Aerojet Nuclear Company

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SPECIFICATION INC - 60007

ORDERING DATA FOR LOFT FUEL ASSEMBLIES

Note: Paragraph changes are indicated by the Revision letters "A" and "B" adjacent to the paragraph number.

L-1602 -
L-1628 -
L-1686 ✓
L-1754 -
L-1932 R2
L-2621 -
L-2835 -
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INC-60007

ORDERING DATA FOR LOFT FUEL ASSEMBLIES

This document modifies specific sections of Standard RDT E13-15T, Fuel Assemblies for Pressurized Water Reactors to meet the requirements of the LOFT Project. This Ordering Data together with its appendix and RDT E13-15T constitute the technical requirements for the LOFT Fuel Assemblies and Control Rod Assemblies.

The heading and numbering of sections and paragraphs in this document correspond to those of the standard. Omission of paragraph numbers in this Ordering Data, where such paragraph numbers are in the standard shall be interpreted that the requirements of the standard apply.

Where the standard contains statements such as "in accordance with the requirements of this standard" it is understood that what is intended is "standard as modified by the Ordering Data".

- 1.1
 - a. Delete the first sentence and insert "This document establishes the requirements for fuel assemblies and associated clustered control rod assemblies for the LOFT reactor."
 - b. Add at the end of Section 1.1, "The finished LOFT fuel assemblies will consist of:
 - (1) Modular type units combining a core section (fuel rods, control rods and skeleton) based on the reactor core arrangement shown in Figure A.1 with; (1) the test instrumentation detectors, leadouts and fittings, and (2) the neutron source.
 - (2) Three basic arrangements: (1) the instrumented center (15 x 15 fuel pin array) assembly, Figure A-2, (2) the control (15 x 15 fuel pin array with the control rod assembly) assembly, Figure A-2, and (3) the corner (triangular shaped) assembly, Figure A-3.
 - (3) This specification does not include design requirements for the test instrumentation detectors and leads. These components will be furnished by others for installation in the fuel assemblies by the Contractor.
- 1.1.2
 - a. In the first sentence delete the phrase "or burnable poison rod".
 - b. In the third sentence delete all after "heat exchangers."
- 1.1.3
 - a. In the first sentence delete the phrase "or burnable poison rod".
 - b. Add: "In general, all work shall be performed in accordance with the Contractor's commercial LPWR fuel practice."
- 1.2.1
 - a. In the first sentence delete the phrase "or burnable poison rod."
- 1.2.2
 - "The Contractor shall furnish complete the following items (quantities as specified in the Subcontract):

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- a. Center fuel assembly
- b. Control fuel assembly of each type
- c. Corner fuel assembly of each type
- d. Control rods (Figure A-4)

e. Source

- f. Noninstrumented fuel rod spares
- g. Flow restricting devices of each type
- h. Archive samples (see Subcontract)

1.2.2.2 Delete 1.2.2.2.

1.2.3 Delete and revise to read:

The following services shall be furnished by the Contractor:

1.2.3.1 Design Services

- a. Design of the instrumented fuel assemblies (nuclear, thermal-hydraulic, mechanical and irradiation performance aspects) including the effect of instrumentation. Also verification of the design features and performance characteristics of the proposed fuel assembly, associated clustered control rods and the neutron source shall be included. Reference design conditions for the nuclear design are contained in Appendix B.
- b. Preparation of fuel assembly design reports including a summary of basic design criteria used.
- c. Preparation of fuel assembly verification reports
- d. Testing, as necessary, to verify the predicted fuel assembly performance characteristics.
- e. Preparation of drawings and specifications for instrumented fuel assemblies, associated control rods and the neutron source.
- f. Preparation of inspection requirements and acceptance criteria for all production fuel assembly inspection including instrumentation.
- g. Establishment and implementation of a quality assurance program to control the design activities.

1.2.3.2 Fabrication Services

- a. Acquisition of raw materials exclusive of instrumentation components.

- b. Qualification of fabrication procedures, equipment and equipment operators.
- c. Qualification of inspection procedures, equipment and equipment operators.
- d. Fabrication of all contractor furnished equipment listed in 1.2.2.
- e. Establishment and execution of a quality assurance and control program to ensure the fabricated equipment quality is that specified.
- f. Packaging and shipment of all contractor's furnished equipment listed in 1.2.2 in contractor furnished containers.
- g. Compilation and submittal of fuel assembly as-built data specified in section 3.3.
- h. Preparation and submittal of archive samples specified in Section 1.2.2.
- i. Preparation of required documentation.
- j. Preparation of all manufacturing drawings, fabrication process outlines and operating procedures (welding, brazing, heat treating, cleaning, upsetting, fastener torquing, etc.,) for the equipment listed in 1.2.2.
- k. Preparation of inspection procedures for the equipment listed in 1.2.2.

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B 2.1.1

- a. Delete the following standards and specifications:

RDT F3-6T	RDT M5-6T	AMS 5542	ASTM A194
RDT M2-2T	RDT M6-3T	AMS 5582	ASTM B167
RDT M3-2T	RDT M7-2T	AMS 5589	
RDT M3-8T	RDT M7-3T	AMS 5596	
RDT M4-2T	RDT M7-4T	AMS 5662	
RDT M5-1T	RDT M7-9T		
RDT M5-4T	RDT M8-1T		

- b. RDT F8-1T, add "(correction: page 11, paragraph 5.1.5, 'RDT M6-3' should read 'RDT M6-2')".
- c. ANSI N5.7, change "Reference" to "Referee" and "Tests" to "Fuel".

- b. Add to Section 2.1.1: ASTM B353 "Specification for Wrought Zirconium and Zirconium Alloy Seamless and Welded Tubes for Nuclear Service."

A 2.1.2 Add Section 2.1.2 as follows:

"Interface drawings contained in Appendix A".

Figure A-1 - Core Layout

Figure A-2 - 15 x 15 Fuel Assembly Layout

Figure A-3 - Triangular (corner) Fuel Assembly Layout

Figure A-4 - Control Rod Assembly Mandatory Dimensions

Figure A-5 - Flow Skirt - Inside Envelope

204065 - Lower Core Support Structure Assembly

204066 - Core Mounting Plate

204070 - Lower Core Support Structure - Miscellaneous Details

204385 - LOFT Reactor - 5.5 Foot Core - Fuel Assembly Attachment

3.1.1 Add Item e to read as follows:

"e. Support and locate attached instrumentation detectors and leads".

In the last paragraph following the phrase, "fuel assembly design", insert "(including instrumentation)".

In addition, add at the end of this paragraph, "the Contractor is not responsible for the functional performance of the instrumentation". Contractor responsibility for instrumentation is further defined in INC specification INC-60040.

B 3.1.3 Delete Items e, f, and g, and substitute the following:

- e. Maximum insertion time from control rod assembly release to 75% insertion shall be not greater than 2.0 seconds and to 100% insertion not greater than 3.0 seconds, assuming the rods are fully withdrawn. The control rod drop time and the fuel assembly final control rod deceleration (including hard stop) features shall be compatible with the control rod drive mechanism (CRDM) control rod snubber features. ~~described in Appendix C.~~

A 3.2.1.1 Delete this paragraph and insert:

The fuel assemblies when assembled into a reactor core shall be capable of achieving the design life of 2000 effective full power hours (EFPH) with uniform enrichment. This design life shall be obtained without operation of the fuel beyond the depletion of reactivity defined below and without mechanical damage, as defined in Section 3.2.1.1.2, to the fuel, fuel assembly structurals, or the control rod assembly resulting from operating the fuel under normal design conditions as defined in Sections 3.2.2 and 3.2.3. The fuel assembly shall

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be capable, except for enrichment, of obtaining without mechanical damage, an average burnup of 30,000 MWD/MTU under the operating plant power history conditions normally assumed for design of LPWR fuel assemblies.

NOTES:

- (1) This last sentence is only included to assure that standard commercial design practices are used and that no modifications are made because of the reduced design life and the pin pressurization requirements in Section 3.3.1.

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- (2) The purchaser furnished instrumentation is designed to withstand 15 LOCES without a loss of function during or after a LOCE. The contractor's responsibility includes assuring that the instrumentation work within his design scope, including routing of leads and tubing, design and attachment of mounting devices and installation of purchaser supplied instruments meets this requirement. The contractor shall not be responsible for failures of the instrumented fuel rods or guide tubes which are traceable to the attachment of thermocouples to the fuel cladding or guide tubes when this attachment is made in accordance with the requirements in the purchaser provided welding and attachment procedures. It is also the contractor's responsibility to assure that the source and its support within the fuel assembly must meet this requirement.

In order to satisfy this requirement the contractor shall assume that a LOCE transient is initiated from nominal full power, low flow, steady-state conditions. For design purposes it shall be assumed that the following conditions exist during a LOCE:

(a) Differential Pressure Conditions

A differential pressure loading of 300 psi taken in the most adverse direction across each component, instrument, or mounting device, etc. The 300 psi loading requirement shall be evaluated assuming the same thermal conditions that exist at reactor full power (55 Mwt).

(b) Temperature Conditions

	<u>Rate of Change</u>	<u>Peak Temperature</u>
Components attached to support tubes	20°F/sec	1450°F FIRST 14 LOCES. 2100°F 15 th LOCE
Components attached to fuel assembly end boxes	20°F/sec	900°F

(c) Transient Termination

After five seconds at the maximum temperature, the equipment shall be assumed to be quenched by immersion in a saturated steam-water mixture at a pressure of 25 psia.

3.2.1.1.2 Delete Paragraphs 3.2.1.1.2a, 3.2.1.1.2b, and 3.2.1.1.2d.

3.2.1.2 The design life of the control rods shall be 15,000 EFPH minimum.

A 3.2.1.3 Add to paragraph: "The contractor shall promptly advise the purchaser of any additional conditions which he considers must be established in order for him to achieve this requirement. The analytical verification of this requirement shall be limited to determining the response of the fuel assembly and components using the data provided in Sections 3.2.2 and 3.2.3. 'Systems' type analysis involving other systems such as the Plant Protection System or the Primary Coolant System is not intended".

A 3.2.2.2 a. Normal Coolant Operating Pressure

High and Max. Flow 2253 psig

Low Flow 2242 psig

b. Delete Item b

c. Core inlet and outlet mixed mean coolant temperature for normal operation as a function of power--Figure 1.

d. Delete Item d

e. Delete and substitute:

"Core coolant mass flow rate (average)X

Max. Flow 4.28×10^6 lb/hr

High Flow 3.42×10^6 lb/hr

Low Flow 2.04×10^6 lb/hr "

f. Delete and substitute:

"Normal pressure drop (including pressure losses across end boxes and spacer grids) at maximum and high flow shall be determined and transmitted to the purchaser within 30 days from contract commencement".

g. Delete Item g

h. Delete Item h

i. Delete Item i

j. Delete Item j

k. Design flow maldistribution (fuel assembly inlet) 0.90 to 1.10 of theoretical uniform flow.

Fig. 1 REACTOR POWER %

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1. Delete Item 1

m. Delete and substitute, "nominal reactor power level 55 MWt. (Note: Maximum reactor power is limited to the heat removal capability (65 MW_t) of the secondary system. This overpower margin in conjunction with a variable core coolant flow rate (2.04 x 10⁶ to 4.28 x 10⁶ lbs/hr) may be used by the purchaser to provide the hot fuel rod peak power specified below without violating the minimum allowable DNB margin.)"

n. Delete Item n through q and substitute:

"n. Hot fuel rod peak power (KW/ft) 19.0 ± 0.5 KW/ft max. at any time in the design life of 2000 EFPH. (Note: The fuel shall be designed to withstand operation at 19 kw/ft. Overpower reactor limits shall be set such that incipient fuel melting temperature is not exceeded under normal operating transients. Reactor flow shall be such as to ensure staying above an MDNER of 1.30 based on the W-3 correlation at maximum operating transient".

Determination of local heat generation rates may be based on reactor calorimetric measurements, in-core neutron flux measurements and mutually acceptable computer determinations. Allowance for uncertainties in the calculations and measurements shall be made in ascertaining that the governing overpower limits are met.)

3.2.2.3

The reactor coolant chemistry conditions shall be as specified in Table I.

TABLE I

Reactor Coolant Chemistry Conditions

Parameter	Normal Operation
pH at 77°F	4.5 to 10.5
Total Dissolved Gasses	
Maximum	150 cc/kg
Design Operating	100 cc/kg
Hydrogen	15-60 cc/kg
Oxygen (max.)	0.1 ppm
Chlorides (max.)	0.15 ppm
Boric Acid (as Boron)	0-3000 ppm
Fluoride (max.)	0.10 ppm
Total Suspended Solids	1.0 ppm
pH Control Agent (⁷ LiOH)	0.2 to 2.2 ppm Li-7
Oxygen Control Agent (Hydrazine)	1.0 ppm in excess of O ₂ (nonnuclear operation only)
Refueling coolant condition shall be standard commercial practice.	

3.2.2.4 Delete Section 3.2.2.4 and all subparagraphs and substitute the following:

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* "The fuel assemblies and associated control rods shall be designed to withstand the operating transient cycles defined below without impairing their functional capability for the design life defined in Section 3.1. Unless specifically stated otherwise, all transients discussed below shall be considered normal operating transients.

3.2.2.4.1 Plant Heatup and Cooldown

Plant heatup and cooldown shall be accomplished as shown in Figure 2. One hundred of these transients will be applied to the fuel and associated control rods.

C 3.2.2.4.2 Steady State Fluctuations

Reactor Coolant System imbalances and Control System corrections result in fluctuations from normal steady state conditions. These fluctuations are:

Temperature	<i>structural design</i> + 6°F	<i>Thermal-hydraulic design</i> ± 4°F
Pressure	* ± 100 psig	* ± 45 psig
Flow	+ 5%	± 3%
<i>power</i>	<i>not specified</i>	± 5%

For one cycle, the temperature, pressure, and flow will increase or decrease by the amount defined above and return to normal. The length of each cycle shall be assumed to be one minute and the total number of cycles shall be assumed to be 10^6 cycles.

A 3.2.2.4.3 Plant Loading and Unloading

Normal plant loading and unloading will be a ramp function at a fixed rate of 10% of full power per minute from 10% to 100% and 100% to 10%. Coolant flow will be held constant at the high flow rate value; system pressure will remain essentially constant at 2250 psig. Average coolant temperature shall be assumed to vary as shown in Figure 1. This transient shall be assumed to occur 1000 times, each transient is assumed to be one increase and one decrease. Sufficient time between up and down cycles shall be assumed to allow a steady-state to be achieved. (Note: These conditions apply to the 30,000 MWD/T requirement of 3.2.1.1).

3.2.2.4.4 Reactor Trip (Scram)

The fuel and associated control rods shall be designed to withstand 100 scrams from full power assuming the control rods are fully withdrawn. No thermal-hydraulic or nuclear analysis of this transient is required.

A 3.2.2.4.5 Reactor Overpower

The reactor shall be capable of operation at 118% of full power without any impairment of functional capability other than a reduction in design life caused by increased burnup. (See 3.2.2.2m)

HEATUP AND COOLDOWN

Figure 2

C 3.2.2.4.6 Cold Hydrostatic Test

Five cold hydrostatic tests shall be performed at ³¹²⁵~~3250~~ psia and 70°F. In each test, the pressure will be held for 6 hours.

3.2.3.1 Change the second sentence to read as follows:

* "For design purposes, the refueling and servicing operations shall be assumed to occur 20 times over the design life of the assemblies".

Add the following paragraph:

"The Contractor shall provide design drawings and specifications to completely define the design requirements for each finished component included in the scope of supply. Final inspection of components shall be made using Contractor's design (not manufacturing) drawings and specifications. The Contractor's design drawings and specifications shall be submitted to the Purchaser for approval. The Contractor shall specify those drawings and specifications that represent his standard commercial practice. Revisions of the contractor's design drawings and specifications shall be submitted for approval.

3.3.1 After the fourth sentence, insert a new sentence which reads:

"Filler gas pressure shall be in the range of 1.0 atmosphere [±] 5 psig under standard temperature and pressure (STP) conditions.

A 3.3.3 Delete and revise to read as follows:

"1. The assemblies and neutron source shall be designed to be compatible with the reactor support structures defined in Figure A-5 and Drawings 204065, 204066, and 204070, and the fuel assembly upper support structures defined in Drawing 204385.

"2. Dimensional Requirements

a. Two types of fuel assembly structures shall be provided:

Type A fuel assembly structures (Figure A-2) that are of square cross section and Type B fuel assembly structures (Figure A-3) that are of triangular-shape using a portion of Type A structure. Figures A-2 and A-3 show the mandatory dimensional requirements for the two fuel assembly types.

b. The preliminary design studies for the LOFT reactor are based on the mandatory dimensions shown on Figure A-1 and the nominal dimensions listed below:

- (1) Fuel pellet O.D. - 0.367 in.
- (2) Fuel rod cladding I.D. - 0.373 in.

- (3) Fuel rod cladding thickness - 0.024 in.
- (4) Fuel pellet stack length - 66 in.
- (5) Fuel rod spacing 0.563 in. (square pitch)
- (6) Spacer grid locations - No spacer grid shall be located in the region from 0 inches above to 12 inches below the core (fuel section) mid-plane. Each fuel assembly shall have five spacer grids.

NOTE: The tolerances for (allowable deviations from) the dimensions listed above shall be determined by the Contractor and shall be based on the tolerances to be used for his normal commercial LPWR fuel assemblies.

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* The Contractor may propose alternate nominal dimensions in the event there is a conflict between the dimensions and the performance requirements specified or, in the event the Contractor has a proven fuel assembly design which the Contractor considers equivalent, if not identical to the assembly defined above. The technical basis for the alternate dimension(s) shall be clearly defined by the Contractor in his proposal and the equivalency of any proposed alternative assembly shall be determined by the Purchaser.

- c. "The control rod design shall be based on (1) the mandatory dimensions shown on Figure A-4 and (2) the use of stainless steel clad ~~B₄C absorber rods~~ having a nominal O.D. of 0.440 inches, a nominal clad thickness of 0.019 inches, and an active length of 66 inches. The control rod assembly ~~shall have 20 rods, 12 shall contain neutron absorber material and 8 shall be full length dummy rods located as shown on Figure A-1. (dummy rods shall have the same envelope and weight as the absorber rods and shall be fabricated from austenitic stainless steel).~~
- d. Location, dimensional and material specifications for the test instrumentation detectors and leads to be attached to the fuel assemblies by the Contractor are provided in ANC specification, INC-60040.
- e. Neutron source location shall be in the control rod guide tube of a Type C fuel assembly (see Figure A. 1 for source location in fuel assembly).

C 3.3.4 b. Add at the end of this paragraph: These forces shall be as follows:

	<u>Holdown load</u>	<u>Spring Rate (lbs./In.)</u>
Center and Control Assembly (lbs)	1000 1000 (max.)	2000 2000 (max.)
Corner Assembly (lbs)	1000 1000 (max.)	1600 1600 (max.)

The fuel assembly design shall be evaluated for
NOTE: These ~~test~~ ~~values~~ ~~discuss~~ ~~100 inch~~ plastic strain of the control rod guide tubes during reactor operation. The Contractor shall provide, within ~~30~~ ⁹⁰ days of contract commencement, data (total fuel assembly longitudinal elastic and plastic strain versus core lifetime) to the Purchaser to allow finalization of the holdown spring design.

3.3.7 Add Section 3.3.7 to read as follows:

As-Built Fuel Assembly Data - The Contractor shall report the as-built instrumented fuel assembly characteristics listed below:

- a. Pressure Drop - Disclosure of total and partial (across bottom end box, spacer grid and top end box) pressure drops (at anticipated flow rates and at both ambient and 550°F and 2250 psig coolant conditions) based on analysis and/or models or prototypes used in hydraulic verification. Certification that as-built fuel assemblies have the same pressure drop characteristics shall also be supplied.
- b. Spacer Grid Mixing Coefficient - Disclosure of spacer grid mixing coefficient as determined by analysis and/or thermal-hydraulic verification tests and certification that as-built spacer grids have the same mixing coefficient characteristics. CARD
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- c. Coolant Distribution - Disclosure of coolant distribution characteristics (maps showing local-to-average flow) upstream and downstream of the first, second, and third spacer grids as determined by analysis and/or model or prototype hydraulic verification. Certification that as-built fuel assemblies have the same coolant distribution characteristics shall also be supplied.

3.3.8 Add Section 3.3.8 to read as follows:

Neutron Source - The neutron source shall be in accordance with the contractor's normal commercial practice and shall have a minimum source strength of 2×10^8 neutrons/sec, 700 days after delivery.

- 3.4
- a. In the first sentence, delete the phrase "or burnable poison rods" and substitute "and neutron source".
 - b. Delete remainder of first paragraph and the entire second paragraph and substitute "Contractor furnished equipment shall use the following materials:

<u>Part</u>	<u>Material</u>
*1. Fuel Material	UO ₂
*2. Fuel Pin Cladding	Zircaloy-4

*3. Fuel Pin End Caps	Zircaloy-4
4. Fuel Pin Filler Gas	Inert Gas (90% helium minimum)
5. Control Rod Poison Material	Ag-In-Cd
or Contractor's commercial practice
*6. Control Rod Poison Sheath	Austenitic Stainless Steel or Inconel 718
*7. Spacer Grids	Inconel 718
*8. Control Rod Guide Tubes	Austenitic stainless steel, cold worked to provide a column strength equivalent or greater than a 0.035 inch wall thickness 0.434 inch ID tube having a minimum material yield strength (0.2% offset method) of 49,000 psi at 650°F
Type A, B, C, D & E - Austenitic stainless steel	
Type F - Zircaloy	
*9. Skeleton End Boxes	Austenitic Stainless Steel
10. Sources (neutron)	Contractor's commercial practice
11. All Other Components	Contractor's commercial practice

The materials used shall be representative of the Contractor's normal commercial practice and shall meet all requirements of the Contractor's material specifications.

* For the components denoted by an asterisk, certified mill test reports are required. These reports shall:

- (1) Give the actual results of the chemical analysis and physical property tests for the material
- (2) State the analytical or test method used in making the determination for each characteristic."

c. Delete Paragraphs 3.4.1 through 3.4.2.5 inclusive.

d. Delete Section 3.4.3 and all subparagraphs.

A 3.4.2.6.12 Moisture

The average moisture content of finished ground pellets as contained in the loaded fuel rod shall not exceed 10 ppm H₂O.

3.5 a. In the first sentence, delete the phrase "and burnable poison" and substitute "and neutron source".

3.5.2 a. In the first sentence, delete the phrase "and burnable poison" and substitute "and neutron source".

b. Insert between the second and third sentences in the fourth paragraph the following:

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"Deviations from the Purchaser approved Contractor's design drawings and specifications shall be submitted to the Purchaser for approval if they affect fit or function, or for information if they do not".

- 3.5.3.3 a. Delete phrase "and burnable poison" from Item a.
- b. Add "including attachment of thermocouples to fuel rod cladding" to the end of Item b.
- 3.5.3.4 Item 3.5.3.4.g — Change "RDT M 3-8T" to "ASTM B353".
- 3.5.3.5 Add Item f — "f. The thermocouple to fuel rod attachment welds".
- A 3.5.4.2 Add to first sentence "except that reference to RDT E 2-1 shall be deleted (see RDT F 8-1 Paragraphs 2.1, 4.2, 6.2.1.6.3B and 6.2.1.7)". Add to second sentence "and nondestructive weld examination need not be performed in accordance with RDT F 3-6 (see RDT M 6-2T, Paragraphs 2.1 and 4.5.2)".
- B 3.6.2 Deleted.
- 3.7 Item 3.7.b — Add "Physical standards shall be used to define quality for attachment of instrumentation including corrosion appearance. These standards shall be submitted to the Purchaser for approval prior to use."
- 3.7.1.2 Delete phrase "RDT M 3-8T and other requirements contained in".
- 3.7.1.3 Delete from first sentence the phrase "RDT M 3-8T (Tubing) and RDT M 7-9T (End-caps) as well as other requirements contained in" and delete from second sentence the phrase "RDT M 3-2T (Tubing) and RDT M 7-3T (End-caps) as well as other requirements contained in".
- 3.7.3.1 a. Section 3.7.3.1.g - Add to the end of this, "Instrument attachment welds shall be evaluated using physical standards, Confirmation shall be obtained that instrumentation has been attached and operational checks performed such as electrical continuity and insulation resistance in accordance with design requirements".
- b. Change the first sentence in 3.7.3.1.h. to read: "Each finished fuel rod shall be helium leak tested in accordance with the Contractor's commercial practice".
- c. Change Section 3.7.3.1.i. to read: "Each fuel rod weld shall be evaluated using the Contractor's volumetric nondestructive technique".
- 3.7.5 Item 3.7.5.h. Change "RDT M 3-8T" to "ASTM B 353".
- 3.7.6 q Add Section 3.7.6.q. - "Confirmation that instrumentation has been attached and operational checks such as electrical continuity and insulation resistance have been performed in accordance with the Contractor's design requirements. Instrument attachment weld quality shall be evaluated using physical standards.

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A 3.8.2 Change "pins" to "rods" (3 places).

4.2 Delete the last sentence and revise to read, "The specific number of copies and the scheduler requirements shall be as indicated in the subcontract terms and conditions."

4.2.1 Add an Item 1. which reads as follows: "1. Drawings and procedures for manufacture and inspection are in accordance with Section 3.5.2."

5.2.2 Add a Section 5.2.2 which reads as follows: "5.2.2 Neutron Source - sealing, packaging, and marking requirements for the neutron source shall be in accordance with Section 5.2.1".

5.3.5 Add a Section 5.3.5 which reads as follows: "5.3.5 Neutron Source - Shipping requirements for the neutron source shall be in accordance with Section 5.3.1"

5.2.1

- a. Delete "moisture and vapor proof" and "sealed" from first sentence.
- b. Add after first sentence, "Nonfuel-bearing component polyethylene shipping bags shall be moisture and vapor proof and sealed."
- c. Add to third (original) sentence "except dessicant provisions for shipping fuel-bearing components shall be in accordance with the Contractor's normal approved fuel shipping method."
- d. Change 2.5 g to 5.0 g."

