT THE TOP EDGE OF CASK CENTERED ON THE PLANE OF THE ALIGNMENT KEY. PACTEC TO APPROVE PAINT.
13. USING 2 ADJACENT BOLTS (LOCATION OPTIONAL) DRILL A 1/4" DIAMETER HOLE THRU EACH HEAD. AFTER INSTALLATION, INSTALL TAMPER INDICATING SEAL ACROSS BOLT HEADS.
14. IDENTIFY CASK ASSEMBLY IN AREA 24" ABOVE DRAIN PORT USING 5/8" HIGH (MIN) BLACK CHARACTERS WITH THE FOLLOWING INFORMATION:
    (STENCIL ONLY)

    MFG- PACKAGING TECHNOLOGY, INC.
    TACOMA, WA 98402-3526
    DATE OF MFG-
    GROSS WEIGHT- 85,000 Lbs.
    SERIAL NO.-
    DRAWING NO.- 12099-200

    NOTE:
    PAINT BLACK AMERCOTE 450HS

FABRICATION/CONSTRUCTION SUBMITTAL
AFC [X] INF/REC [ ] VI [ ]
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-200 Rev. 3
Serial No.(s) 01
Signature [signature] Date 11/26/02

INFORMATION ONLY

QUAL CAT.					QTY	ITEM	PART NO.	DESCRIPTION	
					24	16		WASHER, 1-9/16"ID X 2.25 MIN-2.35 MAX OD X 0.145" THK B6 RWC 26 410 SST	
									REID TOOL
C					1	15	HH-117	D-RING TIE DOWN	
					6	14	38030-98-C-6-Z	CAP SCREW, BHD #8-32 X 3/8 LG	UNBRAKO OR EQUAL
					6	13	U-260325	RETAINER CLIP	HELICOFLEX
A					1	12	U2318-01437SEB	DRAIN METAL O-RING	HELICOFLEX
					1	11	12099-270-3	PLUG, DRAIN PORT	
					1	10	12099-270-4	DRAIN PORT CAP	
					3	9	12099-270-2	PORT CLOSURE CAP	
A					1	8	H-307510	LID HN200 SEAL, 63.435±0.020 X 0.268±0.006	HELICOFLEX
C (9)					1	7		O-RING, 64.07±.25 X ø.275±.004	RAINIER RUBBER
A					3	6	U2212-00875SEB	PORT METAL O-RING	HELICOFLEX
					2	5	12099-272-1	LID ALIGNMENT PIN	
					3	4	12099-270-1	PORT CLOSURE BOLT	
					24	3	12099-271-1	LID CLOSURE BOLT	
					1	2	12099-240-A1	LID WELDMENT	
					1	1	12099-210-A1	BODY WELDMENT	
					X	A1		CASK ASSEMBLY	
					A1	ITEM	PART NO.	DESCRIPTION	
					ASSEMBLY & QUANTITY			LIST OF MATERIAL	

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	1/30/02
			APPD		
			APPD		
			APPD	K. BROWNELL	1/29/02
			ENGR	J. NICHOLS	1/29/02
			QA	B. COUNTERMAN	1/29/02
A1	1	12099-100	CHECK	F. STEINER	1/29/02
			DRAWN	T. WAAGAN	10/12/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± N/A
2 PLACE DECIMALS ± N/A
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

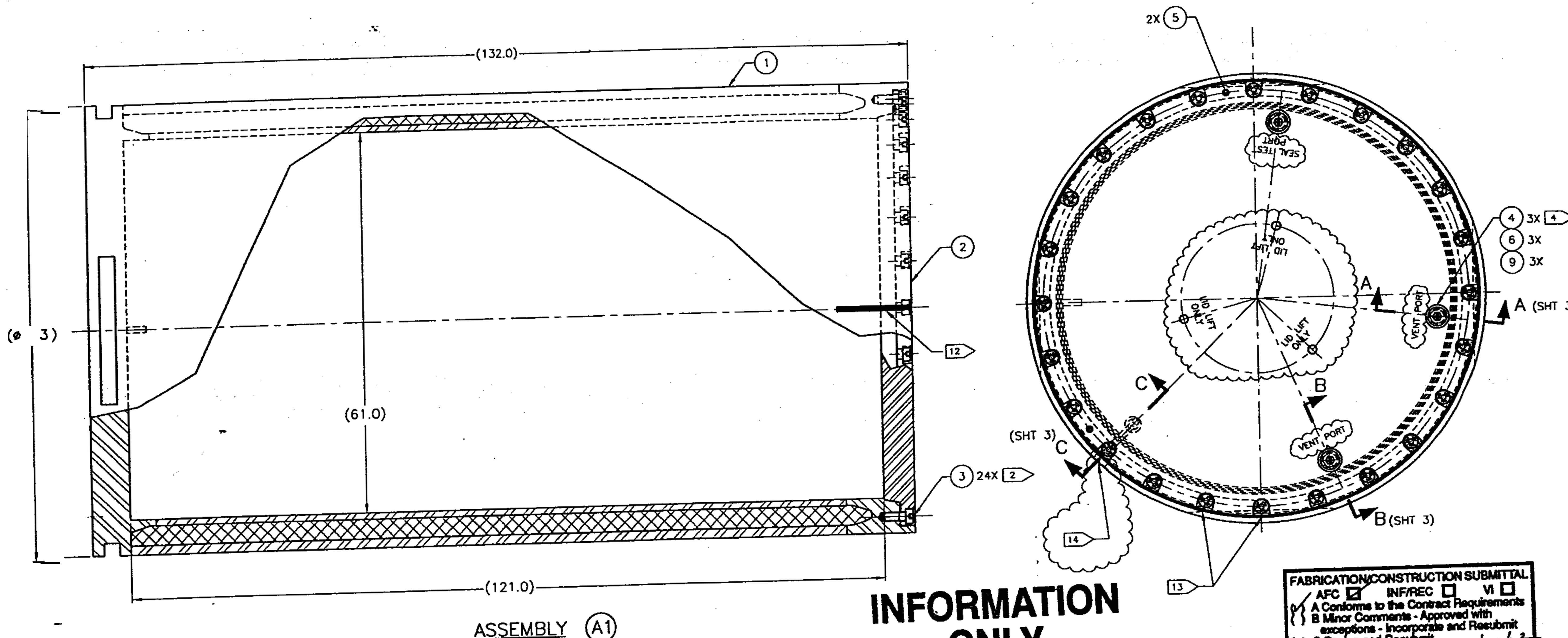
CASK ASSEMBLY
CASK
SLUDGE TRANSPORTATION SYSTEM

SCALE: NONE WT. N/A
REV: 3 SHEET 1 OF 3
DWG SIZE D DWG NO. 12099-200
CADFILE: 1209920013.DWG

12099?-200	2	3

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	1/30/02
1	SEE DCN 1/0 THRU 8/0	BH	8/14/02
2	SEE DCN 1/1	BH	9/10/02
3	SEE DCN 1/2 THRU 4/2	BH	11/26/02



INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-200 Rev. 3
Serial No.(s) 01
Signature [signature] Date 11/26/02

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	1/30/02
			APPD		
			APPD		
			APPD	K. BROWNELL	1/29/02
			ENGR	J. NICHOLS	1/29/02
			QA	B. COUNTERMAN	1/29/02
			CHECK	F. STEINER	1/29/02
			DRAWN	T. WAAGAN	10/4/01

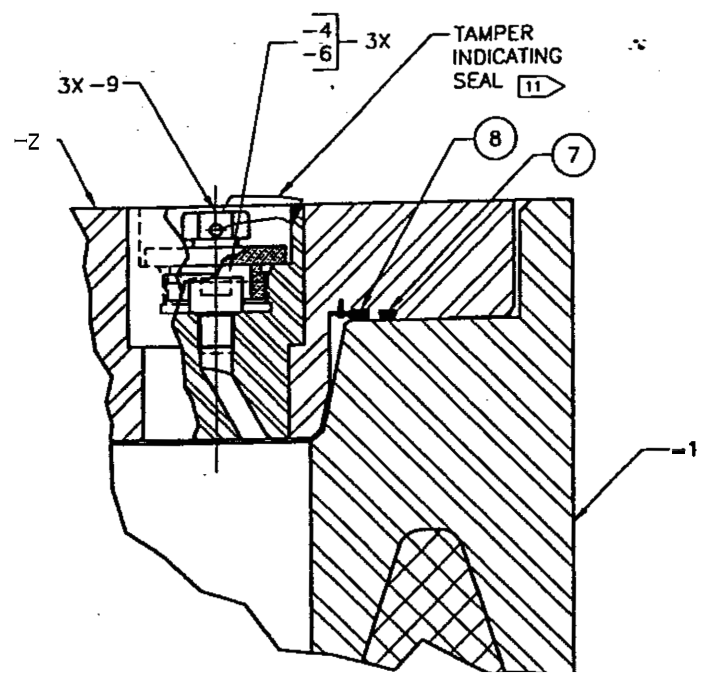
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± N/A
2 PLACE DECIMALS ± N/A
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

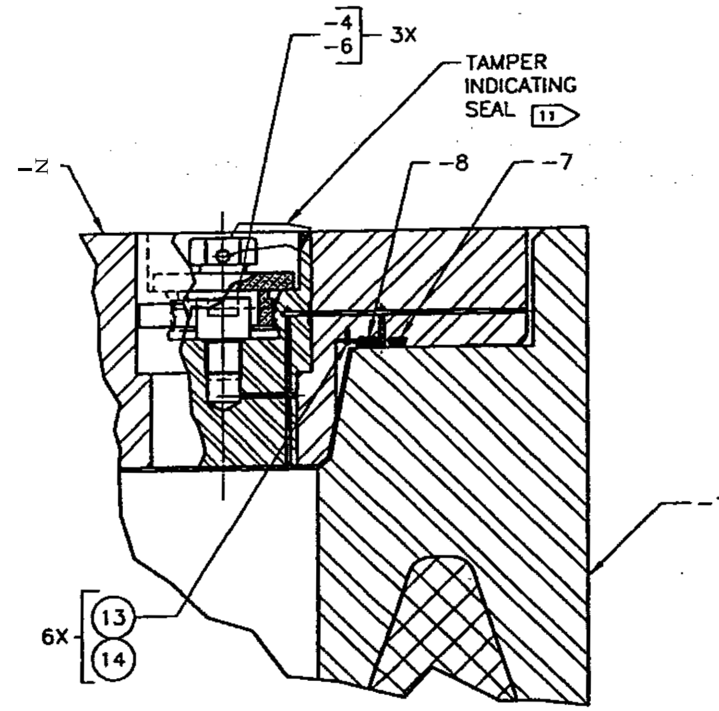
CASK ASSEMBLY
CASK
SLUDGE TRANSPORTATION SYSTEM

SCALE: 1/8 | WT. N/A
REV: 3 | SHEET 2 OF 3
DWG SIZE D | DWG NO. 12099-200
CADFILE: 1209920023.DWG

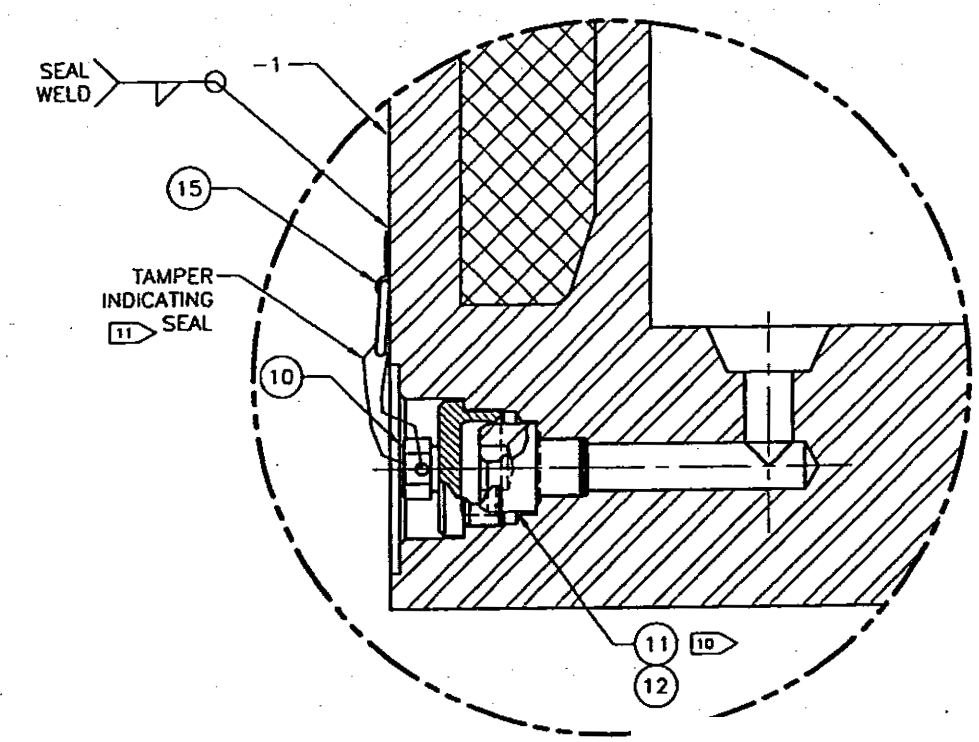
12099-200	3	3		
REVISION HISTORY				
REV	DESCRIPTION		REL	DATE
0	INITIAL RELEASE		BH	1/30/02
1	SEE DCN 1/0 THRU 8/0		BH	8/14/02
2	SEE DCN 1/1		BH	9/10/02
3	SEE DCN 1/2 THRU 4/2		BH	11/26/02



SECTION D-D (SHT 2)



SECTION B-B (SHT 2)



SECTION C (SHT 2)

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-200 Rev. 3
Serial No.(s) 01
Signature [signature] Date 11/26/02

INFORMATION ONLY

			REL	B. HARGIS	1/30/02
			APPD		
			APPD		
			APPD	K. BROWNELL	1/29/02
			ENGR	J. NICHOLS	1/29/02
			QA	B. COUNTERMAN	1/29/02
			CHECK	F. STEINER	1/29/02
ITEM	QTY	NEXT ASSY	DRAWN	T. WAAGAN	10/11/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± N/A
ANGLES ± N/A
3 PLACE DECIMALS ± N/A
2 PLACE DECIMALS ± N/A
1 PLACE DECIMAL ± N/A

Packaging Technology, Inc.
A Transnuclear Company

CASK ASSEMBLY
CASK
SLUDGE TRANSPORTATION SYSTEM

SCALE: 1/2	WT. N/A	
REV: 3	SHEET 3 OF 3	
DWG SIZE D	DWG NO. 12099-200	
	CADFILE 12099200033.DWG	

12099-210	1	3

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	10/30/01
1	SEE DCN 1/0 THRU 4/0	BH	2/28/02
2	SEE DCN 1/1 THRU 3/1	BH	5/17/02
3	SEE DCN 1/2 THRU 4/2	BH	9/10/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.

3. THIS WELD IS MADE AFTER LEAD POUR ACCEPTANCE.

4. OUTER AND INNER SHELLS SHALL COMPLY WITH TOLERANCE REQUIREMENTS OF THE ASME CODE, SECTION III, DIVISION 1, SUBSECTION NB, ARTICLE NB-4200, SUBARTICLE NB-4220, PARAGRAPH NB-4221, SUB-PARAGRAPH NB-4221.1.

5. LEAD POURING SHALL BE IN ACCORDANCE WITH PACTEC LEAD POUR PROCEDURE FP-035 AND LEAD POUR PREPARATION SHALL BE IN ACCORDANCE WITH PACTEC DRAWING 12099-215.

6. PRIOR TO LEAD POUR, THE INNER SHELL OF THE OUTER CASK SHALL BE HELIUM LEAKAGE RATE TESTED TO DEMONSTRATE A LEAKAGE RATE NOT TO EXCEED 1 X 10^{-7} STANDARD CUBIC CENTIMETER PER SECOND AIR, IN ACCORDANCE WITH ANSI N14.5-1987. TESTING SHALL BE PERFORMED IN ACCORDANCE WITH PACTEC LEAKAGE RATE PROCEDURE LT-020, OR APPROVED ALTERNATE.

7. WELD SIZE TO MATCH THICKNESS OF THINNER MATERIAL.

8. NOTE ANGULAR ORIENTATION OF NOTCHES IN BASE (ITEM 2), AND THE ALIGNMENT PIN HOLES IN THE BODY COLLAR (ITEM 1).

10. THE INNER SHELL TO BOTTOM FORGING WELD JOINT DOES NOT LEND ITSELF TO THE PERFORMANCE OF RADIOGRAPHIC EXAMINATION. THUS, THE JOINT IS ULTRASONIC EXAMINED, AS ALLOWED PER NB-5279.

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-210 Rev. 3
Serial No.(s) 01
Signature [signature] Date 11/26/02

INFORMATION ONLY

QUAL CAT.							QTY	ITEM	PART NO.	DESCRIPTION	MATERIAL
C							1	7		PLATE, 1" X 3.0 X 3.0	ASTM A240, TYPE 304
							1	6	12099-212-2	ANGLE RING	
B (5)							A/R	5	12099-215	LEAD	FEDERAL SPEC. QQ-L-171E, GR A OR C
							1	4	12099-214-1	OUTER SHELL	
							1	3	12099-213-1	INNER SHELL	
							1	2	12099-212-1	BASE	
							1	1	12099-211-1	BODY COLLAR	
							☒	A1		BODY WELDMENT	
							A1	ITEM	PART NO.	DESCRIPTION	LIST OF MATERIAL

ASSEMBLY & QUANTITY

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	10/30/01
			APPD		
			APPD		
			APPD	J. NICHOLS	10/30/01
			ENGR	D. HILLSTROM	10/30/01
			QA	B. COUNTERMAN	10/30/01
A1	1	12099-200	CHECK	F. STEINER	10/30/01
			DRAWN	T. WAAGAN	10/29/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± N/A
ANGLES ± N/A
3 PLACE DECIMALS ± N/A
2 PLACE DECIMALS ± N/A
1 PLACE DECIMAL ± N/A

Packaging Technology, Inc.
A Transnuclear Company

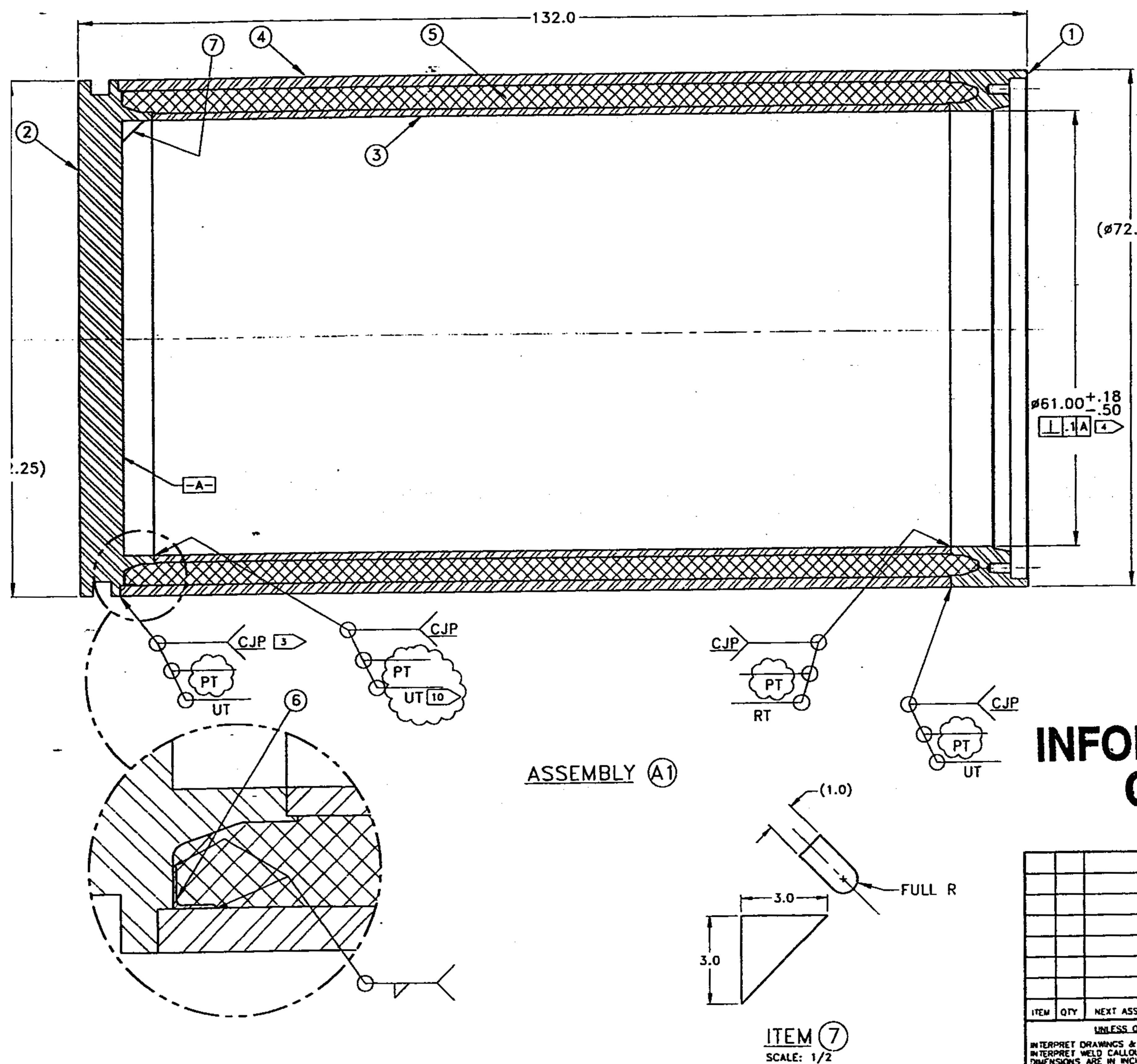
CASK WELDMENT
CASK
SLUDGE TRANSPORT

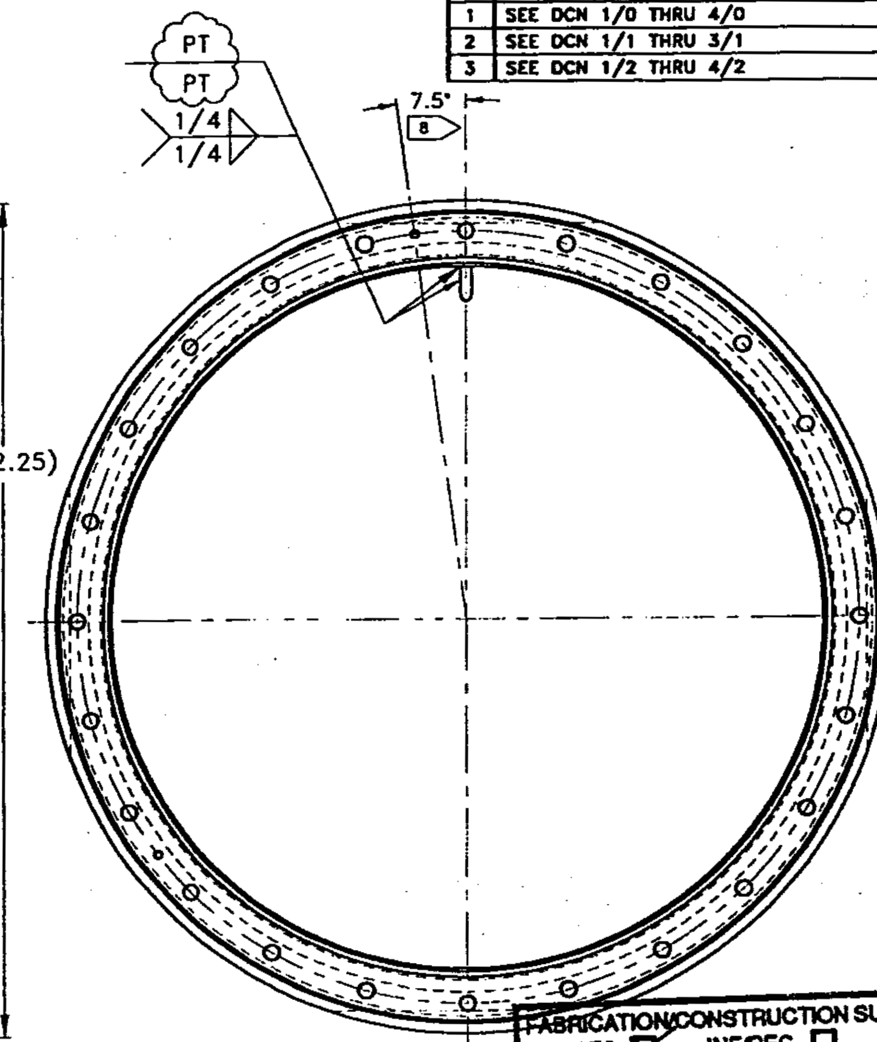
SCALE: N/A | WT. N/A LBS
REV: 3 | SHEET 1 OF 2
DWG SIZE D | DWG NO. 12099-210
CADFILE: 1209921013.DWG

12099-210	2	3	

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	10/30/01
1	SEE DCN 1/0 THRU 4/0	BH	2/28/02
2	SEE DCN 1/1 THRU 3/1	BH	5/17/02
3	SEE DCN 1/2 THRU 4/2	BH	9/10/02





FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 1261
Serial No (s) 3
Signature [signature] Date 11/26/02

INFORMATION ONLY

			REL	B. HARGIS	10/30/01
			APPD		
			APPD		
			APPD	J. NICHOLS	10/30/01
			ENGR	D. HILLSTROM	10/30/01
			QA	B. COUNTERMAN	10/30/01
			CHECK	F. STEINER	10/30/01
ITEM	QTY	NEXT ASSY	DRAWN	T. WAAGAN	10/29/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4 2
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

CASK WELDMENT
CASK
SLUDGE TRANSPORT

SCALE: 1/8 WT. N/A
REV: 3 SHEET 2 OF 2
DWG SIZE D DWG NO. 12099-210
CADFILE: 1209921023.DWG

12099-211	1	3

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	10/30/01
1	SEE DCN 1/0 THRU 4/0	BH	2/28/02
2	SEE DCN 1/1 THRU 4/1	BH	5/17/02
3	SEE DCN 1/2	BH	9/10/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.

3. NOT USED

4. VERIFY AND MATCH, -.00, +.05 WITH INSIDE DIAMETER OF INNER SHELL, 12099-213-1.

5. VERIFY AND MATCH, -.00, +.05 WITH OUTSIDE DIAMETER OF INNER SHELL, 12099-213-1.

6. VERIFY AND MATCH, -.05, +.00 WITH INSIDE DIAMETER OF OUTER SHELL, 12099-214-1.

7. FINAL MACHINING OF INDICATED SURFACES AND PLACEMENT OF BOLT HOLES MAY BE PERFORMED AFTER WELDING AND LEAD POUR.

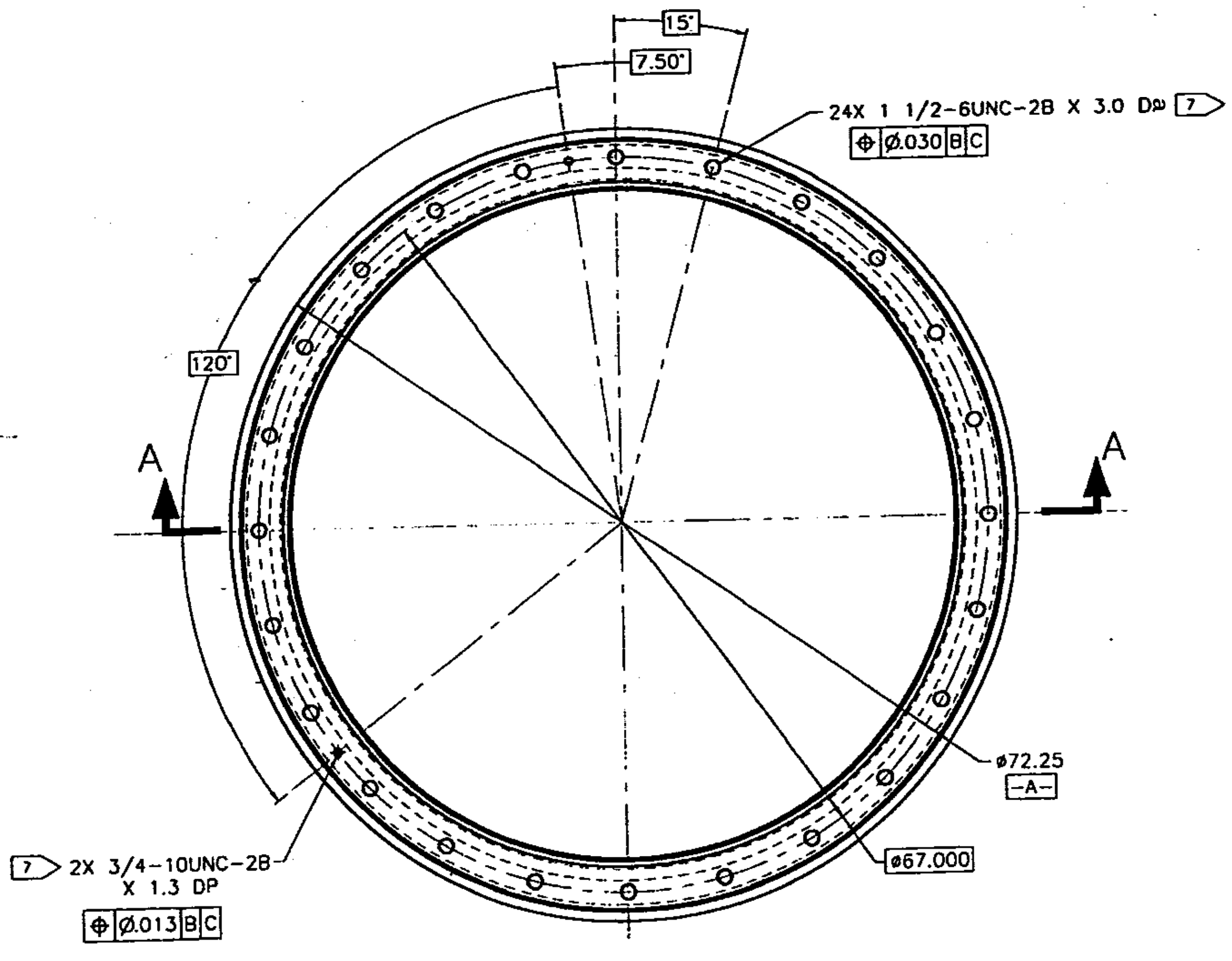
8. NOT USED

9. OPTIONAL: MATERIAL MAY BE ASME SA240, TYPE 304. EXAMINATION (AND REPAIRS, IF REQUIRED) TO BE PERFORMED ON PLATE IN ACCORDANCE WITH ASME CODE, SECTION III, DIVISION 1, SUBSECTION NB, ARTICLE NB-2530 AND SECTION V, ARTICLE 5.

10. EXAMINATION (AND REPAIRS, IF REQUIRED) TO BE PERFORMED ON FORGING IN ACCORDANCE WITH ASME CODE, SECTION III, DIVISION 1, SUBSECTION NB, ARTICLE NB-2540, AND SECTION V, ARTICLES 2 AND 5.

11. THREADS PER ANSI/ASME B1.1.

12. INTEGRAL BACKING BAR MAY BE USED. SEE "OPTIONAL: INTEGRAL BACKING BAR DETAIL".



DETAIL ITEM 1 7

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-211 Rev. 3
Serial No.(s) 01
Signature [signature] Date 11/26/02

INFORMATION ONLY

9 10 A						1		FORGING, ø72.3 X 11.4	ASME SA-182, TYPE F304
QUAL CAT.						ITEM	PART NO.	DESCRIPTION	
						ASSEMBLY & QUANTITY		LIST OF MATERIAL	

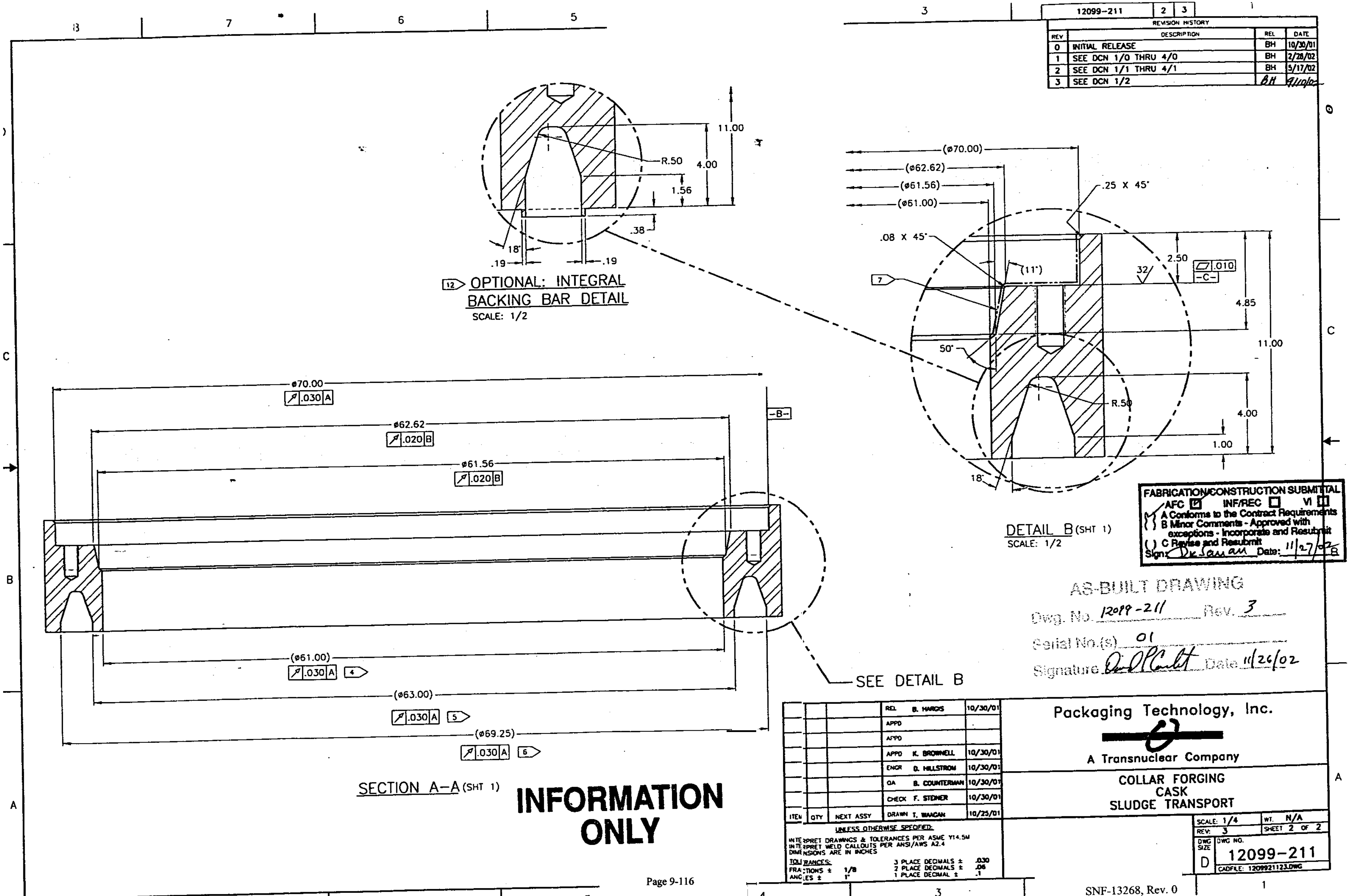
		REL	B. HARGIS	10/30/01
		APPD		
		APPD		
		APPD	K. BROWNELL	10/30/01
		ENGR	D. HILLSTROM	10/30/01
		QA	B. COUNTERMAN	10/30/01
1 1	12099-210	CHECK	F. STEINER	10/30/01
ITEM QTY	NEXT ASSY	DRAWN	T. WAGAN	10/25/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8 — 3 PLACE DECIMALS ± .030
ANGLES ± 1° — 2 PLACE DECIMALS ± .06
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

COLLAR FORGING
CASK
SLUDGE TRANSPORT

SCALE: 1/8	WT. N/A
REV: 3	SHEET 1 OF 2
DWG SIZE D	DWG NO. 12099-211
	CADFILE: 1209921113.DWG


12099-211
2
3
REVISION HISTORY
REV | DESCRIPTION | REL | DATE
0 | INITIAL RELEASE | BH | 10/30/01
1 | SEE DCN 1/0 THRU 4/0 | BH | 2/28/02
2 | SEE DCN 1/1 THRU 4/1 | BH | 5/17/02
3 | SEE DCN 1/2 | BH | 9/10/02
11.00
R.50
4.00
1.56
.38
18°
.19
.19
12 OPTIONAL: INTEGRAL BACKING BAR DETAIL
SCALE: 1/2
(ø70.00)
(ø62.62)
(ø61.56)
(ø61.00)
.25 X 45°
.08 X 45°
(11°)
2.50
32
.010
-C-
7
4.85
11.00
50°
R.50
4.00
1.00
18°
DETAIL B (SHT 1)
SCALE: 1/2
FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Sign: DkSauam Date: 11/27/02 B
AS-BUILT DRAWING
Dwg. No. 12099-211 Rev. 3
Serial No.(s) 01
Date 11/26/02
ø70.00
.030 A
ø62.62
.020 B
ø61.56
.020 B
-B-
(ø61.00)
.030 A
4
(ø63.00)
.030 A
5
(ø69.25)
.030 A
6
SEE DETAIL B
SECTION A-A (SHT 1)
INFORMATION ONLY
ITEM | QTY | NEXT ASSY
REL B. HARDIS 10/30/01
APPD
APPD
APPD K. BROWNELL 10/30/01
ENGR D. HILLSTROM 10/30/01
QA B. COUNTERMAN 10/30/01
CHECK F. STONER 10/30/01
DRAWN T. WAAGAN 10/25/01
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .030
2 PLACE DECIMALS ± .06
1 PLACE DECIMAL ± .1
Packaging Technology, Inc.
A Transnuclear Company
COLLAR FORGING
CASK
SLUDGE TRANSPORT
SCALE: 1/4
WT. N/A
REV: 3
SHEET 2 OF 2
DWG SIZE D
DWG NO. 12099-211
CADFILE: 1209921123.DWG

0	INITIAL RELEASE	BH	10/30/01
1	SEE DCN 1/0 THRU 9/0	BH	6/21/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.

3 NOT USED

4 VERIFY AND MATCH, -.00, +.05 WITH INSIDE DIAMETER OF INNER SHELL, 12099-213-1.

5 VERIFY AND MATCH, -.00, +.05 WITH OUTSIDE DIAMETER OF INNER SHELL, 12099-213-1.

6 VERIFY AND MATCH, -.05, +.00 WITH INSIDE DIAMETER OF OUTER SHELL, 12099-214-1.

7 NOT USED

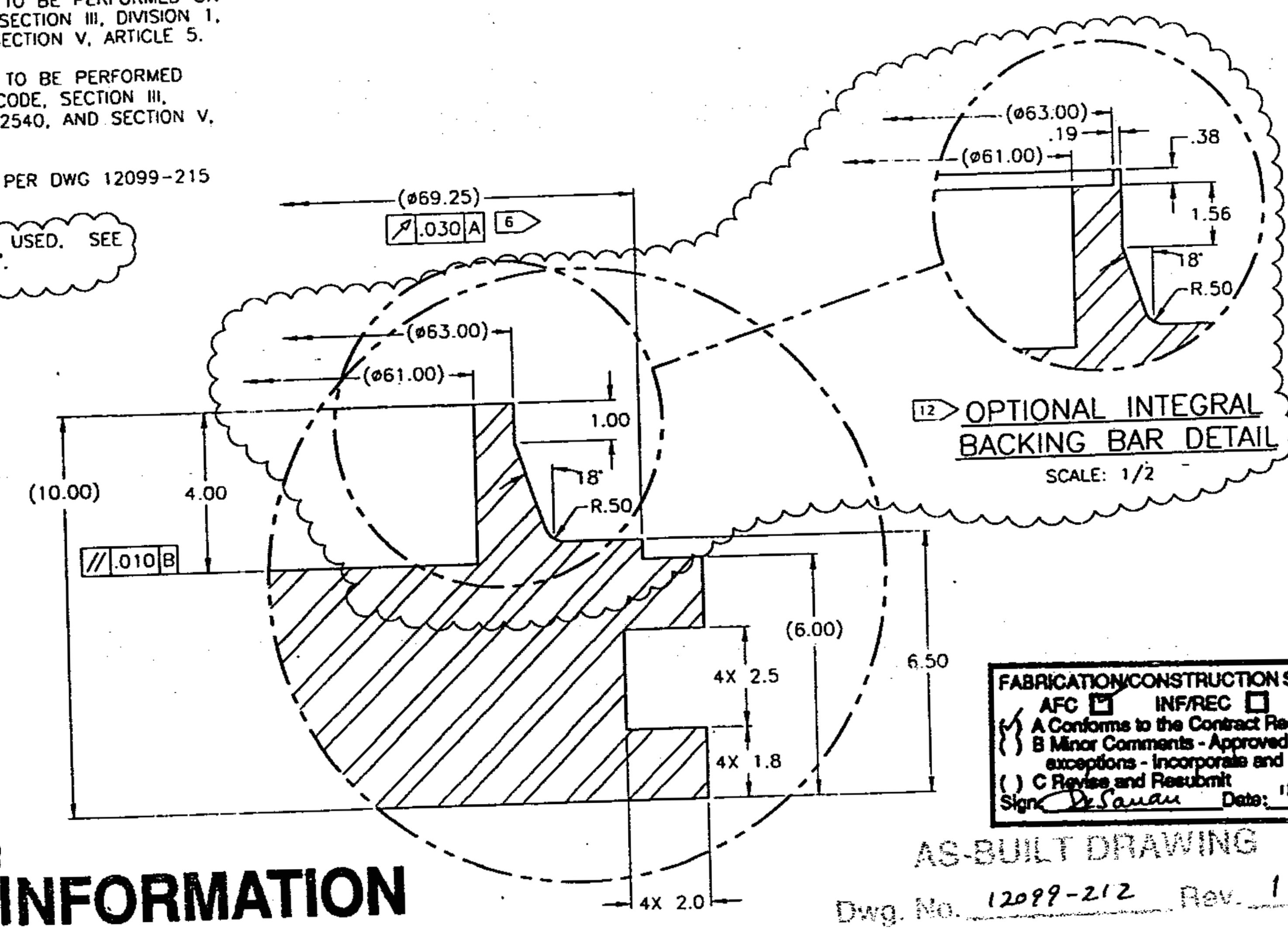
8 ROLLED ANGLE (ITEM 2) MAY BE FABRICATED OUT OF MULTIPLE ANGLES.

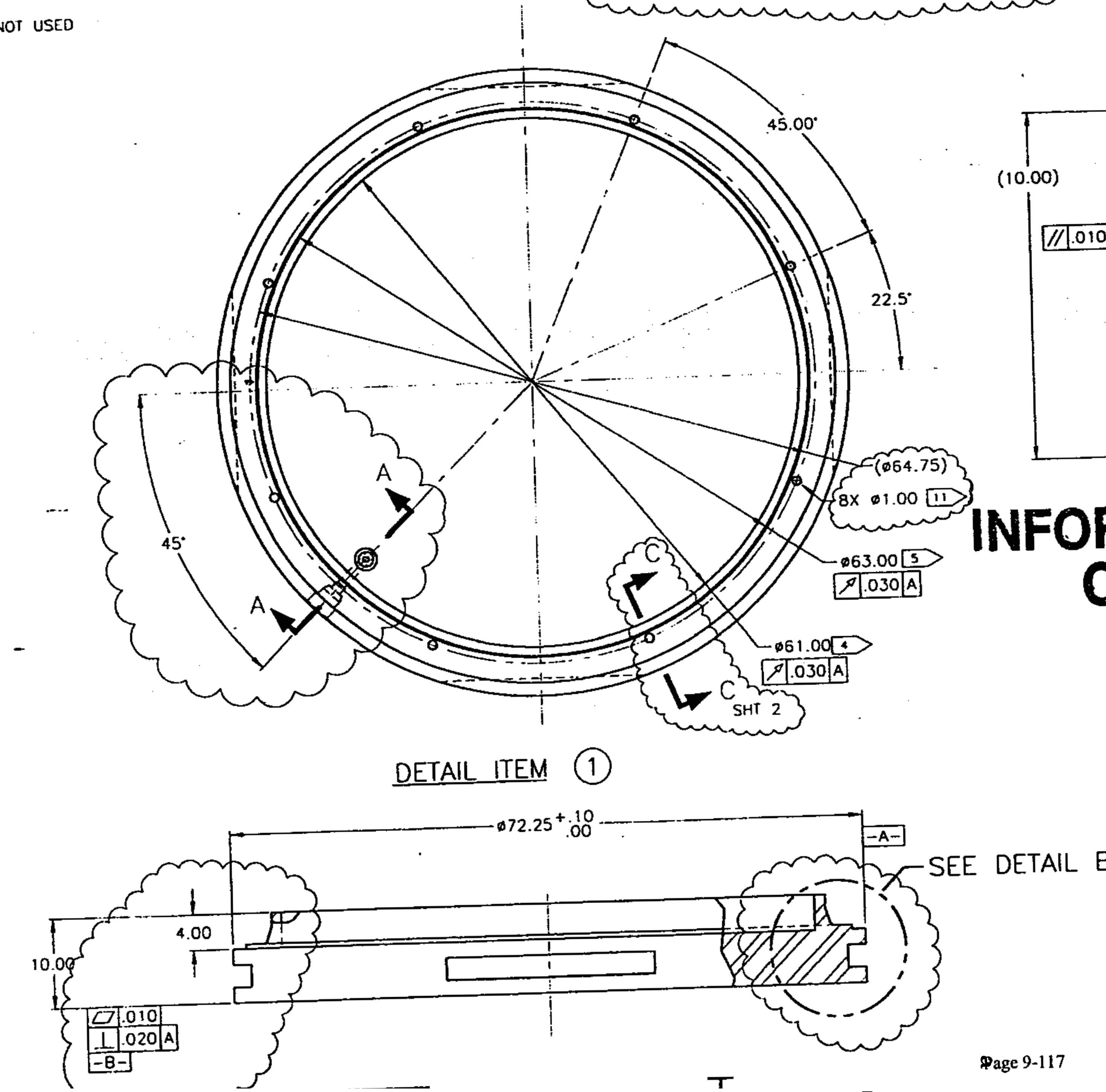
9 OPTIONAL: MATERIAL MAY BE ASME SA240, TYPE 304. EXAMINATION (AND REPAIRS, IF REQUIRED) TO BE PERFORMED ON PLATE IN ACCORDANCE WITH ASME CODE, SECTION III, DIVISION 1, SUBSECTION NB, ARTICLE NB-2530 AND SECTION V, ARTICLE 5.

10 EXAMINATION (AND REPAIRS, IF REQUIRED) TO BE PERFORMED ON FORGING IN ACCORDANCE WITH ASME CODE, SECTION III, DIVISION 1, SUBSECTION NB, ARTICLE NB-2540, AND SECTION V, ARTICLES 2 AND 5.

11 LEAD POUR VENT HOLES TO BE PLUGGED PER DWG 12099-215 AFTER LEAD POUR ACCEPTANCE.

12 OPTIONAL: INTEGRAL BACKING BAR MAY BE USED. SEE "OPTIONAL: INTEGRAL BACKING BAR DETAIL".





INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ V ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: DeSaulu Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-212 Rev. 1
Serial No.(s) 01
Signature [signature] Date 11/26/02

8	C	2		ANGLE, 1 1/2 X 1 1/2 X 1/8 X 120	ASTM A276, TYPE 304
9, 10	A	1		FORGING, ø72.3 X 11.0	ASME SA-182, TYPE F304
QUAL CAT		ITEM	PART NO.	DESCRIPTION	
				LIST OF MATERIAL	

ASSEMBLY & QUANTITY

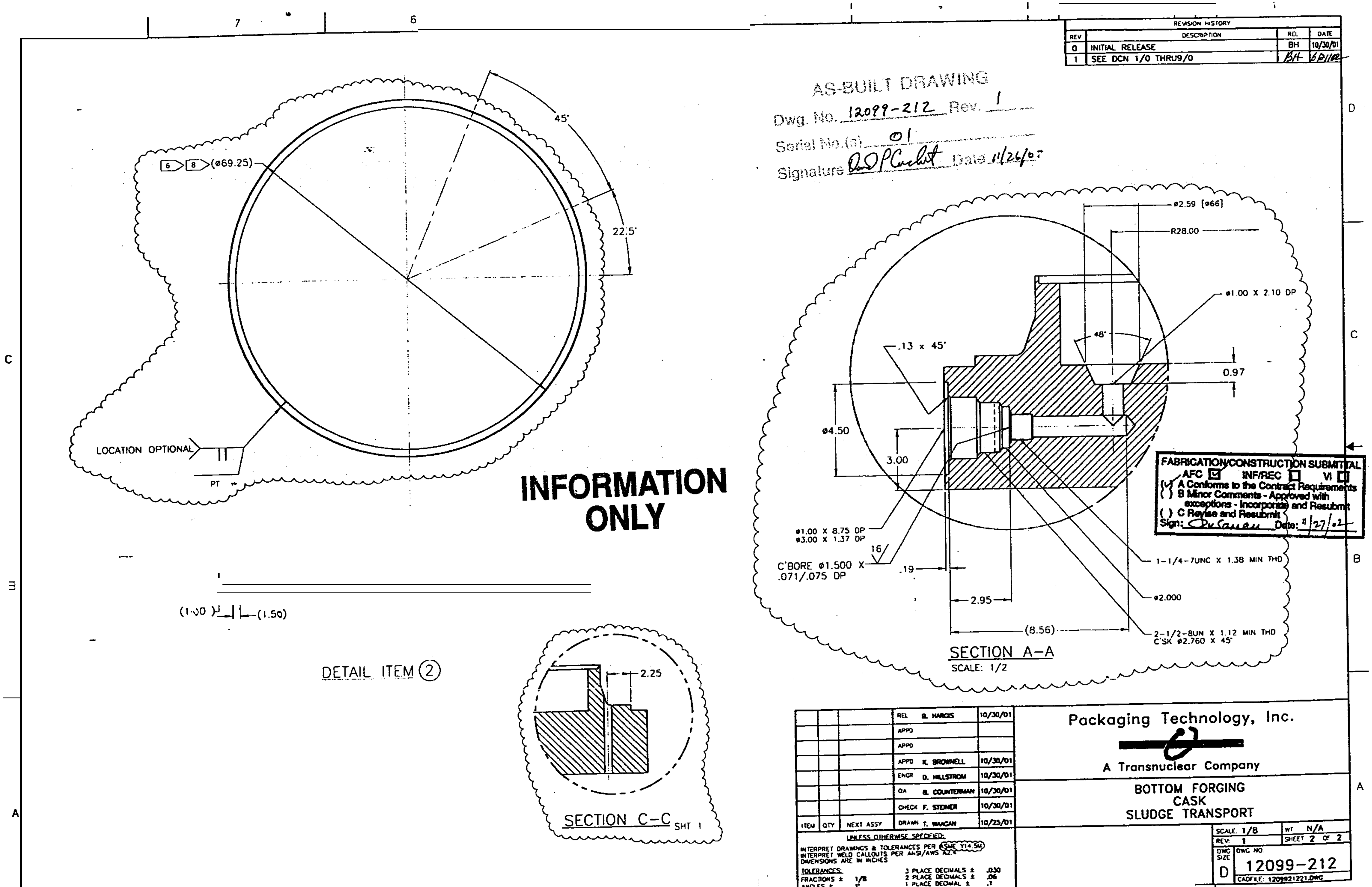
ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	10/30/01
			APPD		
			APPD		
			APPD	K. BROWNELL	10/30/01
			ENGR	D. HILLSTROM	10/30/01
2	1	12099-210	QA	B. COUNTERMAN	10/30/01
1	1	12099-210	CHECK	F. STEINER	10/30/01
			DRAWN	T. WAAGAN	10/23/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .030
2 PLACE DECIMALS ± .06
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

BOTTOM FORGING
CASK
SLUDGE TRANSPORT

SCALE: 1/8 | WT. N/A
REV: 1 | SHEET 1 OF 2
DWG SIZE D | DWG NO. 12099-212
CADFILE: 12099212I1.DWG



REVISION HISTORY
REV | DESCRIPTION | REL | DATE
0 | INITIAL RELEASE | BH | 10/30/01
1 | SEE DCN 1/0 THRU9/0
AS-BUILT DRAWING
Dwg. No. 12099-212 Rev. 1
Serial No.(s) 01
Signature
Date 11/26/07
(ø69.25)
45°
22.5°
LOCATION OPTIONAL
PT
INFORMATION ONLY
(1.00)
(1.50)
DETAIL ITEM 2
2.25
SECTION C–C SHT 1
ø2.59 [ø66]
R28.00
ø1.00 X 2.10 DP
48°
.13 x 45°
0.97
ø4.50
3.00
FABRICATION/CONSTRUCTION SUBMITTAL
AFC INF/REC VI
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Sign:
Date: 11/27/02
ø1.00 X 8.75 DP
ø3.00 X 1.37 DP
16
C'BORE ø1.500 X .071/.075 DP
.19
1-1/4-7UNC X 1.38 MIN THD
2.95
ø2.000
(8.56)
2-1/2-8UN X 1.12 MIN THD C'SK ø2.760 X 45°
SECTION A–A
SCALE: 1/2
REL B. HARGIS 10/30/01
APPD
APPD
APPD K. BROWNELL 10/30/01
ENGR D. HILLSTROM 10/30/01
QA B. COUNTERMAN 10/30/01
CHECK F. STEINER 10/30/01
DRAWN T. WAACAN 10/25/01
ITEM QTY NEXT ASSY
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .030
2 PLACE DECIMALS ± .06
1 PLACE DECIMAL ± .1
Packaging Technology, Inc.
A Transnuclear Company
BOTTOM FORGING
CASK
SLUDGE TRANSPORT
SCALE: 1/8
WT N/A
REV: 1
SHEET 2 OF 2
DWG SIZE D
DWG NO. 12099-212
CADFILE: 12099212 1.DWG

12099-213	1	2

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BSH	10/30/01
1	SEE DCN 1/0 THRU 3/0	BH	5/17/02
2	SEE DCN 1/1	BH	9/10/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.

3 OPTIONAL: SHELLS MAY BE OF ONE PIECE CONSTRUCTION, OR HAVE AN OPTIONAL CIRCUMFERENTIAL WELD. WHEN OPTIONAL CIRCUMFERENTIAL WELD IS USED, LONGITUDINAL WELDS SHALL BE STAGGERED MINIMUM 90° ±10°.

4 DIMENSIONS ARE FOR INFORMATION ONLY, ACTUAL DIMENSIONS ARE DICTATED BY DWG NO. 12099-210.

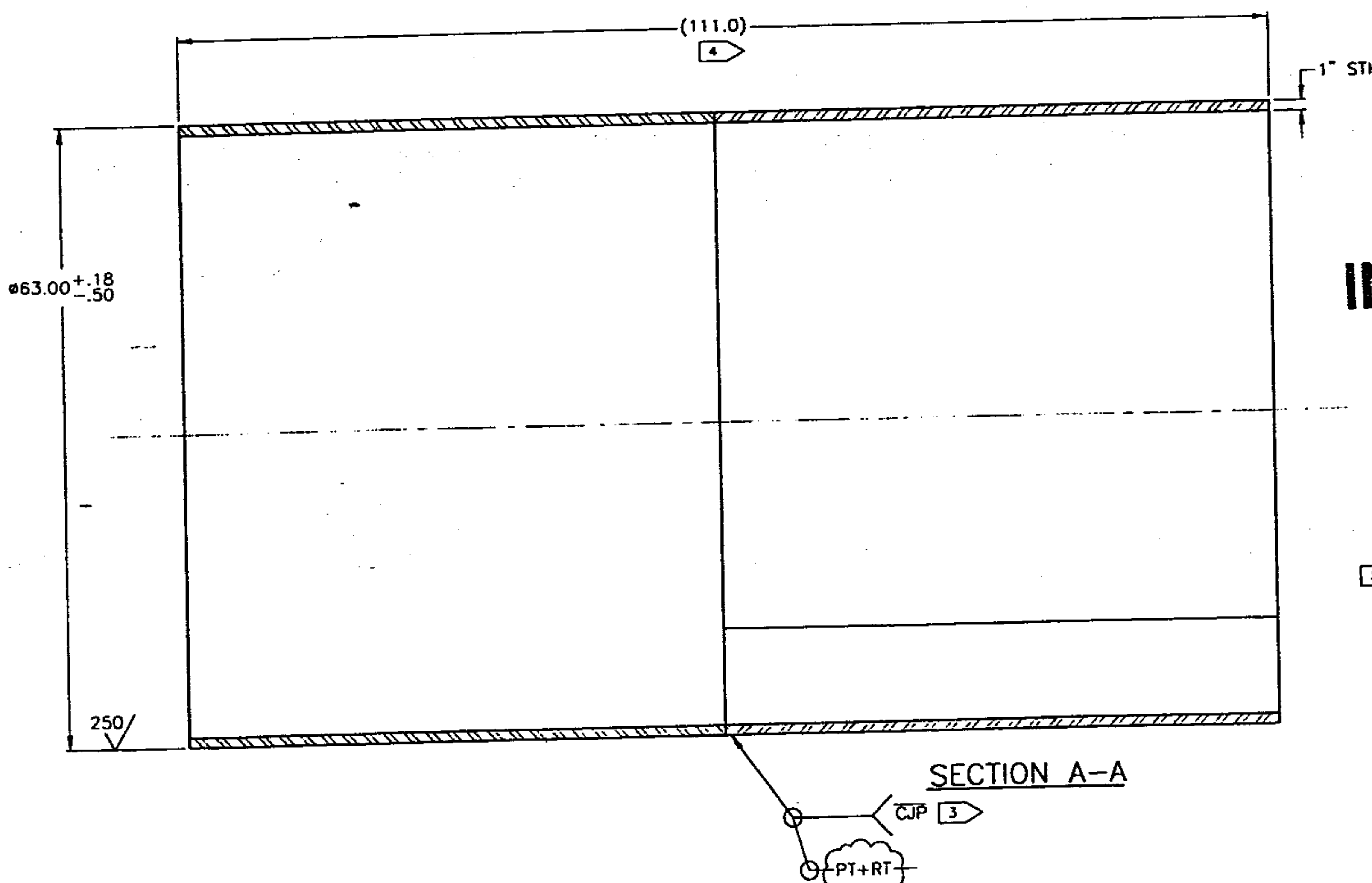
5 EXAMINATION AND REPAIR (IF REQUIRED) ON MATERIAL PROVIDED BY THE PLATE MANUFACTURER SHALL BE PERFORMED IN ACCORDANCE WITH ASME CODE, SECTION III, DIVISION 1, SUBSECTION-NB ARTICLE NB-2530.

