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SPECIFICATION

REACTOR BUILDING LINER AND PENETRATIONS

CRYSTAL RIVER - UNIT NO. 3
FLORIDA POWER CORPORATION

SP-5965 JULY 17, 1968
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FPC-321-sh.2

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4.01 Scope of Work

4.01.1 The WORK to be performed under this Contract shall include the design, furnishing, fabrication, delivery, unloading, storage as necessary, erection of the steel liner including penetration sleeves and installation of penetration inserts, supplied by others and all necessary testing of steel liner and penetration installation for the Reactor Building, complete and as specified herein and/or as shown on Drawings.

4.01 The Reactor Building for the Crystal River Plant, Unit No. 3 of the Florida Power Corporation will be a steel lined concrete shell in the form of a vertical right cylinder with an ellipsoidal dome and flat base. The concrete thickness will be 3'-6" for the cylindrical walls and 3'-0" for the dome.

4.01.3 The CONTRACTOR shall be responsible for erecting a leak tight liner. The degree of leak tightness shall require a containment leak rate of no greater than 0.25 per cent by weight of contained air in 24 hours at 55 psig. The CONTRACTOR shall be fully responsible for designing liner reinforcement adequate to resist all erection loads including those additional erection loads specified herein, but excluding those erection loads resulting from using the liner as a form for concrete work. The CONTRACTOR shall also be responsible for properly fabricating a liner which will be an element of the composite steel and concrete shell. The structural design of that portion of the equipment access door extending beyond the reinforced concrete shell shall be the CONTRACTOR'S responsibility.

4.01.4 In addition, the CONTRACTOR shall be responsible for the shop or field installation of all instrument and electrical penetration inserts, including all testing as specified herein. Any leak detected, requiring repair, shall be the responsibility of those making the weld.

4.02 Work Included

The WORK shall include, but not necessarily be limited to, the following:

a. Detailed design of:

1. Equipment access penetration in collaboration with the ENGINEER based upon the parameters specified hereinafter and/or as shown on the Drawings, except that the CONTRACTOR shall be totally responsible for the structural design of that portion of the equipment access door extending beyond the reinforced concrete shell.

b. Liner reinforcement about openings.

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c. Reinforcement to resist all erection loads except concrete placement.

2. Preparation of shop details and erection drawings for the liner and penetrations.

3. Furnishing, fabricating, erecting, and specified testing of the following:

a. Liner main shell including cylindrical wall, dome and flat base.

b. One equipment access hatch with a minimum inside diameter of 20'-0".

c. All sleeves as indicated on attached Penetration List.

d. Delete.

e. Crane girder brackets and anchorage plates.

f. Liner anchors

g. Six (6) grounding studs 6" x 6" x 3/8" steel, welded on one end to the liner and suitable for embedding in concrete, spaced around the outside surface at azimuths and elevation as specified later; and four grounding studs each from 2-1/2" x 1/2" rods, welded at required locations with 5/16" hole suitable for bolted cable connection, on the inside surface.

h. All brackets and hanger supports for piping and ventilating systems including supervising, shop and field welding, and painting.

i. Insulation as required for mechanical penetrations.

4. Installation of the cooling coils in the wet penetrations.

5. Designing reinforcement and performing all work for required temporary access opening.

6. Performing all quality control measures and preliminary tests as specified hereinafter.

7. Preparation of the surfaces, one coat of primer, and one coat of finish paint on all surfaces exposed to the interior of the reactor building.

8. Installation of electrical and mechanical items, furnished by others, in penetration sleeves.

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3.03 **Work Not Included**

The following items associated with the reactor building liner and penetrations are not included under this Contract but will be furnished and erected by Others.

1. Concrete Work.
2. Piping here embedded in the concrete base mat. Base mat will be sloped for adequate drainage.
3. Deleted.
4. Deleted.
5. The furnishing of electrical and mechanical penetration inserts including process pipe, attachments to process pipe, bellows and heat exchangers.

3.04 **Codes and Regulations**

Except as noted hereinafter, the materials, details of fabrication, and erection shall conform to the requirements of the ASME Nuclear Vessels Code for Class B Vessels. The containment liner and penetrations shall conform in all respects to the applicable sections of USAS Standards Unfired Code N 6-1968, "Safety Standard for Design, Fabrication and Maintenance of Steel Containment Structures for Stationary Nuclear Power Reactors." That portion of the equipment access door extending into the reinforced concrete shall shall conform in all respects to the requirements of the ASME Nuclear Vessels Code for Class B Vessels.

