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Distribution	Tank Waste Remediation System Vitrification Development	Date February 9, 1995

Project Title/Work Order	EDT No. 609259
Tank Waste Remediation System High-Level Waste Vitrification System Development and Testing Requirements	ECN No.

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Phone: 376-2449 H5-27
Date: February 9,1995
Subject: TANK WASTE REMEDIATION SYSTEM HIGH-LEVEL WASTE VITRIFICATION SYSTEM DEVELOPMENT AND TEST REQUIRMENTS DOCUMENT WHC-SD-WM-RD-053, REVISION 0

To: R. W. Powell G3-20

cc: R. B. Calmus H5-27
P. S. Schaus G3-20
J. A. Swenson H5-49
RLG File/LB H5-27

Attached is the Tank Waste Remediation System High-Level Waste Vitrification System Development and Test Requirements document, WHC-SD-WM-RD-053, Revision 0. Transmittal of this approved document completes performance of the contractor milestone to provide TWRS HLW vitrification system development and test requirements.

R. L. Gibby, Acting Manager
TWRS Vitrification Development

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Attachment

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1	1	Cog.Eng. R. B. Calmus	[signature]		H5-27						
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V.L. Birkland

SUPPORTING DOCUMENT

1. Total Pages 35

2. Title

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High-temperature ceramic melter, high-frequency induction melter

6. Author

Name: R. B. Calmus

RB Cal

Signature

Organization/Charge Code W71250/D5040

7. Abstract

This document provides the fiscal year (FY) 1995 recommended high-level waste melter system development and testing requirements. The first phase of melter system testing (FY 1995) will focus on the feasibility of high-temperature operation of recommended high-level waste melter systems. These test requirements will be used to establish the basis for defining detailed testing work scope, cost, and schedules.

8. RELEASE STAMP

CONTENTS

LIST OF FIGURES

TANK WASTE REMEDIATION SYSTEM HIGH-LEVEL WASTE VITRIFICATION SYSTEM DEVELOPMENT AND TESTING REQUIREMENTS

1.0 INTRODUCTION AND SCOPE

A Tank Waste Remediation System (TWRS) High-Level Waste (HLW) Program (hereafter referred to as the HLW Program) melter assessment activity was initiated in fiscal year (FY) 1994 to develop a recommendation regarding the most viable vitrification technologies for immobilization of Hanford Site HLW. A melter assessment recommendation (Honeyman 1994) was prepared for the U.S. Department of Energy, Richland Operations Office (RL) and subsequently approved for implementation (Erickson 1994). A strategy for performing the recommended melter test program was prepared (Calmus 1995) and provides the scheme or tactical approach for evaluating the recommended technologies and selecting the reference melter for the HLW vitrification plant. This selection is scheduled for the end of FY 1998 (Tri-Party Agreement Milestone M-51-02 [Ecology et al. 1994]).

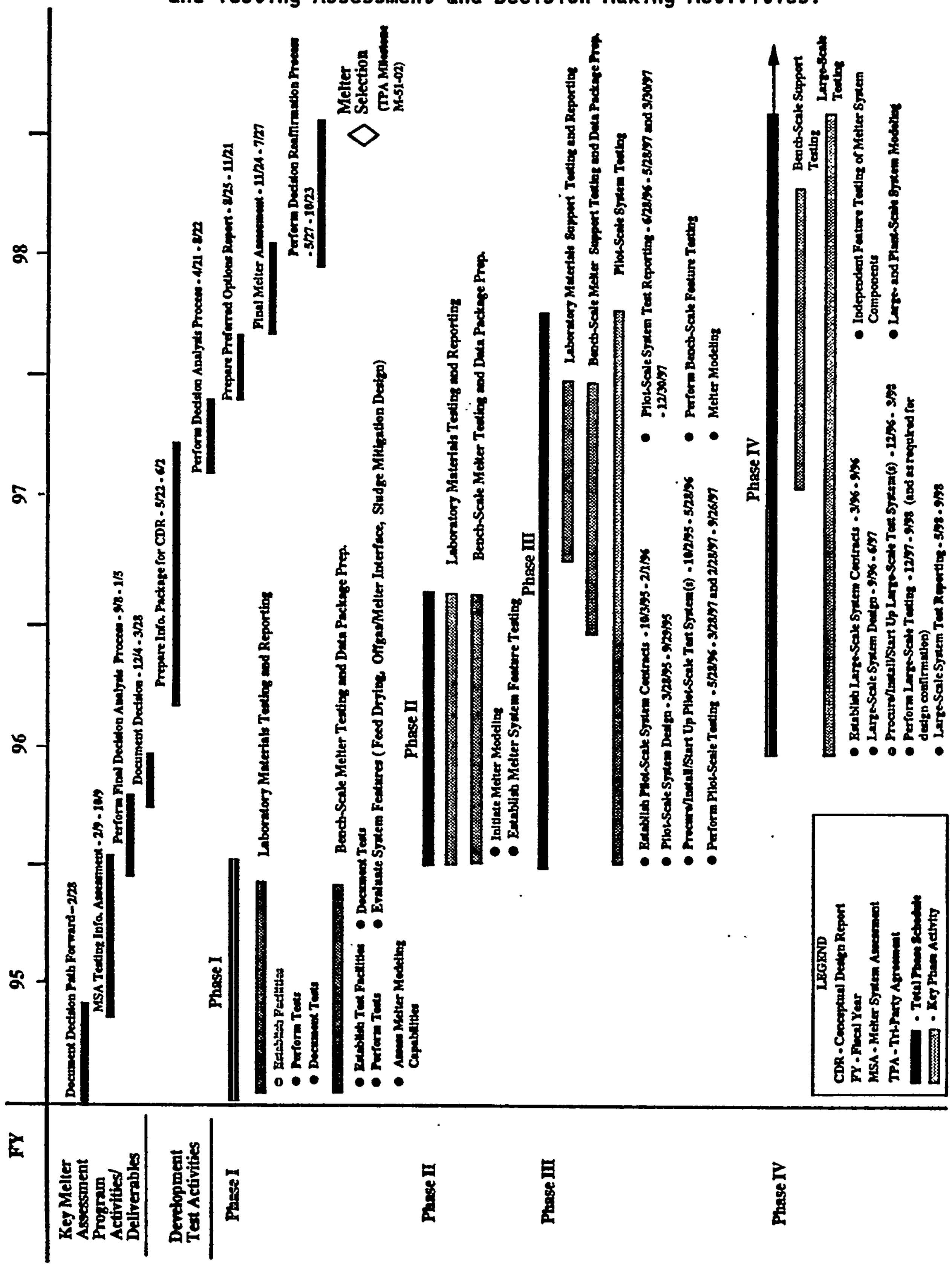
This document provides the vitrification system development and testing (D&T) requirements for FY 1995 in accordance with the multi-year strategy described in WHC-SD-WM-SD-007, *Tank Waste Remediation System High-Level Waste Vitrification System Development and Testing Strategy* (Calmus 1995). Figure 1-1 presents the general strategy for progressing from laboratory- to larger-scale testing to support the selection of the reference melter system for the plant. Figure 1-1 also includes melter assessment activities and key decision-making activities. The FY 1995 technology requirements will be used to guide TWRS HLW baseline planning and provide specific work scope definitions and testing costs. The work scope and associated costs will be developed by the responsible organizations, and reviewed and approved by the TWRS HLW Program Office.

The overall goal of this document is to focus development and planning of FY 1995 activities on high-priority tasks in accordance with the intent of the Westinghouse Hanford Company (WHC) TWRS vitrification system D&T program. Additional goals are to provide an indication of the type, extent, duration, and timing of these activities to support periodic vitrification system assessments and key HLW Program decision points.

This document includes a brief summary of the recommended technologies and technical issues associated with each technology. In addition, this document presents the key D&T activities and engineering evaluations to be performed for a particular technology or general melter system support feature.

The strategy for testing in Phase I (FY 1995) is to pursue testing of the recommended high-temperature technologies (Honeyman 1994), namely the high-temperature, ceramic-lined, joule-heated melter, referred to as the HTCM, and the high-frequency, cold-wall, induction-heated melter, referred to as the cold-crucible melter (CCM). This document provides a detailed description of the FY 1995 D&T needs and requirements relative to each of the high-temperature technologies. In addition, a general discussion of D&T planning

Figure 1-1. High-Level Waste Melter System Development and Testing Assessment and Decision-Making Activities.



for the low-temperature technologies is provided in the event that an HLW Program decision is made that one, or both, of the high-temperature technologies has a low probability of success based on Phase I test results. If this decision is made, testing emphasis may be shifted to D&T of the low-temperature technologies. The recommended low-temperature technologies are the low-temperature, ceramic-lined, joule-heated melter with Inconel* electrodes, referred to in this report as the LTCM, and the low-temperature, metal-lined (Inconel) stirred, joule-heated melter, commonly referred to as the stirred melter (SM). Westinghouse Hanford Company will continue to evaluate the feasibility of other (high-risk) melter technologies, but these evaluations will not be included in the scope of the present HLW melter development program.

This document includes the key D&T requirements for each technology and provides a schedule of specific activities relative to each technology. The target schedules are intended to support the FY 1995 melter system assessment, and the subsequent decision point at the end of calendar year (CY) 1995. The presented schedules are provided for baseline planning purposes only and will most likely be divided into smaller tasks, at a working level, by the task performer(s). Note that the schedules presented in this document are subject to change based primarily on uncertainty in establishing testing contracts and arranging for the requisite facilities and equipment.

*Inconel is a trademark of International Nickel Company.