AS-BUILT DRAWING

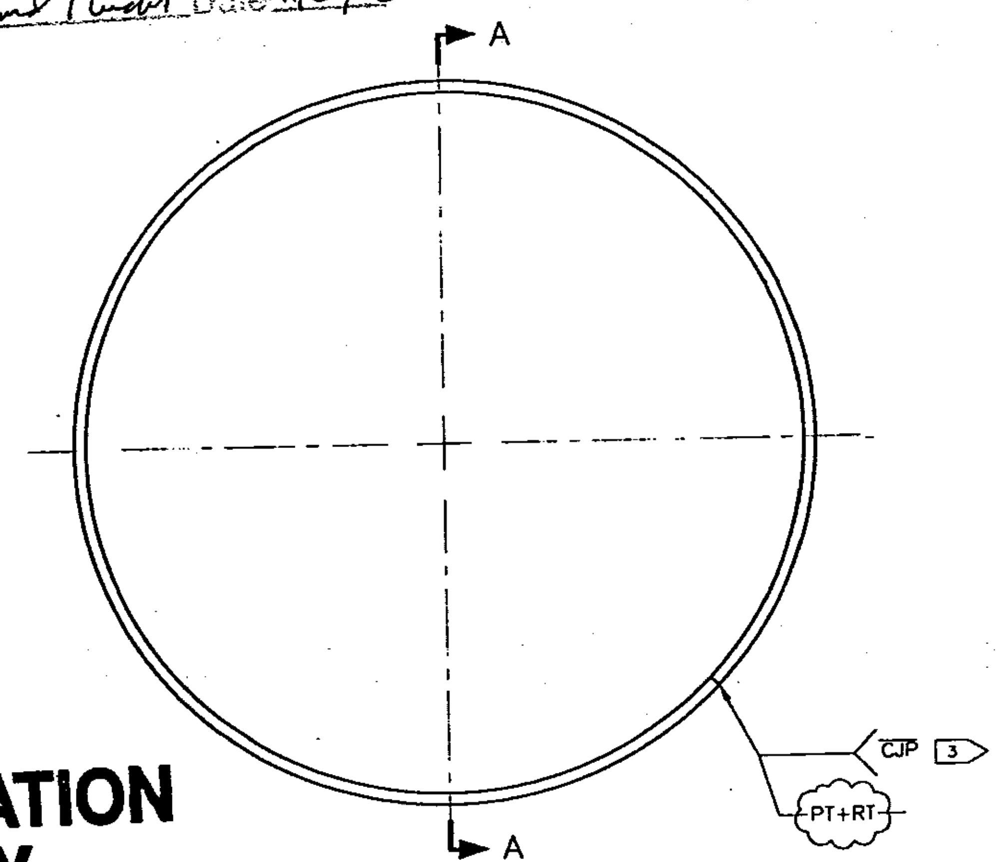
Dwg. No. 12099-213 Rev. 2

Serial No.(s) 01

Signature [signature] Date 11/26/02



SECTION A-A



DETAIL ITEM (1)

INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

5 A (QUAL. CAT.)	1 (ITEM)	PART NO.	PLATE, 1.0" THK, X 111.0 X 195.0	ASME SA-240, TYPE 304
			DESCRIPTION	
	ASSEMBLY & QUANTITY		LIST OF MATERIAL	

			REL	B. HARGIS	10/30/01
			APPD		
			APPD		
			APPD	K. BROWNELL	10/30/01
			ENGR	D. HILLSTROM	10/30/01
			QA	B. COUNTERMAN	10/30/01
1	1	12099-210	CHECK	F. STEINER	10/30/01
ITEM	QTY	NEXT ASSY	DRAWN	T. WAAGAN	10/25/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .030
2 PLACE DECIMALS ± .06
1 PLACE DECIMAL ± .2

Packaging Technology, Inc.
A Transnuclear Company

INNER SHELL
CASK
SLUDGE TRANSPORT

SCALE: 1/8 | WT. N/A
REV: 2 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-213
CADFILE: 1209921312.DWG

12099-214	1	2

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	10/30/01
1	SEE DCN 1/0 THRU 3/0	BH	5/17/02
2	SEE DCN 1/1 & 2/1	BH	9/10/02

AS-BUILT DRAWING
Dwg. No. 12099-214 Rev. 2
Serial No.(s) 01
Signature [signature] Date 11/26/02

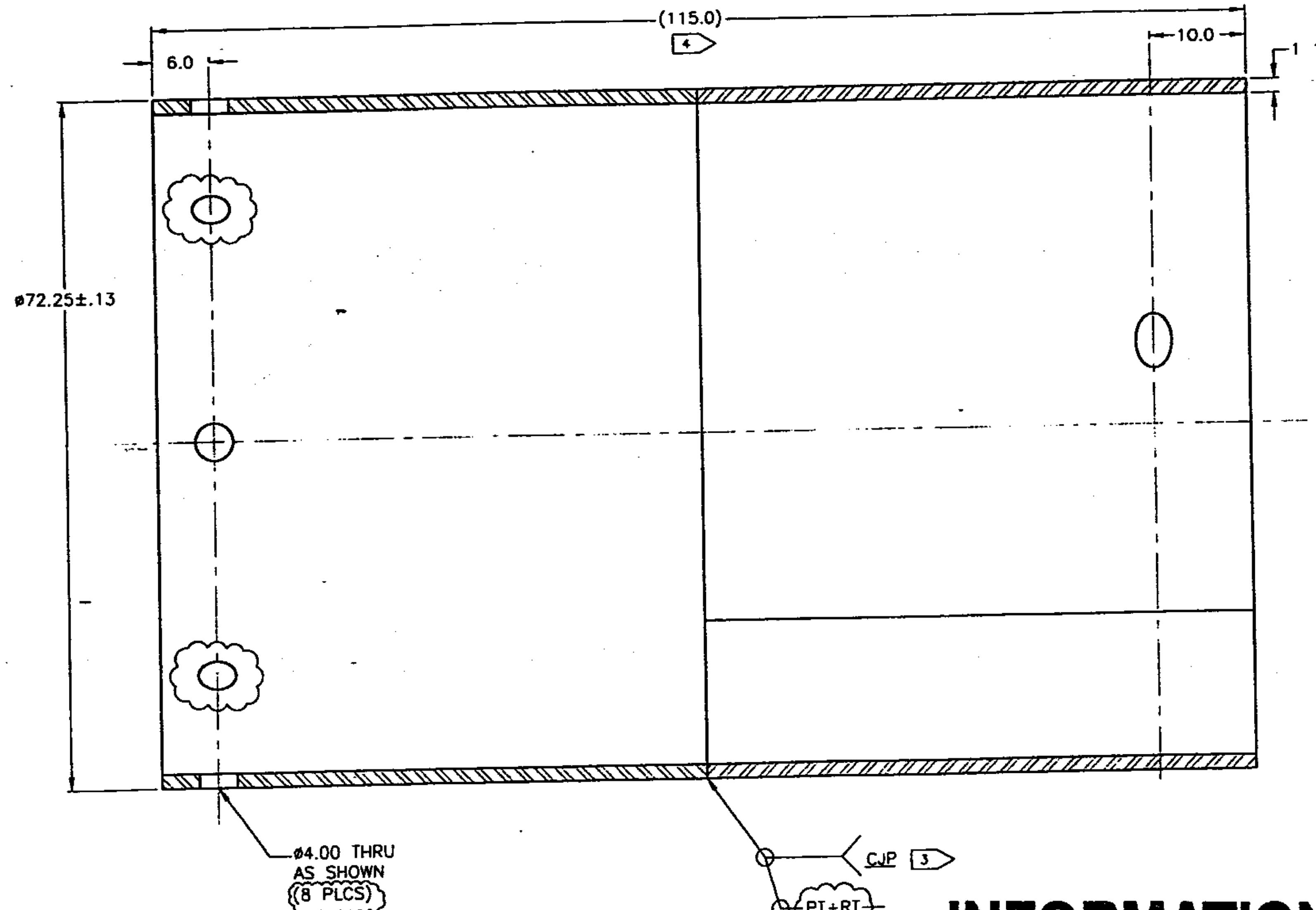
NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.

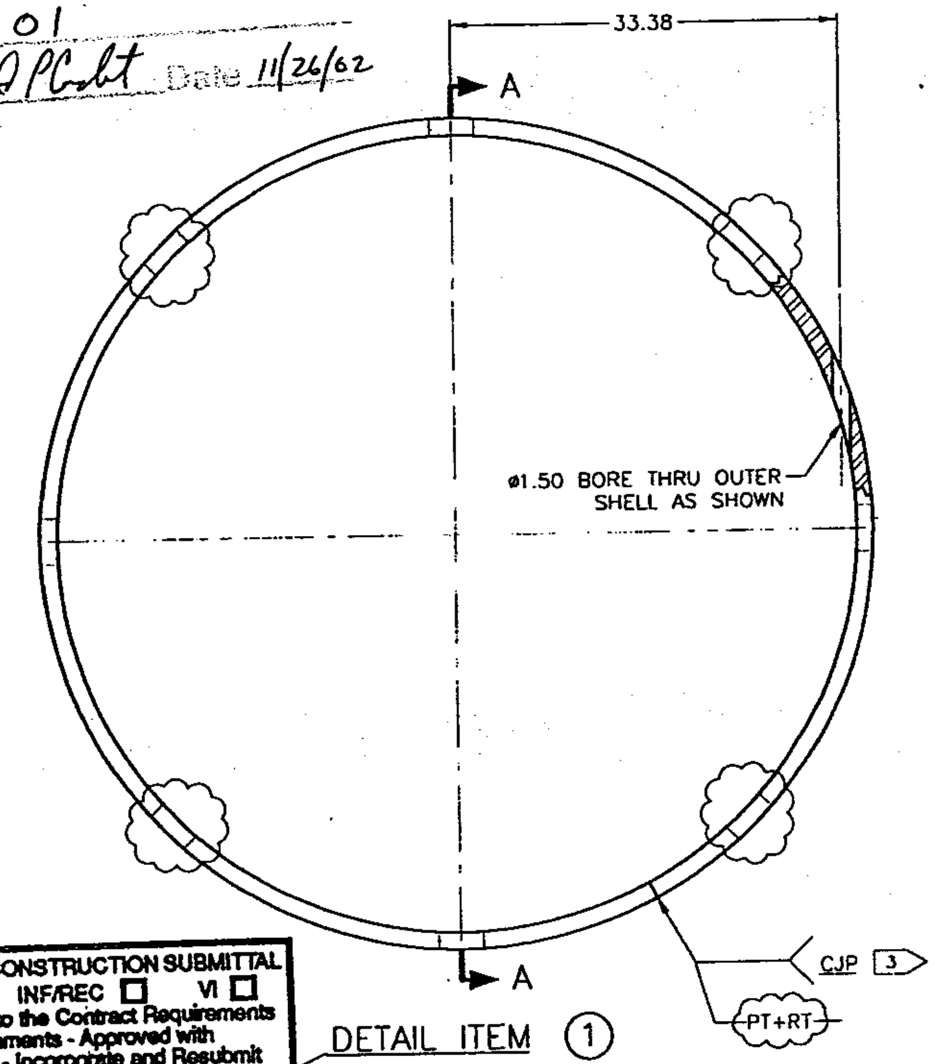
3 OPTIONAL: SHELLS MAY BE OF ONE PIECE CONSTRUCTION, OR HAVE AN OPTIONAL CIRCUMFERENTIAL WELD. WHEN OPTIONAL CIRCUMFERENTIAL WELD IS USED, LONGITUDINAL WELDS SHALL BE STAGGERED A MINIMUM OF 90°.

4 DIMENSIONS ARE FOR INFORMATION ONLY. ACTUAL DIMENSIONS ARE DICTATED BY DWG NO. 12099-210.

5 EXAMINATION (AND REPAIR IF REQUIRED) ON MATERIAL PROVIDED BY THE PLATE MANUFACTURER SHALL BE PERFORMED IN ACCORDANCE WITH ASME CODE, SECTION III, DIVISION 1, SUBSECTION NB, ARTICLE NB-2530.



SECTION A-A



DETAIL ITEM 1

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

5 QUAL CAT	ITEM	PART NO.	DESCRIPTION
A	1		PLATE, 1 1/2" THK, X 115.0 X 223.0 ASME SA-240, TYPE 304

ASSEMBLY & QUANTITY — LIST OF MATERIAL

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	10/30/01
			APPD		
			APPD		
			APPD	K. BROWNELL	10/30/01
			ENGR	D. HILLSTROM	10/30/01
			QA	B. COUNTERMAN	10/30/01
1	1	12099-210	CHECK	F. STEINER	10/30/01
			DRAWN	T. WAAGAN	10/25/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .030
2 PLACE DECIMALS ± .06
1 PLACE DECIMAL ± .2

Packaging Technology, Inc.
A Transnuclear Company

OUTER SHELL
CASK
SLUDGE TRANSPORT

SCALE: 1/8 | WT. N/A
REV: 2 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-214
CADFILE: 1209921412.DWG

INFORMATION ONLY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	6/24/02
1	SEE DCN 1/0 & 2/0	BH	9/11/02

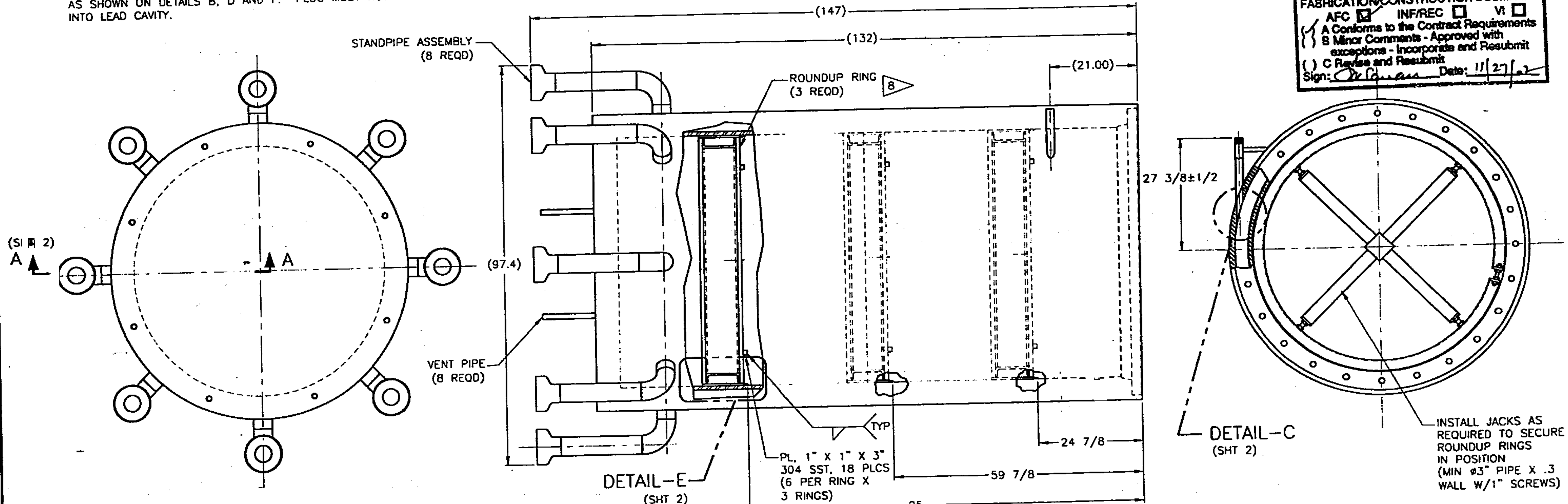
12099-215 1 1 — REVISION HISTORY

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. LEAD INSTALLATION SHALL BE IN ACCORDANCE WITH PACTEC PROCEDURE FP-035 OR APPROVED ALTERNATE.
3. GAMMA SCAN OF POURED LEAD SHIELDING INTEGRITY SHALL BE PERFORMED IN ACCORDANCE WITH PACTEC SPECIFICATION IP-008. OR APPROVED ALTERNATE.
4. CASK FABRICATOR'S QUALITY ASSURANCE PROGRAM SHALL FULLY DOCUMENT THE INTERIOR DIMENSIONS OF THE OUTER CASK INNER SHELL PRIOR TO AND FOLLOWING LEAD POUR PER PACTEC PROCEDURE FP-035 OR APPROVED ALTERNATE.
5. AFTER LEAD POUR, CASK FABRICATOR SHALL REMOVE PIPE, AND TRIM LEAD TO DEPTH SHOWN. GRIND EXTERNAL SURFACE OF PLUG TO CASK CONTOUR PRIOR TO INSTALLATION. INSTALL PLUGS AS SHOWN ON DETAILS B, D AND F. PLUG MUST NOT PROTRUDE INTO LEAD CAVITY.
6. ALL LEAD CAVITY PENETRATIONS SHALL BE SEALED PRIOR TO SHIPPING TO AND FROM LEAD POUR FACILITY TO PREVENT DIRT AND WATER FROM ENTERING LEAD CAVITY.
7. DUE TO SEQUENCE IN FABRICATION STEPS AS DEFINED BY THE CASK FABRICATOR, OUTER CASK CONFIGURATION MAY NOT BE EXACTLY AS SHOWN.
8. SUGGESTED CONFIGURATION OF ROUNDUP RING. IF ALTERNATE DESIGN IS USED, SUBMIT TO PACTEC ENGINEERING FOR REVIEW AND APPROVAL.
9. DIAMETRAL CLEARANCE TO BE MINIMIZED AND LIMITED TO .09" MAX BETWEEN PLUG AND HOLE.

AS-BUILT DRAWING
Dwg. No. 12099-215 Rev. 1
Serial No.(s) 01
Signature [signature] Date 11/26/02

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02



SLUDGE SHIPPING CASK W/LEAD POUR FIXTURING

INFORMATION ONLY

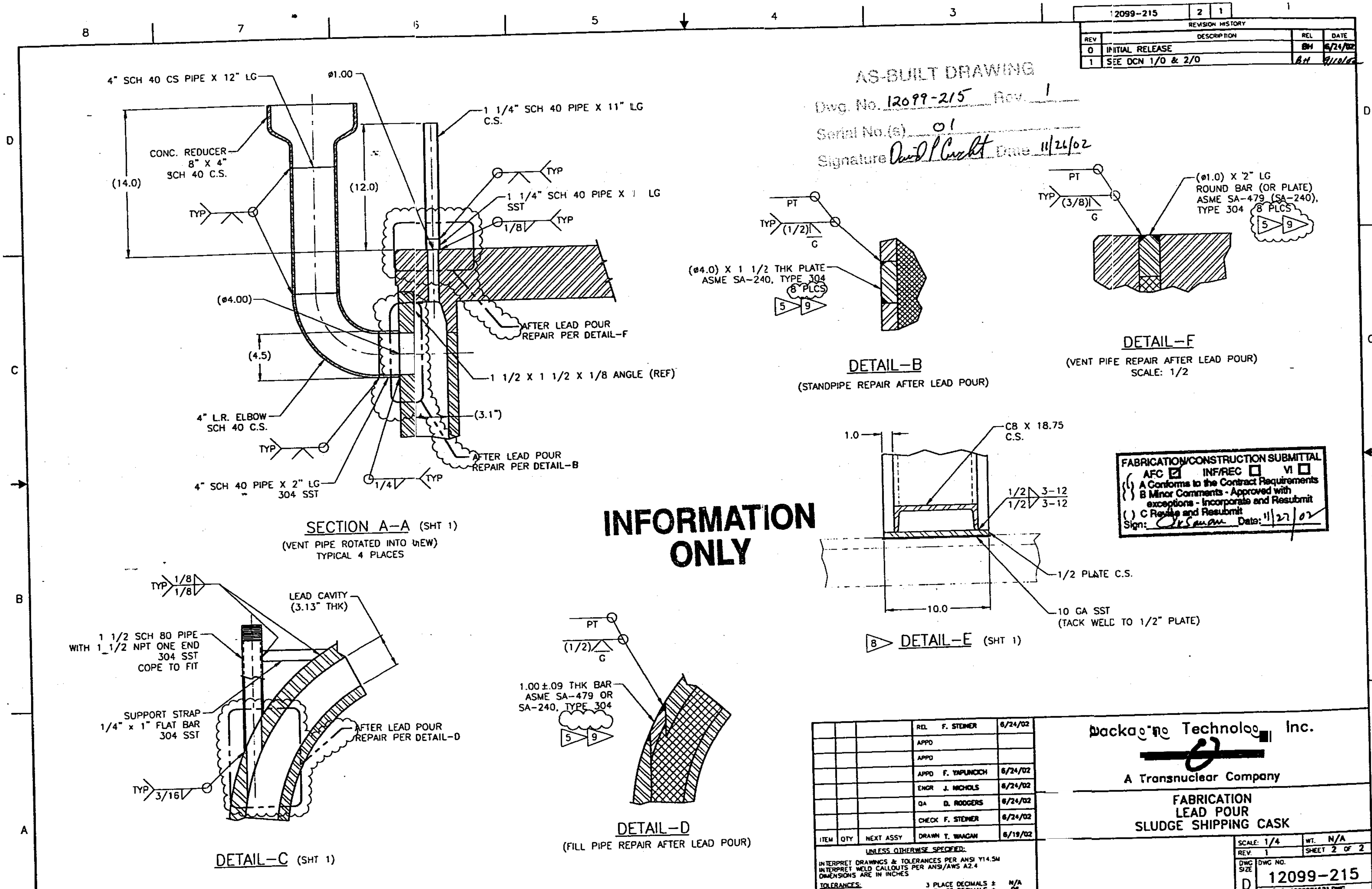
ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	6/24/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	6/24/02
			ENGR	J. NICHOLS	6/24/02
			QA	D. RODGERS	6/24/02
			CHECK	F. STEINER	6/24/02
			DRAWN	T.WAACAN	6/19/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ± 1/8, ANGLES ± 1°; 3 PLACE DECIMALS ± N/A, 2 PLACE DECIMALS ± .06, 1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

FABRICATION
LEAD POUR
SLUDGE SHIPPING CASK

SCALE: 1/12 | WT. N/A
REV: 1 | SHEET 1 OF 2
DWG SIZE D | DWG NO. 12099-215
CADFILE: 12099215I1.DWG

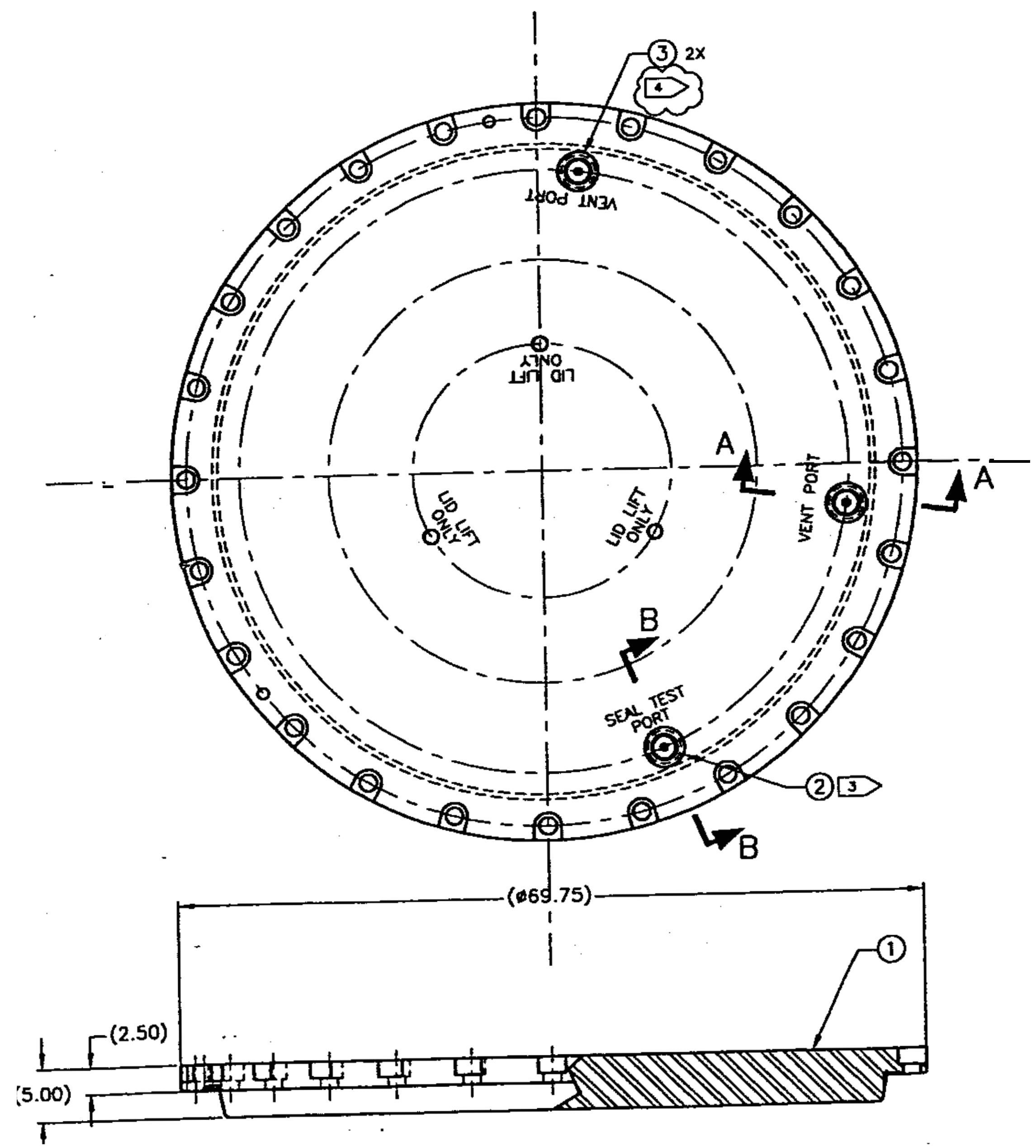

12099-215 2 1
REVISION HISTORY
REV DESCRIPTION REL DATE
0 INITIAL RELEASE BH 6/24/02
1 SEE DCN 1/0 & 2/0
AS-BUILT DRAWING
Dwg. No. 12099-215 Rev. 1
Serial No.(s) 01
Signature
Date 11/26/02
4" SCH 40 CS PIPE X 12" LG
ø1.00
1 1/4" SCH 40 PIPE X 11" LG C.S.
CONC. REDUCER 8" X 4" SCH 40 C.S.
(14.0)
(12.0)
TYP
1 1/4" SCH 40 PIPE X 1 LG SST
1/8
AFTER LEAD POUR REPAIR PER DETAIL-F
(ø4.00)
(4.5)
1 1/2 X 1 1/2 X 1/8 ANGLE (REF)
4" L.R. ELBOW SCH 40 C.S.
(3.1")
AFTER LEAD POUR REPAIR PER DETAIL-B
4" SCH 40 PIPE X 2" LG 304 SST
1/4
SECTION A-A (SHT 1)
(VENT PIPE ROTATED INTO VIEW) TYPICAL 4 PLACES
PT
(1/2)
G
(ø4.0) X 1 1/2 THK PLATE ASME SA-240, TYPE 304
8 PLCS
5
9
DETAIL-B
(STANDPIPE REPAIR AFTER LEAD POUR)
(3/8)
(ø1.0) X 2" LG ROUND BAR (OR PLATE) ASME SA-479 (SA-240), TYPE 304
DETAIL-F
(VENT PIPE REPAIR AFTER LEAD POUR) SCALE: 1/2
1.0
C8 X 18.75 C.S.
1/2 3-12
1/2 3-12
1/2 PLATE C.S.
10 GA SST (TACK WELD TO 1/2" PLATE)
10.0
8
DETAIL-E (SHT 1)
FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Sign: Date: 11/27/02
INFORMATION ONLY
1/8
LEAD CAVITY (3.13" THK)
1 1/2 SCH 80 PIPE WITH 1 1/2 NPT ONE END 304 SST COPE TO FIT
SUPPORT STRAP 1/4" x 1" FLAT BAR 304 SST
AFTER LEAD POUR REPAIR PER DETAIL-D
3/16
DETAIL-C (SHT 1)
1.00±.09 THK BAR ASME SA-479 OR SA-240, TYPE 304
DETAIL-D
(FILL PIPE REPAIR AFTER LEAD POUR)
REL F. STEINER 6/24/02
APPD
APPD
APPD F. YAPUNCICH 6/24/02
ENGR J. NICHOLS 6/24/02
QA D. RODGERS 6/24/02
CHECK F. STEINER 6/24/02
DRAWN T. WAAGAN 6/19/02
ITEM QTY NEXT ASSY
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ± 1/8 ANGLES ± 1°
3 PLACE DECIMALS ± N/A
2 PLACE DECIMALS ± .06
1 PLACE DECIMAL ± .1
Packaging Technology Inc.
A Transnuclear Company
FABRICATION
LEAD POUR
SLUDGE SHIPPING CASK
SCALE: 1/4 WT. N/A
REV. 1 SHEET 2 OF 2
DWG SIZE D DWG NO. 12099-215
CADFILE: 1209921521.DWG

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.

3. ORIENTATION OF SEAL TEST PORT TO LID IS NOT IMPORTANT. ORIENTATION SHOWN IS FOR GRAPHICAL PURPOSES ONLY.

4. ORIENT THE BOTTOM HOLE OF THE VENT PORT (ITEM 3) TO BE CLOSEST TO THE O.D. OF THE LID AS SHOWN.

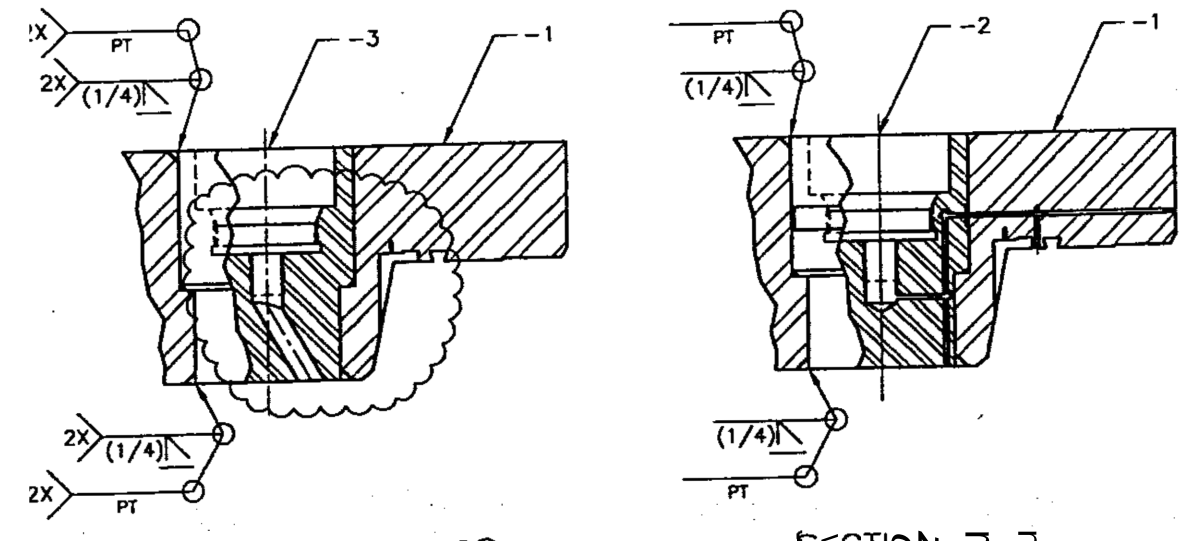


WELDMENT (A1)

12099-240 | 1 | 3

REVISION HISTORY			
REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	11/27/01
1	SEE DCN 1/0	BH	2/28/02
2	SEE DCN 1/1 & 2/1	BH	5/17/02
3	SEE DCN 1/2	BH	11/11/02

AS-BUILT DRAWING
Dwg. No. 12099-240 Rev. 3
Serial No.(s) 01
Signature [signature] Date 11/26/02



SECTION A-A (4)
2 PLACES
SCALE: 1/2

SECTION B-B
SCALE: 1/2

INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
( ) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

QUAL CAT.			ITEM	PART NO.	DESCRIPTION
	2		3	12099-243-1	VENT TEST PORT INSERT
	1		2	12099-242-1	SEAL TEST PORT INSERT
	1		1	12099-241-1	CASK LID
		X	A1		CASK LID WELDMENT
		A1	ITEM	PART NO.	DESCRIPTION
	ASSEMBLY & QUANTITY				LIST OF MATERIAL

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	11/27/01
			APPD		
			APPD		
			APPD	K. BROWNELL	11/28/01
			ENGR	J. NICHOLS	11/28/01
			QA	B. COUNTERMAN	11/28/01
A1	1	12099-200	CHECK	D. HILLSTROM	11/28/01
ITEM	QTY	NEXT ASSY	DRAWN	T. WAAGAN	11/20/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Tri Nuclear Company

LID WELDMENT
CASK
SLUDGE TRANSPORTATION

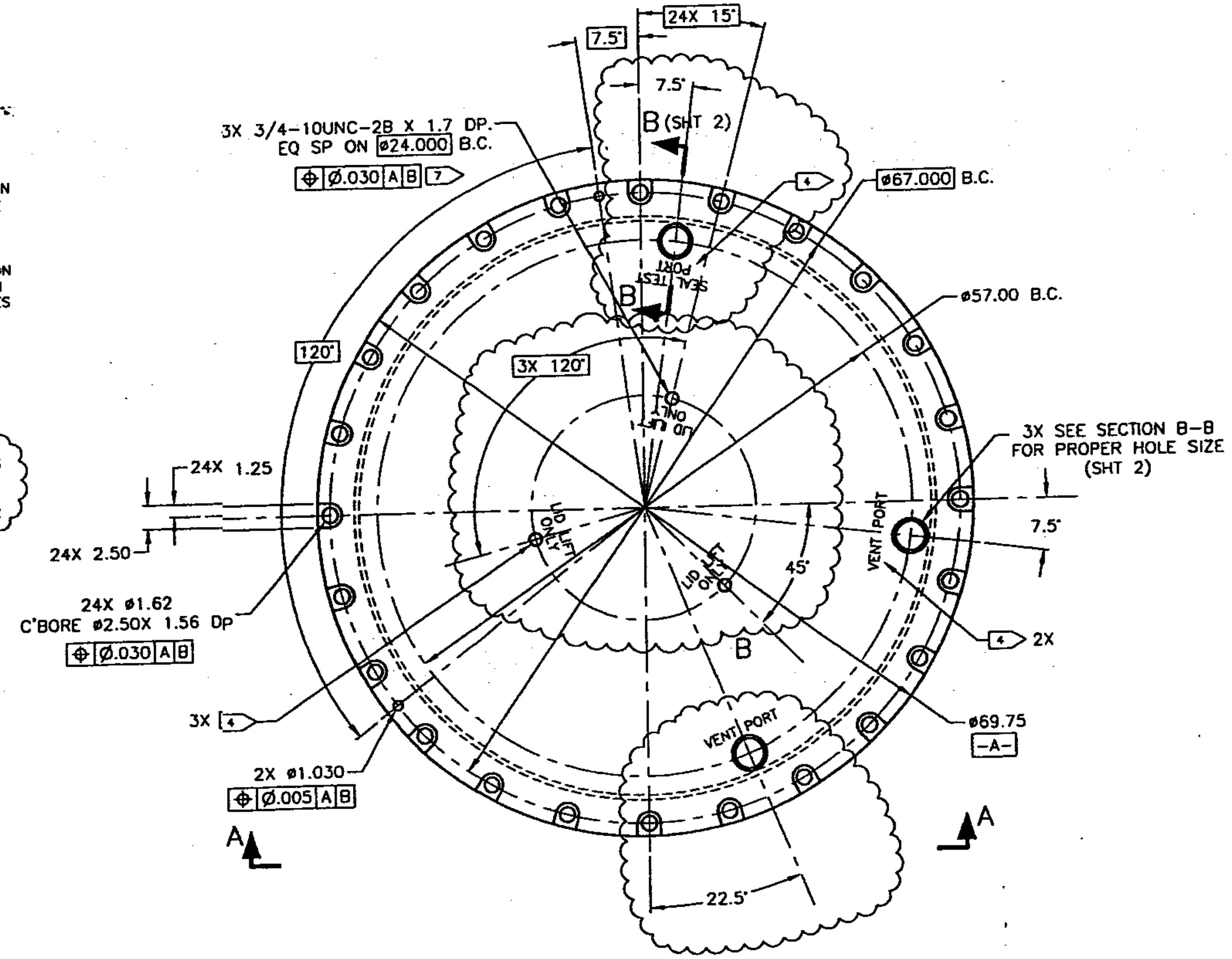
SCALE: 1/8 | WT. N/A
REV: 3 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-240
CADFILE: 1209924013.DWG

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	11/27/01
1	SEE DCN 1/0 THRU 3/0	BH	2/28/02
2	SEE DCN 1/1 THRU 4/1	TW	6/27/02
3	SEE DCN 1/2 THRU 5/2	BH	11/11/02

12099-241 | 1 | 3 REVISION HISTORY

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006
2. GEOMETRIC TOLERANCING IS TYPICAL FOR ALL THREE PLUG POSITIONS. ø.09 HOLES ARE FOR SEAL TEST PORT ONLY (SECTION B-B). THE OTHER TWO PLUG POSITIONS WILL NOT HAVE THESE HOLES.
3. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
4. USE LOW STRESS IMPRESSION STAMP OR ENGRAVE IDENTIFICATION TITLE AS SHOWN USING 1" HIGH CHARACTERS, CENTERED ABOVE EACH PORT AND TAPPED HOLES. LOCATE APPROXIMATELY AS SHOWN.
5. EXAMINATION (AND REPAIRS, IF REQUIRED) TO BE PERFORMED ON FORGING IN ACCORDANCE WITH ASME CODE SECTION III DIVISION 1, SUBSECTION NB, ARTICLE NB-2540, AND SECTION V, ARTICLES 2 AND 5.
6. PROVIDE WELD PREPARATION AS NECESSARY FOR WELD CALLED OUT ON DWG # 12099-240.
7. DELETED
8. ~~THREADS PER ANSI/ASME B1.1~~
9. VIBROETCH OR EQUIVALENT 1/2" HIGH MIN. NUMBERS 1-24 AS SHOWN ON TOP SURFACE OF CASK LID.
10. VIBROETCH OR EQUIVALENT 1/2" HIGH MIN. NUMBERS 1 AND 2 AS SHOWN FOR VENT PORTS ON TOP SURFACE OF CASK LID.

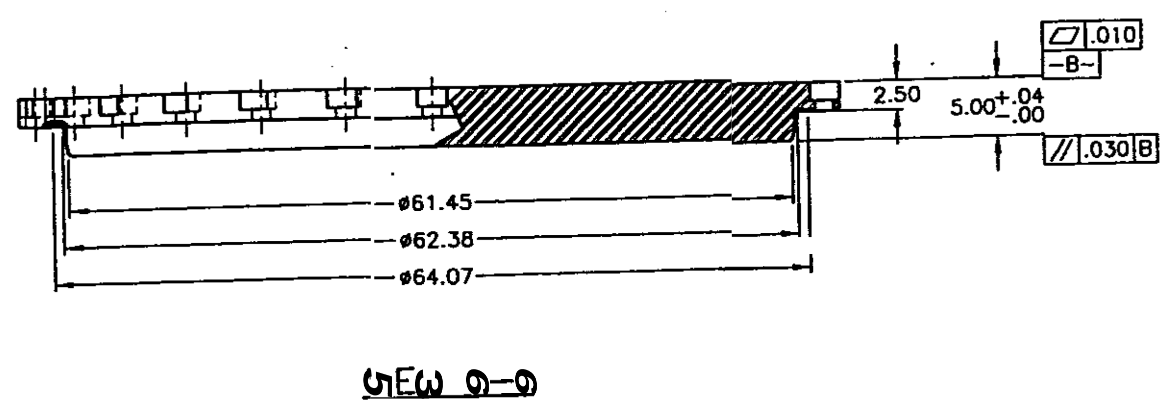


INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-241 Rev. 3
Serial No.(s) 01
Signature [signature] Date 11/26/02

DETAIL ITEM ①



SECTION A-A

QUAL. CAT.	ITEM	PART NO.	DESCRIPTION	
A	1		FORGING, ø69.8 X 5.1 THK	ASME SA182, TYPE F304

LIST OF MATERIAL — 5

ITEM	QTY	NEXT ASSY		
1	1	12099-240		
			REL B. HARGIS	11/27/01
			APPD	
			APPD	
			APPD K. BROWNELL	11/26/01
			ENGR J. NICHOLS	11/26/01
			QA B. COUNTERMAN	11/26/01
			CHECK M. RICHARDS	11/26/01
			DRAWN T. WAAGAN	11/8/01

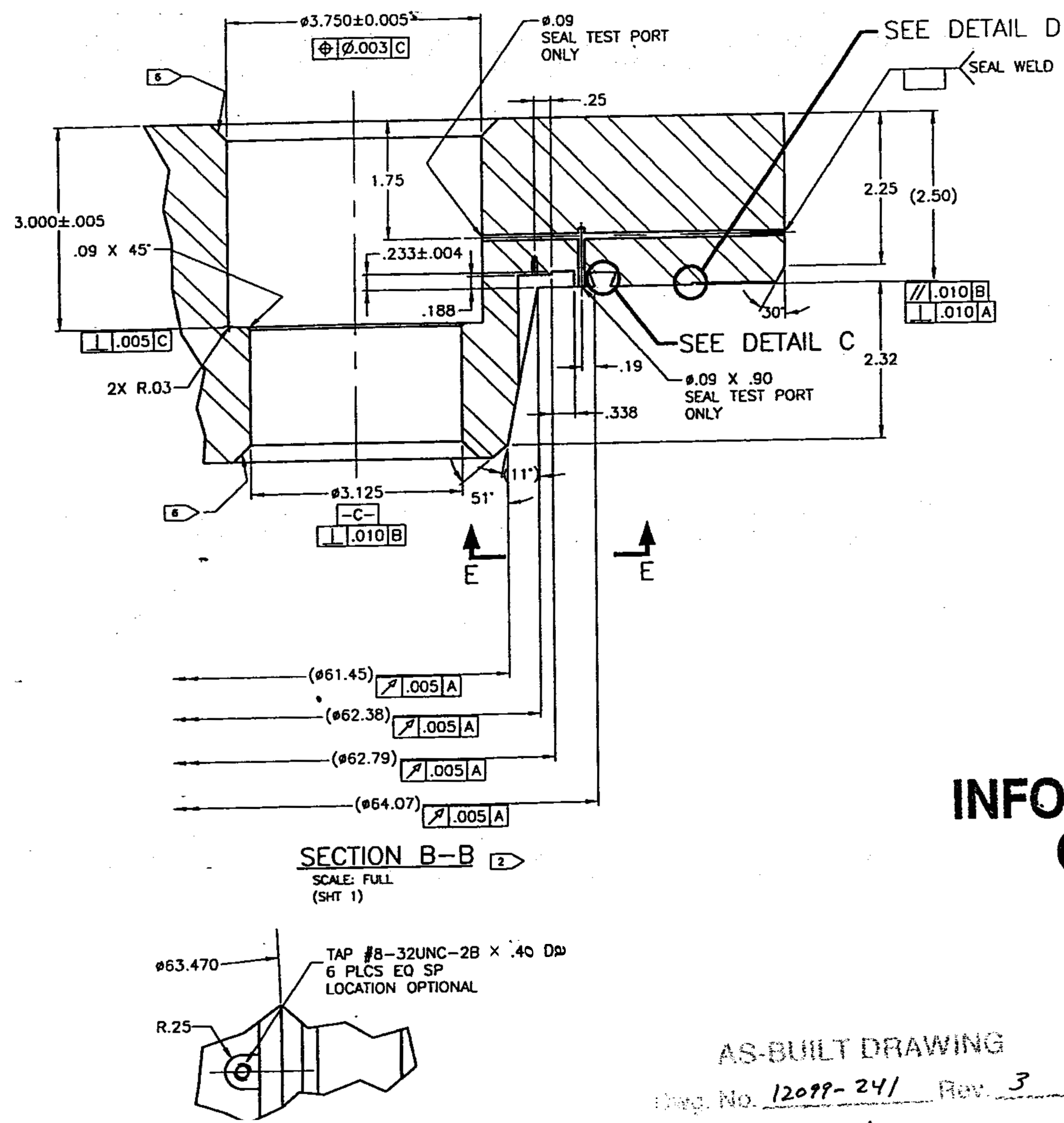
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ± 1/8, ANGLES ± 1°
3 PLACE DECIMALS ± .010, 2 PLACE DECIMALS ± .03, 1 PLACE DECIMAL ± .1

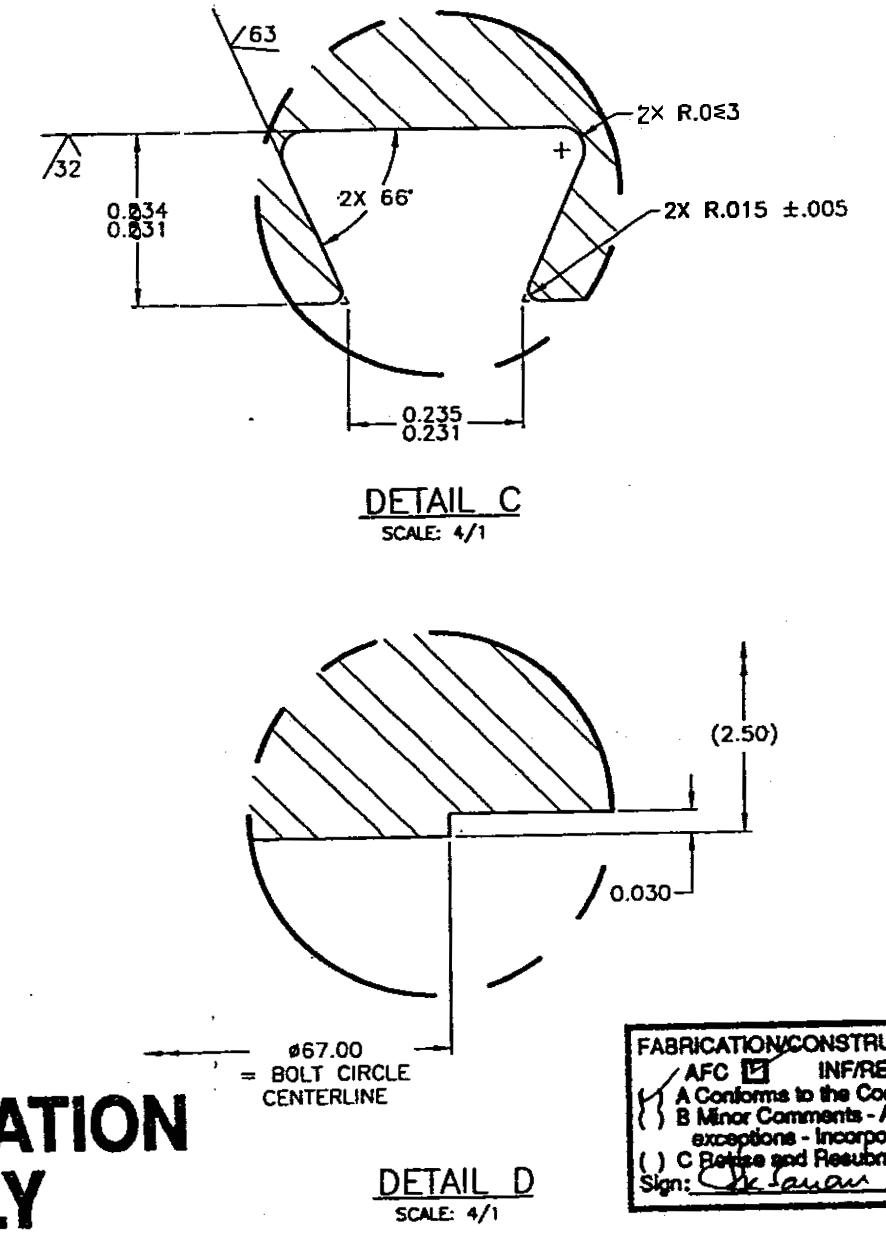
Pacific Technology, Inc.
Transnuclear Company

LID FORGING
CASK
SLUDGE TRANSPORTATION

SCALE: 1/8	WT. 4800 lbs
REV: 3	SHEET 1 OF 2
DWG SIZE D	DWG NO. 12099-241
	CADFILE: 1209924113.DWG

12099-241	2	3		
REVISION HISTORY				
REV	DESCRIPTION		REL	DATE
0	INITIAL RELEASE		BH	11/27/01
1	SEE DCN 1/0 THRU 3/0		BH	2/28/02
2	SEE DCN 1/1 THRU 4/1		TW	6/27/02
3	SEE DCN 1/2 THRU 5/2		BH	11/4/02





INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
( ) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: Dx Sanan Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-241 Rev. 3
Serial No.(s) 61
Signature [signature] Date 11/26/02

ITEM	QTY	NEXT ASSY		
			REL B. HARGIS	11/27/01
			APPD	
			APPD	
			APPD K. BROWNELL	11/28/01
			ENGR J. NICHOLS	11/28/01
			QA B. COUNTERMAN	11/28/01
			CHECK M. RICHARDS	11/28/01
			DRAWN T. WAGAN	11/7/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

LID FORGING
CASK
SLUDGE TRANSPORTATION

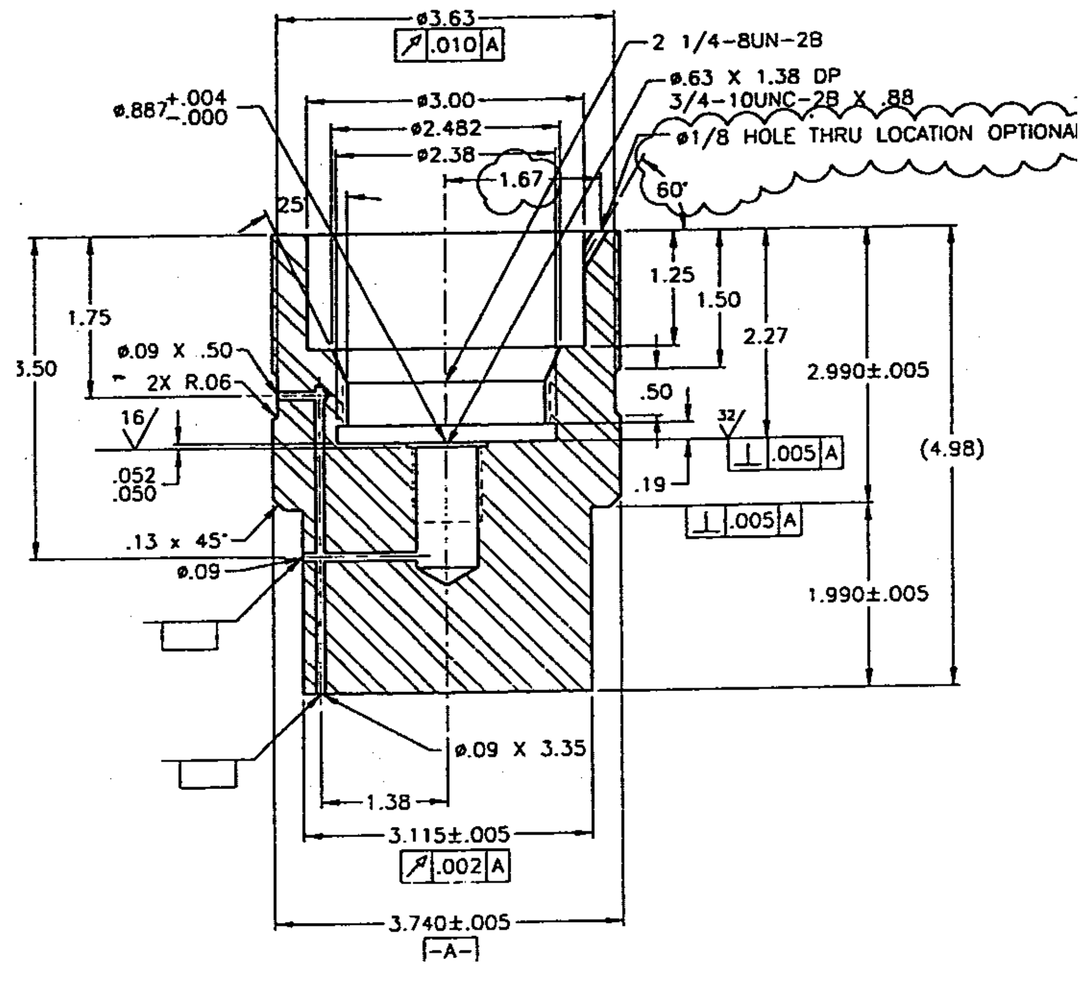
SCALE: 1/2	WT. N/A
REV: 3	SHEET 2 OF 2
DWG SIZE D	DWG NO. 12099-241
	CADFILE: 1209924123.DWG

12099-242 | 1 | 3

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	11/27/01
1	SEE DCN 1/0	BH	2/28/02
2	SEE DCN 1/1 & 2/1	BH	5/17/02
3	SEE DCN 1/2	BH	9/10/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. ALL MACHINED SURFACES, UNLESS OTHERWISE SPECIFIED, SHALL HAVE A MAXIMUM SURFACE FINISH OF 63 RMS PER ANSI B46.1.
4. THREADS PER ANSI/ASME B1.1.



DETAIL ITEM (1)

INFORMATION ONLY

COPY

DESIGN REVIEW SUBMITTAL
30% ☐ 60% ☐ 90% ☐ DRFT ☑
(X) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: Alva E. Brodie Date: 9-13-2002

QUAL CAT.	ITEM	PART NO.	DESCRIPTION	
A	1		RND BAR, ø4.0 X 5.0	ASME SA-479, TYPE 304
	ASSEMBLY & QUANTITY		LIST OF MATERIAL	

ITEM	QTY	NEXT ASSY			
1	1	12099-240	CHECK	M.RICHARDS	11/26/01
			DRAWN	T. WAKCAN	10/17/01
			REL	B. HARGIS	11/27/01
			APPD		
			APPD		
			APPD	K. BROWNELL	11/26/01
			ENGR	J. NICHOLS	11/26/01
			QA	B. COUNTERMAN	11/26/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8 — 3 PLACE DECIMALS ± .010
ANGLES ± 1° — 2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc
A Transnuclear Company

SEAL TEST
PORT INSERT
SLUDGE TRANSPORTATION SYSTEM

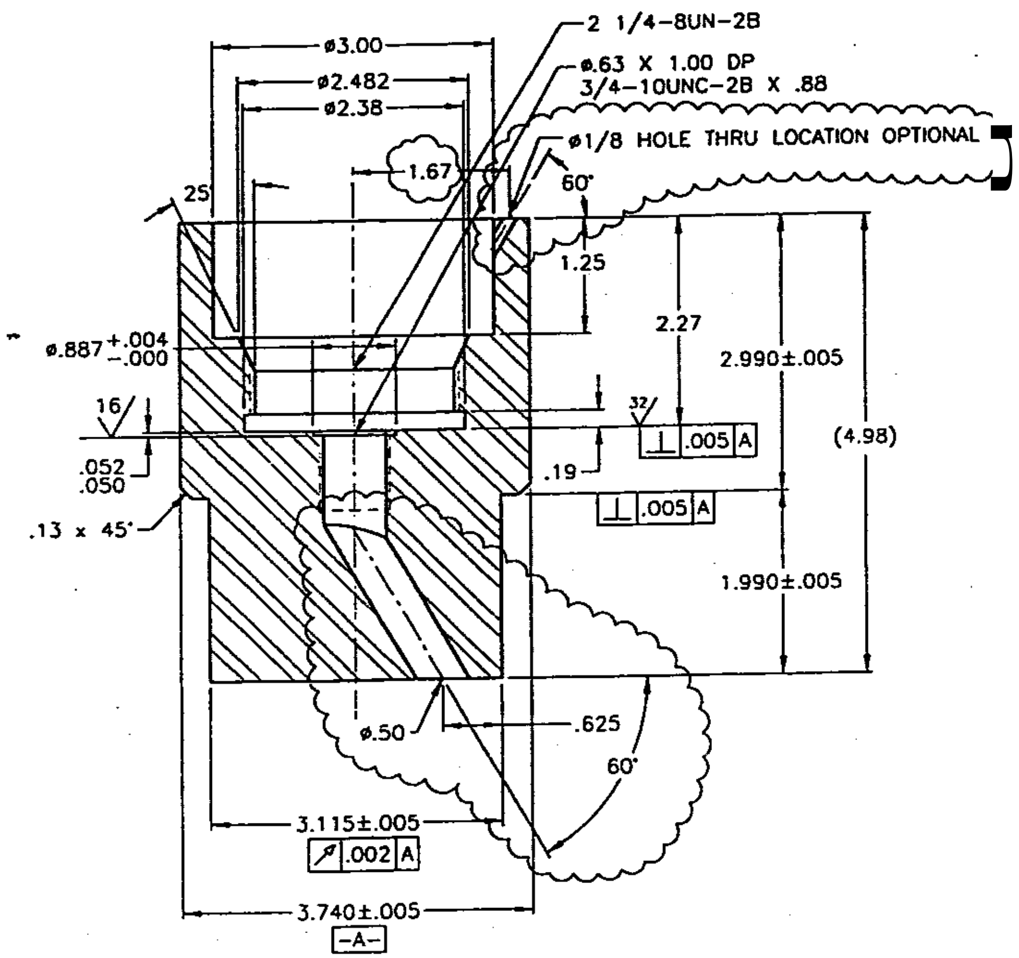
SCALE: FULL | WT. N/A
REV: 3 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-242
CADFILE: 12099242I3.DWG

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	10/30/01
1	SEE DCN 1/0	BH	2/28/02
2	SEE DCN 1/1 & 2/1	BH	5/17/02
3	SEE DCN 1/2	BH	9/10/02

REVISION HISTORY — 12099-243, 1 of 3

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. ALL MACHINED SURFACES, UNLESS OTHERWISE SPECIFIED, SHALL HAVE A MAXIMUM SURFACE FINISH OF 63 RMS PER ANSI B46.1.



DETAIL ITEM ①

INFORMATION ONLY

DESIGN REVIEW SUBMITTAL
30% ☐ 60% ☐ 90% ☐ DRFT ☐
(X) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Review and Resubmit
Sign: [signature] Date: 9-13-2002

COPY

QUAL CAT.						ITEM	PART NO.	DESCRIPTION
A						1		RND BAR, ø4.0 X 5.0 — ASME SA-479, TYPE 304
							ASSEMBLY & QUANTITY	LIST OF MATERIAL

ITEM	QTY	NEXT ASSY		
			REL	
			APPD	
			APPD	
			APPD	
			ENGR	
			QA	
1	2	12099-240	CHECK	
			DRAWN T. WAAGAN	10/17/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

VENT PORT
PORT INSERT
SLUDGE TRANSPORTATION SYSTEM

SCALE: FULL | WT. N/A
REV. 3 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-243
CADFILE: 12099243I3.DWG

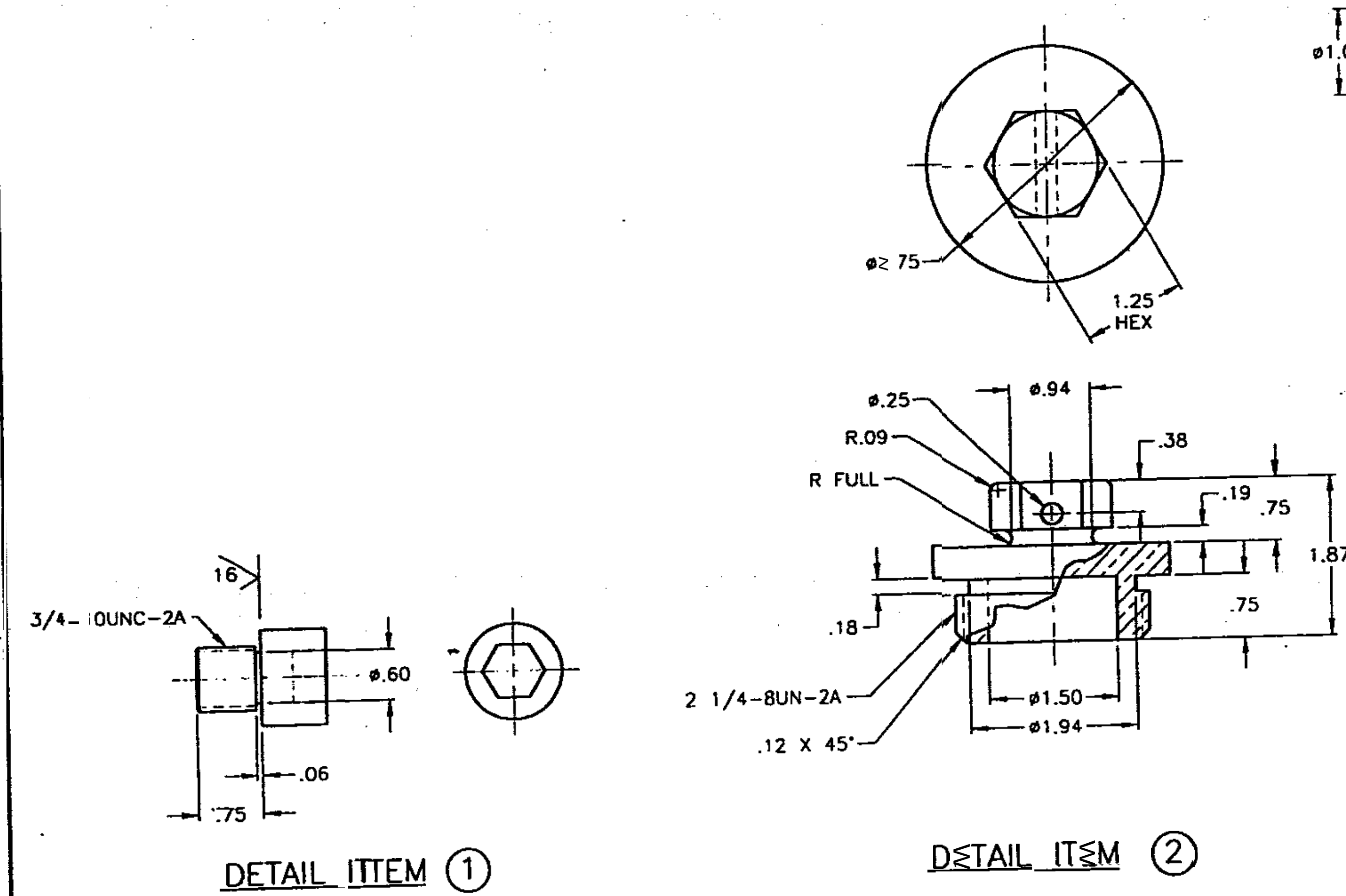
12099-270	1	3

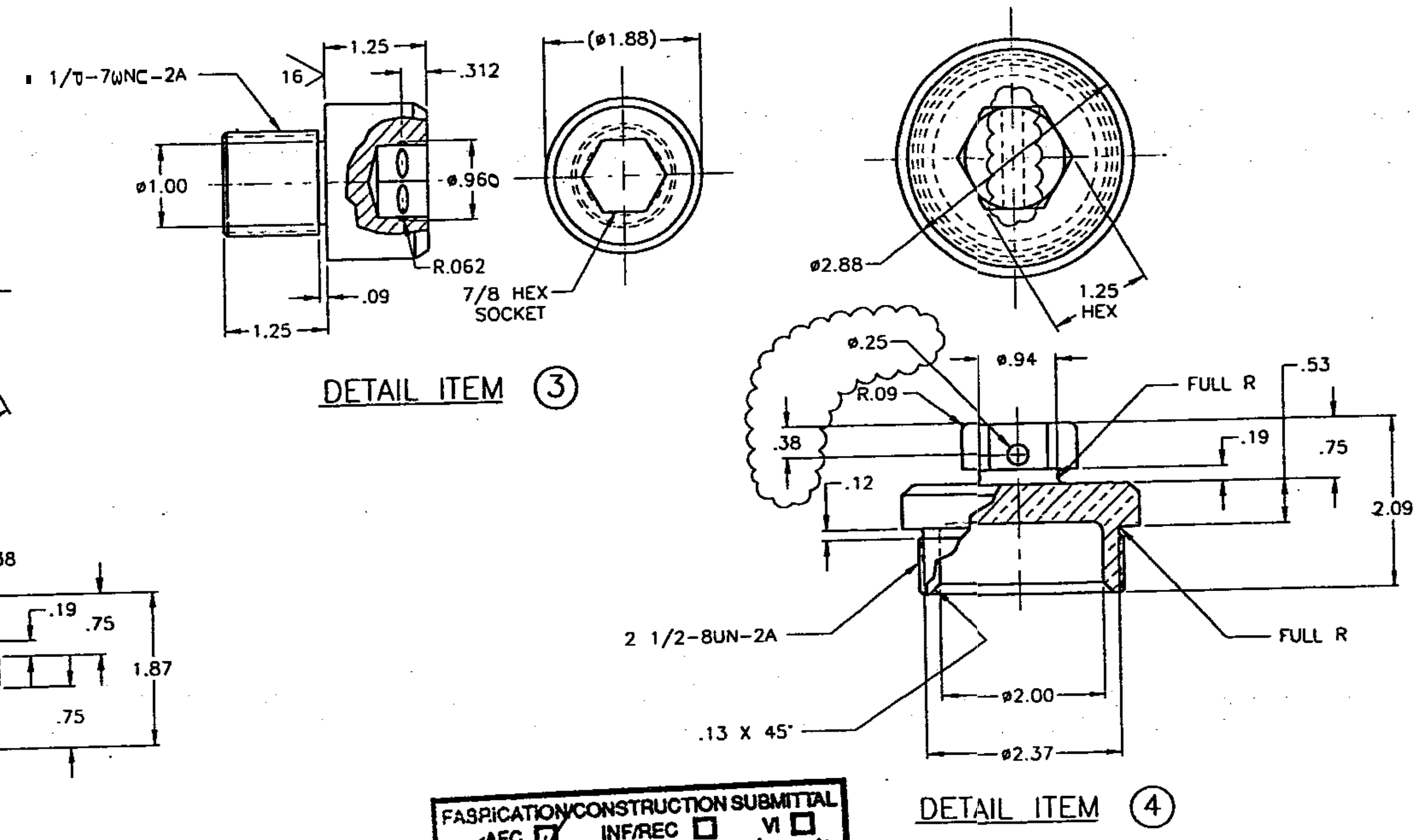
REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	12/18/01
1	SEE DCN 3/0	BH	2/28/02
2	SEE DCN 1/1 TO 5/1	TW	6/27/02
3	SEE DCN 1/2	BH	9/10/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. BOLT HEAD DIMENSIONS FOR ITEM 3 ARE PER ANSI B18.3.





FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

LIST OF MATERIAL

QUAL CAT						ITEM	PART NO.	DESCRIPTION
C						4		BAR, RD, ø3 X 2.1 — ASTM B16, TYPE C360
A						3		SCH CAP SCR, 1 1/4-7UNC X 1.25 — ASME SA320, GRADE L43
C						2		BAR, RD, ø3 X 1.9 — ASTM B16, TYPE C360
A						1		SCH CAP SCR, 3/4-10UNC X 3/4 — ASME SA320, GRADE L43

ASSEMBLY & QUANTITY

ITEM	QTY	NEXT ASSY
2	3	12099-200
1	3	12099-200

REL	B. HARGIS	12/18/01
APPD		
APPD		
APPD	K. BROWNELL	12/14/01
ENGR	J. NICHOLS	12/13/01
QA	B. COUNTERMAN	12/14/01
CHECK	F. STEINER	12/13/01
DRAWN	T. WAAGAN	10/17/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology Inc.
A Transnuclear Company

BOLT & COVER
PORT CLOSURE
SLUDGE TRANSPORTATION SYSTEM

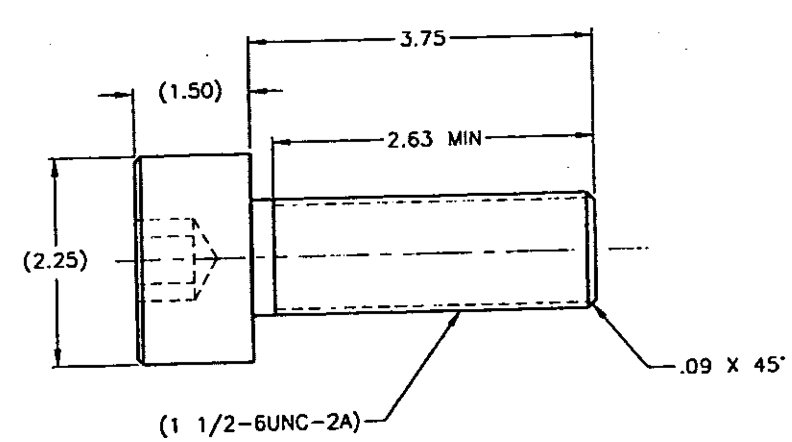
SCALE: FULL | WT. N/A
REV. 3 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-270
CADFILE: 12099270I3.DWG

INFORMATION ONLY

AS-BUILT DRAWING
Dwg. No. 12099-270 Rev. 3
Field Rev(s) 01
Signature [signature] Date 11/26/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. THREADS PER ANSI/ASME B1.1.
4. BOLT DIMENSIONS PER ANSI/ASME B18.3



D L ITEM (5)

INFORMATION ONLY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	12/14/01
1	SEE DCN 1/0 THRU 3/0	BH	2/28/02
2	SEE DCN 1/1 & 2/1	BH	5/17/02

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Sign: Duncan Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-271 Rev. 2
Serial No (s) 01
Signature [signature] Date 11/26/02

ITEM	QTY	NEXT ASSY			ITEM	DESCRIPTION
1	24	12099-200			1	SCH CAP SCR, 1 1/2-6UNC X 4" LG ASME SA-564, 630 (H1100)

REL	B. HARGIS	12/14/01
APPD		
APPD		
APPD	K. BROWNELL	12/14/01
ENGR	J. NICHOLS	12/13/01
QA	B. COUNTERMAN	12/14/01
CHECK	F. STEINER	12/13/01
DRAWN	T. WAAGAN	10/17/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ± 1/8, ANGLES ± 1°; 3 PLACE DECIMALS ± .010, 2 PLACE DECIMALS ± .03, 1 PLACE DECIMAL ± .1

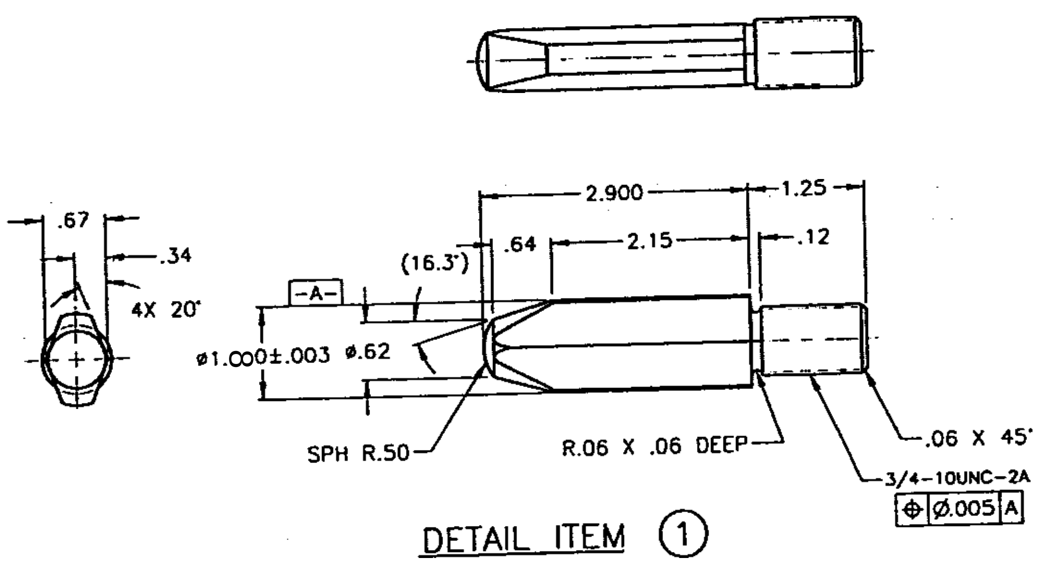
Packaging Technology, Inc.
A Transnuclear Company

LID CLOSURE BOLT
CASK
SLUDGE TRANSPORTATION SYSTEM

SCALE: FULL | WT. N/A | REV: 2 | SHEET 1 OF 1 | DWG SIZE D | DWG NO. 12099-271 | CADFILE: 1209927112.DWG

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO DETERMINE ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. THREADS PER ANSI/ASME B1.1.



DETAIL ITEM (1)

REVISION HISTORY — 12099-272 | 1 | 2

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	12/18/01
1	SEE DCN 1/0	BH	2/28/02
2	SEE DCN 1/1	BH	5/17/02

FABRICATION/CONSTRUCTION SUBMITTAL
✓AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 5/27/02

INFORMATION ONLY

AS-BUILT DRAWING
Dwg. No. 12099-272 Rev. 2
Serial No.(s) 01
Signature [signature] Date 11/26/02

QUAL. CAT.						ITEM	PART NO.	DESCRIPTION	
C						1		BAR, RND, ø1.0 X 4.3	ASTM A276, TYPE 304

ASSEMBLY & QUANTITY — LIST OF MATERIAL

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	12/18/01
			APPD		
			APPD		
			APPD	K. BROWNELL	12/14/01
			ENGR	J. NICHOLS	12/13/01
			DA	B. COUNTERMAN	12/14/01
1	2	12099-200	CHECK	F. STEINER	12/13/01
			DRAWN	T. WAAGAN	10/17/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

LID ALIGNMENT PIN
CASK
SLUDGE TRANSPORTATION SYSTEM

SCALE: FULL | WT. N/A | REV: 2 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-272
CADFILE: 12099272I2.DWG

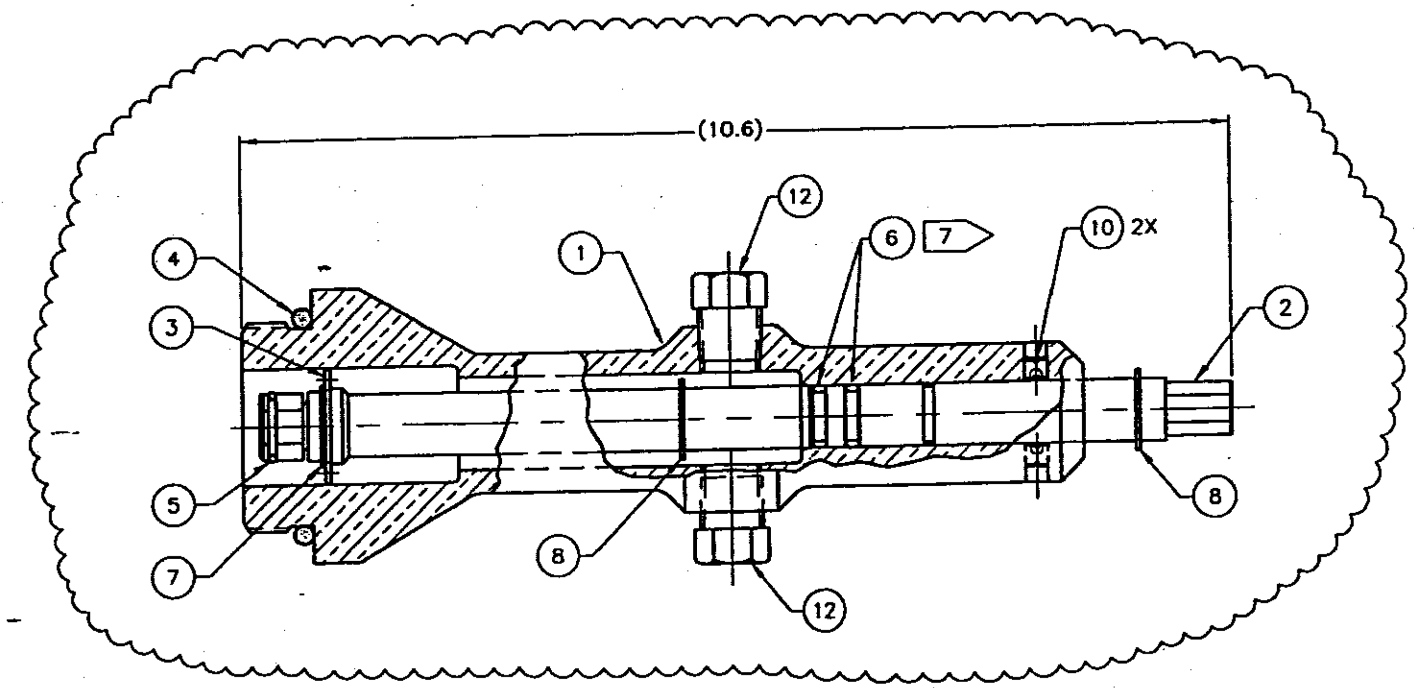
12099-273	1	1

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	4/16/02
1	SEE DCN 1/0 THRU 7/0	BH	11/15/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-006.
2. THREADS PER ANSI/ASME B.11.
3. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. MANUFACTURER SHALL CONFIRM ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
4. ELECTROLESS NICKEL PLATE TO A THICKNESS OF .0005-.0010 IN ACCORDANCE WITH MIL-C-26074 (LATEST REV), CLASS I, GRADE B. AFTER MACHINING.
5. REMOVED
6. EQUIVALENT COMPONENTS AND/OR SOURCES OF SUPPLY MAY BE SUBSTITUTED UPON APPROVAL OF PACTEC ENGINEERING.
7. LUBRICATE O-RING SEALS (ITEM 6) WITH DOW CORNING HIGH VACUUM GREASE OR EQUIVALENT.
8. IMPRESSION STAMP OR ENGRAVE THE DRAWING NUMBER AND A TWO DIGIT NUMERIC SERIAL NUMBER. CONTACT PACTEC TO CONFIRM SERIAL NUMBER TO BE PLACED PRIOR TO PLACEMENT.



ASSEMBLY A1

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

INFORMATION ONLY

AS-BUILT DRAWING
Dwg. No. 12099-273 Rev. 1
Serial No (s) 01
Signature [signature] Date 11/26/02

ITEM	QTY	NEXT ASSY	QTY	ITEM	PART NO.	DESCRIPTION	MATERIAL
			2	12		HEX HD PLUG, (1/2 NPT)	SST
				11		REMOVED	
			2	10	W-16N	BALL PLUNGER, 1/4-20UNC	REID
				9		REMOVED	
			2	8	5108-68-H	RETAINING RING, INVERTED EXT SERIES	WALDES TRUARC
			1	7	5103-75	RETAINING RING, CRESCENT	WALDES TRUARC
			2	6	#2-112	O-RING, .487 I.D. X ø.103 ±.003, BUNA-N	PARKER OR EQUIVALENT
			1	5	#2-014	O-RING, .489 I.D. X ø.070, BUNA-N	PARKER OR EQUIVALENT
			1	4	#2-330	O-RING, 2.100 I.D. X ø.210 ±.005, BUNA-N	PARKER OR EQUIVALENT
			1	3		SHT, .06 THK X 1.3 DIA	ASTM B21, 464 OR 482 ALLOY BRASS, 1/2 HARD TEMPER
			1	2		RD BAR, ø.88 X 10.4	ASTM A193, GRADE B7 OR ASTM A322, GRADE 4140
			1	1		RD BAR, ø3.0 X 9.1	ASTM B21, 464 OR 482 ALLOY BRASS, 1/2 HARD TEMPER
			X	A1		VENT/TEST TOOL ASSEMBLY	
			A1	ITEM	PART NO.	DESCRIPTION	
			ASSEMBLY & QUANTITY			LIST OF MATERIAL	

REL	B. HARGIS	4/16/02
APPD		
APPD		
APPD	K. BROWNELL	4/16/02
ENGR	J. NICHOLS	4/16/02
QA	B. COUNTERMAN	4/16/02
CHECK	F. STEINER	4/16/02
DRAWN	R. VAN LE	02/01/02

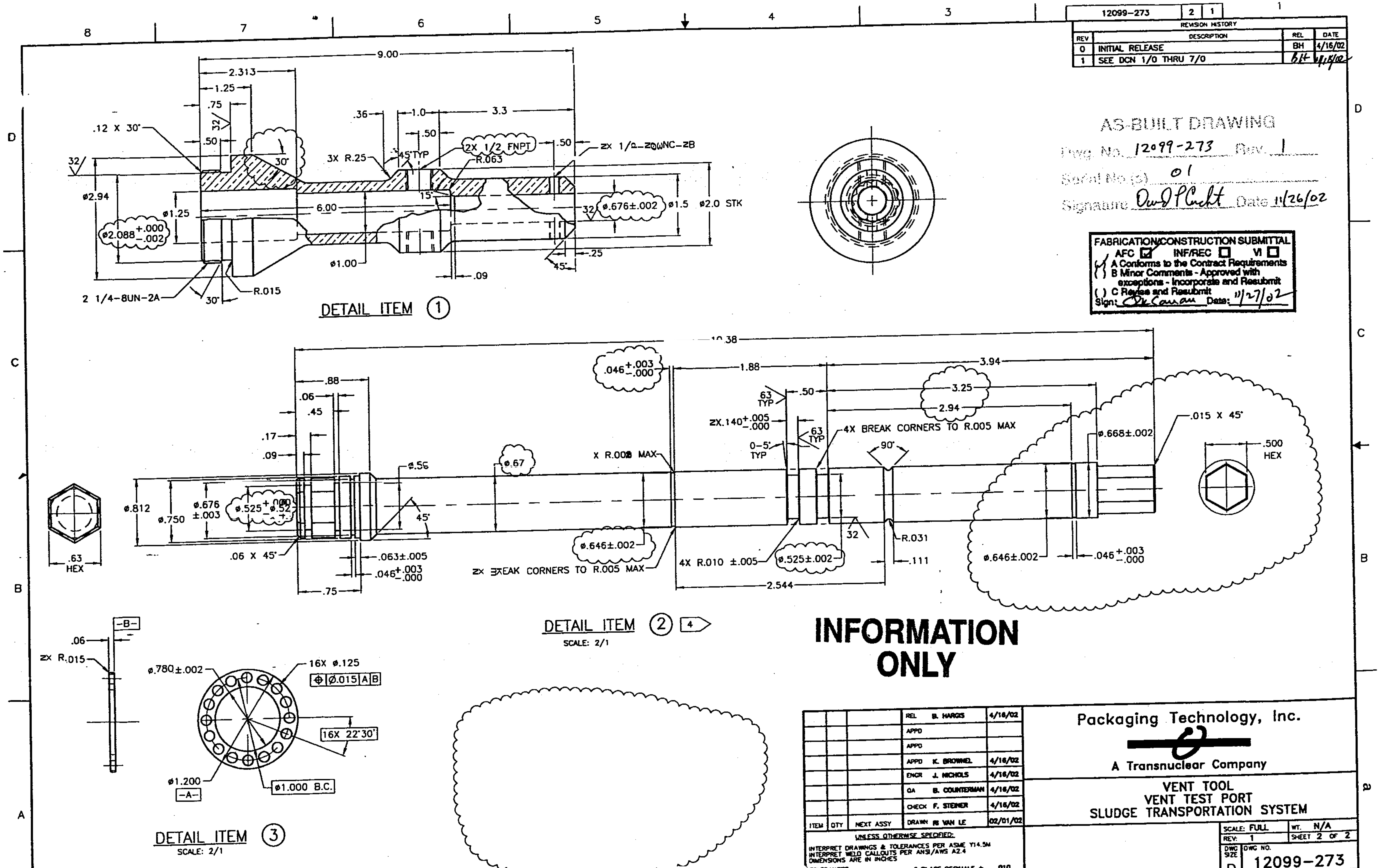
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8 — 3 PLACE DECIMALS ± .010
ANGLES ± 1° — 2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

VENT TOOL
VENT TEST PORT
SLUDGE TRANSPORTATION SYSTEM

SCALE: FULL | WT. N/A | REV: 1 | SHEET 1 OF 2
DWG SIZE D | DWG NO. 12099-273
CADFILE: 1209927311.DWG

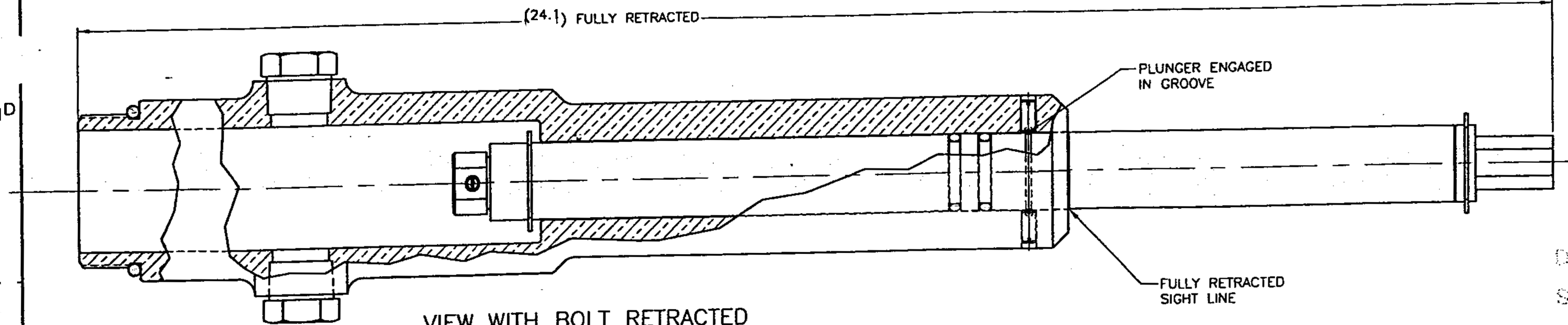

12099-273 2 1
REVISION HISTORY
REV | DESCRIPTION | REL | DATE
0 | INITIAL RELEASE | BH | 4/16/02
1 | SEE DCN 1/0 THRU 7/0
AS-BUILT DRAWING
Dwg No. 12099-273 Rev. 1
Serial No.(s) 01
Signature Date 11/26/02
FABRICATION/CONSTRUCTION SUBMITTAL
AFC INF/REC VI
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Sign: Date: 11/27/02
DETAIL ITEM 1
DETAIL ITEM 2
SCALE: 2/1
DETAIL ITEM 3
SCALE: 2/1
INFORMATION ONLY
2 1/4-8UN-2A
2X 1/2 FNPT
3X R.25
4X BREAK CORNERS TO R.005 MAX
2X BREAK CORNERS TO R.005 MAX
4X R.010 ±.005
16X ø.125
16X 22°30'
ø1.000 B.C.
ø.780±.002
ø1.200
.63 HEX
.500 HEX
ø2.0 STK
REL B. HARGIS 4/16/02
APPD
APPD
APPD K. BROWNEL 4/16/02
ENGR J. NICHOLS 4/16/02
QA B. COUNTERMAN 4/16/02
CHECK F. STEINER 4/16/02
DRAWN R. VAN LE 02/01/02
ITEM QTY NEXT ASSY
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ± 1/8 ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1
Packaging Technology, Inc.
A Transnuclear Company
VENT TOOL
VENT TEST PORT
SLUDGE TRANSPORTATION SYSTEM
SCALE: FULL
WT. N/A
REV: 1
SHEET 2 OF 2
DWG SIZE D
DWG NO. 12099-273
CADFILE: 12099273Z1.DWG

12099-274 | 1 | 1

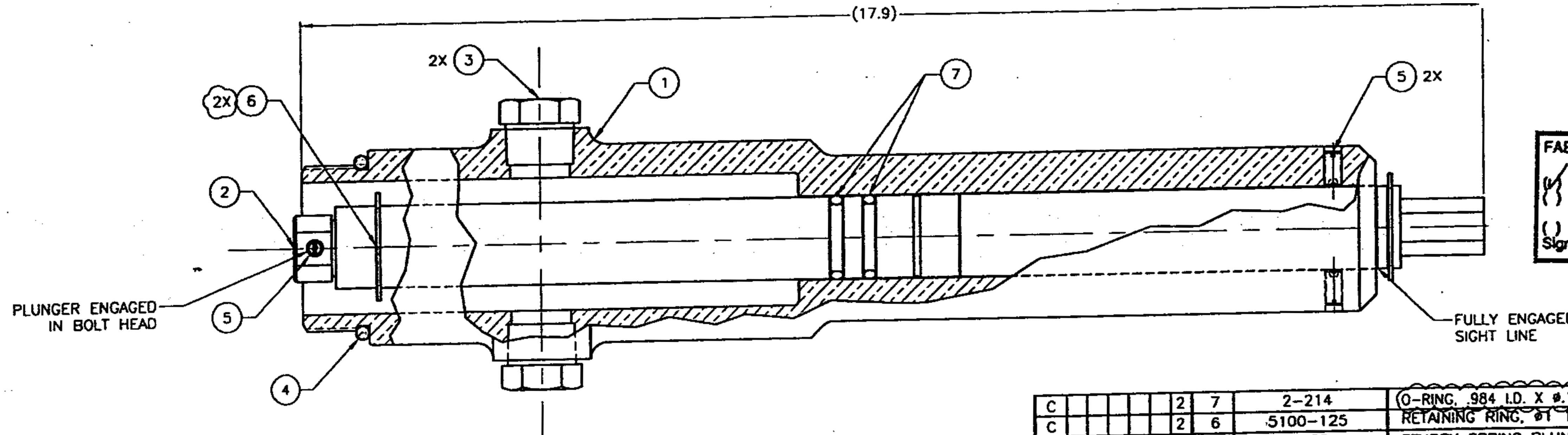
REVISION HISTORY			
REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	6/13/02
1	SEE DCN 1/0 THRU 6/0	BH	11/18/02

AS-BUILT DRAWING
Dwg. No. 12099-274 Rev. 1
Serial No.(s) 01
Signature [signature] Date 11/26/02

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02



VIEW WITH BOLT RETRACTED



ASSEMBLY (A1)
FULLY ENGAGED

NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-001
2. THREADS PER ANSI/ASME B.1.1.
3. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. MANUFACTURER SHALL CONFIRM ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
4. SIGHT LINES ARE TO BE .015 WIDE AND .010 DEEP. LOCATION AS SHOWN.
5. ELECTROLESS NICKEL PLATE TO A THICKNESS OF .0005-.0010 IN ACCORDANCE WITH MIL-C-26074 (LATEST REV.) CLASS I, GRADE B AFTER MACHINING.
6. IMPRESSION STAMP OR ENGRAVE THE DRAWING NUMBER AND A TWO DIGIT NUMERIC SERIAL NUMBER. CONTACT PACTEC TO CONFIRM SERIAL NUMBER TO BE PLACED PRIOR TO PLACEMENT.

INFORMATION ONLY

Q/C						A1	ITEM	PART NO.	DESCRIPTION	
C						2	7	2-214	O-RING, .984 I.D. X ø.139±.005, BUNA-N	PARKER OR EQUIVALENT
C						2	6	5100-125	RETAINING RING, ø1 1/4	WALDES OR EQUIV
C						3	5	K-3S	STUBBY SPRING PLUNGER, 1/4-20UNC	REID
C						1	4	2-332	O-RING, 2.350 I.D. X ø.210 ±.005, BUNA-N	PARKER OR EQUIVALENT
C						2	3		HEX HD PLUG, 3/4 NPT	SST
C						1	2		RD BAR, ø1.3 X 18.00	ASTM A193, GRADE B7
C						1	1		RD BAR, ø3.5 X 16.3	ASTM B21, 464 OR 482 ALLOY BRASS, 1/2 HARD TEMPER
					X		A1		DRAIN PORT TOOL ASSEMBLY	
						ASSEMBLY & QUANTITY			LIST OF MATERIAL	

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	6/13/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	6/5/02
			ENGR	J. NICHOLS	6/5/02
			QA	B. COUNTERMAN	6/5/02
			CHECK	F. STEINER	6/5/02
			DRAWN	T. WAKAN	5/24/02

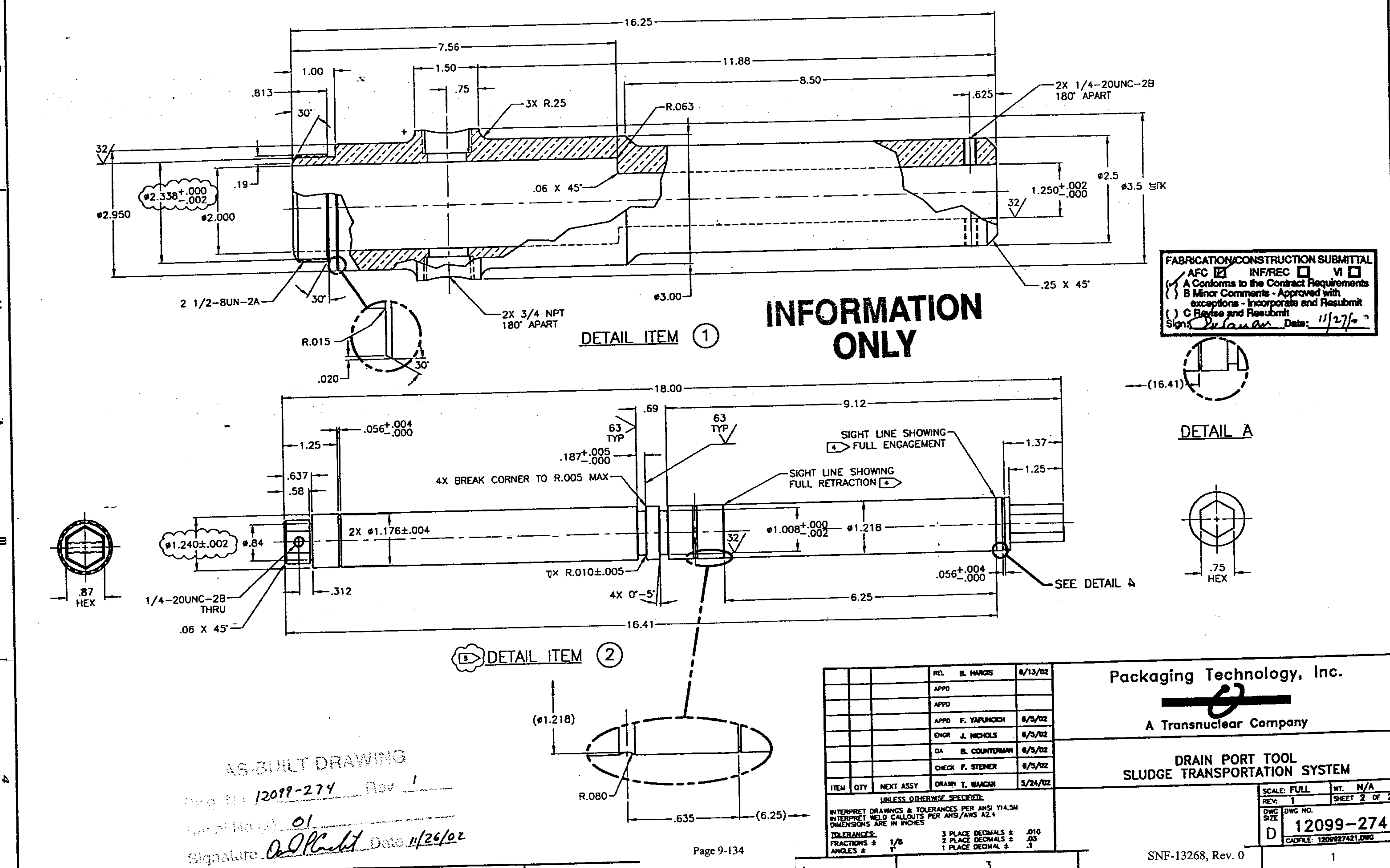
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

DRAIN PORT TOOL
SLUDGE TRANSPORTATION SYSTEM

SCALE: NONE | WT. N/A
REV: 1 | SHEET 1 OF 2
DWG SIZE: D | DWG NO. 12099-274
CADFILE: 1209927411.DWG

SF-03268, Rev. 0



ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	6/13/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	6/5/02
			ENGR	J. NICHOLS	6/5/02
			QA	B. COUNTERMAN	6/5/02
			CHECK	F. STEINER	6/5/02
			DRAWN	T. WAGAN	5/24/02

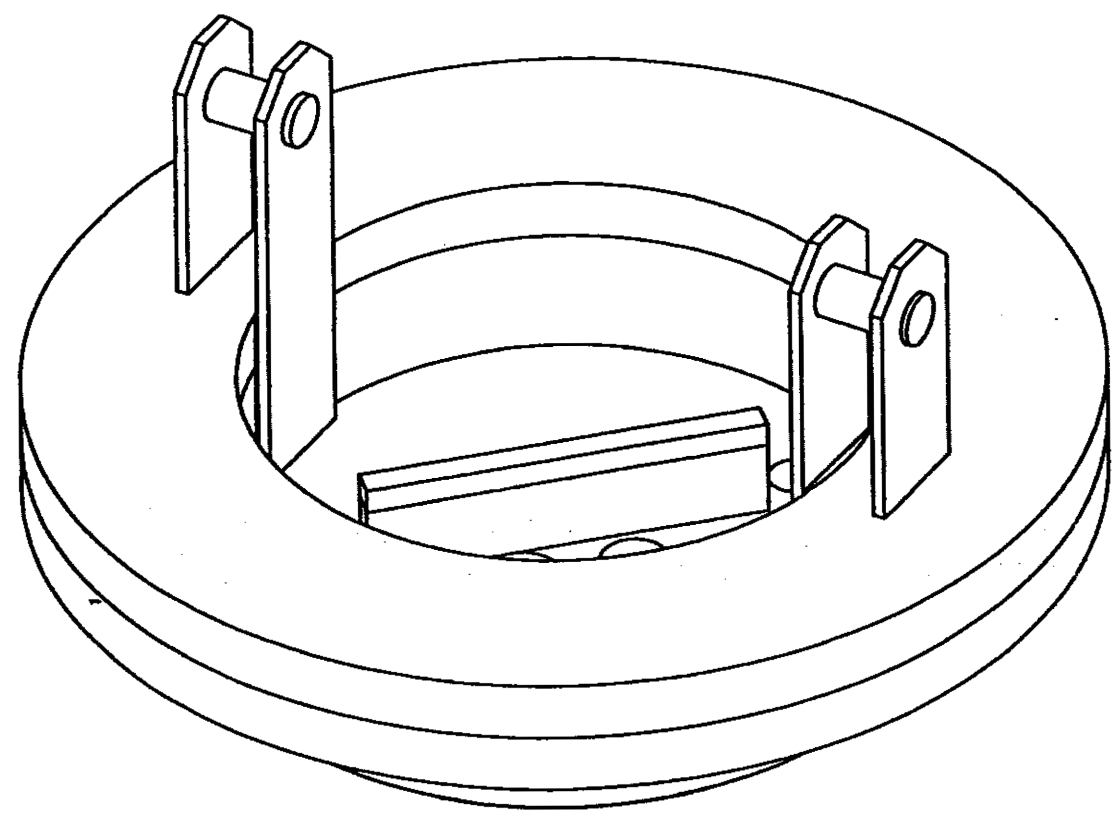
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

DRAIN PORT TOOL
SLUDGE TRANSPORTATION SYSTEM

SCALE: FULL | WT. N/A | REV: 1 | SHEET 2 OF 2 | DWG SIZE D | DWG NO. 12099-274 | CADFILE: 1209927421.DWG

12099-400	1	5		
REVISION HISTORY				
REV	DESCRIPTION		REL	DATE
0	INITIAL RELEASE		BH	5/7/02
1	GENERAL REVISION		TW	6/27/02
2	GENERAL REVISION		TW	8/8/02
3	GENERAL REVISION		BH	8/29/02
4	SEE DCN 1/3 THRU 10/3		BH	10/25/02
5	SEE DCN 1/4		DH	11/26/02



SLUDGE TRANSPORT SYS PROCESS SHIELD PLATE ISO

SCALE: NONE

GENERAL NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL MATERIAL SHALL BE AS SPECIFIED OR AN APPROVED EQUAL.
2. ABBREVIATIONS ARE IN ACCORDANCE WITH ANSI Y1.1-1972.
3. DIMENSIONING AND TOLERANCING ARE PER ASME Y14.5M-1994.
4. GRIND ALL SHARP EDGES AND REMOVE ALL BURRS.
5. STRUCTURAL WELDING & NDE SHALL BE IN ACCORDANCE WITH AWS D1.1 (CS) AND AWS D1.6 (SST) UNLESS OTHERWISE SPECIFIED. VT ALL WELDS AT FINAL PASS.
6. ITEM 3 MAY BE FABRICATED AS FULLY MACHINED, ROLLED OR AS A MULTIPLE PIECED WELDMENT WITH FINISH MACHINING PER FABRICATORS PREFERENCE.
7. UTILIZE ITEM 8 AS REQUIRED TO FABRICATE A SHROUD TO COMPLETELY COVER GAP BETWEEN ASSEMBLY A1 AND A2. SEAL WELD ALL AROUND SHROUD AS REQUIRED.
8. PROCESS SHIELD PLATE TO BE IDENTIFIED AS "TOOL 12099-400 S/N 00X PROCESS SHIELD PLATE, RATED WT=18,000 LBS, WT=(XX,XXX) LBS" WITH STAMPED LETTERING APPROX. ½" HIGH ALONG OUTER DIAMETER OF ASSEMBLY FLANGE. SERIAL NUMBERING (00X) TO BEGIN AT 001 AND END AT 002.
9. RATED MAXIMUM CAPACITY IS 18,000 LBS.
10. ASSEMBLY SHALL BE PROOF TESTED TO 150% OF ITS RATED CAPACITY FOR A PERIOD OF NOT LESS THAN 10 MINUTES. AFTER LOAD TESTING, A2 LUG WELDMENT AND A2 LUG WELDMENT TO A1 PROCESS SHIELD WELDMENT WELDS SHALL BE SUBJECT TO NDE.
11. VERIFY ASSEMBLY DRY WEIGHT (±100 LBS) BY WEIGHING AFTER ASSEMBLY IS COMPLETE.
12. PAINT ALL EXPOSED AND OTHERWISE NON-TREATED CARBON STEEL SURFACES WITH ONE COAT OF AMERCOTE 400 PRIMER AND TWO COATS OF AMERCOTE 450 HS, OR APPROVED EQUAL. APPLICATION SHALL BE IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. FINAL COLOR TO BE WHITE. MASK TAPPED HOLES.

INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: DeSau... Date: 11/27/02

QTY A2	QTY A1	ITEM	PART NO.	DESCRIPTION	MATERIAL
	2	12		PL, 3/8 THK X 2.35 X 6.25	ASTM A36 CS
	1	11		PL, 2 THK X 2.35 X 32.25	ASTM A36 CS
	2	10		PL, 3/8 THK X 6.25 X 31.5	ASTM A36 CS
	1	9	12099-401-A1	SHIELD CAP ASSY	
AR		8		SHEET, 12 GA	ASTM A569 CS
		7		LUG SUPPORT BAR #4 1/4" X 9 1/4" L	ASTM A108 CS
1		6		SHORT LUG PLATE, 1" THK PL	ASTM A36 CS
1		5		LONG LUG PLATE, 1" THK PL	ASTM A36 CS
	1	4		BOTTOM PLATE	ASTM A36 CS
	1	3		INNER MIDDLE PLATE, 59.50 OD X 51.25 ID X 10.75 THK	ASTM A36 CS
	1	2		OUTER MIDDLE PLATE	ASTM A36 CS
	1	1		TOP PLATE	ASTM A36 CS
X	2	A2		LUG WELDMENT	
	X	A1		PROCESS SHIELD PLATE WELDMENT	
ASSEMBLY & QUANTITY				LIST OF MATERIAL	

REL	B. HARGIS	8/29/02
APPD		
APPD		
APPD	F. YAPUNCICH	8/26/02
ENGR	A. BURNS	8/26/02
QA	B. COUNTERMAN	8/28/02
CHECK	F. STEINER	8/26/02
DRAWN	RI VAN LE	8/23/02

ITEM | QTY | NEXT ASSY

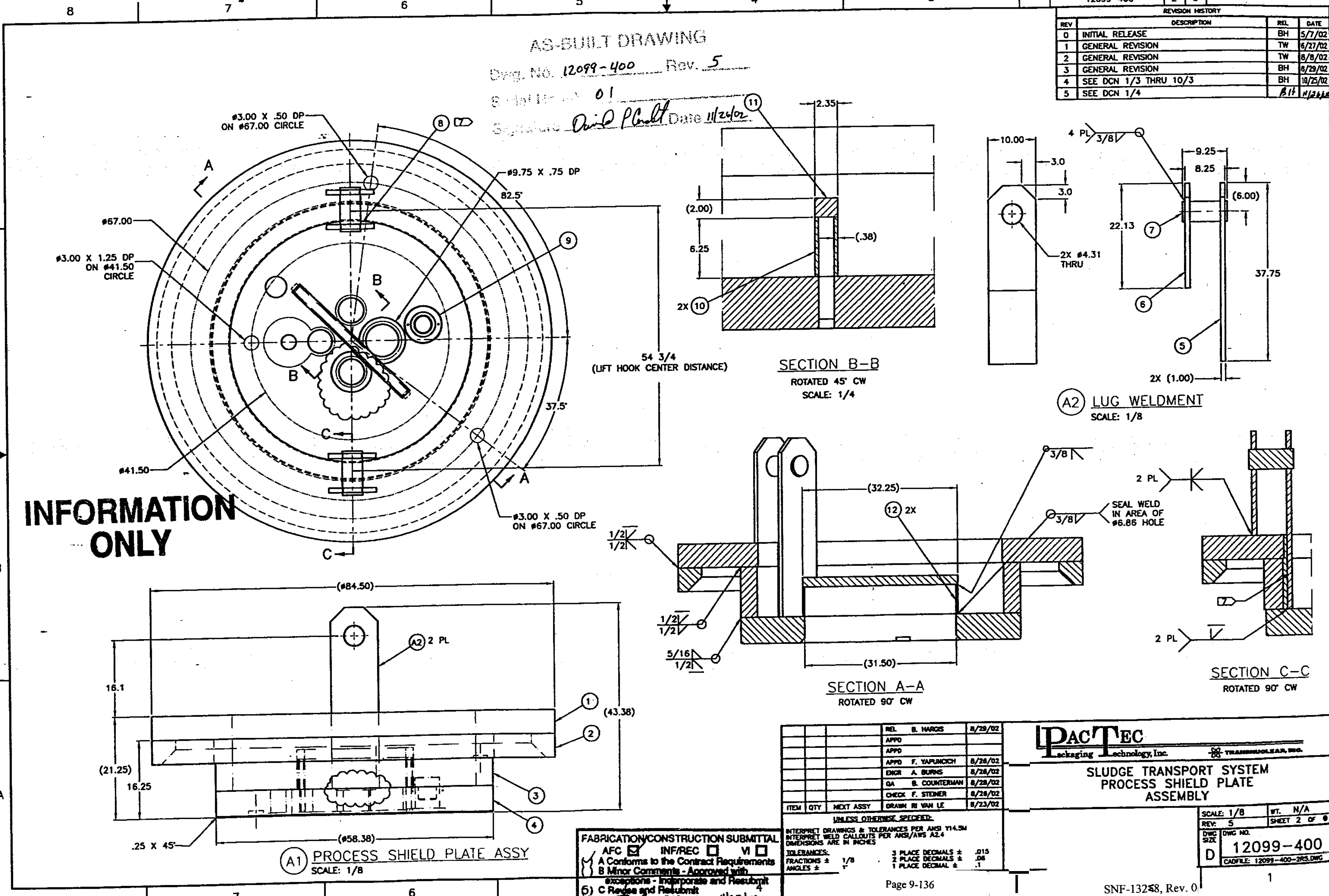
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ± 1/16; ANGLES ± 1°; 3 PLACE DECIMALS ± .005; 2 PLACE DECIMALS ± .03; 1 PLACE DECIMAL ± .06

PACTEC Packaging Technology, Inc. — TRANSNUCLEAR, INC.

SLUDGE TRANSPORT SYSTEM
PROCESS SHIELD PLATE
ASSEMBLY

SCALE: NONE | WT. N/A | REV: 5 | SHEET 1 OF 4
DWG SIZE: D | DWG NO. 12099-400 | CADFILE: 12099-400-1R5.DWG

AS-BUILT DRAWING
Dwg. No. 12099-400 Rev. 5
Serial No. 01
Signature [signature] Date 11/26/02



REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	5/7/02
1	GENERAL REVISION	TW	6/27/02
2	GENERAL REVISION	TW	8/8/02
3	GENERAL REVISION	BH	8/29/02
4	SEE DCN 1/3 THRU 10/3	BH	10/25/02
5	SEE DCN 1/4	BH	11/26/02

12099-400 2 5 REVISION HISTORY

REL	B. HARGIS	8/29/02
APPD		
APPD		
APPD	F. YAPUNCICH	8/28/02
ENGR	A. BURNS	8/28/02
QA	B. COUNTERMAN	8/28/02
CHECK	F. STEINER	8/28/02
DRAWN	RI VAN LE	8/23/02

ITEM | QTY | NEXT ASSY

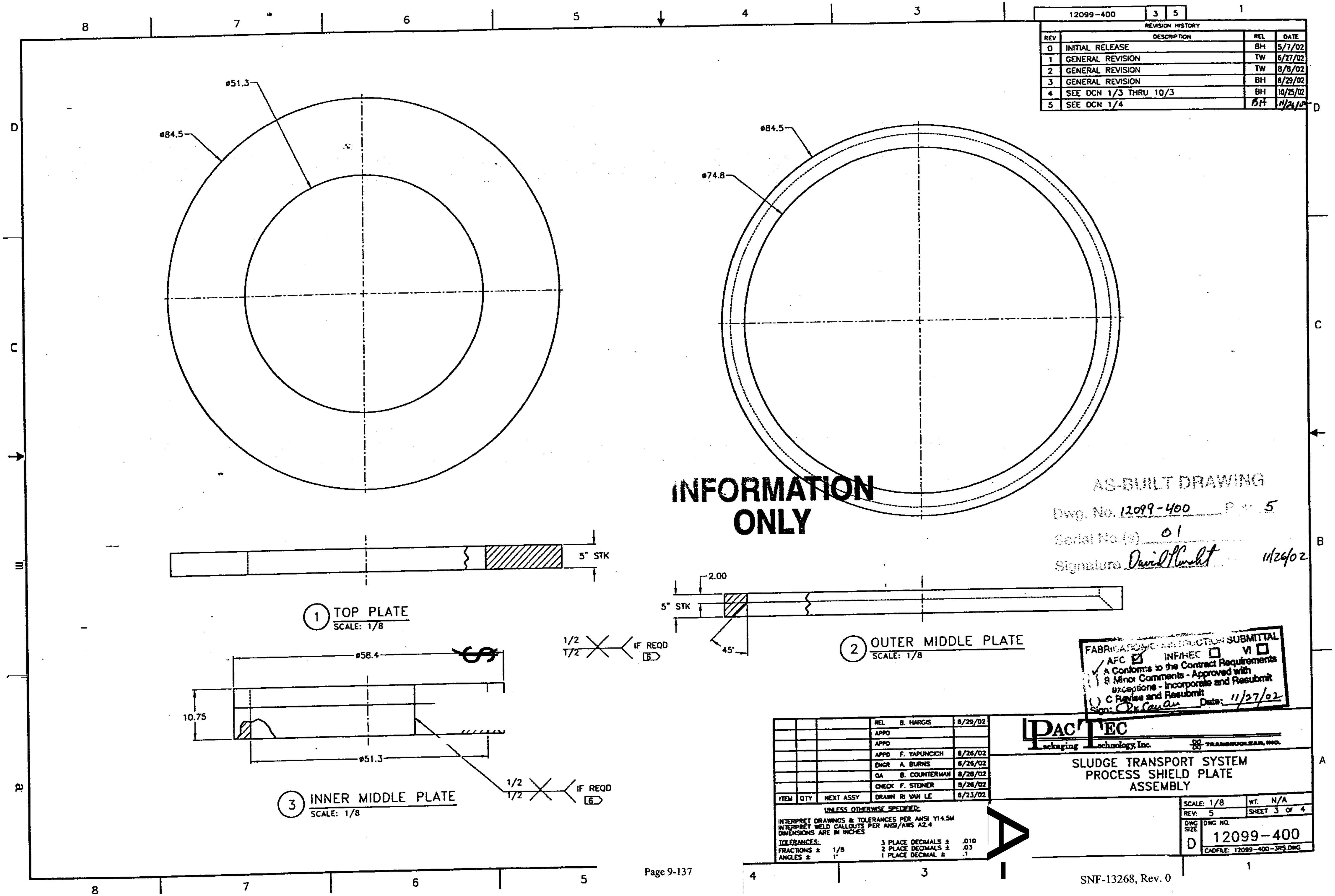
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES: FRACTIONS ± 1/8; ANGLES ± 1°; 3 PLACE DECIMALS ± .015; 2 PLACE DECIMALS ± .06; 1 PLACE DECIMAL ± .1

PACTEC Packaging Technology, Inc. — TRANSNUCLEAR, INC.

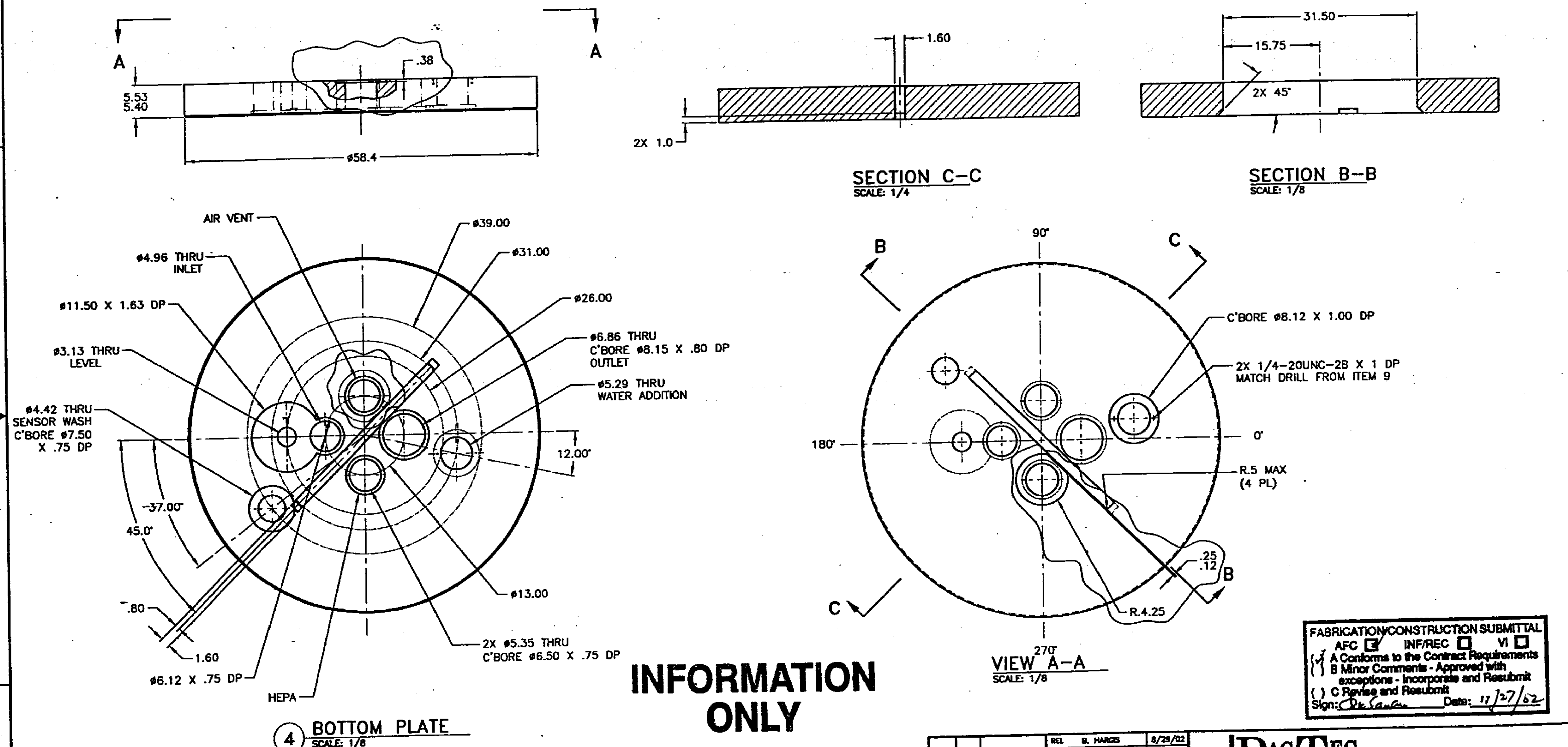
SLUDGE TRANSPORT SYSTEM
PROCESS SHIELD PLATE
ASSEMBLY

SCALE: 1/8 | WT. N/A | REV: 5 | SHEET 2 OF 8 | SIZE D | DWG NO. 12099-400 | CADFILE: 12099-400-2R5.DWG

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Sign: [signature] Date: 11/27/02


12099-400 3 5
REVISION HISTORY
REV DESCRIPTION REL DATE
0 INITIAL RELEASE BH 5/7/02
1 GENERAL REVISION TW 6/27/02
2 GENERAL REVISION TW 8/8/02
3 GENERAL REVISION BH 8/29/02
4 SEE DCN 1/3 THRU 10/3 BH 10/25/02
5 SEE DCN 1/4 BH
ø51.3
ø84.5
ø74.8
INFORMATION ONLY
AS-BUILT DRAWING
Dwg. No. 12099-400 Rev. 5
Serial No.(s) 01
11/26/02
5" STK
1 TOP PLATE SCALE: 1/8
2.00
45°
2 OUTER MIDDLE PLATE SCALE: 1/8
1/2 1/2 IF REQD 6
ø58.4
10.75
ø51.3
3 INNER MIDDLE PLATE SCALE: 1/8
FABRICATION/CONSTRUCTION SUBMITTAL
AFC INF/HEC VI
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Date: 11/27/02
REL B. HARGIS 8/29/02
APPD
APPD
APPD F. YAPUNCICH 8/28/02
ENGR A. BURNS 8/26/02
QA B. COUNTERMAN 8/28/02
CHECK F. STEINER 8/26/02
DRAWN RI VAN LE 8/23/02
ITEM QTY NEXT ASSY
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1
PacTec Packaging Technology, Inc.
TRANSNUCLEAR, INC.
SLUDGE TRANSPORT SYSTEM PROCESS SHIELD PLATE ASSEMBLY
SCALE: 1/8 WT. N/A
REV: 5 SHEET 3 OF 4
DWG SIZE D DWG NO. 12099-400
CADFILE: 12099-400-3R5.DWG
A-

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	5/7/02
1	GENERAL REVISION	TW	6/27/02
2	GENERAL REVISION	TW	8/8/02
3	GENERAL REVISION	BH	8/29/02
4	SEE DCN 1/3 THRU 10/3	BH	10/25/02
5	SEE DCN 1/4		



FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

INFORMATION ONLY

AS-BUILT DRAWING
Dwg. No. 12099-400 Rev. 5
Serial No.(s) 61
Signature [signature] Date 11/26/02

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	8/29/02
			APPD		
			APPD		
			APPD	F. YAPUNICH	8/28/02
			ENGR	A. BURNS	8/28/02
			QA	B. COUNTERMAN	8/28/02
			CHECK	F. STEINER	8/26/02
			DRAWN	RI VAN LE	8/23/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

PacTec Packaging Technology, Inc. — Transnuclear, Inc.

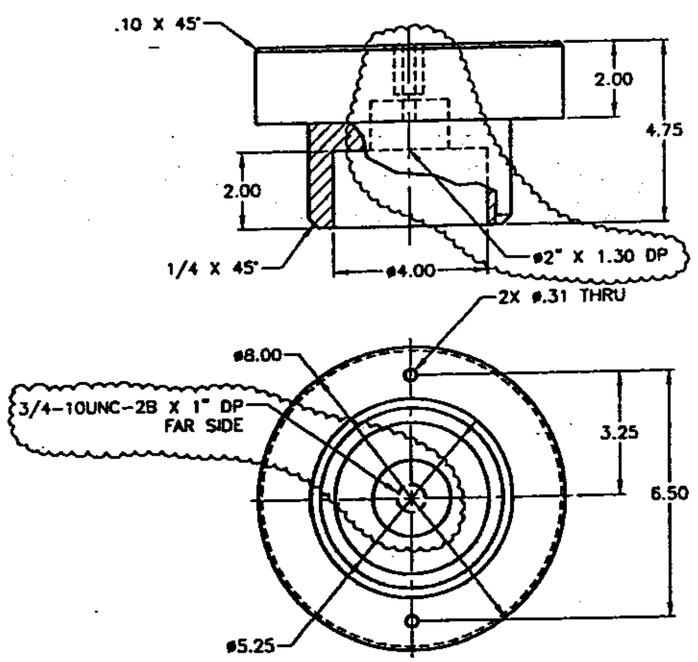
SLUDGE TRANSPORT SYSTEM
PROCESS SHIELD PLATE
ASSEMBLY

SCALE: 1/8 | WT. N/A | REV: 5 | SHEET 4 OF 4
DWG SIZE D | DWG NO. 12099-400
CADFILE: 12099-400-4R5.DWG

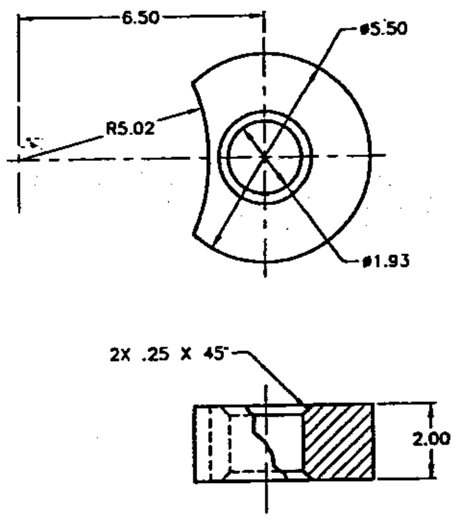
12099-401	1	4

REVISION HISTORY

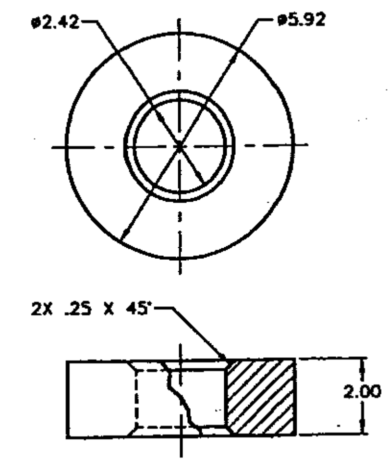
REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	5/7/02
1	GENERAL REVISION	TW	6/27/02
2	GENERAL REVISION	TW	8/8/02
3	GENERAL REVISION	BH	8/29/02
4	SEE DCN 1/3 & 2/3	BH	11/26/02



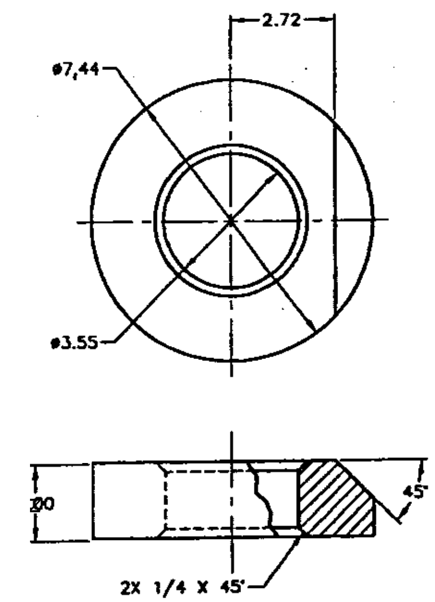
(1) WATER ADDITION SHIELD CAP
SCALE: 1/2



(2) INLET SHIELD PUCK
SCALE: 1/2

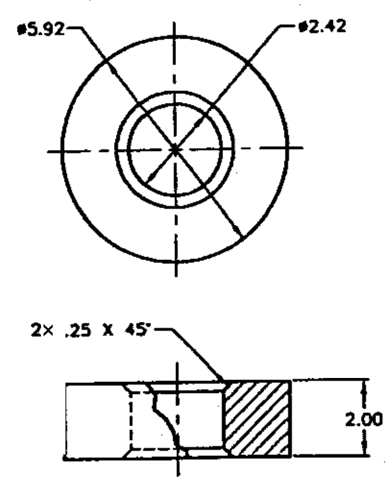


(3) AIR VENT SHIELD PUCK
SCALE: 1/2

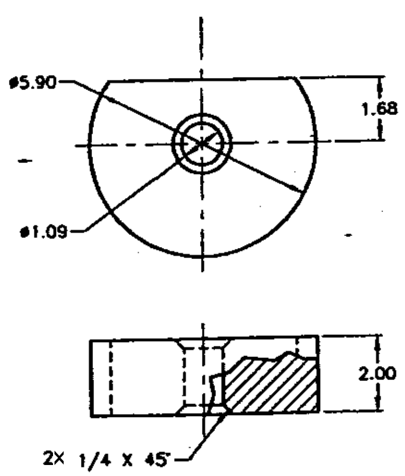


(4) OUTLET SHIELD PUCK
SCALE: 1/2

INFORMATION ONLY



(6) HEPA SHIELD PUCK
SCALE: 1/2



(5) SENSOR WASH SHIELD PUCK
SCALE: 1/2

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

AS-BUILT DRAWING
Dwg. No. 12099-401 Rev. 4
Serial No.(s) 01
Signature [signature] Date 11/26/02

GENERAL NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL MATERIAL SHALL BE AS SPECIFIED OR AN APPROVED EQUAL QUALITY.
2. ABBREVIATIONS ARE IN ACCORDANCE WITH ANSI Y1.1-1972.
3. DIMENSIONING AND TOLERANCING ARE PER ASME Y14.5M-1994.
4. GRIND ALL SHARP EDGES AND REMOVE ALL BURRS.
5. REFERENCE DWG 3C40-0126-D FOR INSTALLATION OF ITEMS 2-6. COMPLETE FIT AND FORM OF DETAIL ITEM 4 DURING INSTALLATION ON THE CONTAINER OUTLET NOZZLE. REMOVE MINIMUM MATERIAL REQUIRED FOR INSTALLATION AT PROPER ELEVATION ABOVE CONTAINER.
6. REFERENCE PROCESS SHIELD PLATE 12099-400 FOR INSTALLATION OF ITEM 1.