3.05 **Design Requirements**

3.05.1 **Technical Parameters:**

The technical conditions applicable to the complete reactor building are as follows:

Inside diameter	130 ft
Cylinder height	157 ft
Hemispherical dome	
1. Inner radius	65 ft
2. Inner height	32.5 ft
Design pressure	410 ft
Design temperature	55 psig
Operating pressure, normal	281 F.
Operating pressure, range	+1 to -1 psig
Operating temperature, normal	
1. Inside	120 to 130 F
2. Outside	+25 to 100 F.
Design wind	
Mean hourly rate at 55 ft.	2.5 psig
	0.95/25 hours

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4:05.2 **Cylinder Reinforcement:**

Liner Plate Reinforcement:

1. The cylinder walls shall be reinforced so as to support the dead load of the liner plus erection and wind loads. An additional 6 in. WF 15.5 lb member shall be located at each buttress centerline as shown on the Drawings.

2. The dome shall be reinforced to withstand a superimposed load of 100 pounds per square foot.

3. The outside walls shall be reinforced on the outside face so as to support the dead load of the liner plus erection and wind loads or by other methods approved by the ENGINEER.

4:05.3 **Opening Reinforcement:**

The liner shall be reinforced about all openings in accordance with the ASME Unfired Pressure Vessels Code (i.e., by replacing the cut out area of the 3/8 in. liner plate).

4:05.4 **Plate Thickness:**

The steel plate for the main shell, including the cylindrical walls and the dome but excluding specially reinforced areas, shall be 3/8 inches thick. The steel plate for the containment base liner including the sump shall be 1/4 in. thick.

4:05.5 **Engineer's Review:**

The CONTRACTOR shall submit design calculations and detail drawings to the ENGINEER for review and record prior to initiating fabrication. Review and/or approval of information submitted to the ENGINEER shall not relieve the CONTRACTOR of any responsibility for design, fabrication, erection, and testing as herein specified.

4:06 **Materials**

4:06.1 **Main Shell:**

Steel plate for the main shell including the dome, cylindrical walls, and base shall conform to "Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Spec. For," ASTM A 283-67, Grade C. Rolled sections including test channels and stiffeners shall conform to "Structural Steel, Spec. For," ASTM A 36-67.

Special Note: Steel plate material per ASTM A283-67 does not meet the requirements for a Class B Nuclear Vessel, but conformance is not required since the liner is not a load-carrying component.

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Special Note: The steel plate for the main shell, including the bowl mat plate, the knuckle plate, and the adjacent portion of the cylindrical wall plate in the area of the cross girder bracket, shall have a maximum copper content of 0.2%. The material for the unlabeled portion of the cylindrical wall plate in the area of the cross girder bracket shall be ASME A516, Grade 60.

b.06.2 Penetration Sleeves

The materials for penetration sleeves including the equipment access hatch as well as the mechanical and electrical penetrations shall conform with the requirements of the ASME Boiler Pressure Vessel Code, Section III and shall exhibit ductility and weldability characteristics compatible with the main shell material. The selection of materials for penetration sleeves shall consider a lowest service metal temperature of 120 F within containment and >50 F without containment. All materials for penetration sleeves shall exhibit impact properties as required for Class "1" vessels. The materials for penetration sleeves shall be carbon steel except as otherwise specified herein or shown on the drawings.

b.06.3 Deleted.

b.06.4 Material Restriction and Cleanliness Requirements:

1. Process piping materials shall contain no lead, mercury, or zinc, and care shall be taken to prevent contamination of these materials by halides, sulphur, and phosphorus.

2. The following restrictions are applicable to avoid contamination of the piping exposed to the reactor coolant or steam and water of the steam system:

   a. Mercury or mercury compound-containing instruments or equipment such as thermometers, manometer, and vacuum pumps shall not be used for any service in connection with fluid system components during fabrication, assembly, preheat, installation, examination, testing, or repair.

   b. Every effort shall be made to prevent lead or lead compounds as a basic chemical constituent from coming into contact with parts of a component that will be exposed to reactor coolant or steam and water of the steam system. Lead contaminants which are unavoidably present shall be removed prior to heat treatment, hot forming, repair welding and shipment. The final cleaned surfaces of the equipment prior to operation shall be free of lead or lead compound contamination.

   c. Materials such as oils, greases, rubber and plastics containing sulphur, phosphorus, and halides shall not be present on the final cleaned surfaces which will be exposed to reactor coolant or steam and water of the steam system.