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2.0 PHASE I AND II MELTER SYSTEM D&T REQUIREMENTS

The FY 1995 (Phase I) and FY 1996 (Phase II) testing activities necessary to meet the HLW Program's melter system testing strategy are discussed in the following sections for each recommended technology. The D&T requirements for each technology and specific activities, and time phasing of these activities, are also included. The activity schedules are presented in Figure 2-1. Also, the D&T activities common to more than one technology are presented separately at the end of Figure 2-1. The activities presented in Figure 2-1 focus on FY 1995 activities and present FY 1996 activities to provide planning continuity. Many of the Phase II testing activities depend on the testing results and program decisions made at the end of CY 1995, and therefore are not as well defined and may be subject to change. The following subsections are technology specific and provide a general discussion of the technology and technical issues requiring D&T. A listing of specific D&T activities and associated testing requirements is also included. In this document, "shall" denotes a test requirement for FY 1995.

2.1 JOULE-HEATED, CERAMIC-LINED MELTER SYSTEMS

The baseline recommended technology for D&T to establish the Hanford Site HLW vitrification plant melter system is the LTCM. This technology was selected as the baseline technology due to the significant maturity of this technology in successfully vitrifying Hanford Site HLW feed types. However, significant benefits could be obtained from high-temperature operation of this technology. Therefore, the initial phase (Phase I) of D&T focuses on developing and confirming the feasibility of high-temperature operation.

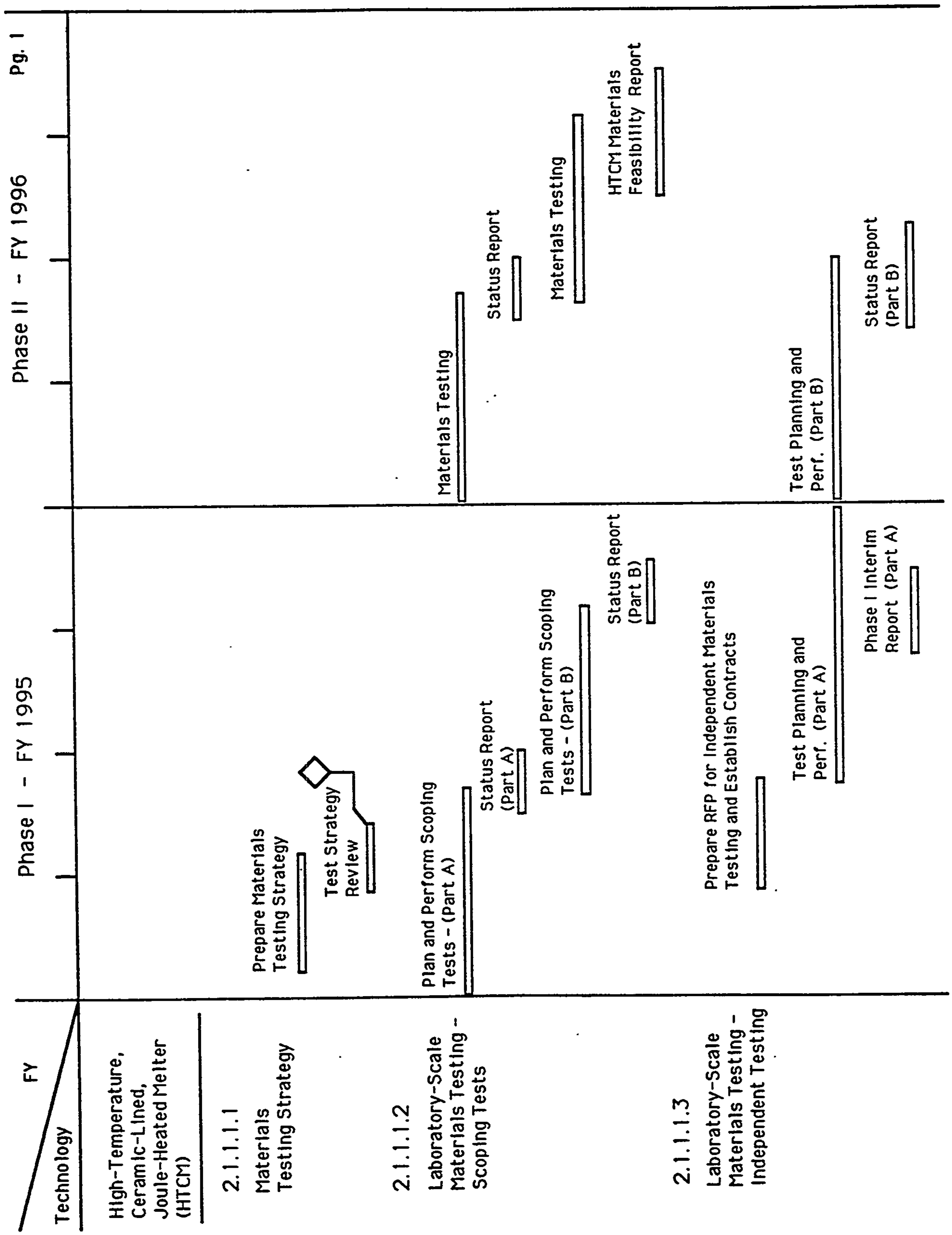
Common to the HTCM and LTCM systems is a need to evaluate the following independent system features.

- A reduction in liquid content of the feed (feed drying) could lead to improvement in melter glass processing rates (1.5X to 2X). Candidate technologies include rotary calciners similar to those used with French high-frequency, induction-heated melter systems and wiped film evaporators (e.g., horizontal and vertical evaporators).

- Melters designed for use at the Defense Waste Processing Facility (DWPF) and the Hanford Waste Vitrification Plant (HWVP) incorporate offgas line film coolers at the melter outlet to control offgas line plugging. However, the use of film coolers with high-capacity melters (greater than DWPF/HWVP systems--100 kg/h) could result in large air/steam flow rates that adversely affect the overall size and capacity of the offgas system. Offgas line reamers and air blasters similar to those used in German melter designs could significantly reduce the offgas flow rate and result in a smaller and less complex offgas system.

- Melter operation and/or designs to mitigate noble metal and refractory sludge buildup on the melt cavity floor (by increasing convection in the melter, or adding a sloped-bottom configuration/ bottom-drain system to the melter). The accumulation of sludge

Figure 2-1. Activity Schedules. (9 sheets)



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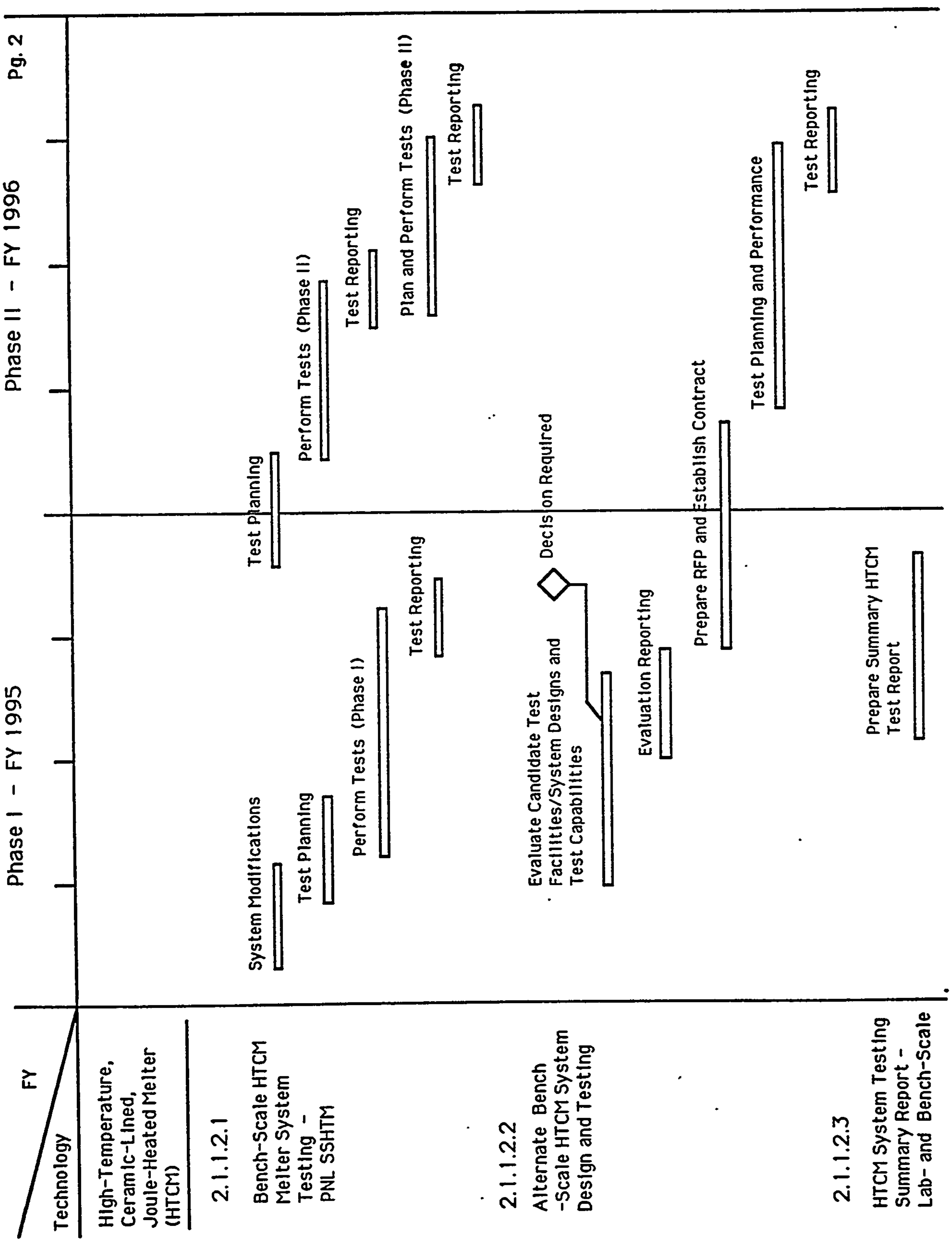

