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**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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UNITED STATES DEPARTMENT OF ENERGY
UNDER CONTRACT NUMBER DE-AC06-76RL01857

Document No.

UNI-3653

Date

April 1986

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Title
PRESSURE TUBE TESTING
TEST PLAN DOCUMENT
PRODUCTION ASSURANCE PROGRAMAuthor
F. R. Zaloudek, PNL, for E. S. Ruff, UNC

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PRODUCTION ASSURANCE PROGRAM

PRESSURE TUBE TESTING: TEST PLAN DOCUMENT

F. R. Zaloudek

April 1986

UNI-3653

Prepared for
The U. S. Department of Energy
Under Contract DE-AC06-76 RLO-1830

Pacific Northwest Laboratory
Richland, Washington 99352

PRODUCTION ASSURANCE PROGRAM
PRESSURE TUBE TESTING: TEST PLAN DOCUMENT
ISSUED BY
BATTELLE, PACIFIC NORTHWEST LABORATORY

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ACKNOWLEDGMENTS

The authors wish to thank Milt Lewis of ~~Battelle~~ Pacific Northwest Laboratories for his contribution to this document in the sections on Corrosion Rate Testing and Chemical Composition Analysis. Leo J. Defferding also generously assisted in planning task activities for pressure tube development.

The authors especially wish to acknowledge the technical comments given by Eric L. Shaber, Ray E. Gross, David S. Cifuni, Robert T. Johnson, John E. Tobin, Dennis J. Trimble, and Don C. Board of UNC Nuclear Industries. Without their insight and expertise, this document would be less than what it is.

TEST PLAN
ZIRCONIUM PRESSURE TUBE TESTING
PRODUCTION ASSURANCE PROGRAM

1.0 INTRODUCTION

UNC Nuclear Industries (UNC) has initiated a plan for the manufacture of zirconium alloy pressure tubes required for the future operation of N-Reactor. As part of this plan, UNC is establishing a program to qualify and develop a manufacturing process capable of fabricating these pressure tubes to the requirements of UNC specification HWS 6502, REV 4, Amendment 1. The objective of the task described in this test plan is to support the UNC program by performing physical/chemical testing on prototype tubes sections produced or procured during FY-1986, 1987 and 1988 and to test samples from production runs after 1988 as may be required.

The types of tests included in this pressure tube testing task will be as follows:

- . Tensile tests
- . Burst testing
- . Tests to evaluate fracture properties
- . Corrosion tests
- . Spectrographic analysis of chemical composition
- . Metallographic evaluation of grain size and oxide layer thickness.

2.0 TEST SPECIMENS

It is anticipated that testing will be initially performed on short trial extrusions; later, testing will be performed on full length prototype tubes. Samples will be removed from excess material at the ends of all of these prototype tubes for some tests and/or for archival purposes. In addition, it is assumed that 3 of these prototype tubes will be sacrificed for destructive testing. These tubes will be divided to provide a number of samples along their lengths.

For the purpose of cost estimation, it was assumed that the samples taken from the ends of the tubes will be subjected to metallographic, spectroscopic, tensile and corrosion tests. Burst testing and fracture tests as well as metallographic, spectroscopic, tensile and corrosion tests will be performed on samples removed from both ends and the center of the 3 sacrificed tubes.

PNL will also be prepared to perform such additional testing on special samples such as may be required during the manufacturing phase after FY-1988.

2.1 Specimen Removal and Preparation

Test specimens will be obtained from small lengths of tubing removed from the ends or from another specified location along the tube length. Each of these small lengths will be carefully machined into one or more specimens for the specified testing. During the specimen removal and preparation process, procedures will be followed to preserve the properties of material. Specifically, overheating the material or changing its chemical composition will be scrupulously avoided.

Each specimen will be permanently marked with an identification number using a metal stamp or electric pencil, as appropriate. The identification number will include digits signifying 1) the tube number, 2) the distance from the "A" end of the tube where sample was obtained, 3) the number of the task under which the specimen was prepared, 4) the sequential number of the specimen if more than one was taken from a given location, and 5) other identification such as may be appropriate to identify the specimens.

2.2 Specimen Storage

If a prepared specimen is not tested promptly following its removal, it will be stored in such a manner that will preserve its chemical and physical properties. Generally, this storage will be in sealed plastic bags. Archival samples will be packaged and labeled and transported to a storage site designated by UNC.

After testing, specimens will be stored in sealed plastic bags for future reference. PNL will store all tested specimens until the final report is published, after which the custody of the samples will be transferred to UNC.

3.0 SUBTASK DESCRIPTIONS

The Zirconium Pressure Tube Testing Task will be divided into 7 subtasks. Six of these tasks will be concerned with a specific type of testing listed in Section 1.0. Tentative principal investigators for each of these tasks are identified in Section 6.0. The function of the management subtask is to coordinate technical and financial matters and to provide monthly and topical reporting.

A document defining the detailed procedures for sample preparation, testing, and data analysis for each testing subtask will be prepared and submitted to UNC for review and approval. The typical contents of a test procedure document are outlined in Appendix A. The approved test procedure documents will provide the basis for the performance of the work.

3.1 PNL Task Management (Subtask 01)

This subtask will provide the leadership, coordination and reporting function for all testing subtasks. The specific responsibilities of the PNL manager will be to

- . direct and participate in the test plan document
- . identify and arrange for the participation of laboratory staff and support services
- . provide progress/variance report for project and line management
- . monitor progress for conformance to scope, schedule, and cost estimates
- . maintain control of changes
- . provide monthly report to project manager

- . participate in project reviews as may be requested by the sponsor.
- . promptly provide test results to UNC process development personnel as they become available.

3.2 Tensile Testing (Subtask 02)

The objective of this subtask is to determine the tensile properties of the zirconium alloy tubing material as fabricated.

3.2.1 Testing Method

Tensile testing will be performed at room temperature and at an elevated temperature to be specified in the test procedures (approximately 570 F) using the testing method specified in ASTM-E8, "Standard Methods of Tension Testing of Metallic Materials", and ASTM-E21, "Elevated Temperature Testing of Metallic Materials". The tests will be performed by qualified personnel using existing equipment with calibration traceable to the Bureau of Standards.

3.2.2 Sample Description

Samples will be removed from one end of each pressure tube fabricated and from the central part of the sacrificed tubes. Test specimens will be machined from these samples to facilitate the measurement of the tensile strength of the tube material in both the axial and transverse orientations according to the requirements of ASTM-E8 and ASTM-E21. The hardness of each sample will be measured at a point on the sample that would not influence the tensile test. On axial specimens, no attempt will be made to remove existing curvature due to its being cut from a cylindrical shape. Transverse specimens will be fabricated from the curved tube wall by the straightening process specified in ASTM-E8.