ITEM	PART NO.	DESCRIPTION	MATERIAL
6		HEPA SHIELD PUCK, 2 THK X ø5.9	300 SERIES SST
5		SENSOR WASH SHIELD PUCK, 2 THK X ø5.9	300 SERIES SST
4		OUTLET SHIELD PUCK, 2 THK X ø7.4	300 SERIES SST
3		AIR VENT SHIELD PUCK, 2 THK X ø5.9	300 SERIES SST
2		INLET SHIELD PUCK, 2 THK X ø5.5	300 SERIES SST
1		SHIELD CAP, 4 3/4 THK X ø8.0	300 SERIES SST

ASSEMBLY & QUANTITY — LIST OF MATERIAL

ITEM	QTY	NEXT ASSY		
			REL	
			APPD	
			APPD	
			APPD	
			ENGR	
			QA	
			CHECK	
			DRAWN RI VAN LE	8/23/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

PACTEC Packaging Technology, Inc. — TRANSNUCLEAR, INC.

SLUDGE STRANSPORT SYSTEM
PROCESS SHIELD PLATE
SHIELD CAP AND PUCKS

SCALE: 1/2 | WT. N/A
REV: 4 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-401
CADFILE 12099-401-1R4.DWG

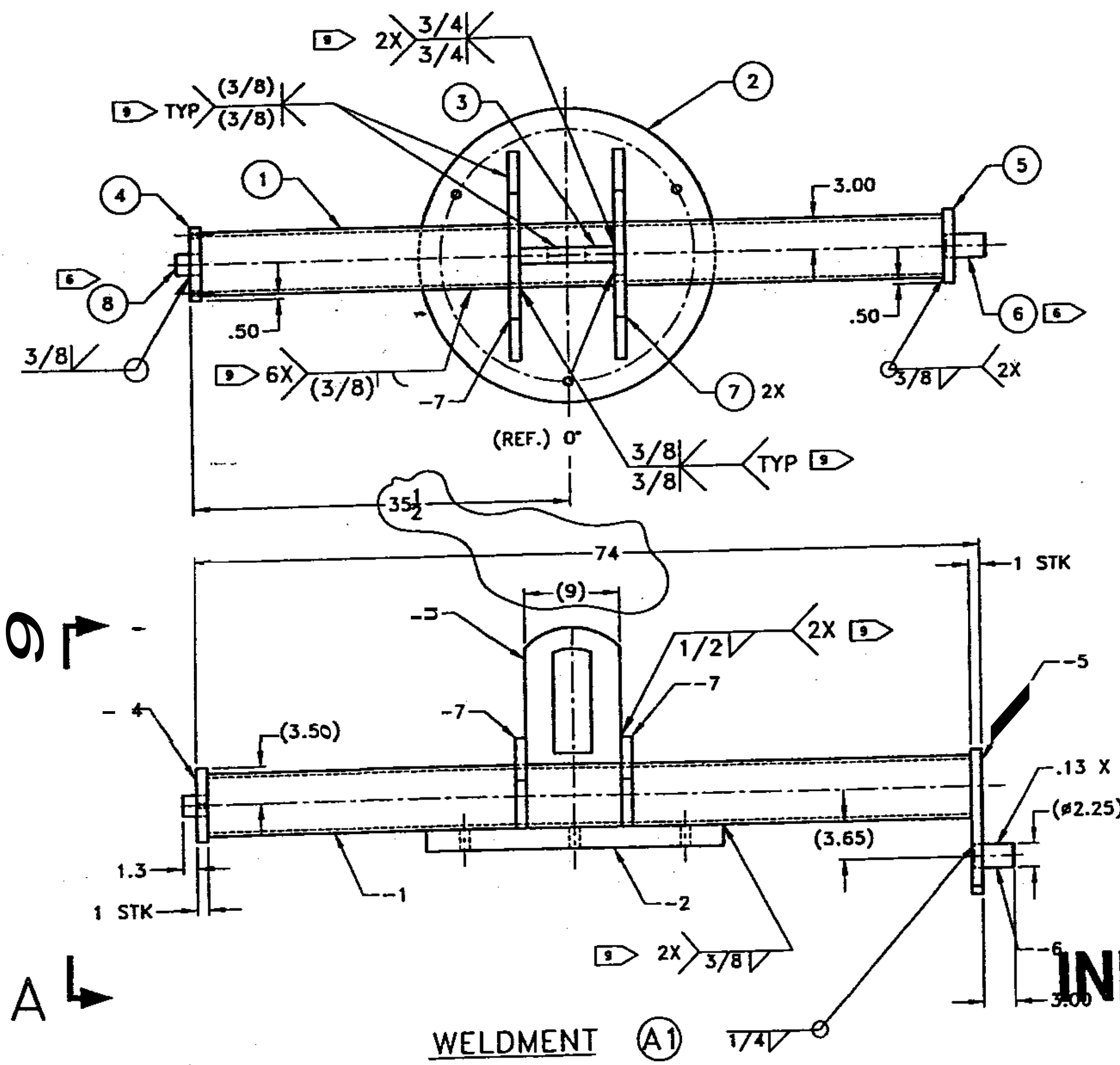
REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	4/26/02
1	SEE DCN 1/0	BH	4/26/02
2	SEE DCN 1/1, 2/1	BH	9/12/02
3	SEE DCN 1/2, 2/2	BH	11/19/02

12099-500 REVISION HISTORY

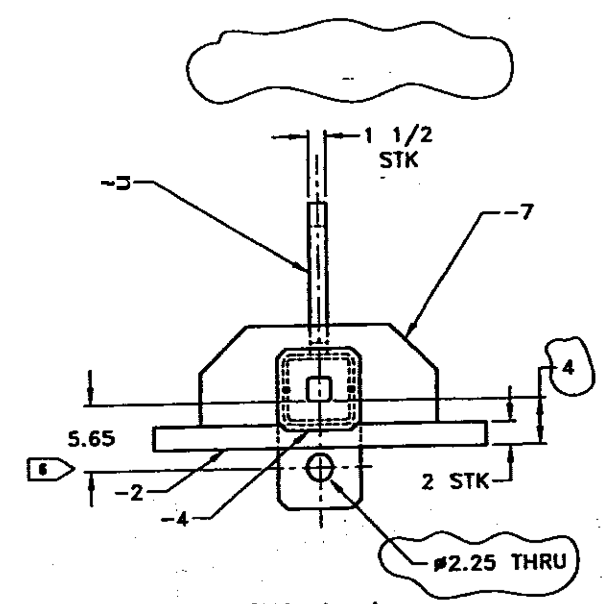
NOTES, UNLESS OTHERWISE SPECIFIED:

1. FABRICATE IN ACCORDANCE WITH PACTEC SPECIFICATION GF-001.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. IT IS THE RESPONSIBILITY OF THE MANUFACTURER TO CONFIRM ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. ALL WELDING PROCEDURES AND PERSONNEL SHALL BE QUALIFIED IN ACCORDANCE WITH ASME CODE, SECTION IX.
4. ALL WELDS SHALL BE VISUALLY INSPECTED BY A CERTIFIED WELD INSPECTOR (CWI) PRIOR TO AND AFTER THE LOAD TEST, IN ACCORDANCE WITH ANSI/AWS D14.1.
5. COAT WITH AMERCOTE 400 AND TWO (2) COATS OF AMERCOTE 450-HS OR BUYER APPROVED EQUIVALENT. LIFTING DEVICE BAIL SHALL BE YELLOW. BUYER SHALL APPROVE COLOR.
6. ITEM 8 AND ITEM 6 BAR MUST BE PARALLEL AND INLINE WITHIN ±.03.
7. LID LIFTING FIXTURE SHALL BE TESTED BY FABRICATOR TO 150% OF THE RATED LOAD (+5%, -0%) FOR A MINIMUM OF TEN (10) MINUTES. AFTER LOAD TEST IS COMPLETE, VISUALLY INSPECT FOR DEFORMATION, CRACKS, OR OTHER DEFECTS.
8. IDENTIFY LID LIFTING TOOL AS "TOOL 12099, S/N 00X "LID LIFTING TOOL" LOAD RATING=5,000 LBS WT=670 LBS" " WITH STAMPED LETTERS APPROX. 1/4" HIGH ALONG OUTER EDGE CIRCUMFERENCE OF ITEM 2.
9. MAGNETIC-PARTICLE TEST PRIOR TO AND AFTER THE LOAD TEST IN ACCORDANCE WITH ANSI/AWS D14.1

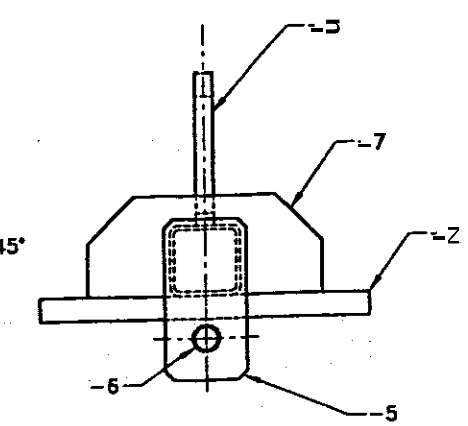
FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/21/02



WELDMENT (A1)



VIEW A-A



COPY

INFORMATION ONLY

O/C	QTY	ITEM	PART NO.	DESCRIPTION	MATERIAL
	1	8		BAR, 2 X 2 X 2.3	ASTM A36
	2	7		PL, 1" THK X 8.5 X 20.0	ASTM A36
	1	6		BAR, RD ø2.25 x 3.8	ASTM A36
	1	5		PL, 1" THK X 7 X 14.1	ASTM A36
	1	4		PL, 1" THK X 7 X 7.0	ASTM A36
	1	3		PL, 1 1/2" THK X 9 X 13.0	ASTM A36
	1	2		PL, 2" THK X ø28.0	ASTM A36
	1	1		TUBING 6 X 6 X 3/8 X 72.0	ASTM A500, GRADE B
	X	A1		LIFTING FIXTURE WELDMENT	

ASSEMBLY & QUANTITY — LIST OF MATERIAL

REL	B. HARGIS	4/26/02
APPD		
APPD		
APPD	K. BROWNELL	4/24/02
ENGR	J. NICHOLS	4/24/02
DA	B. COUNTERMAN	4/25/02
CHECK	F. STEINER	4/24/02
DRAWN	T. WAAGAN	4/24/02

ITEM | QTY | NEXT ASSY

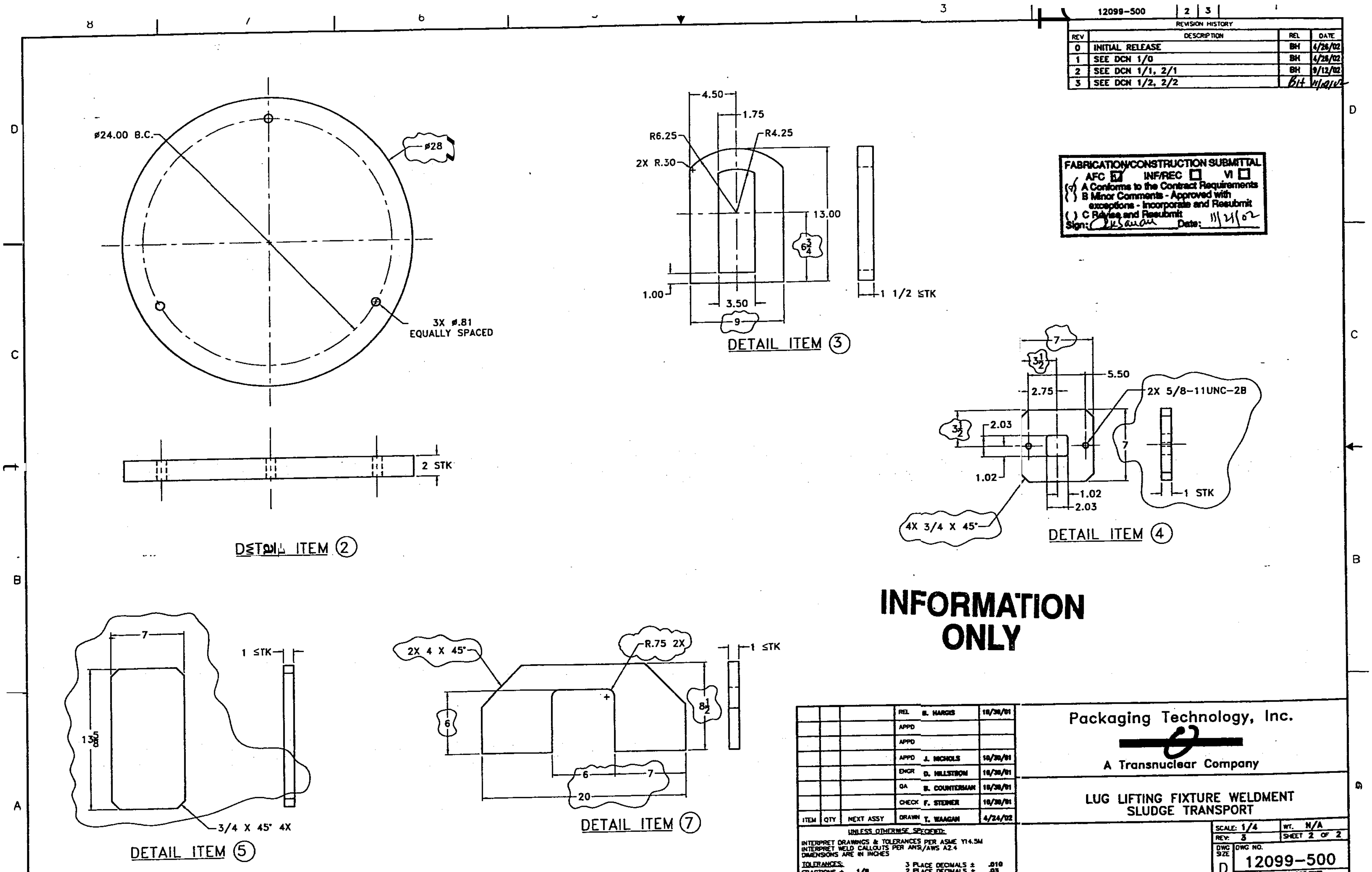
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

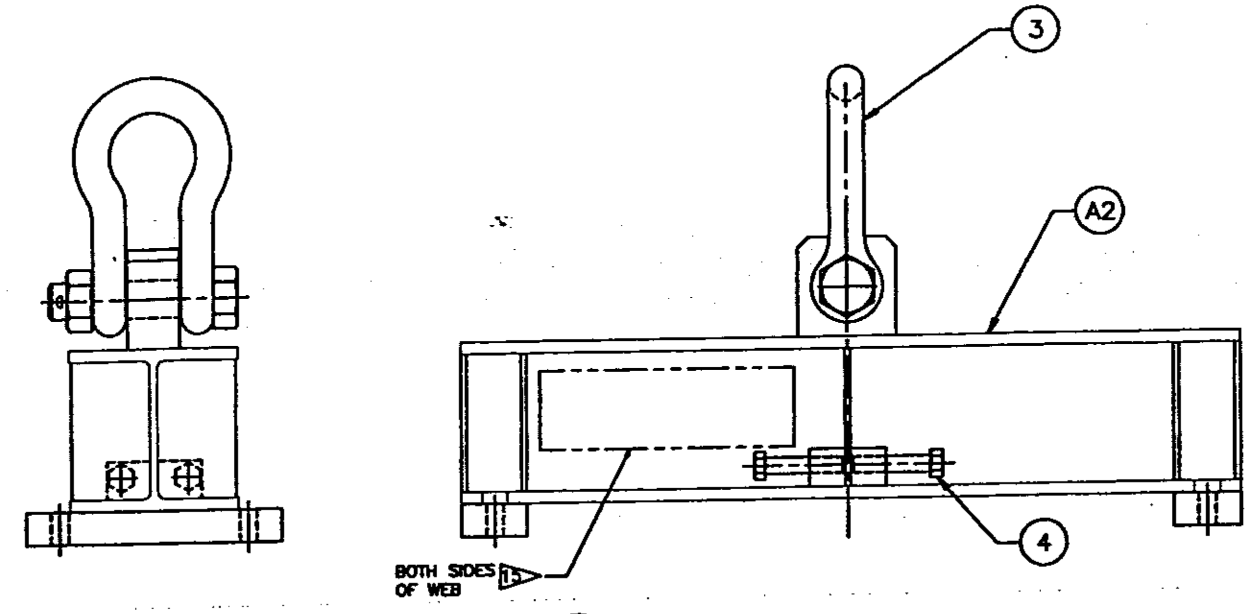
LUG LIFTING FIXTURE WELDMENT
SLUDGE TRANSPORT SYSTEM

SCALE: 1/8 | WT. N/A
REV. 3 | SHEET 1 OF 2
DWG SIZE D | DWG NO. 12099-500
CADFILE: 1209950013.DWG

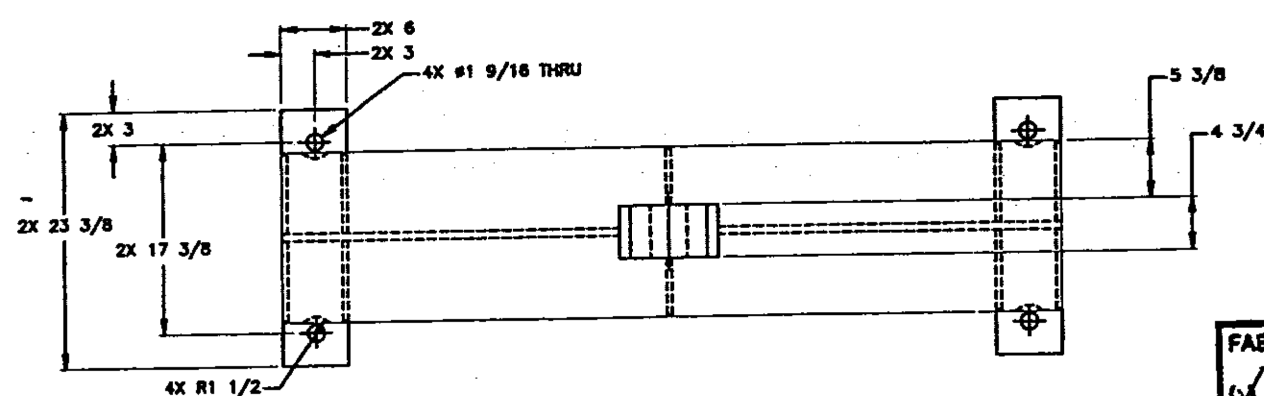

12099-500
REVISION HISTORY
REV | DESCRIPTION | REL | DATE
0 | INITIAL RELEASE | BH | 4/26/02
1 | SEE DCN 1/0 | BH | 4/26/02
2 | SEE DCN 1/1, 2/1 | BH | 9/12/02
3 | SEE DCN 1/2, 2/2 | BH
FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: Date: 11/21/02
ø24.00 B.C.
ø28
3X ø.81 EQUALLY SPACED
2 STK
DETAIL ITEM 2
4.50
1.75
R6.25
R4.25
2X R.30
13.00
6 3/4
1.00
3.50
9
1 1/2 STK
DETAIL ITEM 3
7
3 1/2
5.50
2.75
2X 5/8-11UNC-2B
2.03
1.02
1.02
2.03
1 STK
4X 3/4 X 45°
DETAIL ITEM 4
INFORMATION ONLY
7
1 STK
13 5/8
3/4 X 45° 4X
DETAIL ITEM 5
2X 4 X 45°
R.75 2X
1 STK
6
8 1/2
6
7
20
DETAIL ITEM 7
REL B. HARGIS 10/30/01
APPD
APPD
APPD J. NICHOLS 10/30/01
ENGR D. HILLSTROM 10/30/01
QA B. COUNTERMAN 10/30/01
CHECK F. STEINER 10/30/01
ITEM QTY NEXT ASSY DRAWN T. WAAGAN 4/24/02
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1
Packaging Technology, Inc.
A Transnuclear Company
LUG LIFTING FIXTURE WELDMENT
SLUDGE TRANSPORT
SCALE: 1/4
WT. N/A
REV: 3
SHEET 2 OF 2
DWG SIZE D
DWG NO. 12099-500
CADFILE: 12099500023.DWG

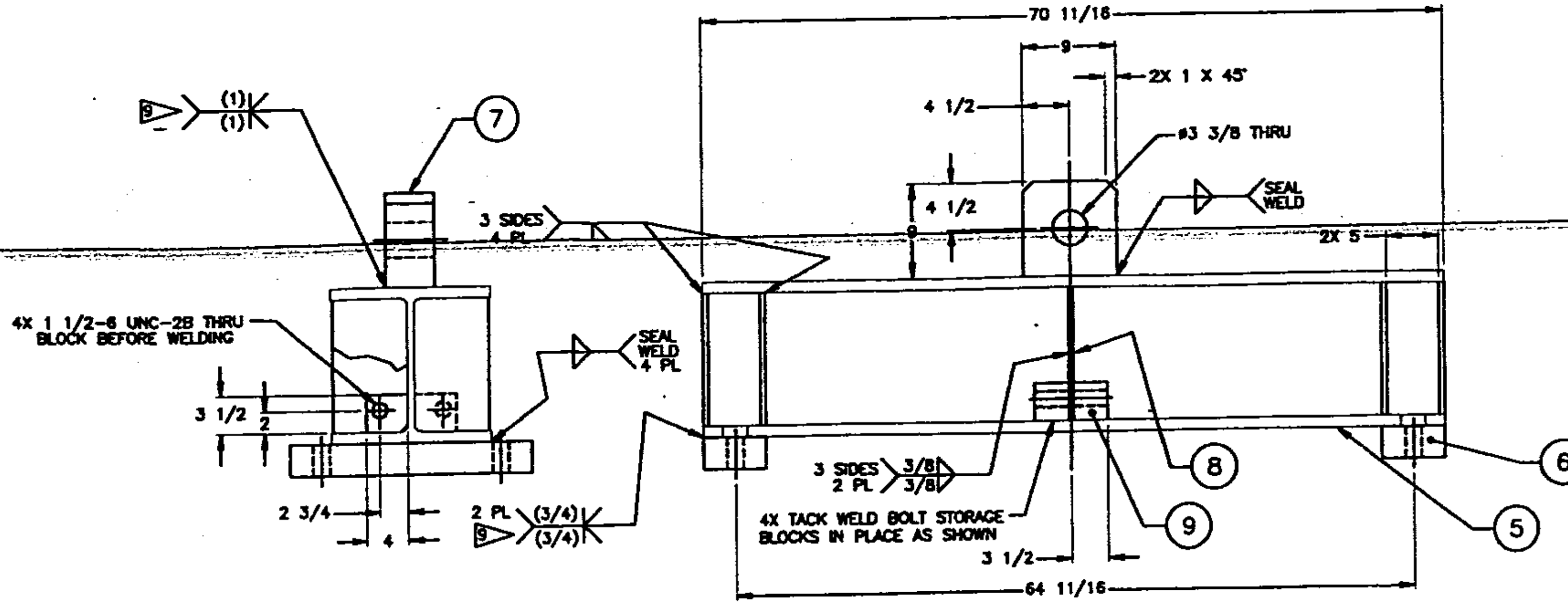
REV	DESCRIPTION	REL.	DATE
0	INITIAL RELEASE	B.H.	4-17-02
1	SEE DCN 1/0 THRU 4/0	BH	11/23/02

REVISION HISTORY — 12099-510



(A1) LIFTING DEVICE ASSEMBLY





(A2) LIFTING DEVICE WELDMENT

INFORMATION ONLY

GENERAL NOTES: (UNLESS OTHERWISE SPECIFIED)

1. BREAK ALL SHARP EDGES, REMOVE ALL BURRS.
2. ABBREVIATIONS ARE IN ACCORDANCE WITH ANSI Y1.1-1972.
3. RATED CAPACITY IS 85,000 LBS.
4. FABRICATE IN ACCORDANCE WITH ANSI N14.6 REQUIREMENTS.
5. ALL MATERIAL SHALL BE PROCURED FROM QUALIFED SUPPLIERS. ALL STRUCTURAL STEEL MATERIAL SHALL BE SUPPLIED WITH CERTIFIED MATERIAL TEST REPORTS. NON-STRUCTURAL STEEL MATERIAL SHALL BE SUPPLIED WITH A MINIMUM OF CERTIFICATE OF CONFORMANCE.
6. WELDERS, WELD PROCEDURES, SHALL BE QUALIFIED IN ACCORDANCE WITH ASME SECTION IX OR AWS D1.1.
7. NDE PROCEDURES AND PERSONNEL SHALL BE QUALIFIED IN ACCORDANCE WITH ASME SECTION V, ARTICLES 1, 6, 7, 24, AND 25. ACCEPTANCE STANDARDS FOR LIQUID PENETRANT AND MAGNETIC PARTICLE SHALL BE AS INDICATED IN ASME SECTION III, NF-5350 AND NF-5340 RESPECTIVELY.
8. NOT USED

9. CRITICAL WELD. THESE WELDS SHALL BE SUBJECTED TO FIT-UP INSPECTION, VISUAL INSPECTION OF EACH PASS, AND NDE OF THE ROOT AND FINAL PASS. NDE SHALL CONSIST OF EITHER LIQUID PENETRANT OR MAGNETIC PARTICLE EXAMINATION AT THE FABRICATORS DISCRETION.

10. ITEM NO. 4 SHALL BE PROCURED WITH SUPPLEMENTAL REQUIREMENT S3 "CHARPY IMPACT TESTING, LATERAL EXPANSION". TESTING SHALL BE PERFORMED IN ACCORDANCE WITH REQUIREMENTS OF ASTM A320 AND ASTM A370. TESTING SHALL BE PERFORMED AT A TEMPERATURE NOT GREATER THAN -27°F. ACCEPTABLE LATERAL EXPANSION IS NOT LESS THAN 0.025 INCHES.

11. ITEM NO. 3 SHALL BE PROOF TESTED TO TWO TIMES THE WORKING LOAD LIMIT OF 120 METRIC TONS. FOLLOWING THE PROOF TEST, ITEM NO. 3 SHALL BE SUBJECTED TO MAGNETIC PARTICLE EXAMINATION WITH ACCEPTANCE CRITERIA AS INDICATED IN NOTE 7 OR AN APPROVED EQUAL. PERFORMANCE OF THIS SERIES OF TESTING, ALL OR IN PART, BY A QUALIFIED SUPPLIER IS ACCEPTABLE IF APPROPRIATE CERTIFICATES ARE PROVIDED WITH THE SHIPMENT.

12. ITEM 8, BOLTS, SHOWN THREADED LOOSELY IN STORAGE BLOCK. WHEN INSTALLING FOR LIFTING, BOLTS TO BE TORQUED TO A VALUE BETWEEN 480 AND 635 FOOT POUNDS.
13. ~~PRIOR TO~~ PAINTING, THE LIFTING DEVICE SHALL BE LOAD TESTED TO 150% (+5%,-0%) OF ITS RATED CAPACITY FOR A PERIOD OF NOT LESS THAN 10 MINUTES. AFTER LOAD TESTING, ALL CRITICAL WELDS SHALL BE SUBJECTED TO NDE.
14. PAINT ALL EXPOSED AND OTHERWISE NON-TREATED CARBON STEEL SURFACES WITH ONE COAT OF AMERCOTE 400 PRIMER AND TWO COATS OF AMERCOTE 450 HS, OR APPROVED EQUAL. APPLICATION SHALL BE IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. FINAL COLOR TO BE YELLOW.

15. PROVIDE RATED CAPACITY IDENTIFICATION IN THE AREA IDENTIFIED USING 5/8 INCH HIGH (MIN) BLACK CHARACTERS. OTHER MARKINGS SHALL INCLUDE WEIGHT (OF ASSEMBLY), SERIAL NUMBER, DRAWING NUMBER, CONTRACT NUMBER, AND MANUFACTURER, PLACED IN A MANNER TO PROVIDE LEGIBILITY FROM A DISTANCE OF 5 FEET. STAMPING OR ETCHING, IF DESIRED, SHALL BE PERFORMED ON A SEPARATE PIECE OF STEEL AND ATTACHED TO THE STRUCTURE IN A MANNER APPROVED BY ENGINEERING.

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/26/02

COPY

QUAL CAT	A2	A1	ITEM	PART NO.	DESCRIPTION	SPECIFICATION
C	4		9		BAR, 3 1/2 X 3 1/2 X 4 LG	ASTM A-36 STEEL
C	10		8		1/2 PLATE, 7 1/4 X 12 1/2 (COPE AS REQD)	ASTM A-36 STEEL
C	1		7		4 3/4 PLATE, 9 X 9	ASTM A-36 STEEL
C	2		6		3" PLATE, 6 X 23 3/8	ASTM A-36 STEEL
C	1		5		~~W14 X 145 X 70 11/16 LG~~	~~ASTM A-36 STEEL~~
C (10)		1	4		HEX HEAD CAP SCREW, 1 1/2-6 UNC-2A X 7 1/2 LG	ASTM A-320, GRADE L7M
C (11)		1	3	1021192	BOLT TYPE ANCHOR SHACKLE, 3 INCH, G2140 (120 METRIC TON CAPACITY)	CROSBY GROUP
	X	1	A2		LIFTING DEVICE WELDMENT	
	X		A1		LIFTING DEVICE ASSEMBLY	

ITEM	QTY	NEXT ASSY			
			REL	B. HARGIS	4/17/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	4/17/02
			ENGR	J. NICHOLS	4/17/02
			QA	B. COUNTERMAN	4/17/02
			CHECK	J. NICHOLS FOR FWS	4/17/02
			DRAWN	TGH	11/01

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± NA
2 PLACE DECIMALS ± NA
1 PLACE DECIMAL ± NA

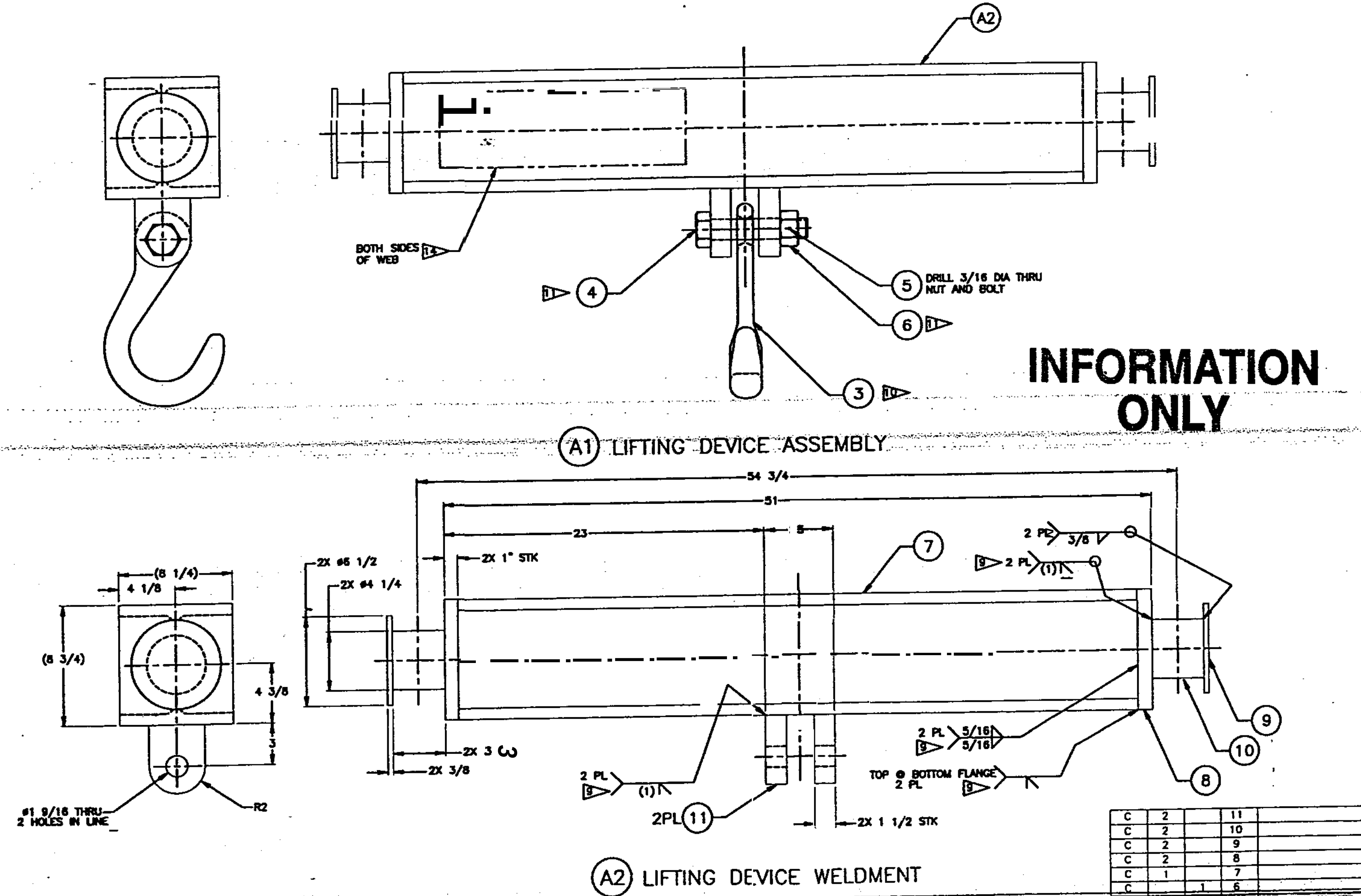
PacTec Packaging Technology, Inc. — TRANSNUCLEAR, INC.

SLUDGE TRANSPORT SYSTEM
CASK LIFTING DEVICE
ASSEMBLY

SCALE: 1/8 | WT. N/A
REV: 1 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-510
CADFILE: 12099-510-1R1.DWG

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	4/17/02
1	SEE DCN 1/0 THRU 3/0	BH	11/11/02
2	SEE DCN 1/1	BH	11/22/02

REVISION HISTORY — 12099-520 | 1 | 2



INFORMATION ONLY

GENERAL NOTES: (UNLESS OTHERWISE SPECIFIED)

1. BREAK ALL SHARP EDGES, REMOVE ALL BURRS.
2. ABBREVIATIONS ARE IN ACCORDANCE WITH ANSI Y1.1-1972.
3. RATED CAPACITY IS 7,000 LBS.
4. FABRICATE IN ACCORDANCE WITH ANSI N14.6 REQUIREMENTS.
5. ALL MATERIAL SHALL BE PROCURED FROM QUALIFIED SUPPLIERS. ALL STRUCTURAL STEEL MATERIAL SHALL BE SUPPLIED WITH CERTIFIED MATERIAL TEST REPORTS. NON-STRUCTURAL STEEL MATERIAL SHALL BE SUPPLIED WITH A MINIMUM OF CERTIFICATE OF CONFORMANCE.
6. WELDERS, WELD PROCEDURES SHALL BE QUALIFIED IN ACCORDANCE WITH ASME SECTION IX OR AWS D1.1.
7. NDE PROCEDURES AND PERSONNEL SHALL BE QUALIFIED IN ACCORDANCE WITH ASME SECTION V, ARTICLES 1, 6, 7, 24, AND 25. ACCEPTANCE STANDARDS FOR LIQUID PENETRANT AND MAGNETIC PARTICLE SHALL BE AS INDICATED IN ASME SECTION III, NF-5350 AND NF-5340 RESPECTIVELY.
8. NOT USED
9. CRITICAL WELD. THESE WELDS SHALL BE SUBJECTED TO FIT-UP INSPECTION, VISUAL INSPECTION OF EACH PASS, AND NDE OF THE ROOT AND FINAL PASS. NDE SHALL CONSIST OF EITHER LIQUID PENETRANT OR MAGNETIC PARTICLE EXAMINATION AT THE FABRICATORS DISCRETION.
10. ITEM NO. 3 SHALL BE PROOF TESTED TO 2 1/2 TIMES THE WORKING LOAD LIMIT OF 17,500 POUNDS. FOLLOWING THE PROOF TEST, ITEM NO. 3 SHALL BE SUBJECTED TO MAGNETIC PARTICLE EXAMINATION WITH ACCEPTANCE CRITERIA AS INDICATED IN NOTE 7 OR AN APPROVED EQUAL. PERFORMANCE OF THIS SERIES OF TESTING, ALL OR IN PART, BY A QUALIFIED SUPPLIER IS ACCEPTABLE IF APPROPRIATE CERTIFICATES ARE PROVIDED WITH THE SHIPMENT.
11. ASSEMBLE ITEM 4 BOLT, ITEM 6 NUT, AND ITEM 5 SPRING PIN, TO PROVIDE BETWEEN 1/16 INCH TO 1/8 INCH OF TOTAL LASH.
12. PRIOR TO PAINTING, THE LIFTING DEVICE SHALL BE LOAD TESTED TO 150% (+5%,-0%) OF ITS RATED CAPACITY FOR A PERIOD OF NOT LESS THAN 10 MINUTES. AFTER LOAD TESTING, ALL CRITICAL WELDS SHALL BE SUBJECTED TO NDE.
13. PAINT ALL EXPOSED AND OTHERWISE NON-TREATED CARBON STEEL SURFACES WITH ONE COAT OF AMERCOTE 400 PRIMER AND TWO COATS OF AMERCOTE 450 HS, OR APPROVED EQUAL. APPLICATION SHALL BE IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. FINAL COLOR TO BE YELLOW.
14. PROVIDE RATED CAPACITY IDENTIFICATION IN THE AREA IDENTIFIED USING 5/8 INCH HIGH (MIN) BLACK CHARACTERS. OTHER MARKINGS SHALL INCLUDE WEIGHT (OF ASSEMBLY), SERIAL NUMBER, DRAWING NUMBER, CONTRACT NUMBER, AND MANUFACTURER, PLACED IN A MANNER TO PROVIDE LEGIBILITY FROM A DISTANCE OF 5 FEET. STAMPING OR ETCHING, IF DESIRED, SHALL BE PERFORMED ON A SEPARATE PIECE OF STEEL AND ATTACHED TO THE STRUCTURE IN A MANNER APPROVED BY ENGINEERING.

COPY

QUAL CAT	A2	A1	ITEM	PART NO.	DESCRIPTION	SPECIFICATION
C	2		11		1 1/2 PLATE, 4 X 5	ASTM A-36 STEEL
C	2		10		ROUND BAR, #4 1/4 X 3 3/4 LG	ASTM A-36 STEEL
C	2		9		PLATE, 3/8 X #6 1/2	ASTM A-36 STEEL
C	2		8		1" PLATE, 8 1/4 X 8 3/4	ASTM A-36 STEEL
C	1		7		W8 X 58 X 49 LG	ASTM A-36 STEEL
C		1	6		HVY HEX NUT, 1 1/2-6 UNC-2B	ASTM A-563, GRADE A STEEL
C		1	5		SPRING PIN, 3/16 DIA X 2 1/4 LG	
C		1	4		HEX BOLT, 1 1/2-6 UNC-2A X 8 LG	ASTM A-307, GRADE A
C (10)		1	3	(1026277)	EYE FOUNDRY HOOK, 7/8", CAT. NO. A-329	CROSBY GROUP
	X	1	A2		LIFTING DEVICE WELDMENT	
		X	A1		LIFTING DEVICE ASSEMBLY	

REL	B. HARGIS	4/17/02
APPD		
APPD		
APPD	K. BROWNELL	4/17/02
ENGR	J. NICHOLS	4/17/02
QA	B. COUNTERMAN	4/17/02
CHECK	BRIAN KOONS	4/17/02
DRAWN	TGH	12/01

ITEM | QTY | NEXT ASSY

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8 — 3 PLACE DECIMALS ± NA
ANGLES ± 1° — 2 PLACE DECIMALS ± NA
1 PLACE DECIMAL ± NA

PACTEC Packaging Technology, Inc. — TRANSNUCLEAR, INC.

SLUDGE TRANSPORT SYSTEM
CASK LID LIFTING ADAPTER
ASSEMBLY

SCALE: 1/4 | WT. N/A
REV: 2 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-520
CADFILE: 12099-520-1R2.DWG

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/26/02

12099-600	1	1

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
	INITIAL RELEASE	TW	7/2/02
	1/0 & 2/0	BH	11/20/02

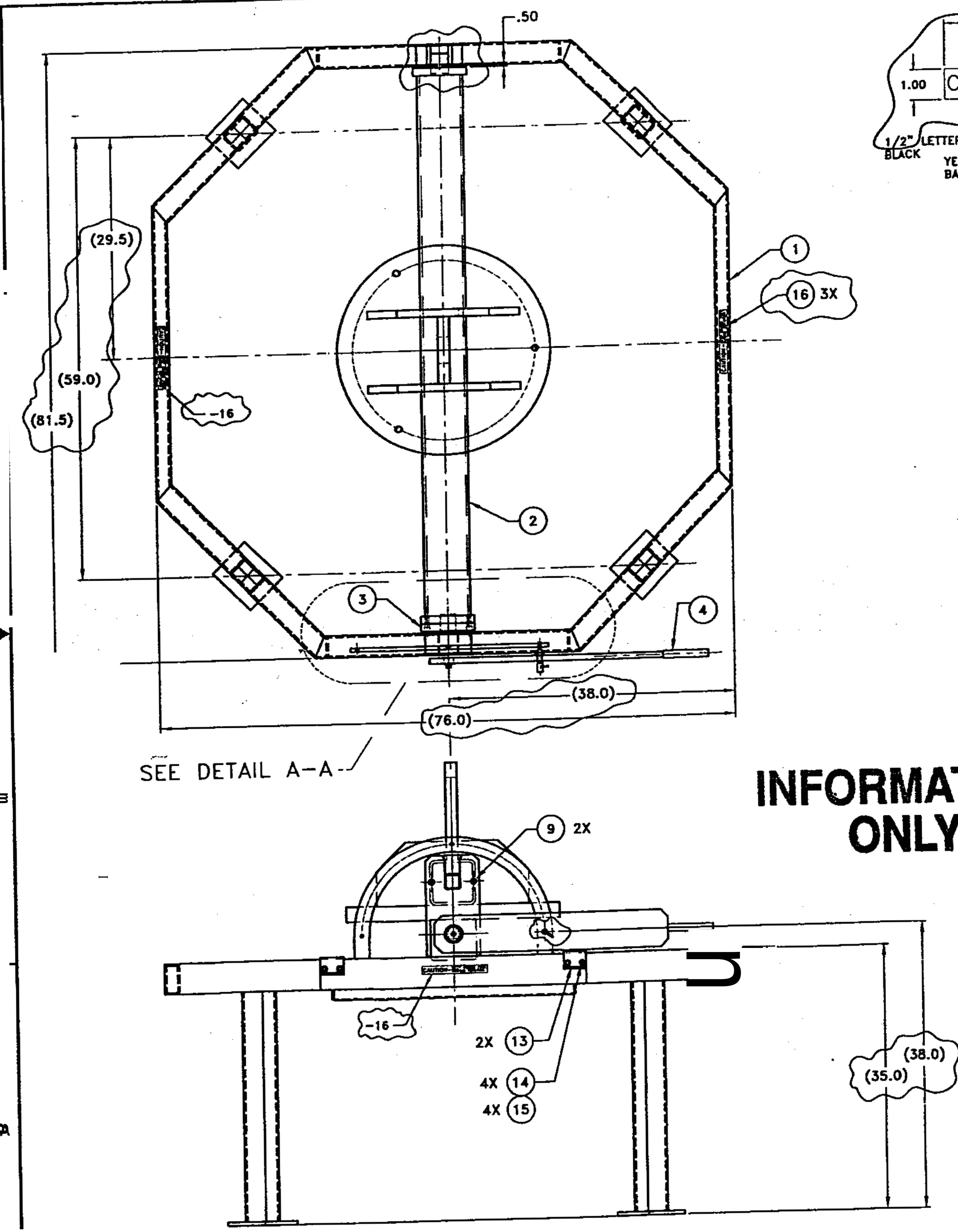
AS BUILT DRAWING

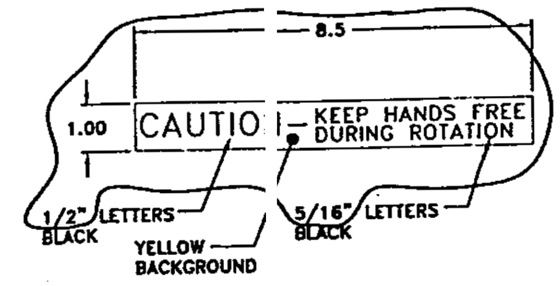
12099-600 Rev. 1

5709

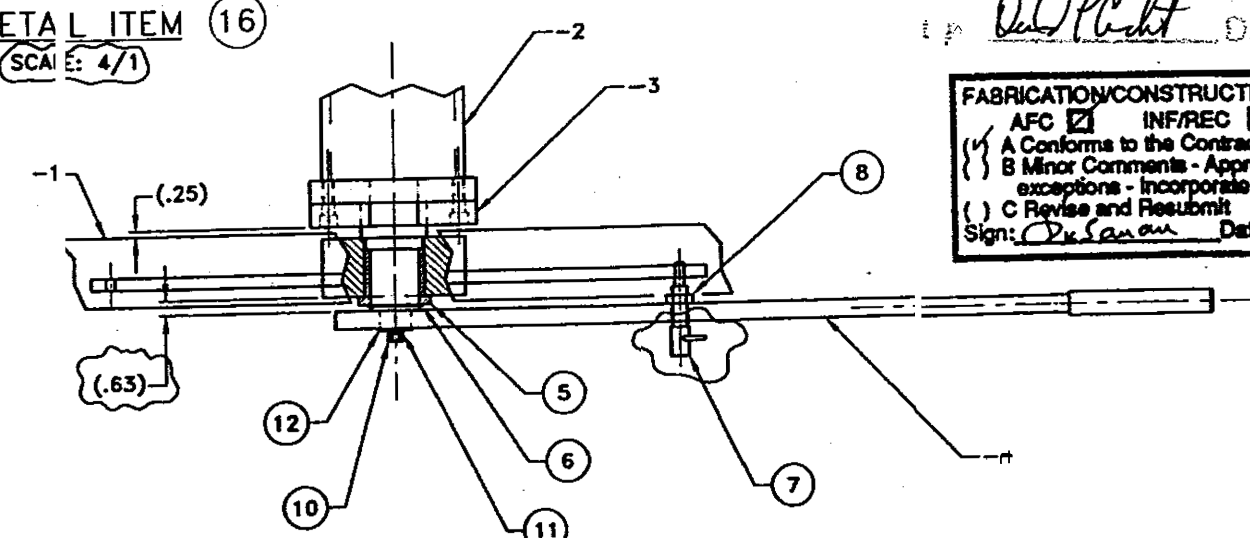
Date 11/26/02

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: Date: 11/27/02





DETAIL ITEM 16
SCALE: 4/1



DETAIL A-A
SCALE: 1/4

INFORMATION ONLY

Q/C	QTY (A1)	ITEM	PART NO.	DESCRIPTION	MATERIAL
	4	16		CAUTION LABEL - ADHESIVE BACKED	PLASTIC
	4	15		WASHER, FLAT, 1/4 NOM	ZN. PL. CS
	4	14		HHCS - 1/4-20UNC X 1-1/2	ZN. PL, ASTM A307
	2	13	8981K19	NEOPRENE PAD, 3/4" X 2 X 3 -70 DURO	McMASTER-CARR
	1	12		WASHER, FENDER, 17/32 ID X 2 OD	ZN. PL. CS
				WASHER, LOCK, 1/2 NOM	ZN. PL. CS
				BOLT, HEX HD, 1/2-13UNC X 1" LG	ZN. PL, ASTM A307
	1	10		SHCS, 5/8-11UNC X 1-1/4 LG	ASTM A574
	2	9		NUT, HEX, JAM, 5/8-11UNC	ZN PL, ASTM A563
	1	8			
	1	7	CL-10-LHRP	HAND RETRACTABLE PLUNGER	CARR-LANE
	1	6	5100-200	RETAINING RING	WALDES TRU-ARC
	1	5	FB3240-19	BRONZE BEARING	BOSTON GEAR
	1	4	12099-612	OPERATING LEVER WELDMENT	
	1	3	12099-611	PIVOT ARM WELDMENT	
	1	2	12099-500	LID LIFTING FIXTURE	
	1	1	12099-610	FRAME WELDMENT	
	X	A1		LID TURNING FIXTURE ASSEMBLY	

ASSEMBLY & QUANTITY — LIST OF MATERIAL

ITEM	QTY	NEXT ASSY			
A1	1	12099-100	REL	T. WAAGEN	7/2/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	7/2/02
			ENGR	D. RAELSIO	7/2/02
			QA	B. COUNTERMAN	7/2/02
			CHECK	F. STEINER	7/2/02
			DRAWN	DAN	6-19-02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

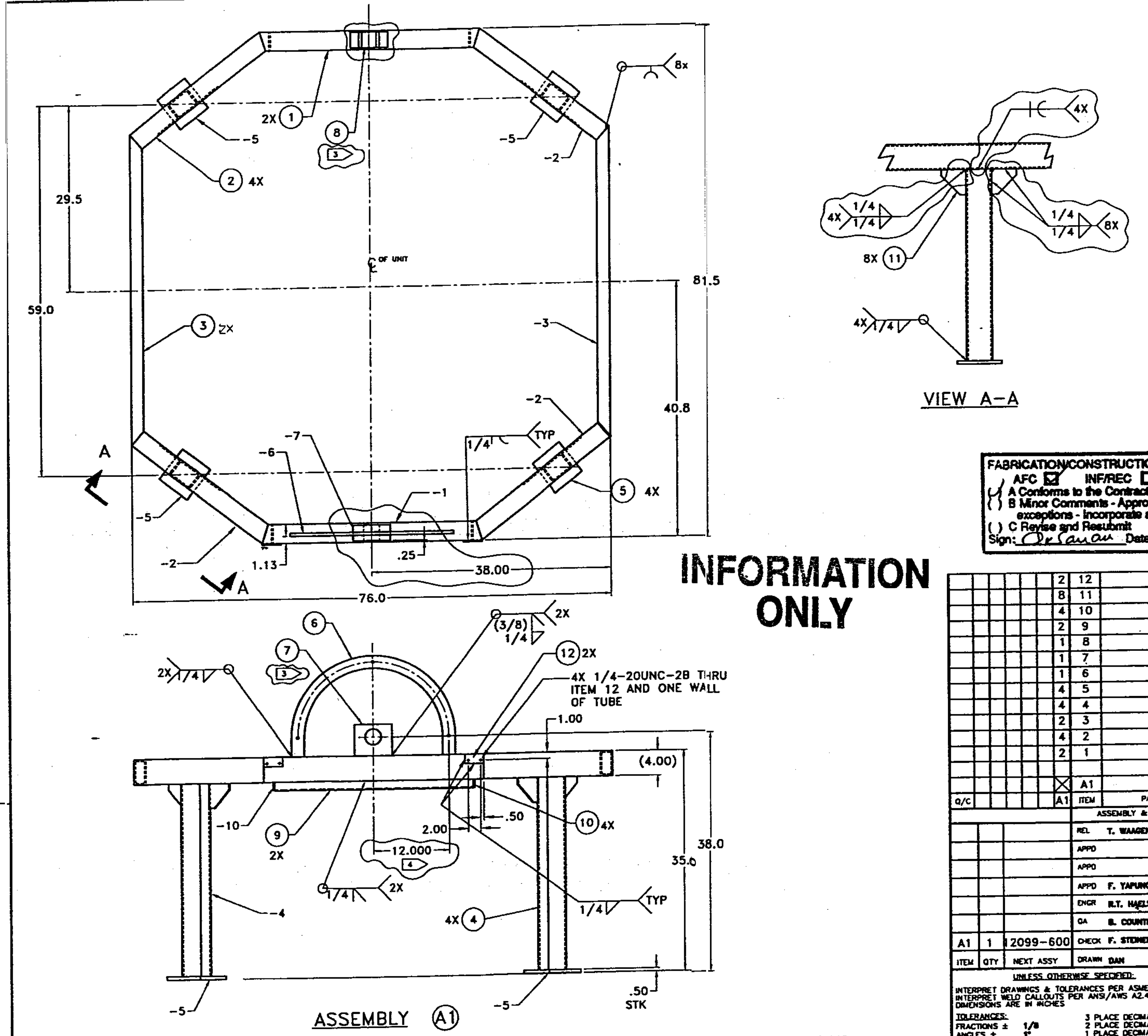
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

FRAME ASSEMBLY
LID TURNING FIXTURE
SLUDGE TRANSPORTATION SYSTEM

SCALE: 1/8 | WT. N/A
REV: 1 | SHEET 1 OF 1
DWG SIZE D | DWG NO. 12099-600
CADFILE: 12099600011.DWG

12099-610	1	1		
REVISION HISTORY				
REV	DESCRIPTION		REL	DATE
0	INITIAL RELEASE		TW	7/2/02
1	SEE DCN 1/0		BH	11/1/02



INFORMATION ONLY

NOTES, UNLESS OTHERWISE SPECIFIED:

1. MANUFACTURER'S FABRICATION STANDARDS SHALL APPLY.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. MANUFACTURER SHALL CONFIRM ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. PRIOR TO WELDING ASSURE THAT HOLE IN ITEM 7 AND SLOT IN ITEM 8 ARE INLINE WITHIN .03.
4. INDICATED DIMENSION IS CRITICAL.
5. ALL WELD PROCEDURES AND WELDING OPERATORS SHALL BE QUALIFIED IN ACCORDANCE WITH ASME CODE, SECTION IX.

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: De Saulau Date: 11/27/02

AS-BUILT DRAWING
No. 12099-610 Rev. 1
Serial No.(s) 5709
Signature David Probst Date 11/26/02

QTY	ITEM	PART NO.	DESCRIPTION	MATERIAL
2	12		PL, 1/4 THK X 2 X 3	ASTM A36
8	11		PL, 1/4 THK X 4 X 4	ASTM A36
4	10		PL, 1/4 THK X 1.3 X 2.8	ASTM A36
2	9		C3X4.1 X 31.5	ASTM A36
1	8		PL, 2-1/2 THK X 5.0 X 6.0	ASTM A36
1	7		PL, 2-1/2 THK X 5.0 X 6.0	ASTM A36
1	6		PL, 1/2 THK X 16.0 X 26.0	ASTM A36
4	5		PL, 1/2 THK X 6.0 X 7.0	ASTM A36
4	4		TUBING, RECT, 4 X 3 X 1/4 X 30.5	ASTM A500 GRB
2	3		TUBING,RECT, 4 X 2 X 1/4 X 49.5	ASTM A500 GRB
4	2		TUBING, RECT, 4 X 3 X 1/4 X 26.1	ASTM A500 GRB
2	1		TUBING, RECT, 4 X 3 X 1/4 X 34.9	ASTM A500 GRB
X	A1		FRAME WELDMENT	
Q/C A1	ITEM	PART NO.	DESCRIPTION	
ASSEMBLY & QUANTITY			LIST OF MATERIAL	

ITEM	QTY	NEXT ASSY			
			REL	T. WAAGEN	7/2/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	7/2/02
			ENGR	R.T. HAELSIG	7/2/02
			QA	B. COUNTERMAN	7/2/02
A1	1	12099-600	CHECK	F. STEINER	7/2/02
			DRAWN	DAN	6-19-02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

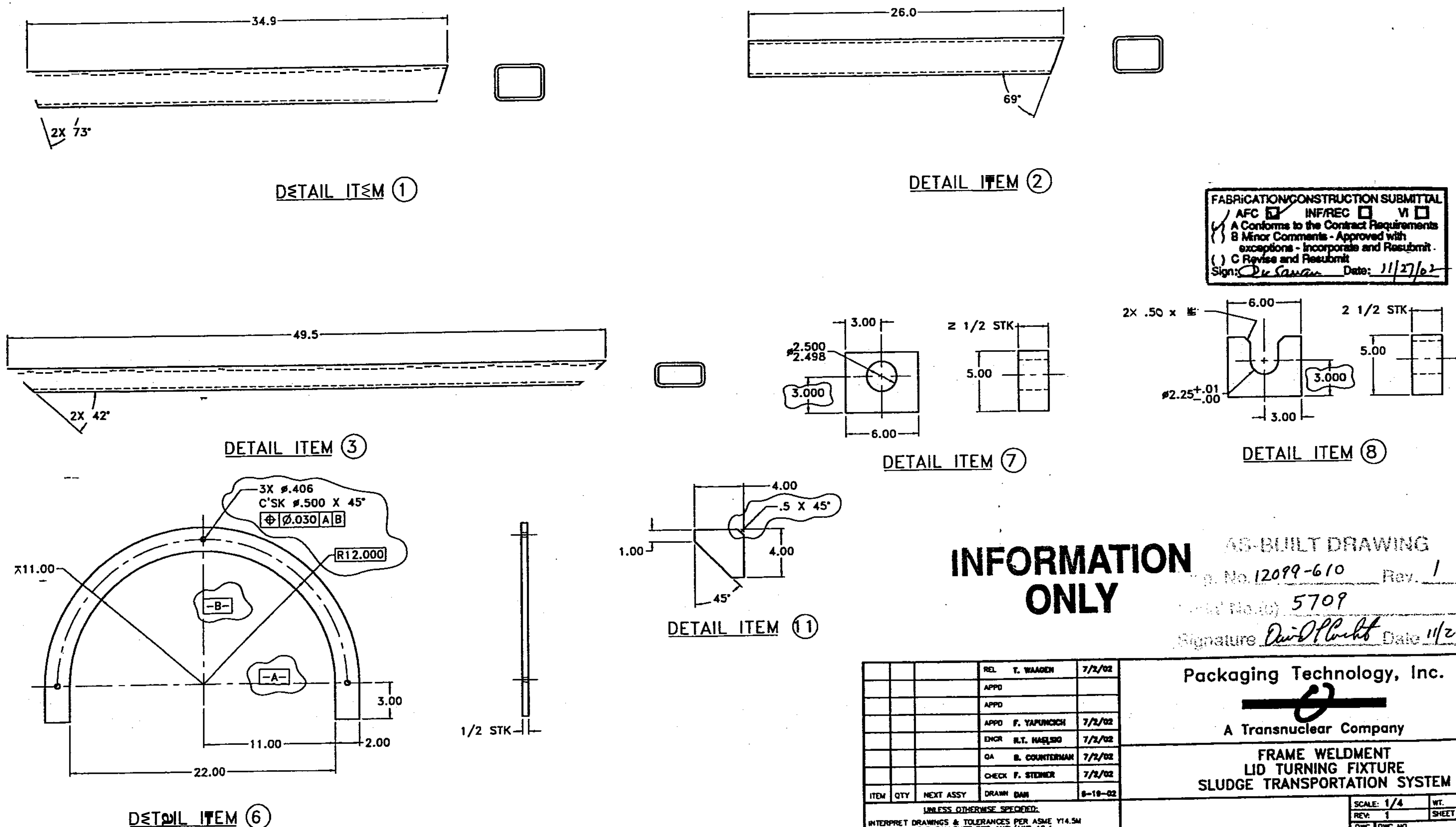
FRAME WELDMENT
LID TURNING FIXTURE
SLUDGE TRANSPORTATION SYSTEM

SCALE: 1/8 | WT. N/A
REV: 1 | SHEET 1 OF 2
DWG SIZE D | DWG NO. 12099-610
CADFILE: 12099610I1.DWG

12099-610	2	1

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	TW	7/2/02
1	SEE DCN 1/0	BH	11/11/02



FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit.
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

INFORMATION ONLY

AS-BUILT DRAWING
Dwg. No. 12099-610 Rev. 1
[illegible] No.(s) 5709
Signature [signature] Date 11/26/02

ITEM	QTY	NEXT ASSY		
			REL T. WAAGEN	7/2/02
			APPD	
			APPD	
			APPD F. YAPUNCICH	7/2/02
			ENGR R.T. HAELSIG	7/2/02
			QA B. COUNTERMAN	7/2/02
			CHECK F. STEINER	7/2/02
			DRAWN DAN	6-19-02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

FRAME WELDMENT
LID TURNING FIXTURE
SLUDGE TRANSPORTATION SYSTEM

SCALE: 1/4	WT. N/A
REV: 1	SHEET 2 OF 2
DWG SIZE D	DWG NO. 12099-610
CADFILE: 1209961021.DWG	

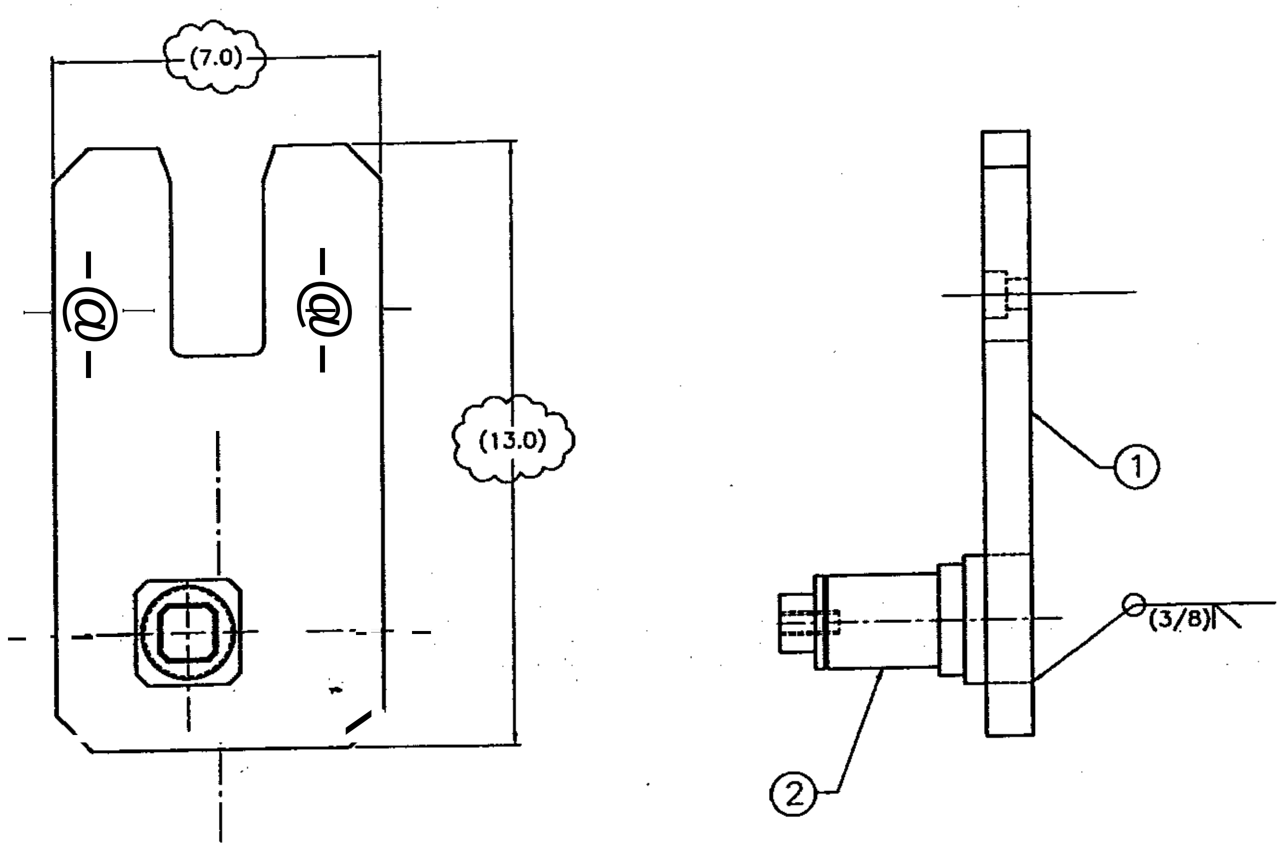
12099-611	1	1

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	TW	7/2/02
1	SEE DCN 1/0 & 2/0	BH	11/11/02

NOTES, UNLESS OTHERWISE SPECIFIED:

1. MANUFACTURER'S FABRICATION STANDARDS SHALL APPLY.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERANCE ONLY. MANUFACTURER SHALL CONFIRM ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. ALL WELD PROCEDURES AND WELDING OPERATORS SHALL BE QUALIFIED IN ACCORDANCE WITH ASME CODE, SECTION IX.