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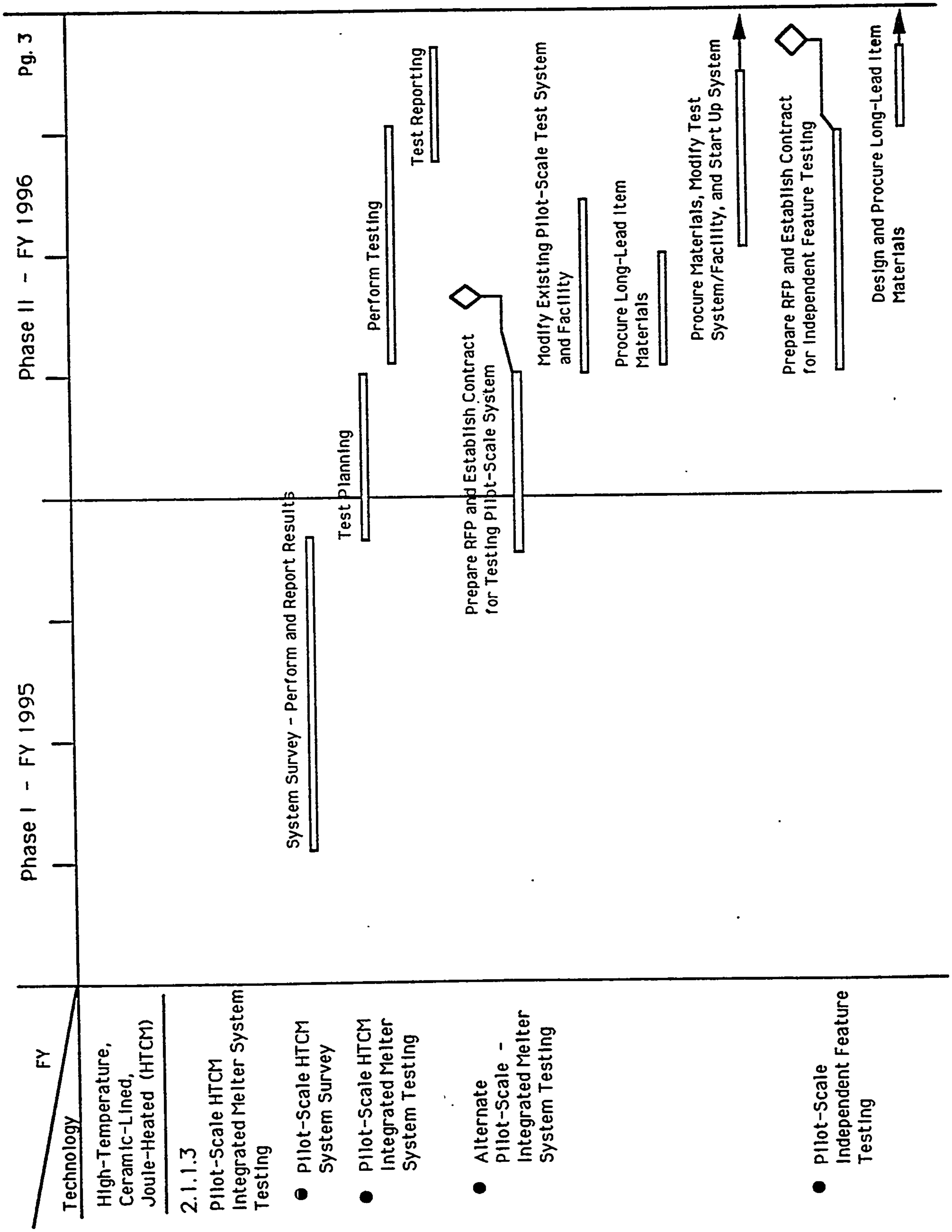

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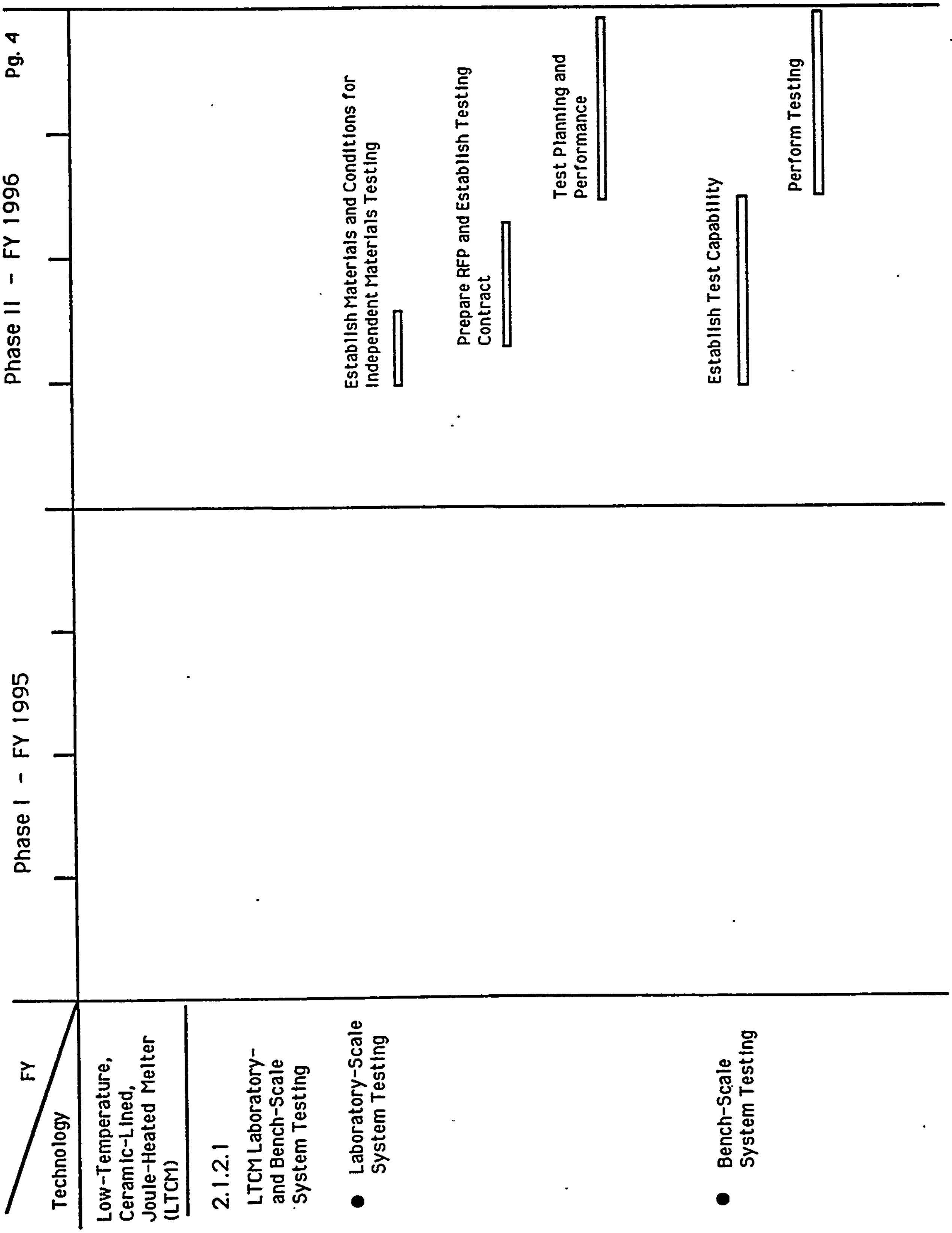