3.2.3 Data Analysis

The test data will be analyzed to obtain the axial and transverse tensile strength, yield strength (0.2% offset), elongation, reduction of area, and modulus of elasticity at both room temperature and at the specified elevated temperature.

3.3 Burst Testing (Subtask 03)

The objective of the burst testing of the pressure tube sections is to provide a high degree of confidence that the production tubes will have adequate strength for long term use in the N-Reactor, and that they are not subject to brittle failure.

The facilities previously available at Hanford (330 Bldg.) for the burst testing of N-Reactor pressure tubes have been decommissioned, and a new or a renovated existing facility must be identified. One of the major objectives of the FY-1986 effort in this subtask will be to determine the most cost-effective way to provide a facility for this test (either onsite or offsite). It is anticipated that testing will not start until FY-1987.

3.3.1 Testing Method

Sections of pressure tubing with a minimum length/OD ratio of 10 will be subjected to increasing internal pressure (approximately 2000 psi/min.) until bursting occurs. Test will be performed at both room temperature and at elevated temperature in a furnace. Prior to testing and following bursting, the tube sample will be analyzed dimensionally, and the fracture will be analyzed to assess ductility and area reduction.

Burst test procedures will be written in FY-1986 and will be submitted to UNC for review and approval. The approved procedure will be used as a basis for

identifying the most effective facility, either on- or off-site, to perform this testing. Recommendations for a site will be developed considering availability, safety of operating personnel and the public, and cost effectiveness. The approved testing procedures will also be used as a basis for obtaining cost quotations from other laboratories such as Battelle Columbus Laboratories (BCL) and Wyle Laboratories, etc.

3.3.2 Specimen Description

Burst test specimens will be sections of the pressure tube with length/OD ratio of 10 machined from tubes sacrificed for destructive testing. Generally, these specimens will be taken from the center and near both ends of these tubes. Clamp-on end fittings will be used to effect end closure on the specimens.

3.3.3 Data Analysis

The pre- and post-test measurements of the test specimen will be analyzed and the circumferential elongation at the point of maximum bulge, excluding the opening of the rupture will be determined. Metallographic analysis of the fracture zone will be performed to determine the ductility of the metal. The results of these tests will be compared and correlated with the results of the tensile tests and fracture properties tests performed on the same tubes.

3.4 Fracture Properties Testing (Subtask 04)

The objective of this subtask is to assure that the tube material as fabricated has the required strength and fracture toughness.

3.4.1 Testing Method

Fracture properties testing will be performed at room temperature and at an elevated temperature using methods specified in ASTM-E399, "Standard Test Method for Plane-Strain Fracture Toughness of Metallic Materials" using the electric potential method to determine crack extension. If the toughness of a specimen is such that valid results cannot be obtained using ASTM-E399, then the results will be analyzed according to ASTM-E813 "Standard Test for J_{IC} , a Measure of Fracture Toughness".

3.4.2 Specimen Description

Compact test specimens conforming to the requirements of ASTM-E399 will be machined from the excess length at the ends of all prototype tubes and from the central sections of those prototype tubes sacrificed for destructive testing. These samples will be oriented for both C-L (axial) and L-C (circumferential) flaw orientations.

3.4.3 Data Analysis

Values of K_{IC} , the critical stress intensity factor will be calculated or inferred from the data using the methods of either ASTM-E399 or ASTM-E813 depending on the outcome of the validity tests performed on the results as specified in these standards. Selected fracture surfaces will be examined by electron microscope for evidence of brittle fracture.

3.5 Corrosion Testing (Subtask 05)

The objective of corrosion rate testing is to determine if the tubes have adequate corrosion resistance to meet the requirements HWS 6502 REV 4.

3.5.1 Testing Method

Thin corrosion test coupons will be cut from the excess length at the end of prototype tubes and from several locations along the length of the sacrificed tubes. The cut surfaces will be smoothed and etched to remove 0.001 to 0.002 inch of metal from all surfaces. The coupons will then be subjected to accelerated corrosion tests as specified in HWS 6502 REV 4. The weight gains of coupons after 72 hours and 336 hours will be determined and compared to the requirements of ASTM B353-83, Paragraph 11.2.1. Following the corrosion tests, the hydride orientation will be determined.

3.5.2 Specimen Description

High surface-to-volume samples are desirable for corrosion testing. The simplest method of obtaining such samples will be to reduce the thick-wall tube samples into thin rings samples by machining. These rings should be no more than 1/16 inch thick on the radius, and some should include the original inner tube surface and some the original outer tube surface. For convenience, the rings may be further divided into sectors. Generally, these coupons will be obtained from excess length at the ends of the drawn tubing. Further samples will be obtained from the center section of sacrificed tubes.

3.5.3 Data Analysis

The coupons will be examined following autoclave exposure for condition of the oxide film and the weight gain measured. The oxide film will be examined to determine if it is smooth and glossy black and if there is any evidence of white or gray (zirconium hydride) in the coating.

3.6 Analysis of Chemical Composition (Subtask 06)

The objective of this subtask is to determine the chemical composition of the tubing material and to compare it with the requirements of specification HWS 6502

REV 4.

3.6.1 Testing method

Spectroscopic analysis of small samples will be performed to measure the concentration of the following list of elements:

Normal constituents

- . Tin
- . Iron
- . Chromium
- . Nickel
- . Zirconium

Impurities

. Aluminum	. Manganese
. Boron	. Molybdenum
. Cadmium	. Nitrogen
. Carbon	. Oxygen
. Cobalt	. Silicon
. Copper	. Sodium
. Hafnium	. Titanium
. Hydrogen	. Tungsten
. Lead	. Uranium
. Magnesium	. Vanadium

The normal constituents will be reported in percentages; impurities will be reported in parts per million (PPM). A detailed testing procedure will include estimated measurement accuracies. Suitable equipment to perform these spectroscopic analyses is available at PNL.

3.6.2 Specimen Description

Small samples will be cut from the ends of tubes and from several locations along the lengths of the sacrificed tubes for spectrographic analysis. Each sample will be dissolved and analyzed separately. Also, several samples taken along the length of each sacrificed tube will be dissolved together to provide a representative sample of the tube.

3.6.3 Data Analysis

The data from the chemical analysis will be compared with the specification HWS-6502 Rev.4.

3.7 Grain Structure Evaluation (Subtask 07)

The objective of the evaluation of the grain structure is to determine if the fabrication process was properly performed and that the product has certain desired properties that are important for long reactor service.

3.7.1 Testing Method

Coupons will be cut from the excess length at the ends of tubes and from various locations along the length of the sacrificed tubes. These coupons will be mounted, polished and etched for metallographic inspection of grain size and orientation and for the presence of hydrides. The thickness of the existing oxide layer on the external surfaces of autoclaved tubes will be measured and its porosity will be estimated. Following the metallographic studies, the samples will be subject to X-ray diffraction analysis. This analysis will provide both tabular and graphical data on crystalline pole orientation.

