Department of the Interior
US Geological Survey
PO Box 25046 MS 974
Denver, CO 80225-0046

August 30, 2011

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Reference: U.S. Geological Survey TRIGA Reactor (GSTR), Docket 50-274, License R-113
Request for Additional Information (RAI) dated September 29, 2010

Subject: Response to Question 1 of the Referenced RAI

Mr. Wertz:

Question 1: The ISG requires the NRC staff to review significant changes to the facility, including those done in accordance with the provisions of Title 10 of the Code of Federal Regulations Section (10 CFR) Section 50.59. In 1988, changes to the GSTR were made which involved the installation of a new reactor tank liner. The details of this change are not provided in the GSTR Safety Analysis Report (SAR). As such, please provide a description of the new tank liner, the applicable design and construction criteria, and any associated additional instrumentation or equipment added as a result of the new tank liner. In addition, please describe any analyses of accidents and malfunctions associated with the new tank liner.

Response: Twenty three years ago, in 1988, corrosion and the resultant water leakage in the original, aluminum reactor tank was resolved by installing a tank liner inside the leaking tank. The tank liner has a slightly (4") smaller diameter than the original tank so it could be easily slipped into place. The tank liner is constructed of 6061-T6 aluminum with an overall height of 25' 3" and with an outer diameter of 7' 7.25". The bottom of the tank liner is supported by twelve ribs that are welded to the outer surface of the liner. These twelve ribs are welded to the liner in a spoke pattern, at a 30° spacing. The ribs are 4" tall, 1" thick, and 32" long. The floor of the liner is one inch thick, and the wall thickness varies from 3/8" near the bottom to 1/4" at 90.375" up from the bottom.

The reactor core structure is supported by a triangular base. The base connects to the floor of the tank liner at three pads that are located 30.625" from the center and separated from each other by 120°. These pads are supported by the ribs on the underside of the tank, with each pad centered directly over a rib. The pads are 4" wide, 8.5" long, and 1" thick. The triangular base is connected to the pads through adjusting screws that allow for the base to be leveled manually. The triangular shape is reinforced by crossing support beams. The reactor core structure sits on the crossing support beams of the triangular base and is connected via nuts and bolts.

A020
NRR

Design and Construction Criteria

The ASME pressure vessel code was used as the basis for the reasonable, safe and economical design of the tank. The design included seismic, strength and thermal calculations for the mechanical and structural integrity of the tank liner and lifting lugs.
Pressure: Int:10.83 PSI EXT: 1.184 PSI
Temp: Max: 150 ° F Min: 50 ° F
Liquid Level: Full of water
Corrosion Allowance: None
Joint Efficiency: 1.0 (100% X-Ray)
Specific Gravity of Contents : 1.0 (Water)
Seismic: PER API 650, APP'E' , Zone 1
A copy of the design specifications is provided as Attachment 1.

Added instrumentation or Equipment Because of Change

The only equipment that was added because of the change was a "pump tube" located at the liner's edge in the SE quadrant of the tank liner. This tube is an aluminum tube, 6" diameter at the top and 3" diameter for the lower 5 feet. This tube penetrates the bottom of the tank liner so that access can be gained into the bottom annulus between the original tank and the tank liner. This access is needed to check the annulus for water accumulation and to allow removal of any accumulated water. An eductor pump system was purchased to fit in the pump tube for the removal of accumulated water. The pump is only located in the tube when water is being removed; otherwise the pump tube is empty. A radiation shield plug is located at the top of the pump tube to prevent radiation streaming into accessible locations. The pump tube is checked regularly, when the reactor is shutdown, for water accumulation.

Accident and/or Malfunction Analyses

A copy of the design calculations for the tank liner is attached as Attachment 2. These accident/malfunction calculations include static and dynamic pressures that could result from water pressure, lifting and placement, and a design basis (0.2 G force) earthquake.

Additional Preliminary Responses Based on Information Received from the Colorado School of Mines:

Question 8. The technical parameters of the GSTR are being analyzed using the MCNP version 5 and RELAP version 5, mod 3.3. These analyses are being performed using the Oregon State University relicensing work as a starting point for the methodology. The code results will be benchmarked to the GSTR operating data. After the existing core model is finalized, the limiting core configuration will be modeled and analyzed. These models are being worked on and we expect to have final neutronic and thermal hydraulic results by October 31, 2011.