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APPENDIX A

Interfaces

CORE LAYOUT

FIG. A.1 REV. A

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letter revision*

15 X 15
FUEL ASSEMBLY LAYOUT

FIG. A.2

TRIANGULAR (CORNER) FUEL ASSEMBLY

FIG. A.3

CONTROL ROD ASSEMBLY
MANDATORY DIMENSIONS

FIG. A.4

FLOW SKIRT
INSIDE ENVELOPE

FIG. A.5

REV	DATE	DESCRIPTION	BY	CHKD
A	5/18	LOCATION ON 4 NUMBER OF PIN & BOLT HOLES CHANGED	TI	

PRELIMINARY

INTERFACE CONTROL DRAWING

DRAWN BY T. BRYANT 927		CHECKED BY J. BRYANT 927	
DATE 5/18/68		DATE 5/18/68	
PROJECT 204385		PROJECT 204385	
SHEET NO. 1		SHEET NO. 1	
TOTAL SHEETS 1		TOTAL SHEETS 1	
REVISIONS 1. 5/18/68 2. 5/18/68		REVISIONS 1. 5/18/68 2. 5/18/68	
APPROVED T. BRYANT		APPROVED J. BRYANT	
TITLE 204385		TITLE 204385	

INC-60007

APPENDIX B

REFERENCE NUCLEAR DESIGN CONDITIONS

APPENDIX B REFERENCE NUCLEAR DESIGN CONDITIONS

The volume fraction of material external to the core region for X-Y geometry are given in Figure B.1.

The volume fractions of the materials, by region, above and below the core, R-Z geometry, are as follows: (Figure B.2).

<u>Region (axial)</u>	<u>Composition</u>	<u>Material</u>	<u>Vol. Frac.</u>
1-2	water	H ₂ O	1.000
2-3	end box, water	304 SS	.223
		H ₂ O	.777
3-4	end plugs, water	Zr-4	.322
		H ₂ O	.678
4-5	springs, washers, clad & water	Al ₂ O ₃	.041
		Zr-4	.095
		Inconel	.059
		Void	.210
		H ₂ O	.595
5-7	Core region	Not Specified	
7-8	washers, end plugs, water	Zr-4	.231
		Al ₂ O ₃	.061
		H ₂ O	.708
8-9	End box plate, water	Zr-4	.014
		304 SS	.687
		H ₂ O	.299
9-10	End box plate, water	304 SS	.104
		H ₂ O	.876
10-11	Lower support plate, etc.	304 SS	.284
		H ₂ O	.716

The control rods in the LOFT core are used as flux shaping rods, safety rods and rapid shimming rods. For normal operation the control rods will be withdrawn 54 inches and have a control band of 54 ± 3 in.

Region Description

1. Fueled Core
 2. Support Tube (Rod)
 3. Water Gap
 4. Flow Skirt (pure sst)
 5. Cells (31% stainless steel, 69% water)
 6. Steel Core Filler (pure sst)
 7. Cells (43% stainless steel, 57% water)
 8. Bypass Water (pure H₂O)
 9. Steel Core Barrel (pure sst)
 10. Downcomer Water (pure H₂O)
 11. Steel Vessel Filler (pure sst)
- } Core Region

Figure B.1

LOFT CORE 1 - RADIAL VOLUME FRACTIONS

FIGURE B.2

LOFT CORE 1 BOUNDARY ARRANGEMENT

LOFT TECHNICAL REPORT
LOFT PROGRAM

FORM T-100 (Rev. 12-76)

TITLE Fuel Bundle, Control Rod, and Neutron Source Specifications		REPORT NO. LTR 1111-40
AUTHOR M. L. Russell <i>M. L. Russell</i>		GWA NO. 56131-100-354
PERFORMING ORGANIZATION		
LOFT APPROVAL M. L. Russell <i>M. L. Russell</i>		DATE

PRELIMINARY

SUMMARY

This LTR contains the Exxon generated parts lists and technical specifications for the LOFT fuel bundles, control rods, and neutron source. The technical specifications consist of both material and product specifications and provide the design, test, fabrication, and inspection requirements. The LTR consists of the following documents:

PRELIMINARY

PARTS LIST

- (1) XN-S30105, Revision 26, Master Parts List, LOFT Fuel Supply
- (2) XN-S30471, Revision 3, Center Fuel Assembly (with 2 Liquid Level Detectors) Type A1 Unpressurized Fuel Rods, Type A2 Pressurized Fuel Rods, Parts List
- (3) XN-S30473, Revision 3, Center Fuel Assembly (without Liquid Level Detectors) Type A3 Unpressurized Fuel Rods, Type A4 Pressurized Fuel Rods, Parts List
- (4) XN-S30475, Revision 3, Center Fuel Assembly (with 1 Liquid Level Detector) Type A5 Unpressurized Fuel Rods, Type A6 Pressurized Fuel Rods, Parts List
- (5) XN-S30477, Revision 2, Control Fuel Assembly Type B1 Unpressurized Fuel Rods and Type B2 Pressurized Fuel Rods, Parts List
- (6) XN-S30479, Revision 3, Corner Fuel Assembly (with Liquid Level Detector) Type C1 Unpressurized Fuel Rods, Type C2 Pressurized Fuel Rods, Parts List
- (7) XN-S30481, Revision 3, Corner Fuel Assembly (without Liquid Level Detectors) Type C3 Unpressurized Fuel Rods, Type C4 Pressurized Fuel Rods, Parts List
- (8) XN-S30483, Revision 1, Control Fuel Assembly Type D1 Unpressurized Fuel Rods and Type D2 Pressurized Fuel Rods, Parts List
- (9) XN-S30485, Revision 5, Corner Fuel Assembly Type E1 Unpressurized Fuel Rods and Type E2 Pressurized Fuel Rods, Parts List

- (10) XN-S30487, Revision 3, Center Fuel Assembly (with Zircaloy-4 Guide Tubes) Type F1 Pressurize Fuel Rods and with 2 Liquid Level Detectors, Parts List
- (11) XN-S30489, Revision 3, Center Fuel Assembly (with Zircaloy-4 Guide Tubes), Type F2 Pressurized Fuel Rods and without Liquid Level Detectors, Parts List
- (12) XN-S30491, Revision 3, Center Fuel Assembly (with Zircaloy-4 Guide Tubes), Type F3 Pressurized Fuel Rods and 1 Liquid Level Detector, Parts List
- (13) XN-S30492, Revision 0, Control Rod Cluster Assembly
Appendix A - List of Product and Material Specifications
- (14) XN-S30493, Revision 2, Neutron Source, Parts List.

XN-S30105, Revision 26

Issue Date 12/13/76MASTER PARTS LISTEXTERNAL DISTRIBUTIONLOFT FUEL SUPPLYNOT FOR FABRICATION

<u>Parts List Number</u>	<u>Revision No.</u>	<u>Title</u>
XN-S30471	3 *	Center Fuel Assembly (with 2 Liquid Level Detectors) Type A1 Unpressurized Fuel Rods Type A2 Pressurized Fuel Rods
XN-S30473	3 *	Center Fuel Assembly (without Liquid Level Detectors) Type A3 Unpressurized Fuel Rods Type A4 Pressurized Fuel Rods
XN-S30475	3 *	Center Fuel Assembly (with 1 Liquid Level Detector) Type A5 Unpressurized Fuel Rods Type A6 Pressurized Fuel Rods
XN-S30477	2 *	Control Fuel Assembly Type B1 Unpressurized Fuel Rods Type B2 Pressurized Fuel Rods
XN-S30479	3 *	Corner Fuel Assembly (with Liquid Level Detector) Type C1 Unpressurized Fuel Rods Type C2 Pressurized Fuel Rods
XN-S30481	3 *	Corner Fuel Assembly (without Liquid Level Detector) Type C3 Unpressurized Fuel Rods Type C4 Pressurized Fuel Rods
XN-S30483	1 *	Control Fuel Assembly Type D1 Unpressurized Fuel Rods Type D2 Pressurized Fuel Rods
XN-S30485	5 *	Corner Fuel Assembly Type E1 Unpressurized Fuel Rods Type E2 Pressurized Fuel Rods

General Instructions:

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3. Where more than one revision to a document may be used, each revision number will be explicitly stated in the parts list.
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XN-S30105, Revision 26

<u>Parts List Number</u>	<u>Revision No.</u>	<u>Title</u>
XN-S30487	3 *	Center Fuel Assembly (with Zircaloy-4 Guide Tubes) Type F1 Pressurized Fuel Rods and with 2 Liquid Level Detectors
XN-S30489	3 *	Center Fuel Assembly (with Zircaloy-4 Guide Tubes) Type F2 Pressurized Fuel Rods and without Liquid Level Detectors
XN-S30491	3 *	Center Fuel Assembly (with Zircaloy-4 Guide Tubes) Type F3 Pressurized Fuel Rods and with 1 Liquid Level Detector
XN-S30492	0	Control Rod Cluster Assembly
XN-S30493	1	Neutron Source

XN 5304/1, Revision 3

PARTS LISTIssue Date 12/13/76LOFT FULL SUPPLYEXTERNAL DISTRIBUTION
NOT FOR FABRICATIONCenter Fuel Assembly (with 2 Liquid Level Detectors)Type A1 Unpressurized Fuel Rods, Type A2 Pressurized Fuel Rods

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Center Fuel Assembly - Type A1	-	300,329 Assy. 1	6*	S30232	4	--	-
Center Fuel Assembly - Type A2	-	300,329 Assy. 2	6*	S30232	4	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	204	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Caps	204	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type A1)	185	300,460 Opt. 2	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type A2)	185	301,271	0	S30065	0	S30085	5

General Instructions:

1. The latest revision of the parts list is the only authoritative definition of the Product. The effective parts list is always the latest revision.
2. The latest revision of a document (specification or drawing) may not be applicable to a given project. The correct revision will be shown in the parts list.
3. Where more than one revision to a document may be used, each revision number will be explicitly stated in the parts list.
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5. Other documents pertinent to preparation of the product will be found in the appropriate Project Key Document List.

See page 8 for footnotes.

XN-S30471, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>End Caps (Continued)</u>							
Zr-4 Upper End Cap, Inst. (for Type A1)	19	300,436	2	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst. (for Type A2)	19	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring (for Type A1)	204	300,338	1	S30066	2	--	-
Upper Plenum Spring (for Type A2)	204	301,657	0	S30066	2	--	-
Insulator Disc	408	300,337	0	S30067	1	--	-
<u>Rods</u>							
Standard Rod Assembly ⁽⁺⁺⁾ (for Type A1)	185	300,463	2	S30106	3	--	-
Standard Rod Assembly ⁽⁺⁺⁾ (for Type A2)	185	301,275	1	S30353	1	--	-
Instrumented Rod Assy. ⁽⁺⁺⁾ (for Type A1)	2	300,466	6	S30198	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					

XN-S30471, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods (Continued)</u>							
Instrumented Rod Assy. (++) (for Type A2)	2	301,277	1	S30354	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					
Cap Screw, Instrumented Rod	19	300,437	1	--	-	S30086	2
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non-Instrumented)	11	300,345	4*	S30144	8	--	-
		Assy. 1					
Guide Tube	11	300,346	2	S30144	8	S30034	1
		Opt. 1					
Sleeve, Guide Tube	11	300,347	2*	S30144	8	S30086	2
Lower End Fitting	11	300,349	2	S30144	8	S30086	2
		Opt. 1					
Liquid Level Detector	2	ANC Supplied		--	-	--	-
Pin, Liquid Level Detector	2	300,991	0	S30232	4	--	-
Instrumented Guide Tube Assy.	2	300,487	3	S30232	2	--	-
	1	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
	2	Assy. 6					

XN-S30471, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Guide Tube Inst. Assy. (2 sheets)	4 1 1	300,413 Assy. 1 Assy. 3 Assy. 4	5	S30203	2	--	-
Support (5 sheets)	6 10 23 1 1	300,411 Part 1 Part 2 Part 3 Part 4 Part 5	5	S30203	2	--	-
Spring Clip	41 35	300,412 Part 1 Part 2	2	S30203	2	S30088	1
Slotted Guide Tube Assy.	2 2 1 1	300,490 Assy. 1 Assy. 3 Assy. 4 Assy. 6	3*	S30144	8	--	-
Slotted Guide Tube	2 2 1 1	300,491 Opt. 1 Opt. 3 Opt. 4 Opt. 5	2	S30144	8	S30034	1
Slotted Sleeve	6	300,492	3*	S30144	8	S30086	2
Lower End Fitting	5 1	300,349 Opt. 2 Opt. 4	2	S30144	8	S30086	2
Guide Tube Support	6	300,415 Opt. 1	0	--	-	S30086	2

XN-5304/1, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Fixed Flux Det. Guide Tube Assembly	1	300,489	2	S30232	4	--	-
Fixed Flux Det. Inst. Assy.	1	300,969	2	S30203	2	--	-
Support (5 sheets)	4	300,411 Part 3	3	S30203	2	S30086	2
Spring Clip	7 7	300,412 Part 1 Part 2	2	S30203	2	S30088	1
Support	1	300,971 Assy. 2	4	S30203	2	S30086	2
Slotted Guide Tube Assy.	1	300,490 Assy. 5	3*	S30144	8	--	-
Slotted Guide Tube	1	300,491 Opt. 5	2	S30144	8	S30034	1
Slotted Sleeve	1	300,492	3*	S30144	8	S30086	2
Lower End Fitting	1	300,349 Opt. 2	2	S30144	8	S30086	2
Guide Tube Support	1	300,415 Opt. 1	0	--	-	S30086	2
<u>Instrumentation Tube and Associated Hardware</u>							
Instrumentation Tube Assy.	1	300,351	6*	S30145	4	--	-
Instrumentation Tube	1	300,352 Opt. 1	2	S30145	4	S30034	1

XN-S30471, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Instrumentation Tube & Associated Hardware</u> (Continued)							
Sleeve, Inst. Tube	1	300,353	4*	S30145	4	S30086	2
Plug, Instrumentation Tube	1	300,394 Opt. 1	1	S30145	4	S30086	2
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip	20	300,441 Opt. 2	1	S30154	4	S30088	1
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					
Central Spacer Strip	10	300,442 Opt. 8	1	S30154	4	S30088	1
	10	Opt. 9					
Spacer Side Plate	20	300,405	3	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy. (with instrumentation grooves)	1	300,395	5	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,378 Assy. 1	3	S30155	0,2	S30091	1+
Upper End Box	1	300,396	3	S30155	0,2	S30091	1+
Dowel Pin	8	300,399	0	--	-	S30086	2
Lower Tie Plate Assy. (with instrumentation grooves)	1	300,383 Opt. 1	3	S30155	0,2	S30091	1+

XN-S304/1, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware (Continued)</u>							
Lower Tie Plate Assy.	1	300,382 Opt. 1	4*	S30155	0,2	S30091	1+
Thermocouple Cover Plate	1	300,387 Opt. 2	4	S30155	0,2	S30091	1+
Nut Upper Guide Tube	19	300,355 Opt. 1	3*	S30205	0	S30086	2
Nut Lower Guide Tube	35	300,356 Opt. 1	3	S30205	0	S30086	2
Nut Lower Guide Tube	1	300,356 Opt. 2	3	S30205	0	S30086	2
Locking Ring	180	300,428 Opt. 1	3	S30279	0	--	-
Instrumentation Routing Fixture	1	300,416	3	--	-	S30086	2
Instrumentation Routing Fixture	1	300,417	3	--	-	S30086	2
Thermocouple Lead Clamp	12 4 6 3	300,444 Opt. 2 Opt. 3 Opt. 4 Opt. 5	1	--	-	S30091 AWS-ER-308L	1+
Sleeve Routing Fixture	1 1	300,419 Opt. 1 Opt. 2	0	--	-	S30086	2
Fuel Assy. Length Interface & Tie Plate Attachment Detail	-	300,556	1	(see Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

XN-S30471, Revision 3

FOOTNOTES

+ EBC requirements excepted.

++ All standard and instrumented fuel rods shall be characterized per Change Order No. 14.

XN-S30473, Revision 3

Issue Date: 12/13/76

PARTS LIST
LOFT FUEL SUPPLY

EXTERNAL DISTRIBUTION
NOT FOR FABRICATION

Center Fuel Assembly (without Liquid Level Detectors.)

Type A3 Unpressurized Fuel Rods, Type A4 Pressurized Fuel Rods.

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Center Fuel Assembly Type A3	-	301,269 Assy. 1	2*	S30232	4	--	-
Center Fuel Assembly Type A4	-	301,269 Assy. 2	2*	S30232	4	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	204	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Caps	204	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type A3)	185	300,460 Opt. 2	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type A4)	185	301,271	0	S30065	0	S30085	5

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See page 8 for footnotes.

XN-S30473, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>End Caps (Continued)</u>							
Zr-4 Upper End Cap, Inst. (For Type A3)	19	300,436	2	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst. (for Type A4)	19	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring (for Type A3)	204	300,338	1	S30066	2	--	-
Upper Plenum Spring (for Type A4)	204	301,657	0	S30066	2	--	-
Insulator Disc	408	300,337	0	S30067	1	--	-
<u>Rods</u>							
Standard Rod Assembly ⁽⁺⁺⁾ (for Type A3)	185	300,463	2	S30106	3	--	-
Standard Rod Assembly ⁽⁺⁺⁾ (for Type A4)	185	301,275	1	S30353	1	--	-
Instrumented Rod Assy. ⁽⁺⁺⁾ (for Type A3)	2	300,466	6	S30198	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					

XN-S30473, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods (Continued)</u>							
Instrumented Rod Assy. (††) (for Type A4)	2	301,277	1	S30354	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					
Cap Screw, Instrumented Rod	19	300,437	1	--	-	S30086	2
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non-Instrumented)	13	300,345 Assy. 1	4*	S30144	8	--	-
Guide Tube	13	300,346 Opt. 1	2	S30144	8	S30034	1
Sleeve, Guide Tube	13	300,347	2*	S30144	8	S30086	2
Lower End Fitting	13	300,349 Opt. 1	2	S30144	8	S30086	2
Instrumented Guide Tube Assy.	2	300,487	3	S30232	4	--	-
	1	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
	2	Assy. 6					

XN-S30473, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Guide Tube Inst. Assy. (2 sheets)	4 1 1	300,413 Assy. 1 Assy. 3 Assy. 4	5	S30203	2	--	-
Support (5 sheets)	6 10 23 1 1	300,411 Part 1 Part 2 Part 3 Part 4 Part 5	5	S30203	2	S30086	2
Spring Clip	41 35	300,412 Part 1 Part 2	2	S30203	2	S30088	1
Slotted Guide Tube Assy.	2 2 1 1	300,490 Assy. 1 Assy. 3 Assy. 4 Assy. 6	3*	S30144	8	--	-
Slotted Guide Tube	2 2 1 1	300,491 Opt. 1 Opt. 3 Opt. 4 Opt. 5	2	S30144	8	S30034	1
Slotted Sleeve	6	300,492	3*	S30144	8	S30086	2
Lower End Fitting	5 1	300,349 Opt. 2 Opt. 4	2	S30144	8	S30086	2

XN-S30473, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Instrumentation Tube & Associated Hardware</u>							
Instrumentation Tube Assy.	1	300,351 Assy. 1	6*	S30145	4	--	-
Instrumentation Tube	1	300,352 Opt. 1	2	S30145	4	S30034	1
Sleeve, Inst. Tube	1	300,353	4*	S30145	4	S30086	2
Plug, Inst. Tube	1	300,394 Opt. 1	1	S30145	4	S30086	2
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip	20	300,441 Opt. 2	1	S30154	4	S30088	1
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					
Central Spacer Strip	10	300,442 Opt. 8	1	S30154	4	S30088	1
	10	Opt. 9					
Spacer Side Plate	20	300,405	3	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy. (with instrumentation grooves)	1	300,395	5	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,378 Assy. 1	3	S30155	0,2	S30091	1+

XN-S30473, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Instrumentation Tube & Associated Hardware</u>							
Instrumentation Tube Assy.	1	300,351 Assy. 1	6*	S30145	4	--	-
Instrumentation Tube	1	300,352 Opt. 1	2	S30145	4	S30034	1
Sleeve, Inst. Tube	1	300,353	4*	S30145	4	S30086	2
Plug, Inst. Tube	1	300,394 Opt. 1	1	S30145	4	S30086	2
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip	20	300,441 Opt. 2	1	S30154	4	S30088	1
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					
Central Spacer Strip	10	300,442 Opt. 8	1	S30154	4	S30088	1
	10	Opt. 9					
Spacer Side Plate	20	300,405	3	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy. (with instrumentation grooves)	1	300,395	5	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,378 Assy. 1	3	S30155	0,2	S30091	1+

XN-S304/3, Revision 3

Part Description	Number Per Assy.	Drawing No.	Rev. No.	Prod. Spec. No.	Rev. No.	Mat. Spec. No.	Rev. No.
<u>Assembly Hardware (Continued)</u>							
Upper End Box	1	300,396	3	S30155	0,2	S30091	1+
Dowel Pin	8	300,399	0	--	-	S30086	2
Lower Tie Plate Assy. (with instrumentation grooves)1		300,383 Opt. 1	3	S30155	0,2	S30091	1+
Lower Tie Plate Assy.	1	300,382 Opt. 1	4*	S30155	0,2	S30091	1+
Thermocouple Cover Plate	1	300,387 Opt. 2	4	S30155	0,2	S30091	1+
Nut Upper Guide Tube	21	300,355 Opt. 1	3*	S30205	0	S30086	2
Nut Lower Guide Tube	19	300,356 Opt. 1	3	S30205	0	S30086	2
Nut Lower Guide Tube	1	300,356 Opt. 2	3	S30205	0	S30086	2
Locking Ring	200	300,428 Opt. 1	3	S30279	0	--	-
Thermocouple Lead Clamp	13	300,444 Opt. 2	1	--	-	S30091	1+
	3	Opt. 3				AWS-ER-308L	
	6	Opt. 4					
	3	Opt. 5					
Fuel Assy. Length Interface & Tie Plate Attachment Detail	-	300,556	1	(see Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

XN-S30473, Revision 3

FOOTNOTES

- + EBC requirements excepted.
- ++ All standard and instrumented fuel rods shall be characterized per Change Order No. 14.

XN 530475, Revision 3

PARTS LISTIssue Date 12/13/76EOI FULL SUPPLYCenter Fuel Assembly (with 1 Liquid Level Detector)Type A5 Unpressurized Fuel Rods, Type A6 Pressurized Fuel Rods

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Center Fuel Assembly - Type A5	-	302,318 Assy. 1	1*	S30232	4	--	-
Center Fuel Assembly - Type A6	-	302,318 Assy. 2	1*	S30232	4	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	204	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Caps	204	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type A5)	185	300,460 Opt. 2	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type A6)	185	301,271	0	S30065	0	S30085	5

General Instructions:

1. The latest revision of the parts list is the only authoritative definition of the Product. The effective parts list is always the latest revision.
2. The latest revision of a document (specification or drawing) may not be applicable to a given project. The correct revision will be shown in the parts list.
3. Where more than one revision to a document may be used, each revision number will be explicitly stated in the parts list.
4. Asterisks (*) will indicate documents changed since the last revision of the parts list.
5. Other documents pertinent to preparation of the product will be found in the appropriate Project Key Document List.

* Added at Revision 3
See page 8 for footnotes.

XN-S30475, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>End Caps (Continued)</u>							
Zr-4 Upper End Cap, Inst. (for Type A5)	19	300,436	2	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst. (for Type A6)	19	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring (for Type A5)	204	300,338	1	S30066	2	--	-
Upper Plenum Spring (for Type A6)	204	301,657	0	S30066	2	--	-
Insulator Disc	408	300,337	0	S30067	1	--	-
<u>Rods</u>							
Standard Rod Assembly ⁽⁺⁺⁾ (for Type A5)	185	300,463	2	S30106	3	--	-
Standard Rod Assembly ⁽⁺⁺⁾ (for Type A6)	185	301,275	1	S30353	1	--	-
Instrumented Rod Assy. ⁽⁺⁺⁾ (for Type A5)	2	300,466	6	S30198	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods (Continued)</u>							
Instrumented Rod Assy. (++) (for Type A6)	2	301,277	1	S30354	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					
Cap Screw, Instrumented Rod	19	300,437	1	--	-	S30086	2
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non- Instrumented)	12	300,345 Assy. 1	4*	S30144	8	--	-
Guide Tube	12	300,346 Opt. 1	2	S30144	8	S30034	1
Sleeve, Guide Tube	12	300,347	2*	S30144	8	S30086	2
Lower End Fitting	12	300,349 Opt. 1	2	S30144	8	S30086	2
Liquid Level Detector	1	ANC Supplied					
Pin, Liquid Level Detector	1	300,991	0	--	-	S30086	2
Instrumented Guide Tube Assy.	2	300,487	3	S30232	4	--	-
	1	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
	2	Assy. 6					

XN-S30475, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Guide Tube Inst. Assy. (2 sheets)	4 1 1	300,413 Assy. 1 Assy. 3 Assy. 4	5	S30203	2	--	-
Support (5 sheets)	6 10 23 1 1	300,411 Part 1 Part 2 Part 3 Part 4 Part 5	3	S30203	2	S30086	2
Spring Clip	41 35	300,412 Part 1 Part 2	2	S30203	2	S30088	1
Slotted Guide Tube Assy.	2 2 1 1	300,490 Assy. 1 Assy. 3 Assy. 4 Assy. 6	3*	S30144	8	--	-
Slotted Guide Tube	2 2 1 1	300,491 Opt. 1 Opt. 3 Opt. 4 Opt. 5	2	S30144	8	S30034	1
Slotted Sleeve	6	300,492	3*	S30144	8	S30086	2
Lower End Fitting	5 1	300,349 Opt. 2 Opt. 4	2	S30144	8	S30086	2
Guide Tube Support	6	300,415 Opt. 1	0	--	-	S30086	2

XN 530475, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Fixed Flux Detector Guide Tube Assembly	1	300,489	2	S30232	4	--	-
Fixed Flux. Det. Inst. Assy.	1	300,969	2	S30203	2	--	-
Support (5 sheets)	4	300,411 Part 3	3	S30203	2	S30086	2
Spring Clip	7	300,412 Part 1	2	S30203	2	S30088	1
	7	Part 2					
Support	1	300,971 Assy. 2	4	S30203	2	S30086	2
Slotted Guide Tube Assy.	1	300,490 Assy. 5	3*	S30144	8	--	-
Slotted Guide Tube	1	300,491 Opt. 5	2	S30144	8	S30034	1
Slotted Sleeve	1	300,492	3*	S30144	8	S30086	2
Lower End Fitting	1	300,349 Opt. 2	2	S30144	8	S30086	2
Guide Tube Support	1	300,415 Opt. 1	0	--	-	S30086	2
<u>Instrumentation Tube & Associated Hardware</u>							
Instrumentation Tube Assy.	1	300,351 Assy. 1	6*	S30145	4	--	-
Instrumentation Tube	1	300,352 Opt. 1	2	S30145	4	S30034	1

XN-S30475, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Instrumentation Tube & Asso. Hardware (Continued)</u>							
Sleeve, Instrumentation Tube	1	300,353	4*	S30145	4	S30086	2
Plug, Instrumentation Tube	1	300,394 Opt. 1	1	S30145	4	S30086	2
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip	20	300,441 Opt. 2	1	S30154	4	S30088	1
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					
Central Spacer Strip	10	300,442	1	S30154	4	S30088	1
	10	Opt. 8					
	10	Opt. 9					
Spacer Side Plate	20	300,405	3	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy. (with instrumentation grooves)	1	300,395	5	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,378 Assy. 1	3	S30155	0,2	S30091	1+
Upper End Box	1	300,396	3	S30155	0,2	S30091	1+
Dowel Pin	8	300,399	0	--	-	S30086	2

XN-S304/5, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware (Continued)</u>							
Lower Tie Plate Assy. (with instrumentation grooves)	1	300,383 Opt. 1	3	S30155	0,2	S30091	1+
Lower Tie Plate Assy.	1	300,382 Opt. 1*	4*	S30155	0,2	S30091	1+
Thermocouple Cover Plate	1	300,387 Opt. 2	4	S30155	0,2	S30091	1+
Nut Upper Guide Tube	20	300,355 Opt. 1	3*	S30205	0	S30086	2
Nut Lower Guide Tube	37	300,356 Opt. 1	3	S30205	0	S30086	2
Nut Lower Guide Tube	1	300,356 Opt. 2	3	S30205	0	S30086	2
Locking Ring	190	300,428 Opt. 1	3	S30279	0	-	-
Instrumentation Routing Fixture	1	300,416	3	--	-	S30086	2
Thermocouple Lead Clamp	13 3 7 2	300,444 Opt. 2 Opt. 3 Opt. 4 Opt. 5	1	--	-	S30091 AWS-ER-308L	1+
Sleeve Routing Fixture	1	300,419 Opt. 2	0	--	-	S30086	2
Fuel Assy. Length Interface & Tie Plate Attachment Detail	-	300,556	1	(See Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

XN-S30475, Revision 3

FOOTNOTES

+ EBC Requirement excepted.