3.7.2 Specimen Descriptions

Small coupons including the entire wall thickness will be machined from the ends and/or center of the tubes examined. At least three such coupons will be obtained at each location sampled. These coupons will be mounted so that the grain dimensions can be measured in each plane; i.e., surface, axial and transverse. Each of these surfaces will be polished, etched and analyzed metallographically. The same samples will be used in the X-ray diffraction analysis.

3.7.3 Data Analysis

The following information will be determined by metallographic observation and compared to tubing specifications

- . Grain size in each plane
- . Distribution of grain orientations
- . Size of any voids, if present
- . Predominant ratio of major to minor axes of the grains
- . Surface oxide thickness and porosity (autoclaved samples only)
- . The presence of hydrides.

The X-ray diffraction studies will provide data on the crystalline pole orientation. These data will be used with representative dislocation densities calculated from data appearing in literature to predict dimensional stability under expected future irradiation conditions.

4.0 DATA RECORDS

All written data and associated calculations will be entered into bound laboratory notebooks with numbered pages. Each entry or series of related entries will be dated and initialed by the experimenter. Following submittal of the final report, the notebooks or copies of relevant pages from these notebooks along with all suitably identified stripcharts and/or DAS printouts will be transmitted to UNC

for archiving or disposal.

5.0. REPORTING

The PNL task leader will prepare a weekly highlight and a monthly progress/cost/schedule report which will be included in the periodic PNL reports to UNC. Following the performance of each major test or related series of tests, an informal memorandum report summarizing the principal results will be promptly prepared and forwarded to UNC. An interim report will be prepared and issued at the end of FY-1986 and a final UNC document will be prepared upon completion of the task

6.0 TEST WITNESS REQUIREMENTS

PNL will provide access to the testing laboratory for one or two UNC representative to observe any testing performed under this program. For testing performed at the Hanford site, the UNC project manager will be notified of PNL's intent to perform a test at least one working day prior to its scheduled performance. For testing performed offsite, notification will be given at least 5 working days before testing. UNC may choose to exercise or waive its right to witness any or all testing performed under any subtask.

7.0 Quality Assurance

See attached PNL quality assurance plan.

8.0 PERSONNEL

Individuals responsible for the various subtasks are shown in the following Table.

<u>Task</u>	<u>Task Name</u>	<u>Principal Investigator</u>
01	Task Management	F.R. Zaloudek
02	Tensile Tests	E.R. Gilbert/E.B. Schwenk
03	Burst Tests	E.B. Schwenk/F.R. Zaloudek
04	Fracture Properties	E.B. Schwenk
05	Corrosion Tests	M. Lewis/K.R. Wheeler
06	Chemical Analysis	M. Lewis/K.R. Wheeler
07	Grain Structure	E.R. Gilbert

Other key test personnel will be identified in the operating procedure documents.

9.0 SCHEDULE

The task schedule and milestones are provided in the following table.

[illegible]

TASK AND MILESTONE	O	N	D	J	F	M	A	M	J	J	A	S	
06 CHEMISTRY									1	2	3	4	**
1. Test Proc. draft to UNC													
2. Rev. Test Proc. to UNC													
3. Proc. Approved													
4. Start testing*													
07 GRAIN STRUCTURE									1	2	3	4	**
1. Test Proc. draft to UNC													
2. Rev. Test Proc. to UNC													
3. Proc. Approved													
4. Start testing*													

* Depending on receipt of samples

** Continuing into FY 1987

10.0 COSTS

Preliminary costs for budgetary purposes are provided in Appendix B.

APPENDIX A TESTING PROCEDURE REPORT CONTENTS

The following is an outline of the typical contents of a testing procedure report. A separate report will be provided for each task.

- 1.0 INTRODUCTION
 - 1.1 Background
 - 1.2 Objective
- 2.0 METHOD
 - 2.1 Standards and Specifications Applicable to Testing
(Key standards will be included as an appendix)
 - 2.2 General Description of Method
 - 2.3 Discussion
 - Basis for selection
 - Validity of application
- 3.0 SAMPLE DESCRIPTION
 - 3.1 Description of a Sample
 - Dimensions
 - Drawings
 - 3.2 Sampling Method
 - Location
 - Number
 - Statistical bases
 - 3.3 Sample Preparation
 - Instructions for removal from tube
 - Identification Instructions (numbers, method and location)
 - Machining Instructions
 - Storage Instructions
 - 3.4 Sample Disposition After Testing
 - Storage Instructions
 - Where/Who/When
- 4.0 TEST EQUIPMENT
 - 4.1 Description of Equipment and Arrangement
 - Manufacturer, Model and Serial No.
 - Accuracy, sensitivity, etc.
- 5.0 TEST PROCEDURE
 - 5.1 Calibration
 - How BofS Traceability is Assured
 - 5.2 Testing
 - Step-by-Step procedure
- 6.0 DATA ANALYSIS
 - 6.1 Data Reduction Methodology
 - Equations, etc.
 - Tabular Presentations
 - Graphical Presentations
 - Statistical Treatment
 - 6.2 Interpretation (if applicable)
 - 6.3 Comparisons with Specification and Standards
- 7.0 PERSONNEL

Appendix B
PRELIMINARY COST ESTIMATE
PRESSURE TUBE TESTING PROGRAM

Preliminary costs were estimated on the basis of tests being performed on a lot of 10 tubes. These tubes would include 3 tubes sacrificed for burst testing and analysis of fracture properties. These sacrificed tubes would also be subjected to additional tensile, corrosion, chemical and metallographic tests at several locations along their lengths.

The numbers of samples to be tested from each tube and the total numbers of tests included in the cost estimate are summarized in the following table:

<u>Type Test</u>	<u>Subject Tubes</u>	<u>Samples/ Tube</u>	<u>No. of Prototype Tubes</u>	<u>No. of Tests</u>
1) Tensile	All tubes in lot	4	7	28
	Sacrificed tubes	6	3	18
2) Burst	Sacrificed tubes	3	3	9
3) Fracture	Sacrificed tubes	2	3	6
4) Corrosion	All tubes in lot	2	7	14
	Sacrificed tubes	3	3	9
5) Chemical	All tubes in lot	2	7	14
	Sacrificed tubes	3	3	9
6) Grain Struct.	All tubes in lot	2	7	14
	Sacrificed tubes	3	3	9

The costs estimated for each program task based on the above schedule of tests are summarized in the following table:

SUMMARY OF COST (Thousands)

<u>Subtask</u>	<u>Total Cost</u>
3.1 Management	41
3.2 Tensile	13.2
3.3 Burst*	30.5
3.4 Fracture	24.6
3.5 Corrosion	7.3
3.6 Chemical*	6.9
3.7 Grain Structure	<u>7.4</u>
Total	130.9
30% Contingency	<u>39.3</u>
TOTAL	170.2

* Includes subcontract costs.