Question 9. We have a limiting core configuration determined, which will include a number of new 12 weight% fuel elements in the center of the core. However, since our neutronic and thermal hydraulic models are not completed, we do not have control rod worths or excess reactivities calculated for all configurations. Again, we expect to have these results by October 31, 2011.

Question 10. The fuel and moderator temperatures that are used are 293 K for low power operations and 600 K for full power operations. The void and power coefficients will be determined by October 31, 2011.

Question 12. The DNBR analysis will be done using RELAP version 5, mod 3.3. The model used for the GSTR was received from the Oregon State University relicensing effort and has been adapted for the GSTR conditions. These results will be available by October 31, 2011.

Question 15.1 The power density values given in our original license renewal submission are being recalculated with the MCNP version 5 model. Preliminary MCNP results are showing power peaks around 17 kW per element in the existing core. The limiting core will obviously have higher values. We expect that the peak power per element will stay below 22 kW for all core configurations. These results will be available by October 31, 2011.

Sincerely,

Tim DeBey

USGS Reactor Supervisor

I declare under penalty of perjury that the foregoing is true and correct.
Executed on 8/30/11

Attachment 1: TRIGA Reactor Aluminum Tank Liner Specifications

Attachment 2: Design Calculations for United States Geological Survey 1MW Mark I TRIGA Reactor – Tank Liner

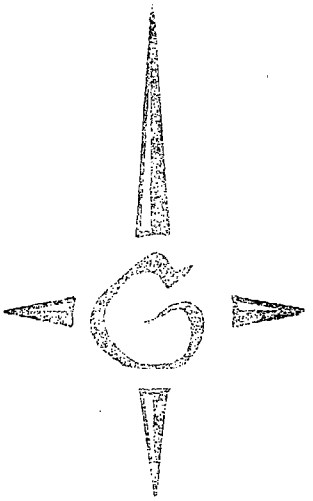
Copy to:

Betty Adrian, Reactor Administrator, MS 975
USGS Reactor Operations Committee

Attachment 1: TRIGA Reactor Aluminum Tank Liner Specifications

TRIGA REACTOR
ALUMINUM TANK LINER
SPECIFICATIONS

FOR
UNITED STATES GEOLOGICAL SURVEY
FEDERAL CENTER
6TH & KIPLING
LAKEWOOD, CO



BY
GILLAN'S ENGINEERING, INC.
5126 W 38TH AVE
DENVER, CO 80212
(303) 480-0471

(revised original tank specification)

9-25-87

Part 1. General

A. Definitions. Whenever used in any part of this specification, the following shall have the respective meanings set forth below:

1. Purchaser shall mean an authorized representative of the organization issuing the contract for the work contained herein.

2. Fabricator shall mean the successful bidder for the work, material, and equipment included under this specification.

3. Inspector shall mean an authorized representative of the Purchaser.

B. Drawings and Specifications. The Purchaser will furnish to the Fabricator, free of charge, such numbers of drawings and specifications reasonably necessary for the execution of the work. The drawings accompany the specifications and they are by this reference incorporated into and shall become a part of the specifications.

C. Tests and Inspection. Where tests are required by the specifications, arrangements for the conduction of such tests shall be made and all expenses in connection therewith shall be borne by the Fabricator. Such tests and inspections shall be made by an independently qualified inspection firm or agency approved by the Purchaser. All tests shall be witnessed by the Purchaser. The Fabricator shall review, certify and submit to Purchaser for review all inspection reports, radiographs and material certifications. It shall be the responsibility of the fabricator to notify the Purchaser five (5) working days in advance so witnessing of tests can be arranged without delaying the work.

D. Quality of Work and Materials. All materials, parts and equipment furnished by the Fabricator shall be new, high grade, and free from defects and imperfections. Workmanship shall be in accord with the highest standard practices. Both materials and workmanship throughout shall be at all times subject to the approval of the Inspectors.