++ All standard and instrumented fuel rods shall be characterized per Change Order No. 14.

XN 5304/7, Revision 2

PARIS 115F

Issue Date: 12/13/76

LOFT FUEL SUPPLYEXTERNAL DISTRIBUTION
NOT FOR FABRICATION

Control Fuel Assembly Type B1 Unpressurized Fuel Rods
and Type B2 Pressurized Fuel Rods

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Control Fuel Assy. - Type B1	-	300,330 Assy. 1	6	S30232	4	--	-
Control Fuel Assy. - Type B2	-	300,330 Assy. 2	6	S30232	4	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	204	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Caps	204	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type B1)	189	300,460 Opt. 2	1	S30065	0	S30085	5

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XN-S30477, Revision 2

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>End Caps (Continued)</u>							
Zr-4 Upper End Cap, Std. (for Type B2)	189	301,271	0	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst. (for Type B1)	15	300,436	2	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst. (for Type B2)	15	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring (for Type B1)	204	300,338	1	S30066	2	--	-
Upper Plenum Spring (for Type B2)	304	301,657	0	S30066	2	--	-
Insulator Disc	408	300,337	0	S30067	1	--	-
<u>Rods</u>							
Standard Rod Assy. (for Type B1)	189	300,463	2	S30106	3	--	-
Standard Rod Assy. (for Type B2)	189	301,275	1	S30353	1	--	-
Instrumented Rod Assy. (for Type B1)	2	300,466	6	S30198	1	--	-
	2	Assy. 6					
	3	Assy. 7					
	2	Assy. 8					
	3	Assy. 9					
	1	Assy. 10					
	1	Assy. 11					
	1	Assy. 12					
	1	Assy. 13					

XN-S30477, Revision 2

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods (Continued)</u>							
Instrumented Rod Assy. (for Type B2)	2	301,277	1	S30354	1	--	-
	2	Assy. 6					
	3	Assy. 7					
	2	Assy. 8					
	3	Assy. 9					
	1	Assy. 10					
	1	Assy. 11					
	1	Assy. 12					
	1	Assy. 13					
Cap Screw, Instrumented Rod	15	300,437	1	--	-	S30086	2
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non- Instrumented)	20	300,345	4*	S30144	8	--	-
		Assy. 3					
Guide Tube	20	300,346	2	S30144	8	S30034	1
		Opt. 1					
Sleeve Guide Tube	20	300,347	2*	S30144	8	S30086	2
Lower End Fitting	20	300,349	2	S30144	8	S30086	2
		Opt. 3					
<u>Instrumentation Tube & Associated Hardware</u>							
Instrumentation Tube Assy. (Type B Fuel Assembly)	1	300,488	2	S30232	4	--	-
Instrumentation Assembly	1	300,970	4	S30203	2	--	-
Support (5 sheets)	1	300,411	3	S30203	2	S30086	2
	2	Part 2					
		Part 5					

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Instrumentation Tube & Assoc. Hardware (Continued)</u>							
Spring Clip	9	300,412	2	S30203	2	S30088	1
	9	Part 1					
		Part 2					
Detector Support	1	300,971	4	S30203	2	S30086	2
		Assy. 1				S30294	0
Support	3	301,160	1	S30203	2	S30086	2
Slotted Instrumentation Tube Assembly	1	300,425	3*	S30144	8	--	-
Slotted Instrumentation Tube	1	300,431	1	S30144	8	S30034	1
Sleeve	1	300,353	4*	S30144	8	S30086	2
Plug	1	300,394	1	S30144	8	S30086	2
		Opt. 2					
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip		300,441	1	S30154	4	S30088	1
	20	Opt. 2					
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					
Central Spacer Strip		300,442	1	S30154	4	S30088	1
	10	Opt. 8					
	10	Opt. 9					
Spacer Side Plate	20	300,405	3	S30154	4	S30088	1

EXXON NUCLEAR COMPANY, Inc.

XN-S30477, Revision 0

Issue Date 9/9/74PARTS LIST

TITLE: LOFT Fuel Supply - Control Fuel Assembly Type B1 Unpressurized Fuel Rods
and Type B2 Pressurized Fuel Rods

Supersedes Issue Dated: NEW

Fuel Design Council Members

Approved by: J. F. Patterson for
Manager, Product Design
8/23/74

Prepared by: J. F. Patterson
Design Coordinator

Accepted and Audited: [Signature]
Manager, Quality Assurance
8/23/74

Accepted: D. J. Connelley for W. L. H.
Manager, Plant Operations

Accepted: J. E. Neumuth 8/23/74
Director, Customer Projects

Accepted: CRK [Signature] for E. K. R.
Manager, Process Engineering

Accepted: [Signature] 8/23/74
Manager, Fuel Management Services

Accepted: [Signature] D. J. Connelley 8/23/74
Manager, Quality Control

Accepted: [Signature] 8/23/74
Manager, Materials and Purchasing

Approved: [Signature] 8/28/74
Manager, Research and Engineering

XN-S30477, Revision 2

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy. (with instrumentation grooves)	1	300,424	5	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,378 Assy. 2	3	S30155	0,2	S30091	1+
Upper End Box	1	300,423	3	S30155	0,2	S30091	1+
Dowel Pin	8	300,399	0	--	-	S30086	2
Lower Tie Plate Assembly (with instrumentation grooves)	1	300,384	5	S30155	0,2	S30091	1+
Lower Tie Plate Assembly	1	300,382 Opt. 1	4*	S30155	0,2	S30091	1+
Thermocouple Cover Plate	1	300,387 Opt. 1	4	S30155	0,2	S30091	1+
Nut Upper Guide Tube	21	300,355 Opt. 1	3*	S30205	0	S30086	2
Nut Lower Guide Tube	40	300,356 Opt. 1	3	S30205	0	S30086	2
Locking Ring	200	300,428 Opt. 1	3	S30279	0	--	-
Thermocouple Lead Clamp	3 20 2	300,444 Opt. 1 Opt. 2 Opt. 5	1	--	-	S30091 AWS-ER-308L	1+
Fuel Assy. Length Inter- face & Tie Plate Attach- ment Detail	-	300,556	1	(Reference drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

+ EBC requirements excepted.

XH-5304/9, Revision 3

PARTS LIST

Issue Date: 12/13/76

LOFT FUEL SUPPLY

EXTERNAL DISTRIBUTION
NOT FOR FABRICATION

Corner Fuel Assembly (with Liquid Level Detector)

Type C1 Unpressurized Fuel Rods, Type C2 Pressurized Fuel Rods

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Corner Fuel Assembly - Type C1	-	300,331 Assy. 1	6	S30232	4	--	-
Corner Fuel Assembly - Type C2	-	300,331 Assy. 2	6	S30232	4	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	70	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Cap	70	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type C1)	64	300,460 Opt. 2	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type C2)	64	301,271	0	S30065	0	S30085	5

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XN-S30479, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>End Caps (Continued)</u>							
Zr-4 Upper End Cap, Inst. (For Type C1)	6	300,436	2	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst. (for Type C2)	6	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring (for Type C1)	70	300,338	1	S30066	2	--	-
Upper Plenum Spring (for Type C2)	70	301,657	0	S30066	2	--	-
Insulator Disc	140	300,337	0	S30067	1	--	-
<u>Rods</u>							
Standard Rod Assy. (for Type C1)	64	300,463	2	S30106	3	--	-
Standard Rod Assy. (for Type C2)	64	301,275	1	S30353	1	--	-
Instrumented Rod Assy. (for Type C1)	1	300,466	6	S30198	1	--	-
	1	Assy. 8					
	1	Assy. 10					
	1	Assy. 11					
	1	Assy. 12					
	1	Assy. 13					
	1	Assy. 14					
Instrumented Rod Assy. (for Type C2)	1	301,277	1	S30354	1	--	-
	1	Assy. 8					
	1	Assy. 10					
	1	Assy. 11					
	1	Assy. 12					
	1	Assy. 13					
	1	Assy. 14					

XM 530479, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods (Continued)</u>							
Cap Screw, Instrumented Rod	6	300,437	1	--	-	S30086	2
Dummy Half Rod	11	300,398	0	S30204	1	S30086	2
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non-Instrumented)	5	300,345 Assy. 1	4*	S30144	8	--	-
Guide Tube	5	300,346 Opt. 1	2	S30144	8	S30034	1
Sleeve Guide Tube	5	300,347	2*	S30144	8	S30086	2
Lower End Fitting	5	300,349 Opt. 1	2	S30144	8	S30086	2
Liquid Level Detector	1	(ANC Supplied)	--	--	-	--	-
Pin Liquid Level Detector	1	300,991	0	--	-	S30086	2
Instrumented Guide Tube Assembly	1	300,487 Assy. 5	3	S30232	4	--	-
Guide Tube Inst. Assy. (2 sheets)	1	300,413 Assy. 5	5	S30203	2	--	-
Support (5 sheets)	1 8	300,411 Part 1 Part 3	3	S30203	2	S30086	2
Spring Clip	9 8	300,412 Part 1 Part 2	2	S30203	2	S30088	1
Slotted Guide Tube Assy.	1	300,490 Assy. 7	3*	S30144	8	--	-

XN-530479, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Slotted Guide Tube	1	300,491 Assy. 5	2	S30144	8	S30034	1
Slotted Sleeve	1	300,492	3*	S30144	8	S30086	2
Lower End Fitting	1	300,349 Opt. 3	2	S30144	8	S30086	2
Guide Tube Support	1	300,415 Opt. 1	0	--	-	S30086	2
Differential Pressure Guide Tube Assy.	1	300,501	3*	S30203 S30144	2 8	--	-
Lower End Fitting	1	300,504	2	S30144	8	S30086	2
Spring	3	300,505	1	S30203	2	S30088	1
Locking Ring	6	300,506	0	S30279	0	--	--
Guide Tube	1	300,507	1	S30144	8	S30034	1
Guide Tube	1	300,346 Opt. 1	2	S30144	8	S30034	1
Support	1	300,512	0	S30203	2	S30086	2
Tubing	1	300,501	3*	--	-	S30319	0
Sleeve	1	300,347	2*	S30144	8	S30086	2
<u>Grid Spacer Assembly</u>							
Corner Spacer Assembly	5	300,443	3	S30154	4	S30088	1

XN-S30479, Revision 3

<u>Part Description</u>	<u>Number Per. Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Grid Spacer Assembly (Continued)</u>							
Basic Spacer Strip		300,445	2	S30154	4	S30088	1
	10	Opt. 2					
	10	Opt. 3					
	10	Opt. 4					
	10	Opt. 5					
	10	Opt. 6					
	10	Opt. 7					
	10	Opt. 8					
	10	Opt. 9					
	10	Opt. 10					
	10	Opt. 11					
	10	Opt. 12					
	10	Opt. 13					
Side Plate, Corner Spacer		300,408	1	S30154	4	S30088	1
	5	Opt. 1					
	5	Opt. 2					
Side Plate, Corner Spacer	5	300,409	1	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy.	1	300,420	7	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,389	2	S30155	0,2	S30091	1+
Upper End Box	1	300,422	5	S30155	0,2	S30091	1+
Dowel Pin	4	300,399	0	--	--	S30086	2
Lower Tie Plate Assembly (with instrumentation grooves)	1	300,385	4	S30155	0,2	S30091	1+
Lower Tie Plate Assembly	1	300,388	4	S30155	0,2	S30091	1+
Thermocouple Cover Plate	1	300,387	4	S30155	0,2	S30091	1+
ilut Upper Guide Tube		300,355	3*	S30205	0	S30086	2
	7	Opt. 1					

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware (Continued)</u>							
Nut Lower Guide Tube	13	300,356 Opt. 1	3	S30205	0	S30086	2
Nut Lower Guide Tube	1	300,356 Opt. 2	3	S30205	0	S30086	2
Locking Ring	50 19 1	300,428 Opt. 1 Opt. 3 Opt. 4	3	S30279	0	--	-
Instrumentation Routing Fixture	1	300,417	3	--	-	S30086	2
Thermocouple Lead Clamp	2 6 2	300,444 Opt. 1 Opt. 2 Opt. 4	1	--	-	S30091 AWS-ER-308L	1+
Sleeve Routing Fixture	1	300,419 Opt. 1	0	--	-	S30086	2
Fuel Assembly Length Interface & Tie Plate Attachment Detail	-	300,556	1	(Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

† EBC requirements excepted.

XN-530481, Revision 3

Issue Date: 12/13/76

PARTS LISTLOFT FUEL SUPPLY

EXTERNAL DISTRIBUTION ONLY

NOT FOR FABRICATIONCorner Fuel Assembly (Without Liquid Level Detectors)Type C3 Unpressurized Fuel Rods, Type C4 Pressurized Fuel Rods

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Corner Fuel Assembly - Type C3	-	301,278 Assy. 1	2	S30232	4	--	-
Corner Fuel Assembly - Type C4	-	301,278 Assy. 2	2	S30232	4	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	70	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Cap	70	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type C3)	64	300,460 Opt. 2	1	S30065	0	S30085	5

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XN-S30481, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>End Caps (Continued)</u>							
Zr-4 Upper End Cap, Std. (for Type C4)	64	301,271	0	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst. (for Type C3)	6	300,436	2	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst. (for Type C4)	6	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring (for Type C3)	70	300,338	1	S30066	2	--	-
Upper Plenum Spring (for Type C4)	70	301,657	0	S30066	2	--	-
Insulator Disc	140	300,337	0	S30067	1	--	-
<u>Rods</u>							
Standard Rod Assy. (for Type C3)	64	301,463	2	S30106	3	--	-
Standard Rod Assy. (for Type C4)	64	301,275	1	S30353	1	--	-
Instrumented Rod Assy. (for Type C3)	1	300,466	6	S30198	1	--	-
	1	Assy. 8					
	1	Assy. 10					
	1	Assy. 11					
	1	Assy. 12					
	1	Assy. 13					
	1	Assy. 14					

XN-S30481, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods (Continued)</u>							
Instrumented Rod Assy. (for Type C4)	1	301,277	1	S30354	1	--	-
	1	Assy. 8					
	1	Assy. 10					
	1	Assy. 11					
	1	Assy. 12					
	1	Assy. 13					
	1	Assy. 14					
Cap Screw, Instrumented Rod	6	300,437	1	--	-	S30086	2
Dummy Half Rod	11	300,398	0	S30204	1	S30086	2
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non- Instrumented)	6	300,345	4 *	S30144	8	--	-
		Assy. 1					
Guide Tube	6	300,346	2	S30144	8	S30034	1
		Opt. 1					
Sleeve Guide Tube	6	300,347	2 *	S30144	8	S30086	2
Lower End Fitting	6	300,349	2	S30144	8	S30086	2
		Opt. 1					
Instrumented Guide Tube Assy.	1	300,487	3	S30232	4	--	-
		Assy. 5					
Guide Tube Inst. Assy. (2 sheets)	1	300,413	5	S30203	2	--	-
		Assy. 5					
Support (5 sheets)	1	300,411	3	S30203	2	S30086	2
	8	Part 1					
		Part 3					
Spring Clip	9	300,412	2	S30203	2	S30088	1
	8	Part 1					
		Part 2					

XH 500401, Revision 1

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Slotted Guide Tube Assy.	1	300,490 Assy. 7	3*	S30144	8	--	-
Slotted Guide Tube	1	300,491 Assy. 5	2	S30144	8	S30034	1
Slotted Sleeve	1	300,492	3*	S30144	8	S30086	2
Lower End Fitting	1	300,349 Opt. 3	2	S30144	8	S30086	2
Guide Tube Support	1	300,415 Opt. 1	0	--	-	S30086	2
Differential Pressure Guide Tube Assy.	1	300,501	3*	S30203 S30144	2 8	--	-
Lower End Fitting	1	300,504	2	S30144	8	S30086	2
Spring	3	300,505	1	S30203	2	S30088	1
Locking Ring	6	300,506	0	S30279	0	--	-
Guide Tube	1	300,507	1	S30144	8	S30034	1
Guide Tube	1	300,346 Opt. 1	2	S30144	8	S30034	1
Support	1	300,512	0	S30203	2	S30086	2
Tubing	1	300,501	3*	--	-	S30319	0
Sleeve		300,347	2*	S30144	8	S30086	2

XN-S30481, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Grid Spacer Assembly</u>							
Corner Spacer Assembly	5	300,443	3	S30154	4	S30088	1
Basic Spacer Strip	10	300,445	2	S30154	4	S30088	1
	10	Opt. 2					
	10	Opt. 3					
	10	Opt. 4					
	10	Opt. 5					
	10	Opt. 6					
	10	Opt. 7					
	10	Opt. 8					
	10	Opt. 9					
	10	Opt. 10					
	10	Opt. 11					
	10	Opt. 12					
	10	Opt. 13					
Side Plate, Corner Spacer	5	300,408	1	S30154	4	S30088	1
	5	Opt. 1					
	5	Opt. 2					
Side Plate, Corner Spacer	5	300,409	1	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy.	1	300,420	7	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,389	2	S30155	0,2	S30091	11
Upper End Box	1	300,422	5	S30155	0,2	S30091	1+
Dowel Pin	4	300,399	0	--	-	S30086	2
Lower Tie Plate Assembly (with instrumentation grooves)	1	300,385	4	S30155	0,2	S30091	1+
Lower Tie Plate Assembly	1	300,388	4	S30155	0,2	S30091	1+
Thermocouple Cover Plate	1	300,387 Opt. 3	4	S30155	0,2	S30091	1+

XN-530481, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware (Continued)</u>							
Nut Upper Guide	8	300,355 Opt. 1	3*	S30205	0	S30086	2
Nut Lower Guide Tube	15	300,356	3	S30205	0	S30086	2
Nut Lower Guide Tube	1	300,356 Opt. 2	3	S30205	0	S30086	2
Locking Ring	50 19 1	300,428 Opt. 1 Opt. 3 Opt. 4	3	S30279	0	--	-
Thermocouple Lead Clamp	2 4	300,444 Opt. 1 Opt. 2	1	--	-	S30091 AWS-ER-308L	1+
Fuel Assembly Length Interface & Tie Plate Attachment Detail	-	300,556	1	(Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

FOOTNOTES

+ EBC requirement excepted.

++ All standard and instrumented fuel rods shall be characterized per
Change Order No. 14.

XN-530483, Revision 1

PARTS LIST

Issue Date 12/13/76

LOFT FUEL SUPPLYEXTERNAL DISTRIBUTION
NOT FOR FABRICATIONControl Fuel AssemblyType D1 Unpressurized Fuel Rods and Type D2 Pressurized Fuel Rods

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Control Fuel Assy. - Type D1	-	300,470 Assy. 1	6	S30193	4	--	-
Control Fuel Assy. - Type D2	-	300,470 Assy. 2	6	S30193	4	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	204	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Cap	204	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type D1)	204	300,460 Opt. 2	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type D2)	204	301,271	0	S30065	0	S30085	5

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XN-S30483, Revision 1

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Plenum Hardware</u>							
Upper Plenum Spring (for Type D1)	204	300,338	1	S30066	2	--	-
Upper Plenum Spring (for Type D2)	204	301,657	0	S30066	2	--	-
Insulator Disc	408	300,337	0	S30067	1	--	-
<u>Rods</u>							
Standard Rod Assy. (for Type D1)	204	300,463	2	S30106	3	--	-
Standard Rod Assy. (for Type D2)	204	301,275	1	S30353	1	--	-
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non- Instrumented)	20	300,345 Assy. 3	4 *	S30144	8	--	-
Guide Tube	20	300,346 Opt. 1	2	S30144	8	S30034	1
Sleeve Guide Tube	20	300,347	2 *	S30144	8	S30086	2
Lower End Fitting	20	300,349 Opt. 3	2	S30144	8	S30086	2
<u>Instrumentation Tube and Associated Hardware</u>							
Instrumentation Tube Assy.	1	300,351 Assy. 1	6 *	S30145	4	--	-
Instrumentation Tube	1	300,352 Opt. 1	2	S30145	4	S30034	1

XN-S30483, Revision 1

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Instrumentation Tube and Assoc. Hardware (Continued)</u>							
Instrumentation Tube Sleeve	1	300,353	4 *	S30145	4	S30086	2
Plug, Instrumentation Tube	1	300,394 Opt. 1	1	S30145	4	S30086	2
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip	20	300,441 Opt. 2	1	S30154	4	S30088	1
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					
Central Spacer Strip	10	300,442 Opt. 8	1	S30154	4	S30088	1
	10	Opt. 9					
Spacer Side Plate	20 ²⁵	300,405	3	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy. (no instrumentation grooves)	1	300,378 Assy. 1	3	S30155	0,2	S30091	1+
Dowel Pin	8	300,399	0	--	-	S30086	2
Upper End Box Assembly	1	300,379	3	S30155	0,2	S30091	1+
Lower Tie Plate Assembly (no instrumentation grooves)	1	300,382 Opt. 1	4 *	S30155	0,2	S30091	1+
Nut Upper Guide Tube	21	300,355 Opt. 1	3 *	S30205	0	S30086	2

XN-S30483, Revision 1

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware</u>							
Nut Lower Guide Tube	40	300,356 Opt. 1	3	S30205	0	S30086	2
Locking Ring	200	300,428 Opt. 1	3	S30279	0	--	-
Fuel Assembly Length Interface and Tie Plate Attachment Detail	-	300,556	1	(Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

+ EBC requirements excepted.

XN-530485, Revision 5

PARTS LISTIssue Date 12/13/76LOFT FUEL SUPPLYEXTERNAL DISTRIBUTION
NOT FOR FABRICATIONCorner Fuel AssemblyType E1 Unpressurized Fuel Rods and Type E2 Pressurized Fuel Rods

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Corner Fuel Assy. - Type E1	-	300,471 Assy. 1	6	S30193	4	--	-
Corner Fuel Assy. - Type E2	-	300,471 Assy. 2	6	S30193	4	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	70	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Cap	70	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type E1)	70	300,460 Opt. 2	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std. (for Type E2)	70	301,271	0	S30065	0	S30085	5

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XN-530485, Revision 5

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Plenum Hardware</u>							
Upper Plenum Spring (for Type E1)	70	300,338	1	S30066	2	--	-
Upper Plenum Spring (for Type E2)	70	301,657	0	S30066	2	--	-
Insulator Disc	140	300,337	0	S30067	1	--	-
<u>Rods</u>							
Standard Rod Assy. (for Type E1)	70	300,463	2	S30106	3	--	-
Standard Rod Assy. (for Type E2)	70	301,275	1	S30353	1	--	-
Dummy Half Rod	11	300,398	0	S30204	1	S30086	2
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non- Instrumented)	8	300,345 Assy. 1	4 *	S30144	8	--	-
Guide Tube	8	300,346 Opt. 1	2	S30144	8	S30034	1
Sleeve Guide Tube	8	300,347	2 *	S30144	8	S30086	2
Lower End Fitting	8	300,349 Opt. 1	2	S30144	8	S30086	2
<u>Grid Spacer Assembly</u>							
Corner Spacer Assembly	5	300,443	3	S30154	4	S30088	1

XN-S30485, Revision 5

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Grid Spacer Assembly (Continued)</u>							
Basic Spacer Strip		300,445	2	S30154	4	S30088	1
	10	Opt. 2					
	10	Opt. 3					
	10	Opt. 4					
	10	Opt. 5					
	10	Opt. 6					
	10	Opt. 7					
	10	Opt. 8					
	10	Opt. 9					
	10	Opt. 10					
	10	Opt. 11					
	10	Opt. 12					
	10	Opt. 13					
Side Plate, Corner Spacer		300,408	1	S30154	4	S30088	1
	5	Opt. 1					
	5	Opt. 2					
Side Plate, Corner Spacer	5	300,409	1	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Grid Plate Assy. (no instrumentation grooves)	1	300,389	2	S30155	0,2	S30091	1+
Dowel Pin	4	300,399	0	--	-	S30086	2
Upper End Box	1	300,390	7	S30155	0,2	S30091	1+
Lower Tie Plate Assembly (no instrumentation grooves)	1	300,388	4	S30155	0,2	S30091	1+
Nut Upper Guide Tube		300,355	3*	S30205	0	S30086	2
	8	Opt. 1					

XN-S30485, Revision 5

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware (Continued)</u>							
Nut Lower Guide Tube	16	300,356 Opt. 1	3	S30205	0	S30086	2
Locking Ring	60 20	300,428 Opt. 1 Opt. 3	3	S30279	0	--	-
Fuel Assembly Length Interface & Tie Plate Attachment Detail	-	300,556	1	(Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

+ EBC requirements excepted.