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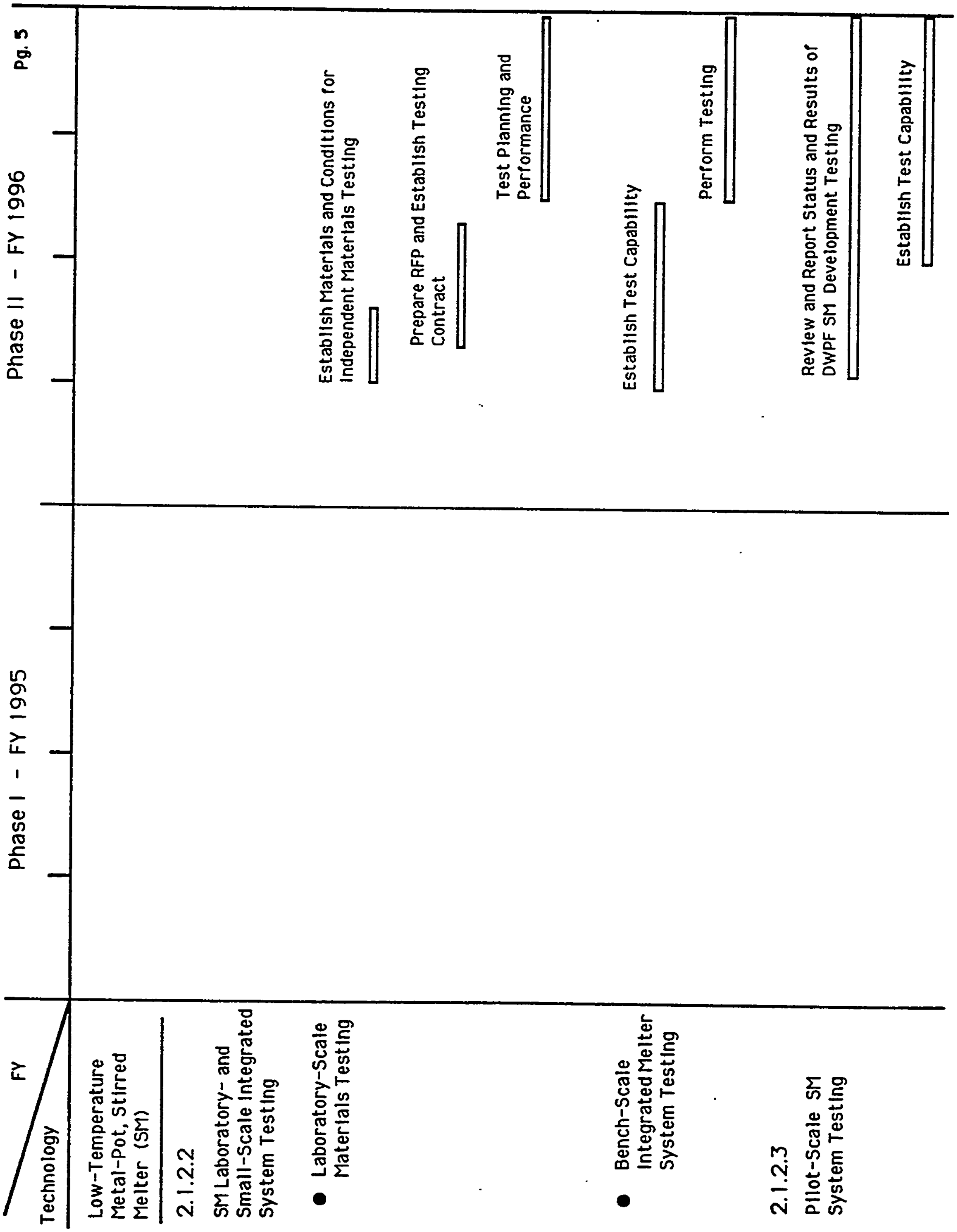

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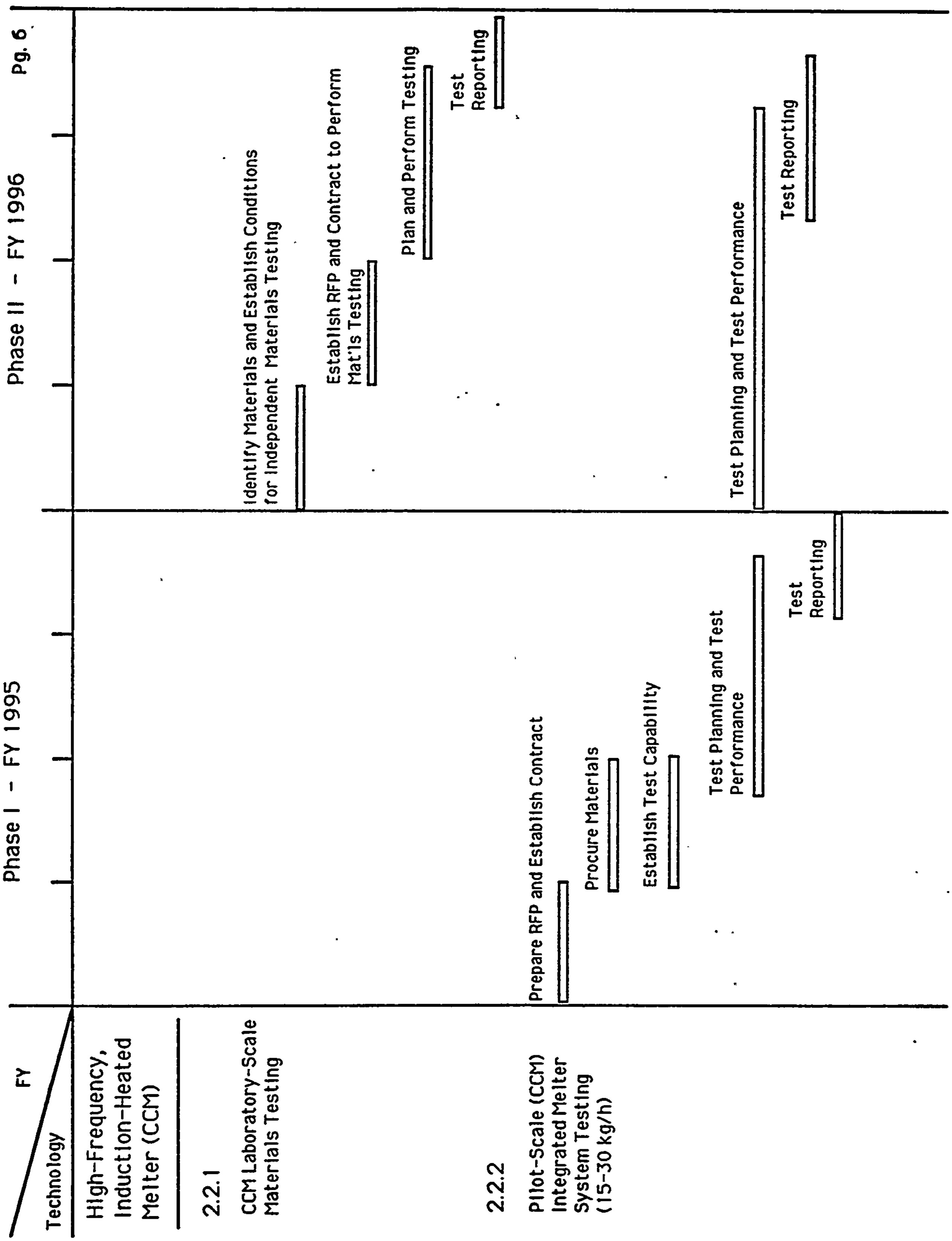

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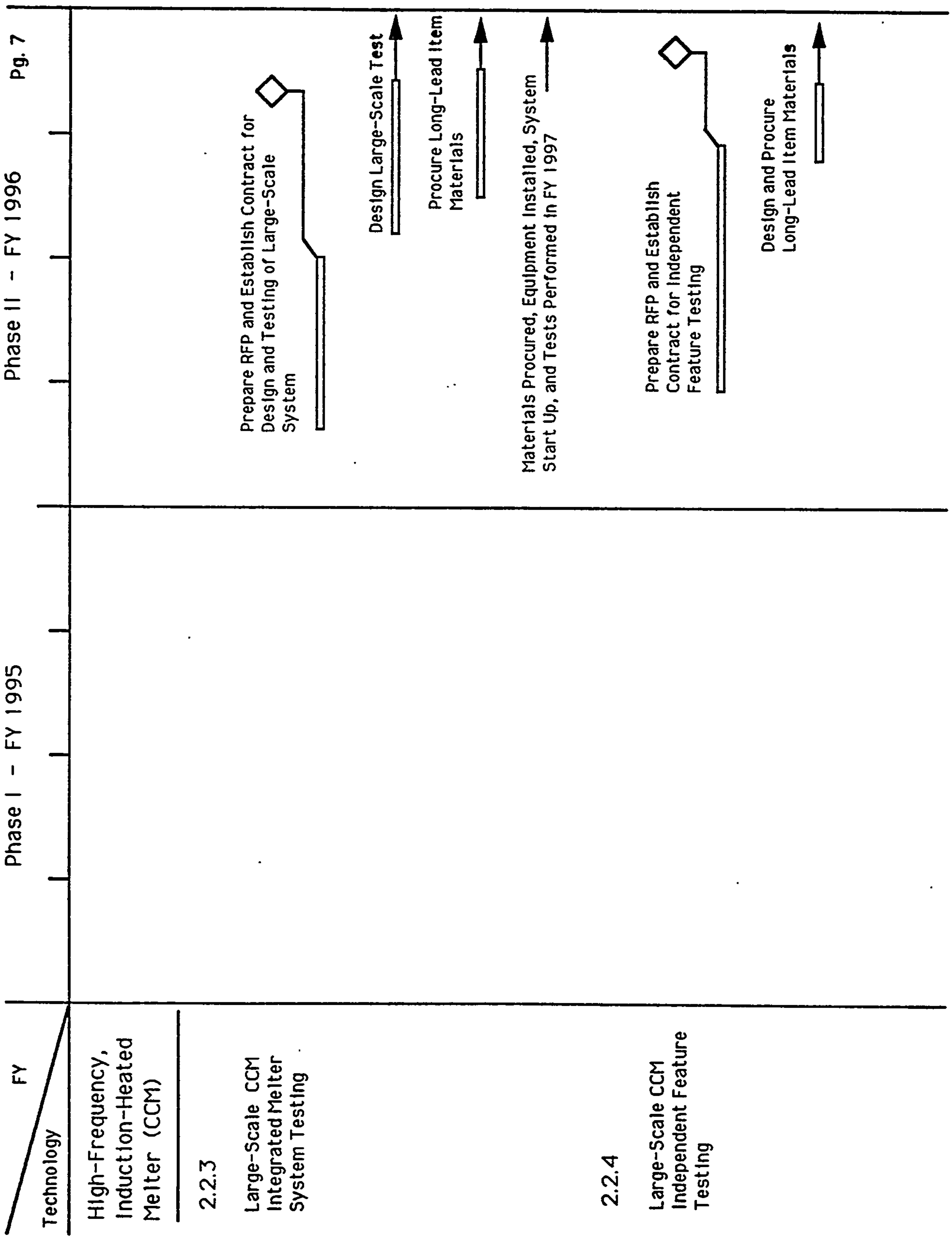