E. Reference Standards and Specifications. The following listed standards and specifications, as applicable to the work involved, form a part of this specification. American Society of Mechanical Engineers (ASME)

Parts of Section II Materials Specifications, Part B--Nonferrous Materials, of the 1986 edition of the ASME Boiler and Pressure Vessel Code as follows:

ASME SB-209	Specification for Aluminum--Alloy Sheet and Plates
ASME SB-211	Specification for Aluminum--Alloy Bars, Rods and Wire
ASME SB-221	Specification for Aluminum--Alloy Extruded Bars, Rods and Shapes
ASME SB-241	Specification for Aluminum--Alloy Seamless Pipe and Seamless Extruded Pipe
AMSE SB-211	Specification for Aluminum --Alloy Bolts

Parts of Section II Materials Specifications:

Part C	Welding Rods, Electrodes, and Filler Metals, of the 1986 edition of the ASME Boiler and Pressure Vessel Code
ASME SFA-5.10	Specification for Aluminum and Aluminum Alloy Welding Rods, Class ER 4043

Part of Section V, Nondestructive Examination, Subsection A of the 1986 edition of the ASME Boiler and Pressure Vessel Code as follows:

Article 6	Liquid Penetrant Examination

Parts of Section V, Nondestructive Examination, Subsection B, for the 1986 edition of the ASME Boiler and Pressure Vessel Code as follows:

Article 24	Liquid Penetrant Standards

Parts of Section III, Division I, of the 1986 edition of the ASME Boiler and Pressure Vessel Code as follows:

Subsection NB Para. NB-5300	Acceptance Standards
Subpara NB-5320	Radiographic Acceptance Standards
Subpara NB-5350	Liquid Penetrant

Parts of Section IX, Welding & Brazing Qualifications, of the 1986 edition of the ASME Boiler and

Pressure Vessel Code as follows:

Part QW Welding

Aerospace Material Specifications (AMS) as follows:

AMS 2568A Hard Coating Treatment--Aluminum Alloys

F. Packaging and Shipment.

1. All items shall be thoroughly cleaned of all grease, water, and other foreign matter.

2. All fabricated items shall be packed for shipment and shall conform to standards of packaging requirements for the carriers. No stacking of items will be permitted where metal surfaces can come in contact with other metal surfaces.

3. Seal off the open end of the tank with a wood frame, dust tight cover. A minimum of 3/4 inch plywood shall be used over opening.

4. The tank shall be loaded in a secure and safe manner. Extra bracing and special handling shall be supplied by the Fabricator as necessary to prevent deformation of the tank in shipment. All aluminum surfaces shall be protected from direct contact with bracing or crating and the elements during shipping or storage.

5. Fabricator will prepare all items for shipment and load aboard truck carrier selected by Purchaser.

Part 2. Scope.

The work covered by this specification consists of furnishing all labor, materials, appliances, and equipment, and performing all operations in connection with the fabrication, assembly, testing, bracing, shoring and loading for shipment of one aluminum reactor tank, complete, including special test fittings and cover plates, in strict accordance with this specification and the applicable drawings and subject to the terms and conditions of the contract.

Part 3. Aluminum Tank.

A. Codes. The fabrication, inspection, testing, handling, and installation shall be in strict accordance with this specification and with Section VIII and IX of the latest edition of the ASME Boiler and Pressure Vessel Code; however, a Code Stamp is not required. In the event of conflict between this specification and the codes, the Fabricator shall notify the Purchaser and secure a written clarification before proceeding with the work.

B. Alternate Quotations and Deviations. The Fabricator may quote prices based on alternate construction methods when deviations from this construction will improve design, delivery, or decrease cost. List all such deviations and submit to the Purchaser in writing. Written approval will be required prior to putting changes into effect. If no exceptions are taken, it will be assumed that the proposal is in strict compliance with this specification.

C. Drawings by Fabricator. The Fabricator shall submit to the Purchaser one reproducible tracing of his final fabrication drawings and any applicable standard. These drawings and standards shall locate plate joints in plan and elevations, show construction details, such as all weld joint design, welding procedures and processes to be used, lifting lugs, slings, bracing jigs, fixtures, gussets, other reinforcements, and fabrication tolerances. One copy will be returned to the Fabricator stamped for fabrication as noted. Fabricator shall not proceed until this stamped drawing is received unless written instructions are given to the contrary. Shop drawings stamped by Purchaser does not relieve the Fabricator of the responsibility for fabrication and testing of the tank in accordance with the specification.