XN-S30487, Revision 3

PARTS LIST

Issue Date 12/13/76

LOFT FUEL SUPPLY

EXTERNAL DISTRIBUTION
NOT FOR FABRICATIONCenter Fuel Assembly (with Zircaloy-4 Guide Tubes)Type F1 Pressurized Fuel Rods and with 2 Liquid Level Detectors

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Center Fuel Assembly - Type F1 (3 sheets)	-	300,472	3*	S30243	2*	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	204	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Cap	204	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std.	185	301,271	0	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst.	19	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring	204	301,657	0	S30066	2	--	-
Insulator Disc	408	300,337	0	S30067	1	--	-

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XN-530487, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods</u>							
Standard Rod, Assy. (++)	185	301,275	1	S30353	1	--	-
Instrumented Rod Assy. (++)		301,277	1	S30354	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					
Cap Screw, Instrumented Rod	19	300,437	1	--	-	S30086	2
<u>Guide Tube & Associated Hardware</u>							
Guide Tube Assembly (Non-Instrumented)	11	301,263	1*	S30603	0*	--	-
Guide Tube	11	300,346 Opt. 2	2	S30603	0*	S30247	1
Sleeve, Guide Tube	11	301,256	2*	S30603	0*	S30085	5
Lower End Fitting	11	300,494 Opt. 1	1	S30603	0*	S30085	5
Pin, Liquid Level Detector	2	300,991	0	--	-	S30086	2
Liquid Level Detector	2	ANC Supplied		--	-	--	-
Instrumented Guide Tube Assy.		301,257	0	S30243	2*	--	-
	2	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
	2	Assy. 6					

XN-530487, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Associated Hardware (Continued)</u>							
Guide Tube Inst. Assy.	4	301,258	2	S30203	2	--	-
	1	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
Support (5 sheets)	6	300,411	3	S30203	2	S30085	5
	10	Part 6					
	23	Part 7					
	1	Part 8					
	1	Part 9					
	1	Part 10					
Spring Clip	41	300,412	2	S30203	2	S30088	1
	35	Part 1					
		Part 2					
Slotted Guide Tube Assy.	2	300,502	3*	S30603	0*	--	-
	2	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
	1	Assy. 6					
Slotted Guide Tube	2	300,503	1	S30603	0*	S30247	1
	2	Opt. 1					
	1	Opt. 3					
	1	Opt. 4					
	1	Opt. 5					
Slotted Sleeve	6	302,815	0*	S30603	0*	S30085	5
Lower End Fitting	5	300,494	1	S30603	0*	S30085	5
	1	Opt. 2					
		Opt. 3					
Guide Tube Support	6	300,415	0	--	-	S30085	5
		Opt. 2					

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Fixed Flux Det. Guide Tube Assembly	1	301,260	0	S30243	2*	--	-
Fixed Flux Det. Inst. Assy.	1	301,264	0	S30203	2	--	-
Support (5 sheets)	4	300,411 Part 3	3	S30203	2	S30085	5
Spring Clip	7	300,412 Part 1	2	S30203	2	S30088	1
	7	Part 2					
Support	1	300,971 Assy. 12	4	S30203	2	S30085	5
Slotted Guide Tube Assy.	1	300,502 Assy. 5	3*	S30603	0*	--	-
Slotted Guide Tube	1	300,503 Opt. 5	1	S30603	0*	S30247	1
Slotted Sleeve	1	302,815	0*	S30603	0*	S30085	5
Lower End Fitting	1	300,494 Opt. 2	1	S30603	0*	S30085	5
Guide Tube Support	1	300,415 Opt. 2	0	--	-	S30085	5
<u>Instrumentation Tube and Associated Hardware</u>							
Instrumentation Tube Assy.	1	300,351 Assy. 2	6*	S30239	2*	--	-
Instrumentation Tube	1	300,352 Opt. 2	2	S30239	2*	S30247	1
Sleeve, Instrumentation Tube	1	302,811	0*	S30239	2*	S30085	1

XN-530487, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Instrumentation Tube and Associated Hardware (Continued)</u>							
Plug, Instrumentation Tube	1	300,394 Opt. 2	1	S30239	2*	S30085	5
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip	20	300,441 Opt. 2	1	S30154	4	S30088	1
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					
Central Spacer Strip	10	300,442 Opt. 8	1	S30154	4	S30088	1
	10	Opt. 9					
Spacer Side Plate	20	300,405	3	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Ass. (with instrumentation grooves)	1	300,395	5	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,378 Assy. 1	3	S30155	0,2	S30091	1+
Upper End Box	1	300,396	3	S30155	0,2	S30091	1+
Dowel Pin	8	300,399	0	--	-	S30086	2
Lower Tie Plate Assy. (with instrumentation grooves)	1	300,383 Opt. 2	3	S30155	0,2	S30091	1+
Lower Tie Plate Assy.	1	300,382 Opt. 2	4*	S30155	0,2	S30091	1+
Thermocouple Cover Plate	1	300,387 Opt. 2	4	S30155	0,2	S30091	1+

XN 530487, Revision 3

Part Description	Number Per Assy.	Drawing No.	Rev. No.	Prod. Spec. No.	Rev. No.	Mat. Spec. No.	Rev. No.
<u>Assembly Hardware</u>							
Nut Upper Guide Tube (Zr-4)	18	301,253	1*	S30241	1	S30085	5
Nut Upper Guide Tube (Zr-4) (for Inst. Tube)	1	300,355 Opt. 2	3*	S30241	1	S30085	5
Locking Pin (for Inst. Tube)	1	300,990	1*	--	-	S30086	2
Nut Lower Guide Tube (SST)	17	300,356 Opt. 1	3	S30205	0	S30086	2
Nut Lower Guide Tube (SST)	1	300,356 Opt. 2	3	S30205	0	S30086	2
Nut Lower Guide Tube (Zr-4)	18	301,255	1*	S30241	1	S30085	5
Locking Ring	180	300,428 Opt. 2	3	S30242	1	S30358	0
Locking Cup	18	301,254	1	--	-	S30086	2
Instrumentation Routing Fixture	1	300,416	3	--	-	S30086	2
Instrumentation Routing Fixture	1	300,417	3	--	-	S30086	2
Thermocouple Lead Clamp	12 4 6 3	300,444 Opt. 2 Opt. 3 Opt. 4 Opt. 5	1	--	-	S30091 AWS-ER-308L	1+
Sleeve Routing Fixture	1 1	300,419 Opt. 1 Opt. 2	0	--	-	S30086	2
Fuel Assy. Length Interface & Tie Plate Attachment Detail	-	300,556	1	(Reference drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

XN-530487, Revision 3

FOOTNOTES

+ EBC requirements excepted.

++ All standard and instrumented fuel rods shall be characterized per Change Order No. 14.

XN-S30489, Revision 3

PARTS LIST

Issue Date 12/13/76

LOFT FUEL SUPPLYEXTERNAL DISTRIBUTION
NOT FOR FABRICATIONCenter Fuel Assembly (with Zircaloy-4 Guide Tubes)Type F2 Pressurized Fuel Rods and without Liquid Level Detectors

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Center Fuel Assembly - Type F2 (3 sheets)	-	301,279	2 *	S30243	2 *	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	204	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Cap	204	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std.	185	301,271	0	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst.	19	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring	204	301,657	0	S30066	2	--	-
Insulator Disc	408	300,337	0	S30067	1	--	-

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XN-S30489, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods</u>							
Standard Rod Assy. (++)	185	301,275	1	S30353	1	--	-
Instrumented Rod Assy. (++)		301,277	1	S30354	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					
Cap Screw, Inst. Rod	19	300,437	1	--	-	S30086	2
<u>Guide Tube & Assoc. Hardware</u>							
Guide Tube Assembly (Non-Instrumented)	13	301,263	1*	S30603	0*	--	-
Guide Tube	13	300,346 Opt. 2	2	S30603	0*	S30247	1
Sleeve, Guide Tube	13	301,256	2*	S30603	0*	S30085	5
Lower End Fitting	13	300,494 Opt. 1	1	S30603	0*	S30085	5
Instrumented Guide Tube Assembly	2	301,257	0	S30243	2*	--	-
	1	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
	2	Assy. 6					
Guide Tube Inst. Assy.	4	301,258	2	S30203	2	--	-
	1	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					

XN-S30489, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Associated Hardware (Continued)</u>							
Support (5 sheets)	6	300,411	3	S30203	2	S30085	5
	10	Part 6					
	23	Part 7					
	1	Part 8					
	1	Part 9					
	1	Part 10					
Spring Clip	41	300,412	2	S30203	2	S30088	1
	35	Part 1					
		Part 2					
Slotted Guide Tube Assy.		300,502	3*	S30603	0*	--	-
	2	Assy. 1					
	2	Assy. 3					
	1	Assy. 4					
	1	Assy. 6					
Slotted Guide Tube		300,503	1	S30603	0*	S30247	1
	2	Opt. 1					
	2	Opt. 3					
	1	Opt. 4					
	1	Opt. 5					
Slotted Sleeve	6	302,815	0*	S30603	0*	S30085	5
Lower End Fitting		300,494	1	S30603	0*	S30085	5
	5	Opt. 2					
	1	Opt. 3					
Guide Tube Support		300,415	0	--	-	S30085	5
	6	Opt. 2					
Fixed Flux Det. Guide Tube Assembly	1	300,260	0	S30243	2*	--	-
Fixed Flux Det. Inst. Assy.	1	301,264	0	S30203	2	--	-
Support (5 sheets)		300,411	3	S30203	2	S30085	5
	4	Part 3					
Spring Clip		300,412	2	S30203	2	S30088	1
	7	Part 1					
	7	Part 2					

XN-S30489, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Assoc. Hardware (Continued)</u>							
Support	1	300,971 Assy. 12	4	S30203	2	S30085	5
Slotted Guide Tube Assy.	1	300,502 Assy. 5	3*	S30603	0*	--	-
Slotted Guide Tube	1	300,503 Opt. 5	1	S30603	0*	S30247	1
Slotted Sleeve	1	302,815	0*	S30603	0*	S30085	5
Lower End Fitting	1	300,494 Opt. 2	1	S30603	0*	S30085	5
Guide Tube Support	1	300,415 Opt. 2	0	--	-	S30085	5
<u>Instrumentation Tube and Associated Hardware</u>							
Instrumentation Tube Assy.	1	300,351 Assy. 2	6*	S30239	2*	--	-
Instrumentation Tube	1	300,352 Opt. 2	2	S30239	2*	S30247	1
Sleeve, Instrumentation Tube	1	302,811	0*	S30239	2*	S30085	5
Plug, Instrumentation Tube	1	300,394 Opt. 2	1	S30239	2*	S30085	5
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip	20	300,441 Opt. 2	1	S30154	4	S30088	1
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					

XN-530489, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Grid Spacer Assembly (Continued)</u>							
Central Spacer Strip	10	300,442	1	S30154	4	S30088	1
	10	Opt. 8					
		Opt. 9					
Spacer Side Plate	20	300,405	3	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy. (with instrumentation grooves)	1	300,395	5	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,378	3	S30155	0,2	S30091	1+
		Assy. 1					
Upper End Box	1	300,396	3	S30155	0,2	S30091	1+
Dowel Pin	8	300,399	0	--	-	S30086	2
Lower Tie Plate Assy. (with instrumentation grooves)	1	300,383	3	S30155	0,2	S30091	1+
		Opt. 2					
Lower Tie Plate Assy.	1	300,382	4*	S30155	0,2	S30091	1+
		Opt. 2					
Thermocouple Cover Plate	1	300,387	4	S30155	0,2	S30091	1+
		Opt. 2					
Nut Upper Guide Tube (Zr-4)	20	301,253	1*	S30241	1	S30085	5
Nut Upper Guide Tube (Zr-4) (for Inst. Tube)	1	300,355	3*	S30241	1	S30085	5
		Opt. 2					
Locking Pin (for Inst. Tube)	1	300,990	1*	--	-	S30086	2
Nut Lower Guide Tube (SST)	19	300,356	3	S30205	0	S30086	2
		Opt. 1					
Nut Lower Guide Tube (SST)	1	300,356	3	S30205	0	S30086	2
		Opt. 2					

XN-S30489, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware (Continued)</u>							
Nut Lower Guide Tube (Zr-4)	20	301,255	1*	S30241	1	S30085	5
Locking Ring	200	300,428 Opt. 2	3	S30242	1	S30358	0
Locking Cup	20	301,254	1	--	-	S30086	2
Thermocouple Lead Clamp	13 3 6 3	300,444 Opt. 2 Opt. 3 Opt. 4 Opt. 5	1	--	-	S30091	1+
Fuel Assy. Length Interface & Tie Plate Attachment Detail	-	300,556	1	(Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

+ EBC requirements excepted.

++ All standard and instrumented fuel rods shall be characterized per
Change Order No. 14.

XN-530491, Revision 3

PARTS LIST

Issue Date 12/13/76

LOFT FUEL SUPPLY

EXTERNAL DISTRIBUTION
NOT FOR FABRICATION

Center Fuel Assembly (with Zircaloy-4 Guide Tubes)
Type F3 Pressurized Fuel Rods and with 1 Liquid Level Detector

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Center Fuel Assembly - Type F3 (3 sheets)	-	302,320	1*	S30243	2 *	--	-
<u>Pellets</u>							
UO ₂ Fuel Pellet	AR	300,343	3	S30061	4	S30081	1
<u>Cladding</u>							
Zr-4 Cladding	204	300,461	2	--	-	S30084	4
<u>End Caps</u>							
Zr-4 Lower End Cap	204	300,460 Opt. 1	1	S30065	0	S30085	5
Zr-4 Upper End Cap, Std.	185	301,271	0	S30065	0	S30085	5
Zr-4 Upper End Cap, Inst.	19	301,273	0	S30065	0	S30085	5
<u>Plenum Hardware</u>							
Upper Plenum Spring	204	301,657	0	S30066	2	--	-
Insulator Disc	408	300,337	0	S30067	1	--	-

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5. Other documents pertinent to preparation of the product will be found in the appropriate Project Key Document List.

XN-S30491, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Rods</u>							
Standard Rod Assy. (++)	185	301,275	1	S30353	1	--	-
Instrumented Rod Assy. (++)		301,277	1	S30354	1	--	-
	2	Assy. 1A					
	2	Assy. 2A					
	2	Assy. 3A					
	2	Assy. 4A					
	2	Assy. 5A					
	1	Assy. 1B					
	1	Assy. 2B					
	1	Assy. 3B					
	1	Assy. 4B					
	1	Assy. 5B					
	2	Assy. 14					
	2	Assy. 15					
Cap Screw, Instrumented Rod	19	300,437	1	--	-	S30086	2
<u>Guide Tube & Associated Hardware</u>							
Guide Tube Assembly (Non-Instrumented)	12	301,263	1 *	S30603	0 *	--	-
Guide Tube	12	300,346 Opt. 2	2	S30603	0 *	S30247	1
Sleeve, Guide Tube	12	301,256	2 *	S30603	0 *	S30085	5
Lower End Fitting	12	300,494 Opt. 1	1	S30603	0 *	S30085	5
Pin, Liquid Level Detector	1	300,991	0	--	-	S30086	2
Liquid Level Detector	1	ANC Supplied		--	-	--	-
Instrumented Guide Tube Assy.		301,257	0	S30243	2 *	--	-
	2	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
	2	Assy. 6					

XN 530494, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Guide Tube & Associated Hardware (Continued)</u>							
Guide Tube Inst. Assy.	4	301,258	2	S30203	2	--	-
	1	Assy. 1					
	1	Assy. 3					
	1	Assy. 4					
Support (5 sheets)	6	300,411	3	S30203	2	S30085	5
	10	Part 6					
	23	Part 7					
	1	Part 8					
	1	Part 9					
	1	Part 10					
Spring Clip	41	300,412	2	S30203	2	S30088	1
	35	Part 1					
		Part 2					
Slotted Guide Tube Assy.	2	300,502	3 *	S30603	0*	--	-
	2	Assy. 1					
	1	Assy. 3					
	6	Assy. 4					
		Assy. 6					
Slotted Guide Tube	2	300,503	1	S30603	0 *	S30247	1
	2	Opt. 1					
	1	Opt. 3					
	1	Opt. 4					
	1	Opt. 5					
Slotted Sleeve	6	302,815	0 *	S30603	0 *	S30085	5
Lower End Fitting	5	300,494	1	S30603	0 *	S30085	5
	1	Opt. 2					
		Opt. 3					
Guide Tube Support	6	300,415	0	--	-	S30085	5
		Opt. 2					

XN 530491, Revision 3

Part Description	Number Per Assy.	Drawing No.	Rev. No.	Prod. Spec. No.	Rev. No.	Mat. Spec. No.	Rev. No.
Fixed Flux Det. Guide Tube Assembly	1	301,260	0	S30243	2*	--	-
Fixed Flux Det. Inst. Assy.	1	301,264	0	S30203	2	--	-
Support (5 sheets)	4	300,411 Part 3	3	S30203	2	S30085	5
Spring Clip	7	300,412 Part 1	2	S30203	2	S30088	1
	7	Part 2					
Support	1	300,971 Assy. 12	4	S30203	2	S30085	5
Slotted Guide Tube Assy.	1	300,502 Assy. 5	3*	S30603	0*	--	-
Slotted Guide Tube	1	300,503 Opt. 5	1	S30603	0*	S30247	1
Slotted Sleeve	1	302,815	0*	S30603	0*	S30085	5
Lower End Fitting	1	300,494 Opt. 2	1	S30603	0*	S30085	5
Guide Tube Support	1	300,415 Opt. 2	0	--	-	S30085	5
<u>Instrumentation Tube & Associated Hardware</u>							
Instrumentation Tube Assy.	1	300,351 Assy. 2	6*	S30239	2*	--	-
Instrumentation Tube	1	300,352 Opt. 2	2	S30239	2*	S30247	1
Sleeve, Instrumentation Tube	1	302,811	0*	S30239	2*	S30085	5

XN-S30491, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Instrumentation Tube and Assoc. Hardware (Continued)</u>							
Plug, Instrumentation Tube	1	300,394 Opt. 2	1	S30239	2 *	S30085	5
<u>Grid Spacer Assembly</u>							
Spacer Assembly	5	300,440	4	S30154	4	S30088	1
Basic Spacer Strip	20	300,441 Opt. 2	1	S30154	4	S30088	1
	20	Opt. 3					
	20	Opt. 4					
	20	Opt. 5					
	20	Opt. 6					
	20	Opt. 7					
Central Spacer Strip	10	300,442 Opt. 8	1	S30154	4	S30088	1
	10	Opt. 9					
Spacer Side Plate	20	300,405	3	S30154	4	S30088	1
<u>Assembly Hardware</u>							
Upper Tie Plate Grid Assy. (with instrumentation grooves)	1	300,395	5	S30155	0,2	S30091	1+
Upper Tie Plate Grid Assy.	1	300,378 Assy. 1	3	S30155	0,2	S30091	1+
Upper End Box	1	300,396	3	S30155	0,2	S30091	1+
Dowel Pin	8	300,399	0	--	-	S30086	2
Lower Tie Plate Assy. (with instrumentation grooves)	1	300,383 Opt. 2	3	S30155	0,2	S30091	1+
Lower Tie Plate Assy.	1	300,382 Opt. 2	4*	S30155	0,2	S30091	1+

XN-530491, Revision 3

Part Description	Number Per Assy.	Drawing No.	Rev. No.	Prod. Spec. No.	Rev. No.	Mat. Spec. No.	Rev. No.
<u>Assembly Hardware (Continued)</u>							
Thermocouple Cover Plate	1	300,387 Opt. 2	4	S30155	0,2	S30091	1+
Nut Upper Guide Tube (Zr-4)	19	301,253	1*	S30241	1	S30085	5
Nut Upper Guide Tube (Zr-4) (for Inst. Tube)	1	300,355 Opt. 2	3*	S30241	1	S30085	5
Locking Pin (for Inst. Tube)	1	300,990	1*	--	-	S30086	2
Nut Lower Guide Tube (SST)	18	300,356 Opt. 1	3	S30205	0	S30086	2
Nut Lower Guide Tube (SST)	1	300,356 Opt. 2	3	S30205	0	S30086	2
Nut Lower Guide Tube (Zr-4)	19	301,255	1*	S30241	1	S30085	5
Locking Ring	190	300,428 Opt. 2	3	S30242	1	S30358	0
Locking Cup	19	301,254	1	--	-	S30086	2
Instrumentation Routing Fixture	1	300,416	3	--	-	S30086	2
Thermocouple Lead Clamp	13	300,444 Opt. 2	1	--	-	S30091	1+
	3	Opt. 3				AWS-ER-308L	
	7	Opt. 4					
	2	Opt. 5					
Sleeve Routing Fixture	1	300,419 Opt. 2	0	--	-	S30086	2

XN-S30491, Revision 3

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly Hardware (Continued)</u>							
Fuel Assy. Length Interface and Tie Plate Attachment Detail	-	300,556	1	(Reference Drawing)			
Equivalent Boron Content	-	--	-	--	-	S30100	0

+ EBC requirements excepted.

++ All standard and instrumented fuel rods shall be characterized per Changed Order No. 14.

XN 530492, Revision 0

Issue Date 9/9/74

PARTS LIST

LOFT FUEL SUPPLY

Control Rod Cluster Assembly

<u>Part Description</u>	<u>Number Per Assy</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Product Spec. No.</u>	<u>Rev. No.</u>	<u>Material Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Control Rod Cluster Assy.	--	300,358	7	S30221	2	---	---
<u>Absorber</u>							
Poison Rod	AR	300,373	3	---	---	S30220	1
<u>Cladding</u>							
Stainless Steel Cladding	20	300,369	1	---	---	S30034	1
<u>End Fittings</u>							
Upper End Fitting	20	300,370	1	S30194	0	S30086	2
Lower End Fitting	20	300,371	0	S30194	0	S30086	2
<u>Plenum Hardware</u>							
Plenum Spring	20	300,372	1	S30066	2	---	---
<u>Rods</u>							
Control Rod Assembly	20	300,368	1	S30231	4	---	---
<u>Hardware</u>							
Spider	1	300,359	7	S30202	3	---	---
Spring Outer	1	300,364	0	S30066	2	---	---
Spring Inner	1	300,365	0	S30066	2	---	---
Bolt	1	300,366	1	S30221	2	S30086	2
Spring Retainer	1	300,367	1	S30221	2	S30086	2
Shaft	1	300,374	3	S30221	2	S30086	2
Pin Long	1	300,376	0	S30221	2	S30086	2
Pin Short	20	300,377	0	S30221	2	S30086	2
Plug	1	300,992	0	S30221	2	S30086	2

APPENDIX A - LIST OF PRODUCT AND MATERIAL SPECIFICATIONSXN NumberTitlePRODUCT SPECIFICATIONS

S30066, Revision 2

Coil Springs

S30194, Revision 0

Control Rod End Fittings

S30202, Revision 3

Control Rod Spider

S30221, Revision 2

Control Rod Cluster - LOFT

S30231, Revision 4

Control Rod - LOFT

MATERIAL SPECIFICATIONS

S30034, Revision 1

304L Stainless Steel Tubing

S30086, Revision 2

304L Rod and Bar Stock

S30220, Revision 1

Silver Indium Cadmium Alloy Rod

PARTS LISTIssue Date 06/22/77

Page 1 of 2

LOFT FUEL SUPPLYNeutron Source

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Assembly</u>							
Neutron Source Assembly	-	300,496	3*	S30306	2*	--	-
<u>Source</u>							
Neutron Source	1	--	-	S30306	2*	--	-
<u>Shaft Assembly</u>							
Locking Sleeve	1	300,497	0	S30306	2*	S30086	2
Outer Compression Spring	1	300,446	0	S30066	2	--	-
Inner Compression Spring	1	300,447	0	S30066	2	--	-
Shaft	1	300,473	4*	S30306	2*	S30086	2
Collar	1	300,448	2*	S30306	2*	S30086	2
Pin	1	300,449	0	S30306	2*	S30086	2

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* Denotes added at Revision 2.

XN-S30493, Revision 2

<u>Part Description</u>	<u>Number Per Assy.</u>	<u>Drawing No.</u>	<u>Rev. No.</u>	<u>Prod. Spec. No.</u>	<u>Rev. No.</u>	<u>Mat. Spec. No.</u>	<u>Rev. No.</u>
<u>Tube Assembly</u>							
Threaded Sleeve	1	300,476	0	S30306	2*	S30086	2
Tube	1	300,474	0	--	-	S30034	1
Washer	1	303,072	0*	S30306	2*	S30086	2
Plenum Spring	1	300,372	2*	S30066	2	--	-
Lower End Fitting	1	300,371	0	S30194	0	S30086	2
<u>Mounting Hardware</u>							
Retaining Sleeve	1	300,498	1	S30306	2*	S30086	2

- (1) JN-S30034, Revision 1, Material Specification, 304L Stainless Steel Tubing
- (2) JN-S30081, Revision 1, Uranium Dioxide Powder
- (3) JN-S30084, Revision 4, Zircaloy Tubing
- (4) #ZTT-302, Zirconium Technology Corporation Method for Hydriding F_N Specimens
- (5) JN-S30086, Revision 6, 304L Rod and Bar Stock
- (6) XN-S30088, Revision 5, Inconel 718 Sheet Stock
- (7) XN-S30091, Revision 9, 304L Sheet and Plate Stock
- (8) JN-S30100, Revision 0, Equivalent Boron Content
- (9) JN-S30220, Revision 1, Silver-Indium-Cadmium Alloy Rod
- (10) JN-S30247, Revision 1, Zircaloy Tubing, Guide Tube
- (11) JN-S30283, Revision 0, Zircaloy Strip and Sheet Stock
- (12) JN-S30294, Revision 0, 304 Stainless Steel Rod and Bar Stock
- (13) XN-S30319, Revision 0, 304L Stainless Steel Tubing
- (14) XN-S30358, Revision 0, Zircaloy Tube, Locking Ring

MATERIAL SPECIFICATIONS

MATERIAL SPECIFICATION

1.0 TITLE: 304L STAINLESS STEEL TUBING

2.0 SCOPE

- 2.1 This specification describes the material requirements for 304L stainless steel tubing used for fuel and control rod assemblies.
- 2.2 A glossary of terms is given in Appendix A.
- 2.3 Pertinent references are listed in Appendix B.
- 2.4 A list of elements significant in the determination of equivalent boron content is given in Appendix C.

3.0 TECHNICAL SPECIFICATIONS

3.1 Material and Manufacture

Except as amended by this specification, the 304L stainless steel tubing shall be supplied in accordance with ASTM A213-70*, cold drawn and solution annealed. Annealed tubing may be cold worked, to a maximum of 20%, and stress relieved in order to meet the mechanical property requirements of section 3.3. Cold worked tubing shall be stress relieved at 650°F-750°F. The completeness of the last solution anneal shall be verified by metallographic examination; no continuous carbide precipitation network is permitted in grain boundaries.

3.2 Equivalent Boron Content

The total equivalent boron content (EBC) of tubing used for guide tubes (including impurities), shall not exceed 850 ppm, based on either a comparative reactivity test using an analyzed standard of the same general composition, or a quantitative analysis for the elements listed in Appendix C and a summation of their contribution

* Alternate specification shall be submitted to the Buyer for approval before

to the equivalent boron content. Factors for converting constituent concentrations to equivalent boron concentrations are given in the Equivalent Boron Content Specification (See JN-S30100).