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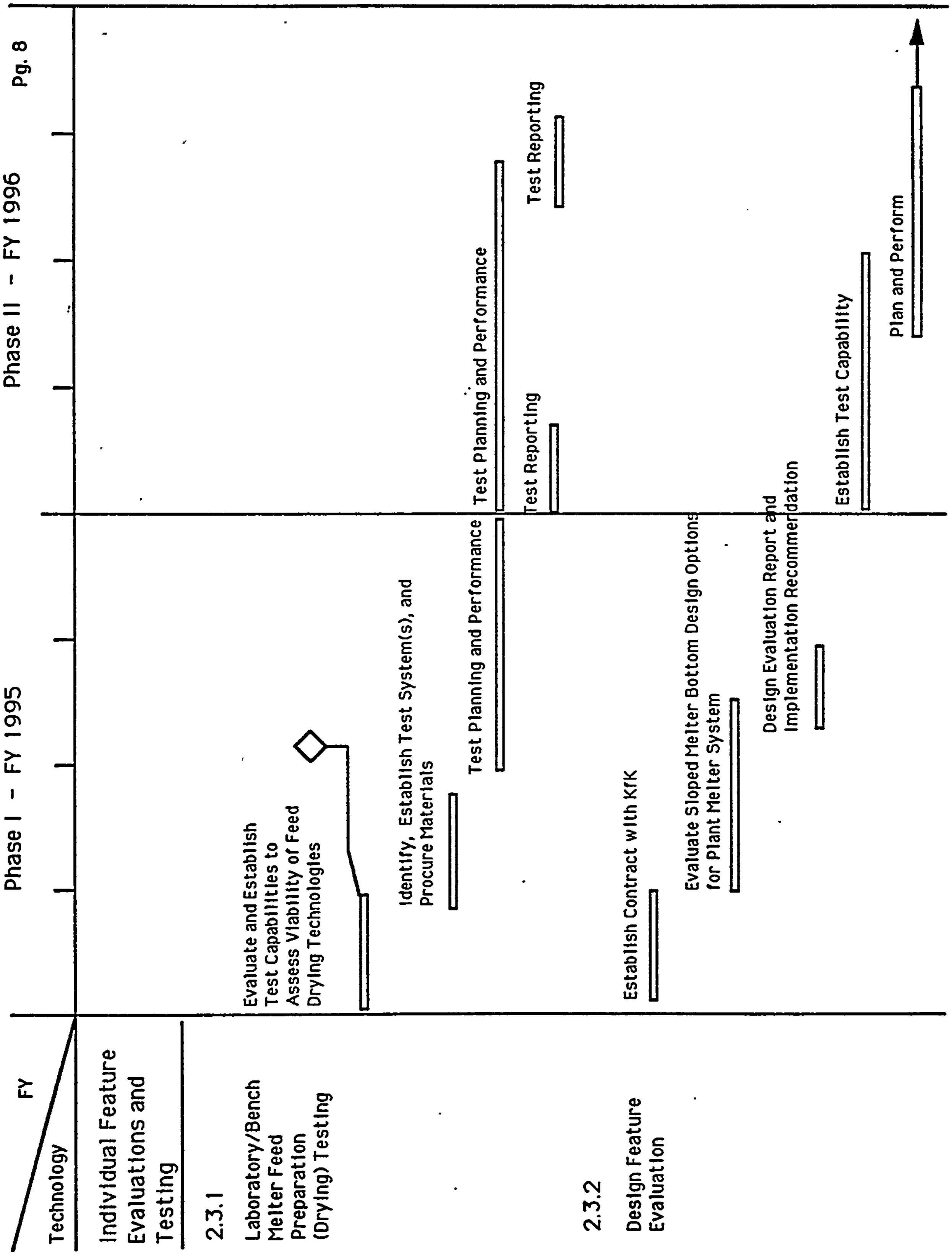

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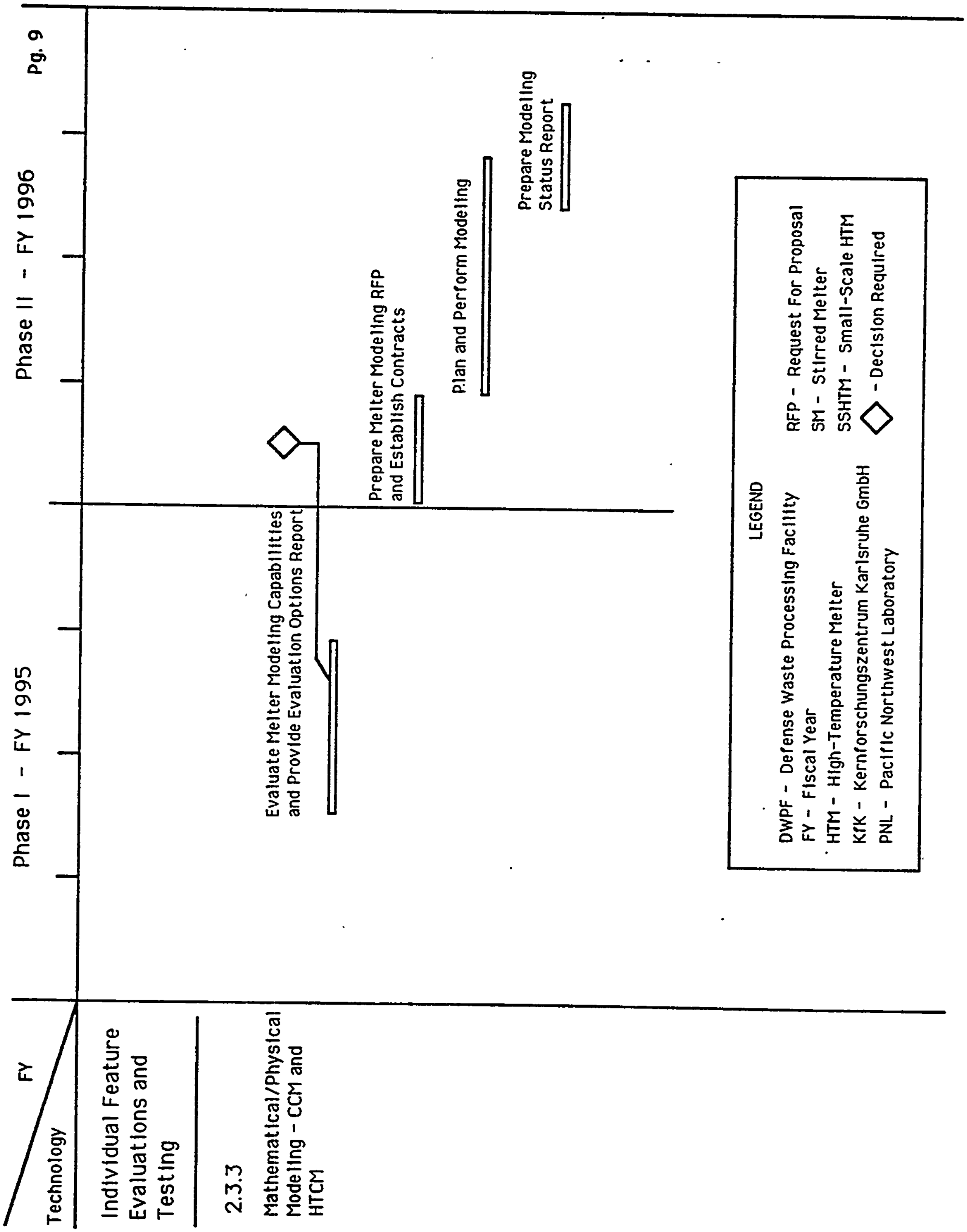

could impact melter electrical behavior and performance and block the pour spout and bottom drain, thus limiting the potential life of the melter.

- Agitation of the melt pool has been shown to significantly increase the melter glass processing rate. Agitation of the melt could result in melter processing rate increases by up to 3X. Agitation could be provided with physical agitators or gas bubbler systems.

Evaluations of the feed drying and sludge mitigation features will be emphasized in Section 2.3. In general, these evaluations will include a survey of existing technologies and equipment with recommendations regarding the type, size, extent of testing, test conditions, and cost required to confirm performance of these system features to the point where they can be included in Hanford Site HLW vitrification plant conceptual and definitive designs. These evaluations will be performed in Phase I and at the beginning of Phase II. Development and testing recommendations derived from evaluations in Phases I and II will be implemented in the Phase II and III test program.

2.1.1 HTCM

The primary technical issue relative to this technology is the viability of high-temperature operation with Hanford Site HLW feed compositions. Viable high-temperature operation primarily depends on electrode and refractory materials performance at expected plant operating conditions. In addition, characterization of melter offgas and waste processing capacities at the higher temperatures is required to establish the basis for prediction of plant-scale melter system performance. Therefore, Phase I testing will focus on laboratory-scale (crucible scale, 100 to 200 g) materials testing of high-temperature candidate electrode and refractory materials and bench-scale (typically 1 to 15 kg/h) integrated melter system testing. This testing will be used to obtain melter processing and performance data for a base case "all tank blend" feed composition.

The results of Phase I materials testing will be used to determine the feasibility of high-temperature operation, define the scope of additional materials testing (post-FY 1995), and provide the basis for larger-scale integrated system and independent equipment/component feature testing.