It is also anticipated that a number of single tests may be required by UNC during development of the manufacturing processes. The incremental additional cost of such testing can be estimated on a prorata basis from the above tables.

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QA PLAN FOR LICENSE-RELATED PROJECTS

☒ Project ☒ 1830 ☐ 1831
☐ Program ☐ 1830 ☐ 1831

REFERENCE ONLYTitle: Zirconium Pressure Tube Testing, H-700Sponsor: U.N.C.Authorized By (DOC. No.): U.N.C. W.O. B-35213

QA Requirement Specification:

- ☒ ANSI/ASME NQA-1 as delineated in PNL-MA-60, Quality Assurance Manual for License Related Programs.
☒ Other (Specify) UNC QA Level II, UNI-3118 Quality Assurance for H-700, Production Assurance Program

The sections of PNL-MA-60 (as identified by section number) designated in this QA Plan are applicable to the scope of work covered by this QA Plan. Additional information is also provided when useful for clarification of the selected requirement or to include additional sponsor requirements.

Approvals:

Date Approved <u>April 8, 1986</u>	Signature (Quality Engineer) <u>V. C. Launala</u>
Date Approved <u>4/8/86</u>	Signature (Quality Engineering Manager) <u>D. E. Ryder</u>
Date Approved <u>4/8/86</u>	Signature (Project Manager) <u>L. T. Pedersen</u>
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QA PLAN INDEX FOR LICENSE-RELATED PROJECTS

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Project

Zirconium Pressure Tube Testing, H-700

QAP No.

EPD-190

Rev.

0

	APPLIES	W/C ^(a)	REV ^(b)
1. <u>ORGANIZATION</u>			
Organization	●	●	
2. <u>QUALITY ASSURANCE PROGRAM</u>			
2.1 Quality Assurance Program	●	○	
2.2 Indoctrination and Training	○	○	
3. <u>DESIGN CONTROL</u>			
3.1 Hardware Design Control	●	●	
3.2 Computer Software Control	○	○	
4. <u>PROCUREMENT DOCUMENT CONTROL</u>			
4.1 Procurement Document Control	●	○	
4.2 RHO Store Order Control	●	○	
4.3 Work Order Control	●	○	
5. <u>INSTRUCTIONS, PROCEDURES, AND DRAWINGS</u>			
5.1 Instructions, Procedures, and Drawings	●	●	
6. <u>DOCUMENT CONTROL</u>			
6.1 Document Control	●	○	
7. <u>CONTROL OF PURCHASED ITEMS AND SERVICES</u>			
7.1 Control of Purchased Items and Services	●	○	
8. <u>IDENTIFICATION AND CONTROL OF ITEMS</u>			
8.1 Identification and Control of Items	●	●	
9. <u>CONTROL OF PROCESSES</u>			
9.1 (Reserved)	●	●	
10. <u>INSPECTION</u>			
10.1 Inspection	●	○	
11. <u>TEST CONTROL</u>			
11.1 Test Control	●	○	
12. <u>CONTROL OF MEASURING AND TEST EQUIPMENT</u>			
12.1 Control of Measuring and Test Equipment	●	○	
13. <u>HANDLING, STORAGE, AND SHIPPING</u>			
13.1 Handling, Storage, and Shipping	●	●	
14. <u>INSPECTION, TEST, AND OPERATING STATUS</u>			
14.1 Inspection, Test, and Operating Status	○	○	
15. <u>CONTROL OF NONCONFORMING ITEMS</u>			
15.1 Control of Nonconforming Items	●	○	
15.2 Control of Deviations	●	○	
16. <u>CORRECTIVE ACTION</u>			
16.1 Corrective Action	●	○	
16.2 Control of Incidents	○	○	
17. <u>QUALITY ASSURANCE RECORDS</u>			
17.1 Quality Assurance Records	●	○	
17.2 Test Material and Sample Archiving	●	○	
18. <u>AUDITS</u>			
18.1 Audits	●	○	
Additions	●	●	

See Introduction, Parts 3.1, 5.1, and 9.1 of this QA Plan.

(a)W/C — With clarification presented in this QA Plan

(b)REV — Indicates revision number in which changes were made

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INTRODUCTION

This QA Plan, EPD-190, identifies in the index, sections of the Quality Assurance Manual For License-Related Programs, PNL-MA-60, that shall be imposed upon and implemented by the Zirconium Pressure Tube Testing, H-700 Project. The imposed sections shall be implemented using the methods delineated in the Administrative Procedures listed in Attachment A of this QA Plan. The implementation of Administrative Procedures will occur when activities described are to be performed.

Additional clarifications not covered in PNL-MA-60 are included in the following written statements.

1.1 ORGANIZATION

The Project Organization is shown in Attachment B. Responsibilities for positions on the organization chart are given in PNL-MA-60. The Project Manager shall also be the Program Manager when interpreting Administrative Procedure PAP-101.

3.1 DESIGN CONTROL

The Project Manager shall establish and maintain project-specific design controls for the design of equipment used for this project. These controls shall include:

- A. A Design Control Plan prepared in accordance with Attachment C.
- B. Project-specific design control procedures for the following activities:
 - 1. Design Document Control in accordance with Attachment D.
 - 2. Design Verification/Analysis
 - 3. Design Reviews
 - 4. Design Interface Control
- C. Sponsor interface and requirements.

The documents and procedures identified above shall be developed and issued in accordance with PAP-501 and PAP-601. Reference to applicable procedures DCP-301, PAP-301, PAP-1101, and PAP-1501 shall be included.

5.1 INSTRUCTIONS, PROCEDURES AND DRAWINGS

Technical procedures shall be developed, approved and issued in accordance with PAP-501 for the following activities:

- Burst Test Facility Operation and Maintenance
- Burst Testing Procedure
- Tensile Testing
- Fracture Properties Testing
- Corrosion Rate Testing
- Chemical Composition Testing
- Grain Structure Analysis
- Shipping and Handling of Test Samples

In addition:

1. The sponsor has requested procedure review prior to use.
2. The sponsor has requested prior notification for each Burst Test.

8.1 IDENTIFICATION AND CONTROL OF ITEMS

This section shall apply to the Zirconium Pressure Tubes and their test samples.

9.1 CONTROL OF PROCESSES

When Craft Services personnel are required to be qualified and certified in accordance with ASME, AWS, and other nationally recognized codes and standards, the Crafts Services QA Plan CSD-2, latest revision, shall be identified on the work order.

13.1 HANDLING, STORAGE, AND SHIPPING

This section shall apply to the Zirconium Pressure Tubes and their test samples.