3.3 Mechanical Properties

3.3.1 Tensile Properties

The tubing shall have the following minimum tensile properties at designated temperatures when tested in accordance with procedures prescribed in ASTM Standard E8-69 and E21-70.

	<u>Room Temperature</u>	<u>650°F</u>
Ultimate Strength	100,000 psi	70,000 psi
Yield Strength (0.2% offset)	75,000 psi	60,000 psi
Elongation in 2 in.	20% min.	

3.3.2 Grain Size

Two metallographic specimens, one longitudinal and one transverse section, shall be selected at random from each lot for grain size determination. The maximum grain size shall be ASTM Micro-Grain Size Number 7.0, as specified in ASTM-E-112-63, "Estimating the Average Grain Size of Metals".

3.3.3 Burst Test

A section of tubing from each lot shall be hydrostatically tested to failure in an open-end burst test at room temperature. The minimum tube length shall be 10 inches. The pressure shall be increased uniformly over a minimum period of five minutes. The minimum burst pressure shall be reported to the Buyer.

Circumferential Elongation

The minimum circumferential elongation shall be determined by the following formula and reported to the Buyer.

$$\% \text{ Elongation} = \frac{C_1 - C_2}{C_1} \times 100$$

where C_1 = Original circumference = (nominal outside diameter).

C_2 = Final circumference to be measured on the fractured burst test specimen. (This measurement does not include the distance between the fracture faces).

3.3.4 Flare Test

One flaring test per ASTM-A-450-70, shall be made on as-received specimens from each end of one finished tube from each lot.

3.4 Dimensions

3.4.1 Dimensions, tolerances and surface finish for tubing shall conform to the applicable drawings per the job parts list.

3.4.2 Tubes shall be free of bends and kinks; bow in each tube shall not exceed one part in 1200 overall per 0.015 inch in any one 12 inch span as determined by deviation from straight edge or flat surface.

3.5 Surface Condition

The internal and external surfaces of the finished tubing shall be free of scale, grease, metal particles and other foreign matter.

3.6 Defects

Tubing shall be free of burrs, tears, grooves, laminations, slivers or foreign bodies, pits, grinding marks and internal and external imperfections such as handling marks, dents, die, roll, or mandrel marks. In local areas from which metal is removed, displaced, or absent, the defect shall not exceed a depth of .002* inches, width of .004 inches and length of .125 inches. Compliance with the defect requirements shall be established by methods described in Section 3.8.

3.7 Corrosion Resistance

Two representative samples per lot shall be corrosion tested in accordance with ASTM-A262-70, Practice C. The target corrosion rate shall be less than 0.002 inches per month as determined by the average of five 48-hour test periods. The maximum permissible limit is 0.005 inches per month as determined by the average of five 48-hour periods, with no single period rate exceeding 0.006 inches per month.

3.8 Defect Inspection

3.8.1 Ultrasonic Inspection

In order to satisfy the defect criterion stated in paragraph 3.6 above, the tubing shall be 100% nondestructively tested for defects using the submerged tube ultrasonic technique.

The inspection shall be performed with a minimum of 2 transducers. One shall be positioned to inspect for circumferentially oriented defects, and the other shall be positioned to

* Target defect depth .001 inches.

inspect for axially oriented defects. If only 2 transducers are used, the tube shall be inspected twice, the tube being turned end-to-end for the second run. This allows defects to be inspected from opposite sides.

A suitable alternate test can be performed by using 4 transducers and inspecting the tube only once. Two transducers shall be positioned to inspect for circumferentially oriented defects; one shall be angulated to the right and the other angulated to the left. The remaining two transducers shall be positioned to inspect for axially oriented defects. One shall be positioned to send energy clockwise around the tube and the other shall be positioned to send energy counterclockwise around the tube. The ultrasonic test shall be capable of positively detecting defects of sizes given in paragraph 3.6 above.

Test equipment shall be calibrated immediately before and after testing each lot of tubing or at one-hour intervals, whichever is more frequent, and after any test equipment adjustments. If a calibration check indicates the test equipment is operating incorrectly, all tubing tested since the last calibration shall be retested. The calibration standard shall contain both OD and ID square-bottomed defects 0.125 inches long by 0.004 inches wide by 0.002 inches deep. Both transverse and longitudinal defects shall be machined on the surface of the tube standard. The standard shall be

manufactured from tubing of the same size, finish and manufacturing process as the tubing to be inspected.

3.9 Dimensional Inspection

All tubes shall be inspected for dimensions, straightness, surface finish and freedom from stains on a 100 percent basis. Minimum wall thickness shall be inspected using an exacting ultrasonic wall thickness test. Inner and outer diameter measurements shall be on a spiral path of at least 720° every four inches of tubing length. Mechanical gauging equipment which contacts tube inner surfaces shall be free of materials containing chlorides and halides.

3.10 Rework

Repair or rework of any tube shall not impair the mechanical strength, corrosion resistance, or other specified properties of the tube.

Repair and rework procedures shall be approved by the Buyer prior to rework. Reworked parts shall be identified.

4.0 QUALITY ASSURANCE

4.1 Characteristics

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Chemistry	Major	3.1
Equivalent Boron Content	Major	3.2
Tensile-Room Temperature	Critical	3.3
Tensile - 650°F	Critical	3.3
Flare Test	Major	3.3
Burst Test	Critical	3.3
Grain Size	Critical	3.3
Outside Diameter	Major	3.4
Inside Diameter	Critical	3.4

4.1 Characteristics (Continued)

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Minimum Wall Thickness	Critical	3.4
Straightness	Major	3.4
External Surface Finish	Major	3.5
Internal Surface Finish	Critical	3.5
Defects	Critical	3.6
Corrosion Resistance	Critical	3.7

4.2 Traceability

The identity of all material in a lot shall be maintained at all times with respect to starting ingot melt number and tube lot number.

4.3 Final Tube Condition and Shipping

All tubing shall be cleaned and dried prior to final inspection and packaging for shipment or storage. The tubing shall be free of dust, dirt, lubricants, stains, and other foreign material. The tubing shall be packaged, shipped and stored in such a fashion that complete traceability and identification of each tube lot is maintained, and the abrading of tubes is prevented.

4.4 Certification

The Seller shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation.

4.5 Process Description

The Seller shall furnish to the Buyer a description of the process by which production quantities of tubing are to be produced. The purpose of this requirement is to clearly establish the nature of the process steps affecting product quality. The Seller is not required to divulge proprietary techniques. The Seller's process

description shall include, but not be limited to, the following items:

- Hot and cold reduction methods
- Temperatures at which fabricating operations are done
- Magnitudes of reductions
- Cleaning and surface preparation methods
- Heat treating times and temperatures
- Temperature profile of furnace used in intermediate and final product heat treatments
- Quality Control Procedures
- Identification and disposition of nonconforming material
- Identification and marking of conforming products.

APPENDIX A - GLOSSARY OF TERMS

Critical	A specification value, inspection criterion, test result, or defect measure, which if not properly controlled, could result in a reactor fuel failure. A critical defect, for example, is one that (judgment and experience indicate) is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or it is one that (judgment and experience indicate) is likely to prevent performance of the essential function of a components such as a fuel rod, fuel assembly, or fuel reload core.
Major	A specification value, inspection criterion, test result, or defect measure other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in shipping dates. Such a defect, for example, is likely to reduce materially the usability of a product such as a fuel rod or fuel assembly.
Minor	A specification value, inspection criterion, test result or defect measure other than critical or major, which if not controlled, does not materially reduce the usability of the product, such as a fuel rod, for its intended purpose, or is not a departure from established standards significant to the effective use or operation of the product, or affects the appearance only to a minor degree where appearance is a significant characteristic.
Buyer	Jersey Nuclear Company
Seller	Supplier of tubing

Lot

A lot shall be composed of all material of the same size finished from the same ingot and heat treated in the same final vacuum annealing charge. A lot shall consist of units which are successively produced by the same manufacturing processes at essentially the same time. The lot size shall not exceed 7000 feet.

APPENDIX B - REFERENCES

SPECIFICATIONS

ASTM-A213-70	Specification for Seamless Ferritic and Austenitic -
Steel Boiler, Superheater, and Heat-Exchanger Tubes
ASTM E8-69	Methods of Tension Testing Metallic Materials
ASTM E21-70	Elevated Temperature Tension Tests of Materials
ASTM-E-112-63	Estimating the Average Grain Size of Metals
ASTM-A-370-71	Methods and Definitions for the Mechanical Testing
of Steel Products
ASTM-A262-70	Detecting Susceptibility to Intergranular Attack in
Stainless Steel
Mil-Std-271	Non-Destructive Testing Requirements for Metals
ASTM-A450-70	General Requirements for Carbon, Ferritic Alloy and
Austenitic Alloy Steel Tubes

APPENDIX C -- IMPURITY SPECIFICATIONS

In lieu of a comparative reactivity test, the concentration of each of the elements listed below may be determined and used to calculate the total equivalent boron content.

Alloying Elements

Chromium

Iron

Nickel

Impurity Elements

Boron

Cadmium

Cobalt

Dysprosium

Europium

Gadolinium

Manganese

Samarium

Section 3.0. All testing shall be conducted by techniques mutually agreed to by the Buyer and Seller.

*5.4.2 The Seller shall provide to the Buyer documents certifying the isotopic content and identity of the starting material (UF₆) lot, that the powder meets all of the requirements of Section 3.0, and providing test data on the following characteristics:

- Uranium isotopic content
- Individual impurity levels
- Sinterability test results
- Uranium content
- Moisture content

*5.5 Lot Acceptance

Acceptance testing will be performed by the Buyer on a sample taken at the Buyer's plant by sampling one or more individual containers. Acceptance shall be on a lot basis and shall be contingent upon the material properties meeting the requirements of Section 3.0. A description of the lotting procedures shall be submitted to the Buyer for approval.

*5.6 Referee Method

The Buyer and Seller shall agree to third party methods in the event of a dispute in analytical results.

*5.7 Residence Inspection

A representative of the Buyer shall have access to the Seller's production facilities to witness all blending, packaging, sampling, and testing operations. The Seller shall furnish the Buyer a schedule of the aforementioned operations. Witnessing of the operation shall be at the Buyer's discretion.

* For powder purchased offsite.

APPENDIX A - GLOSSARY OF TERMS

Critical	A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
Major	A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
Minor	A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.
Buyer	Jersey Nuclear Company
Seller	Supplier of uranium dioxide.

APPENDIX B - REFERENCES

Specifications

ASTM-B329- 70

Apparent Density of Refractory
Metals and Compounds by the
Scott Volumeter

ASTM-B214-66

Sieve Analysis of Granular Metal
Powders

APPENDIX C - IMPURITY SPECIFICATIONS

The following list of elements require quantitative determination. Where individual element concentration limits are significant, these limits are specified in the first column. The total equivalent boron content shall be determined from a summation of the contribution from each element checked in the EBC column.

<u>Element</u>	<u>Impurity Acceptance Limit (ppm)</u>	<u>EBC</u>
Aluminum -----	100	
Barium -----	250	
Beryllium -----	250	
Boron -----	-----	X
Carbon -----	100	
Calcium plus Magnesium -----	200*	
Cadmium -----	-----	X
Cesium -----	-----	X
Chlorine plus Fluorine -----	125	X
Chromium -----	200	X
Cobalt -----	100	X
Copper -----	250	X
Dysprosium -----	-----	X
Europium -----	-----	X
Gadolinium -----	-----	X
Hafnium -----	-----	X
Iron -----	400**	X
Lead -----	250	
Lithium -----	-----	X+
Manganese -----	250	X
Molybdenum -----	250	X
Nickel -----	200	X
Nitrogen -----	200	X
Phosphorus -----	250	
Samarium -----	-----	X
Silicon -----	200	
Tantalum -----	250	X
Tin -----	250	
Titanium -----	250	X
Tungsten -----	250	X
Vanadium -----	250	X
Zinc -----	250	X
Zirconium -----	250	

Total Impurities -----1500

* Goal limit 100 ppm.

** Virgin powder acceptance limit 250 ppm.

+ Analysis may be waived if assumed to give 1 ppm EBC.

APPENDIX D - SINTERING PERFORMANCE TEST

D.1.1 The purpose of the sintering performance test is to verify the sinterability of each lot of uranium dioxide powder. It is not intended to duplicate the Buyer's pellet fabrication process.

D.1.2 The geometrical density of fired and unfired pellets shall be determined as follows:

Diameter - Record the average of five readings taken at equally spaced intervals along a 180 degree helix beginning and ending 1/16 in. from each end of the pellet, using a blade micrometer and reading to the nearest 0.0002 inch.

Length - Record the average of three readings taken from end to end of the pellet at equally spaced intervals along a vertically bisecting plane using a pointed anvil micrometer and reading to the nearest 0.0002 inch.

Weight - Weigh to the nearest 0.001 g.

Density - Calculate the density to the nearest 0.01 g/cc.

Alternate Test 1

D.2.1 The UO₂ powder shall be pre-slugged to a density of 5.5 g/cc maximum and granulated through a 20 mesh U.S. Standard sieve.

D.2.2 The granulated UO₂ shall be thoroughly blended with 0.3 weight percent dry sterotex.

D.2.3 Ten pellets shall be cold pressed to a maximum density of 6.6 g/cc. The density of each pellet shall vary no more than ± 0.05 g/cc from the average of the ten required test pellets. The density pressing pressure and dwell time (if used) shall be reported.

- D.2.4 The dimensions of the unfired test pellets shall be 0.500 $\pm$ 0.010 in. in diameter and the length-to-diameter ratio shall be unity or greater. The variation in length of the unfired pellets shall be held to $\pm$ 0.020 in. The type of press and pressing conditions shall be reported.
- D.2.5 The pellets shall be fired as one batch in hydrogen or in a dissociated ammonia atmosphere through a firing schedule to allow the pellets to be a maximum of four hours at a maximum temperature of 3000°F. The type of furnace and the atmosphere shall be reported and shall remain unchanged throughout all performance tests. The actual firing schedule shall be mutually agreed upon by the Buyer and Seller.
- D.2.6 The sintered pellets shall have a minimum density of 94 percent of theoretical.

Alternate Test 2

- D.3.1 Ten pellets shall be pressed at each of the following conditions:
- A. The highest green density that can be achieved without end-capping, laminating, etc. Usually this will be in the range of 5.5 to 6.0 gms/cc $\pm$ 2 percent.
 - B. A green density approximately 0.5 gm/cc lower than part A.
 - C. A green density approximately 0.5 gm/cc lower than part B.
- D.3.2 Five pellets from each of the above green densities shall be sintered at 1500°C and five from each density sintered at 1650°C.
- D.3.3 The sintered pellets from at least one of the above tests must have measured densities which fall entirely within the range of percent of theoretical density specified in the appropriate product specification.

MATERIAL SPECIFICATION

1.0 TITLE: Uranium Dioxide Powder

2.0 SCOPE

2.1 This specification describes the material requirements for sinterable uranium dioxide for use in fuel pellets.

2.2 A glossary of terms is given in Appendix A.

2.3 Pertinent references are listed in Appendix B.

2.4 Impurity content specifications are listed in Appendix C.

2.5 Special tests and procedures are given in Appendix D.

3.0 TECHNICAL REQUIREMENTS

3.1 Isotopic Content

The ^{235}U content shall be as specified in the product specification. Blending to adjust the isotopic content after conversion to UO_2 is not permitted except in accordance with separate approved specifications.

3.2 Equivalent Boron Content

The total equivalent boron content (EBC), based on a summation of the contributions from each of the elements indicated in Appendix C, shall not exceed 4.0 ppm on a uranium weight basis. Factors for converting constituent concentrations to equivalent boron concentrations are given in the specification for Equivalent Boron Content.

3.3 Chemical Requirements

3.3.1 Uranium Content: The uranium content shall be a minimum of 87.3 percent by weight on a dry weight basis.

3.3.2 Impurity Content: The impurity content shall not exceed the individual element and total content limits specified in Appendix C, on a uranium weight basis.

3.3.3 Moisture Content: The moisture content shall not exceed 0.80 weight percent.

3.4 Physical Characteristics

3.4.1 Particle Size: All of the uranium dioxide shall be capable of passing through a 20 mesh U.S. Standard Sieve. Sieving practice shall be in accordance with ASTM B214-66.

3.4.2 Bulk Density: Bulk density shall be a minimum of 0.75 g/cc as determined by the Scott Volumeter, ASTM B329-70.

3.5 Sinterability

Test pellets shall be produced and measured in accordance with the dry sintering performance tests described in Appendix D, or the sinterability test given in the applicable process specification.

4.0 PACKAGING AND LABELING

4.1 Packaging *

Uranium dioxide powder shall be packaged in sealed plastic bags placed inside sealed metal containers or in fiberpaks to prevent loss of material and undue contamination** from air or the container materials. The exact size and method of packaging shall be as mutually agreed upon by the Buyer and Seller. For enrichments of 5 percent or less the limit shall be 18 kg per container.

4.2 Identification

Each metal container shall bear a label on the lid and side with the following information:

* For powder purchased offsite.

** Undue contamination is that which leads to impurities in excess of specification.

- Seller's Name *
- Lot Number
- Uranium Weight
- Gross, Tare, Net Oxide Weights
- Material in Container
- Uranium Enrichment
- Purchase Order Number

4.3 Safeguarding*

The containers shall be sealed with AEC approved Automatic Type E seals furnished by the Buyer.

5.0 QUALITY ASSURANCE

5.1 Characteristics

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Isotopic Content	Critical	3.1
Equivalent Boron Content	Major	3.2
Uranium Content	Major	3.3
Impurity Content	Major	3.3
Moisture Content	Major	3.3
Particle Size	Minor	3.4
Bulk Density	Minor	3.4
Sinterability	Major	3.5

5.2 Manufacturing Process *

The Seller shall furnish the Buyer a description of his manufacturing process from receipt of the UF_6 to the packing of the finished product. The intent of this requirement is to clearly identify the process steps affecting product quality, but the Seller is not expected to divulge proprietary techniques. The Seller shall also furnish a description of his quality assurance program to the Buyer. If uranium oxide not conforming to the technical requirements of this

*For powder purchased offsite

specification is introduced into a lot at any point in the manufacturing, blending, or packaging operations, the Seller shall, prior to final packaging of the lot, inform the Buyer of the nature and amount of such material used, and additional tests and analyses performed at the Seller's expense may be required by the Buyer.

5.3 Sampling

5.3.1 A representative sample of powder from each lot shall be taken for the purpose of determining chemical and physical properties and for sintering performance testing.

*5.3.2 The sample shall be of sufficient size to perform quality assurance testing by the Seller. The referee sample shall be clearly identified and retained at the Seller's plant until the lot has been formally accepted by the Buyer.

5.3.3 The lot sample shall be prepared by blending and splitting the container samples.

5.3.4 To obtain a container sample, specimens shall be taken with a thief at random location along any vertical traverse through each container selected at random to be sampled. The thief samples from the selected containers shall then be blended and split down to the required size.

*5.3.5 The number of containers sampled shall be $5 + n/10$, where n is the total number of containers per lot rounded to the nearest decade. If there are five or fewer containers per lot, each container shall be so sampled. Alternate sampling will be accepted if approved.

5.4 Testing and Certification

*5.4.1 The Seller shall test the sample described in Section 5.3 to assure conformance of the powder to the requirements of

* For powder purchased offsite

MATERIAL SPECIFICATION

1.0 TITLE: Zircaloy Tubing

2.0 SCOPE

- 2.1 This specification describes the material requirements for Zircaloy tubing for use as fuel rod cladding in fuel rods.
- 2.2 A glossary of terms is given in Appendix A.
- 2.3 Pertinent references are listed in Appendix B.
- 2.4 Impurity content specifications are listed in Appendix C.
- 2.5 Special Test and Procedures are given in Appendix D.

3.0 TECHNICAL REQUIREMENTS

3.1 Alloy Composition

Zircaloy shall be supplied with an alloy composition in accordance with ASTM-B353-71 Grade RA-1 (Zircaloy-2) or Grade RA-2 (Zircaloy-4).

3.2 Impurity Content

The impurity content shall not exceed the individual element limits specified in Appendix C.

3.3 Sampling

The chemical composition of each lot of tubing shall be verified by analysis of samples taken from the top, middle, and bottom of the starting ingot for alloying elements and impurities.

Samples for nitrogen, hydrogen, and oxygen shall also be taken from each lot of finished tubing.

3.4 Equivalent Boron Content

The total equivalent boron content (EBC) for this material, including impurities, shall not exceed 40 ppm, based on either a comparative reactivity test using an analyzed standard of the same general composition, or a quantitative analysis for zirconium, alloying constituents and the elements listed in Appendix C and a summation of their contribution to the equivalent boron content. Factors for converting constituent concentrations to equivalent boron concentrations are given in the specification for Equivalent Boron Content.

3.5 Mechanical Properties

3.5.1 Stress Relief: The tubing shall be stress relieved at 780° to 1000°F in a vacuum furnace following the final cold working operation.

3.5.2 Tensile Properties: The stress relieved tubing shall have the following minimum tensile properties at room temperature and at 720°F when tested in accordance with the procedures prescribed in ASTM Standards E8-69 & E21-70.

<u>Zircaloy-2</u>	<u>Room Temperature</u>	<u>720°F</u>
Ultimate Tensile Strength	70,000 psi	50,000 psi
Yield Strength (0.2% offset)	60,000 psi	40,000 psi
Elongation in 2 in.	16%	14%
<u>Zircaloy-4</u>		
Ultimate Tensile Strength	90,000 psi	60,000 psi
Yield Strength (0.2% offset)	75,000 psi	45,000 psi
Elongation in 2 in.	15%	14%

3.5.3 Flare Test: A section of fully annealed tubing, approximately 4 in. in length, shall be capable of being flared without cracking visible to the unaided eye. The flare shall be made with a tool having a 60 degree included angle until the specified outside diameter has been increased by at least 15 percent.

3.5.4 Burst Test: A section of tubing from each lot shall be hydrostatically tested to failure in an open-end burst test at room temperature. The minimum tube length shall be 12 inches, and pressure increased uniformly over a minimum period of five minutes. The minimum burst pressure shall be greater than the pressure determined from the following formula:

$$P = \frac{2ST}{D}$$

P = Minimum burst pressure, psig

S = Specified minimum tensile strength, psi

D = Specified tubing outside diameter, inches

T = Specified minimum wall thickness, inches

The circumferential elongation shall be 16%, or greater (14% for Zr-4) as determined by the following formula, on the basis of at least one acceptable test method:

$$E = \frac{C_2 - C_1}{C_1} \times 100$$

E = Percent elongation

C₂ = Final circumference less fracture width

C₁ = Initial circumference

A closed end burst test may be used as an alternate. The supplier may propose test criteria for approval.

3.6 Dimensions

3.6.1 Dimensions, tolerances and surface finish for cladding shall conform to the applicable drawings per the job parts list.

3.6.2 Tubes shall be free of bends and kinks, and bow in each tube shall not exceed one part in 1200 overall or 0.015 inch in any one 12 inch span as determined by deviation from a straight edge or flat surface.

3.7 Surface Finish

The internal and external surfaces of the finished tubing shall be bright etched, free of stains, and have a roughness less than 32 microinches, with a target finish of less than 8 microinches for internal surfaces.

3.8 Defects

The tubes shall be free of inclusions. Voids, laps, seams, cracks, pits, dents, nicks and mars shall not exceed a depth of 0.002 x 0.004 inch wide x .125 inch long as compared with the ultrasonic standard described in paragraph 3.14.2 below.

3.9 Corrosion Resistance

Samples of finished tubing from each lot shall be corrosion tested in accordance with the steam corrosion test of ASTM B 353-71 and ASTM Recommended Practice G-2 for Corrosion Testing of Zirconium Alloys. Maximum weight gain shall not exceed the limits listed in ASTM B 353-71.

3.10 Hydride Orientation

The hydride orientation ratio shall be determined by the procedure described in Appendix D and shall not exceed 0.30.

3.11 Residual Contaminants

During each day of cleaning operation, two representative tubing samples shall be cleaned along with the tubing. One of these samples shall be packaged, sealed and stored in polyethylene plastic tubes and delivered to the Buyer. Complete traceability of these samples to their respective cleaning lots shall be maintained. The other sample shall be subjected to the steam corrosion test of ASTM B 353-71. After cleaning and before testing, only wiping with acetone will be allowed. All corrosion samples may be steam corrosion tested at one time provided complete traceability of the tubing samples to the respective cleaning lots is maintained.

3.12 Grain Size

The grain size of tubing samples annealed at 1250°F for 45 minutes shall not exceed that corresponding to ASTM Micro-grain number 7 in the longitudinal direction and ASTM Micro-grain number 8 in the transverse direction. The grain size of the samples shall be rated in accordance with ASTM E 112-63 "Estimating the Average Grain Size of Metals".

3.13 Manufacturing Process

All tubing shall be manufactured by a seamless process from vacuum melted Zircaloy ingots meeting ASTM Standard B 350-67.

3.14 Ultrasonic Inspection

3.14.1 In order to satisfy the defect criterion stated in paragraph 3.8 above, the tubing shall be 100% nondestructively

tested for defects using the submerged tube ultrasonic technique. The inspection shall be performed with a minimum of 2 transducers. One shall be positioned to inspect for circumferentially oriented defects, and the other shall be positioned to inspect for axially oriented defects. If only 2 transducers are used, the tube shall be inspected twice, the tube being turned end-to-end for the second run. This allows defects to be inspected from opposite sides.

A suitable alternate test can be performed by using 4 transducers and inspecting the tube only once. Two transducers shall be positioned to inspect for circumferentially oriented defects; one shall be angulated to the right and the other angulated to the left. The remaining two transducers shall be positioned to inspect for axially oriented defects. One shall be positioned to send energy clockwise around the tube and the other shall be positioned to send energy counterclockwise around the tube. The ultrasonic test shall be capable of positive detection of defect sizes given in paragraph 3.8 above.

- 3.14.2 Test equipment shall be calibrated immediately before and immediately after each lot of tubing or in one hour intervals, whichever is more frequent, and after any test equipment adjustments. If a calibration check should indicate the test equipment is operating incorrectly, all tubing tested since the last previous satisfactory calibration shall be retested.

The calibration standard shall contain both OD and ID square bottomed defects 0.125 inches long by 0.004 inches wide by 0.002 inches deep. Both transverse and longitudinal defects shall be machined on the surface of the tube standard. The standard shall be manufactured from tubing of the same size, finish and manufacturing process as the tubing to be inspected.