It is expected that the second phase of materials testing (performed in Phases II and III) will focus on (1) obtaining additional laboratory-scale performance data to predict the life of the materials using a wider range of melter feed compositions, and (2) performing bench-scale melter system materials testing to provide quantitative materials performance correlations. Materials performance results obtained from laboratory- and bench-scale materials tests will be correlated with pilot-scale system testing to predict plant-scale materials performance.

2.1.1.1 HTCM Laboratory-Scale Materials D&T. The primary laboratory-scale test activities include the preparation of a materials test strategy, and scoping and independent materials testing activities. The specific Phase I and II materials testing activities and test requirements are described in the following subsections.

Phase I laboratory-scale materials testing shall include materials scoping tests as well as independently performed (non-Pacific Northwest Laboratory [PNL]) materials testing. Independent materials testing shall be performed by an organization that commercially tests melter refractory and electrode materials or routinely subcontracts materials testing, and uses the test information to assess large-scale design and operation. In addition, the independent materials test performer shall test all the necessary candidate materials (PNL and non-PNL). The independent testing shall be performed using predetermined and agreed upon test conditions that simulate the expected plant operating environment. In addition to the accepted "all tank blend" composition, variations of this composition shall be tested to define materials performance related to potential problem feed constituents.

Specific Phase I and II materials and bench-scale testing activities are described in the following subsections.

2.1.1.1.1 Materials Testing Strategy. The materials testing strategy shall include, but not be limited to, the following:

- Summary of FY 1994 and other related HLW, high-temperature, laboratory-scale materials testing activities and results
- Laboratory-scale test objectives (scoping tests [Section 2.1.1.1.2] and independent tests [Section 2.1.1.1.3])
- Laboratory test methodologies and procedures (ASTM C621-84/1992 [ASTM 1992] or equivalent)
- General test conditions
- Overall strategy of inspections and autopsies of melter system glass contact materials
- Estimated test (time) intervals necessary to predict plant-scale melter materials performance.

Materials testing shall, to the extent practical, be established in accordance with standard (or glass industry accepted) materials testing methodologies and test requirements (e.g., American Society for Testing and Materials standards). Potential materials test candidates shall include materials considered for non-PNL HTCM system designs and consideration of commercial glass industry experience. The PNL and non-PNL system electrode and refractory materials shall be tested in the independent materials testing activity.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.1.1.2 Laboratory-Scale Materials Testing - Scoping Tests. These scoping tests shall include the following activities.

- Identify, report, and provide a basis of selection for potential materials of construction (refractory, electrode, mechanical/bubbler components, bottom drain, other related materials, etc.) for the HTCM systems.

- Establish the requisite materials test facilities/equipment. The laboratory-scale testing equipment shall be established in accordance with the detailed test strategy and shall provide expected plant melter operating conditions, to the extent practical. The proposed test equipment shall be reviewed and approved by WHC.

- Establish test simulant compositions (specific variations to the double-shell tank [DST]/single-shell tank [SST] "all tank blend" composition to be determined) to characterize the impact of problem constituents on materials performance. The "all tank blend" composition shall be the baseline feed composition for materials testing (Lambert 1994). Glass formulations for the "all tank blend" feed and variations of this composition shall be proposed and agreed to during the test planning activity. Westinghouse Hanford Company will provide the "all tank blend" feed composition for testing and PNL shall select simulant compositions for testing. Pacific Northwest Laboratory shall determine appropriate feed preparation processes, formulate appropriate glass compositions, and prepare melter feed and feed makeup procedures. These activities shall be defined and brief test plans prepared for WHC approval.

- Perform tests and report test results. The interim and final Phase I summary test reports shall be structured for use in the melter assessment activity (decision-making process) to be performed at the end of FY 1995. A summary of feed compositions, glass formulations, feed preparation work, and basis shall be included in the report. A final report on the viability of high-temperature materials is scheduled to be completed at the end of Phase II. The test plans and test conditions shall be reviewed and approved by WHC.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.1.1.3 Laboratory-Scale Materials Testing - Independent Testing. Activities are as follows.

- Prepare a Request for Proposal (RFP) and establish a testing contract. Testing shall be performed by an organization that has expertise in performing laboratory-scale glass contact materials performance tests and in assessing the materials testing results for use in predicting materials performance in large-scale melter systems. A survey shall be performed of existing testing organizations and their experience in assessing materials performance data to predict plant-scale performance. Survey results shall be provided to WHC for a decision to initiate an RFP for testing services. The RFP shall be prepared and managed by PNL.

- Plan and perform tests. Independent testing shall be performed during Phases I and II using test conditions and feed compositions that are representative of expected plant operating conditions. Testing shall be performed to establish independent materials performance data using accepted glass industry test methodologies, to the extent practical. The test performer or separate melter development organization may assess the test results to predict plant-scale materials performance. Testing shall be performed using electrode and refractory materials identified for use in PNL and alternate HTCM system designs.

- Prepare a summary test report. The independent materials test report shall be prepared for use in the melter assessment and decision-making activity to be performed at the end of CY 1995. This report shall include summary results of the Phase I independent materials testing and conclusions relative to plant melter performance. The results presented in this report shall be used to prepare the status of Phase I laboratory-scale materials testing (Task 3.1.1.2). The Phase I and II independent materials test results will be used to prepare the final report on the viability of high-temperature materials, scheduled at the end of Phase II.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.1.2 Bench-Scale Integrated Melter System Testing. Bench-scale testing of the HTCM technology will be performed using the PNL small-scale HTM (SSHTM) system (8 kg/h) located on the Hanford Site (300 Area, 324 Building) to obtain data relative to the feasibility and overall performance of HTCM technology. Phase I SSHTM testing will provide performance data on materials, offgas, melter, glass pour spout and bottom drain, and supporting systems. Phase I activities also include an investigation of alternate bench-scale system designs to determine the impact of alternate designs and system features on system performance. If alternate system designs provide significant benefits, testing of the alternate designs will be included in Phase II D&T activities. Descriptions of key activities for the PNL and non-PNL (alternate systems) bench-scale testing activities and test requirements are provided in Sections 2.1.1.2.1 and 2.1.1.2.2, respectively.

2.1.1.2.1 Bench-Scale HTCM System Testing - PNL SSHTM. The primary activities for the PNL SSHTM Phase I testing are to complete planned system modifications and perform and report integrated system testing. Test requirements for each activity are as follows.

- SSHTM system modifications--System modifications required as a result of FY 1994 testing shall be completed before FY 1995 testing.

- Test planning and performance--Bench-scale integrated melter system testing shall be performed using the PNL bench-scale HTCM (referred to as the SSHTM) system. Tests shall be performed to correlate laboratory-scale materials test data with SSHTM materials performance data obtained using operating conditions more representative (than laboratory scale) of expected plant-scale melter operating conditions. Phase I SSHTM testing shall be performed with an accepted DST and SST "all tank blend" feed composition. Tests shall also be planned to perform testing using a more challenging variation of the "all tank blend" composition (e.g., higher chromium, iron, and phosphate levels). Phase II testing will focus on correlating materials performance with other DST/SST blended feed types or the "all tank blend" spiked with problem constituents.

Expected limiting amounts of constituents may be tested to predict HTCM operating/design limits. The test compositions and test conditions shall be reviewed and approved by WHC.

In addition to obtaining bench-scale materials performance data, data shall be obtained to resolve or characterize the following issues.

- Waste processing capacity--Phase I bench-scale tests shall provide information for use in predicting the glass melter processing capacity at larger scale. The bench-scale production capacities, in conjunction with larger-scale test results, shall be used to predict plant production capacities necessary to accurately size and design plant-scale equipment.

- Feed processability--Additional information is needed regarding the ability to process Hanford Site waste feed compositions at high temperatures and the processability of these feeds in the melting process. Phase I testing shall obtain data to assess HTCM system feed processability of the "all tank blend" Hanford Site feed simulant test composition and a more challenging composition, which will be identified by WHC. Bench-scale tests will be performed in Phases II and III to provide an indication of potential feed and related glass composition limits (particularly for high chromium and phosphate content feeds) using a wider range of feed compositions than used during Phase I testing. The extent of testing required to establish feed composition limits is yet to be determined.

- Offgas characteristics--Offgas data shall be obtained in Phase I to establish the basis to predict plant offgas system requirements and performance, and to determine additional bench- or pilot-scale testing required to resolve key technical issues. Key technical issues include quantity and emission rate of semivolatile components, ability to capture key radionuclides in the glass, flow rate and composition of offgas, offgas surges and other potential upset conditions, and general offgas generation modes and characteristics.

- Test reporting--The FY 1995 SSHTM report shall include, but not be limited to, discussions of the following: chronology of testing events; reiteration of test objectives with discussion of results relating to test objectives; unusual or noteworthy equipment problems and recommended mitigation action; and conclusions relative to overall system performance, including refractory and electrode materials performance, melter feed system and cold cap behavior, offgas/melter system interface, offgas system, pour system, system scaleup, and melting performance.

  System modifications made after FY 1994 SSHTM testing shall be included in FY 1995 test reports. Test reporting shall focus on providing a level of detail suited for use in the FY 1995 melter assessment and decision-making activities.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.1.2.2 Alternate Bench-Scale HTCM System(s) Design and Testing. Bench- or pilot-scale testing is also proposed to evaluate alternate HTCM designs with significantly different operating conditions and configurations compared to the PNL design. The key D&T activities and test requirements are provided in the following discussion.