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Administrative and Technical Procedures

Administrative Procedures

<u>PNL-MA-60 Section</u>	<u>See Note Below</u>	<u>Applicable Administrative Procedures</u>
1. ORGANIZATION	1	PAP-101, Communication and Commitment (Interface) control
	2	QAP-101, Stop Work Order
2. QUALITY ASSURANCE PROGRAM	1	PAP-201, Indoctrination and Training
	1	PAP-203, Qualification of Inspection and Test Personnel
	2	QAP-201, Preparation of QA Plans
	2	QAP-202, Indoctrination and Training of QAO Personnel
	2	QAP-204, QA Audit Personnel Qualification
3. DESIGN CONTROL	1	DCP-301, Drawing Control
	1	PAP-301, Hand Calculation Documentation and Review
	2	QAP-301, Engineering Drawing Review
4. PROCUREMENT DOCUMENT CONTROL	4	CAP-401, Preparation and Control of RFPs
	4	CAP-402, Preparation and Award of Purchase Orders/Subcontracts
	1	PAP-401, Preparation, Review, and Approval of Purchase Requisitions
	1	PAP-402, Preparation and Control of Store Orders
	1	PAP-404, Obtaining Services Via Work Orders
	2	QAP-401, Purchase Requisition Review
	2	QAP-403, Review of Statements of Work and Work Orders
5. INSTRUCTIONS, PROCEDURES, AND DRAWINGS	1	PAP-501, Preparation and Issue of Procedures

Notes:

1. Required for project personnel
2. Required for the QAD personnel
3. Required for Records Center personnel
4. Required for Procurement/Subcontracts personnel

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Administrative and Technical Procedures

Administrative Procedures (Cont'd)

PNL-MA-60 Section	See Note Below	Applicable Administrative Procedures
6. DOCUMENT CONTROL	1 1	PAP-601, Document Control PAP-602, Document Change Control
7. CONTROL OF PURCHASED ITEMS AND SERVICES	4 4 1 1 1 1 1 1 2 2 2 2	CAP-701, Proposal Evaluation and Supplier/ Subcontractor Selection CAP-702, Purchase Order and Subcontract Administration (Post Award) PAP-701, Supplier/Subcontractor Perform- ance Evaluation PAP-702, Preparation and Use of ITIs PAP-703, Commercial Grade Items PAP-704, Source Inspections, Tests, and Surveillances PAP-705, Control of Supplier/Subcontractor Originated Nonconformance Notices PAP-706, Receiving Inspection QAP-701, Pre-Award Evaluations/Surveys QAP-703, Material Overcheck QAP-704, Supplier and Other Hanford Contractor Audits QAP-705, Review of Supplier/Subcontractor Submitted Documents
8. IDENTIFICATION AND CONTROL OF ITEMS	1	PAP-801, Sample Identification and Control
10. INSPECTION	2	QAP-1001, Planning and Performing Surveil- lance
11. TEST CONTROL	1	PAP-1101, Test/Analysis Planning, Perform- ance and Evaluation
12. CONTROL OF MEASURING AND TEST EQUIPMENT	1 1 1 2	PAP-1201, Calibration Control System PAP-1202, Preparation and Maintenance of an M&TE Control Listing PAP-1203, Calibration Discrepancy System QAP-1201, Optimization of Calibration Intervals
14. INSPECTION, TEST AND OPERATING STATUS	1	PAP-1401, Inspection and Testing Status and Tagging

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Administrative and Technical Procedures

Administrative Procedures (Cont'd)

PNL-MA-60 Section	See Note Below	Applicable Administrative Procedures
15. CONTROL OF NONCONFORMING ITEMS	1 1 2	PAP-1501, Nonconformance Reports PAP-1502, Controlling Deviations From QA Requirements and Established Procedures QAP-1501, Nonconformance Reports
16. CORRECTIVE ACTION	2	QAP-1601, Corrective Action Requests
17. QUALITY ASSURANCE RECORDS	1 1 1 1 2 3 3 3 3	PAP-1701, Research Project Records System PAP-1702, Records Maintenance and Storage in Research Project Files PAP-1703, Records Transmittal to PNL Records Center PAP-1704, Laboratory Record Books QAP-1701, QAO Records RCP-1701, Records Storage System RCP-1702, Receipt of Records RCP-1703, Storage and Access Control RCP-1704, Records Turnover to Sponsor
18. AUDITS	2	QAP-1801, Internal Audits

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FY 1986 Project Organization

— Administrative Direction
 --- Sponsor Technical Direction
 Project QA Support
 oooo Program QA Support

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DESIGN CONTROL PLAN CONTENT REQUIREMENTS

1.0 INTRODUCTION

This Attachment contains the requirements that shall be satisfied in a Design Control Plan. The Plan shall prescribe project-specific requirements and methods for implementing the requirements and guidelines of this Attachment during design activities. It shall be consistent with contractual requirements for the project and shall provide the detailed plan for controlling design work and achieving design objectives.

2.0 DESIGN CONTROL PLAN REQUIREMENTS

The Design Control Plan shall be developed using the format of Attachment E and controlled for each project requiring design activities unless documented as unnecessary by the Program/Project Manager and the Project Quality Engineer. The Plan may be approved and issued incrementally commensurate with the phase of the design activity (e.g., conceptual design or detailed design). However, the approved Plan or portions thereof, and any required procedures shall be available and in effect to control authorized design work prior to performing the work. The Plan shall address the following elements for which the requirements of each are discussed in more detail in 3.0:

- Scope of design work and objectives
- PNL design management responsibility
- Design interfaces
- Design input
- Design process
- Design verification
- Change control
- Baseline and status
- As-built data
- Documentation and records
- Applicable procedures.

It is recognized that there is substantial diversity in the projects conducted by PNL. The elements list is comprehensive so that all potential projects are covered. Some of these elements may not apply to all projects and shall be noted as not applicable in the Plan. Each shall be considered and included in the Plan if applicable. The Plan shall specify the requirements from this Attachment, as appropriate to the project scope of design work, for all required design activities and shall prescribe methods for accomplishing each. Other project requirements including sponsor interface activities and applicable design-related documents shall be included to completely describe the controls for design activities.

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Project-specific procedures shall be prepared, issued and controlled in accordance with PAP-501 and PAP-601 to supplement existing administrative and technical procedures for the above elements, except when the necessary controls are adequately specified within the Plan itself. Subjects listed in Attachment E are typical of the subjects within the elements which require procedural coverage. Applicable procedures shall be listed in the Plan. Reference DCP-301, PAP-301 and PAP-1501, as appropriate, for drawing and NCR controls.

The Plan shall be maintained current during design activities and controlled in accordance with PAP-601 to facilitate achievement of design objectives within PNL's scope of work.

3.0 DESIGN CONTROL PLAN CONTENT

The Design Control Plan shall be sufficiently detailed to provide adequate control of design activities appropriate to the project. Emphasis should be on plan content and assuring that all applicable requirements and methods of achievement are covered. Paragraphs 3.1 through 3.11 prescribe requirements and guidelines which shall be considered and appropriately covered in the Plan.