3.15 Dimensional Inspection

Tube lots shall be inspected for straightness, surface finish, and freedom from stains on a 100% basis in conformance with the applicable Quality Control Standards. Minimum wall thickness shall be inspected using an exacting ultrasonic wall thickness test. Inner and outer diameter measurements shall be on a spiral path of at least 720° every four inches of tubing length. Mechanical gauging equipment which contacts tube inner surfaces shall be free of materials containing halides or hydrogenous material unless shown not to prevent the formation of a smooth black lustrous oxide film on the internal surfaces exclusive of cut ends using the steam corrosion test conditions specified in ASTM B353-71. This visual verification shall be made on each lot of tubing, using sample (s) cut from the middle of a full length furnished tube taken from the lot ready for packaging and having completed all normal handling and inspection operations. The combined length of the sample (s) shall be a minimum of 12 inches. The internal surface of the samples shall remain untouched after cutting from the tube.

3.16 Rework

Repair or rework of any tube shall not impair the mechanical strength, corrosion resistance, or other specified properties of the tube.

Repair and rework procedures shall be approved by the Buyer prior to rework. Reworked parts shall be identified.

4.0 QUALITY ASSURANCE

4.1 <u>Characteristics</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Ingot Chemistry	Major	3.1
Tubing Chemistry	Major	3.1
Equivalent Boron Content	Major	3.4
Tensile-Room Temp	Critical	3.5
Tensile - 720°F	Critical	3.5
Flare Test	Major	3.5
Burst Test	Critical	3.5
Outside Diameter	Major	3.6
Inside Diameter	Critical	3.6
Minimum Wall Thickness	Critical	3.6
Straightness	Major	3.6
External Surface Finish	Major	3.7
Internal Surface Finish	Critical	3.7
Defects	Critical	3.8
Corrosion Resistance	Critical	3.9
Hydride Orientation	Critical	3.10
Residual Contaminants	Critical	3.11
Grain Size	Critical	3.12

4.2 Traceability

The identity of all material in a lot shall be maintained at all times with respect to starting ingot melt number and tube lot number.

4.3 Final Tube Condition and Shipping

All tubing shall be etched, cleaned and dried prior to final inspection and packaging for shipment or storage. The tubing shall be free of dust, dirt, lubricants, stains, and other foreign material. The tubing shall be packaged, shipped and stored in such a fashion that

complete traceability and identification of each lot of tubing is maintained and abrading and contamination of tubes is prevented.

4.4 Certification

The Seller shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation. Copies of the latter documentation shall be transmitted to Product Design for review.

4.5 Process Description

The Seller shall furnish to the Buyer a description of the process by which production quantities of tubing are to be produced. A detailed description of the process shall be supplied to the Fuel Design Council. The purpose of this requirement is to clearly establish the nature of the process steps affecting product quality. The Seller is not required to divulge proprietary techniques. The Seller's process description shall include, but not be limited to, the following items:

- Hot and cold reduction methods
- Temperatures at which fabricating operations are done
- Magnitudes of reductions
- Cleaning, etching and surface preparation methods
- Heat treating times and temperatures
- Temperature profile of furnace used in intermediate and final product heat treatments
- Quality Control Procedures
- Identification and disposition of nonconforming material
- Identification and marking of conforming product.

APPENDIX A - GLOSSARY OF TERMS

Critical . A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.

Major A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.

Minor A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

Buyer	Jersey Nuclear Company
Seller	Supplier of Zircaloy tubing.
Lot	That quantity of tubes of the same nominal size and condition originating from one ingot and processed as a job unit to the finished product. Each lot shall receive the final anneal as a unit making up all or part of a single furnace charge.

APPENDIX B - REFERENCESSpecifications

ASTM B353-71	Wrought Zirconium and Zirconium Alloy Seamless and Welded Tubes for Nuclear Service
ASTM E8-69	Methods of Tension Testing Metallic Materials
ASTM E21-70	Elevated Temperature Tension Tests of Materials
ASTM B350-67	Zirconium and Zirconium Alloy Ingots for Nuclear Applications
ASTM E112-63	Estimating the Average Grain Size of Metals
ASTM Recommended Practice G-2 for Corrosion Testing Zirconium Alloys	

APPENDIX C - IMPURITY SPECIFICATIONS

Following is a list of elements which require quantitative determination.

Where individual element concentration limits are significant, these limits are specified in the first column. The total equivalent boron content shall be determined from a summation of the contribution from each element checked in the EBC column.

Element	Impurity Limit (ppm)	EBC
Aluminum*-----	75 -----	
Boron -----		X
Cadmium-----		X
Carbon*-----	270 -----	
Cesium -----		X
Chlorine -----	20 -----	X
Cobalt* -----	20 -----	X
Copper* -----	50 -----	X
Dysprosium -----		X
Europium -----		X
Gadolinium -----		X
Hafnium -----	100 -----	X
Hydrogen* -----	25 -----	X
Lead -----	130 -----	
Magnesium -----	20 -----	
Manganese* -----	50 -----	X
Molybdenum -----	50 -----	X
Nickel (Zircaloy-4 only) -----	70 -----	
Nitrogen* -----	80 -----	X
Niobium -----	120 -----	X
Oxygen -----	1500 -----	
Samarium -----		X
Silicon* (Zircaloy-2) -----	200 -----	X
(Zircaloy-4) -----	120 -----	X
Silver -----		X
Tantalum -----	200 -----	X
Titanium* -----	50 -----	X
Tungsten* -----	100 -----	X
Uranium* -----	3.5 -----	X
Vanadium -----	50 -----	

*These values are consistent with ASTM B353.

APPENDIX D - SPECIAL TESTS AND PROCEDURESHydride Orientation

Two samples per lot of as-finished tubing shall be cleaned and hydrided in 0.25 M LiOH at 680°F (liquid phase) for 36 hours.* The hydrogen content of the hydrided samples shall be 100-150 ppm. A full circumference transverse section shall be taken from each test sample. The wall thickness shall be divided into three equal counting zones representing an outer, middle, and inner section. Each of these sections shall contain a minimum of 100 hydride platelets. The sections shall be prepared for metallographic examination in the 100X to 250X magnification range. The hydride orientation of each sample shall be determined by examining the sample in the "test area" of maximum hydride content in each of the three zones. Hydride platelets oriented within 45° of the radial direction shall be defined as radial platelets. The use of a grid overlay for ease in counting is suggested. The hydride orientation ratio is defined as a number of radial hydride platelets in the test zone divided by the total number of hydrided platelets in the test zone. Each hydrided orientation ratio calculation shall include all the hydrides within the test zone. A test zone may include multiple radial scans in order to obtain 100 hydrides. When a branch of a hydride platelet longer than 1/8 inch (100 magnification) departs from the principal direction of the primary hydride, it is considered a separate hydride platelet. The hydride orientation ratio shall not exceed 0.30 in any of the three zones. 100X to 250X photomicrographs shall be taken of each test area and copies shall be furnished the Buyer as part of the hydride orientation data.

* Alternate methods of introducing hydrogen into the as-finished tubing will be considered subject to written approval by Product Design. Specification No. ZTT-302 by Zirconium Technology Corporation is an acceptable alternate.

ZIRCONIUM TECHNOLOGY CORPORATION
METHOD FOR HYDRIDING F_H SPECIMENS

1. SCOPE

This method is to be used for hydriding reactor-grade Zircaloy tube specimens to determine the hydride orientation factor (F_H).

2. PRINCIPLE

A thin layer of zirconium hydride is formed on the specimen by electrolyzing in dilute H₂SO₄. The electrolyzed sample is "baked" in a helium atmosphere to diffuse atomic hydrogen throughout the tube. Slow cooling to room temperature produces the required hydride platelets uniformly distributed in the Zircaloy matrix.

3. PROCEDURE

3.1 Sample Preparation

Lathe cut a 1 1/4" tube length and mark off a 1" distance, using the lathe or a vibra-tool. Clean the sample thoroughly by immersing in "Bright Dip" until bright and shiny.

3.2 Electrolyzing

Prepare one (1) liter of 0.05 molar H₂SO₄ (96%) by adding 3 ml of conc. acid to deionized H₂O and diluting to 1 liter.

Set up the cell with the cylindrical platinum anode fully immersed and concentrically surrounding the tube section. The sample must only be immersed one (1) inch during the term of electrolyzing. (Add H₂O to line as necessary during run.) All electrolyzing parameters must be carefully controlled to the following values:

Electrolyte-----0.05M H₂SO₄
Temperature-----75°C, with magnetic stirring
Current Density-----100 ma per cm² of sample
Time (Zr-4)-----4 1/5 hours (100 to 125 ppm H₂ level)

The specimen is ready for the "bake" cycle after discarding the 1/4" waste end.

3.3 Bake or Diffusion Cycle

Place specimen in center of stainless steel retort and close flange. Set up getter retort and energize furnace (set to 850°F). Cold purge specimen retort with gettered

SPECIFICATION #Z11-302

PAGE 2

zero-grade helium for 30 minutes and energize specimen furnace. The temperature should reach the diffusion temperature (750°F) in approximately 1 hour. Close retort gas vent and record time. Turn off furnace after 6 hours and allow furnace to cool to room temperature. The specimen is now ready for metallography. Half the specimen should be submitted for hydrogen determination.

Submitted by: Clark M. Owens
Clark M. Owens
Laboratory Manager

Approved by: Ivan Baksay
Ivan Baksay
Quality Control Manager

CMO:cmp
5/11/70

MATERIAL SPECIFICATION

1.0 TITLE: 304L ROD AND BAR STOCK

2.0 SCOPE

2.1 This specification describes the material requirements for the 304L stainless steel rod and bar stock for use in fabricating fuel assembly components.

2.2 A glossary of terms is given in Appendix A.

2.3 Impurity list for EBC evaluation is given in Appendix B.

3.0 TECHNICAL SPECIFICATIONS

3.1 Alloy Composition

304L stainless steel rod and bar stock shall be supplied with an alloy composition in accordance with ASTM A276-70 or later version or an equivalent specification*.

3.2 Equivalent Boron Content

For components used in the core region, the total equivalent boron content (EBC) for bar stock, including impurities, shall not exceed 850 ppm, based on either a comparative reactivity test using an analyzed standard of the same general composition, or a quantitative analysis for the elements listed in Appendix B and a summation of their contribution to the equivalent boron content.

* An equivalent specification is one which is approved by Fuel Design and Engineering as having equivalent chemical composition limits, mechanical and corrosion properties or any other property judged to be critical.

XN-S30086, Revision 6

Factors for converting constituent concentrations to equivalent boron concentrations are given in the specifications for equivalent boron content.

3.3 Mechanical Properties

The mechanical properties shall conform to those listed in ASTM A276-70 or later version.

3.4 Surface Condition

The surface condition and finish shall preferably conform to that specified in ASTM A276-70 or later version for hot-finished stock.

3.5 Heat Treatment

Heat treatment shall conform to that specified in ASTM A276-70 or later version, Condition A, annealed.

3.6 Corrosion Resistance

A representative sample from a heat lot shall be corrosion tested in accordance with XN-S30378.

4.0 QUALITY ASSURANCE

4.1 Characteristics

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Alloy Composition	Major	3.1
Carbon Content	Critical	3.1
Mechanical Properties	Major	3.2
Surface Condition	Major	3.3
Heat Treatment	Major	3.4
Corrosion Resistance	Critical	3.5

XN-S30086, Revision 6

4.2 Certifications

The Seller shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation.

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MATERIAL SPECIFICATION1.0 TITLE: Inconel 718 Sheet Stock2.0 SCOPE

2.1 This specification describes the material requirements of Inconel 718 sheet for use in fuel assembly components.

2.2 A glossary of terms is given in Appendix A.

2.3 Pertinent references are listed in Appendix B.

2.4 Significant elements for equivalent boron content determination are listed in Appendix C.

3.0 TECHNICAL REQUIREMENTS

3.1 Alloy Composition: Alloying and impurity elements shall be as specified in AMS 5596 C, or an equivalent specification*, except that the requirements of Section 3.2 must be met.

3.2 Equivalent Boron Content: The total equivalent boron content (EBC) for this material, including impurities, shall not exceed 1250 ppm, based on either a comparative reactivity test using an analysis standard of the same general composition, or a quantitative analysis for the elements listed in Appendix C and a summation of their contribution to the equivalent boron content. Factors for converting constituent concentrations to equivalent boron concentrations are given in the specification for equivalent boron content.

3.3 Mechanical Properties: The mechanical properties shall conform to those listed in AMS 5596 C or an equivalent specification, excluding hardness, 1200°F tensile and stress rupture testing.

* Equivalent specification is one which has equivalent chemical composition limits, mechanical and corrosion properties or any other properties judged to be critical.

XN-530088, Revision 5

- 3.4 Surface condition: the surface finish shall conform to that specified on AMS-5596 C or better.
- 3.5 Metallurgical Condition: Solution heat treatment, grain size and other metallurgical characteristics shall conform to that specified in AMS 5596 C or an equivalent specification.

4.0 QUALITY ASSURANCE

4.1 Characteristics:

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Alloy Composition	Critical	3.1
Equivalent Boron Content	Major	3.2
Mechanical Properties	Critical	3.3
Surface Condition	Critical	3.4
Metallurgical Condition	Critical	3.5

- 4.2 Certification: The Seller shall certify that he has complied with all parts of this specification or shall provide inspection and test results as required in the purchase order documentation.

APPENDIX A - GLOSSARY OF TERMS

Critical	A specification value, inspection criterion, test result or defect measure, which, if not properly controlled, could result in a reactor fuel failure. A critical defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or it is one that judgment and experience indicate is likely to prevent performance of the essential function of a component such as a fuel rod, fuel assembly, or fuel reload core.
Major	A specification value, inspection criterion, test result or defect measure, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in shipping dates. Such a defect, for example, is likely to reduce materially the usability of a product such as a fuel rod or fuel assembly.
Minor	A specification value, inspection criterion, test result or defect measure, other than critical or major, which if not controlled, does not materially reduce the usability of the product such as a fuel rod for its intended purpose, or is not a departure from established standards significant to the effective use or operation of the product, or affects the appearance only to a minor degree where appearance is a significant characteristic.
Buyer	Exxon Nuclear Company, Inc.
Seller	Supplier of Inconel 718 Sheet Material
Lot	A lot is defined as a quantity of parts or material of the same ingot, condition, design, size and processed as a job unit to the finished product.

APPENDIX B - REFERENCES

Specifications

AMS-5596 C

Alloy Sheet, Strip and Plate
Corrosion and Heat Resistant

XN 530088 Revision 5

APPENDIX C - IMPURITY SPECIFICATIONS

In lieu of a comparative reactivity test, the concentration of each of the elements listed below may be determined and used to calculate the total equivalent boron content.

Alloying Elements

Chromium
Iron
Molybdenum
Nickel
Tantalum
Titanium

Impurity Elements

Boron
Cobalt
Dysprosium
Europium
Gadolinium
Manganese
Samarium

JN-S30,088 Revision 0
Issue Date: 12/1/71JERSEY NUCLEAR COMPANYMATERIAL SPECIFICATION

Title: Inconel 718 Sheet Stock

Supersedes Issue Dated: NEW

Fuel Design Council MembersRecom-
mend

Approval:

George J. Soper
Manager, Product Design

Concur:

R. Wilson
Manager, Quality Assurance
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Coordinator

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Donald For R. Kelly
Manager, Process Design

Accepted:

J. Brown
Manager, Fuel Management
ServicesOther AcceptancesD. F. Cornell 12-28-71
Manager, Quality ControlR. W. Carls
Manager, Materials

Approved:

A. P. Bupp
Manager, Research and Engineering

MATERIAL SPECIFICATION

1.0 TITLE: 304L SHEET AND PLATE STOCK

2.0 SCOPE

- 2.1 This specification describes the material requirements for the 304L stainless steel sheet and plate used in fabricating fuel assembly components.
- 2.2 A glossary of terms is given in Appendix A.
- 2.3 A list of elements significant in the determination of equivalent boron content is given in Appendix B.
- 2.4 Radiography sampling procedure is given in Appendix C.

3.0 TECHNICAL SPECIFICATIONS

- 3.1 Alloy Composition: 304L stainless steel sheet and plate shall be supplied with an alloy composition in accordance with ASTM A240-70, or an equivalent specification*, except that the requirements of Section 3.2 must be met for sheet used in fabricating spacer grid components.
- 3.2 Equivalent Boron Content: The total equivalent boron content (EBC) including impurities, for sheet stock used within active zone of a reactor, shall not exceed 850 ppm, based on either a comparative reactivity test using an analyzed standard of the same general composition, or a quantitative analysis for the elements listed in Appendix B and a summation of their contribution to the equivalent boron content. Factors for converting constituent concentrations to equivalent boron concentrations are given in the specification for equivalent boron content.

* An equivalent specification is one which has equivalent chemical composition limits, mechanical and corrosion properties or any other properties judged to be critical and shall be approved by Fuel Design & Engineering.

- 3.3 Mechanical Properties: The mechanical properties shall conform to those listed in ASTM A240-70 or later version.
- 3.4 Surface Condition: The surface condition and finish shall preferably conform to that specified in ASTM A480-70, or later version, #2B finish for sheet and #1 finish for plate.
- 3.5 Heat Treatment: Heat treatment shall conform to that specified in ASTM A240-70 annealed or later version for annealed material.
- 3.6 Corrosion Resistance: A representative sample from a heat lot shall be corrosion tested in accordance with XN-S30378.
- 3.7 Ultrasonic Examination: Plate stock (thickness $\geq 3/16"$) shall be examined as follows:

This examination is intended to assure quality of plate, or parts fabricated from the plate, when the thickness remains substantially unaltered after testing. If, in subsequent operations or fabrication, the thickness is reduced below 80 percent of the tested thickness, alternate test procedures or acceptance criteria may be imposed in lieu of, or in addition to, this test. Such alternates will be specified in the appropriate Product Specification or in purchasing documentation.

- 3.7.1 Plates in all thickness shall be examined by the longitudinal wave method in accordance with ASTM A578-75 or later version; supplementary requirements S1 through S4 shall apply. Examination shall be performed over 100 percent of one major plate surface with at least 10 percent overlap with each pass. The test apparatus shall be capable of detecting flat-bottomed referenced holes as specified in Table I. A description of the calibration standard shall be supplied to the Buyer.

XN-S30091, Revision 9

Acceptance Criteria - The following indications or conditions are unacceptable:

- 1) for thicknesses ≥ 1 inch, any indication with amplitude equal to that of the signal from the reference hole.
- 2) for all thicknesses, any condition which causes 90 percent loss of back reflection.

3.7.2 Plates ≤ 2 inches in thickness shall be examined by the angle beam method in accordance with ASTM A577-70a or a later version. Scan paths shall be sufficiently close together to assure 100 percent inspection of the plate at the required sensitivity level. Continuous scanning shall be employed in directions parallel and perpendicular to the longitudinal axis of the plate.

Acceptance Criteria - The following indications are unacceptable:

- 1) Any indications with amplitude equal to or greater than that produced by the reference notch.

Table I

Flat-Bottomed Hole Sizes for Longitudinal Wave Calibration

<u>Section Thickness</u>	<u>Hole Diameter</u>	<u>Hole Depth</u>
1" to 2"	3/16"	25% thickness
2" to 3"	1/4"	1/2"
3" to 8"	1/2"	the greater of 1/2" or 10% thickness

3.7.3 Radiography procedure approved by Fuel Design and Engineering will be considered as an acceptable alternate to the above ultrasonic examination. The X-ray sampling procedures are given in Appendix D.

4.0 QUALITY ASSURANCE

4.1 Characteristics

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Alloy Composition	Major	3.1
Carbon Content	Critical	3.1
Equivalent Boron Content	Major	3.2
Mechanical Properties	Critical	3.3
Surface Condition	Major	3.4
Heat Treatment	Major	3.5
Corrosion Resistance	Critical	3.6
Ultrasonic Inspection	Critical	3.7

4.2 Certification

The Seller shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation.

XN-S30091, Revision 9

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification value, inspection criterion, test result, or defect measure, which if not properly controlled, could result in a reactor fuel failure. A critical defect, for example, is one that (judgment and experience indicate) is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or it is one that (judgment and experience indicate) is likely to prevent performance of the essential function of a components such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification value, inspection criterion, test result, or defect measure other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in shipping dates. Such a defect, for example, is likely to reduct materially the usability of a product such as a fuel rod or fuel assembly.
- Minor** A specification value, inspection criterion, test result or defect measure other than critical or major, which if not controlled, does not materially reduce the usability of the product, such as a fuel rod, for its intended purpose, or is not a departure from established standards significant to the effective use or operation of the product, or affects the appearance only to a minor degree where appearance is a significant characterisitc.

Buyer Exxon Nuclear Company, Inc.

Seller Supplier of Stainless Steel Sheet Material

Lot A quantity of sheet or plate originating from one heat and processed under the same specified conditions to the finished product.

APPENDIX B - IMPURITY SPECIFICATIONS

In lieu of a comparative reactivity test, the concentration of each of the elements listed below may be determined and used to calculate the total equivalent boron content.

Alloying Elements

Chromium

Iron

Nickel

Impurity Elements

Boron

Cadmium

Cobalt

Dysprosium

Europium

Gadolinium

Manganese

Samarium

APPENDIX C

X-Ray Sampling Procedure

<u>Lot Size</u>	<u>Sample Size</u>	<u>Lot Size</u>	<u>Sample Size</u>
2-4	all	18-27	7
5-6	4	28-48	8
7-11	5	49 and over	9
12-17	6		

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$$\text{EBC (ppm)} = \sum_i (\text{EBC Factor})(\text{ppm element})$$

where σ_a = the 2200 m/sec thermal neutron cross section
in barns

i = index for all significant elements.

A list of EBC factors is given in Appendix A for convenience in determining the equivalent boron content contribution from each element. When an analytical result is expressed as less than some value, one half of that value shall be used in calculating the EBC.

- 3.3 Where the EBC is determined by a comparative reactivity test the reported value shall be used directly.

XN-S30086, Revision 6

APPENDIX B - IMPURITY SPECIFICATIONS

In lieu of a comparative reactivity test, the concentration of each of the elements listed below may be determined and used to calculate the total equivalent boron content:

Alloying Elements

Chromium

Iron

Nickel

Impurity Elements

Boron

Cadmium

Cobalt

Dysprosium

Europium

Gadolinium

Manganese

Samarium

MATERIALS SPECIFICATION

1.0 TITLE: SILVER-INDIUM-CADMIUM ALLOY ROD

2.0 SCOPE:

2.1 This specification describes the material requirements for silver-indium-cadmium alloy rod for use in control rod assemblies.

2.2 A glossary of terms is given in Appendix A.

2.3 Impurity Specifications are listed in Appendix B.

3.0 TECHNICAL SPECIFICATIONS

3.1 Alloy Composition: The alloy shall be supplied with the following composition:

<u>Element</u>	<u>Weight Percent</u>
Silver	80 $\pm$ 0.5
Indium	15 $\pm$ 0.25
Cadmium	5 $\pm$ 0.25

3.2 Impurity Content: The impurity content shall not exceed the limits specified in Appendix C.

3.3 Dimensions: The dimensions, tolerances and surface finish shall conform to those given in the applicable drawing per the job/parts list.

3.4 Density: The alloy rod as fabricated density shall be at least 9.5 g/cm³ and no greater than 10.3 g/cm³ as determined from a full length rod.

- 3.5 Cleanliness: The rod surface shall be clean and free of all extraneous materials such as grease, dust, lint or finger marks.

4.0 QUALITY ASSURANCE

4.1 Characteristics

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material	Critical	3.1
Impurity Content	Major	3.2
Diameter	Critical	3.3
Other Dimensions	Major	3.3
Density	Major	3.4
Cleanliness	Major	3.1.5

- 4.2 Traceability: The identity of all material shall be maintained with respect to the starting melt number.
- 4.3 Shipping and Storage: Shipping, storage and handling of the rods shall be such that conformance to this specification is maintained.
- 4.4 Sampling: Appropriate samples shall be taken to ascertain the chemical homogeneity of the alloy source material.

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - IMPURITY SPECIFICATIONS

Following is a list of elements which require quantitative determination for determination of the total impurity content. Also listed are individual element concentration limits where significant.

<u>Element</u>	<u>Impurity Limit</u> (ppm)
Bismuth	300
Copper	---
Iron	---
Lead	300
Magnesium	---
Manganese	---
Nickel	---
Silicon	---
Zinc	---
Total	2000

MATERIAL SPECIFICATION

1.0 TITLE: ZIRCALOY TUBING, GUIDE TUBE

2.0 SCOPE:

2.1 This specification describes the material requirements for Zircaloy-4 tubing for use as guide tubes in Loft Type F fuel assemblies.

2.2 A glossary of terms is given in Appendix A.

2.3 Pertinent references are listed in Appendix B.

2.4 Impurity content specifications are listed in Appendix C.

2.5 Hydriding Test Procedures are given in Appendix D.

2.6 Burst Test Procedures are given in Appendix E.

3.0 TECHNICAL REQUIREMENTS

3.1 Alloy Composition

Zircaloy shall be supplied with an alloy composition in accordance with ASTM-B353-71 Grade RA-2, Zircaloy-4.

3.2 Impurity Content

The impurity content shall not exceed the individual element limits specified in Appendix C.

3.3 Sampling

The chemical composition of each lot of tubing shall be verified by analysis of samples taken from the top, middle, and bottom of the starting ingot for alloying elements and impurities. Samples for nitrogen, hydrogen, and oxygen shall also be taken from each lot of finished tubing.

3.4 Equivalent Boron Content

The total equivalent boron content (EBC) for this material,

JN-S30247, Revision 1

Including impurities, shall not exceed 40 ppm, based on either a comparative reactivity test using an analyzed standard of the same general composition, or a quantitative analysis for zirconium, alloying constituents and the elements listed in Appendix C and a summation of their contribution to the equivalent boron content. Factors for converting constituent concentrations to equivalent boron concentrations are given in the specification for Equivalent Boron Content.

3.5 Mechanical Properties

3.5.1 Stress Relief: The tubing shall be annealed between 780° to 1000° F in a vacuum furnace following the final tube reduction operation.

3.5.2 Tensile Properties: The stress relieved tubing shall have the following minimum tensile properties at room temperature and at 600° F when tested in accordance with the procedures prescribed in ASTM Standards E8-69 and E21-70.

<u>Zircaloy-4</u>	<u>Room Temperature</u>	<u>600°F</u>
Ultimate tensile strength	80,000 psi	60,000 psi
Yield strength (0.2% Offset)	60,000 psi	40,000 psi
Elongation in 2 in.	16%	15%

The above minimum tensile properties may be established on the basis of average values of two or more samples where no single value falls more than 5% below the specified level.