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9.07 Welding

9.07.1 General:

1. The qualification of the welding procedures and welders for the liner plate shall be in accordance with the requirements of Section IX, "Welding Qualifications" of the ASME Boiler and Pressure Vessel Code. The qualifying procedures and welders for the welding of the attachment plate to the sleeve, and the welding of the liner plate to the sleeve shall be in accordance with the requirements of Section IX, "Welding Qualifications" and paragraph N-391 of Section III of the ASME Boiler and Pressure Vessel Code. The repair of defective welds shall be in accordance with paragraph N-500, Section III. The Contractor shall submit welding procedures to the Owner for review. The review and/or approval of procedures shall not relieve the Contractor of welding responsibility.

B/C

2. Welding procedures and qualifications shall incorporate instructions outlined to control porosity. These instructions shall cover allowable welding currents, removal of slag and flux and welding techniques to control porosity. Porosity shall meet the requirements of Paragraph [redacted] Section VIII of the ASME Code.

3. Postweld heat treatment shall be conducted in accordance with Section III of the ASME Boiler and Pressure Vessel Code for Class 3 Vessels. All welds that are designated to be radiographed to Section III, Class 3 shall have postweld heat treatment if the code so requires.

B/C

4. The use of ion hydrogen electrodes or automatic submerged arc welding is required for field welding. Manual welding of vertical welds shall be required, except that cover passes and weld-deposit cover passes will be qualified and can be welded by manual welding.

B/C

9.07.2 Quality Control:

1. Longitudinal and circumferential welded joints within thermal shield, the welded joint connecting the dome to the cylindrical side shell, and any welded joints within the dome shall be inspected by the liquid penetrant method and spot radiography, all as hereinafter specified. All penetrations including the equipment access door shall be examined in accordance with the requirements of the ASME Nuclear Vessels Code for Class "A" Vessels. All other shop fabricated components, including the reinforcement about openings, shall be fully radiographed. All other joint details shall be examined by the liquid penetrant method as specified in Item 9.07.2 - 3. of this Specification.

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2. Full radiography shall be in accordance with N-1150, Section III, ASME Boiler and Pressure Vessel Code. The procedure and acceptance criteria shall conform to UW-51, Section VIII, ASME Code. Spot radiography shall be in accordance with the procedures and governed by the acceptance criteria of Paragraph UW-52, Section VIII, ASME Boiler and Pressure Vessel Code with the following conditions:

   a. Two percent of all welds shall be radiographed. Care should be taken to include approximately 2% of welds by each welder.

   Special Note: The 2% spot radiography shall include all radiographable welds in the liner that are not covered by the full radiography specification.

   b. Spot radiography shall be at the frequency of twelve (12) inches in every fifty (50) feet of welding.

   c. The quality assurance inspector shall select the spots to be radiographed on a timely basis except in those specific instances where he waives this privilege to the CONTRACTOR's quality control supervisor.

3. Methods of liquid penetrant examination shall be in accordance with Appendix VIII of the ASME Unfired Pressure Vessels Code, except that 20% of the welds shall be tested by liquid penetrant.

4. A visual inspection for defects shall be made of all liner welds.

5. Certified copies of mill test reports describing the chemical and physical properties of the steel plate materials used for the liner plate and the reinforcing plates to the penetration sleeves shall be submitted to the OWNER for approval. Certificates of compliance or typical certificates of analyses for the weld rod or weld filler metal for the main liner welds are acceptable and they shall be submitted to the OWNER for approval. The penetration welds and penetration assembly material is covered by Section III, Class 2 and shall have the necessary traceability of materials as covered by this Code. The plate material shall be identifiable with specific mill test reports through a numbering system and/or sketches, such that at any time during construction or after completion of construction, any plate or piece of plate can be positively identified.

6. Results of weld radiography, liquid penetrant inspection, leak testing by halogen sniffing and vacuum box methods, and visual inspection shall be recorded as part of construction records. After completion of construction, these records shall be delivered to the OWNER.

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7. The stiffened flange plate at the elevation of the cross girder knuckle shall be ultrasonically inspected to insure the steel is free from gross internal discontinuities such as pipes, ruptured, or laminations. The procedure and acceptance standards shall be in accordance with "Longitudinal-Wave Ultrasonic Inspection of Heavy Plates for Pressure Vessels," ASTM A 435-67.

8. The CONTRACTOR shall, before receipt of material, submit a Quality Control Manual to the OWNER or his Agent for review and comment. This document shall contain as least the following items:

a. Clear procedures for NDT inspection techniques.

b. Material Control Procedures.

c. Electrode Control Procedures.

d. Marking and Material Identification procedures.

e. Control of construction conditions by a dimensional check up procedure.

f. Qualification requirements for NDT personnel and welders.

g. Document and drawing control, procedures.

h. Non-conformance procedures.

i. Control and storage of inspection test records.

j. Control of purchase parts.

k. Criteria for approval and rejection work.

l. Documentation checklists.

m. Corrective action procedures.

n. Traceability coding.

o. Peripheral test procedures.