D. Functional Requirements and Basis for Design.

1. The Tank is to be a leak-tight container for demineralized water, filled to 3 inches below the top channel. The tank plate thicknesses specified on the Purchaser's drawings are minimum allowable. The Fabricator shall be responsible for design of tank bracing required to support the tank during fabrication, shipping and handling, all in accordance with the basis for design.

2. The Following Requirements are the basis for design of the aluminum tank using Part UNF of Section VIII of the ASME Unfired Pressure Vessel Code, latest edition.

a. Operating Pressure: 24.5 foot static head of water.

b. Design Temperatures: 150 degrees F (maximum).

c. No Bracing, Internal or External.

d. Shell Thickness shall be at least 1/4 inch.

E. Materials.

1. Tank material shall be one of the following aluminum alloys: 5052-H32, 6061-T4 or 5154-H32, and shall conform to Specification SB-209 from the ASME Pressure Vessel Code, Section VIII, latest edition. Other materials may be considered, but may be used only if approved in writing by Purchaser. The first choice shall be 5052-H32 alloy. Welding filler wire shall be as follows (or equivalent approved by Purchaser): on the 5052 alloy use AWS-ASTM E 5154; on the 6061 alloy use AWS-ASTM E 4043; on the 5154 alloy use AWS-ASTM E 5554; on combinations of 5000 series to 6061 alloy use AWS-ASTM E 4043.

2. Bolts that weld to tank bottom shall be 6061-T6 aluminum alloy and hardcoat anodized per AMS-2468, except anodize shall be clear.

3. Aluminum Angle (Alcoa die #892) shall be of alloy 6061-T6, or equivalent as a approved by the Purchaser.

F. Shop Fabrication.

1. Handling and Forming. With the following exceptions, the aluminum used in the work is to be handled and formed in a normal manner.

a. Aluminum to be used for the tank shall be stored in a clean place, free from dirt, grease, etc.

b. Care shall be taken not to nick, scratch, or otherwise mar aluminum surfaces.

c. All rolls and machine tools used in forming the aluminum parts shall be clean and free from grease, dirt, shavings, turnings, etc.

d. Tolerances as specified on drawings shall be maintained. Deviations shall be subject to written approval by the Purchaser.

e. Suitable lifting lugs, slings and handling equipment shall be provided by the Fabricator, either as shown on the Purchaser's drawings or in other locations where lifting of the tank can be accomplished during fabrication and shipping.

2. Special Construction Features shall be complied with in fabrication, testing, and preparation for shipping and field installation.

a. Round-off all sharp corners to 1/16" radius minimum.

b. Fabricator shall locate all shell girth and longitudinal seams on shop drawings and identify by number each plate or shell course.

c. The tank shall be completely fabricated and tested in the shop prior to shipment.

3. Welding. All welds shall be full penetration welds unless otherwise specified, and shall be in conformance with this specification, Part 4.

4. Testing Sequence shall be as follows:

a. Penetrant inspection of all welds shall be in conformance with Part 5B of this specification.

b. Welds shall be radiographed in conformance with Part 5A of this specification.

c. Air pressure test of the completed tank shall be in conformance with Part 5C of this specification.

d. As an alternate to the air pressure test, a hydrostatic test may be performed in conformance with Part 5D of this specification.

e. A leak test of all welds shall be performed in conformance with Part 5E of this specification.

5. Defects found at any stage of testing shall be repaired at that stage, and all tests shall be repeated for the defective area.

6. Responsibility. The Fabricator shall conduct and be fully responsible for the inspection and tests called for in these specifications, and shall maintain complete records of all tests. Certified copies of all test and inspection reports shall be supplied to the Purchaser.

7. Finish.

a. All wire brushes, welders' hammers or scrapers used on tank must be of AISI 300 series stainless steel. When welds are to be ground, aluminum oxide disks shall be used. The disks shall be new or dressed to remove any trace of non-aluminum grindings, and of a type that does not leave abrasive particles embedded in welds.

b. Inside of tank shall be kept clean, free of grease, dirt, etc.

c. Care shall be exercised during fabrication not to mar the inside surfaces of the tank.

d. At the conclusion of all work and testing, the tank shall be thoroughly cleaned inside and out with a suitable solvent (Toluene, acetone, or others) to remove all grease, dirt, grime, etc., before packing for shipment.