3.5.3 Burst Test

Samples of as-fabricated tubing from each lot shall be closed end burst tested to failure at room temperature (procedure described in Appendix E). The minimum burst pressure shall be greater than the pressure determined from the following formula:

$$P = \frac{2ST}{D}$$

P = Minimum burst pressure, psig

S = Specified minimum tensile strength, psi

D = Specified tubing outside diameter, inches

T = Specified minimum wall thickness, inches

The total circumferential elongation shall be determined by the following formula:

$$\epsilon = \frac{C_f - C_i}{C_i} 100$$

where ϵ = Percent elongation

C_f = Final circumference less fracture width

C_i = Initial circumference

The circumferential ductility shall not be less than:

Avg. Min. Value	15%
Single Value	10%

3.6 Dimensions

Dimensions, tolerances and surface finish for cladding shall conform to the applicable drawings per the job parts list.

3.7 Surface Condition

The internal surface of the tubing shall be bright-etched and the external surface shall be either bright-etched or belt-polished. All surfaces shall be free of stains and regions indicating preferential etching. If belt polishing is used, it shall be with a 400 grit (mesh) or finer, silicon carbide or aluminum oxide belt.

3.8 Defects

The tubes shall be free of inclusions, voids, laps, seams and preferential etched areas. Dents, nicks, marks, or scratches shall not exceed a depth of 0.002 inch, as determined by visual inspection and resultant measurements or with the ultrasonic testing procedures described in paragraph 3.14 of this specification.

3.9 Corrosion Resistance

Samples of finished tubing from each lot shall be corrosion tested in accordance with ASTM Recommended Practice G-2 for Corrosion Testing of Zirconium Alloys. Maximum weight gain shall not exceed 22 mg/dm^2 for three day test, or 38 mg/dm^2 for 14 day test.

3.10 Hydride Orientation

The hydride orientation ratio shall be determined by the procedure described in Appendix D and shall not exceed 0.30.

3.11 Residual Contaminants

Samples of finished tubes shall be selected from each lot for determination of residual contamination on the inside surface. The samples shall be subjected to the steam corrosion test described in ASTM G-2.

The only additional cleaning permitted on the samples prior to corrosion testing is wiping with acetone. A weight gain determination on these samples is not required. The internal surface of the samples shall exhibit a smooth, black, lustrous oxide film, as compared to acceptance standards agreed upon by Exxon Nuclear and the tubing producer.

3.12 Grain Size

The grain size of tubing samples annealed at 1250°F for 45 minutes shall not exceed that corresponding to ASTM micro-grain number 7 in the longitudinal direction and ASTM micro-grain number 8 in the transverse direction. The grain size of the samples shall be rated in accordance with ASTM E-112-63, "Estimating the Average Grain Size of Metals."

3.12 Manufacturing Process

All tubing shall be manufactured by a seamless process from vacuum melted zircaloy ingots meeting ASTM Standard B-350-67.

3.14 Ultrasonic Inspection

3.14.1 In order to satisfy the defect criterion stated in paragraph 3.8 above, the tubing shall be 100% nondestructively tested for defects using the submerged tube ultrasonic technique. The inspection shall be performed with a minimum of two transducers. One shall be positioned to inspect for circumferentially oriented defects, and the other shall be positioned to inspect for axially oriented defects. If only two transducers

are used, the tube shall be inspected twice, the tube being turned end-to-end for the second run. This allows defects to be inspected from opposite sides.

A suitable alternate test can be performed by using four transducers and inspecting the tube only once. Two transducers shall be positioned to inspect for circumferentially oriented defects; one shall be angulated to the right and the other angulated to the left. The remaining two transducers shall be positioned to inspect for axially oriented defects. One shall be positioned to send energy clockwise around the tube and the other shall be positioned to send energy counterclockwise around the tube. The ultrasonic test shall be capable of positive detection of defect sizes given in paragraph 3.8 above. The maximum acceptable ultrasonic signal shall not exceed the amplitude obtained from an E.D.M. standard notch described in paragraph 3.14.2.

- 3.14.2 Test equipment shall be calibrated immediately before and immediately after each lot of tubing or in one hour intervals, whichever is more frequent, and after any test equipment adjustments. If a calibration check should indicate the test equipment is operating incorrectly, all tubing tested since the last previous satisfactory calibration shall be retested.

The calibration standard shall contain both OD and ID square bottomed defects 0.063 inch long by 0.004 inch wide by 0.002 inch deep perpendicular to the tube surfaces. Both transverse and longitudinal defects shall be machined on the surface of the tube standard. The standard shall be manufactured from tubing of the same size, finish and manufacturing process as the tubing to be inspected.

3.15 Dimensional Inspection

Tube lots shall be inspected for OD, ID, wall thickness, straightness, surface finish, and freedom from stains on a 100% basis in conformance with the applicable Quality Control Standards. Minimum wall thickness shall be inspected using an exacting ultrasonic wall thickness test. Inner and outer diameter measurements shall be on a spiral path of at least 720° every four inches of tubing length. Mechanical gauging equipment which contacts tube inner surfaces shall be free of materials containing halides or hydrogenous material unless shown not to prevent the formation of a smooth black lustrous oxide film on the internal surfaces exclusive of cut ends using test conditions in Section 3.11.

- 3.16 Repair or rework of any tube shall not impair the mechanical strength, corrosion resistance, or other specified properties of the tube. Repair and rework procedures shall be approved by the Buyer prior to rework. Reworked parts shall be identified.

4.0 QUALITY ASSURANCE

4.1 <u>Characteristics</u>	<u>Classification</u>	<u>Applicable Section</u>
Ingot Chemistry	Critical	3.1
Tubing Chemistry	Critical	3.1
Equivalent Boron Content	Major	3.4
Tensile-Room Temperature	Major	3.5
Tensile - 720° F	Critical	3.5
Burst Test (TCE)	Critical	3.5
Outside Diameter	Major	3.6
Inside Diameter	Critical	3.6
Minimum Wall Thickness	Critical	3.6
Straightness	Major	3.6
Other Dimensions	Minor	3.6
External Surface Finish	Major	3.7
Internal Surface Finish	Critical	3.7
Defects	Critical	3.8
Corrosion Resistance	Critical	3.9
Hydride Orientation	Critical	3.10
Residual Contaminants	Critical	3.11
Grain Size	Critical	3.12
Tube Manufacturing Process	Critical	3.13

4.2 Traceability

Material identification shall be maintained at all times to assure its traceability to the starting ingot and tube lot number.

4.3 Final Tube Condition and Shipping

All tubing shall be clean and dry, i.e., free of dust, dirt, lubricants, stains, and other foreign material prior to packaging for shipment or storage. The tubing shall be packaged, shipped and stored in such a fashion that abrading or contamination of tubes is prevented, and that identification of each tubing lot is maintained.

4.4 Certification

The Seller shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation.

4.5 Process Description

The Seller shall furnish to the Buyer a description of the process by which production quantities of tubing are to be produced. A detailed description of the process shall be supplied to the Fuel Design Council. The purpose of this requirement is to clearly establish the nature of the process steps affecting product quality. The Seller is not required to divulge proprietary techniques. The Seller's process description shall include, but not be limited to, the following items:

- Hot and cold reduction methods
- Temperatures at which fabricating operations are done
- Cleaning, etching and surface preparation methods
- Heat treating times and temperatures
- Temperature profile of furnace used for final product anneal
- Quality Control Procedures
- Identification and disposition of nonconforming material
- Identification and marking of conforming product
- Final reduction Q values, i.e., ratio of wall reduction to diameter reduction.

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

JN 530247, Revision 1

Buyer Exxon Nuclear Company, Inc.
Seller Supplier of Zircaloy Tubing
Lot That quantity of tubes of the same nominal size and condition originating from one ingot and processed as a job unit to the finished product. Each lot shall receive the final anneal as a unit making up all or part of a single furnace charge.

JN-S30247, Revision 1

APPENDIX B - REFERENCES

Specifications

ASTM B353-71

Wrought Zirconium and Zirconium Alloy
Seamless and Welded Tubes for Nuclear
Service

ASTM E8-69

Methods of Tension Testing Metallic
Materials

ASTM E21-70

Elevated Temperature Tension Tests of
Materials

ASTM B350-67

Zirconium and Zircaloy Alloy Ingots
for Nuclear Applications

ASTM E112-63

Estimating the Average Grain Size of
Metals

ASTM Recommended Practice G-2 for Corrosion Testing Zirconium Alloys

APPENDIX C - IMPURITY SPECIFICATIONS

Following is a list of elements which require quantitative determination.

Where individual element concentration limits are significant, these limits are specified in the first column. The total equivalent boron content shall be determined from a summation of the contribution from each element checked in the EBC column.

<u>Element</u>	<u>Impurity Limit (ppm)</u>	<u>EBC</u>
Aluminum*	75	X
Boron		X
Carbon*	270	
Cesium		X
Chlorine	20	X
Cobalt*	20	X
Copper*	50	X
Syprosium		X
Europium		X
Gadolinium		X
Hafnium	100	X
Hydrogen*	25	X
Lead	130	
Magnesium	20	
Manganese*	50	X
Molybdenum	50	X
Nickel	70	
Nitrogen	80	X
Niobium	120	X
Oxygen	1500	
Samarium		X
Silicon*	120	X
Silver		X
Tantalum	200	X
Titanium*	50	X
Tungsten*	100	X
Uranium*	3.5	X
Vanadium	50	

* These values are consistent with ASTM B353

APPENDIX D - HYDRIDING TEST PROCEDURES

Two samples from each lot of tubing shall be cleaned and hydrided. A full circumference traverse section (complete cross-section) shall be taken from each section. The wall thickness of each sample shall be divided into three equal counting zones representing an outer, middle and inner section. The tubing producer's method of hydriding the samples shall assure that each of the counting zones contain a minimum of 100 hydride platelets.*

The sections shall be prepared for metallographic examination in the magnification range of 100X to 250X. The hydride orientation of each sample shall be determined by examining the sample in the "test area" of maximum hydride content in each of the three zones. A test area may include multiple radial scans on a sample in order to obtain the required count of 100 platelets. The use of a grid overlay for each zone of counting is suggested.

Hydride platelets oriented within 45° of the radial direction shall be defined as radial platelets. When a branch of a hydride platelet longer than $1/8$ inch (100 magnification) departs from the principal direction of the primary hydride, it shall be considered a separate hydride platelet.

The hydride orientation ratio is defined as the number of radial hydride platelets in the test zone divided by the total number of hydride platelets in the test zone. Each ratio calculation shall

include all the platelets within the test zone. The hydride orientation ratio shall not exceed 0.30 in any of the three zones. Photomicrographs at 100X to 250X magnification shall be taken of each test area and copies furnished to the Buyer as part of the tubing certification data.

* Hydriding process shall be reviewed by Product Design. Hydriding methods presently used are as follows:

- 1) 0.25 M LiOH at 680° F (liquid phase) for 36 hours.
- 2) Electrolytic using 0.05 M H₂SO₄, 75° C, current density 100 ma/cm² for four to five hours.
- 3) Three day corrosion per ASTM Recommended Practice G-2.

APPENDIX F

PROCEDURE FOR
PERFORMING A CLOSED-END BURST TEST OF ZIRCALOY CLAD TUBING

PURPOSE

To determine the burst test mechanical properties of zirconium base alloy tubing to be used for fuel rod cladding.

PROCEDURES

The pressurizing rate shall be 2000 ± 500 psi/min. to insure the minimum variation in testing procedures and to insure the best comparison of the test results.

SPECIMEN PREPARATION

1. Length = 9 inches minimum.
2. Minimum length between end fittings = 6 inches.
3. End fittings must be such as to produce 2:1 circumferential to axial stress ratio, i.e., non-restricted closed end fittings.
4. Mandrels shall be used which meet the following requirements:
 - A. Mandrel O.D. = Mean I.D. of tube minus 20 mils $\pm$ 2 mils.
 - B. Ends of mandrel shall be tapered in such a manner as not to restrict axial deformation of tubing during test.
5. All free gases to be vented from specimen prior to test.

SPECIMEN DATA

1. Measurements of O.D. and wall thickness at three equally spaced locations around circumference at each end of specimen.
2. Pretest measurements shall be to an accuracy of ± 0.001 inch.

3. Post test circumferential elongation shall be determined to an accuracy of ± 0.010 inch using shim stock as measurement gauge.

TEST DATA TO BE REPORTED

1. Measurements taken from test specimens.
2. Maximum fluid pressure.
3. Ultimate hoop strength calculated by the formula

$$s = \frac{PD}{2t}$$

where

s = ultimate hoop strength, psi

P = maximum fluid pressure, psi

D = average mean diameter, inches
(avg. OD - avg. wall thickness)

t = minimum wall thickness, inches

4. Total circumferential elongation.

MATERIAL SPECIFICATION

1.0 TITLE: 304L STAINLESS STEEL TUBING

2.0 SCOPE

2.1 This specification describes the material requirements for 304L stainless steel tubing used for differential pressure tube assembly.

2.2 A glossary of terms is given in Appendix A.

2.3 Pertinent references are listed in Appendix B.

3.0 TECHNICAL SPECIFICATIONS

3.1 Material and Manufacture

Except as amended by this specification, the 304L stainless steel tubing shall be supplied in accordance with ASTM A269-71, cold drawn and solution annealed. The completeness of the last solution anneal shall be verified by metallographic examination; no continuous carbide precipitation network is permitted in grain boundaries.

3.2 Mechanical Properties

3.2.1 Tensile Properties

The tubing shall have the following minimum tensile properties at designated temperatures when tested in accordance with procedures prescribed in ASTM Standard E8-69 and E21-70.

	<u>Room Temperature</u>	<u>650°F</u>
Ultimate Strength	70,000 psi	55,000 psi
Yield Strength (0.2% offset)	25,000 psi	15,200 psi
Elongation in 2 in.	20% min.	

3.3 Hydrostatic Test

Each tube shall be subjected to room temperature hydrostatic testing at the test pressure of 4300 psi. Pressure shall be maintained for a period sufficient to allow careful visual inspection of the full tested length for leaks or deformation.

3.4 Dimensions

3.4.1 Dimensions for tubing shall conform to the applicable drawings per the job parts list.

3.4.2 Tubes shall be free of bends and kinks; bow in each tube shall not exceed 0.030 inch in any one 12 inch span as determined by deviation from straight edge or flat surface.

3.5 Surface Condition

The internal and external surfaces of the finished tubing shall be free of scale, grease, metal particles and other foreign matter.

3.6 Defects

Tubing shall be free of burrs, tears, grooves, laminations, slivers or foreign bodies, pits, grinding marks and internal and external imperfections such as handling marks, dents, die, roll, or mandrel marks. In local external areas from which metal is removed, displaced, or absent, the defect shall not exceed a depth of 0.005 inch.

3.7 Corrosion Resistance

Two representative samples per lot shall be corrosion tested in accordance with ASTM-A262-70, Practice C. The target corrosion

XN-530319, Revision 0

rate shall be less than 0.002 inch per month as determined by the average of five 48-hour test periods. The maximum permissible limit is 0.005 inch per month as determined by the average of five 48-hour periods, with no single period rate exceeding 0.006 inch per month.

3.8 Dimensional Inspection

All tubes shall be inspected for outside dimensions, wall thickness, straightness, surface finish, and freedom from stains.

4.0 QUALITY ASSURANCE

4.1 Characteristics

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Chemistry	Major	3.1
Tensile-Room Temperature	Critical	3.3
Tensile - 650° F	Critical	3.3
Hydrostatic Test	Critical	3.3
Outside Diameter	Major	3.4
Wall Thickness	Major	3.4
Straightness	Major	3.4
External Surface Cleanliness	Major	3.5
Internal Surface Cleanliness	Critical	3.5
Surface Defects	Major	3.6
Corrosion Resistance	Critical	3.7

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4.2 Traceability

The identity of all material in a lot shall be maintained at all times with respect to starting ingot melt number and tube lot number.

4.3 Final Tube Condition and Shipping

The tubing shall be packaged, shipped and stored in such a fashion that complete traceability and identification of each tube lot is maintained, and the abrading of tube is prevented.

XN-S30319, Revision 0

APPENDIX A - GLOSSARY OF TERMS

Critical A specification value, inspection criterion, test result, or defect measure, which if not properly controlled, could result in a reactor fuel failure. A critical defect, for example, is one that (judgment and experience indicate) is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or it is one that (judgment and experience indicate) is likely to prevent performance of the essential function of a component such as a fuel rod, fuel assembly, or fuel reload core.

Major A specification value, inspection criterion, test result, or defect measure other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in shipping dates. Such a defect, for example, is likely to reduce materially the usability of a product such as a fuel rod or fuel assembly.

Minor A specification value, inspection criterion, test result or defect measure other than critical or major, which if not controlled, does not materially reduce the usability of the product, such as a fuel rod, for its intended purpose, or is not a departure from established standards significant to the effective use or operation of the product, or affects the appearance only to a minor degree where appearance is a significant characteristic.

Buyer Exxon Nuclear Company

Seller Supplier of tubing

XN-S30319, Revision 0

Lot

A lot shall be composed of all material of the same size, finished from the same ingot, and heat treated in the same final annealing charge. A lot shall consist of units which are successively produced by the same manufacturing processes at essentially the same time.

XN-530319, Revision 0

APPENDIX B - REFERENCES

SPECIFICATIONS

ASTM-A269-71	Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM E8-69	Methods of Tension Testing Metallic Materials
ASTM E21-70	Elevated Temperature Tension Tests of Materials
ASTM-E-112-63	Estimating the Average Grain Size of Metals
ASTM-A-370-71	Methods and Definitions for the Mechanical Testing of Steel Products
ASTM-A262-70	Detecting Susceptibility to Intergranular Attack in Stainless Steel
ASTM-A450-70	General Requirements for Carbon, Ferritic Alloy and Austenitic Alloy Steel Tubes

- (1) JN-S30061, Revision 4, Product Specification, Uranium Dioxide Pellets - LOFT
 - (2) JN-S30065, Revision 0, End Caps and Connectors
 - (3) JN-S30066, Revision 2, Coil Springs
 - (4) JN-S30067, Revision 1, Alumina Insulator Discs
 - (5) JN-S30106, Revision 3, Standard Fuel Rod - LOFT
 - (6) JN-S30144, Revision 8, Guide Tube Assembly
 - (7) JN-S30145, Revision 4, Instrumentation Tube Assembly
 - (8) JN-S30154, Revision 5, Grid Spacer Assembly - Integral Inconel Frame and Springs
 - (9) JN-S30155, Revision 2, Machined Tie Plates
 - (10) JN-S30193, Revision 4, LOFT Fuel Assembly, Types D and E
 - (11) JN-S30194, Revision 0, Control Rod End Fittings
 - (12) JN-S30196, Revision 0, Guide Tube Flow Restrictor
 - (13) JN-S30198, Revision 1, Instrumented Fuel Rod - LOFT
 - (14) JN-S30202, Revision 3, Control Rod Spider
 - (15) JN-S30203, Revision 2, Guide Tube Instrumentation Assemblies - LOFT
 - (16) JN-S30204, Revision 1, Dummy Half-Rods
 - (17) JN-S30205, Revision 0, 304L Stainless Steel Nut
 - (18) JN-S30206, Revision 0, Instrumented Rod Nut
-

- (19) JN-S30221, Revision 2, Control Rod Cluster
- (20) JN-S30231, Revision 4, Control Rod - LOFT
- (21) JN-S30232, Revision 4, LOFT Fuel Assembly, Types A, B, and C
- (22) JN-S30238, Revision 1, Guide Tube Assembly (Zircaloy-4)
- (23) XN-S30239, Revision 2, Instrumentation Tube Assembly (Zircaloy-4)
- (24) JN-S30241, Revision 1, Zircaloy-4 Nut
- (25) JN-S30242, Revision 1, Zircaloy-4 Locking Ring
- (26) XN-S30243, Revision 2, LOFT Fuel Assembly, Type F
- (27) JN-S30279, Revision 0, 304L Locking Ring
- (28) XN-S30306, Revision 2, Neutron Source Assembly - LOFT
- (29) XN-S30353, Revision 1, Standard Pressurized Fuel Rod - LOFT
- (30) XN-S30354, Revision 1, Instrumented Pressurized Fuel Rod - LOFT
- (31) XN-S30603, Revision 0, LOFT Guide Tube Assembly (Zircaloy-4)

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EXXON NUCLEAR COMPANY, INC.

MATERIAL SPECIFICATION

1.0 TITLE: ZIRCALOY TUBE, LOCKING RING

2.0 SCOPE

- 2.1 This specification describes the material requirements for zirconium tubing for use in fabricating fuel assembly spacer locking rings.
- 2.2 A glossary of terms is given in Appendix A.
- 2.3 Pertinent references are listed in Appendix B.
- 2.4 The acceptable limits of significant impurities are given in Appendix C.

3.0 TECHNICAL REQUIREMENTS

3.1 Conformance to ASTM B353-71.

All tubing shall conform to the following requirements of ASTM B353-71, Grade R A-2, Zircaloy-4.

- (a) Manufacture - all requirements.
- (b) Condition - annealed.
- (c) Alloy composition - all requirements for Grade RA-2.
- (d) Corrosion resistance - samples of tubing from each lot shall be corrosion tested in accordance with ASTM Recommended Practice G-2 for Corrosion Testing of Zirconium Alloys. Maximum weight gain shall not exceed 22 mg/dm^2 for 3 day test or 38 mg/dm^2 for 14 day test.

3.2 Impurity Limits

The maximum acceptable limits of significant impurities, on a weight basis, are listed in Appendix C.

3.3 Chemical Analysis Sampling

The chemical composition of each ingot utilized shall be verified by samples taken from the top, middle, and bottom of the starting ingot for alloying elements and impurities. Samples for analysis for nitrogen, hydrogen, and oxygen, shall be taken from each lot of finished tubing.

3.4 Mechanical Properties

The room temperature mechanical properties of the annealed tubing shall be within the following limits:

<u>Tensile Strength</u> <u>min. psi</u>	<u>Yield Strength</u> <u>(0.2% Offset)</u> <u>min. psi</u>	<u>Elongation</u> <u>in 2 inches</u> <u>min. %</u>
50,000	30,000	16

3.5 Grain Size

The grain size of tubing samples annealed at 1250° F for 45 minutes shall not exceed that corresponding to ASTM Micro-grain Number 7 in the longitudinal direction and ASTM Micro-grain Number 8 in the

transverse direction. The grain size of the samples shall be rated in accordance with ASTM E112-63, "Estimating the Average Grain Size of Metals."

3.6 Surface Condition

All tubing shall be free from blisters, inclusions, and cracks.

The maximum depth of marks and scratches shall be 10% of the total thickness of the tube wall.

4.0 QUALITY ASSURANCE

4.1 Characteristics and Classification

<u>Item</u>	<u>Characteristics</u>	<u>Applicable Section</u>
Chemical Composition	Major	3.1
Mechanical Properties	Minor	3.4
Corrosion Resistance	Major	3.1
Impurity Limits	Minor	3.2
Grain Size	Major	3.5
Surface Condition	Major	3.6

4.2 Manufacturing Process and Quality Assurance Program

The Seller shall furnish the Buyer a description of his manufacturing process and quality assurance program. The intent of this requirement is to clearly identify the process steps affecting product quality, but the Seller is not expected to divulge proprietary techniques.

5.0 PACKAGING AND SHIPPING

5.1 The zircaloy tubing shall be packaged in rigid containers that provide adequate protection from shipping and handling damage and corrosive atmosphere. The exact size and method of packaging shall be as mutually agreed upon by the Buyer and Seller.

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

XN-S30358, Revision 0

Buyer Exxon Nuclear Company
Seller Supplier of zircaloy tubing
Lot A quantity of zircaloy tubing originating from a single
ingot, processed in a single continuous production run,
and final annealed as one furnace load.

XN-S30358, Revision 0

APPENDIX B - REFERENCES

ASTM B 353-71 Wrought Zirconium and Zirconium Alloy
Seamless and Welded Tubes for Nuclear Service.

ASTM E 112-63 Estimating the Average Grain Size of
Metals.

XN-S30358, Revision 0

APPENDIX C - SIGNIFICANT IMPURITY LIMITS

The following list of significant impurities shall be included in analyses when determining impurity content and when calculating equivalent boron content of zircaloy tubing. The elements with a limit given in the impurity column shall be included in the impurity analysis and shall not exceed the limit listed.

<u>Element</u>	<u>Maximum Impurity, ppm</u>
	<u>Grade RA-2 (Zirc 4)</u>
Aluminum	75
Boron	
Cadmium	
Carbon	270
Cesium	
Chlorine	20
Cobalt	20
Copper	50
Dysprosium	
Europium	
Gadolinium	
Hafnium	100
Hydrogen	25
Lead	130
Lithium	
Magnesium	20
Manganese	50
Molybdenum	50
Nickel	70
Nitrogen	50
Niobium	120
Oxygen	1500
Samarium	
Silicon	120
Silver	
Tantalum	200

XN-S30358, Revision 0

APPENDIX C - continued

<u>Element</u>	<u>Maximum Impurity, ppm</u> <u>Grade RA-2</u> <u>(Zirc 4)</u>
Titanium	50
Tungsten	100
Uranium	3.5
Vanadium	50

Issue Date: 10/12/72

JERSEY NUCLEAR COMPANY
MATERIAL SPECIFICATION

1.0 TITLE: Zircaloy Strip and Sheet Stock

2.0 SCOPE

- 2.1 This specification describes the material requirements for zirconium alloy strip or sheet stock for use in fuel assembly spacer locking rings.
- 2.2 A glossary of terms is given in Appendix A.
- 2.3 Pertinent references are listed in Appendix B.
- 2.4 The acceptable limits of significant impurities are given in Appendix C.

3.0 TECHNICAL REQUIREMENTS

3.1 Conformance to ASTM B352-67

All sheet or strip shall conform to the following requirements of ASTM B 352-67:

- (a) Manufacture - all requirements
- (b) Condition - cold-rolled, annealed requirement
- (c) Finish - cold-rolled finish requirement
- (d) Chemical Composition - all requirements of Table I except impurities
- (e) Corrosion Resistance - all requirements of Appendix sections A_2 and A_3

3.2 Impurity Limits

The maximum acceptable limits of significant impurities, on a weight basis, are listed in Appendix C.

3.3 Chemical Analysis Sampling

The chemical composition of each lot of sheet or strip utilized

JN-530283, Revision 0

shall be verified by samples taken from the top, middle, and bottom of the starting ingot for alloying elements and impurities. Samples for analysis for nitrogen, hydrogen, and oxygen, shall be taken from each lot of finished sheet and strip.

3.4 Equivalent Boron Content

The equivalent boron content of all Zircaloy ingots utilized shall not exceed 40 ppm boron, as determined by reactor reactivity testing or by chemical analysis and calculations performed in accordance with the applicable Equivalent Boron Content specification. The elements covered by the calculation method shall include zirconium, alloying elements and all significant impurities as listed in Appendix C.