6.06 Test Channels

Steel channels shall be provided along all weld seams which will be inaccessible when all construction is completed. The channels shall be proportioned so as to ensure that any length of weld covered by any one channel segment will not exceed the greatest dimension of the plate. One fitting shall be provided in each channel segment and shall extend through and clear of any covering material including concrete.

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equipment, and piping. Connections in the vent mast terminate at elevation 92'-0" and be plugged. The fittings on the base shall be protected by sleeves at the base weld to ensure no weld failure during placing of concrete. All vent channels shall be located on the face of the liner inside containment. Steel angles shall also be installed to cover penetration sleeve to liner plate weld.

b:09 Erection Tolerances

b:09.1 Erection tolerances for the liner shall be as follows:

1. Overall out of roundness: ±3 in.
2. Deviation from round in 10 ft: 1-1/2 in., except at seams.
3. Overall deviation from a plumb line: ±3 in.
4. Deviation from line between tangent points at cylinder to dome transition and base to cylinder transition: ±3 in.
5. Shell plate edges shall butt for a minimum of 75 per cent of wall thickness.

b:09.2 Tolerances for all penetrations shall be as set forth hereinafter in this specification. These tolerances shall be maintained in the final erected position.

b:10 Penetration and Opening

b:10.1 Equipment Access Hatch:

The following shall apply to the equipment opening in the reactor building liner:

1. All flanged joints shall be designed in such a manner that a double O-ring and double groove with gasket can be employed on a seal. This seal shall be capable of being pressurized between seals to 63.3 psig.
2. The material used in the construction of the opening shall be compatible with the liner material metallurgical characteristics.
3. All seals, gaskets, O-rings, or other sealing materials shall be suitable to withstand design temperature conditions.

b:10.2 Mechanical Penetrations:

The following shall apply to the fabrication and testing of all mechanical penetrations:

1. Details for mechanical penetrations shall be as shown on design drawings.

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2. Delete.

3. The penetration sleeves material shall be compatible with liner materials and must be approved for Class 1 Nuclear Vessels.

4. Where thermal insulation is required, the material shall be "Unlagged." Specification for insulation shall be submitted to the Engineer for review and comment.

5. All penetration sleeves shall be Schedule 80 except as noted on the "Penetration List," or subsequent lists.

6. Delete.

7. The locations of penetrations with regard to azimuth location shall be within ±1/2 in., measured on the circular section. The horizontal and vertical dimensions associated with the radial dimension shall be ±1/2 in. for all pipe lines.

8. All penetrations shall be installed in the respective plate sections prior to testing.

9. All mechanical penetrations shall have double barriers designed for pressurization with air to 61.3 psig for leak testing.

10. All pipe ends shall be protected for shipping and erection as indicated on the Drawings.

11. Delete.

12. Bellows shall be provided on mechanical penetrations as indicated on the Penetration Lists.

13. Delete.

9.10.3 Electrical Penetrations:

All electrical penetrations shall be designed as follows:

1. Penetration cartridges will be supplied by Others but installed in the penetration sleeves by the Contractor.

2. The penetration sleeves to accommodate the aforementioned cartridges shall be 12 in., Schedule 80, carbon steel pipe of A grade approved for Class 1, Nuclear Vessels. Penetration sleeves shall be flow welded to the liner plate.

3. The weight of the liner cartridges will not exceed 500 lbs. but shall be capable of supporting an additional weight of 500 lbs.

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4.10.4 Mechanical Penetration Shop Testing:

The following tests shall be applied to all mechanical penetrations:

1. A pneumatic test shall be applied to each penetration which will pressurize the penetration annulus to 63.3 psig. The pressure shall be reduced to 55 psig and held at this pressure to soap bubble and sniff test all welds and mated surfaces. If leaks are found, they shall be repaired and retested. This procedure shall be followed until no leaks exist. Test shall be conducted as hereinafter set forth in this specification.

2. Local tests shall be conducted in accordance with "Proposed Standard for Leak Rate Testing of Containment Structures for Nuclear Reactors," ANS-7.60, Appendix A.

3. The Owner reserves the right to witness shop tests and shall be notified at least two weeks in advance of all shop tests.