Technology survey and report--Existing system design configurations/ features and the potential impact of the alternate design(s) on system and materials performance shall be evaluated to determine if significant insight in assessing the viability of high-temperature operation could be obtained from testing of alternate designs. The evaluation shall include a survey of existing system designs and the following information:

- Identification of existing domestic and international HTCM-type bench- or pilot-scale systems
- General description of alternate systems with emphasis on unique or special melter or supporting equipment features, test capabilities, test system availability, and perceived system benefit which could warrant testing
- Informal and formal (e.g., *Commerce Business Daily*) solicitation of system descriptions and testing interest. A draft summary evaluation report shall be provided by June 30, 1995, for consideration in developing planning for FY 1996.

If testing of an alternate system design is determined by the TWRS HLW Program Office to be useful in assessing this technology, and testing is practical (existing facility and equipment are available and system modifications are modest), a competitive bid process shall be implemented to establish the test capability and test the alternate system design. Testing of the alternative system shall focus on characterizing the alternate design feature performance. Data generic to high-temperature operation of the HTCM systems shall be obtained in the SSHTM (Task 3.1.1.4.1). Duplication of data from the alternate system shall be avoided, to the extent practical, unless little or no added cost is involved.

The technical survey and initiation of the RFP shall be performed and reported in the third quarter of FY 1995.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.1.2.3 HTCM System(s) Testing Summary Report - Laboratory- and Bench-Scale. A summary report of HTCM testing (Hanford Site and subcontractor testing) shall be prepared for use in the melter assessment decision-making activity to be performed at the end of FY 1995. This report shall include all laboratory- and bench-scale test results, design studies and evaluations (e.g., sloped bottom melter evaluation), and modeling capabilities and modeling results (if initiated). In addition, this report shall provide summary path forward recommendations for Phase II and III laboratory-, bench-, and pilot-scale testing and design/modeling studies.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.1.3 Pilot-Scale HTCM Integrated Melter System Testing. The PNL PSHTM system is located at the Hanford Site (300 Area, 324 Building) and has a glass production rate of 80 kg/h. The PSHTM test could be performed in Phases II and III. The PSHTM testing may provide data to determine scaleup factors and to confirm smaller-scale test results with conditions more representative of a plant-scale system. In addition to the PSHTM system, alternate high-temperature systems will be investigated in Phase I to determine if alternate design or component features that provide significant benefits should be investigated. Alternate system testing, if determined to be necessary, will be included in Phase II and III activities.

Pilot-scale testing of HTCM-based technology is not scheduled until FY 1996. If the FY 1995 recommendation identifies that testing of the high-temperature system should be continued, pilot-scale testing will be performed with an appropriate pilot-scale (expected to be in the range of 50 to 80 kg/h) system and system design.

Two potential pilot-scale testing options are possible. It is expected that pilot-scale integrated system testing will be performed with the PNL PSHTM integrated melter system, assuming that positive results are obtained from Phase I laboratory- and bench-scale testing. The PNL PSHTM test facility is well established and is proposed as the baseline test facility for establishing pilot-scale system performance data (offgas, waste processing capacity at high temperature, general feed processability aspects, and confirmation of PNL materials of construction specific to the PNL PSHTM design). However, it may be necessary to test other high-temperature system designs to evaluate certain features identified in the Phase I survey. A competitively bid, or sole-source, contract for alternate (non-PNL) system testing shall be initiated at the direction of the TWRS HLW Program Office at the end of FY 1995 or start of FY 1996 if initial Phase I pilot-scale system surveys identify significant benefits of alternative systems. As previously identified, a survey of existing alternate HTCM designs will be performed by PNL in FY 1995.

Pilot-scale independent (component) feature testing and individual large-scale (200 to 800 kg/h) feature and integrated melter system testing may be performed in Phases III and IV, respectively. Test services contracting and test capability will be established in Phase II.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.2 LTCM and Metal Pot SM Systems

The LTCM and SM D&T depends on key program decisions to be made at the end of FY 1995. Therefore, Phase I testing of these technologies is not proposed. General discussions of the type and extent of testing required for these technologies and expected post-Phase I test requirements are presented in this section.

2.1.2.1 LTCM Laboratory- and Bench-Scale System Testing. The basis for selecting the LTCM as the baseline technology for the HLW vitrification plant melter system D&T is the comparative maturity of this technology for vitrification of HLW feed types. However, significant benefits may be obtained from high-temperature operation; therefore, the primary intention of the HLW Program, especially in Phases I and II, is testing to confirm the viability of HTCM systems as described in Section 2.1. Consequently, testing of the LTCM technology is not planned in Phase I.

Also, limited materials testing may be required for the LTCM during Phase II to confirm the performance of Inconel 690, certain refractory materials, and other glass-contacting materials in the melter with the "all tank blend" feed composition. This testing may include a limited number of variations of this composition with higher concentrations of expected problem constituents.

If a decision is made at the end of CY 1995 to redirect D&T efforts from the HTCM systems to the development of the LTCM systems, the following LTCM activities would need to be tailored to low-temperature operating conditions and designs: melt pool agitation, process control features, glass formulation of DST/SST feeds to low-temperature regime, bottom drain and sludge mitigation system design, and offgas/melter interface design and feed drying system design.

In addition, significant performance data should be available from DWPF nonradioactive and radioactive test operations (LTCM systems heated with Inconel 690 electrodes at 1150 °C). These data will provide an indication of the type and extent of large-scale testing that may be necessary to confirm scaleup factors for a Hanford Site HLW vitrification plant using LTCM technology. However, variations of the DWPF design relative to melt pool agitation or bottom drain melter cavity design and feed drying interface design may require independent confirmation through large-scale integrated system or independent feature testing. As presented in Figure 2-1, the primary activities needed to initiate testing of this technology are to establish the materials and bench-scale system test capabilities and initiate testing with approved "all tank blend" test simulant feeds. These data and system performance data from operation of the DWPF melter system may be used to define additional testing needs for determining the required scaleup factors.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.2.2 SM Laboratory-Scale Materials Testing and Bench-Scale Integrated System Testing. If a decision is made at the end of CY 1995 to pursue testing of the SM technology, bench-scale integrated system testing may be performed in FY 1996 with the test system located at Clemson University. Limited testing of melter materials at expected system operating temperatures would also be initiated in FY 1996 and performed under PNL or independent materials testing activities.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.2.3 Pilot-Scale SM System Testing. The SM system is being evaluated as an alternative melter system for the DWPF. This facility includes an LTCM system that is essentially the same as the system in the Hanford Site HWVP Project (project status - canceled). A DWPF prototype SM (>100 kg/h) system has been designed and procured, and is scheduled to be installed at the Savannah River Site (SRS) in FY 1996. The costs associated with establishing the DWPF SM test capability were jointly shared by SRS and the Hanford Site. The Hanford Site funding was provided in FY 1993. The HLW Program will participate in system startup testing and will be involved in reviewing additional test data from SRS-funded system testing. After SM system startup, a decision will be made regarding the extent of HLW Program involvement with the DWPF SM testing. This decision will be made based on the results of the Hanford Site high-temperature system testing performed during Phases I and II.

If testing of the SM system is pursued, the focus will be on bench-scale testing to determine feed composition limits and materials performance. Testing will then progress to system testing at the SRS to determine scaleup factors and overall system performance and operability. In addition, the feed preparation and glass formulation work would need to be shifted from the high- to low-operating temperature range glass compositions.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.1.2.4 LTCM Systems (Large-Scale Testing). Large-scale testing of the low-temperature systems (LTCM and SM) is not proposed in Phase I. If at the end of Phase I, or during Phase II testing, high-temperature system operation is determined to be of significantly high technical or programmatic risk, testing emphasis will be refocused on low-temperature system development and detailed D&T planning will be prepared.

2.2 CCM SYSTEM

Phase I and II testing of the CCM <u>shall</u> focus on evaluating (1) the feasibility of drying Hanford Site HLW feed types in an integrated feed drying and CCM system, and (2) overall performance and operability of the integrated system. Feed drying is expected to be required for CCM technology due to its relatively low glass production capacity with slurried feeds and limited scaleup capability. The estimated maximum surface area of the melt pool is about 0.8 to 1.2 m^2, which corresponds to a glass production rate of 165 to 200 kg/h. In addition, the glass melting process for this melter requires more study, especially for Hanford Site feeds which may contain sludge-forming components in the waste.

2.2.1 CCM Laboratory-Scale Materials Testing

Limited materials testing may be performed during Phase II to establish performance of bottom drain and key glass contact materials (e.g., agitator and bubbler materials, etc.). Information on materials of construction and materials performance will be solicited from melter developers and vendors as part of the integrated system RFP (issued in FY 1995) to assess performance, where practical. Materials testing for the CCM technology may be performed by the vendor, or as part of the independent materials test activity described in the materials testing section for HTCM testing (Task 2.1.1.1.3). If independent testing is selected, test planning and performance will be performed in FY 1996.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.2.2 Pilot-Scale (CCM) Integrated Melter System Testing (15 to 30 kg/h)

Pilot-scale (CCM) integrated melter system testing (15 to 30 kg/h), shall be contracted through a competitive bid process and testing initiated in Phase I to obtain system performance data. Phase I pilot-scale development testing of the CCM technology shall focus on the ability of this technology to process Hanford Site feed relative to feed drying; offgas composition and characteristics; melting characteristics (cold cap behavior, mixing and homogenization of the melt, etc.); product quality; overall system performance, operability, and reliability; waste processing capacity; and system compatibility with Hanford Site feeds. Tests shall be performed using drying equipment that is compatible with existing CCM systems. Evaporators and calciners that may be used shall be tested with Hanford Site feed types. Feature testing of drying technologies unevaluated in an integrated test system may be performed under a separate competitively bid contract(s). The RFP and associated Statement of Work for the integrated system testing shall describe the overall approach to assessing the feed drying aspects of this technology and shall be approved by the WHC HLW Program Office. The RFP/Statement of Work shall provide the necessary test requirements relative to Phase I CCM testing. Test requirements not covered by the RFP/Statement of Work (e.g., materials testing, alternate feed drying technology testing, etc.) shall be identified by PNL (as the responsible CCM test manager) for further consideration by the WHC HLW Program Office. Recommendations relative to the testing path forward shall also be provided.