8. Reports.

a. Welding Documents: Prior to fabrication of the tank, the Contractor shall submit to the Purchaser for review one copy of each of the following: welding procedure specification; qualification test results of welding procedures; welder performance qualification test results. The welding procedure specifications and welding personnel shall be qualified in accordance with the requirements of ASME Section IX.

b. Prior to any production fabrications; procedures for welding, liquid penetrant inspection, x-ray inspection, leak testing and cleaning shall be submitted to the Purchaser for approval.

c. Within 10 days after tank is released for shipment, the Fabricator shall submit copies of each of the following to the Purchaser.

(1) Dimensions of finished tank (5 copies).

(2) Two copies of certified test reports of all material used in the fabrication of this equipment. (These are to be available to the Inspector upon request during fabrication.)

(3) Two certified copies of all test and inspection reports.

Part 4. Aluminum Welding.

A. Code. All welds shall be full penetration welds unless otherwise specified, and in accordance with Sections VIII and IX of the ASME Boiler and Pressure Vessel Code, latest edition.

B. Preparation of Joints.

1. Welding joints shall be prepared so as to permit complete fusion with complete joint penetration. Multipass welding from both sides is recommended to minimize distortion.

2. All weld joint edges shall be prepared either by machining, sawing, or grinding with tools which leave no residue on the joint faces.

3. Surfaces to be welded shall be clean and free from foreign material for a distance of at least 2 inches from the joint edges.

4. Prior to welding, all joints shall be thoroughly wire brushed for a distance of at least one inch on each side of the joint to remove aluminum oxide in the weld region. Only Type AISI 300 stainless steel wire brushes shall be used on this work.

5. Prior to welding, but after wire brushing, all joints shall be wiped with methyl alcohol and air-dried to remove any dirt of foreign material in the weld region.

6. After the weld joints have been cleaned, the joints shall be handled only with clean cloth gloves.

7. The joint edges must not be placed in contact with any material which could contaminate the surfaces after cleaning.

8. The use of welding flux of any kind is not permitted on this work.

C. Methods and Mechanics of Welding.

1. Welds shall be made by the inert-gas shielded consumable electrode welding method (MIG) or the tungsten inert-gas shielded arc welding process (AC-TIG or DC-TIG).

2. The inert gas used with the MIG process shall be helium, argon, or a mixture of these gases. The inert gas used with the AC-TIG process shall be argon. The inert gas used with the DC-TIG process shall be helium.

3. Any inert gas used shall have a minimum purity of 99.95 percent. The flow of inert gas shall be sufficient to properly protect the weld region during welding and cooling.

4. Selection of the welding process shall be based on production of the best quality welds with a minimum of distortion and residual stress in the finished work. Processes other than specified may be used only with the written consent of the Purchaser.

5. When a joint requires more than one pass, the preceding pass shall be cleaned with a stainless steel wire brush prior to deposition of the next pass.

6. When a weld joint is welded from both sides; i.e., full penetration welds, the side welded second (opposite side) shall be gound out to sound metal and liquid penetrant inspected in accordance with Part 5 prior to depositing metal on that side.

7. When using the TIG welding process, stopping of the arc shall occur in the joint using a gradual reduction of welding current to permit the molten weld puddle to solidify slowly. After most of the puddle has solidified, the arc will be carried back over the completed weld joint during the final reduction of the welding current to a point where no molten metal is observed beneath the arc. At this point the arc will be broken.

8. No peening of welds will be permitted.

D. Filler Wire.

1. Only filler wire from a special marked container reserved for this work only shall be used for any welding, including tacks or temporary welds.

2. All filler metal shall be clean and dry.

3. All filler wires used for this work shall be stored in a separate area from other filler materials. The area shall be free of dirt, grease, or other foreign material. Access to filler wire shall be permitted only by responsible personnel supervisiong the fabrication of the work. Care must be used to assure that no unapproved wire is used on any aluminum work. The type of wire to be used is specified in Part 3, paragraph E.1 of this specification. The wire shall be smooth, clean and free of surface defects.

E. Visual Inspection shall be made during and after each weld pass. Any defects detected shall be removed and repairs made before deposition of the next weld pass.