WELDMENT (A1)

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

INFORMATION ONLY

AS-BUILT DRAWING
Dwg. No. 12099-611 Rev. 1
5709
Signature [signature] Date 11/26/02

QUAL CAT						QTY	ITEM	PART NO.	DESCRIPTION	
						1	2		BAR, SQ. 2-3/4 X 2-3/4 X 5.4 LG	ASTM A36
						1	1		PL, 1 THK X 7.0 X (13.0)	ASTM A36
						X	A1		LID LIFTING FIXTURE WELDMENT	
						A1	ITEM	PART NO.	DESCRIPTION	
ASSEMBLY & QUANTITY									LIST OF MATERIAL	

ITEM	QTY	NEXT ASSY			
			REL	T. WAGAN	7/2/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	7/2/02
			ENGR	D. HAELSIG	7/2/02
			QA	B. COUNTERMAN	7/2/02
A1	1	12099-600	CHECK	F. STEINER	7/2/02
ITEM	QTY	NEXT ASSY	DRAWN	DAN	6/25/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

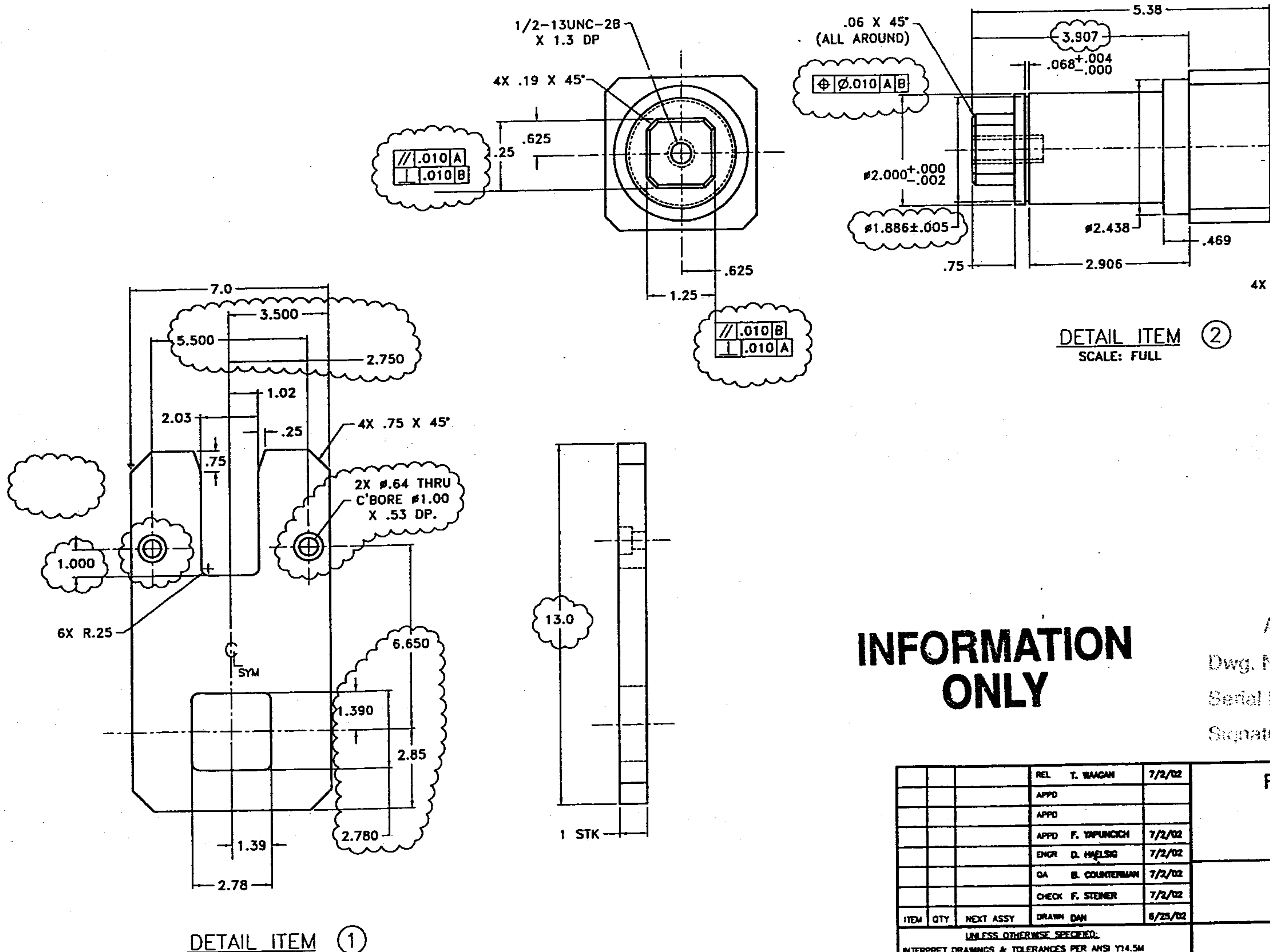
PIVOT ARM WELDMENT
LID TURNING FIXTURE
SLUDGE TRANSPORTATION SYSTEM

SCALE: 1/2 | WT. | REV: 1 | SHEET 1 OF 2
DWG SIZE D | DWG NO. 12099-611
CADFILE: 12099611I1.DWG

12099-611	2	1

REVISION HISTORY

REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	TW	7/2/02
1	SEE DCN 1/0 & 2/0	BH	11/11/02



FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

INFORMATION ONLY

AS-BUILT DRAWING
Dwg. No. 12099-611 Rev. 1
Serial No.(s) 5709
Signature [signature] Date 11/26/02

ITEM	QTY	NEXT ASSY			
			REL	T. WAAGAN	7/2/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	7/2/02
			ENGR	D. HAELSIG	7/2/02
			QA	B. COUNTERMAN	7/2/02
			CHECK	F. STEINER	7/2/02
			DRAWN	DAN	6/25/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

Packaging Technology, Inc.
A Transnuclear Company

PIVOT ARM
LID TURNING FIXTURE
SLUDGE TRANSPORTATION SYSTEM

SCALE: 1/2 | WT.
REV: 1 | SHEET 2 OF 2
DWG SIZE D | DWG NO. 12099-611
CADFILE: 120990611121.DWG

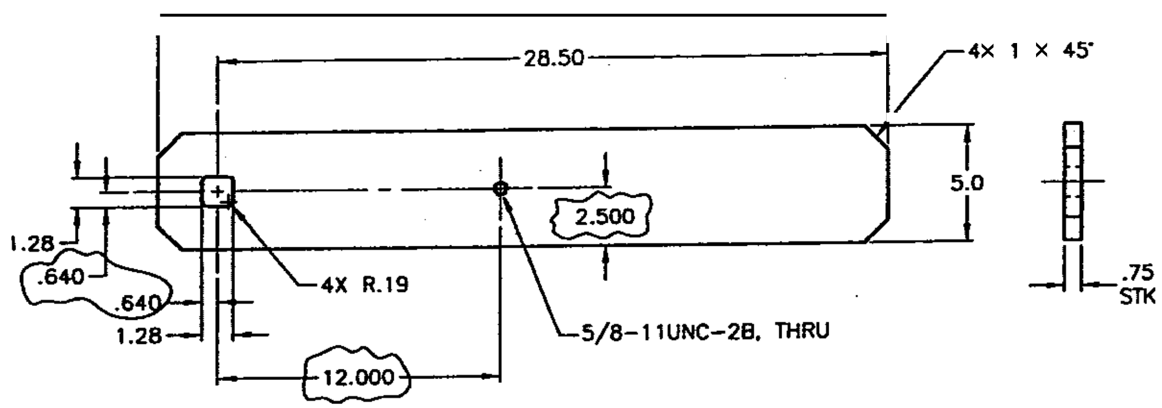
12099-612	1	1

REVISION HISTORY

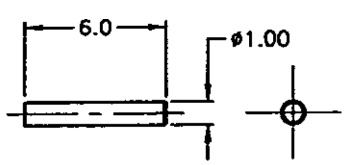
REV	DESCRIPTION	REL	DATE
0	INITIAL RELEASE	BH	9/20/02
1	SEE DCN 1/0	BH	11/19/02

NOTES, UNLESS OTHERWISE SPECIFIED:

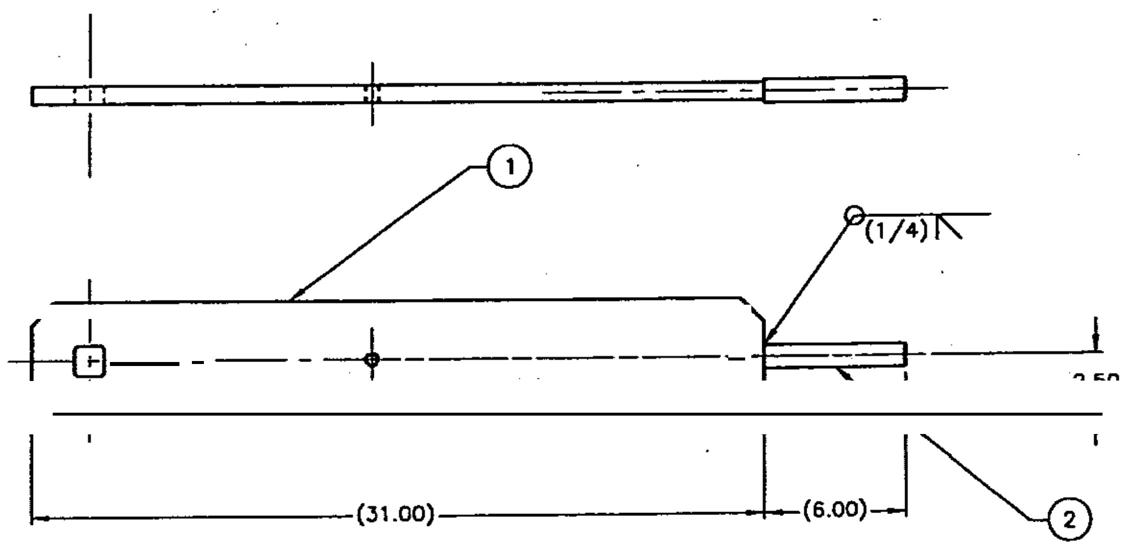
1. MANUFACTURER'S FABRICATION STANDARDS SHALL APPLY.
2. MATERIAL SIZES LISTED IN THE MATERIAL COLUMN ARE FOR REFERENCE ONLY. MANUFACTURER SHALL CONFIRM ACTUAL REQUIREMENTS PRIOR TO FABRICATION.
3. ALL WELD PROCEDURES AND WELDING OPERATORS SHALL BE QUALIFIED IN ACCORDANCE WITH ASME CODE, SECTION IX.



DETAIL ITEM 1



DETAIL ITEM 2



WELDMENT A1

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 11/27/02

INFORMATION ONLY

AS-BUILT DRAWING
Dwg. No. 12099-612 Rev. 1
Serial No.(s) 5709
Signature [signature] Date 11/26/02

QUAL CAT							ITEM	PART NO.	DESCRIPTION	MATERIAL
						1	2		ROUND BAR 1" X 6.0	AISI 1018
						1	1		PL, 3/4 THK X 5.0 X 31.0	ASTM A36
						☒	A1		OPERATING LEVER WELDMENT	
						A1	ITEM	PART NO.	DESCRIPTION	
							ASSEMBLY & QUANTITY		LIST OF MATERIAL	

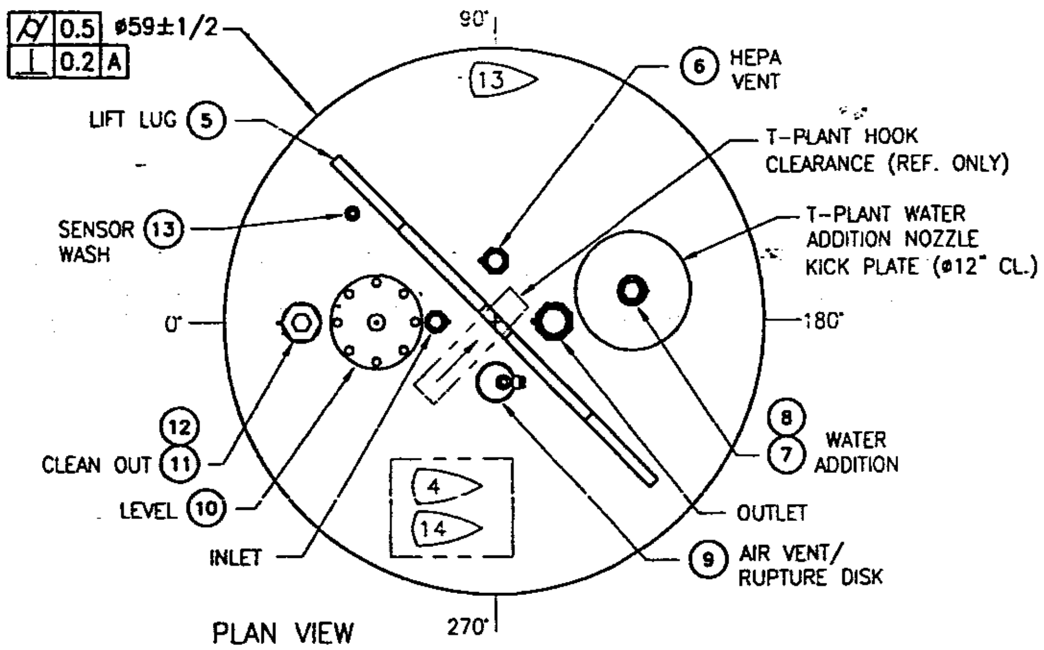
ITEM	QTY	NEXT ASSY			
			REL	T. WAAGEN	7/2/02
			APPD		
			APPD		
			APPD	F. YAPUNCICH	7/2/02
			ENGR	D. HAELSIG	7/2/02
			QA	B. COUNTERMAN	7/2/02
A1	1	12099-600	CHECK	F. STEINER	7/2/02
ITEM	QTY	NEXT ASSY	DRAWN	DAN	6/25/02

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ANSI Y14.5M
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ± 1/8
ANGLES ± 1°
3 PLACE DECIMALS ± .010
2 PLACE DECIMALS ± .03
1 PLACE DECIMAL ± .1

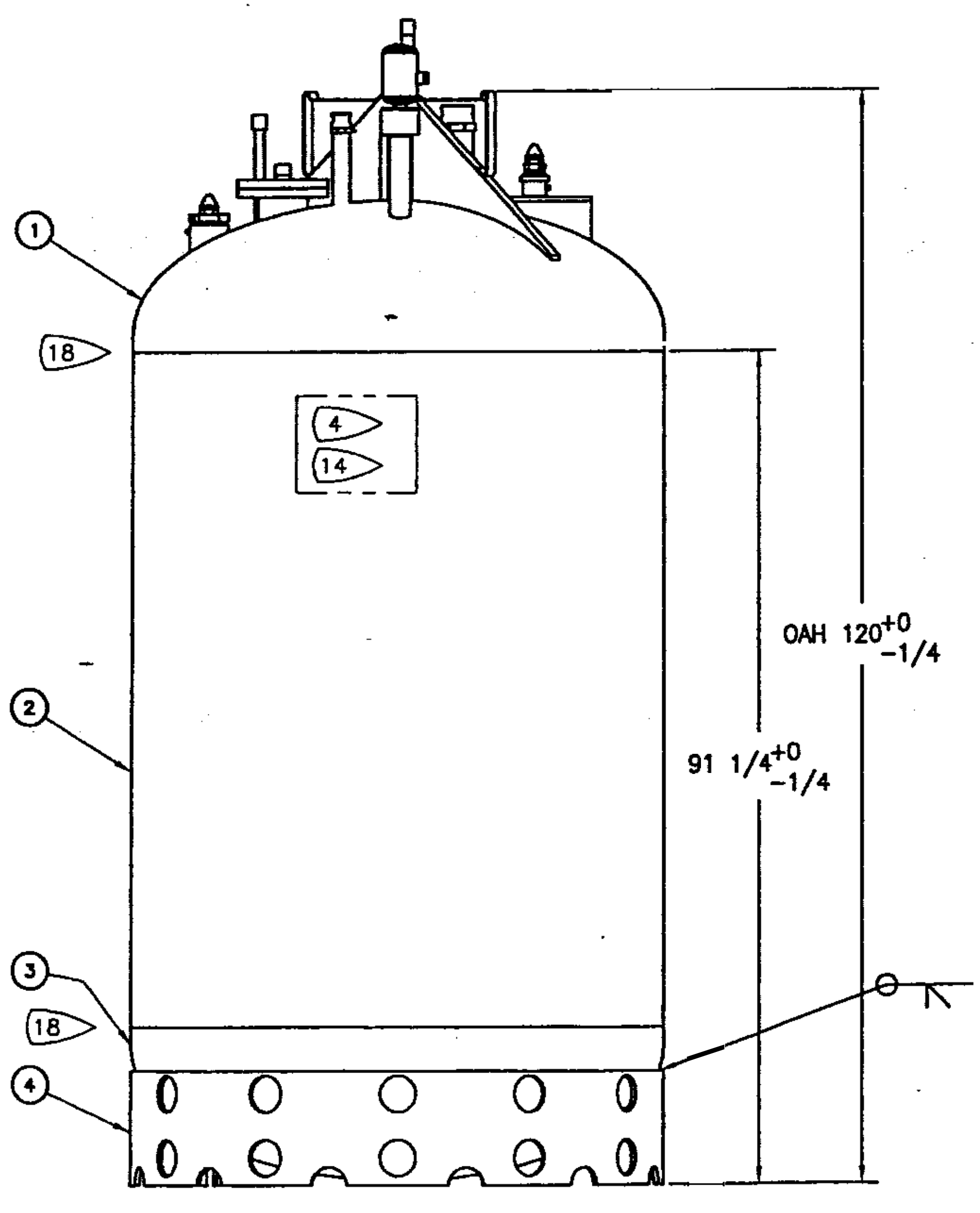
Packaging Technology, Inc.
A Transnuclear Company

OPERATING LEVER WELDMENT
LID TURNING FIXTURE
SLUDGE TRANSPORTATION SYSTEM

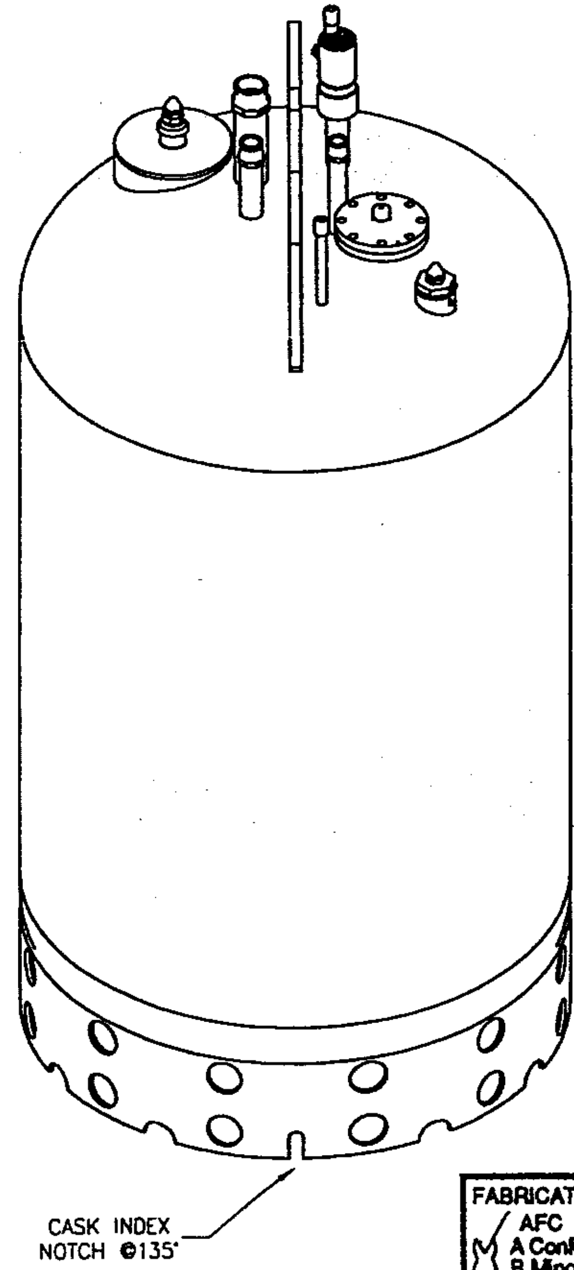
SCALE: 1/4 | WT.
REV: 1 | SHEET 1 OF 1
DWG SIZE: D | DWG NO. 12099-612
CADFILE: 1209961211.DWG



PLAN VIEW
TRUE ORIENTATION



ELEVATION
[OAH TO APEX OF LIFT LUG]



ISOMETRIC

NOTES:

1 MATERIALS, FABRICATION, NDE AND INSPECTIONS SHALL BE IN ACCORDANCE WITH THE ASME BOILER AND PRESSURE VESSEL CODE, SECTION VIII, DIVISION 1, 1998 w/ ADDENDA AND SPECIFICATION 3C40-0126-01.
DESIGN PRESSURE: 150 PSIG
DESIGN TEMPERATURE: 200°F

2 DUAL CERTIFICATION IS ACCEPTABLE FOR STAINLESS STEEL, I.E. 316/316L

3 ITEM-1 SHELL MAY BE FABRICATED FROM MORE THAN ONE PIECE, SEAM WELDED AS REQUIRED.

(4) "STENCIL BLACK PAINT, AMERICOTE 450-HS, 3/4" LETTERS ON THE TOP HEAD AND 1-1/2" LETTERS ON THE SHELL, THE FOLLOWING":
COLUMBIA, SC 29212
USA
AVANTECH INCORPORATED
COLUMBIA, SC 29212
GROSS WEIGHT: 17,100 LBS
EMPTY WT.: [TO BE WEIGHED BY FABRICATOR]
DATE OF MFG.:
SERIAL No.: (5)
LINER I.D.: A-170 PROCESS CONTAINER

(5) SERIAL NUMBER SHALL BE: AVANTECH JOB NUMBER – FIRST FOUR DRAWING NUMBER CHARACTERS – MMYY OF MANUFACTURE – SEQUENTIAL NUMBER, AVANTECH TO PROVIDE.

6 ALL PRESSURE BOUNDARY WELDS SHALL HAVE FULL RADIOGRAPH PERFORMED. AN ASME B16.11, 1" 3000# 1/2-COUPLING, MAY BE INSTALLED INTO THE BOTTOM HEAD TO ALLOW SOURCE ACCESS. THE COUPLING SHALL BE LOCATED TO ENSURE FLOOR CLEARANCE OF NO LESS THAN 1/4" IS MAINTAINED AND SHALL HAVE A MATING ASME B16.11 PIPE PLUG INSERTED, SEAL WELDED PER CODE AND INSPECTED PRIOR TO FINAL HYDRO.

7 DEBURR, BREAK ALL SHARP EDGES, AND REMOVE ALL WELD SPATTER.

8 ALL WELDS ON STAINLESS STEEL PIPE SHALL BE FULL PENETRATION, EXCEPT AS NOTED.

9 CAM-LOCKS SHALL PROPERLY MATE AND SEAL WITH FITTINGS MANUFACTURED TO MIL-C-27487.

10 HYDROSTATIC (OR PNEUMATIC) TEST PRESSURE BOUNDARIES TO 225 PSI, FOR TEN (10) MINUTES. NDE REPORT REQUIRED. NO LEAKS PERMITTED.

11 LIFT TEST TO ANSI N14.6 (25,650 LBS) WITH PT PRE/POST. NDE REPORT REQUIRED.

12 PIPE THREADS SHALL CONFORM TO ANSI/ASME B-1.20.1, (PIPE THREADS, GENERAL PURPOSE), OR ANSI/ASME B-1.20.3, (DRY SEAL PIPE THREADS).
VENDOR SHALL VERIFY CONFORMANCE TO ANSI/ASME B-1.20.1 OR ANSI/ASME B-1.20.3.
USE ANTI-SIEZE ON STAINLESS FASTENERS.

(13) NOZZLES: STENCIL BLACK PAINT, AMERICOTE 450-HS, 3/4" LETTERS, "[AS SHOWN]"

(14) "STENCIL BLACK PAINT, AMERICOTE 450-HS, 3/4" LETTERS ON THE TOP HEAD AND 1-1/2" LETTERS ON THE SHELL, LETTERS: "SWS-[SEQUENTIAL NUMBER]"

15 PAINT LIFT LUG WITH AMERICOTE 450-HS, COLOR YELLOW

16 GENERAL TOLERANCES APPLY UNLESS OTHERWISE NOTED, INCLUDING ALL REFERENCED DRAWINGS

17 SURFACE FINISH IS APPLICABLE ONLY TO EXTERIOR SURFACES.

(18) ENSURE HEAD AND SHELL ARE MATCHED TO MAINTAIN FIT-UP COMPLIANCE WITH THE ASME B&PV CODE, SECTION VIII, DIVISION 1, 1998 w/ ADDENDA

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

AS-BUILT DRAWING
Dwg. No. 3C40-0126-D Rev. 2
Serial No.(s) 01,02,03,04,05,06
Signature [signature] Date 12/4/02

INFORMATION ONLY

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
13	1	LEVEL SENSOR WASH, SEE DETAIL B, SHEET 3 OF 8	–
12	1	3" CLEAN OUT PLUG, SEE DETAIL J SHEET 3 OF 8	–
11	1	3" CLEAN OUT, SEE NOZZLE DETAIL A, SHEET 3 OF 8	–
10	1	LEVEL SENSOR AND MOUNT, SHEET 4 OF 8	–
9	1	AIR VENT OR RUPTURE DISK, (BY OTHERS), SHEET 4 OF 8	–
8	1	2" PUREX PLUG, SEE DETAIL J SHEET 3 OF 8	–
7	1	PUREX WATER ADDITION NOZZLE, SHEET 3 OF 8	–
6	1	HEPA FILTER (BY OTHERS), SHEET 4 OF 8	–
5	1	LIFT LUG AND GUIDE, SHEET 3 OF 8	–
4	1	VESSEL SUPPORT SKIRT, SHEET 2 OF 8	–
3	1	2:1 ELLIPTICAL HEAD, 1/2" THICK x 59±1/2" OD, 316 SS	ASME SA-240
2	1	PLATE, 1/2" THK x 74" x LG AS REQ'D, ROLL TO 59±1/2" OD, 316 SS	ASME SA-240
1	1	2:1 ELLIPTICAL HEAD, 3/4" THICK x 59±1/2" OD, 316 SS	ASME SA-240

BILL OF MATERIALS

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

AVANTech
The POWER of PEOPLE Realizing POTENTIAL

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K-EAST BASIN STS
A-170 ASSEMBLY
LARGE CONTAINER

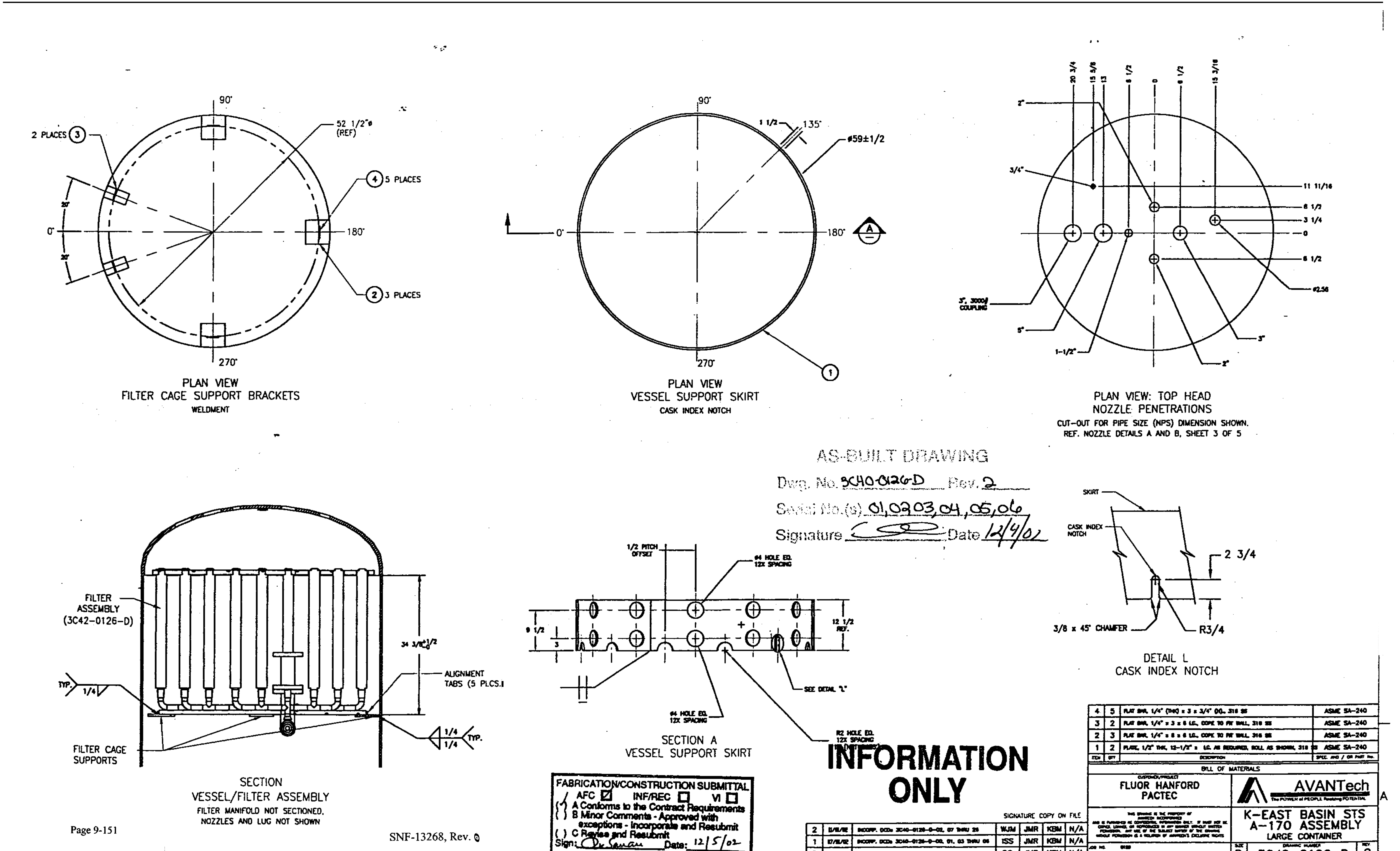
SIZE: D | DRAWING NUMBER: 3C40-0126-D | REV: 2

SIGNATURE COPY ON FILE

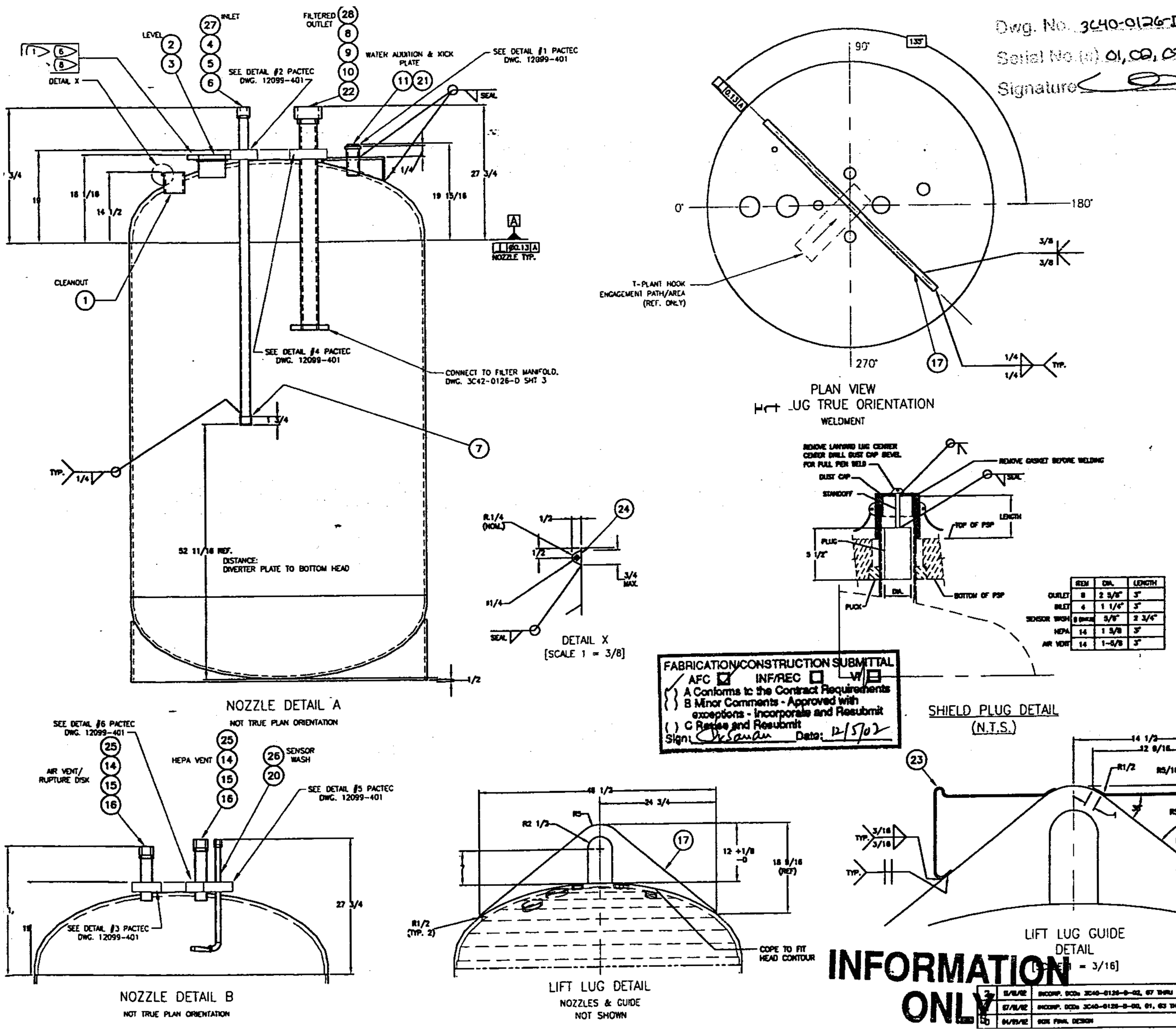
REV	DATE	DESCRIPTION	DRAWN	CHECKED	ENGINEER	APPROVED
2	11/6/02	INCORP. DCDs 3C40-0126-D-02, 07 THRU 29	WJM	JMR	KBM	N/A
1	07/15/02	INCORP. DCDs 3C40-0126-D-00, 01, 03 THRU 06	ISS	JMR	KBM	N/A
0	04/19/02	BOE FINAL DESIGN	DC	JMR	KBM	N/A

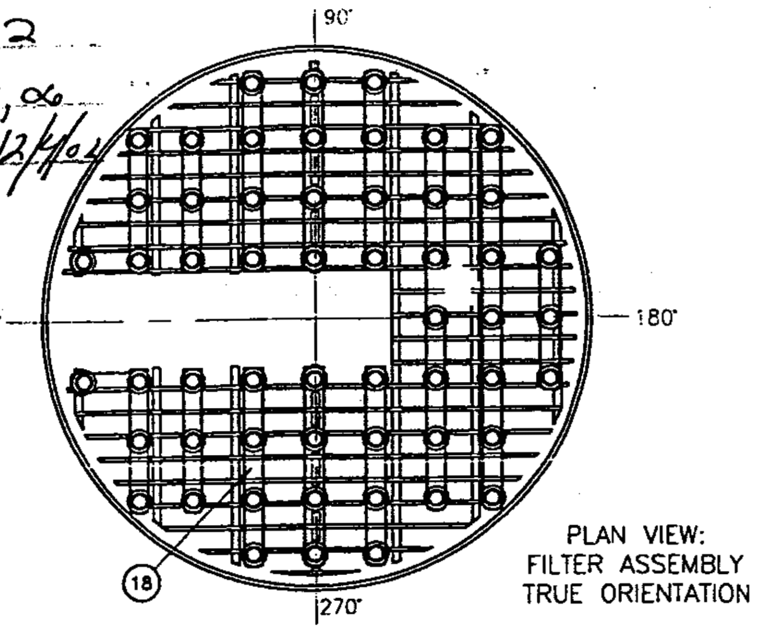
DIMENSIONS IN INCHES UNLESS SPECIFIED

SCALE 1 = 3/28 | SHEET 1 OF 8



PLAN VIEW
FILTER CAGE SUPPORT BRACKETS
WELDMENT
2 PLACES 3
4 5 PLACES
2 3 PLACES
52 1/2"ø (REF)
90°
180°
270°
0°
PLAN VIEW
VESSEL SUPPORT SKIRT
CASK INDEX NOTCH
1 1/2
135°
ø59±1/2
PLAN VIEW: TOP HEAD
NOZZLE PENETRATIONS
CUT-OUT FOR PIPE SIZE (NPS) DIMENSION SHOWN.
REF. NOZZLE DETAILS A AND B, SHEET 3 OF 5
3", 3000# COUPLING
5"
1-1/2"
2"
3"
3/4"
ø2.56
11 11/16
AS-BUILT DRAWING
Dwg. No. 3C40-0126-D Rev. 2
Serial No.(s) 01,02,03,04,05,06
Signature Date 12/4/02
DETAIL L
CASK INDEX NOTCH
SKIRT
CASK INDEX NOTCH
2 3/4
R3/4
3/8 x 45° CHAMFER
SECTION
VESSEL/FILTER ASSEMBLY
FILTER MANIFOLD NOT SECTIONED.
NOZZLES AND LUG NOT SHOWN
FILTER ASSEMBLY (3C42-0126-D)
FILTER CAGE SUPPORTS
ALIGNMENT TABS (5 PLCS.)
34 3/16 ±1/2
SECTION A
VESSEL SUPPORT SKIRT
1/2 PITCH OFFSET
#4 HOLE EQ. 12X SPACING
R2 HOLE EQ. 12X SPACING
SEE DETAIL "L"
12 1/2 REF.
9 1/2
INFORMATION ONLY
FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Sign: Date: 12/5/02
BILL OF MATERIALS
4 5 FLAT BAR, 1/4" (THK) x 3 x 3/4" OD, 316 SS ASME SA-240
3 2 FLAT BAR, 1/4" x 3 x 6 LG, COPE TO FIT WALL, 316 SS ASME SA-240
2 3 FLAT BAR, 1/4" x 8 x 6 LG, COPE TO FIT WALL, 316 SS ASME SA-240
1 2 PLATE, 1/2" THK, 12-1/2" x LG AS REQUIRED, ROLL AS SHOWN, 316 SS ASME SA-240
SIGNATURE COPY ON FILE
2 INCORP. DCDs 3C40-0126-0-02, 07 THRU 25 WJM JMR KBM N/A
1 INCORP. DCDs 3C40-0126-0-00, 01, 03 THRU 06 ISS JMR KBM N/A
0 BOE FINAL DESIGN DC JMR KBM N/A
FLUOR HANFORD PACTEC
AVANTech
K-EAST BASIN STS
A-170 ASSEMBLY
LARGE CONTAINER
D 3C40-0126-D 2





NOTES:

1. TACK WELD, AT LEAST (2) PLACES, FLANGE NUTS (STD. HEX, QTY 8) TO ITEM-2. THE NUT SHOULD BE WELDED DIRECTLY TO THE FLANGE SURFACE AND CENTERED ON THE BOLT HOLE
2. TO FACILITATE ASSEMBLY, NO MORE THAN (2) STD. NUTS (SEE NOTE 1) MAY BE MACHINED TO THICKNESS NO LESS THAN 0.400". ALTERNATIVELY NO MORE THAN (2) THIN JAM NUTS MAY BE USED
3. THE MODIFIED OR THIN (JAM) NUT FASTENER ASSEMBLIES, (SEE NOTE 2) (BOLT, NUT AND WASHER) SHALL BE PERMANENTLY MARKED WITH PAINT TO ENSURE THE ASSEMBLIES ARE DISTINGUISHED FROM THE REMAINING (6).
4. THE 5" FLANGE FASTENERS SHALL BE TORQUED TO 200±10 FT-LB.
5. FLANGE CONNECTIONS SHALL BE MADE USING 1/16" THICK CARBON FIBER GASKET (ASME B16.1) AND SS HEX HEAD FASTENERS.
6. MATCH DRILL 1/4"ø HOLE THRU ITEM-2 TO MATCH HOLE IN ITEM-3 SHEET 4 OF 5.
7. NOZZLE HEIGHT DIMENSIONS SHALL BE TO THE UPPER MOST SURFACE OF THE MALE CAM TYPE CONNECTORS (I.E. ITEMS 5,9 AND 15); EXCLUSIVE OF THE DUST CAP.
8. THE SLIP-ON FLANGE WELD SHALL BE PERFORMED IN GENERAL ACCORDANCE WITH ASME B&PV CODE SECTION VIII DIVISION 1 (1998 ED w/ADDENDA) UW-21, ESPECIALLY FIGURE 2.4 SKETCH 3. WHERE THE FRONT OR THE FACE WELD SHALL BE AS LARGE AS THE ITEM-3 WALL THICKNESS WILL ALLOW. THE BACK WELD SIZE SHALL BE PER THE FIGURE AS CIRCUMFERENTIALLY COMPLETE AS POSSIBLE. IF THE WELD IS NOT CIRCUMFERENTIALLY COMPLETE THEN EFFORT SHOULD BE MADE TO PERFORM A SEAL FILLET WELD AS A MINIMUM WHERE WELDER TIP CLEARANCE IS NOT ADEQUATE FOR THE MINIMUM WELD DIMENSION.

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
28	1	PLUG, 2-5/8" DIA., WITH 3" LG. STANDOFF, SS	PACTEC
27	1	PLUG, 1-1/4" DIA., WITH 3" LG. STANDOFF, SS	PACTEC
26	1	PLUG, 5/8" DIA., WITH 2-3/4" LG. STANDOFF, SS	PACTEC
25	2	PLUG, 1-5/8" DIA., WITH 3" LG. STANDOFF, SS	PACTEC
24	1	PLATE OR WASHER, 3/16" THK x AS REQ'D, FAB AS SHOWN NOM., SS	COMMERCIAL
23	2	PLATE, 3/16" THK, 1-1/4" x LG. AS REQ'D, FORM AS SHOWN, 316 SS	ASTM A-240
22	1	3" LAP JOINT FLANGE w/ SHORT STUB END, CLASS 150, 300 SERIES SS	ASME B16.5
21	1	KICK PLATE, SEE DETAIL H SHEET 5 OF 5	–
20	1	SENSOR WASH SPOOL, SEE DETAIL I SHEET 5 OF 5	–
19	–	[DELETED]	–
18	1	FILTER ASSEMBLY, DWG. 3C42-0126-D	–
17	1	PLATE, 1-1/4" THK, 18-9/16 x 48-1/2, COPE TO FIT, 316 SS	ASTM A-240
16	2	2" PIPE x LG. AS REQUIRED, TOE, SCH 40, 316 SS	ASME SA-312
15	2	2" CAM TYPE ADAPTER, M x FPT, SS	PT COUPLING 20A
14	2	2" CAM TYPE DUST CAP, SS	PT COUPLING 20V
13	–	[DELETED]	–
12	–	[DELETED]	–
11	1	PUREX WATER ADDITION NOZZLE, SEE DETAIL K SHEET 5 OF 5	–
10	1	3" PIPE x 41-1/2" NOM. LG., TOE, SCH 40, 316 SS	ASME SA-312
9	1	3" CAM TYPE ADAPTER, M x FPT, SS	PT COUPLING 30A
8	1	3" CAM TYPE DUST CAP, SS	PT COUPLING 30V
7	1	BAFFLE PLATE, DETAIL F SHEET 4 OF 5	–
6	1	1-1/2 PIPE x 62 3/8" NOM. LG., TOE, SCH 40, 316 SS	ASME SA-312
5	1	1-1/2" CAM TYPE ADAPTER, M x FPT, SS	PT COUPLING 15A
4	1	1-1/2" CAM TYPE DUST CAP, SS	PT COUPLING 15V
3	1	5" PIPE x LG. AS REQUIRED, SCH 10, 316 SS	ASME SA-312
2	1	5" SLIP ON FLANGE, CLASS 150, RF, 300 SERIES SS	ASME B16.5
1	1	3" COUPLING, THD, 3000 LB, 316 SS	ASME B16.3

BILL OF MATERIALS

2	11/6/02	INCORP. DCDs 3C40-0126-D-02, 07 THRU 29	WJM	JMR	KBM	N/A
1	07/11/02	INCORP. DCDs 3C40-0126-D-00, 01, 03 THRU 06	ISS	JMR	KBM	N/A
0	04/11/02	ISSUE FINAL DESIGN	DC	JMR	KBM	N/A

SIGNATURE COPY ON FILE

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FLUOR HANFORD
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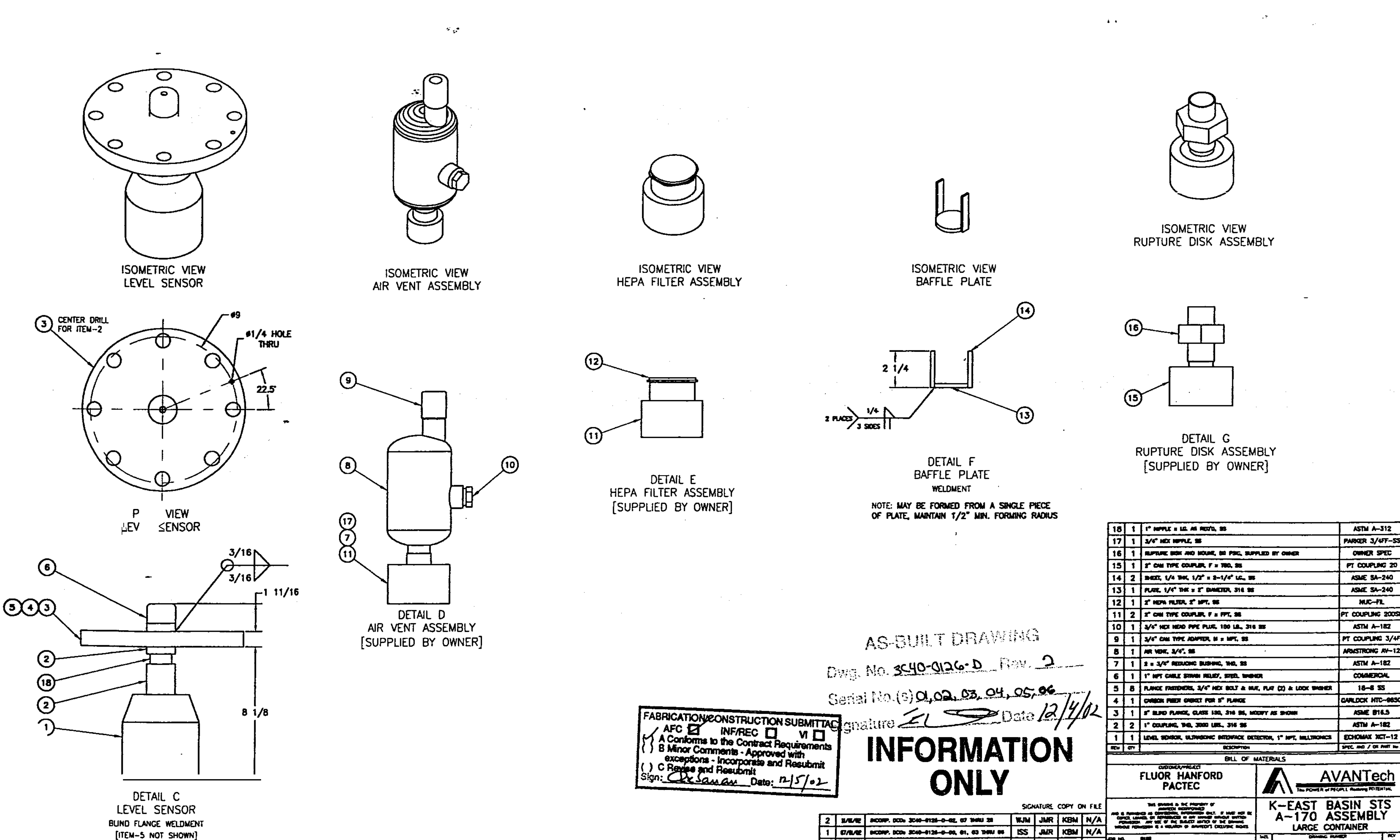
K-EAST BASIN STS
A-170 ASSEMBLY
LARGE CONTAINER

SIZE D | DRAWING NUMBER 3C40-0126-D | REV 2



ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
18	1	1" NIPPLE x LG. AS REQ'D, SS	ASTM A-312
17	1	3/4" HEX NIPPLE, SS	PARKER 3/4FF-SS
16	1	RUPTURE DISK AND MOUNT, 50 PSIG, SUPPLIED BY OWNER	OWNER SPEC
15	1	2" CAM TYPE COUPLER, F x THD, SS	PT COUPLING 20
14	2	SHEET, 1/4 THK, 1/2" x 2-1/4" LG., SS	ASME SA-240
13	1	PLATE, 1/4" THK x 2" DIAMETER, 316 SS	ASME SA-240
12	1	2" HEPA FILTER, 2" MPT, SS	NUC-FIL
11	2	2" CAM TYPE COUPLER, F x FPT, SS	PT COUPLING 200SL
10	1	3/4" HEX HEAD PIPE PLUG, 150 LB., 316 SS	ASTM A-182
9	1	3/4" CAM TYPE ADAPTER, M x MPT, SS	PT COUPLING 3/4F
8	1	AIR VENT, 3/4", SS	ARMSTRONG AV-12
7	1	2 x 3/4" REDUCING BUSHING, THD, SS	ASTM A-182
6	1	1" NPT CABLE STRAIN RELIEF, STEEL WASHER	COMMERCIAL
5	8	FLANGE FASTENERS, 3/4" HEX BOLT & NUT, FLAT (2) & LOCK WASHER	18-8 SS
4	1	CARBON FIBER GASKET FOR 5" FLANGE	GARLOCK HTC-9850
3	1	5" BLIND FLANGE, CLASS 150, 316 SS, MODIFY AS SHOWN	ASME B16.5
2	2	1" COUPLING, THD, 3000 LBS., 316 SS	ASTM A-182
1	1	LEVEL SENSOR, ULTRASONIC INTERFACE DETECTOR, 1" NPT, MILLTRONICS	ECHOMAX XCT-12

BILL OF MATERIALS

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

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K-EAST BASIN STS
A-170 ASSEMBLY
LARGE CONTAINER

3C40-0126-D 2

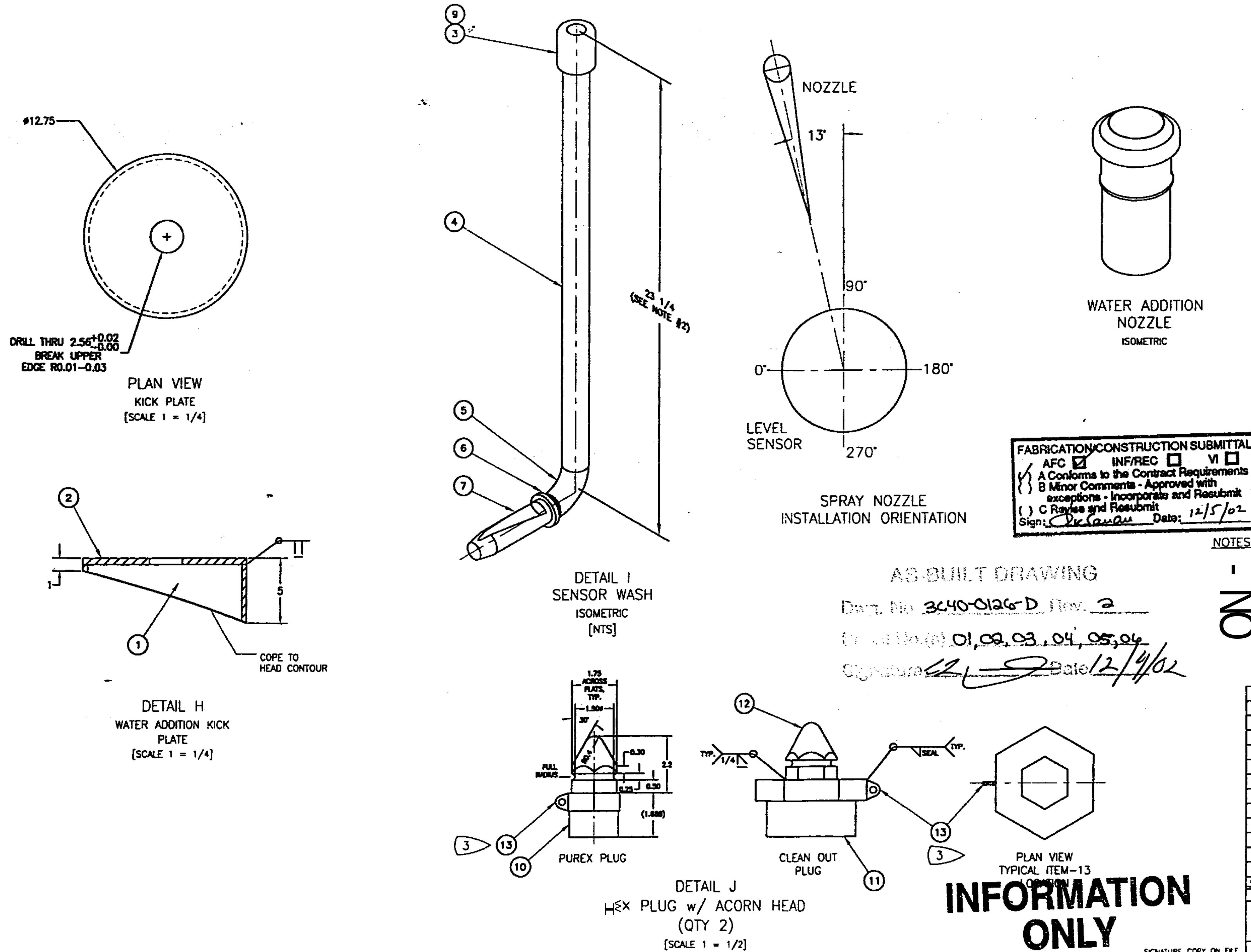
SIGNATURE COPY ON FILE

2	11/6/02	INCORP. DCDs 3C40-0126-0-02, 07 THRU 38	WJM	JMR	KBM	N/A
1	07/8/02	INCORP. DCDs 3C40-0126-0-01, 01, 03 THRU 06	ISS	JMR	KBM	N/A
0		PRELIMINARY DESIGN	DC	JMR	KBM	N/A

AS-BUILT DRAWING
Dwg. No. 3C40-0126-D Rev. 2
Serial No.(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/4/02

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

INFORMATION ONLY



PLAN VIEW
KICK PLATE
[SCALE 1 = 1/4]

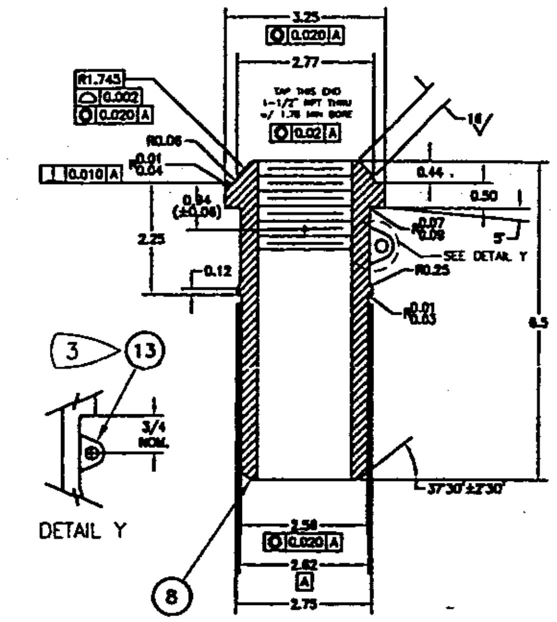
DETAIL H
WATER ADDITION KICK
PLATE
[SCALE 1 = 1/4]

DETAIL I
SENSOR WASH
ISOMETRIC
[NTS]

SPRAY NOZZLE
INSTALLATION ORIENTATION

DETAIL J
HEX PLUG w/ ACORN HEAD
(QTY 2)
[SCALE 1 = 1/2]

PLAN VIEW
TYPICAL ITEM−13
LOCATION



DETAIL K
WATER ADDITION NOZZLE
[SCALE 1 = 1/2]

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: DkCamau Date: 12/5/02

AS-BUILT DRAWING
Dwg. No 3C40-0126-D Rev. 2
Sheet No.(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/4/02

NOTES DETAIL K:

A. SURFACE FINISH 250 ALL OVER EXCEPT TAP AND AS NOTED

B. BREAK ALL SHARP CORNERS 1/64 MAX. ✓

NOTES:

1. SURFACE FINISH ONLY APPLICABLE TO SURFACES EXTERIOR TO THE VESSEL.

2. DETAIL I OVERALL HEIGHT DIMENSION SHALL BE TO THE UPPER MOST SURFACE OR THE MALE CAM TYPE CONNECTION (I.E. ITEMS 3) EXCLUSIVE OF THE DUST CAP.