4.10.5 Penetration Appurtenances:

The following shall apply to all penetrations:

1. Bracing shall be designed to support penetration in liner for shop testing, shipping, and field erection.

2. Bellows are to be suitably protected against field damage and will remain as part of the permanent installation.

4.10.6 Special Penetrations:

1. The penetrations requiring special attention are the "Containment Supply" and "Exhaust Purge Ducts" noted in the Penetration List attached hereto. The following additional requirements are imposed on these penetrations:

   a. Pressed bends shall be supplied with the penetration and shall be suitable for use during liner tests.

   b. Each penetration shall be provided with two test connections, not less than 3/4 in. pipe size to test both pipe and annulus spaces.

   c. Mechanical and electrical spares, as so designated in the Penetration List, shall have both ends of the sleeves capped. The outside cap, (concrete side) shall be equipped with a test connection no less than 3/4 in. pipe size. Unless otherwise stated, all spare mechanical sleeves shall be 10 inch diameter, schedule 80 pipe and spare electrical sleeves shall be 12 inch diameter, schedule 80 pipe.

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h110 Fuel Transfer Penetration

The fuel penetration shall be as detailed on the drawings. The pipe insertion will be supplied by Others. The tolerance on location and orientation shall be as shown on the drawings.

h111 Preliminary Tests

All testing, as hereinafter described, shall be performed by the CONTRACTOR. These tests shall include the following:

a. All weld seams on the base, pits, and between penetration sleeves and liner plate and any additional weld seams which are covered by steel test channels shall be examined by detecting leaks at 63.5 psig using a mixture of air and freon. For the freon test, all exposed seams shall be checked with a halogen leak detector and 100 per cent of detectable leaks corrected. The tests as valid shall be conducted in accordance with those set forth in Para 6.10.1.

Copies of detail test procedures shall be submitted to the OWNER or his agent for review and comment.

b. All weld seams not covered with test channels shall be tested using a soap film and vacuum box. The pressure differential shall not be less than 5 psig. The rate of inspection shall not exceed two feet of weld per minute. The box shall overlap a minimum of six inches over the previously tested section. All detectable leaks shall be corrected.

Copies of detail test procedures shall be submitted to the OWNER or his Agent for review and comment.

c. Pneumatic test connections shall bear metal stamped identification tags firmly affixed and referenced on drawings to test channel section to which it is attached. All other test connections will be dimensioned on "as built" drawings. Any field changes will be subject to the approval of the OWNER and shall be kept current and revised drawings shall be issued at completion of erection.

d. The CONTRACTOR shall provide adequate documentation for all tests and submit copies of such documentation in triplicate to the OWNER.

h112 Painting

After erection of the liner plate is completed, all surfaces of the cylinder, dome, penetrations, crane brackets and miscellaneous attachments exposed to the interior of the Reactor Building, shall be sandblasted to a near white metal in accordance with "Steel Structures Painting Council Specifications", SSPC-SP-10-63T.

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The abrasive shall be selected to obtain a profile as specified by the manufacturer. As soon as practicable after the steel is cleaned, all surfaces shall receive one (1) coat of Wisconsin Protective Coating Co.'s Plastic 7199 WF Primer. The dry film thickness of the primer at any point shall not be less than 2.5 mils. After an adequate curing period, as recommended by the manufacturer, the primed surfaces shall be cleaned and free of all foreign matter before finish application begins. The finish painting shall consist of one (1) coat of Wisconsin Protective Coating Co.'s Plastic 9009. The dry film thickness of the paint at any point shall not be less than 2 mils. When the primer coat and the finish coat shall be applied in accordance with the manufacturer's printed instructions.

b)13 Material Handling

All materials shall be carefully handled so that members or parts which have become damaged after fabrication shall be straightened by methods which will not produce fracture or other injury, and without hammering, unless approved in writing by the Architect. Any members which are so damaged that it is impossible to correct them in the field shall be replaced with new members at no cost to the Owner. Hammering which will injure or distort the members will not be permitted.

b)14 Examination Hint

The "Examination Hint" consists of eight sheets; copies of which are attached hereto and are hereby expressly made a part of this Specification.

b)15 Inspection

The Owner or his Agents reserves the right to inspect fully all phases of manufacture of the materials included hereunder and to witness all tests. Any items found to be unsatisfactory shall be rejected or repaired at no additional cost to the Owner. Any inspection by the Owner or his Agents shall not relieve the contractor of any responsibility for conformance with stated conditions and shall not be considered as a waiver of warranty or other right.

b)16 Lightning Protection During Liner Erection

If the permanent grounding system for the unit has not been completed at the time of liner erection, the supplier shall drive four ground rods, each with a minimum length of eight feet at ninety degree (90°) intervals around the periphery of the liner and connect each rod to each end of the angle clips as soon as that portion of the liner plate is erected. Ground cable shall be #2/0 bare, stranded copper minimum.

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