3.1 SCOPE OF DESIGN WORK AND OBJECTIVES

Describe clearly and concisely the design work and objectives of design activities, including intended end use of the design (e.g., procurement, construction, or as input for a subsequent design phase). Include or reference task descriptions and schedules as necessary.

Reference sponsor and other requirements which must be complied with and the approaches and controls for assuring conformance. Identify the types of design output documents generated during design activities (e.g., permanent or temporary engineering drawings, worksheets, procurement or construction specifications and supplier prepared submittals such as shop drawings) and the PNL or other organization functional responsibility for review, approval and release or distribution of each.

3.2 PNL DESIGN MANAGEMENT RESPONSIBILITIES

The Program/Project Manager shall designate a Project Engineer to manage design activities and to provide technical direction of design accomplished both onsite and offsite throughout the design work.

Functions and responsibilities of the Project Engineer and other key PNL personnel responsible for design tasks and for approval of design documents shall be described. Typical Project Engineer functions and responsibilities are shown in Attachment F as a guide in determining project-specific assignments.

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3.3 DESIGN INTERFACES

Design interfaces shall be identified and controlled and the design efforts shall be coordinated among the participating organizations. Interface controls shall include the assignment of responsibility and the identification or establishment of procedures among participating design organizations for review, approval, release, distribution, and revision of documents involving design interfaces.

Design information transmitted across interfaces shall be documented and controlled. Transmittals shall identify the status of the design information or document provided and, where necessary, identify incomplete items which require further evaluation, review, or approval. Where it is necessary to initially transmit design information orally or by other informal means, the transmittal shall be confirmed promptly by a controlled document. Communications and commitments between project personnel and other organizations associated with design activities shall be performed in accordance with PAP-101, Communication and Commitment (Interface) Control.

3.4 DESIGN INPUT

Applicable design inputs, such as design bases, performance requirements, DOE and regulatory requirements, codes, and standards, including Hanford Plant Standards, shall be identified and documented, and their selection reviewed and approved by the Project Engineer, the responsible design organization and others as required. Functional design criteria and conceptual design, when required, shall include all design inputs and shall be approved by responsible personnel including the Quality Engineer. The design input shall be specified in the Design Control Plan or controlled documents referenced therein and approved on a timely basis and to the level of detail necessary to permit the design activity to be carried out in a correct manner and to provide a consistent basis for making design decisions, accomplishing design verification measures, and evaluating design changes. Changes from approved design inputs, including the reason for the changes, shall be identified, approved, documented, and controlled.

Design inputs include many characteristics and functions of an item or system. These inputs vary depending on the application; however, as a minimum, the inputs listed in Attachment 3 should be considered as they may apply to specific items or systems.

Test activities of PAP-1101, Test/Analysis Planning, Performance and Evaluation, may result in data which become the basis for design criteria to be used in subsequent design activities controlled by this Plan. Approved design documents from one design phase (e.g., conceptual or preliminary) may be used as design input for the next phase (e.g., final design). Regardless of the source or sources of data, the intent of this element is to identify and control all applicable design input.

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3.5 DESIGN PROCESS

The responsible design organization shall prescribe and document the design activities on a timely basis and to the level of detail necessary to permit the design process to be carried out in a correct manner, and to permit verification that the design meets requirements. Appropriate requirements and controls for computer-aided engineering (CAE) systems and software such as computer-aided design and drafting (CADD) and related computer-aided manufacturing (CAM), when used in the design process, shall be prescribed in the Design Control Plan. Internal PNL controls shall be in accordance with applicable Software Control Procedures (SCPs). Design documents shall be adequate to support item or facility design, construction and operation or other purposes specified by the sponsor. Appropriate quality standards shall be identified and documented, and their selection reviewed and approved.

Changes from specified quality standards, including the reasons for the changes, shall be identified, approved, documented, and controlled. Design methods, materials, parts, equipment, and processes that are essential to the function of the structure, system, or component shall be selected and reviewed for suitability of application. Applicable information derived from experience, as set forth in reports or other documentation, shall be made available to cognizant design personnel.

The final design (approved design output documents and approved changes thereto or as otherwise defined by the sponsor) shall:

1. be relatable to the design input by documentation in sufficient detail to permit design verification; and
2. identify assemblies and/or components that are part of the item being designed. When such an assembly or component part is a commercial grade item that, prior to its installation, is modified or selected by special inspection and/or testing to requirements that are more restrictive than the Supplier's published product description, the component part shall be represented as different from the commercial grade item in a manner traceable to a documented definition of the difference.

Design analyses shall be performed in a planned, controlled, and documented manner. Design analysis documents shall be legible and in a form suitable for reproduction, filing, and retrieval. They shall be sufficiently detailed as to purpose, method, assumptions, design input, references, and units such that a person technically qualified in the subject can review and understand the analyses and verify the adequacy of the results without recourse to the originator. Calculations shall be identified by subject (including structure, system, or component to which the calculation applies), originator, reviewer, and date; or by other data such that the calculations are retrievable. Usage of internal PNL computer programs shall be in accordance with applicable SCPs. External computer programs may be utilized for design analysis without individual verification of the program for each application provided:

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1. the computer program has been verified to show that it produces correct solutions for the encoded mathematical model within defined limits for each parameter employed; and
2. the encoded mathematical model has been shown to produce a valid solution to the physical problem associated with the particular application.

External computer programs shall be controlled to assure that changes are documented and approved by authorized personnel. Where changes to previously verified computer programs are made, verification shall be required for the change, including evaluation of the effects of these changes on 1 and 2 above.

Assure that documentation of design analyses includes:

1. definition of the objective of the analyses;
2. definition of design inputs and their sources;
3. results of literature searches or other applicable background data;
4. identification of assumptions and indication of those that must be verified as the design proceeds
5. identification of any computer calculation, including computer type, computer program (e.g., name), revision identification, inputs, outputs, evidence of or reference to computer program verification, and the bases (or reference thereto) supporting application of the computer program to the specific physical problem;
6. review and approval.

The documentation and review of PNL hand calculations shall be performed in accordance with PAP-301, Communication and Commitment (Interface) Control.

3.6 DESIGN VERIFICATION

Design control measures shall be applied to verify the adequacy of design by one or more of the following: the performance of design reviews, the use of alternate calculations, or the performance of qualification tests. The Project Engineer and the responsible design organization shall identify and document the particular design verification method(s) used. The results of design verification shall be clearly documented with the identification of the verifier clearly indicated. Design verification shall be performed by any competent individual(s) or group(s) other than those who performed the original design but who may be from the same organization. This verification may be performed by the originator's supervisor, provided the supervisor did not specify a singular design approach or rule out certain design considerations and did not establish the design inputs used in the design or, provided the supervisor is the only individual in the organization competent to perform the verification. Cursory supervisory reviews do not satisfy this intent.