3. REFERENCE SHEET 3 OF 5 DETAIL X FOR ITEM−13 FABRICATION AND ATTACHMENT WELD DETAILS.

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
13	3	PLATE OR WASHER, 3/16" THK x AS REQ'D, FAB AS SHOWN NOM., SS	COMMERCIAL
12	2	ROUND (OR HEX) BAR, 2" DIA. x LG. AS REQ'D, 316 SS	ASTM A−276
11	1	3" HEX HEAD PIPE PLUG, 316 SS	ASTM A−182
10	1	1−1/2" HEX HEAD PIPE PLUG, 316 SS	ASTM A−182
9	1	3/4" CAM TYPE DUST CAP, SS	PT COUPLING 3/4V
8	1	ROUND BAR, 3.25" DIA. x 6.5" LG., 316 SS	ASTM A−276
7	1	SPRAY NOZZLE, 1/2" MPT, 90° SPRAY ANGLE, SS	BETE SPN180
6	1	3/4 x 1/2 REDUCING BUSHING, THD, 316 SS	ASTM A−182
5	1	3/4" 90 ELBOW, THD, 150 LB., 316 SS	ASTM A−182
4	1	3/4" PIPE x LG. AS REQUIRED, TBE, SCH 40, 316 SS	ASME SA−312
3	1	3/4" CAM TYPE ADAPTER, M x FPT, SS	PT COUPLING 3/4F
2	1	PLATE, 1/2" THK x 12 3/4" OD, 300 SERIES SS	ASTM A−240
1	1	12" PIPE x LG. AS REQ'D, SCH 40 or STD, TRIM AS NEEDED, 300 SERIES SS	ASTM A−312

BILL OF MATERIALS

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

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K−EAST BASIN STS
A−170 ASSEMBLY
LARGE CONTAINER

JOB NO. 0126

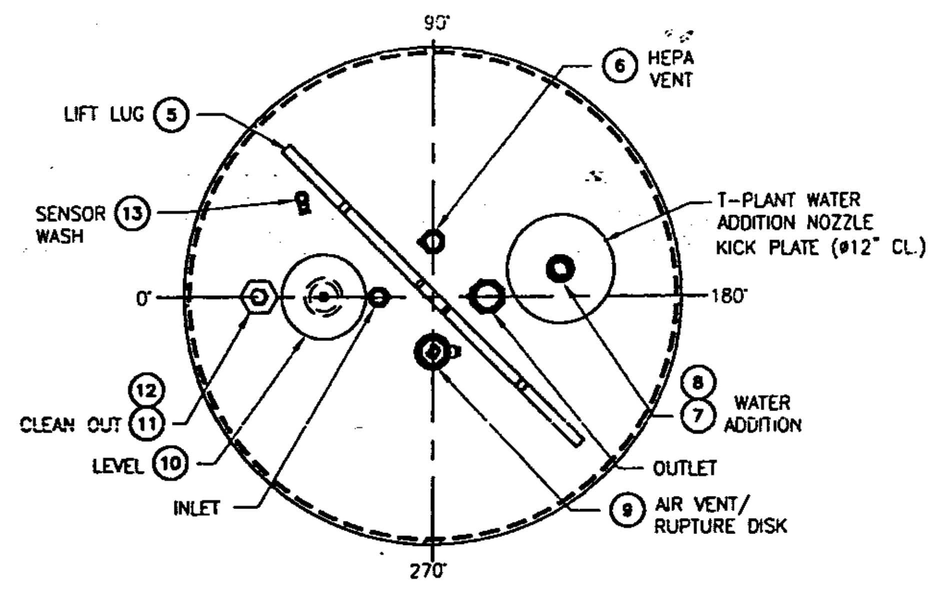
SIZE D | DRAWING NUMBER 3C40−0126−D | REV 2

SIGNATURE COPY ON FILE

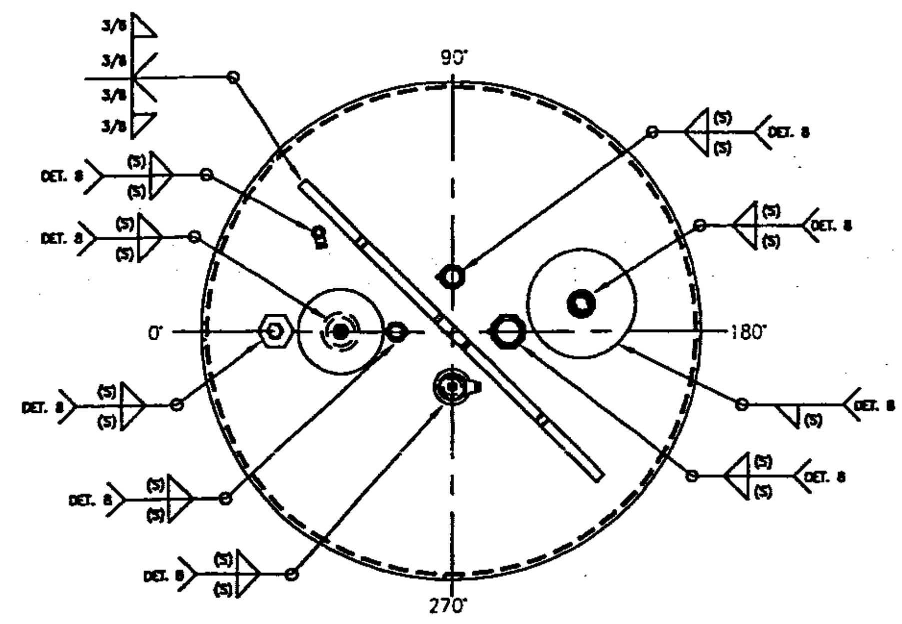
2	11/18/02	INCORP. DCDs 3C40-0126-D-02, 07 THRU 29	WJM	JMR	KBM	N/A
1	07/18/02	INCORP. DCDs 3C40-0126-D-00, 01, 03 THRU 06	ISS	JMR	KBM	N/A
0	04/19/02	FOR FINAL DESIGN; NEW SHEET 8	DC	JMR	KBM	N/A

INFORMATION ONLY

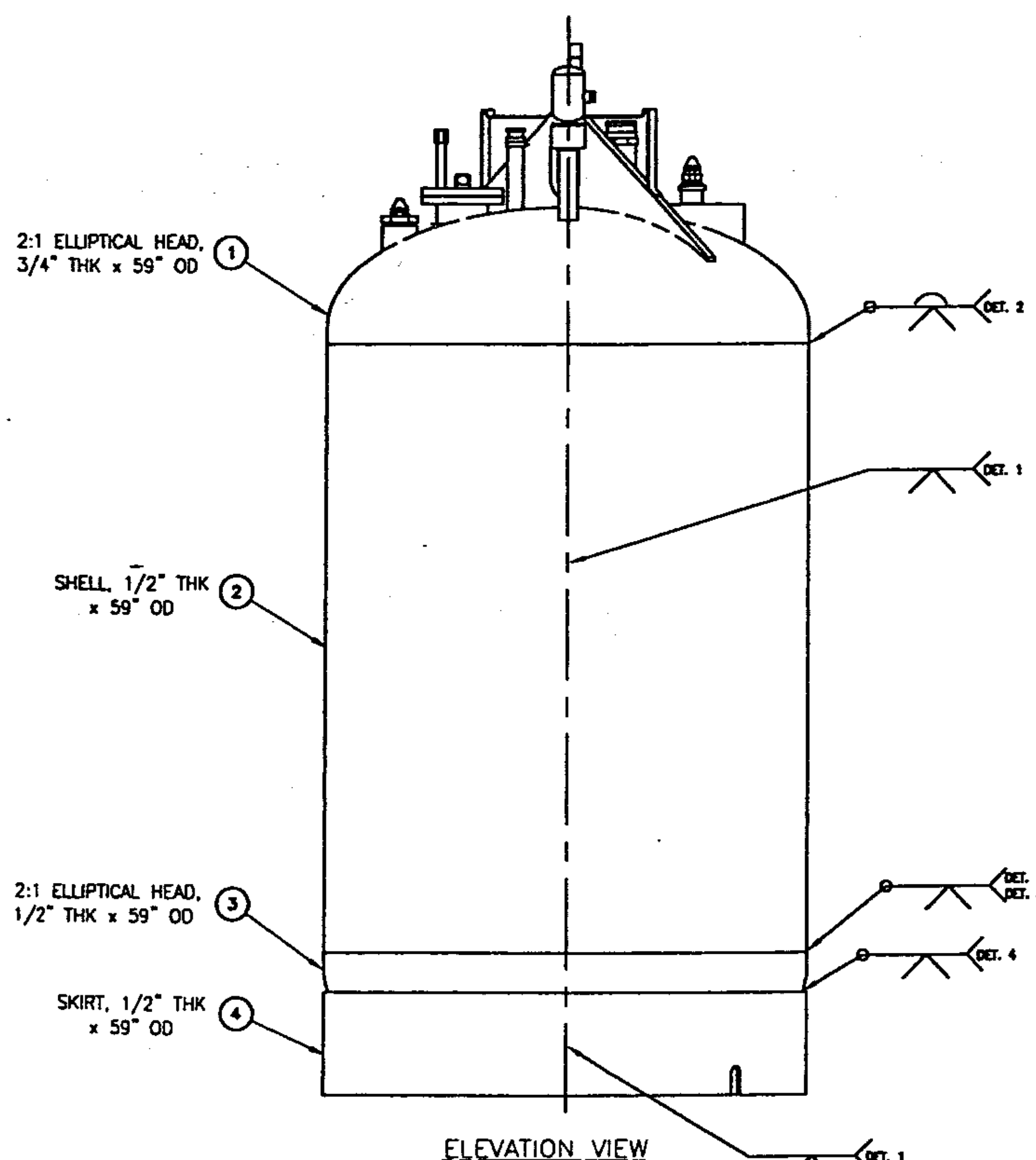
- NO



PLAN VIEW
TRUE ORIENTATION



NOZZLE WELD PENTRATIONS (8)



ELEVATION VIEW

AS-BUILT DRAWING
Dwg. No. 3C41-0126-D Rev. 1
Serial No.(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/4/02

NOTES:

1 MATERIALS, FABRICATION, NDE AND INSPECTIONS SHALL BE IN ACCORDANCE WITH THE ASME BOILER AND PRESSURE VESSEL CODE, SECTION VIII, DIVISION 1, 1998 w/ ADDENDA AND SPECIFICATION 3C40-0126-01 (SEE ALSO DRAWING 3C40-0126-D).
DESIGN PRESSURE: 150 PSIG
DESIGN TEMPERATURE: 200°F

2 DUAL CERTIFICATION IS ACCEPTABLE FOR STAINLESS STEEL, I.E. 316/316L

3 ITEM-2 SHELL MAY BE FABRICATED FROM MORE THAN ONE PIECE, SEAM WELDED AS REQUIRED.

4 FOR ALL WELD INFORMATION REFER TO WELD DETAILS; SHOP ORDER 1246. WD-1246, REV.1 9/4/02.

5 WELD SYMBOLS "S" = PIPE WALL THICKNESS MULTIPLIED BY 1.09".

INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

SIGNATURE COPY ON FILE

1	10/24/02	INCORPORATE DCO 3C41-0126-D-00	JM	ISS	KBM	N/A

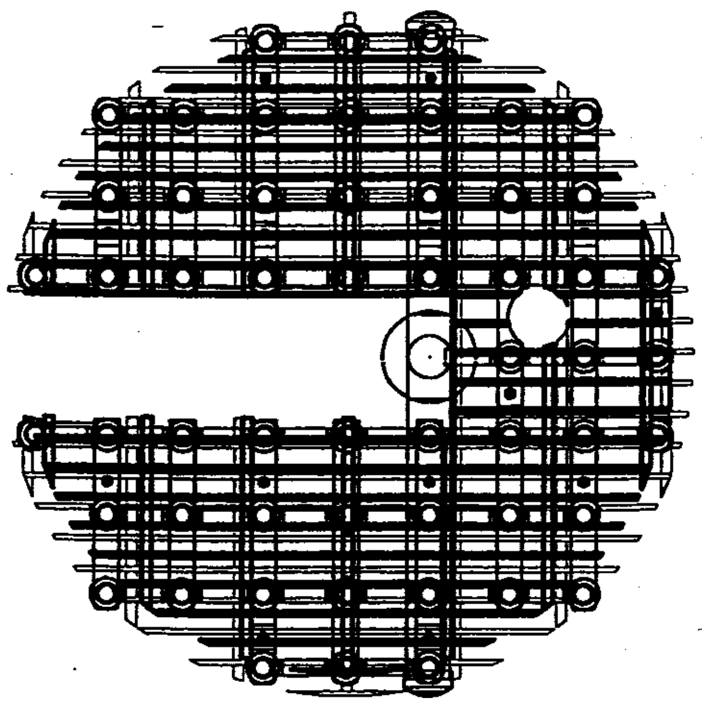
BILL OF MATERIALS

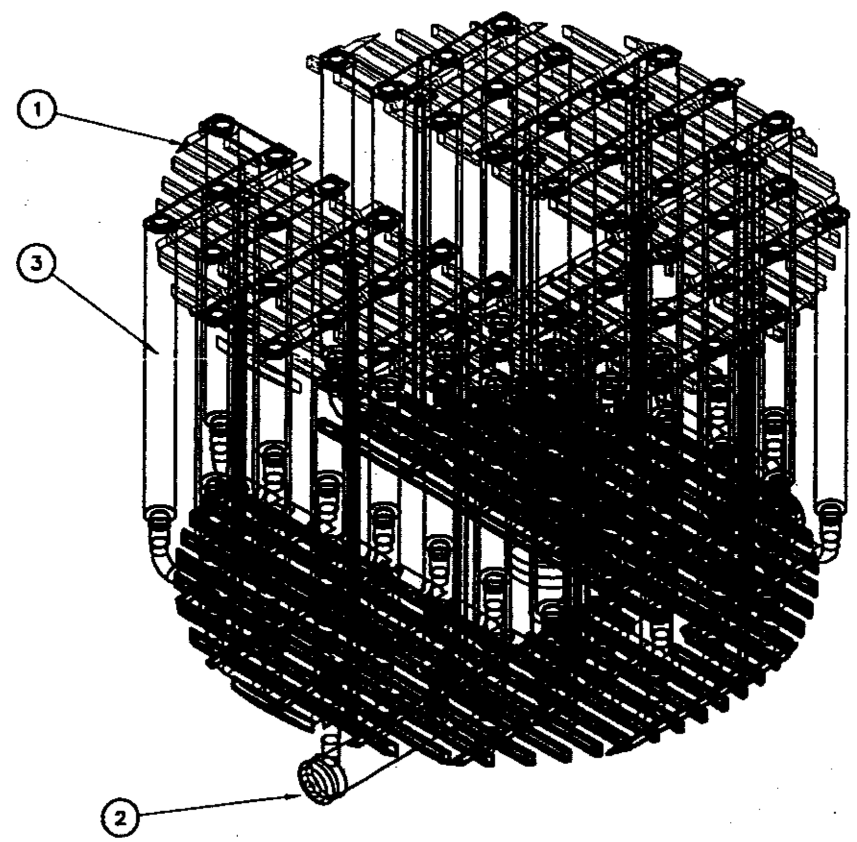
FLUOR HANFORD PACTEC

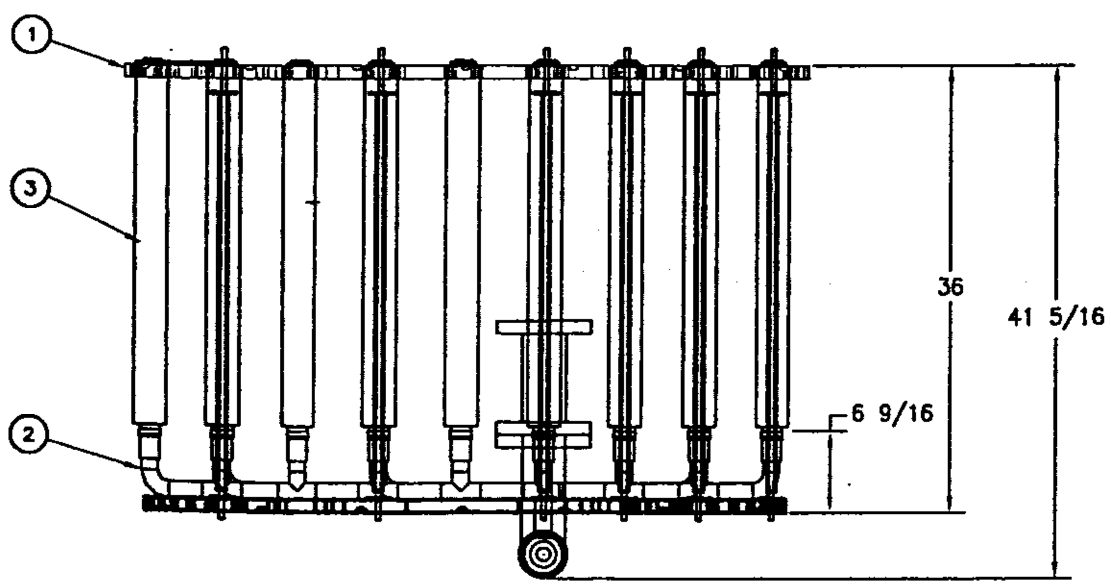
AVANTech

K-EAST BASIN STS A-170 LDC VESSEL FABRICATION

D 3C41-0126-D 1







AS-BUILT DRAWING
Dwg No. 3C42-0126-D Rev. 2
Serial No.(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/9/02

NOTES:

1.) MATERIALS, FABRICATION, NDE AND INSPECTIONS SHALL BE IN ACCORDANCE WITH SPECIFICATION 3C40-0126-01. REFER TO DWG 3C40-0126-D FOR FILTER ASSEMBLY INSTALLATION
2.) DUAL CERTIFICATION IS ACCEPTABLE FOR STAINLESS STEEL, I.E. 316/316L
3.) DIMENSIONS ARE FOR REFERENCE ONLY, UNLESS OTHERWISE NOTED.
4.) DEBURR, BREAK ALL SHARP EDGES, AND REMOVE ALL WELD SPATTER.
5.) THE UPPER AND LOWER SUPPORT GRIDS MAY BE COPED TO FIT TO ENSURE THE OUTLET NOZZLE PROPER FIT WITHIN THE LDC.

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
By: [signature] Date: 12/17/02

INFORMATION ONLY

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
3	55	FILTER, 8μ ABS, PLEATED, 30" LG, DOE w/ 222 O-RINGS, PP [CUNO]	BETAFINE XL
2	1	FILTER MANIFOLD - SEE SHEET 3 OF 4	-
1	1	FILTER CAGE - SEE SHEET 2 OF 4	-

BILL OF MATERIALS

SIGNATURE COPY ON FILE

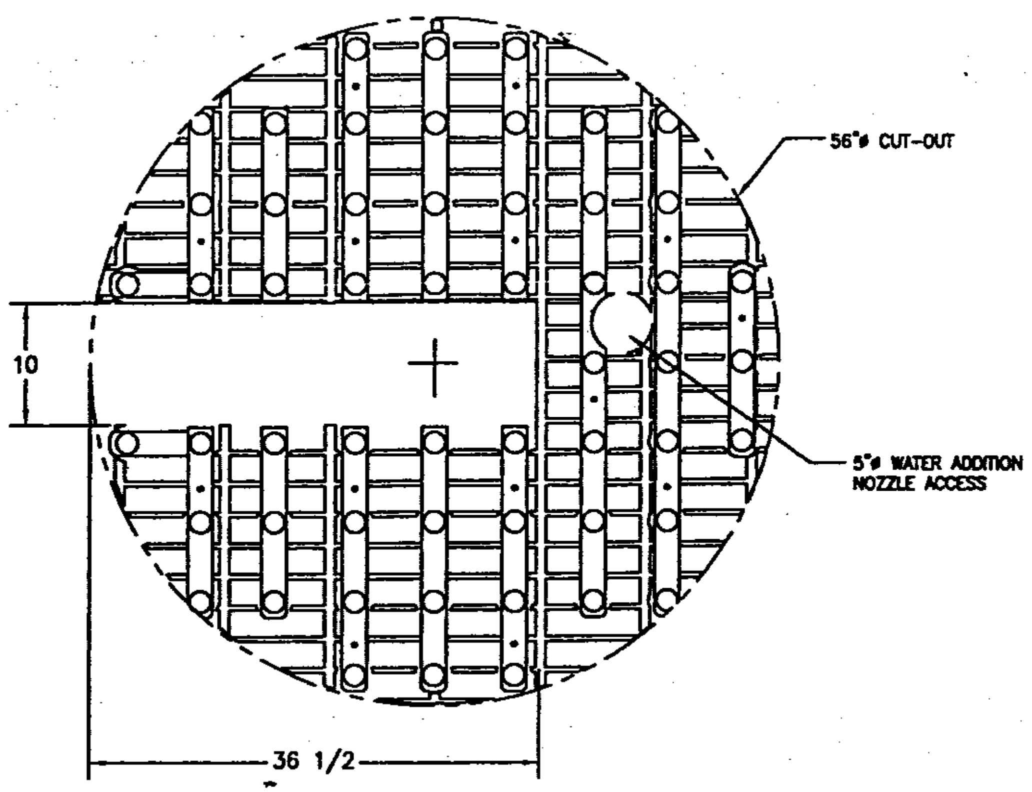
2	11/25/02	INCORP. ECO 3C42-0126-D-02, THRU -07	WJM	JMR	KBM	N/A
1	07/12/02	INCORP ECO 3C42-0126-D-01, -01	ISS	JMR	KBM	N/A
0	04/15/02	90% FINAL DESIGN	DC	JMR	KBM	N/A

CUSTOMER/PROJECT: FLUOR HANFORD PACTEC

AVANTech

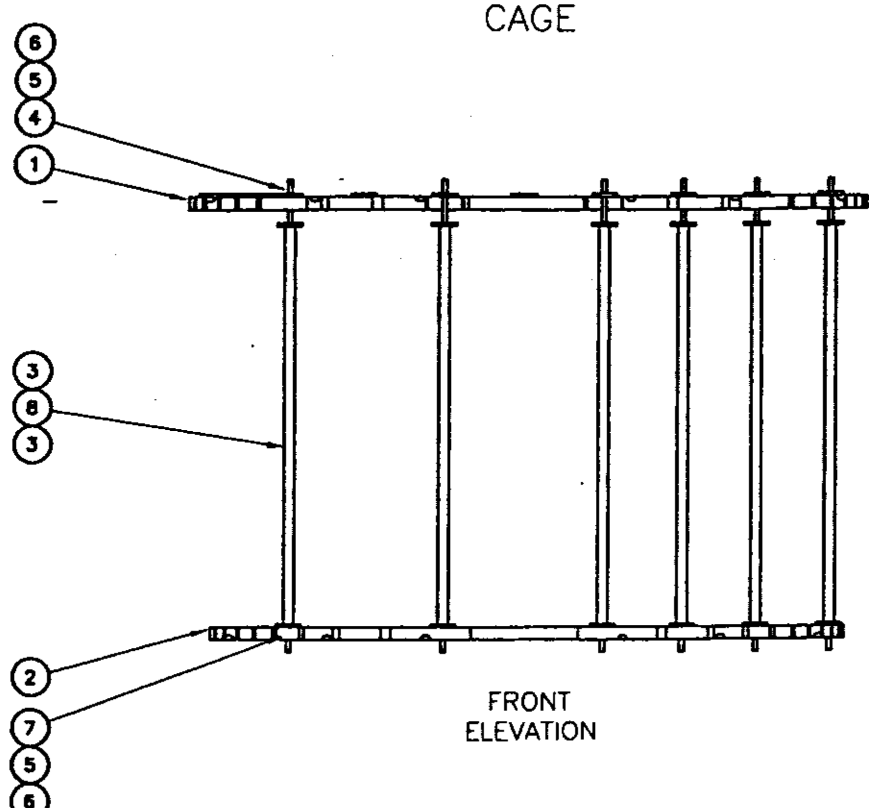
K-EAST BASIN STS A-170 FILTER AS'BLY LARGE CONTAINER

SIZE D DRAWING NUMBER 3C42-0126-D REV 2

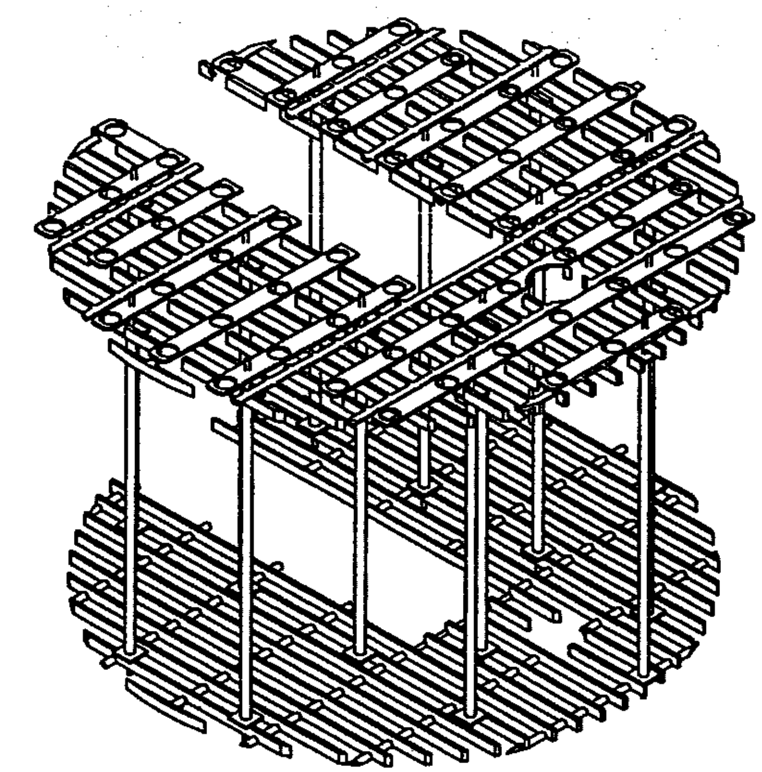


PLAN VIEW

FILTER CAGE



FRONT ELEVATION



ISOMETRIC

AS-BUILT DRAWING
Dwg. No. 3C42-0126-D Rev. 2
Serial No(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/4/02

INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
(✓) AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No
8	14	1/2" PIPE x 33 LG, SCH 40, 300 SERIES SS	ASME SA-312
7	14	FLAT WASHER, 7/16" ID, 2" SQUARE, 1/4" THK, SS	MCMASTR 91122A115
6	28	HEX HEAD LOCK NUT, 3/8, NYLON	18-8 SS
5	28	FLAT WASHER, 3/8	18-8 SS
4	14	ALL THREAD, 3/8-16UNC x 38 LG	18-8 SS
3	28	1/4" PLATE x 2" SQ., w/ 7/16" DIA HOLE THRU CTR., 300 SERIES SS	ASME SA-240
2	1	ASSEMBLY LOWER SUPPORT GRID, SHEET 4 OF 4	–
1	1	ASSEMBLY UPPER SUPPORT GRID, SHEET 4 OF 4	–

BILL OF MATERIALS

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

AVANTech
The POWER of PEOPLE Realizing POTENTIAL

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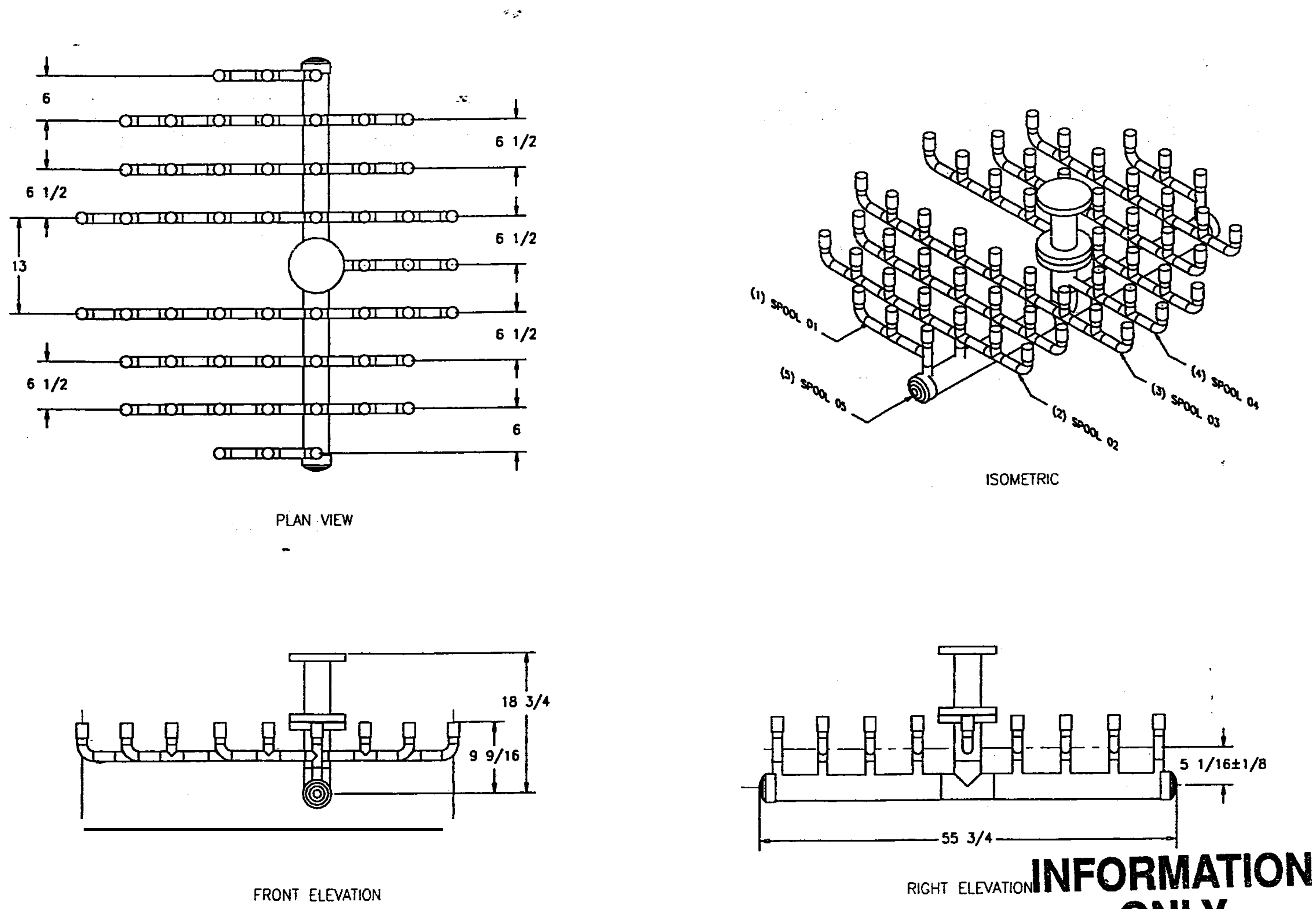
K-EAST BASIN STS
A-170 FILTER AS'BLY
LARGE CONTAINER

JOB NO 0126
SIZE D DRAWING NUMBER 3C42-0126-D REV. 2

SIGNATURE COPY ON FILE

2	10/25/02	INCORP. DCD 3C42-0126-D-02, THRU -07	WJM	JMR	KBM	N/A
1	07/02/02	INCORP. DCD 3C42-0126-D-00, -01	ISS	JMR	KBM	N/A
0	04/09/02	ISSUE FINAL DESIGN	DC	JMR	KBM	N/A



AS-BUILT DRAWING

Dwg. No. 3C42-0126-D Rev. 2

Serial No.(s) 01, 02, 03, 04, 05706

Signature [signature] Date 12/4/02

NOTE:

1. ASSEMBLE FILTER MANIFOLD BY INSERTING SPOOLS 01–04 INTO SPOOL 05 AS SHOWN AND WELDING ON THE OUTSIDE OF THE 3" PIPE HEADER USING A 1/4" FILLET ALL AROUND.

2. DIMENSIONS ARE FOR REFERENCE ONLY, UNLESS OTHERWISE NOTED.

INFORMATION ONLY

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

SIGNATURE COPY ON FILE

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
5	1	SPOOL 05 – 3" 300 SERIES SS	3C44-0126-B
4	1	SPOOL 04 – 1" 300 SERIES SS	3C44-0126-B
3	2	SPOOL 03 – 1" 300 SERIES SS	3C44-0126-B
2	4	SPOOL 02 – 1" 300 SERIES SS	3C44-0126-B
1	2	SPOOL 01 – 1" 300 SERIES SS	3C44-0126-B

BILL OF MATERIALS

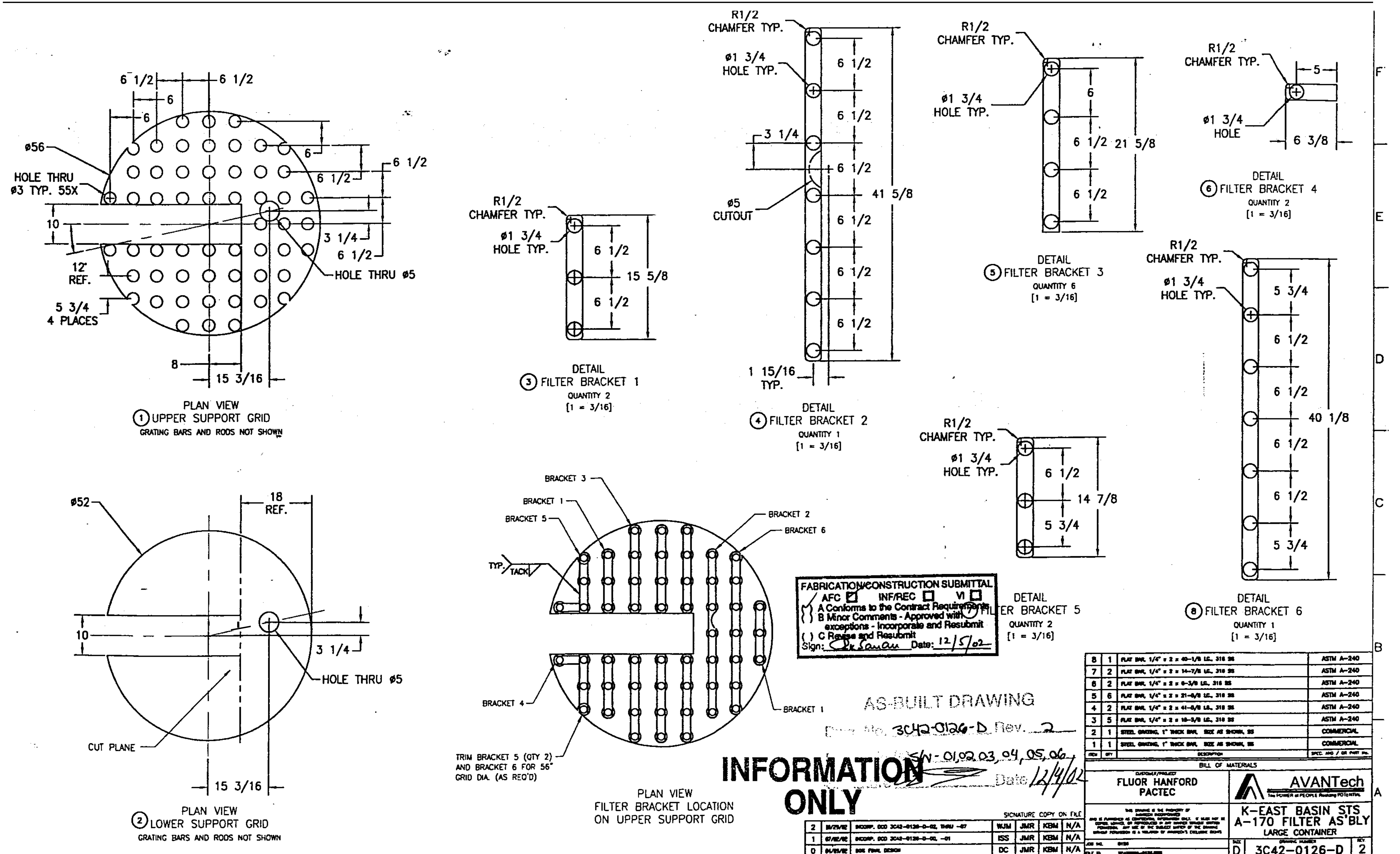
FLUOR HANFORD PACTEC

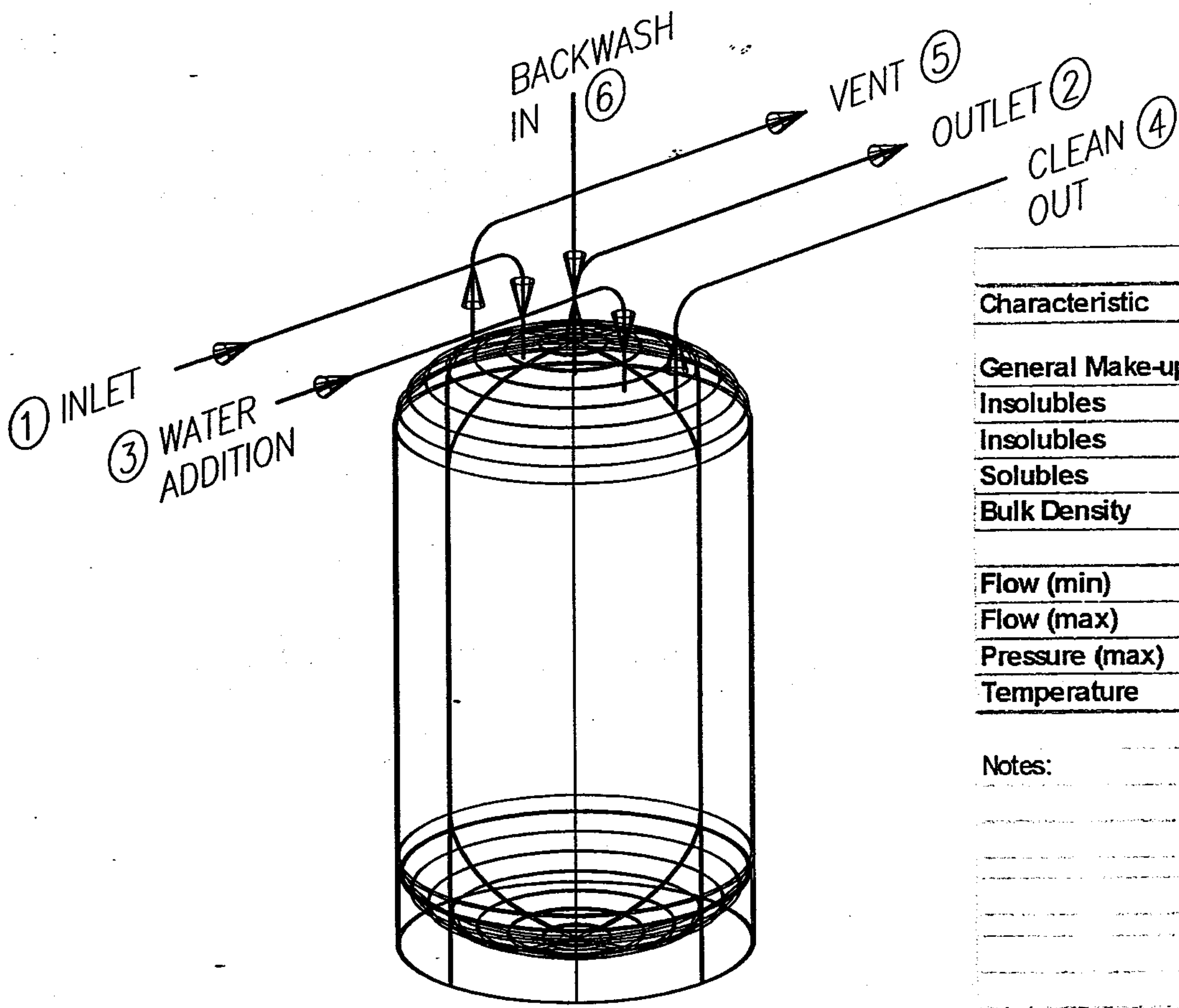
AVANTech

K-EAST BASIN STS A-170 FILTER AS'BLY LARGE CONTAINER

REV	DATE	DESCRIPTION				
2	10/25/02	INCORP. ECO 3C42-0126-D-02, THRU -07	WJM	JMR	KBM	N/A
1	07/12/02	INCORP. ECO 3C42-0126-D-00, -01	ISS	JMR	KBM	N/A
0	04/05/02	ISSUE FINAL DESIGN	DC	JMR	KBM	N/A

D 3C42-0126-D 2


PLAN VIEW
① UPPER SUPPORT GRID
GRATING BARS AND RODS NOT SHOWN
ø56
HOLE THRU ø3 TYP. 55X
HOLE THRU ø5
12" REF.
5 3/4 4 PLACES
15 3/16
PLAN VIEW
② LOWER SUPPORT GRID
GRATING BARS AND RODS NOT SHOWN
ø52
18 REF.
HOLE THRU ø5
CUT PLANE
DETAIL
③ FILTER BRACKET 1
QUANTITY 2
[1 = 3/16]
DETAIL
④ FILTER BRACKET 2
QUANTITY 1
[1 = 3/16]
ø5 CUTOUT
41 5/8
DETAIL
⑤ FILTER BRACKET 3
QUANTITY 6
[1 = 3/16]
21 5/8
DETAIL
⑥ FILTER BRACKET 4
QUANTITY 2
[1 = 3/16]
DETAIL
⑦ FILTER BRACKET 5
QUANTITY 2
[1 = 3/16]
14 7/8
DETAIL
⑧ FILTER BRACKET 6
QUANTITY 1
[1 = 3/16]
40 1/8
R1/2 CHAMFER TYP.
ø1 3/4 HOLE TYP.
PLAN VIEW
FILTER BRACKET LOCATION
ON UPPER SUPPORT GRID
TRIM BRACKET 5 (QTY 2) AND BRACKET 6 FOR 56" GRID DIA. (AS REQ'D)
FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
C Revise and Resubmit
Sign: Date: 12/5/02
AS-BUILT DRAWING
Dwg. No. 3C42-0126-D Rev. 2
Date 12/4/02
INFORMATION ONLY
BILL OF MATERIALS
8 1 FLAT BAR, 1/4" x 2 x 40-1/8 LG., 316 SS ASTM A-240
7 2 FLAT BAR, 1/4" x 2 x 14-7/8 LG., 316 SS ASTM A-240
6 2 FLAT BAR, 1/4" x 2 x 6-3/8 LG., 316 SS ASTM A-240
5 6 FLAT BAR, 1/4" x 2 x 21-5/8 LG., 316 SS ASTM A-240
4 2 FLAT BAR, 1/4" x 2 x 41-5/8 LG., 316 SS ASTM A-240
3 5 FLAT BAR, 1/4" x 2 x 15-5/8 LG., 316 SS ASTM A-240
2 1 STEEL GRATING, 1" THICK BAR, SIZE AS SHOWN, SS COMMERCIAL
1 1 STEEL GRATING, 1" THICK BAR, SIZE AS SHOWN, SS COMMERCIAL
FLUOR HANFORD PACTEC
AVANTech
K-EAST BASIN STS
A-170 FILTER AS'BLY
LARGE CONTAINER
D 3C42-0126-D 2



AS-BUILT DRAWING
3C43-0126-B Rev. 0
S/N- 01,02,03,04,05,06
Date 12/4/02

	Stream	1	2	3	4	5	6
Characteristic	Unit						
General Make-up		Sludge/Water Slurry	Filtered Water	Water	Sludge/Water Slurry	Air	Water
Insolubles	wt%sol	1-10			1-10		
Insolubles	ppm						
Solubles	ppm	TBD	TBD		[demin]		TBD
Bulk Density	lb/cuft	89.9	62.4	62.4	89.9		
Flow (min)	lb/hr	2.20E+04	1.50E+04	[gravity]	2.20E+04		1.00E+06
Flow (max)	lb/hr	6.50E+04	4.50E+04	[gravity]	4.35E+04		1.25E+05
Pressure (max)	psig	50	45	atm	atm	atm	40
Temperature	°F	50	50	77	ambient	ambient	50

Notes: These values are generally either taken directly from or derived from design input parameters found in Specification 8163 Rev. 4 OR are simple estimates based on industry standard practices.

Soluble TBD values for Streams 1 and 2 to be provided by FH.

Stream 4 are typical sluice operating parameters.

Stream 5 parameters are nominal vessel fill venting.

Stream 6 is nominal -- only operating experience will determine actual values.

Stream 6 Pressure is max allowed by filter manufacturer.

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

INFORMATION ONLY

SIGNATURE COPY ON FILE

REV.	DATE	DESCRIPTION	DRAWN BY	CHECKED BY	ENGINEER
0	03/30/01	UPDATE SPEC. REV. TO 4 (90%)	KBM	TAB	KBM

CUSTOMER/PROJECT: FLUOR HANFORD PACTEC

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JOB NO. 0126
FILE ID. 3C430001-0126.DWG
DIMENSIONS IN INCHES UNLESS SPECIFIED

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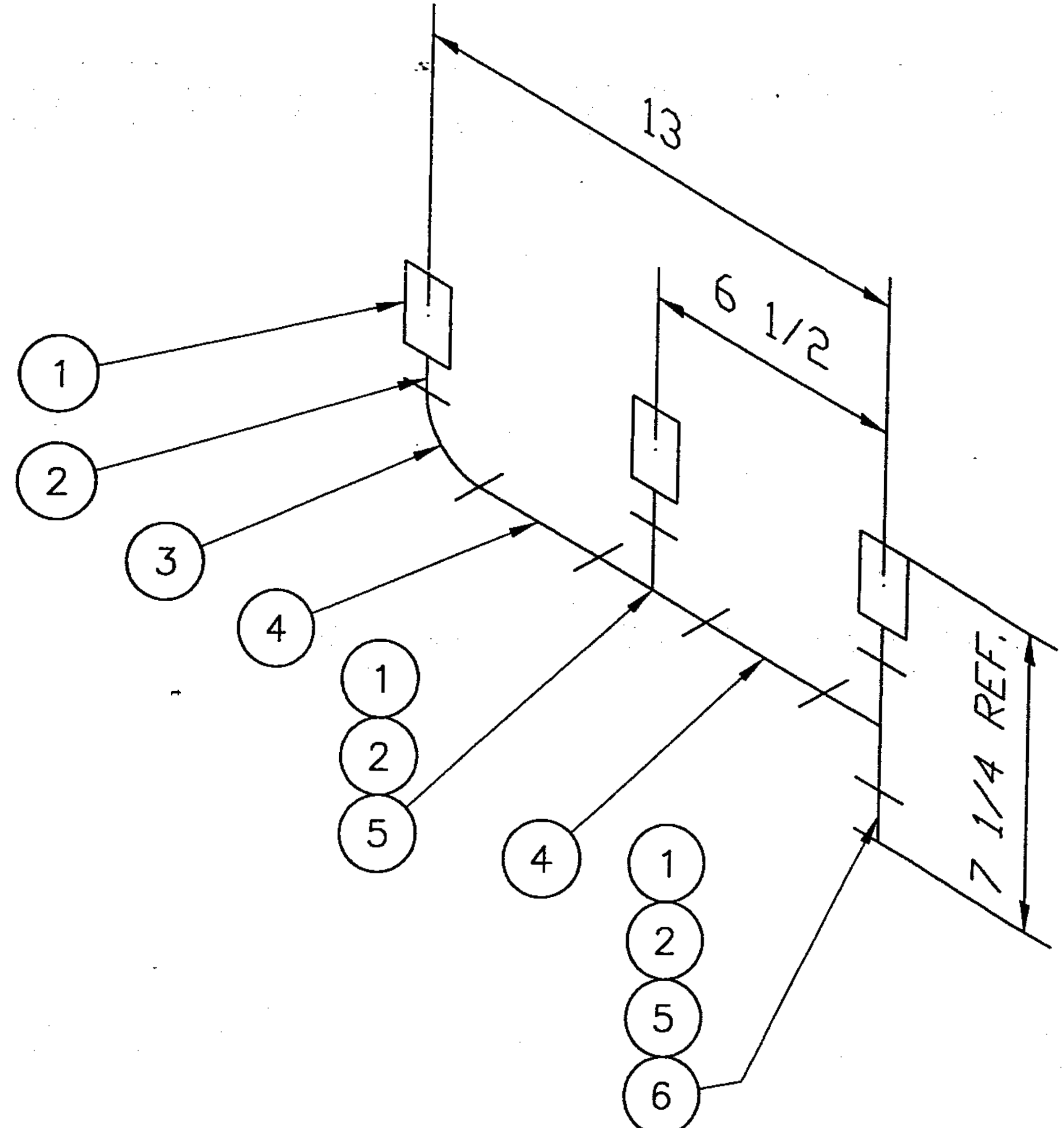
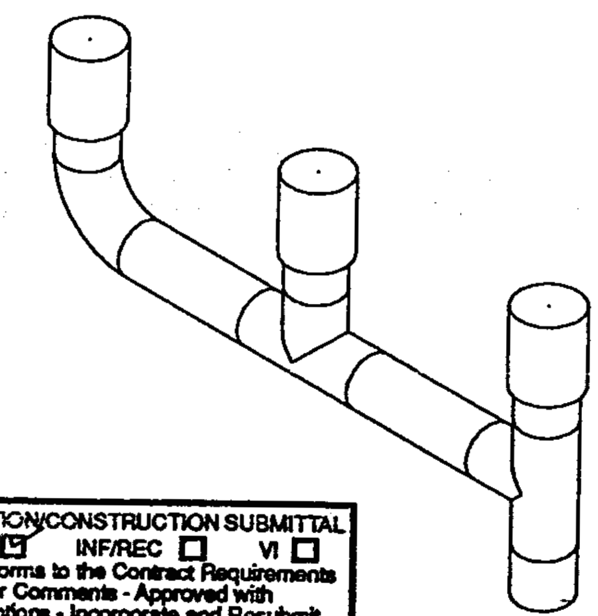
K-EAST BASIN STS
LARGE CONTAINER
PROCESS FLOW DIAGRAM

SIZE: B | DRAWING NUMBER: 3C43-0126-B | REV.: 0
SCALE: N/A | WT. N/A | SHEET 1 OF 1





FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

AS-BUILT DRAWING
Dwg. No. 3C44-0126-B Rev. 2
Serial No.(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/4/02

NOTE: WELD GEOMETRY FOR ALL SOCKET WELD CONNECTIONS SHALL BE IDENTIFIED ON A SHOP TRAVELER APPROVED BY AVANTECH PRIOR TO WELDING.

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
6	1	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
5	2	1" TEE, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
4	2	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
3	1	1" 90 ELBOW, SOCKET, 150 LB., 300 SERIES SS	ASME B-16.11
2	3	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
1	3	REDUCING COUPLING, SHEET 6 OF 6	-

INFORMATION ONLY

SIGNATURE COPY ON FILE

	X/Y	.X	.XX	.XXX
TOLERANCE	±1/8"	±.13"	±.06	±.01"
ANGULAR TOLERANCE		-	-	-
MATERIAL	AS SPEC'D			
SURFACE FINISH	N/A			
SURFACE TREAT	N/A			

REV.	DATE	DESCRIPTION	DRAWN BY	CHECKED BY	ENGINEER
2	10/29/02	DCD 3C44-0126-B-03,-04	WJM	JMR	KBM
1	07/02/02	DCD 3C44-0126-B-00,-01,-02	ISS	JMR	KBM
0	04/09/02	90% FINAL DESIGN	DC	JMR	KBM

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

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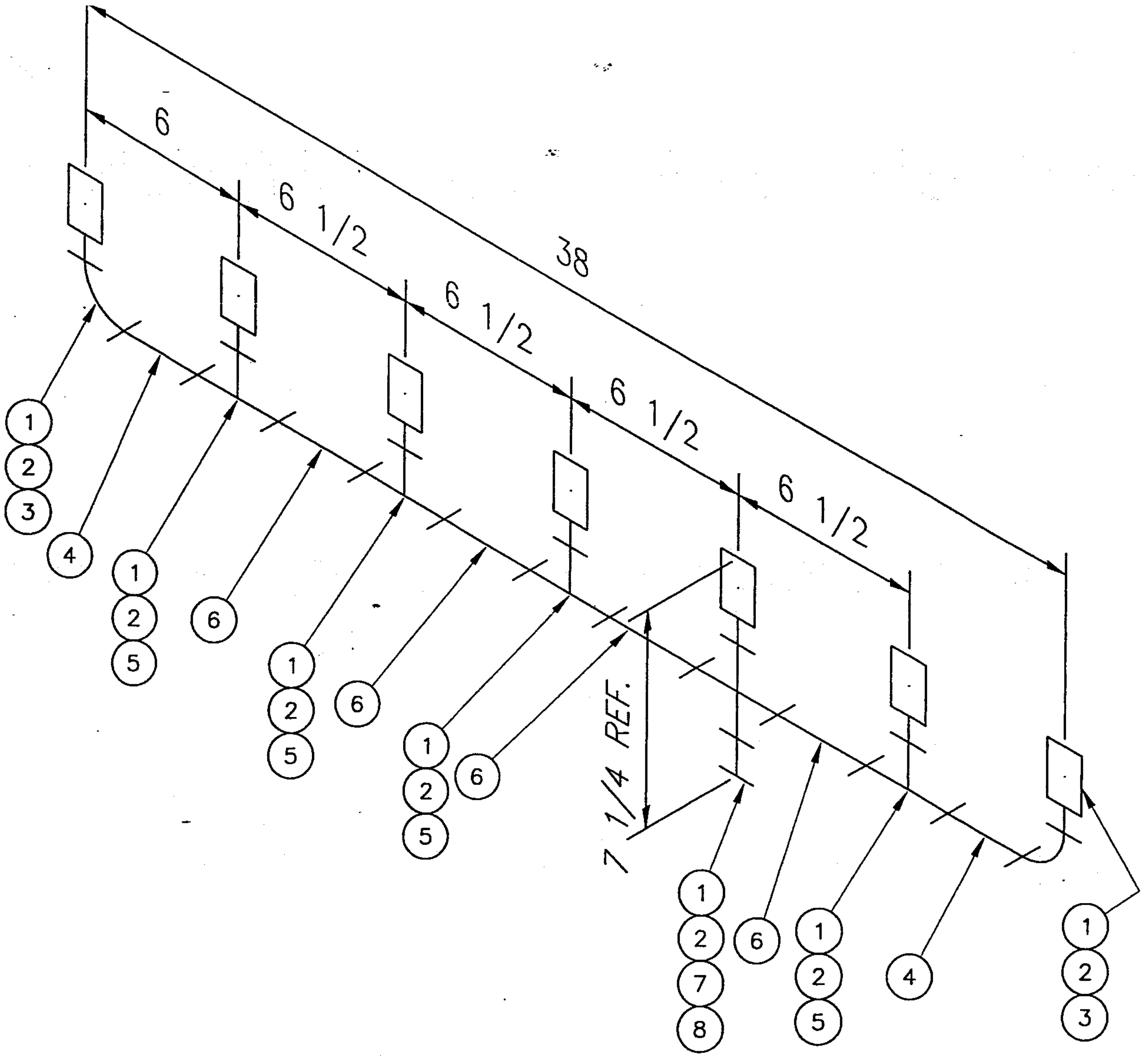
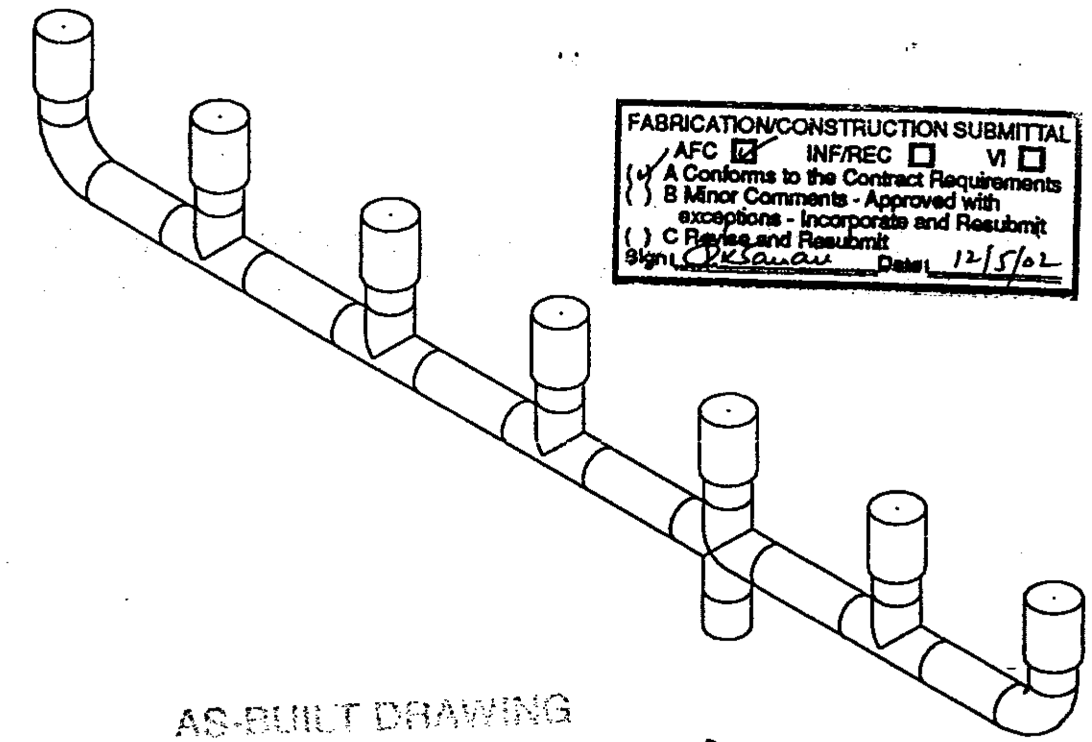
KE BASIN STS: A-170
FILTER ASSEMBLY MANIFOLD
SPOOL-01

JOB NO. 0126
FILE ID. 3C440201-0126.DWG
DIMENSIONS IN INCHES UNLESS SPECIFIED

SIZE B | DRAWING NUMBER 3C44-0126-B | REV. 2
SCALE 1 = 1/4 | WT. N/A | SHEET 1 OF 6





FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: Oksanau Date: 12/5/02

AS-BUILT DRAWING
Dwg. No. 3C44-0126-B Rev. 2
Serial No.(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/4/02

INFORMATION ONLY

NOTE: WELD GEOMETRY FOR ALL SOCKET WELD CONNECTIONS SHALL BE IDENTIFIED ON A SHOP TRAVELER APPROVED BY AVANTECH PRIOR TO WELDING.