A summary Phase I CCM test report shall be prepared for use in the FY 1995 melter assessment activity and include, but not be limited to, a summary of test conditions, test results, test activity, chronology, unusual or noteworthy test events, test results (including analytical and engineering evaluations), and recommendations for Phase II testing. This report may be provided using contracted or supplemental test reporting. Pacific Northwest Laboratory shall prepare and issue the report.

Phase I materials and pilot-scale testing will be used to direct the focus of Phase II pilot-scale systems testing activities. Pilot-scale testing, with a selected range of melter feed compositions, will be the target of Phase II testing activities. The ability to scale up integrated drying/melter systems will be the primary focus of Phase II and III CCM development testing activities.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.2.3 Large-Scale (CCM) Integrated Melter System Testing

Large-scale testing is not proposed for Phase I. Because of the uncertainty associated with development of advanced (CCM and HTCM) technology, results of the CCM pilot-scale tests shall be assessed in Phase I to determine the extent of large-scale testing necessary to resolve key CCM scaleup issues. Because of the limited expected scaleup potential of CCM technology (1.0- to 1.2-m melt pool diameter with 165- to 200-kg/h maximum glass production capacity), it may be cost-effective and logical to test at full scale. If the decision is made to proceed with the CCM technology, the scale of melter testing will be determined during Phase II and the large-scale test system designed and system test capability established in Phases II and III. Large- to full-scale testing will be performed in Phases III and IV.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.2.4 Large-Scale (CCM) Independent Feature Testing

In addition to large-scale integrated system testing, large- to full-scale independent feature testing may be necessary and/or cost-effective. The independent component tests are expected to resolve key issues such as steady state and maximum throughput capacity of the drying system and CCM (to establish the number of units required), overall performance relative to remote operations, reliability (total system operating efficiency), feed composition flexibility, equipment maintenance requirements, and drain system operation and performance under realistic operating conditions. Independent feature testing will be performed in Phases II and III.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.3 INDIVIDUAL FEATURE EVALUATIONS AND TESTING

Features common to the TWRS baseline melter systems (LTCM, SM, HTCM, and CCM) require scoping evaluations independent of melter system testing to determine the type and size of equipment, availability of equipment and independent test capabilities, and existing data relative to vitrification of Hanford Site feed types. Common features include melter feed drying technologies, sludge mitigation design, mathematical and physical modeling capabilities/usefulness/maturity, and high-temperature canister integrity (high-temperature systems). This section presents the requirements for performing independent feature evaluations and testing, and presents a brief description of the type of evaluation/testing to be performed in each phase of testing. For those evaluations/tests performed in Phase I, organizations responsible for managing or performing the work are also identified.

2.3.1 Laboratory-/Bench-Scale Melter Feed Preparation (Drying) Testing

2.3.1.1 Phase I. Technology Evaluation--Potential HLW melter feed drying technologies shall be evaluated in Phase I. The evaluation shall include surveys of existing technologies, equipment designs, and operating/performance data. Existing information on drying technologies and existing data from candidate technologies shall be compiled, and a testing strategy developed and implemented to obtain data with Hanford Site feed types. The technology evaluation will be performed by WHC.

Small-Scale Feed Drying Testing--Laboratory- and/or bench-scale testing methodologies shall be evaluated to determine the drying behavior of Hanford Site HLW feed types. Specific testing capabilities (test methodologies, test equipment, and associated facilities) shall be established and testing initiated in Phase I. The testing strategy will be proposed by PNL and approved by WHC. Pacific Northwest Laboratory will be responsible for test performance and reporting concurrent with WHC review and approval. The required operating conditions for each candidate drying system will be taken into consideration when developing the test program; this will require integration between individuals responsible for the WHC evaluation and PNL testing activities.

2.3.1.2 Phase II. Development of testing requirements and performance of candidate drying system tests will continue as necessary in Phase II with bench- or larger-scale tests.

2.3.1.3 Phases II and III. Independent feature testing of candidate technology designs will be performed in Phases II and III.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.3.2 Design Feature Evaluation

2.3.2.1 Phase I. Potential HLW melter sludge mitigation designs and techniques shall be evaluated in Phase I.

Alternate sloped bottom melter and bottom drain valve designs for plant-scale systems shall be evaluated and recommended design options identified during Phase I. In addition, the scale of testing needed to confirm the design(s) that have a high probability of success shall be prepared and a report issued summarizing the recommended designs and scale of testing required. The evaluation shall be specific to the baseline high-temperature technologies (HTCM and CCM) and include (1) evaluation of the potential for scaleup of existing system designs and equipment; (2) evaluation of existing operating/performance data; (3) modeling capability for use in predicting plant-scale performance of candidate system design features; (4) required scaled melter system testing (SSHTM or HTCM) needed to confirm design performance; and (5) consideration of bottom drain valve designs and system tests performed in Germany, France, and Japan. Pacific Northwest Laboratory will perform the evaluation and report the results of this analysis.

In parallel with the sludge mitigation evaluation, WHC will provide the necessary feed composition and flowsheet information required to evaluate the potential for sludge accumulation in the melter and associated impact on HLW melter system performance/life. The results of the WHC study shall be integrated into the WHC feed processability assessment activity and TWRS Program elements, primarily retrieval and pretreatment.

2.3.2.2 Phase II. Development of testing requirements and bench- and/or larger-scale test contracts will be performed as necessary in Phase II.

2.3.2.3 Phases II, III, and IV. Independent, large-scale feature testing of candidate designs will be performed in Phases II, III, and IV.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.3.3 Mathematical/Physical Modeling

2.3.3.1 Phase I. Existing modeling capabilities for the LTCM, HTCM, and CCM technologies shall be assessed in Phase I. The evaluation shall include a survey and assessment of melter system modeling capabilities and limitations, integration of modeling capabilities with sludge mitigation design activities, and a recommended modeling strategy for Phases I to IV D&T. Pacific Northwest Laboratory will evaluate the performance and report the results.

Modeling evaluation activities shall be coordinated with experienced modelers of commercial glass industry melters to provide additional perspective and guidance on modeling methodologies/codes and most importantly on the interpretation of results.

The RFP/Statement of Work for contracted CCM modeling services shall include solicitation of modeling capabilities from developers or vendors bidding on CCM test contracts in FY 1995.

The assessment of modeling capabilities shall focus on existing and proven modeling codes, methodologies, and correlation with bench- and pilot-scale test activities. Use of physical models shall also be investigated to provide input to modeling of melter systems. If applicable, recommended physical modeling may be included in Phase II and III testing activities.

The evaluation of the LTCM and HTCM models shall also include discussion of the development needs that may be required of mathematical models to predict performance (benefit/feasibility) of sloped bottom designs to remediate sludge buildup problems and assess operational and design impacts of these designs.

Tank Waste Remediation System-funded modeling of SMs is not proposed for Phase I.

Pacific Northwest Laboratory shall independently survey modeling performers, and prepare and submit a summary report to WHC for review by June 30, 1995.

2.3.3.2 Phase II. Modeling of the LTCM, HTCM, and CCM technologies may be initiated in Phase II. The scope of the modeling work will depend on high-temperature laboratory- and small-scale test results.

If large-scale testing is to be performed in Phases II and III, models will be developed to establish the basis for scaleup of the large-scale test systems. Based on the bidders' response, modeling of the CCM may be performed by other qualified organizations.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

2.3.3.3 Phases III and IV. Modeling will be performed to support large-scale system design and to predict behavior of plant unit configurations for conceptual and definitive designs. Additional laboratory- and small-scale testing may be required to obtain the necessary data for more sophisticated models of the advanced melters. These data will be defined in test plans for Phase II testing and obtained, if practical.

2.3.4 High-Temperature Canister Integrity

2.3.4.1 Phase I. Canister integrity confirmation testing will not be performed in Phase I.

2.3.4.2 Phases II and III. Testing to confirm canister performance at high temperatures will be coupled with pilot-scale test activities, or this work scope will be performed as an independent feature test with existing high-capacity HTCMs using appropriate glass compositions and pouring conditions.

Figure 2-1 provides a summary schedule of key Phase I and II activities identified in this section.

3.0 REFERENCES

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4.0 GLOSSARY

ABBREVIATIONS AND ACRONYMS

CCM	cold-crucible melter
CDR	conceptual design report
CY	calendar year
D&T	development and testing
DST	double-shell tank
DWPF	Defense Waste Processing Facility
FY	fiscal year
HLW	high-level waste
HTCM	high-temperature, ceramic-lined melter
HTM	high-temperature melter
HWVP	Hanford Waste Vitrification Plant
KfK	Kernforschungszentrum Karlsruhe GmbH
LTCM	low-temperature, ceramic-lined melter
MSA	melter system assessment
PNL	Pacific Northwest Laboratory
PSHTM	pilot-scale, high-temperature melter
RFP	Request for Proposal
RL	U.S. Department of Energy, Richland Operations Office
SM	stirred melter
SRS	Savannah River Site
SSHTM	small-scale, high-temperature melter
SST	single-shell tank
TPA	Tri-Party Agreement
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company

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