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Verification shall be performed in a timely manner. Design verification, for the level of design activity accomplished, shall be performed prior to release for procurement, manufacture, construction, or release for use in other design activities except in those cases where this timing cannot be met, such as when insufficient data exist. In those cases, the unverified portion of the design shall be identified and controlled. In all cases the design verification shall be completed prior to relying upon the component, system, or structure to perform its function.

Extent of Design Verification - The extent of the design verification required is a function of the importance to health and safety of the item under consideration, the complexity of the design, the degree of standardization, the state of the art, the required environmental protection, the required performance and reliability, and the similarity with previously proven designs. Where the design has been subjected to a verification process in accordance with requirements of this element (i.e., 3.6), the verification process need not be duplicated for identical designs. However, the applicability of standardized or previously proven designs, with respect to meeting pertinent design inputs, shall be verified for each application. Known problems affecting the standardized or previously proven designs and their effects on other features shall be considered. The original design and associated verification measures shall be adequately documented and referenced in the files of subsequent application of the design.

Where changes to previously verified designs have been made, design verification shall be required for the changes, including evaluation of the effects of those changes on the overall design and on any design analyses upon which the design is based that are affected by the change to previously verified design.

Methods - Acceptable verification methods include, but are not limited to, any one or a combination of the following: design reviews, alternate calculations, and qualification testing.

1. Design Reviews. These are documented critical reviews to provide assurance that the final design is correct and satisfactory. Where applicable, a through f below shall be addressed.
 - a. Were the design inputs correctly selected?
 - b. Are assumptions necessary to perform the design activity adequately described and reasonable? Where necessary, are the assumptions identified for subsequent reverification when the detailed design activities are completed?
 - c. Was an appropriate design method used?
 - d. Were the design inputs correctly incorporated into the design?

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- e. Is the design output reasonable compared to design inputs?
- f. Are the necessary design input and verification requirements for interfacing organizations specified in the design documents or in supporting procedures or instructions?

Design reviews shall be performed in a systematic manner using design review guides when necessary to verify completeness and accuracy. A review guide should include such items as shown in Attachment B. The Project Engineer and other reviewers should consider adding other questions such as those shown in Attachment G that are pertinent to the documents being reviewed prior to approval.

- 2. Alternate Calculations. These are calculations or analyses that are made with alternate methods to verify correctness of the original calculations or analyses. The appropriateness of assumptions, input data used, and the computer program or other calculation method used shall also be reviewed.
- 3. Qualification Tests. Where design adequacy is to be verified by qualification tests, the tests shall be identified. Qualification testing by PNL personnel shall be performed in accordance with PAP-1101, Test/Analysis Planning, Performance and Evaluation. The test configuration shall be clearly defined and documented. Testing shall demonstrate adequacy of performance under conditions that simulate the most adverse design conditions. Operating modes and environmental conditions in which the item must perform satisfactorily shall be considered in determining the most adverse conditions. Where the test is intended to verify only specific design features, the other features of the design shall be verified by other means. Test results shall be documented and evaluated by the responsible design organization to assure that test requirements have been met.

If qualification testing indicates that modifications to the item are necessary to obtain acceptable performance, the modification shall be documented and the item modified and retested or otherwise verified to assure satisfactory performance. When tests are being performed on models or mockups, scaling laws shall be established and verified. The results of model test work shall be subject to error analysis, where applicable, prior to use in final design work.

The extent of Quality Engineering participation in design reviews, qualification testing and design approvals shall be determined by the Quality Engineering Manager. As a minimum, Quality Engineer participation shall be required in design reviews of final designs. QAD drawing reviews shall be performed in accordance with QAP-301, Engineering Drawing Review.

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3.7 CHANGE CONTROL

Changes to final designs, field changes, modifications to operating facilities, and nonconforming items dispositioned Use As Is and Repair, shall be justified and subject to design control measures commensurate with those applied to the original design. These measures shall include assurance that design analyses for the structure, system or component are still valid. Changes shall be approved by the same affected groups or organizations which reviewed and approved the original documents, except where an organization which originally was responsible for approving a particular design document is no longer responsible, then the Program/Project Manager or his designee shall designate a new responsible organization. The designated organization shall have demonstrated competence in the specific design area of interest and have an adequate understanding of the requirements and intent of the original design.

Where a significant design change is necessary because of an incorrect design, the design process and verification procedure shall be reviewed and modified as necessary to assure an acceptable design.

As a minimum, Quality Engineer participation shall be required in final design change review and approval activities.

3.8 BASELINE AND STATUS

A configuration management baseline listing all design input and output documents including changes thereto shall be established and maintained throughout the duration of PNL design activities to indicate the current status of documents. All design output documents shall be identified to indicate their intended usage (e.g., for planning, for procurement or construction or for record in the case of as-builts). The baseline and documents shall be distributed and controlled in accordance with PAP-601, Document Control.

3.9 AS-BUILT DATA

If required, initial design output documents shall be revised to incorporate field verifications and subsequent changes approved via change and NCR controls. Appropriate design verification shall be performed. If required and prior to or in conjunction with this verification, verification shall be required to confirm that the as-built configuration actually conforms to applicable design documents including all approved changes, and that the affected documents are revised to accurately describe the as-built configuration.

3.10 DOCUMENTATION AND RECORDS

Design documentation and records, which provide evidence that the design and design verification processes were performed in accordance with the Design Control Plan, shall be collected, stored, and maintained in accordance with PAP-1701, Research Projects Record System.

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The documentation shall include not only final design documents, such as drawings and specifications, and revisions thereto but also documentation which identifies the important steps, including sources of design inputs that support the final design.

3.11 LISTING OF APPLICABLE PROCEDURES

PNL procedures for implementation of each element of the Design Control Plan shall be listed for reference to required methods. Offsite design organization procedures approved by PNL shall also be included.