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
8	1	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
7	1	1" CROSS, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
6	4	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
5	4	1" TEE, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
4	2	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
3	2	1" 90 ELBOW, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
2	7	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
1	7	REDUCING COUPLING, SHEET 6 OF 6	-

REV.	DATE	DESCRIPTION	DRAWN BY	CHECKED BY	ENGINEER
1	10/29/02	DCD 3C44-0126-B-03,-04	WJM	JMR	KBM
1	07/02/02	DCD 3C44-0126-B-00,-01,-02	ISS	JMR	KBM
0	04/09/02	90% FINAL DESIGN	DC	JMR	KBM

SIGNATURE COPY ON FILE

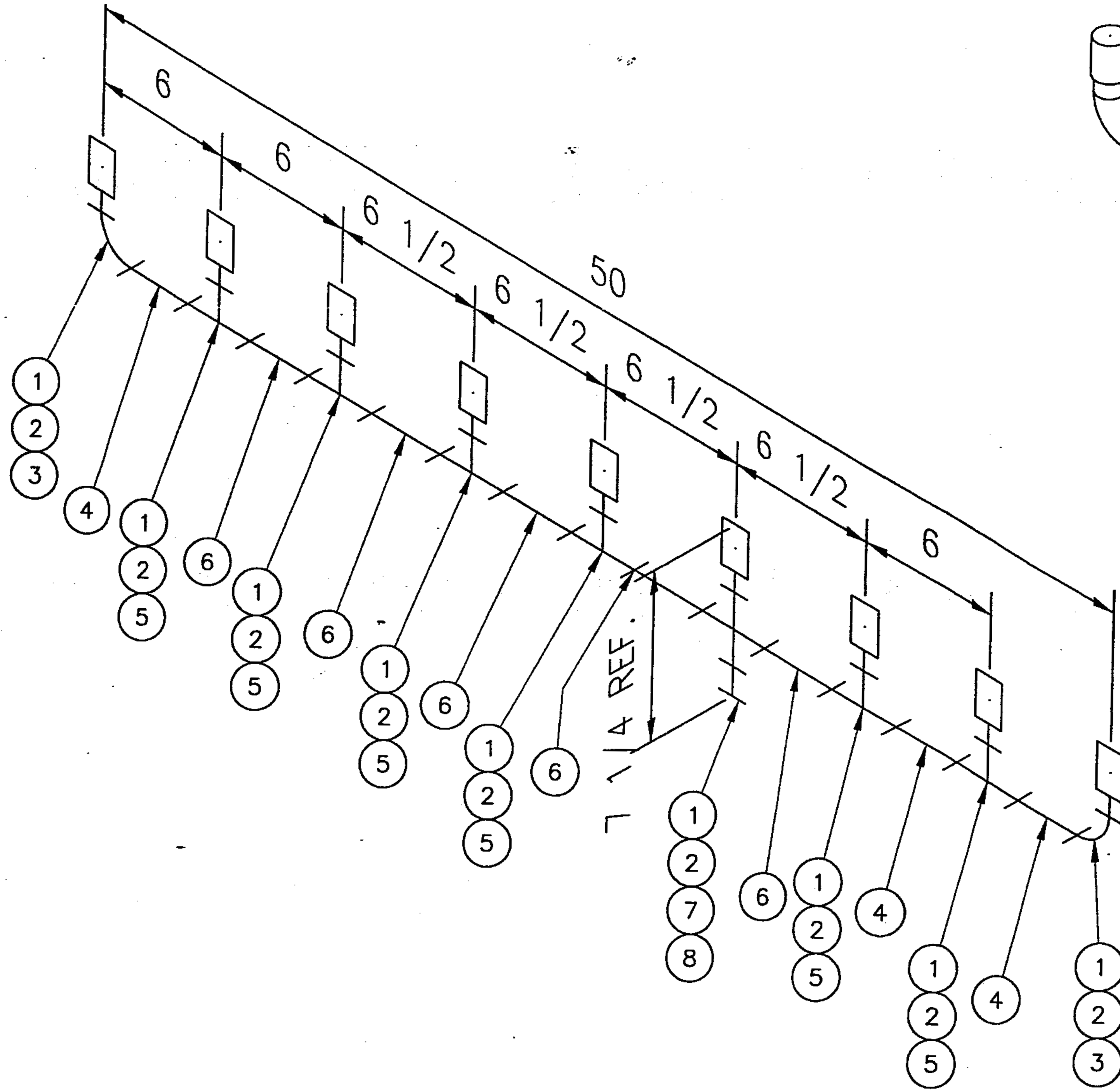
CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

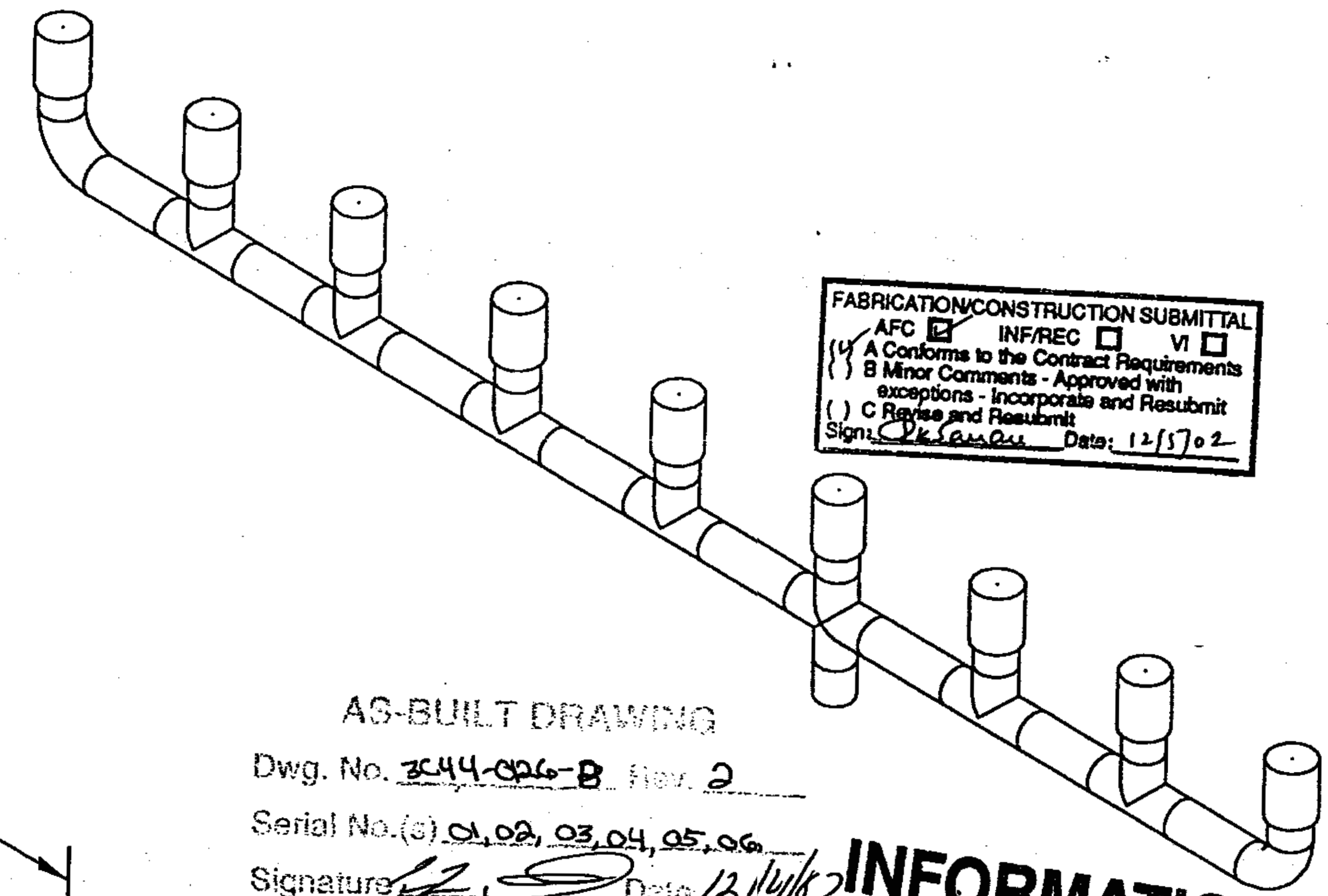
AVANTech
The POWER of PEOPLE Realizing POTENTIAL

KE BASIN STS: A-170
FILTER ASSEMBLY MANIFOLD
SPOOL-02

JOB NO. 0126
FILE ID. 3C440202-0126.DWG
DIMENSIONS IN INCHES UNLESS SPECIFIED

SIZE: B | DRAWING NUMBER: 3C44-0126-B | REV.: 2
SCALE 1 = 1/4 | WT. N/A | SHEET 2 OF 6





FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

AS-BUILT DRAWING
Dwg. No. 3C44-0126-B Rev. 2
Serial No.(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/16/02

INFORMATION ONLY

NOTE: WELD GEOMETRY FOR ALL SOCKET WELD CONNECTIONS SHALL BE IDENTIFIED ON A SHOP TRAVELER APPROVED BY AVANTECH PRIOR TO WELDING.

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
8	1	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
7	1	1" CROSS, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
6	4	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
5	6	1" TEE, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
4	4	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
3	2	1" 90 ELBOW, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
2	9	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
1	9	REDUCING COUPLING, SHEET 6 OF 6	-

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

AVANTech
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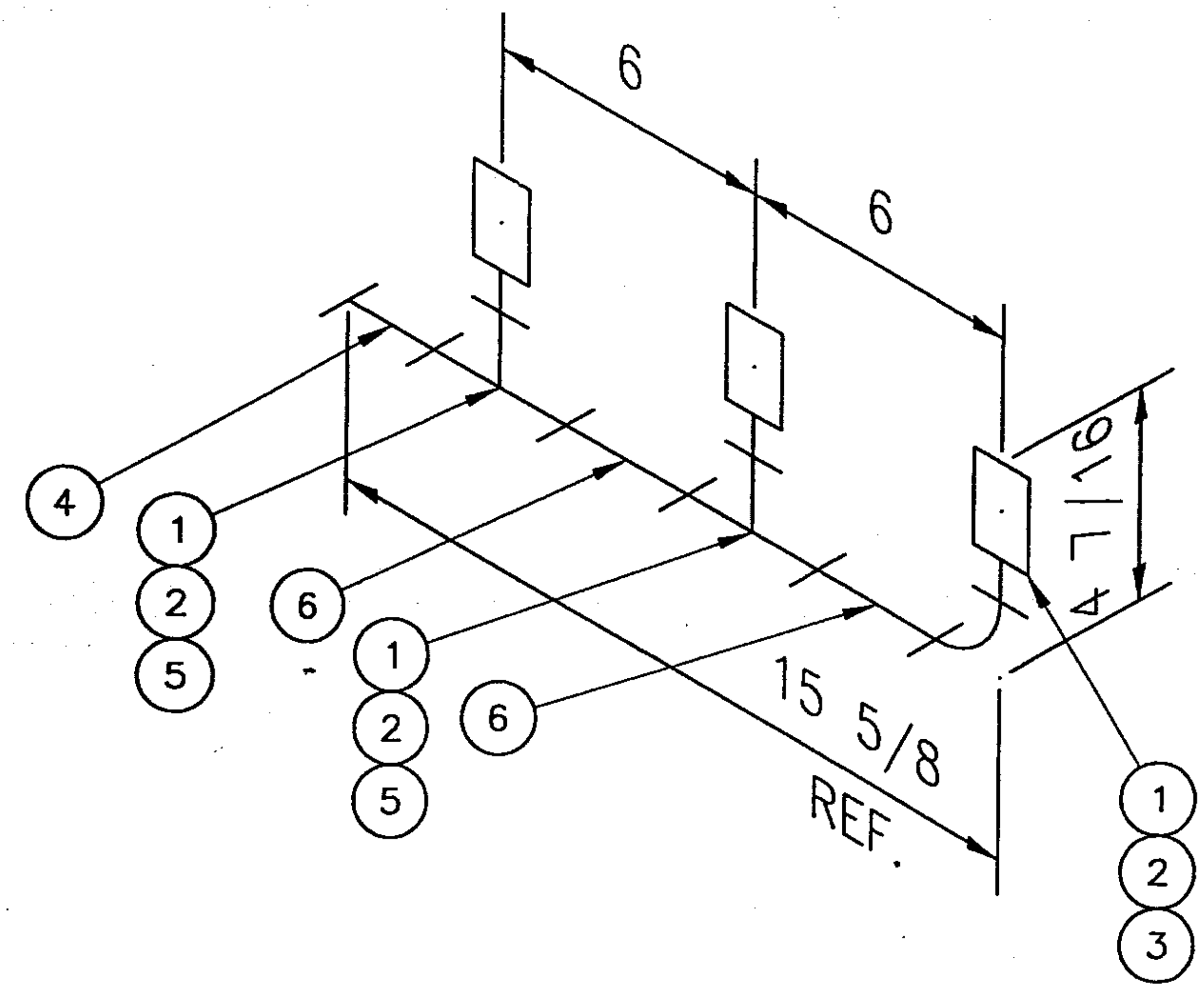
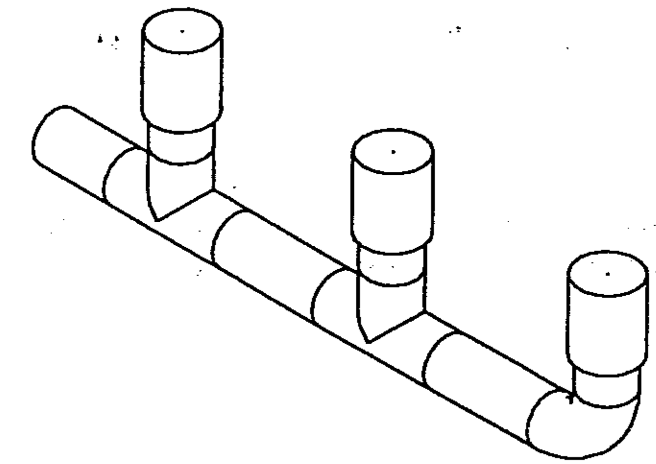
KE BASIN STS: A-170
FILTER ASSEMBLY MANIFOLD
SPOOL-03

JOB NO. 0126
FIL 126.DWG
SIZE B
DRAWING NUMBER 3C44-0126-B
REV. 2

REV.	DATE	DESCRIPTION	DRAWN BY	CHECKED BY	ENGINEER
2	10/29/02	DCD 3C44-0126-B-03,-04	WJM	JMR	KBM
1	07/02/02	DCD 3C44-0126-B-00,-01,-02	ISS	JMR	KBM
0	04/09/02	90% FINAL DESIGN	DC	JMR	KBM

SIGNATURE COPY ON FILE





AS-BUILT DRAWING
Dwg No. 3C44-0126-B Rev. 2
Serial No.(s) 01,02,03,04,05,06
Signature [signature] Date 12/4/02

INFORMATION ONLY

NOTE: WELD GEOMETRY FOR ALL SOCKET WELD CONNECTIONS SHALL BE IDENTIFIED ON A SHOP TRAVELER APPROVED BY AVANTECH PRIOR TO WELDING.

FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☑ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/3/02

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
6	2	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
5	2	1" TEE, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
4	1	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
3	1	1" 90 ELBOW, SOCKET, 150 LB., 300 SERIES SS	ASME B16.11
2	3	1" PIPE x LG AS REQ'D, SCH 40, 300 SERIES SS	ASTM A-312
1	3	REDUCING COUPLING, SHEET 6 OF 6	-

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

AVANTech
The POWER of PEOPLE. Realizing POTENTIAL

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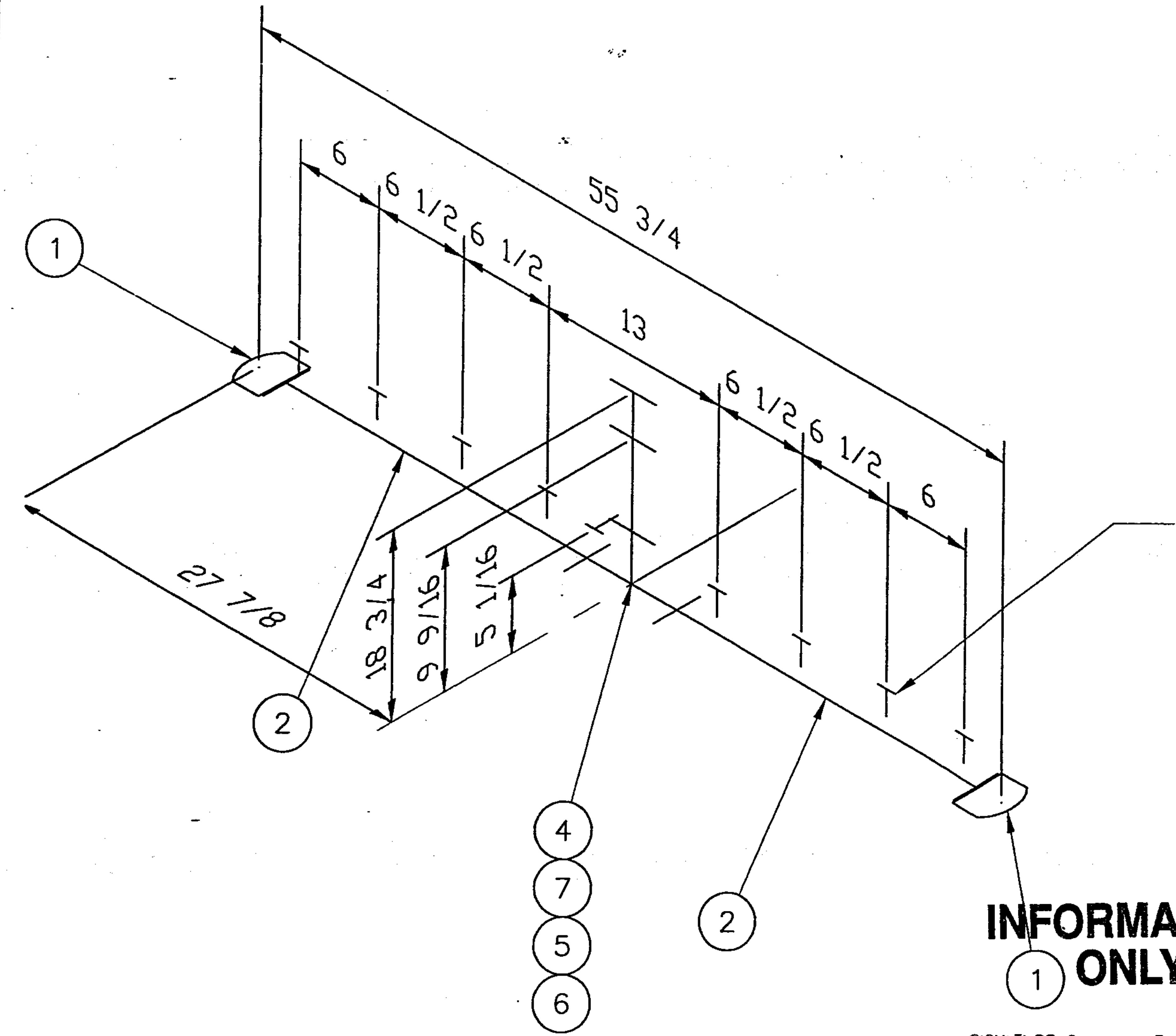
KE BASIN STS: A-170
FILTER ASSEMBLY MANIFOLD
SPOOL-04

JOB NO. 0126
FILE ID. 3C440204-0126.DWG
DIMENSIONS IN INCHES UNLESS SPECIFIED

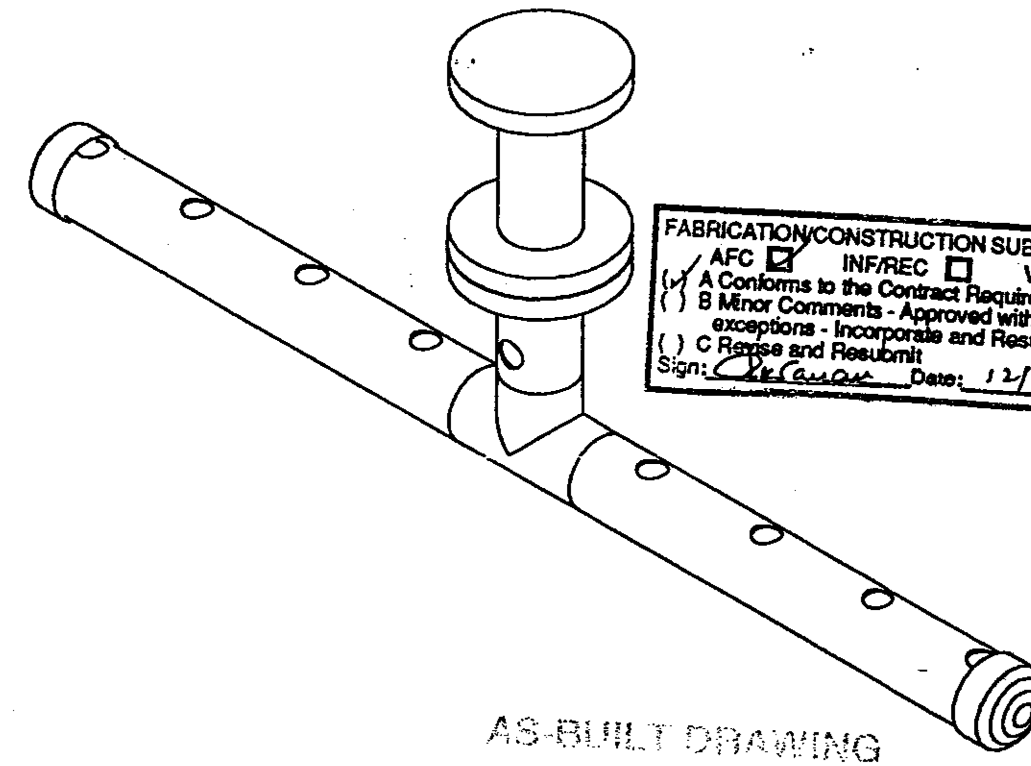
SIZE	DRAWING NUMBER	REV.
B	3C44-0126-B	2

SCALE 1 = 1/4 | WT N/A | SHEET 4 OF 6

REV.	DATE	DESCRIPTION	DRAWN BY	CHECKED BY	ENGINEER
2	10/29/02	DCD 3C44-0126-B-03,-04	WJM	JMR	KBM
1	07/02/02	DCD 3C44-0126-B-00,-01,-02	ISS	JMR	KBM
0	04/09/02	90% FINAL DESIGN	DC	JMR	KBM



CUT HOLE THRU WALL FOR
1" NPS PIPE, TYP. 9X



FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

AS-BUILT DRAWING
Dwg. No. 3C44-0126-B Rev. 2
Serial No.(s) 01,02,03,04,05,06
Signature [signature] Date 12/9/02

NOTE:
1. ALL BUTT WELD CONNECTIONS SHALL BE FULL PENETRATION

2. FLANGE CONNECTIONS SHALL BE MADE USING 1/16 THICK CARBON FIBER GASKET (ASME B16.1) AND SS HEX HEAD FASTENERS.

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
7	1	3" SLIP-ON FLANGE, CLASS 150, 300 SERIES SS	ASME B16.5
6	1	3" TEE, BW, SCH 10, 300 SERIES SS	ASME B16.9
5	1	3" PIPE x LG AS REQ'D, SCH 10, 3.. SS	ASTM A-312
4	1	3" BRAIDED FLEX CONN. * - LG. NOM., CLASS 150 FxF, 304/321 SS	PROCO
3	–	[DELETED]	–
2	2	3" PIPE x LG AS REQ'D, SCH 10, 300 SERIES SS	ASTM A-312
1	2	3" PIPE CAP, BW, SCH 10, 300 SERIES SS	ASME B16.9

INFORMATION ONLY

SIGNATURE COPY ON FILE

REV.	DATE	DESCRIPTION	DRAWN BY	CHECKED BY	ENGINEER
2	10/29/02	DCD 3C44-0126-B-03, -04	WJM	JMR	KBM
1	07/02/02	DCD 3C44-0126-B-00,-01,-02	TSS	JMR	KBM
0	04/09/02	90% FINAL DESIGN	DC	JMR	KBM

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

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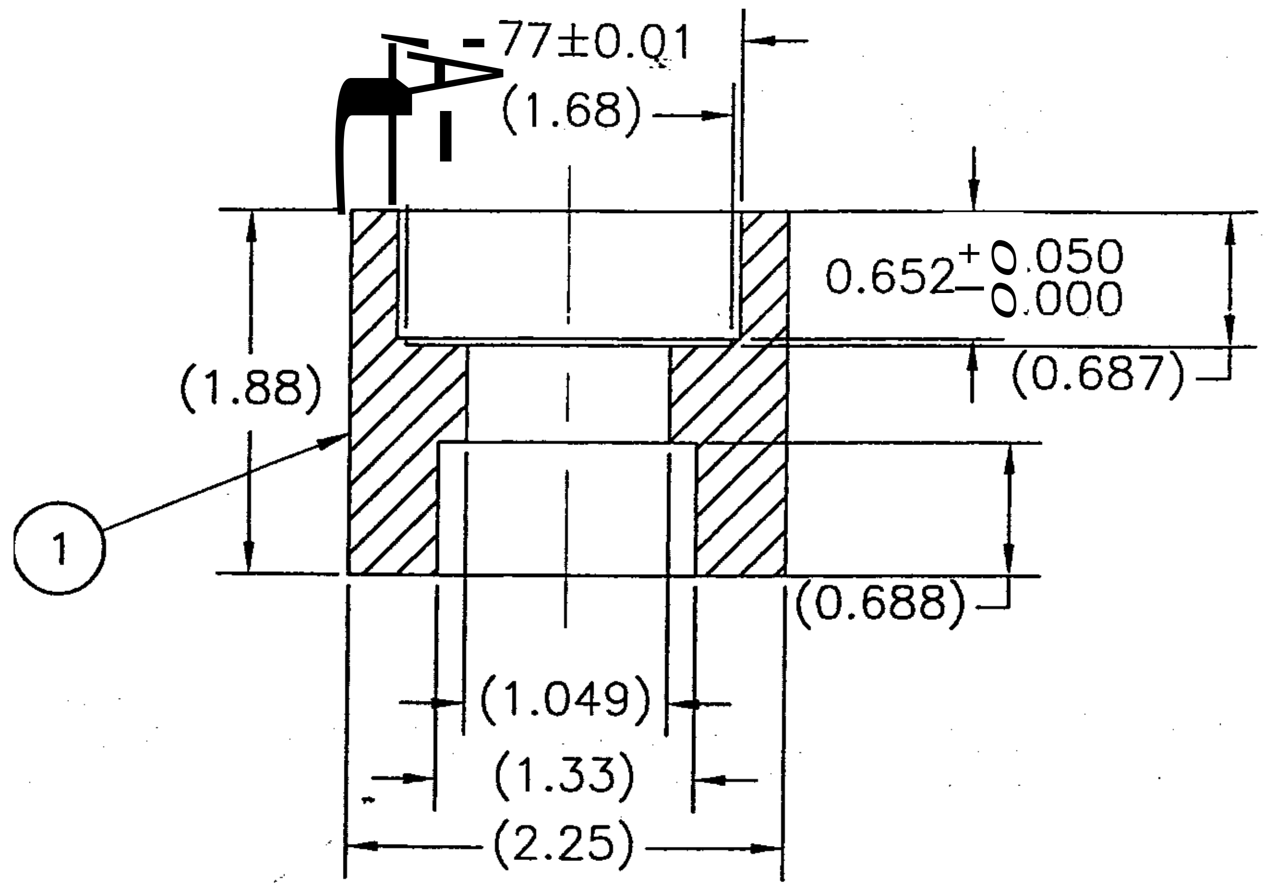
KE BASIN STS: A-170
FILTER ASSEMBLY MANIFOLD
SPOOL-05

JOB NO. 0126	SIZE B	DRAWING NUMBER 3C44-0126-B	REV. 2
FILE ID. 3C440205-0126.DWG	SCALE 1 = 1/4	WT. N/A	SHEET 5 OF 6

DIMENSIONS IN INCHES UNLESS SPECIFIED

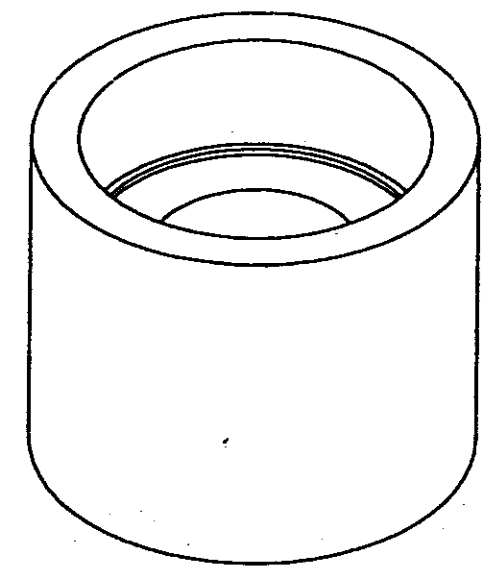


REDUCING COUPLING

COUNTER BORE

1–1/4" END, AS SHOWN

(DIM IN PARENTHESIS ARE AS PURCHASED)



FABRICATION/CONSTRUCTION SUBMITTAL
AFC ☒ INF/REC ☐ VI ☐
(✓) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 12/5/02

AS-BUILT DRAWING
Dwg. No. 3C44-0126-B Rev. 2
Serial No.(s) 01, 02, 03, 04, 05, 06
Signature [signature] Date 12/4/02

INFORMATION ONLY

SIGNATURE COPY ON FILE

ITEM	QTY	DESCRIPTION	SPEC. AND / OR PART No.
1	55	1–1/4 x 1 REDUCING COUPLING, SOCKET, 3000 LB., 300 SERIES SS	ASME B16.11

REV.	DATE	DESCRIPTION	DRAWN BY	CHECKED BY	ENGINEER
2	10/29/02	DCD 3C44–0126–B–03, –04	WJM	JMR	KBM
1	07/02/02	DCD 3C44–0126–B–00,–01,–02	ISS	JMR	KBM
0	04/09/02	90% FINAL DESIGN	X	JMR	KBM

CUSTOMER/PROJECT
FLUOR HANFORD
PACTEC

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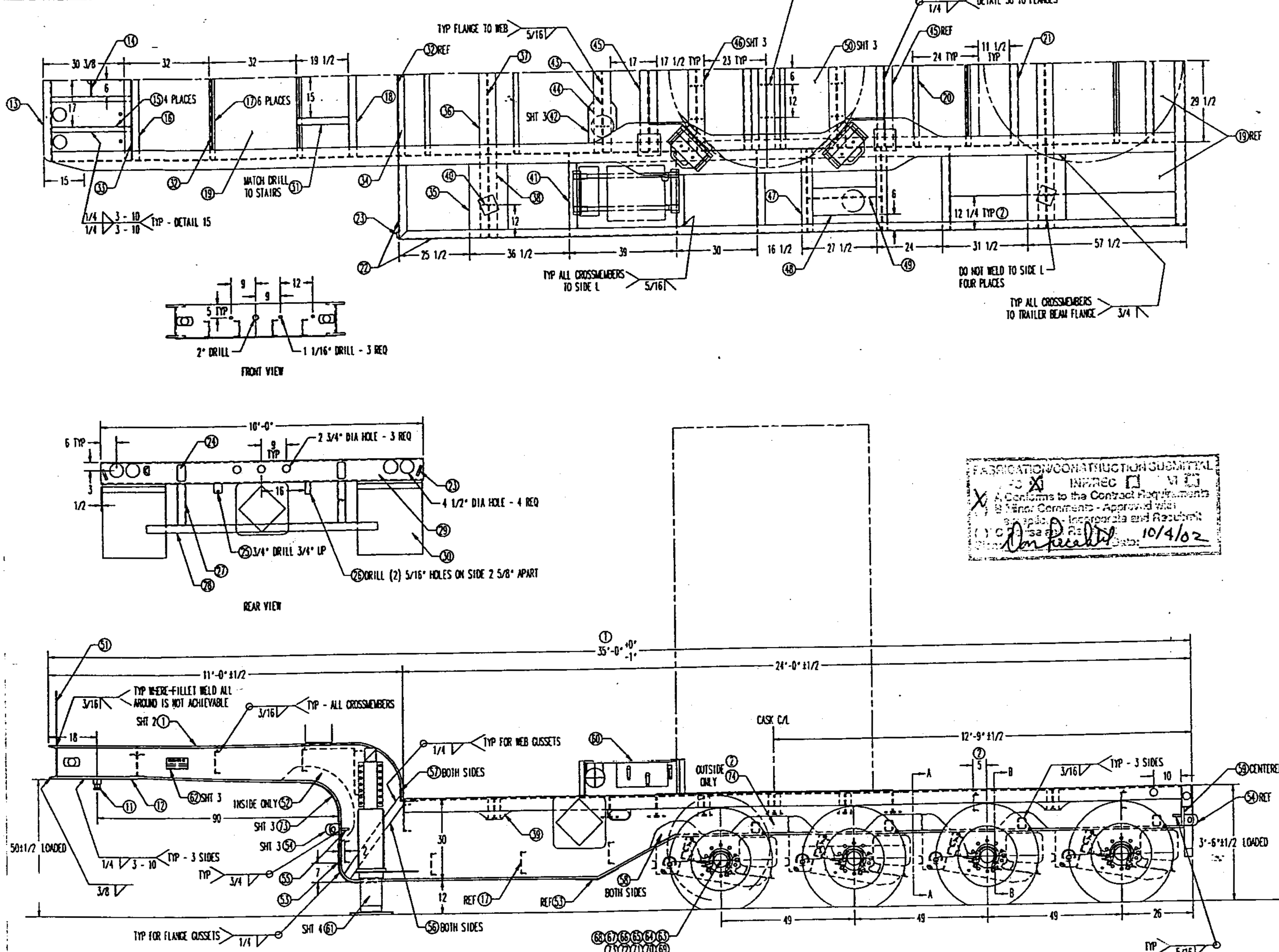
KE BASIN STS: A–170
FILTER ASSEMBLY MANIFOLD
ISO–1

JOB NO. 0126
FILE ID. 3C4400206–0126.DWG

SIZE	DRAWING NUMBER	REV.
B	3C44–0126–B	2

REVISION HISTORY				
REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITAL NUMBER, DIMENSION	CS	TN	5/22/02
2	ADDED DIMENSIONS, UPDATED TO "AS BUILT"	CS	TN	8/20/02



FABRICATION/CONSTRUCTION SUBMITTAL
FO ☒ INFREC ☐ [illegible] ☐
☒ A Conforms to the Contract Requirements
☐ B Minor Comments - Approved with ...
☐ C ... Incorporate and Resubmit
Date: 10/4/02

ITEM NO.	QTY	PART NO./DESCRIPTION
74	6	3/8" A514 GRADE B (T-1) PLATE
73	2	3/8" X 4" A514 GRADE B (T-1) PLATE
72	8	WEBB #20231UH6T HUB & DRUM ASSEMBLIES
71	8	OUTRUNNER #M10HH107 OIL SEALS
70	8	#HM212049-HM212011 OUTER BEARINGS
69	8	#HM218248-HM218210 INNER BEARINGS
68	8	DANA/SPICER #M10HM187 AUTOMATIC SLACK ADJUSTERS
67	8	MGM #3430051 TYPE 30/30 SPRING BRAKE CHAMBERS
66	4	DANA D-22 95" TRACK AXLES 3/4" WALL
65	4	HENDRICKSON HT250US,3 AIR RIDE SUSPENSIONS
64	16	ACCURIDE #28487 STEEL DISC WHEELS - WHITE
63	16	BRIDGESTONE 275/70R X 22.5 16 PLY TIRES
62	1	NELSON NAMEPLATE
61	2	LANDING LEG WELDMENT
60	1	LANDING LEG CONTROL BOX
59	2	1" X 6 5/8" X 7" 514 GRADE B (T-1) PLATE
58	4	3/8" A572 GR 50 PLATE
57	8	3/8" X 2 3/4" A572 GRADE 50 PLATE
56	4	3/8" X 3" A572 GRADE 50
55	4	3/4" X 3" X 3" A514 GRADE B (T-1) PLATE GUSSET
54	4	2" X 4" A36 PLATE
53	4	3/8" X 5 1/2" A572 GRADE 50 PLATE
52	2	3/8" A572 GRADE 50 PLATE
51	4	HRCQ PLACARD
50	1	3/8" A514 GRADE B (T-1) PLATE
49	-	3/8" X 5" A572 GRADE 50 PLATE
48	2	3/8" X 10" X 23 1/2" A514 (T-1) PLATE
47	4	4" X 13 A36 BEAM X 30" LG
46	2	3/4" X 6" A514 GRADE B (T-1) PLATE
45	2	3/4" X 6" X 38" A514 GRADE B (T-1) PLATE
44	6	3/4" X 6" X 58 5/8" A514 GRADE B (T-1) PLATE
43	6	3/8" X 6 3/4" X 58 5/8" A514 GRADE B (T-1) PLATE
42	1	3/4" A514 GRADE B (T-1) PLATE
41	8	4" X 3" X 1/4" A36 L X 30" LG
40	36	3/8" X 2" X 6 3/4" A514 GRADE B (T-1) PLATE
39	4	1/4" A36 PLATE
38	2	1/2" X 6" X 119 3/8" A514 GRADE B (T-1) PLATE
37	2	3/8" X 6 3/4" X 119 3/8" A514 GRADE B (T-1) PLATE
36	3	3/4" X 6" X 52" A514 GRADE B (T-1) PLATE
35	4	3/4" X 14" X 24" A514 GRADE B (T-1) PLATE
34	1	10" X 15.3 A36 CHANNEL X 58 5/8" LG
33	2	1/4" X 3" A36 BAR X 51 1/2" LG
32	5	1/4" X 2" A36 BAR X 51 1/2" LG
31	2	2" X 2" X 1/4" A36 L X 19 1/2" LG
30	2	24" X 27" NELSON MUD FLAP #M302436
29	1	4" X 8" X 3/16" A500 GRADE B TUBE X 120" LG
28	1	3" X 3" X 3/16" A500 GRADE B TUBE X 86" LG
27	2	3" X 3" X 3/16" A500 GRADE B TUBE X 15" LG
26	1	2" X 2" X 1/4" A36 L X 4 1/2" LG
25	1	3/16" X 3" A36 BAR X 3 1/2" LG
24	2	BUYER'S PRODUCTS #B5500 DOCK BUMPER
23	4	FLAG POCKET
22	-	5" X 3" X 5/16" A36 L
21	4	4" X 3" X 1/4" A500 GRADE B TUBE X 58 5/8" LG
20	4	6" X 8.2 A36 CHANNEL X 58 5/8" LG
19	-	3/16" TREADPLATE - COMMERCIAL GRADE STEEL
18	1	1/4" X 3" X 16" A36 FORMED CHANNEL X 58 5/8" LG
17	6	8" X 8.5 A36 CHANNEL X 58 5/8" LG
16	1	8 WF X 18 A572 GRADE 50 BEAM X 58 5/8" LG
15	4	6" X 8.2 A36 CHANNEL X 29 7/8" LG
14	1	3/8" X 3" A36 BAR X 12" LG
13	1	12" X 20.7 A36 CHANNEL X 59 3/8" LG
12	1	3/8" X 32 1/2" X 95" A572 GRADE 50 5TH WHEEL PLATE BURNOUT
11	1	BUYER'S PRODUCTS #KP2003B KINGPIN
1	2	TRAILER FRAME WELDMENT

NELSON MANUFACTURING COMPANY

INFORMATION ONLY

CASK TRANSPORT TRAILER

APPD	TN
CHECK	RD
DRAWN	CS

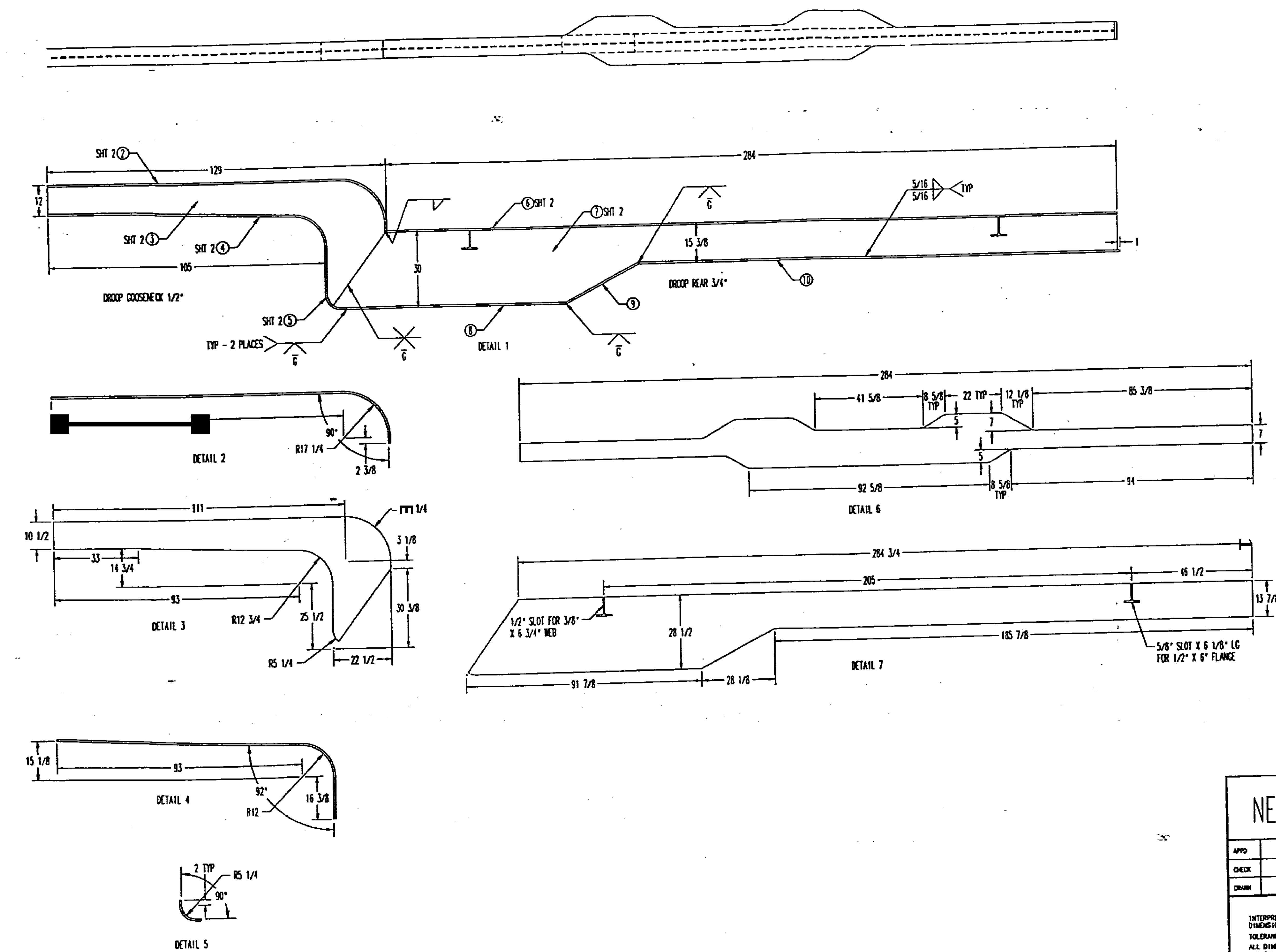
UNLESS OTHERWISE SPECIFIED.
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

SCALE: 5/8"=1'	DATE 10/16/01
REV: 2	SHEET 1 OF 5
DWG SIZE D	DWG NO. TRLR9814
SUBMITTAL DOCUMENT NO.: FAB-24	

GENERAL NOTES
1. THE LOADED AND UNLOADED DECK HEIGHT CAN BE CHANGED BY ADJUSTING THE HEIGHT CONTROL VALVE ON THE TRAILER. SEE THE OWNERS/PARTS MANUAL FOR THE PROPER PROCEDURE.

REVISION HISTORY

REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER	CS	TN	5/22/02
2	UPDATED TO "AS BUILT"	CS	TN	8/20/02



FABRICATION/CONSTRUCTION SUBMITTAL
AFC X INF/REC ☐ VI ☐
X A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions. Incorporate and Resubmit
( ) C ...
Date: 10/4/02

ITEM NO.	QTY	PART NO./DESCRIPTION
10	2	3/4" X 7" X 186 3/4" A514 GRADE B (T-1) PLATE
9	2	3/4" X 7" X 31 1/2" A514 GRADE B (T-1) PLATE
8	2	3/4" X 7" X 86" A514 GRADE B (T-1) PLATE
7	2	3/8" A514 GRADE B (T-1) PLATE
6	2	3/4" A514 GRADE B (T-1) PLATE
5	2	3/4" X 7" A514 GRADE B (T-1) PLATE
4	2	3/4" X 7" A514 GRADE B (T-1) PLATE
3	2	3/8" A514 GRADE B (T-1) PLATE
2	2	3/4" X 7" A514 GRADE B (T-1) PLATE

NELSON MANUFACTURING COMPANY

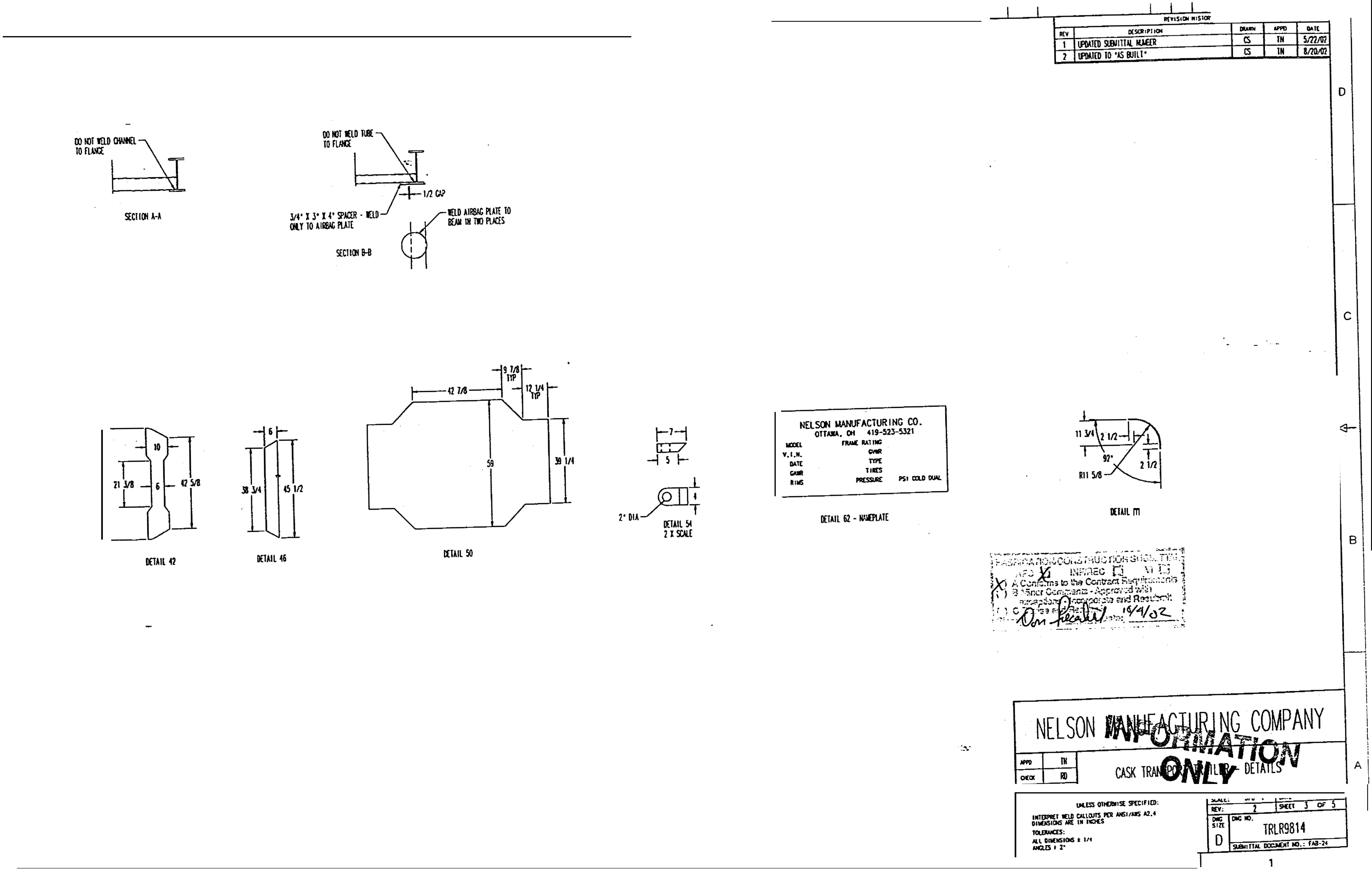
INFORMATION ONLY

CASK TRANSPORT TRAILER - BEAM LAYOUT

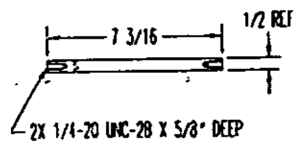
APPD TN
CHECK RD
DRAWN CS

UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

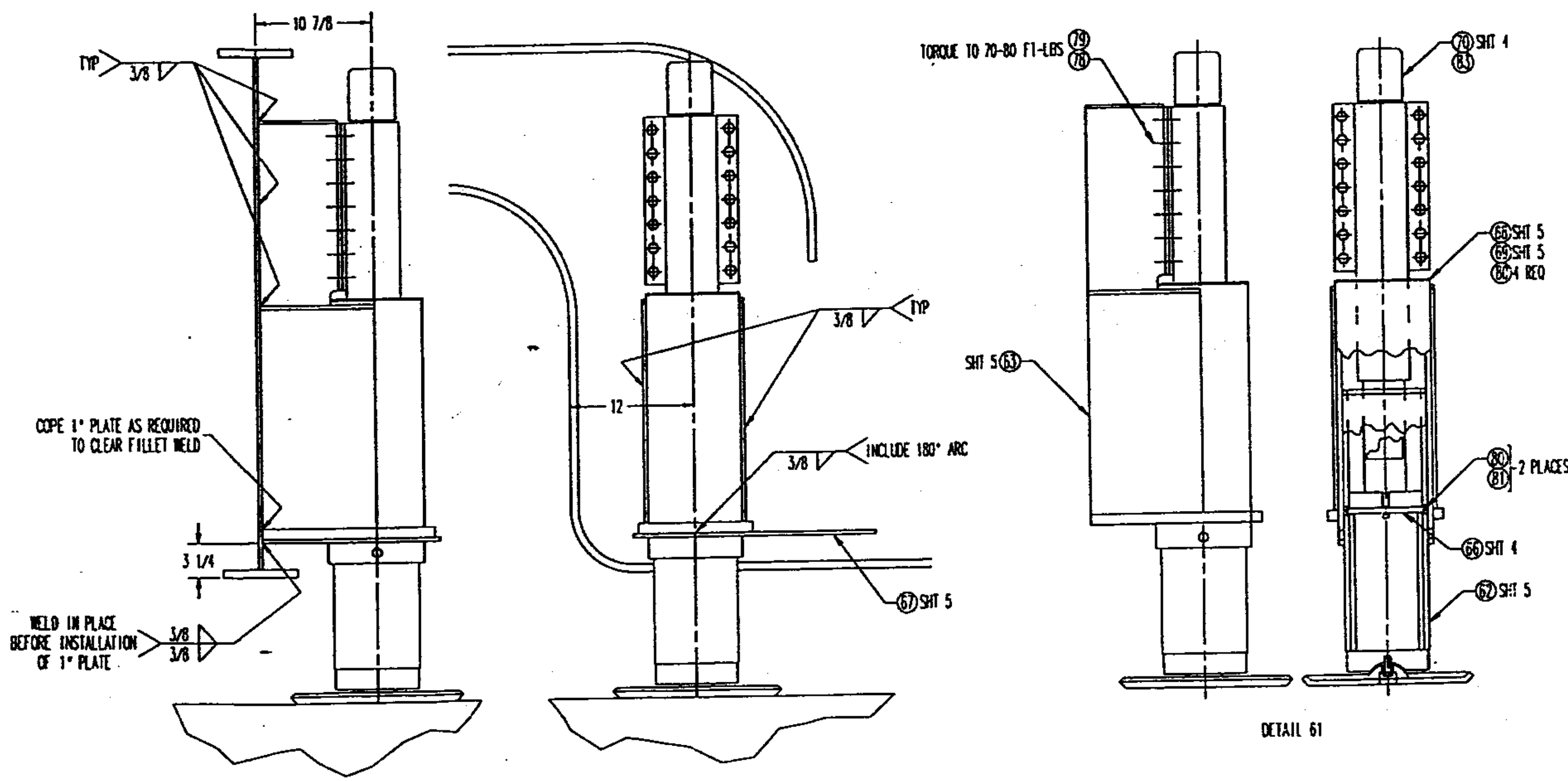
SCALE: 5/8"=1' DATE 11/16/01
REV: 2 SHEET 2 OF 5
DWG SIZE D DWG NO. TRLR9814
SUBMITTAL DOCUMENT NO.: FAB-24


REVISION HISTORY
REV | DESCRIPTION | DRAWN | APPD | DATE
1 | UPDATED SUBMITTAL NUMBER | CS | TN | 5/22/02
2 | UPDATED TO "AS BUILT" | CS | TN | 8/20/02
DO NOT WELD CHANNEL TO FLANGE
SECTION A-A
DO NOT WELD TUBE TO FLANGE
1/2 GAP
3/4" X 3" X 4" SPACER - WELD ONLY TO AIRBAG PLATE
WELD AIRBAG PLATE TO BEAM IN TWO PLACES
SECTION B-B
10
21 3/8
6
42 5/8
DETAIL 42
6
38 3/4
45 1/2
DETAIL 46
42 7/8
9 7/8 TYP
12 1/4 TYP
59
39 1/4
DETAIL 50
7
5
4
2" DIA
DETAIL 54
2 X SCALE
NELSON MANUFACTURING CO.
OTTAWA, OH 419-523-5321
MODEL
V.I.N.
DATE
GAWR
RIMS
FRAME RATING
GVWR
TYPE
TIRES
PRESSURE
PSI COLD DUAL
DETAIL 62 - NAMEPLATE
11 3/4
2 1/2
92°
2 1/2
R11 5/8
DETAIL ???
FABRICATION/CONSTRUCTION SUBMITTAL
AFO X INF/REC VI
X A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions/Incorporate and Resubmit
C Revise and Resubmit
10/4/02
NELSON MANUFACTURING COMPANY
INFORMATION ONLY
APPD TN
CHECK RD
CASK TRANSPORT TRAILER - DETAILS
UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°
REV: 2
SHEET 3 OF 5
DWG SIZE D
DWG NO. TRLR9814
SUBMITTAL DOCUMENT NO.: FAB-24
D
C
B
A
1

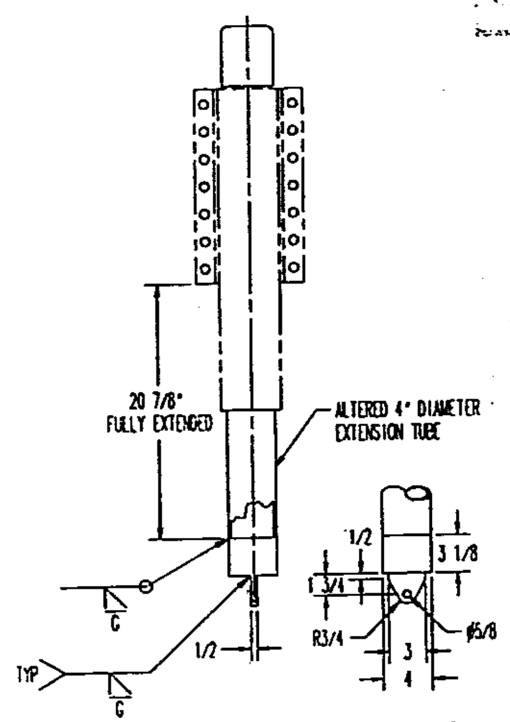
REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER	CS	TN	5/22/02
2	UPDATED TO "AS BUILT"	CS	TN	8/29/02



DETAIL 65 - CYLINDER ATTACHMENT ROD
2 X SCALE



DETAIL 61



DETAIL 70 - LANDING GEAR (ALTERED ITEM)

10/3/02

ITEM NO.	QTY	PART NO./DESCRIPTION
83	1	POWER GEAR #100417 HARDWARE KIT
82	1	1 1/2" A514 GRADE B (T-1) PLATE
81	2	1/4" FLAT WASHER
80	6	1/4-20 UNC-2A X 1/2" LG BUTTON HEAD SCREW
79	14	5/8-11 UNC-2B SAE J429 GRADE 5 NUT
78	14	5/8-11 UNC-2A X 1 1/2" LG SAE J429 GRADE 5 BOLT
77	1	6" SCH 80 A53 PIPE
76	1	9" OD X 1/2" WALL ASTM A519 CWSR 4130 TUBE
75	1	1" A514 GRADE B (T-1) PLATE
74	-	3/8" A514 GRADE B (T-1) PLATE
73	1	POWER GEAR #300442 BEARING PLATE
72	1	POWER GEAR #300167 16" SWIVEL SHOE
71	1	POWER GEAR #100226 MOUNTING PLATE
70	1	POWER GEAR #100922 4" DIA X 15" STROKE LANDING LEG
69	1	3/16" RUBBER DEBRIS SHIELD
68	1	1/8" A36 DEBRIS SHIELD RETAINER
67	1	3/8" A514 GRADE B (T-1) PLATE - WEB ATTACHMENT PLATE
66	1	1/2" 1045 CR ROUND - CYLINDER ATTACHMENT ROD
65	1	8" OD X 1/2" WALL ASTM A519 HFSR 4130 TUBE STIFF LEG CYLINDER
64	1	CYLINDER SUPPORT SUBASSEMBLY
63	1	TRAILER CYLINDER WELDMENT
62	1	STIFF LEG ASSEMBLY

NELSON MANUFACTURING COMPANY

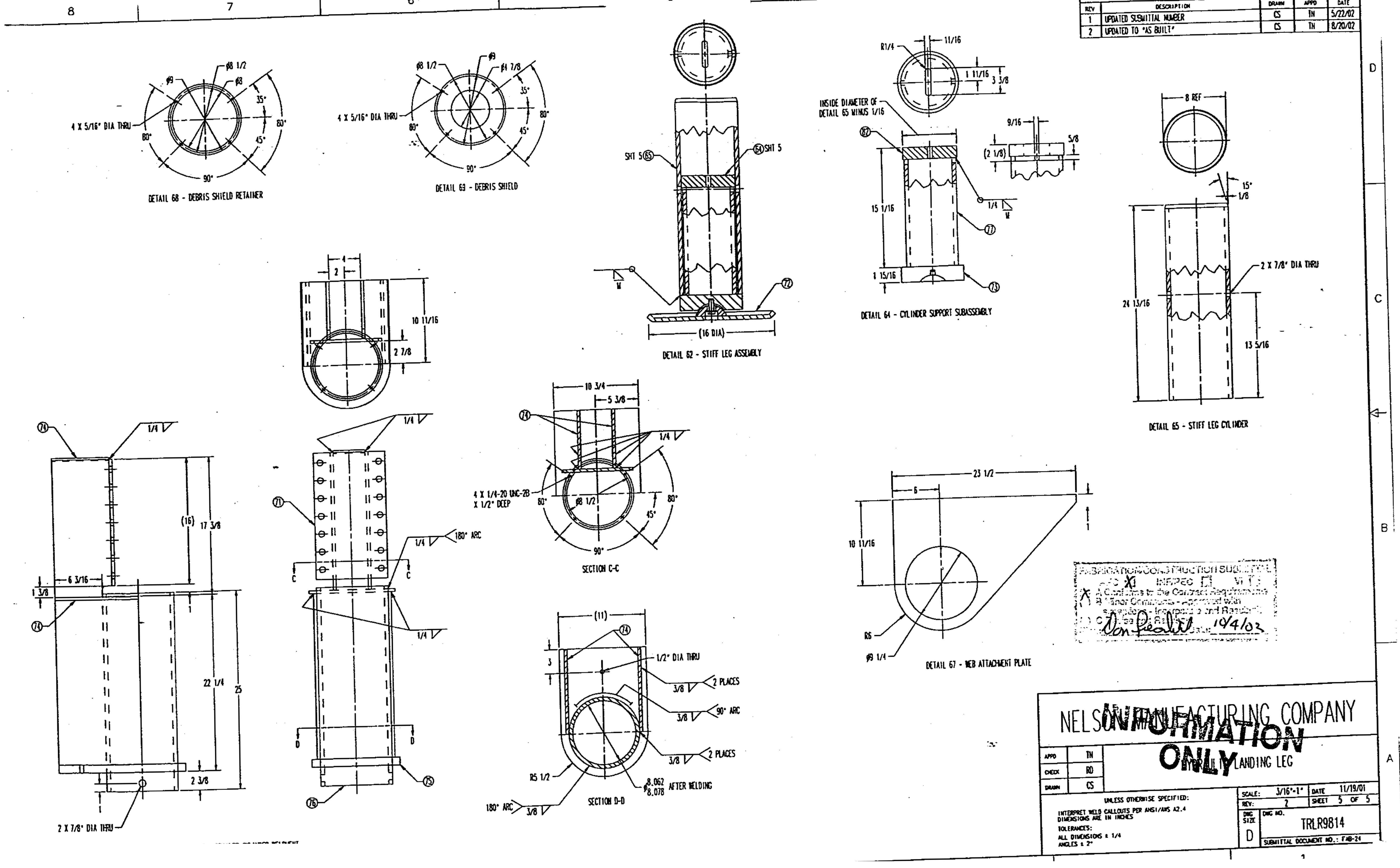
INFORMATION ONLY

HYDRAULIC LANDING LEG

APPD	TN
CHECK	RD
DRAWN	CS

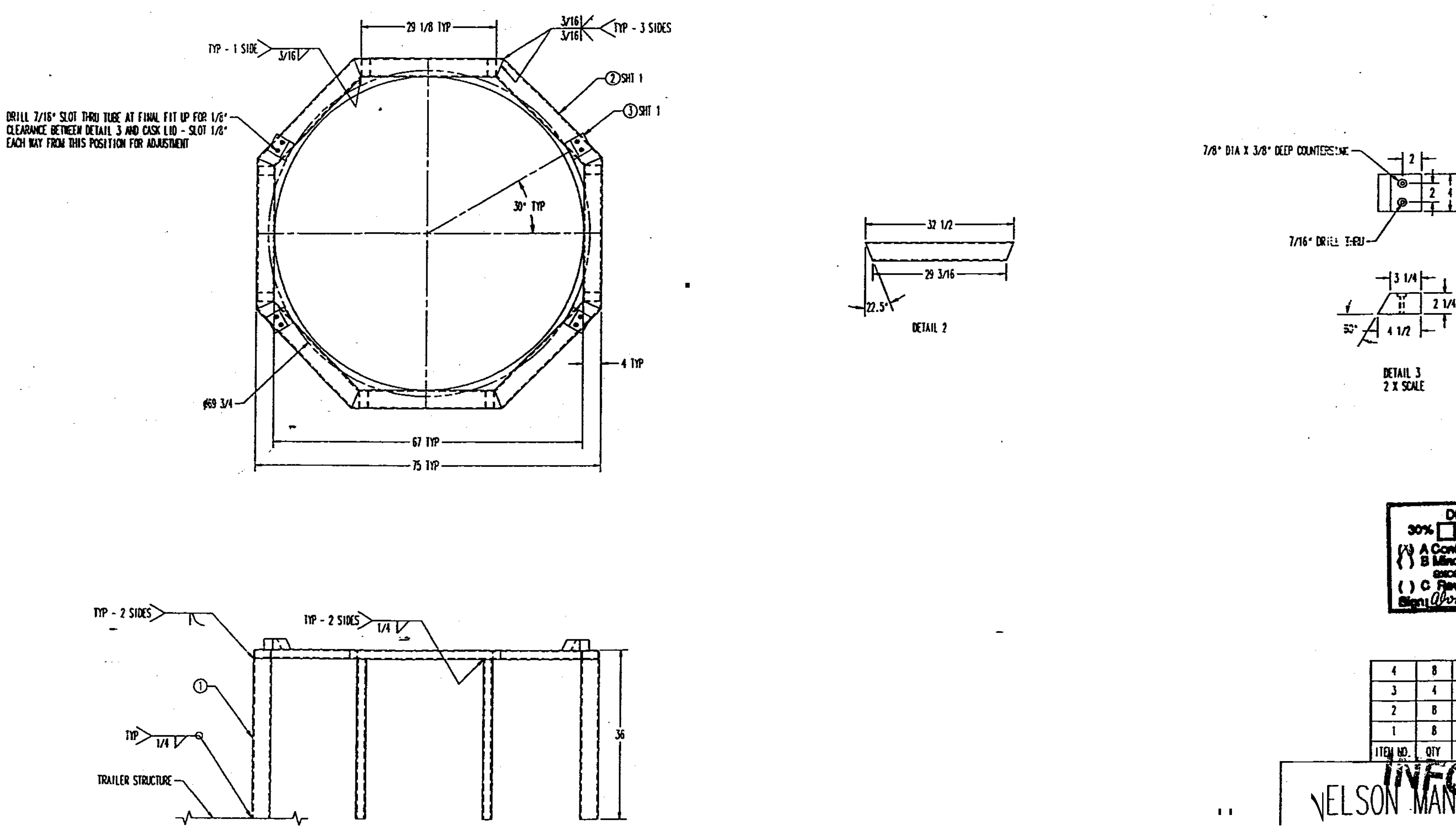
UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