F. Qualification of Welding Procedures and Welders.

1. The welding procedure(s) and welders shall be qualified in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section IX latest edition, with the following additional requirements:

a. Aluminum alloy used for the qualification test plates shall be of the same thickness, alloy and temper as used in the item to be fabricated.

b. The test plates shall receive 100 percent radiographic inspection of the welds and shall meet the requirements of UW-51 fo Section VIII of the ASME Boiler and Pressure Vessel Code, Repair welding is not permitted.

c. The test plates shall be given a liquid penetrant inspection of the welds and shall meet the requirements of Part 5, paragraph B. Any evidence of cracking or excessive porosity shall be cause for re-testing.

d. In addition to the groove weld qualification test plate(s) for performance qualification required by Section IX of th ASME Code, welders shall qualify on a fillet weld test plate in accordance with the requirements of Section IX.

e. At least one weld stop and start per pass shall be made near the center of procedure and welder qualification test plates.

2. All other tests of welds as required by the qualification code shall be performed, and a complete report of the qualification results shall be made.

Part 5. Testing and Inspection.

A. Radiographic Inspection.

1. One hundred percent of every full penetration weld joint not specifically exempted by Purchaser in writing shall be radiographed in conformance with Subsection UW-51 of Section VIII of the ASME Boiler and Pressure Vessel Code to demonstrate that proper weld quality is attained.

2. When any of the weld as represented by radiography contains rejectable defects as specified by UW-51, the weld shall be removed, rewelded and 100 percent radiographed.

3. Each radiograph shall be made as soon as practicable after the completion of the increment of weld that is to be examined.

4. X-ray shall be used; gamma ray is not acceptable.

5. Final acceptance of all radiographs shall be obtained from the inspector.

6. Originals of the developed film of radiographs shall be properly identified and made available to the Purchaser, and after acceptance of the tank shall become the property of the Purchaser.

B. Penetrant Inspection. All finished welds and the second side of a full penetration weld shall be checked for defects using a liquid penetrant test in conformance with

Appendix 8 of the ASME Boiler and Pressure Vessel Code and the following.

1. The Fabricator shall submit a detailed written liquid penetrant inspection procedure for approval by the Purchaser.

2. Liquid Penetrant Acceptance Standards.

a. All linear indications are unacceptable and shall be removed completely and repair welded.

b. All non-linear (rounded) indications with any dimension which exceeds 1/16" are unacceptable and shall be completely removed and repair welded.

3. Rejectable defects shall be repaired and retested.

C. Air-Pressure Test. The air-pressure test shall be conducted to demonstrate adequate strength of the tank.

1. The tank shall be internally pressurized to a pressure of 10 pounds per square inch gage using suitable cover plates and fittings.

2. After completion of the test, the pressure can be decreased to that specified for performance of the leak test (soap bubble).

3. It is the responsibility of the Fabricator for the safe performance of this test.

D. Hydrostatic Test (Alternate to Air-Pressure Test).

1. Hydrostatic testing shall be performed on the completed tank.

2. The hydrostatic test shall consist of placing the tank in a vertical position, and filling the tank with clean water with a pH between 6.0 and 7.0. After 24 hours, all outside surfaces shall be visually inspected for leaks. Any trace of moisture on the outside surfaces must be traced to the source of the leaks. The leaks must be repaired and the test repeated. Water shall not remain in the tank longer than 36 hours; after the water is removed, all surfaces of the tank shall be wiped dry with clean, lint-free rags.

E. Leak Test.

1. The leak testing shall be performed on the completed tank assembly.

2. The tank shall be filled with air at a pressure of 4 pounds per square inch gage. The tank shall be braced and supported as required to maintain the dimensional tolerances specified.

3. After the tank has been pressurized, a soap bubble test shall be applied to all weld regions and regions where a large amount of cold work has been applied to the tank (such as at the knuckle between the side plates and the bottom).

4. The liquid used for testing shall be "Leak-Tec" No. 277-C, a product of American Gas and Chemicals, Inc., P.O. Box 101, Gracie Station, New York, NY 10028, or an equal product.

5. The "Leak-Tec" shall be sprayed or brushed over all surfaces to be checked and the surfaces shall be carefully examined visually for white foam or live bubbles.

6. Any leaks detected by this test shall be repaired, and the test shall be repeated until no leaks are detected.