1. PAP-101, Communication and Commitment (Interface) Control
2. PAP-301, Hand Calculation Documentation and Review
3. PAP-501, Preparation and Issue of Procedures
4. PAP-601, Document Control
5. PAP-1101, Test Analysis Planning, Performance and Evaluation
6. PAP-1501, Nonconformance Reports
7. PAP-1701, Research Project Records System
8. DCP-301, Drawing Control
9. QAP-301, Engineering Drawing Review

3.12 REFERENCED ATTACHMENTS

Attachment D, Procedures
Attachment E, Design Control Format
Attachment F, Project Engineer Functions and Responsibilities
Attachment G, Document Review Guide

ATTACHMENT D

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Procedures

Subjects normally covered by procedures for the preparation and control of design documents include the following:

1. Drawings

- (a) drafting room standards
- (b) standardized symbols
- (c) identification system
- (d) indication of status
- (e) checking methods
- (f) review and approval requirements
- (g) issuance and distribution
- (h) storage and control of originals or master copies
- (i) revisions
- (j) as-built drawings

2. Specifications and Other Design Documents

- (a) format requirements
- (b) identification system
- (c) review and approval requirements
- (d) issuance and distribution
- (e) revisions
- (f) indication of status
- (g) storage and control of originals or master copies

3. Document Change Control

- (a) documenting change requests
- (b) review of change requests
- (c) change implementation
- (d) change approvals
- (e) change records storage

ATTACHMENT E

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DESIGN CONTROL PLAN FORMAT

DCP No. _____, Rev. _____
Issue Date _____
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DESIGN CONTROL PLAN
for

_____ Design
_____ Program/Project

Prepared by:

Preparer/Project Engineer

Date

Approvals:

Program/Project Manager

Date

Quality Engineering Manager

Date

Others (as appropriate)

Date

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ATTACHMENT E

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Note to Attachment: This attachment provides the recommended basic format for a Design Control Plan.

DCP No. _____, Rev. _____
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- 1.0 SCOPE OF DESIGN WORK AND OBJECTIVES
- 2.0 PNL DESIGN MANAGEMENT RESPONSIBILITIES
- 3.0 DESIGN INTERFACES
- 4.0 DESIGN INPUTS
- 5.0 DESIGN PROCESS
- 6.0 DESIGN VERIFICATION
- 7.0 CHANGE CONTROL
- 8.0 BASELINE AND STATUS
- 9.0 AS-BUILT DATA
- 10.0 DOCUMENTATION AND RECORDS
- 11.0 LISTING OF APPLICABLE PROCEDURES

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PROJECT ENGINEER FUNCTIONS AND RESPONSIBILITIES

- Prepare and maintain the Design Control Plan
- Provide technical direction of design accomplished by either onsite or offsite designers
- Assure design quality consistent with requirements
- Establish and maintain project records to provide traceable history of progress
- Establish and maintain cost and schedule controls
- Plan, schedule, estimate, and report the accomplishment of design activities
- Approve design schedules consistent with project requirements
- Assure that cost effectiveness is stressed in criteria, requirements, and controls on projects
- Establish design verification requirements, plans and schedules
- Chair (or designate the chairman) design reviews, resolve comments and issues and issue minutes of these meetings
- Follow up on open items and document their resolution
- Provide and/or concur in engineering and fabrication reports as required
- Assure the update of all project design documents, control media, reports schedules, and cost summaries, as new information becomes available
- Prepare data for management review meetings and prepare and issue minutes of these meetings
- Secure and manage performance of design services and issue work orders as required
- Provide the administration of change control for design and fabrication activities
- Act as a focal point for coordination and integration among designers and provide appropriate direction to assure compliance with the project baseline and other technical design criteria including use of appropriate codes and standards for design and fabrication activities
- Assure that the specific scope of work for any required technical service is carefully delineated so that the contracting party and the party providing technical services clearly understand their responsibilities and authorities

ATTACHMENT G

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DESIGN REVIEW GUIDE

1. When applicable, do documents follow the controlling requirements established relative to drafting practices, official building lists, and site specifications?
2. Is there evidence that the design conforms to the design criteria and to the conceptual design?
3. Are design documents supported by appropriate engineering studies?
4. Are traceability requirements (through the use of lot, heat, part, or serial numbers) specified and adequate for the items being procured, fabricated, or constructed?
5. Are necessary special processes and materials identified as to controlling specifications, standards, and procedures?
6. Has the assigned quality assurance level, if designated, been adhered to?
7. Is there evidence of usage of standardized components and hardware where possible?
8. Are materials, shapes and sizes of standard manufacture readily available?
9. Are specified materials compatible with the system, subsystem, or environment in which they are to be used?
10. Are material certifications required? If so, have they been requested in appropriate documents?
11. If off-the-shelf items are used, will they perform within the planned environments and operating levels of system requirements?
12. Have critical fabrication techniques been adequately specified?
13. Have preservation, packaging, marking and other instruction requirements been included to maintain assembly conformance to specifications during handling, storage, and shipping?
14. Are design dimensions and tolerances shown adequate to make and inspect parts, and are they compatible with fabrication methods?
15. Can standard test and inspection methods, tools, and personnel be used? If not, are "specials" justified and have they been designated?
16. Are interface drawings available and have interface connections and areas, both internal and external, been clearly specified and identified?

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17. Has consideration been given to the effects of:

seismic conditions
tornado
radiation
vibration
humidity
fire

ambient temperature
temperature extremes
electrical interference
failure of adjacent or connected equipment
operations or releases to nearby facilities
construction noises

18. Have test requirements and acceptance criteria been identified and prepared for the following?

Acceptance Test Procedures (ATPs)
Nondestructive Examinations (NDEs)
others

19. Will parts interfere with one another during assembly and operation?

20. In radioactive areas, will the materials specified meet the environmental condition?

21. Can the equipment or facility be easily cleaned or decontaminated for maintenance or operation?

22. Is accessibility provided for installation, operations, equipment or part replacement and maintenance?

23. When changes are made, are the affected process or ATP procedures also changed?

24. Has required room for future expansion been provided, if specified?

25. In the event of failure of any equipment or system:

Will a nuclear hazard exist?
Will a nuclear safeguard be lost?
Will other equipment/systems be damaged?
Will other systems or operating conditions be affected?
Will a toxic release or hazard exist?

26. Will the failure result in the loss of experimental data during operations and testing?

27. Does design meet environmental and safety requirements?

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TYPICAL QUESTIONS FOR REVIEW GUIDE

1. Does the design meet all baseline requirements of current design criteria?
2. Are the interface requirements with Site construction drawings clearly specified and achievable with respect to location?
3. Are there any interface problems?
4. Have engineering standards and criteria been specified properly?
5. Have proper raw materials been specified?
6. Have qualified and certified parts been specified?
7. Have available data or similar designs been used?
8. Does the design meet functional requirements?
 - Are stresses within design limits?
 - Does design represent optimum in simplicity?
 - Steady state and transient conditions?
9. Will the design meet the following environmental conditions:
 - Temperature
 - Pressure
 - Vibration
 - Shock
 - Nuclear radiation
 - Corrosion products
10. Is the design specified producible by conventional means?
11. Has the design been reviewed for maintenance and operational features?
12. Are there unresolved safety comments?
13. Are suitable development needs specified?
14. Have available test data been incorporated?
15. Have all the defined requirements for receiving and storing test assemblies been resolved?
16. Have adequate acceptance criteria been delineated and are the verification methods stated appropriately?
17. Does the design ensure that the function of one subsystem is not defeated by the operation of an interfacing subsystem?
18. Have provisions been made for required spare parts lists and installation, operating and maintenance manuals or procedures and are these documents adequate?