SCALE: 1/8"=1" DATE 11/16/01
REV: 2 SHEET 4 OF 5
DWG SIZE D DWG NO. TRLR9814
SUBMITTAL DOCUMENT NO.: FAB-24


REVISION HISTORY
REV | DESCRIPTION | DRAWN | APPD | DATE
1 | UPDATED SUBMITTAL NUMBER | CS | TN | 5/22/02
2 | UPDATED TO "AS BUILT" | CS | TN | 8/20/02
DETAIL 68 - DEBRIS SHIELD RETAINER
4 X 5/16" DIA THRU
DETAIL 69 - DEBRIS SHIELD
DETAIL 62 - STIFF LEG ASSEMBLY
(16 DIA)
SHT 5
DETAIL 64 - CYLINDER SUPPORT SUBASSEMBLY
INSIDE DIAMETER OF DETAIL 65 MINUS 1/16
DETAIL 65 - STIFF LEG CYLINDER
8 REF
2 X 7/8" DIA THRU
24 13/16
13 5/16
SECTION C-C
4 X 1/4-20 UNC-2B X 1/2" DEEP
SECTION D-D
1/2" DIA THRU
2 PLACES
90° ARC
180° ARC
AFTER WELDING
DETAIL 67 - WEB ATTACHMENT PLATE
23 1/2
10 11/16
NELSON MANUFACTURING COMPANY
INFORMATION ONLY
LANDING LEG
APPD TN
CHECK RD
DRAWN CS
UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°
SCALE: 3/16"=1"
DATE 11/19/01
REV: 2
SHEET 5 OF 5
DWG SIZE D
DWG NO. TRLR9814
SUBMITTAL DOCUMENT NO.: FAB-24

REVISION HISTORY

REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER	CS	TN	5/22/02



DESIGN REVIEW SUBMITTAL
30% ☐ 60% ☐ 90% ☒ DRFT ☐
(X) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Sign: [signature] Date: 7/10/2002

ITEM NO.	QTY	PART NO./DESCRIPTION
4	8	3/8-16 UNC-2A X 3" LG SAE J429 GRADE 8 BOLT, WASHER, & LOCKNUT
3	4	APITONG WOOD BLOCK
2	8	4" X 2" X 1/4" A500 GRADE B TUBE
1	8	4" X 2" X 1/4" A500 GRADE B TUBE X 34" LG

NELSON MANUFACTURING COMPANY

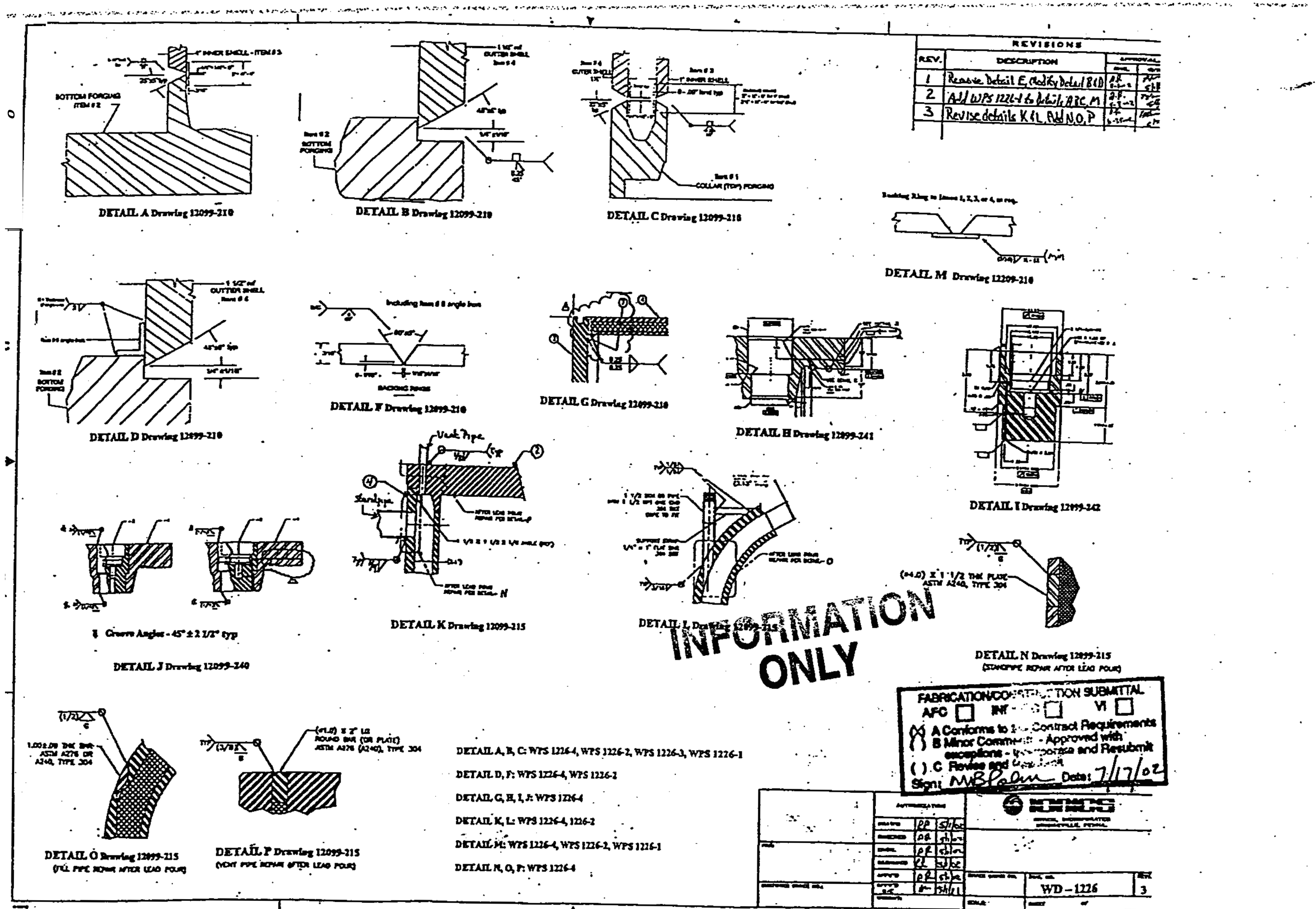
INFORMATION ONLY

LID INSPECTION STAND

APPD	TN
CHECK	JD
DRAWN	CS

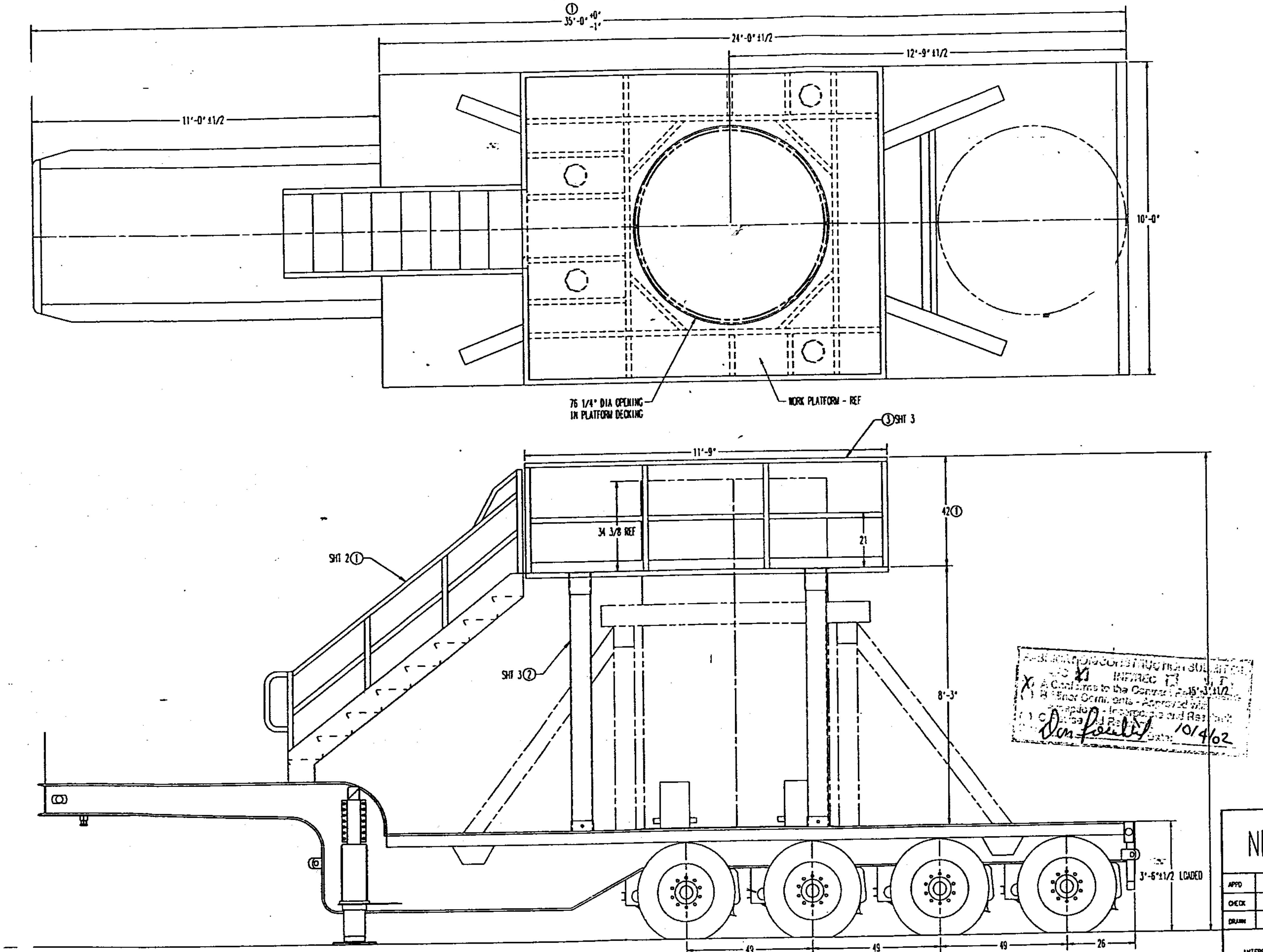
UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

SCALE: 1"=1'   DATE 4/30/02
REV: 1   SHEET 1 OF 1
DWG SIZE D   DWG NO. STND9923
SUBMITTAL DOCUMENT NO.: TIS-2


REVISIONS
REV. | DESCRIPTION
1 | Remove Detail E, Modify Detail B & D
2 | Add WPS 1226-4 to Details A, B, C, M
3 | Revise details K & L, Add N, O, P
DETAIL A Drawing 12099-210
DETAIL B Drawing 12099-210
DETAIL C Drawing 12099-210
DETAIL M Drawing 12209-210
DETAIL D Drawing 12099-210
DETAIL F Drawing 12099-210
DETAIL G Drawing 12099-210
DETAIL H Drawing 12099-241
DETAIL I Drawing 12099-242
Vent Pipe
Standpipe
DETAIL K Drawing 12099-215
DETAIL L Drawing 12099-215
Groove Angles - 45° ± 2 1/2° typ
DETAIL J Drawing 12099-240
DETAIL N Drawing 12099-215
INFORMATION ONLY
DETAIL O Drawing 12099-215
DETAIL P Drawing 12099-215
DETAIL A, B, C: WPS 1226-4, WPS 1226-2, WPS 1226-3, WPS 1226-1
DETAIL D, F: WPS 1226-4, WPS 1226-2
DETAIL G, H, I, J: WPS 1226-4
DETAIL K, L: WPS 1226-4, 1226-2
DETAIL M: WPS 1226-4, WPS 1226-2, WPS 1226-1
DETAIL N, O, P: WPS 1226-4
FABRICATION/CONSTRUCTION SUBMITTAL
AFC
VI
A Conforms to Contract Requirements
B Minor Comments - Approved with exceptions
C Revise and Resubmit
Date: 7/17/02
WD-1226
3

REVISION HISTORY

REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER, WAS 40"	CS	TN	5/22/02
2	UPDATED TO "AS BUILT"	CS	TN	8/20/02



ITEM NO.	QTY	PART NO./DESCRIPTION
37	1	1/4" X 5" X 17" A36 PLATE
36	4	#VC-665-R-M WHITE REFLECTIVE TAPE (12" STRIP)
35	-	1/8" TREADPLATE - COMMERCIAL GRADE STEEL
34	2	1/4" A36 CAP PLATE
33	8	3/16" COTTER PIN
32	8	1" FLAT WASHER
31	2	1/4" X 16" X 16" A36 PLATE
30	2	1/4" X 11" X 14" A36 PLATE
29	-	3/16" X 4" A36 BAR
28	4	8" SCH 40 A53 PIPE X 8 1/4" LG
27	-	1 1/4" SCH 40 A53 PIPE
26	-	2" X 2" X 3/16" A500 GRADE B TUBE
25	-	2" X 2" X 1/8" A500 GRADE B TUBE
24	4	8" SCH 40 A53 PIPE X 4" LG
23	4	1" 1045 CR ROUND X 11" LG
22	4	1" SCH 40 A53 PIPE X 8" LG
21	4	1/4" A36 PLATE X 7 5/8" DIA
20	4	8" OD X 3/16" WALL DOM TUBE X 98 3/4" LG
19	2	MEDALIST #31-40 - 3/4" X 7" LG PIN
18	4	3/4" SCH 40 A53 PIPE X 2" LG
17	2	3" X 2" X 1/4" A36 L X 5" LG
16	2	5/8" X 1" A36 BAR X 1 3/4" LG
15	1	MCMASTER-CARR #3715T41 SPRING SNAP
14	1	MCMASTER-CARR #3448T52 ALLOY CHAIN
13	2	MCMASTER-CARR #8947T16 THREADED CONNECTOR
12	2	3/8" A572 GRADE 50 PLATE
11	4	1/2 - 13 X 2" LG SAE J429 GRADE 8 BOLT & LOCKNUT - PLATED
10	-	3/8" X 2 1/2" A36 BAR
9	2	10" X 15.3 A36 CHANNEL
8	8	1/8" X 16 1/2" X 29 3/4" TREADPLATE - COMMERCIAL GRADE STEEL
7	2	1 1/4" SCH 40 A53 PIPE
6	2	1 1/4" SCH 40 A53 PIPE
5	-	2" X 2" X 1/8" A500 GRADE B TUBE
4	2	1 1/4" SCH 40 A53 PIPE
3	1	WORK PLATFORM
2	4	WORK PLATFORM SUPPORT STRUCTURE
1	1	WORK PLATFORM STAIRS

Stamp: A Conforms to the Contract ... B Minor Comments - Approved ... C ... Don [signature] 10/4/02

INFORMATION ONLY

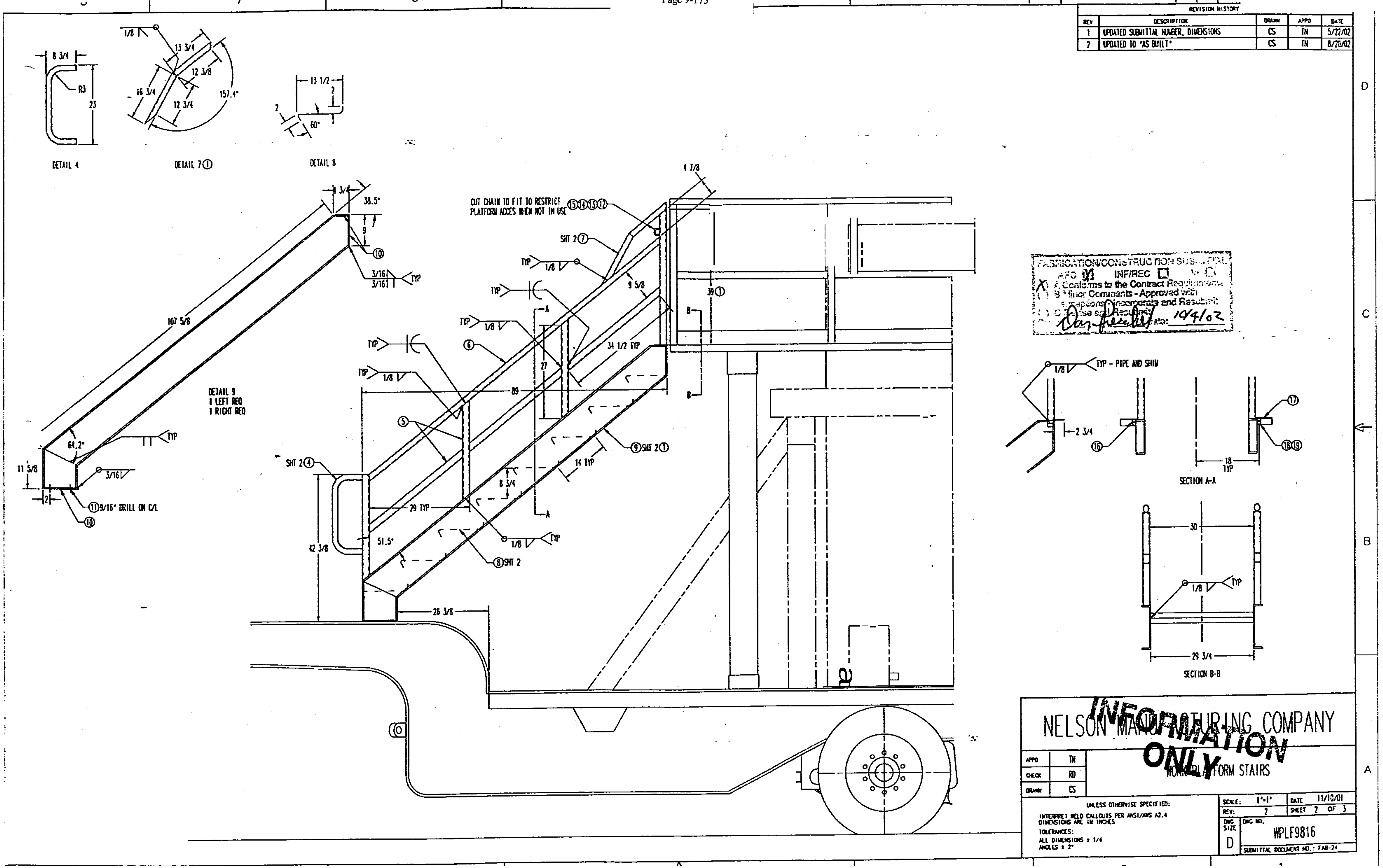
NELSON MANUFACTURING COMPANY

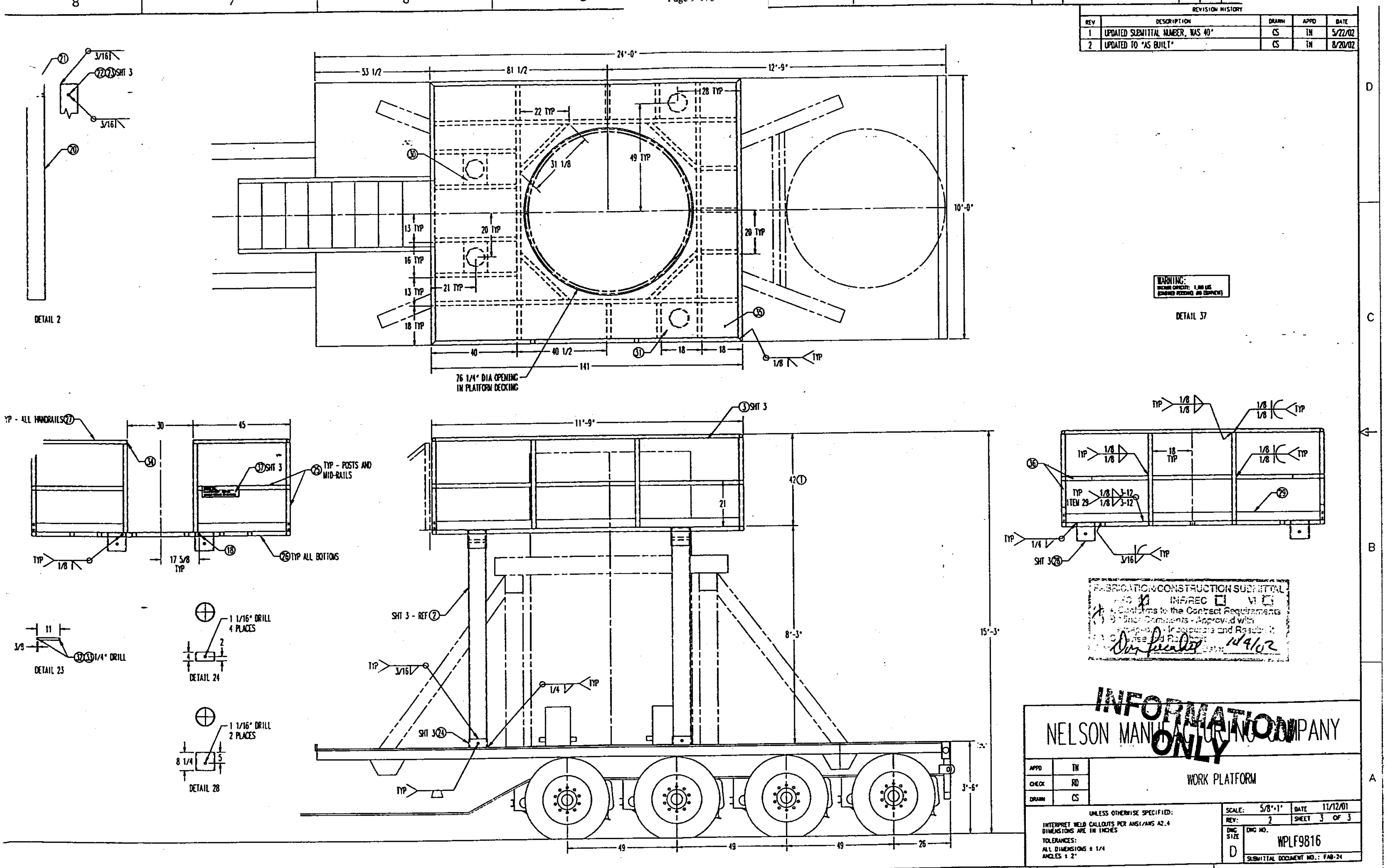
WORK PLATFORM

APPD	TN
CHECK	RD
DRAWN	CS

UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

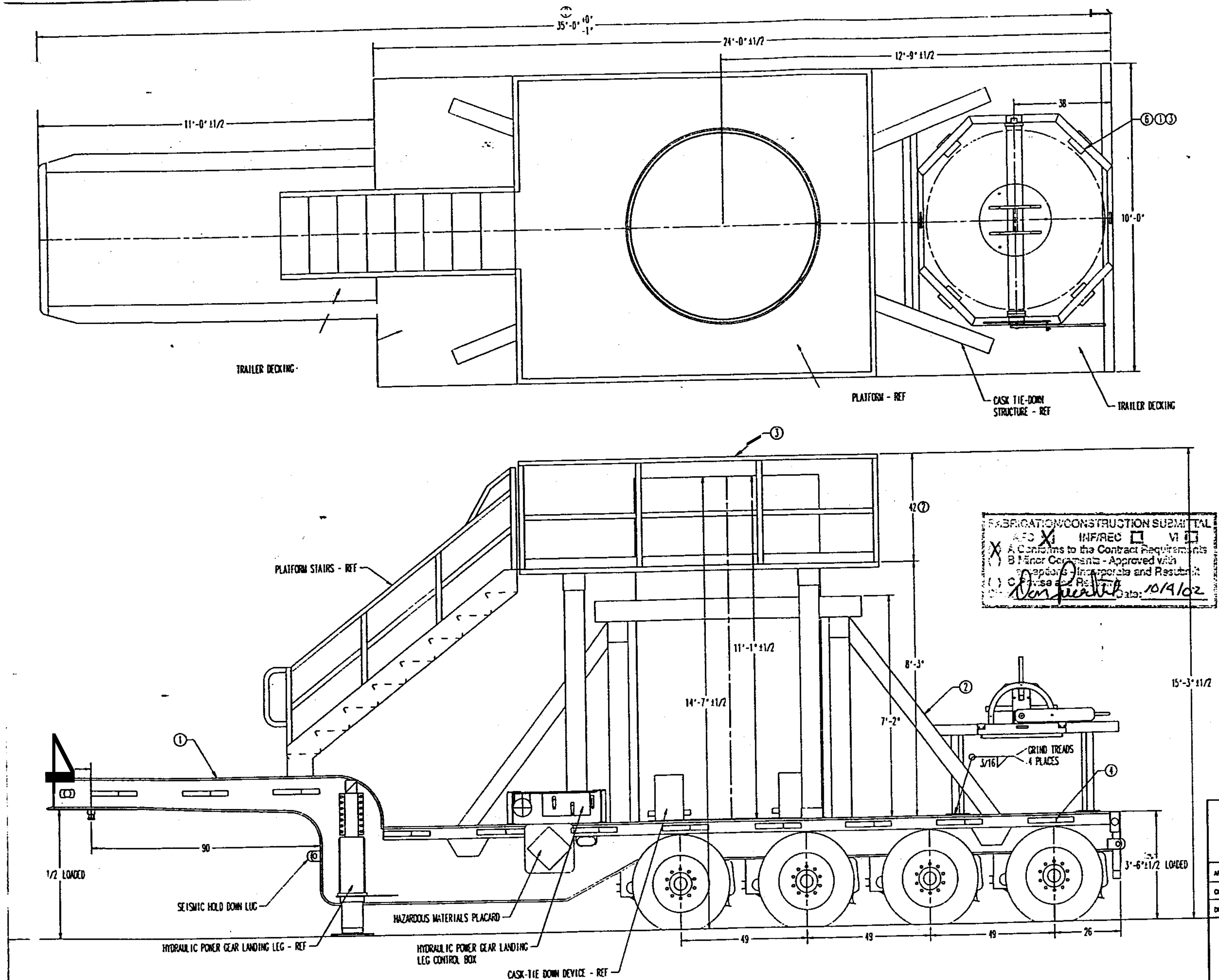
SCALE: 5/8"=1'		DATE 10/17/01	
REV: 2		SHEET 1 OF 3	
DWG SIZE D	DWG NO. WPLF9816		
	SUBMITTAL DOCUMENT NO.: FAB-24		

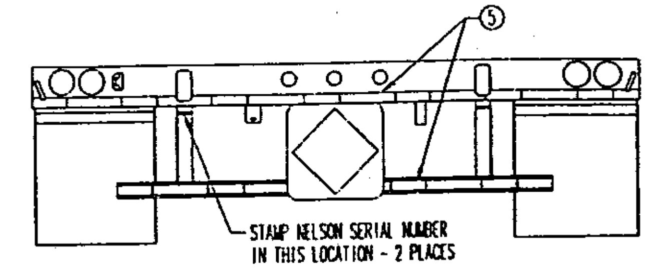

REVISION HISTORY
REV | DESCRIPTION | DRAWN | APPD | DATE
1 | UPDATED SUBMITTAL NUMBER, DIMENSIONS | CS | TN | 5/22/02
2 | UPDATED TO "AS BUILT" | CS | TN | 8/26/02
DETAIL 4
DETAIL 7 ①
DETAIL 8
DETAIL 9
1 LEFT REQ
1 RIGHT REQ
CUT CHAIN TO FIT TO RESTRICT PLATFORM ACCES WHEN NOT IN USE ⑮⑭⑬⑫
SECTION A-A
SECTION B-B
TYP - PIPE AND SHIM
107 5/8
89
34 1/2 TYP
29 TYP
42 3/8
26 3/8
39 ①
30
29 3/4
FABRICATION/CONSTRUCTION SUBMITTAL
A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions/Incorporate and Resubmit
10/4/02
NELSON MANUFACTURING COMPANY
INFORMATION ONLY
WORK PLATFORM STAIRS
APPD TN
CHECK RD
DRAWN CS
UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°
SCALE: 1"=1'
DATE 11/10/01
REV: 2
SHEET 2 OF 3
DWG SIZE D
DWG NO. WPLF9816
SUBMITTAL DOCUMENT NO.: FAB-24


REVISION HISTORY
REV | DESCRIPTION | DRAWN | APPD | DATE
1 | UPDATED SUBMITTAL NUMBER, WAS 40" | CS | TN | 5/22/02
2 | UPDATED TO "AS BUILT" | CS | TN | 8/20/02
24'-0"
53 1/2
81 1/2
12'-9"
10'-0"
28 TYP
22 TYP
31 1/8
49 TYP
20 TYP
13 TYP
16 TYP
21 TYP
18 TYP
40
40 1/2
18
141
76 1/4" DIA OPENING IN PLATFORM DECKING
DETAIL 2
DETAIL 37
WARNING:
DETAIL 23
DETAIL 24
DETAIL 28
1 1/16" DRILL 4 PLACES
1 1/16" DRILL 2 PLACES
1/4" DRILL
TYP - ALL HANDRAILS
TYP - POSTS AND MID-RAILS
TYP ALL BOTTOMS
17 5/8 TYP
11'-9"
42
21
8'-3"
15'-3"
3'-6"
49
26
SHT 3
SHT 3 - REF
ITEM 29
FABRICATION/CONSTRUCTION SUBMITTAL
INFO
INF/REC
VI
Conforms to the Contract Requirements
Comments - Approved with
Incorporate and Resubmit
Revise and Resubmit
10/4/02
INFORMATION ONLY
NELSON MANUFACTURING COMPANY
APPD TN
CHECK RD
DRAWN CS
WORK PLATFORM
UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°
SCALE: 5/8"=1'
DATE 11/12/01
REV: 2
SHEET 3 OF 3
DWG SIZE D
DWG NO. WPLF9816
SUBMITTAL DOCUMENT NO.: FAB-24

REVISION HISTORY

REV	DESCRIPTION	DRAWN	APPD	DATE
1	ADDED LID INSPECTION STAND	CS	TN	4/30/02
2	UPDATED SUBMITTAL NUMBER, NOTES, DIMENSIONS	CS	TN	5/22/02
3	WAS STN09923, UPDATED TO "AS BUILT"	CS	TN	8/20/02





REAR VIEW

GENERAL NOTES

1. WELD IN ACCORDANCE WITH AWS D1.1(94 OR NEWER). WELDING PROCEDURE SPECIFICATIONS, WELDING PRODEDURE QUALIFICATIONS, AND WELDER QUALIFICATIONS IN ACCORDANCE WITH ASME SECTION IX ARE ACCEPTABLE. THE FINAL PASS OF WELDS SHALL BE VISUALLY EXAMINED IAW AWS D1.1. THE INSPECTOR SHALL BE A CERTIFIED WELD INSPECTOR PER AWS D1.1 AND WELD INSPECTIONS SHALL BE DOCUMENTED.
2. REMOVE ALL SHARP EDGES AND BURRS.
3. STEEL COMPONENTS SHALL BE PAINTED WITH AMERON AMERLOCK 400 PRIMER, AMERON AMERCOAT 450HS FINISH COAT, RT-8304 WHITE.
4. ② SAFETY CLASSIFICATION: ALL ITEMS ARE GENERAL SERVICE (GS). QUALITY LEVEL 3
5. DIMENSIONAL CONTROL OF THE MAIN BEAMS IS IN ACCORDANCE WITH NORMAL COMMERCIAL PRACTICE. TOLERANCE FOR CAMBER, SWEEP, AND FLANGE OUT OF SQUARE SHALL BE ± 1/4".
6. FABRICATE, INSPECT, & TEST PER NELSON FIT-2001-5709-5710.
7. ② MAGNETIC PARTICLE OR LIQUID PENETRANT EXAMINE ALL LOAD BEARING WELDS PER FIT PLAN.
8. ② REFER TO FIT PLAN FOR AWS ACCEPTANCE CRITERIA FOR STATICALLY AND DYNAMICALLY LOADED STRUCTURES.
9. ② SEE DRAWING DIAC9817 SHEET 1 FOR ABS AIR PLUMBING, SHEET 2 FOR ABS WIRING, SHEET 3 FOR WIRING DIAGRAMS.

ITEM NO.	QTY	PART NO./DESCRIPTION
③ 6	1	12099-600 - LID INSPECTION STAND
5	2	VC-663-R-W RED/WHITE REFLECTIVE TAPE (ROLL)
4	22	VC-664-R-W RED/WHITE REFLECTIVE TAPE (18" STRIP)
3	1	WPLF9816 - WORK PLATFORM
2	1	CAT09815 - CASK TIE-DOWN
1	1	TRLR9814 - CASK TRANSPORT TRAILER

NELSON MANUFACTURING COMPANY

INFORMATION ONLY

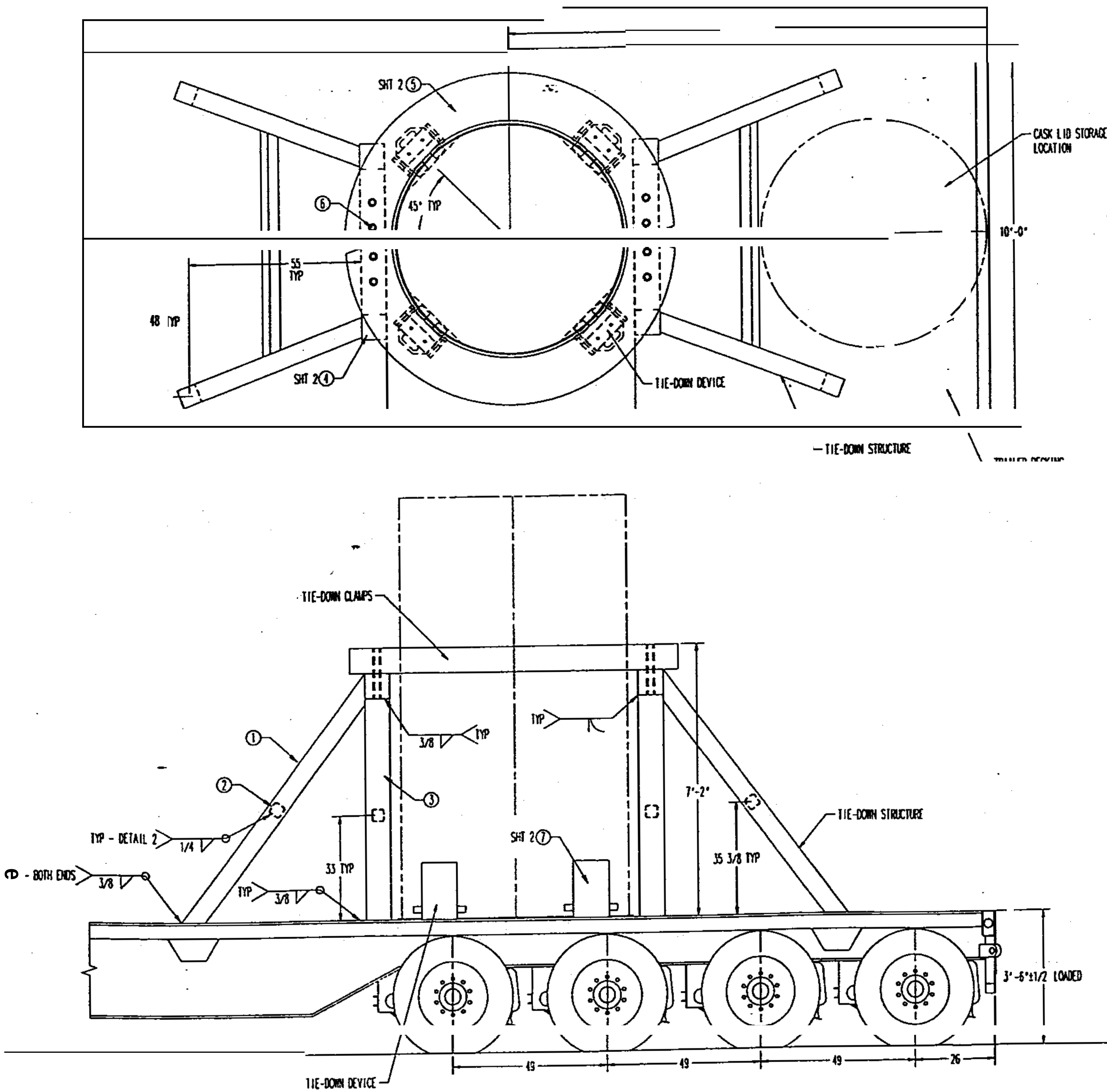
GENERAL ASSEMBLY

APPD	TN
CHECK	RD
DRAWN	CS

UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

SCALE: 5/8"=1'		DATE	10/16/01
REV: 3		SHEET 1 OF 1	
DWG SIZE D	DWG NO. ASSY9813		
	SUBMITTAL DOCUMENT NO. : FAB-24		

REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER, WAS 12"	CS	TN	5/22/02
2	ADDED DETAIL 25	CS	TN	8/17/02



	25	4	1/2" A514 GRADE B (T-1) PLATE
	24	28	1/4" FLAT WASHER
	23	28	1/4-20 UNC-2A X 1 1/4" LG BOLT
	22	8	3/4 - 10 X 5" LG SAE J429 GRADE 8 BOLT & LOCKNUT - PLATED
	21	4	2" X 12" X 13" TYPE 304 STAINLESS STEEL TIE-DOWN BAR
	20	8	3/4" X 8" X 12 1/2" A514 GRADE B (T-1) PLATE
	19	8	3/4" X 7" X 19 1/2" A514 GRADE B (T-1) PLATE
	18	4	1" X 7 1/2" X 16" A514 GRADE B (T-1) PLATE
	17	4	1" X 12 5/8" X 16" A514 GRADE B (T-1) PLATE
	16	10	1/4" X 5 1/2" X 13 1/2" A36 PLATE
	15	8	1 9/16" ID X 2 1/2" OD DOM TUBE X 8" LG
	14	2	3/4" X 8" A572 GRADE 50 PLATE
	13	4	3/4" A572 GRADE 50 PLATE
	12	2	3/4" X 8" A572 GRADE 50 PLATE
	11	2	1" X 8" RUBBER X 117" LG
	10	4	3/8" X 7" X 7" A572 GRADE 50 PLATE
	9	8	1 9/16" ID X 2 1/2" OD DOM TUBE X 8" LG
	8	2	8" X 8" X 1/2" A500 GRADE B TUBE X 62" LG
	7	4	TIE-DOWN DEVICE WELDMENT
	6	8	1 1/2 - 6 X 22" LG SAE J429 GRADE 8 BOLT & LOCKNUT - PLATED
	4	2	TIE-DOWN TUBE WELDMENT
	3	4	8" X 8" X 1/2" A500 GRADE B TUBE X 70" LG
	2	4	4" X 4" X 1/4" A500 GRADE B TUBE
	1	4	6" X 6" X 3/8" A500 GRADE B TUBE
	ITEM NO.	QTY	PART NO./DESCRIPTION

X Don Fecalte 10/4/02

NELSON MANUFACTURING COMPANY

INFORMATION ONLY

CASK TIE-DOWN

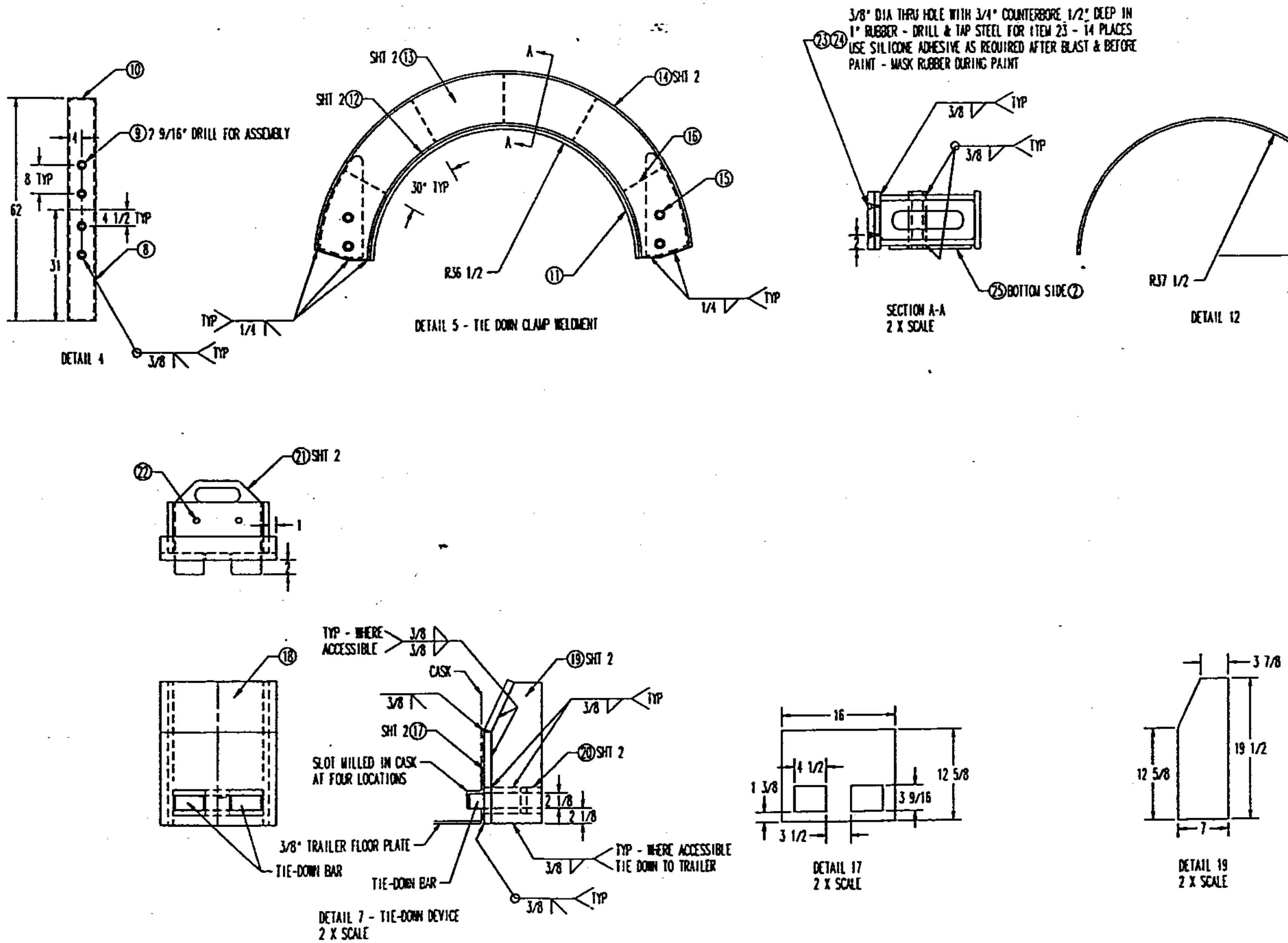
APPD	TN
CHECK	RD
DRAWN	CS

UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4

SCALE: 5/8"=1'	DATE 10/17/01
REV: 2	SHEET 1 OF 2
DWG SIZE D	DWG NO. CATD9815

REVISION HISTORY

REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER	CS	TN	5/22/02
2	ADDED SHIMS, RECESS, UPDATED TO "AS BUILT"	CS	TN	8/20/02



NELSON MANUFACTURING COMPANY

INFORMATION ONLY

CASK TIE-DOWN DETAILS

APPD	TN
CHECK	RD
DRAWN	CS

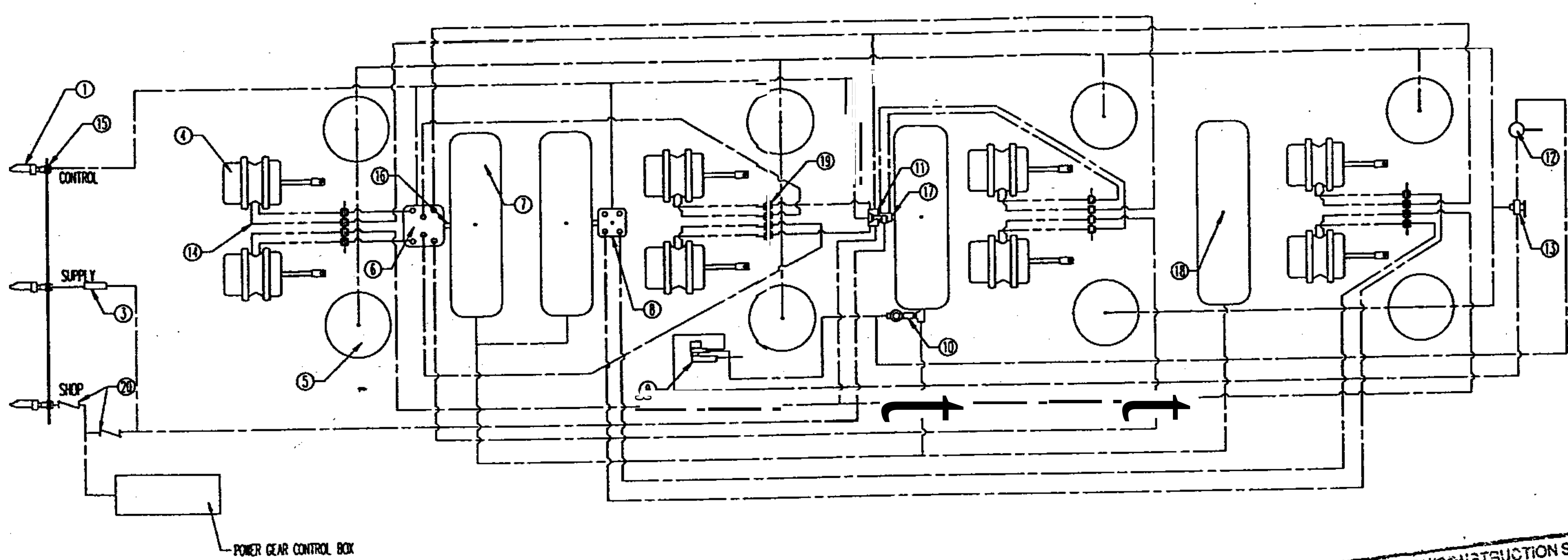
UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

SCALE: 5/8"=1"		DATE	10/17/01
REV: 2		SHEET 2 OF 2	
DWG SIZE D	DWG NO. CAT09815		
SUBMITTAL DOCUMENT NO.: FAB-24			

INFO/REC ☐ 1/4/02

REVISION HISTORY

REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER	CS	TN	5/22/02
2	UPDATED TO FOUR AXLES	CS	TN	6/5/02
3	UPDATED TO "AS BUILT"	CS	TN	8/20/02



FABRICATION/CONSTRUCTION SUBMITTAL
AFC [X] INF/REC [ ] VI [ ]
(X) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
( ) C Revise and Resubmit
Data: 10/4/02

	ITEM NO.	QTY	PART NO./DESCRIPTION
	20	2	1-WAY CHECK VALVE #SE102001
②	19	16	HEBCO BULKHEAD FITTING #HB607
②	18	4	WEATHERHEAD DRAINCOCK #W15310
	17	1	HEBCO HEX NIPPLE #VS332525X12X8
②	16	2	HEBCO HEX NIPPLE #VS332525X12X12
	15	3	HEBCO BULKHEAD FITTING #HB646
②	14	16	3/8" BRAKE HOSE ASSEMBLY #HT-RPS3838-24"
	13	1	B-43XF4 WHITEY DIRECTIONAL VALVE
	12	1	WILLIAMS #WM606C1 HAND CONTROL VALVE
	11	1	SEALCO #100500 SPRING BRAKE CONTROL VALVE
	10	1	HENDRICKSON #A-1128 PRESSURE PROTECTION VALVE
	9	1	HENDRICKSON #AKH-236-3 HEIGHT CONTROL VALVE
②	8	1	MERITOR/WABCO 472 195 030 0 ABS RELAY VALVE
②	7	4	#ATC8052 AIR TANK
	6	1	MERITOR/WABCO 400 500 103 0 ECU VALVE
②	5	8	SUSPENSION AIR SPRING
②	4	8	MGM #3430051 TYPE 30/30 SPRING BRAKE CHAMBER
	3	1	SEALCO #2550 LINE FILTER
	2	-	NOT USED
	1	3	#VE035031 GLAD HAND

NELSON MANUFACTURING COMPANY

INFORMATION ONLY

AIR PLUMBING DIAGRAM WITH 4S/2M ABS BRAKES AND OVERRIDE CONTROLS

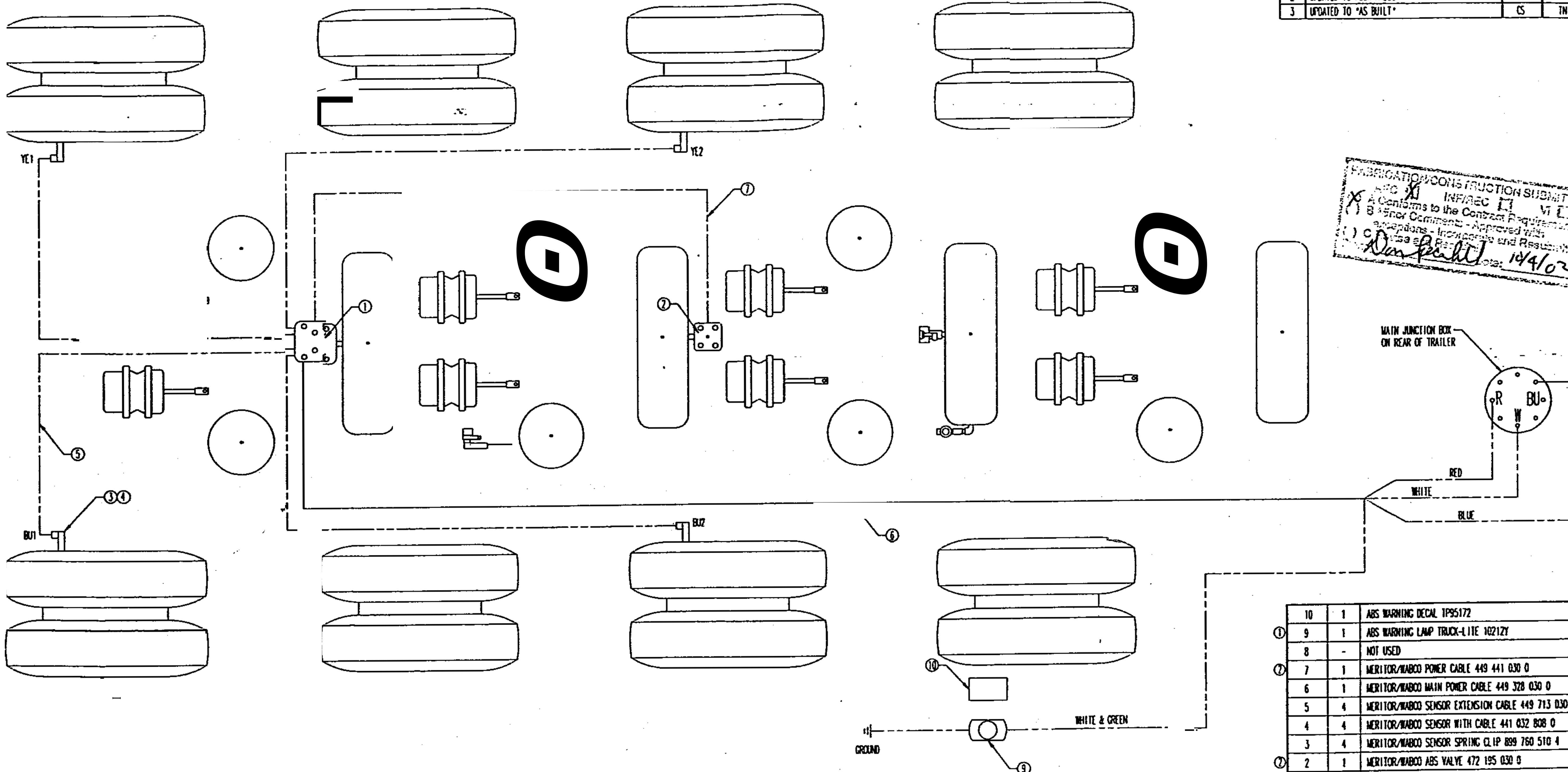
APPD	TN
CHECK	RD
DRAWN	CS

UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

SCALE: N/A		DATE	11/29/01
REV: 3		SHEET	1 OF 3
DWG SIZE D	DWG NO. DIAG9817		
SUBMITTAL DOCUMENT NO.: FAD-24			

REVISION HISTORY

RLV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER, QUANTITY	CS	TN	5/22/02
2	UPDATED TO FOUR AXLES	CS	TN	6/5/02
3	UPDATED TO "AS BUILT"	CS	TN	8/20/02



FABRICATION/CONSTRUCTION SUBMITTAL
(X) A Conforms to the Contract Requirements
( ) B Minor Comments - Approved with exceptions - Incorporate and Resubmit
10/4/02

ITEM NO.	QTY	PART NO./DESCRIPTION
10	1	ABS WARNING DECAL TP95172
① 9	1	ABS WARNING LAMP TRUCK-LITE 10212Y
8	-	NOT USED
② 7	1	MERITOR/WABCO POWER CABLE 449 441 030 0
6	1	MERITOR/WABCO MAIN POWER CABLE 449 328 030 0
5	4	MERITOR/WABCO SENSOR EXTENSION CABLE 449 713 030 0
4	4	MERITOR/WABCO SENSOR WITH CABLE 441 032 808 0
3	4	MERITOR/WABCO SENSOR SPRING CLIP 899 760 510 4
② 2	1	MERITOR/WABCO ABS VALVE 472 195 030 0
1	1	MERITOR/WABCO ECU VALVE 400 500 103 0

NOTE:
1 - LOCATE THE ABS WARNING LAMP ON THE REAR DRIVER'S SIDE OF THE TRAILER 12" IN FRONT OF REAR CLEARANCE LIGHT CENTERLINE

NELSON MANUFACTURING COMPANY

INFORMATION ONLY

...FOR ABS BRAKES

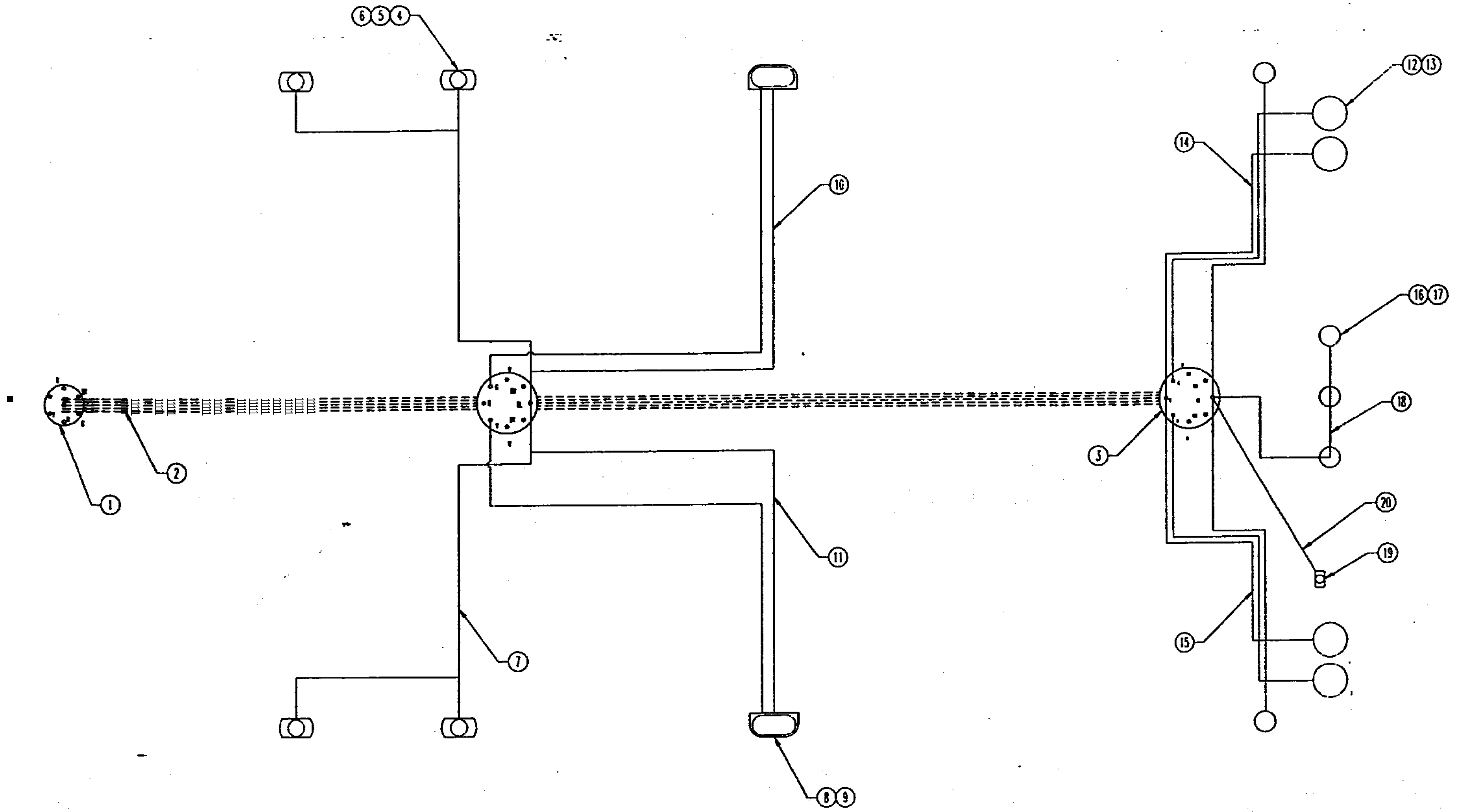
APPD	TN
CHECK	RD
DRAWN	CS

UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4

SCALE: N/A	DATE 11/29/01	REV: 3	SHEET 2 OF 3
DWG SIZE D	DWG NO. DIAG9817		

REVISION HISTORY

REV	DESCRIPTION	DRAWN	APPD	DATE
1	UPDATED SUBMITTAL NUMBER, QUANTITIES	CS	TN	5/22/02
2	UPDATED TO "AS BUILT"	CS	TN	8/20/02



COLOR CODE:
WHITE - GROUND
BLACK - CLEARANCE LIGHTS
RED - BRAKE LIGHTS
GREEN - RH TURN SIGNAL
YELLOW - LH TURN SIGNAL
BROWN - OPEN
BLUE - ABS

FABRICATION/CONSTRUCTION SUBMITTAL
X A Conforms to the Contract Requirements
B Minor Comments - Approved with exceptions - Incorporate and Resubmit
10/4/02

	ITEM NO.	QTY	PART NO./DESCRIPTION
	20	1	TRUCK LITE HARNESS #50307
	19	1	TRUCK-LITE LICENSE PLATE LIGHT #15011
	18	1	TRUCK LITE HANESS #50300
	17	5	TRUCK LITE GROMMET #10710
	16	5	TRUCK LITE RED CLEARANCE LIGHT #10205R
	15	1	TRUCK LITE HARNESS #50209
	14	1	TRUCK-LITE HARNESS #50208
	13	4	TRUCK LITE GROMMET #40700
	12	4	TRUCK LITE COMBINATION LIGHT #40202R
	11	1	TRUCK LITE HARNESS #50345
	10	1	TRUCK LITE HARNESS #50344
①	9	2	TRUCK-LITE BRACKET & GROMMET #60700
①	8	2	TRUCK LITE AMBER CLEARANCE LIGHT #10205Y
	7	4	TRUCK LITE JUNCTION BOX #50400
	6	4	TRUCK LITE GROMMET #10700
	5	4	TRUCK-LITE BRACKET #10725
	4	4	TRUCK LITE AMBER CLEARANCE LIGHT #10205Y
	3	2	TRUCK LITE JUNCTION BOX #50400
	2	-	DEL-CITY #37725 7 CONDUCTOR TRAILER CABLE
	1	1	TRUCK LITE 7-WAY RECEPTICAL #TL50869

NELSON MANUFACTURING COMPANY

INFORMATION ONLY

WIRING DIAGRAM

APPD	TN
CHECK	RD
DRAWN	CS

UNLESS OTHERWISE SPECIFIED:
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES
TOLERANCES:
ALL DIMENSIONS ± 1/4
ANGLES ± 2°

SCALE: N/A		DATE 11/29/01	
REV: 2		SHEET 3 OF 3	
DWG SIZE D	DWG NO. DIAG9817		
	SUBMITTAL DOCUMENT NO.: FAB-24		

ATTACHMENT 10

HNF-8513, Rev. 1

CSER* 01-002: *Criticality Safety Evaluation Report for Loading, Transport, and Storage of K Basin Sludge Containers

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