3.5 Mechanical Properties

The room temperature mechanical properties of the strip and sheet shall be within the following limits.

<u>Direction of Test</u>	<u>Tensile Strength min. psi</u>	<u>Yield Strength (0.2% Offset) min. psi</u>	<u>Elongation in 2 inches min. %</u>
Longitudinal and Transverse	50,000	30,000	25

3.6 Grain Size

Grain size of the strip and sheet in both the longitudinal and transverse direction, shall be ASTM micro-grain number 8 or finer when rated in accordance with ASTM E 112-63.

The grain size shall be estimated by counting, on the ground-glass screen, on a photomicrograph of a representative field of the specimen or on the specimen itself the number of grains intercepted by one or more straight lines sufficiently long to yield at least 50 intercepts.

Grains touched by the end of the line count only as half grains.

Counts should be made on three fields to assure a reasonable average.

The length of the line in millimeters divided by the average number of grains intersected by it gives the average intercept length.

3.7 Surface Condition

All strip and sheet shall be free from blisters, inclusions, and cracks. The maximum depth of marks and scratches shall be 10% of the total thickness of the strip or sheet.

3.8 Weld Repairs

Welding of strips or sheets together or welding repair is prohibited.

4.0 QUALITY ASSURANCE

4.1 Characteristics and Classification

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Manufacture	Minor	3.1
Condition	Major	3.1
Finish	Minor	3.1
Chemical Composition	Major	3.1
Mechanical Properties	Critical	3.1, 3.5
Corrosion Resistance	Critical	3.1
Impurity Limits	Minor	3.2
Chemical Analysis Sampling	Minor	3.3
Equivalent Boron Content	Major	3.4
Grain Size	Minor	3.6
Surface Condition	Major	3.7

4.2 Manufacturing Process and Quality Assurance Program

The seller shall furnish the Buyer a description of his manufacturing process and Quality Assurance Program. The intent of this requirement

JN-530283, Revision 0

is to clearly identify the process steps affecting product quality, but the Seller is not expected to divulge proprietary techniques.

4.3 Testing Samples

A representative sample from each lot of material shall be taken for the purpose of determining chemical and physical properties. The sample shall be of sufficient size to perform quality assurance testing at the Seller's plant, acceptance testing at the Buyer's plant and referee tests in the event they become necessary.

4.4 Testing and Certification

4.4.1 The seller shall test samples to assure conformance to the requirements of Section 3.0. All testing shall be conducted by techniques mutually agreed to by the Buyer and Seller.

4.4.2 The Seller shall provide to the Buyer, documents certifying that all strip and sheet meets all requirements of Section 3.0, including the results of all testing.

5.0 PACKAGING AND SHIPPING

5.1 The Zircaloy strip and sheet shall be packaged in rigid containers that provide adequate protection from shipping and handling damage and corrosive atmospheres. The final rolling direction shall be marked on the sheet stock. The exact size and method of packaging shall be as mutually agreed upon by the Buyer and Seller.

APPENDIX A - GLOSSARY OF TERMS

Critical	A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
Major	A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
Minor	A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.
Buyer	Jersey Nuclear Company
Seller	Supplier of Zircaloy Strip and Sheet
Lot	A quantity of Zircaloy strip or sheet originating from a single ingot, processed in a single continuous production run, and final annealed as one furnace load.

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APPENDIX B - REFERENCES

ASTM B 352-67 Zirconium and Zirconium Alloy Sheet, Strip and
Plate for Nuclear Applications

ASTM E 165-65 Liquid Dye Penetrant Inspection

ASTM E 112-63 Estimating the Average Grain Size of Metals

JN-S30283, Revision 0

APPENDIX C - SIGNIFICANT IMPURITY LIMITS

The following list of significant impurities shall be included in analyses when determining impurity content and when calculating equivalent boron content of Zircaloy strip and sheet. The elements with a limit given in the impurity column shall be included in the impurity analysis and shall not exceed the limit listed. The elements marked in the EBC column shall be included in the EBC calculation of total equivalent boron content.

<u>Element</u>	<u>Maximum Impurity, ppm</u>		<u>Include in EBC Calculation</u>
	<u>Grade RA-1 (Zirc 2)</u>	<u>Grade RA-2 (Zirc 4)</u>	
Aluminum	75	76	X
Boron			X
Cadmium			X
Carbon	270	270	
Cesium			X
Chlorine	20	20	X
Cobalt	20	20	X
Copper	50	50	X
Dysprosium			X
Europium			X
Gadolinium			X
Hafnium	100	100	X
Hydrogen	25	25	X
Lead	130	130	
Lithium			X
Magnesium	20	20	
Manganese	50	50	X
Molybdenum	50	50	X
Nickel		70	X
Nitrogen	65	65	X
Niobium	100	100	X
Oxygen	1200	1200	
Samarium			X
Silicon	200	120	X
Silver			X
Tantalum	200	200	X

APPENDIX C - Continued

<u>Element</u>	<u>Maximum Impurity, ppm</u>		<u>Include in EBC Calculation</u>
	<u>Grade RA-1 (Zirc 2)</u>	<u>Grade RA-2 (Zirc 4)</u>	
Titanium	50	50	X
Tungsten	100	100	X
Uranium	3.5	3.5	X
Vanadium	50	50	X

Issue Date 12-1-71

RECEIVED FEB 16 1972

AEROMET NUCLEAR COMPANY

A.E.C. CONTRACT NO. AT(10-1)-1375

P. O. NO. S-210

DATE REC.

EXPL. DATA NO.

C. S. NO. C4 06 01

SPECIFICATION

1.0 TITLE: EQUIVALENT BORON CONTENT

2.0 SCOPE

2.1 This specification describes the procedures required to determine the equivalent boron content (EBC) of materials used for fuel assemblies, where an equivalent boron content is specified in the applicable material specification.

2.2 A list of factors required in the determination of EBC is given in Appendix A.

3.0 TECHNICAL REQUIREMENTS

3.1 The total equivalent boron content shall be based on either a comparative reactivity test using an analyzed standard of the same general composition as the subject material, or a quantitative analysis for the elements considered significant as given in the applicable material specification. In each case attention must be given to whether the EBC specification is based on the total material or on significant impurities alone.

3.2 The EBC of each element shall be calculated by the following formula:

$$\begin{aligned} \text{EBC Factor} &= \frac{(\text{atomic weight boron}) (\sigma_a \text{ element})}{(\sigma_a \text{ boron}) (\text{atomic weight element})} \\ &= 0.0142 \frac{(\sigma_a \text{ element})}{(\text{atomic weight element})} \end{aligned}$$

APPENDIX A - EQUIVALENT BORON CONTENT

Element	Absorption Cross Section, σ_a (barns-2200 m/sec)	Atomic Weight	EBC Factor
Aluminum	0.235	26.98	0.000124
Americium	490	241.06	0.028865
Barium	1.2	137.34	0.000124
Beryllium	0.0095	9.012	0.000015
Bismuth	.034	208.98	0.000002
Boron	759.	10.81	1.000000
Cadmium	2450.	112.40	0.3104
Calcium	0.44	40.08	0.000156
Carbon	0.0034	12.01	0.000004
Cesium	30.0	138.91	0.00308
Chlorine	33.2	35.45	0.01334
Chromium	3.1	52.00	0.000849
Cobalt	37.2	58.93	0.008991
Copper	3.8	63.54	0.000852
Dysprosium	930.	162.50	0.0815
Europium	4400.	151.96	0.4124
Fluorine	0.0098	19.00	0.000007
Gadolinium	49000.	157.26	4.438
Hafnium	105.	178.49	0.008378
Helium	.007	4.00	0.000025
Hydrogen	.33	1.01	0.004653
Iron	2.55	55.85	0.000650
Lead	0.170	207.19	0.000012
Lithium	71.0	6.939	0.145729
Magnesium	0.063	24.31	0.000037
Manganese	13.30	54.94	0.003448
Molybdenum	2.70	95.94	0.000401
Nickel	4.60	58.71	0.001116
Niobium	1.15	92.91	0.000176
Nitrogen	1.85	14.01	0.001881
Oxygen	.0002	16.00	0.000000
Phosphorus	0.19	30.97	0.000037
Plutonium	1010.	239.0522	0.060175
Rhenium	85.0	186.2	0.00650
Samarium	5820.	150.35	0.5513
Silicon	0.16	28.09	0.000081
Silver	63.6	107.87	0.008397
Sodium	0.534	22.99	0.000331
Sulfur	.51	32.06	0.000227
Tantalum	21.	108.95	0.001653
Tin	0.63	118.69	0.000076
Titanium	6.1	47.90	0.001814
Tungsten	18.5	183.85	0.001433
Uranium	7.6	238.03	0.000455
Vanadium	5.06	50.94	0.001415
Zinc	1.10	65.37	0.000240
Zirconium	0.188	91.22	0.000029

APPENDIX B - IMPURITY SPECIFICATIONS

The following list of elements require quantitative determination. Where individual element concentration limits are significant, these limits are specified in the first column. Impurity content specifications shall be classified as major except for those specifically identified as critical below. The total equivalent boron content shall be determined from a summation of the contribution from each element checked in the EBC column. (See Section 3.3.2).

<u>Element</u>	<u>Impurity Limit (ppm)</u>	<u>EBC</u>	
		<u>EBC</u>	<u>ALT Characteristic</u>
Aluminum-----	250		
Boron-----		X	X
Cadmium-----		X	X
Calcium plus Magnesium-----	100		
Carbon-----	100		Critical
Chlorine-----	25	X	Critical
Chromium-----	250	X	
Cobalt-----	100	X	
Copper-----		X	
Dysprosium-----		X	X
Europium-----		X	X
Fluorine-----	25		Critical
Gadolinium-----		X	X
Hafnium-----		X	
Hydrogen Exclusive of Moisture ----	5*		Critical
Iron -----	500 [†]	X	
Lithium-----		X	
Manganese-----		X	
Nickel-----	250	X	
Nitrogen-----	75	X	Critical
Samarium-----		X	X
Silicon-----	250		
Silver-----		X	X
Tantalum-----		X	
Titanium-----		X	
Tungsten-----		X	
Vanadium-----		X	
Zinc-----		X	
Total Impurities	1500		

[†] Total of these elements (Iron, Chromium, and Nickel) not to exceed 600 ppm.

* Subject to development of a measurement method capable of detecting this level.

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AEROJET NUCLEAR COMPANY

A.E.C. CONTRACT NO. AT(10-1)-1375

P. O. NO. S-210

SPEC. NO.

EQUIP. ITEM NO.

C. S. NO. C4 08 01

PRODUCT SPECIFICATION1.0 TITLE: End Caps and Connectors2.0 SCOPE

2.1 This specification describes the product requirements for the end caps and connectors for fuel rod assemblies.

2.2 The functions of the end caps are to seal the rod and thus provide a pressure boundary, to isolate the fuel or target material inside the rod from the reactor coolant, to provide a means for fixing the location of the rod within the fuel assembly and to provide a means for identifying the rods.

2.3 The functions of the fuel rod connectors are to connect the segments of the spacer capture rod, to isolate the fuel material inside the rod from the reactor coolant and thus provide a pressure boundary, and to capture the fuel rod spacer assembly.

2.4 A glossary of terms is provided in Appendix A.

3.0 TECHNICAL REQUIREMENTS

3.1 Material: The end caps and connectors shall be fabricated from Zircaloy rod stock in accordance with the applicable material specification.

- 3.2 Dimensions: All end cap and connector dimensions, tolerances and surface texture shall conform to those given on the applicable drawing per the job parts list.
- 3.3 Cleanliness: All surfaces of the end caps and connectors shall be clean and free of extraneous materials, particularly halide bearing or hydrogenous materials.
- 3.4 Surface Defects: The end caps and connectors shall be free from cracks and shall have no other surface defects greater than 0.005 inches deep and shall have no inclusions visible to the unaided eye.
- 3.5 Dye Penetrant: Each finished end cap and connector shall be dye penetrant inspected. Indications other than burrs and scratches shall be cause for rejection.
- 3.6 Rework: Mechanical rework shall be allowed, where necessary, to meet these specifications. No repair by welding, or weld metal build-up shall be allowed.

4.0 RECORDS

- 4.1 Fabrication Records: Process control and fabrication records as specified by Quality Control shall be maintained and shall be such as to assure the traceability of each end cap and connector to the initial rod stock lot and heat number and material certification.
- 4.2 Acceptance Testing: Acceptance testing records shall be maintained to document compliance with all requirements of this specification.

5.0 SHIPPING AND STORAGE

- 5.1 End caps shall be handled, shipped and stored in a manner which assures compliance with this specification and prevents damage or contamination which may impair corrosion resistance.

5.2 End caps and connectors shall be packaged, shipped and stored in a manner which assures identification and traceability.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material and Traceability	Critical	3.1
Diameter - Shank	Critical	3.2
Diameter - Weld Prep	Critical	3.2
Diameter - Plug	Critical	3.2
Thickness - Weld Prep	Critical	3.2
Cleanliness	Major	3.3
Surface Defects	Critical	3.4

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.
- Lot** That quantity of end caps of the same drawing number and part number originating from the same rod stock lot and processed as a job unit to the finished product.

PRODUCT SPECIFICATION

1.0 TITLE: Coil Springs

2.0 SCOPE

2.1 This specification describes the Inconel X-750 coil springs used for plenum springs within the fuel rods, and for compression springs bearing on the upper end caps.

2.2 The function of the plenum springs, used in all fuel rods, is to maintain the fuel pellet stack in a compact column during transport and irradiation and for PWR's to prevent collapse of the clad tube in the plenum region.

2.3 The functions of the compression spring which bears on the shoulder of the upper end cap and the lower surface of the upper tie plate, are to seat the fuel rod in the lower tie plate, to provide restraint against hydraulic forces during irradiation, and to support the upper tie plate.

2.4 A glossary of terms is given in Appendix A.

2.5 A list of elements significant in the determination of equivalent boron content is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 Alloy Composition: Inconel X-750 shall be supplied with an alloy

composition in accordance with AMS 5698B, AMS 5699B, or an equivalent specification, except that the requirements of section 3.8 must be met.

- 3.2 Dimensions: The dimensions and tolerances shall conform to those given in the latest revision of the applicable drawing per the job parts list.
- 3.3 Spring Constant: The spring constant shall be as specified in applicable drawings listed in Section 3.2 above.
- 3.4 Mechanical Properties: The mechanical properties shall conform to AMS 5698B, AMS 5699B, or an equivalent specification.
- 3.5 Surface Condition: The condition and finish shall conform to that specified in AMS 5698B, AMS 5699B, or an equivalent specification, except that the copper coating shall be removed from the surface prior to heat treatment.
- 3.6 Heat Treatment: Precipitation heat treatment shall conform to that specified in AMS 5698B, AMS 5699B, or an equivalent specification. Precipitation heat treatment shall be accomplished after coiling.
- 3.7 Cleanliness: Finished springs shall be free of loose, scaly or massive oxide, metallic particles, grease, oil, residual lubricants, cleaning agents, or other extraneous materials. Acid etches shall not be used after precipitation heat treatment.
- 3.8 Equivalent Boron Content: The total equivalent boron content (EBC), including impurities, for the material used for spacer capture rod plenum springs, shall not exceed 1300 ppm, based on either a comparative reactivity test using a fully analyzed standard of the same general composition, or a quantitative analysis for the elements

listed in Appendix B and a summation of their contribution to the equivalent boron content. Factors for converting constituent concentrations to the equivalent boron concentrations are given in the specification for Equivalent Boron Content.

3.9 Rework: Repaired or reworked springs may be allowed provided rework procedure is approved by the Fuel Design Council.

4.0 CERTIFICATION

The fabricator shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation.

5.0 SHIPPING AND STORAGE

5.1 Springs shall be stored, handled, packaged, and shipped in a manner that assures conformance to this specification and prevents damage or deterioration and provides traceability.

5.2 The fabricator shall be responsible for all details of packing, crating, and shipping and for identification of parts and shipping cartons.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Spring Diameter	Major	3.2
Spring Length	Minor	3.2
Spring Constant	Critical	3.3
Heat Treatment	Major	3.6
Alloy Composition	Major	3.1
Surface Condition	Major	3.5
Cleanliness	Major	3.7
Equivalent Boron Content	Major (where applicable)	3.8
Mechanical Properties	Critical	3.4

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

Glossary of Terms -continued

Micro-Cracking Short, fine, unconnected cracks, extending through the pellet structure as elongated voids that do not materially reduce the pellet integrity. Surface micro-cracks are characterized by the shallow extent into the body, the bottom being clearly visible under low power (10X) magnification.

XN-S30086, Revision 6

APPENDIX A - GLOSSARY OF TERMS

Critical A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.

Major A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.

Minor A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

Buyer Exxon Nuclear Company

XN-530036, Revision 6

Seller Supplier of 304L stainless steel Rod and Bar Stock.

Lot That quantity of rods or bars of the same nominal size and condition originating from one heat and processed under the same specified conditions to the finished product.

APPENDIX B - IMPURITY SPECIFICATIONS

In lieu of a comparative reactivity test, the concentration of each of the elements listed below shall be determined and used to determine the total equivalent boron content.

Alloying Elements

Chromium

Iron

Nickel

Tantalum

Titanium

Columbium

Impurity Elements

Boron

Cadmium

Cobalt

Dysprosium

Europium

Gadolinium

Lithium

Manganese

Samarium

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AEROJET NUCLEAR COMPANY

A.E.C. CONTRACT NO. AT(10-1)-1375

P. O. NO. S-210

SPEC. NO.

EQUIP. ITEM NO.

C.S. NO.

C4 05

Q11

PRODUCT SPECIFICATION

1.0 TITLE: Alumina Insulator Discs

2.0 SCOPE

2.1 This specification describes the alumina insulator discs to be used at fuel-end cap, fuel-connector and fuel-plenum spring interfaces of fuel rod assemblies.

2.2 The function of the alumina insulator discs is to assure that plenum springs and Zircaloy end caps and connectors are within acceptable temperature limits.

2.3 A glossary of terms is given in Appendix A.

2.4 A list of elements significant in the determination of equivalent boron content is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 Equivalent Boron Content: The total equivalent boron content (EBC) for this material, including impurities, shall not exceed 76 ppm as determined from an analysis for all significant impurities, or as determined by a comparative reactivity test using an analyzed aluminum or aluminum oxide standard of the same general composition. This determination is required only for discs located within the core active height and may be performed for a sampling of the source material or the finished discs. Factors for converting constituent concentrations to equivalent boron concentrations are given in the specifications for Equivalent Boron Content.

3.2 Chemical Requirements

3.2.1 Aluminum Oxide Content: The aluminum oxide content shall be a minimum of 99.3% on a dry weight basis.

- 3.2.2 Impurity Content: The following impurities shall not exceed the limits shown:

<u>Element</u>	<u>Maximum Limit (ppm)</u>
Carbon	100
Nitrogen	75
Fluorine	10
Chlorine	10

- 3.2.3 Gas Content: The gas release comprising total gas, exclusive of H_2O , shall not exceed 0.05 cc/g of aluminum oxide at standard temperature and pressure. The gas release shall be measured by vacuum outgassing at a temperature of 3000 $\pm$ 90F.

- 3.2.4 Moisture: The moisture content shall not exceed 10 ppm on an aluminum oxide weight basis as loaded into a fuel rod. The moisture content of alumina discs as received from fabricator shall not exceed 35 ppm on an aluminum oxide basis.

3.3 Physical Characteristics

- 3.3.1 Dimensions: The dimensions of insulator discs shall be as specified in the applicable drawing per the job parts list.
- 3.3.2 Compressive Strength: The compressive strength of sintered discs shall be not less than 250,000 psi based on ASTM C528-63T test procedures.
- 3.3.3 End Pits: Disc end surfaces shall not be pitted beyond 10% of the end surface area, and no pit shall exceed 0.005 inches in depth.
- 3.3.4 Circumferential Chips and Pits: Disc circumferential surfaces shall not be chipped beyond 10% of the circumferential surface area. No single chip or pit shall exceed a depth of 0.010 in., a width or diameter of 0.010 in., or an edge length of 0.032 in.
- 3.3.5 Disc Cracks: No cracks visible to the unaided eye are allowed.

4.0 RECORDS

4.1 Fabrication Records: Process control and fabrication records as specified by Quality Control shall be maintained and shall be such as to assure the traceability of each disc in each fuel rod to the initial materials.

4.2 Acceptance Testing Records: Acceptance testing records shall be maintained.

5.0 STORAGE

The discs shall be stored in such a manner that the discs remain clean, the identity is maintained, the discs are not damaged or contaminated with other materials, and the discs retain conformity with this specification.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Equivalent Boron Content	Major (where applicable)	3.1
Aluminum Oxide Content	Major	3.2
Impurity Content	Major	3.2
Gas Content	Major	3.2
Moisture Content (as-received)	Major	3.2
Moisture Content (at rod loading)	Critical (controlled by process procedure)	3.2
Thickness	Major	3.3
Diameter	Critical	3.3
Perpendicularity	Minor	3.3
Surface Cracks	Major	3.3
Chamfer or Radius	Minor	3.3
Chips	Major	3.3
Surface Appearance	Minor	3.3
Compressive Strength	Major	3.3

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the produce or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - IMPURITY SPECIFICATIONS

In lieu of a comparative reactivity test, the concentration of each of the elements listed below shall be determined, and together with the aluminum content, used to determine the total equivalent boron content.

Boron

Cadmium

Cobalt

Dysprosium

Europium

Gadolinium

Lithium

Samarium

PRODUCT SPECIFICATION

1.0 TITLE: STANDARD FUEL ROD - LOFT

2.0 SCOPE

- 2.1 This specification describes the product requirements for the LOFT standard fuel rods to be used in LOFT fuel assemblies.
- 2.2 The functions of the standard fuel rods are to hermetically contain the fuel material and resulting fission products, to isolate the fuel material from the reactor coolant, to provide an adequate heat transfer surface, and to supply its appropriate share of the fuel assembly design energy. The fuel rod shall perform all of these functions throughout irradiation.
- 2.3 A glossary of terms is given as Appendix A.
- 2.4 Pellet stack component weights are given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

- 3.1 The fuel rod assembly shall be fabricated from the following components. The specific drawing number for each component is listed on the rod assembly drawing. The rod assembly drawings are listed in the job parts list and on the fuel assembly drawing. Applicable specifications for each component are listed along with the drawing number in the job parts list.

UO₂ Fuel Pellet

Insulator Disc

Lower End Cap

Plenum Spring

Cladding

Upper End Cap

3.2 Pellet Stack

3.2.1 The active pellet stack shall be included between two insulator pellets (one placed on each end of the stack) in accordance with the applicable drawings.

3.2.2 The active pellet stack and component weights shall be as specified in Appendix B. The following tolerances apply to the various components:

Total Oxide $\pm 2\%$

Fissile Content $\pm 3\%$

3.2.3 Each rod pellet stack shall be weighed to an accuracy of 0.1 percent. Stack weight and pellet lot(s) shall be recorded and remain traceable by individual rod identification.

3.2.4 The length of the active pellet column (excluding insulator discs) shall be as specified on the applicable drawing and shall be measured prior to loading of the pellets into the clad tube.

3.2.5 A short dished pellet, minimum length 0.20 inches, may be used at either or both ends of the fuel column to adjust the fuel column length. A pellet shortened by grinding may be used at the plenum end of the column.

3.2.6 Pellet enrichment is of critical importance and must be controlled by process procedure to insure proper loading and identification.

3.2.7 Pellets shall be vacuum outgassed prior to loading in conformance with the approved applicable Process Specification.

3.3 Welding

3.3.1 The end cap to cladding weld shall be accomplished in an atmosphere at nominally atmospheric pressure containing a

minimum of 95% helium, balance argon, and a minimum of 99.9% inert gas (helium plus argon). The helium used shall be Bureau of Mines grade A, and the argon of comparable purity.

- 3.3.2 The rod to end cap weld shall have a minimum accumulative solid metal path from rod interior to exterior (leak free path) of 0.020 inches after correction for distance across voids, inclusions or areas of non-bond indication in the path. Fusion zone beta grains shall have a Widmanstatten structure indicating uniform second phase distribution and the existence of alpha crystals within beta grains. The heat affected zone shall exhibit no columnar grains. The heat affected zone of the clad shall not extend beyond the end cap.
- 3.3.3 The weld shall be free of cracks, overlaps, or undercuts.
- 3.3.4 The weld shall contain no porosity (a group of pores) or inclusions in any cross section in which an individual pore or inclusion exceeds 0.004 inches in the greatest dimension.
- 3.3.5 The weld shall blend smoothly into the parent material and show no discontinuities due to lack of fusion.
- 3.3.6 The lower and upper end cap welds shall not exhibit a surface convexity (e.g., weld overhang) greater than 0.005 inches on the rod diameter. Weld overhang may be altered by careful hand filing or dressing in order to meet the specified dimensions.
- 3.3.7 An axial tensile test of representative welds on cladding samples conducted at room temperature during initial weld qualification shall yield joint efficiencies of 80% or greater based on the minimum specified ultimate strength and nominal specified clad thickness.

- 3.3.8 Metallographic destructive examination of the closure weld area shall be used to verify that at a confidence level of 95%, 95% of the end cap welds meet the requirements of paragraph 3.3.2 above.
- 3.3.9 Each end cap weld shall be radiographed to further verify the weld quality.
- 3.3.10 Rework - Rods having reject or non-conforming welds may be reworked, provided that the rework process or procedure has been reviewed and approved prior to use.
- 3.4 Etching: All outer surfaces of the finished fuel rod shall be etched. The total amount of metal to be removed from a single surface by etching shall be at least 0.0005 inches and no more than 0.0015 inches.
- 3.5 Pellet Location and Plenum Length: A sampling plan shall be established for full length radiography after final closure welding to verify that fuel rods retain their proper plenum lengths and pellet seating, and to ascertain the absence of gross pellet chipping.
- 3.6 Corrosion Testing: The finished fuel rods shall be corrosion tested by autoclaving for a period of 24 ± 1 hours in steam at $389 \pm 10^\circ\text{C}$ and 1500 psia, nominal. After treatment the fuel rods shall have a continuous black, lustrous oxide film and be free from either or both white and brown corrosion products in excess of quality control visual standards.
- 3.7 Miscellaneous
- 3.7.1 The autoclaved rods shall be helium leak tested. The leak rate shall not exceed 1×10^{-8} std cc/sec of helium and the chamber shall be evacuated to 50 microns or less. The leak

rate shall be measured within 8 days after welding, and again subsequent to prefilming.

3.7.2 Rods shall have no mars greater than 0.002 inches deep.

3.7.3 The maximum allowable bow for the rod, after autoclaving, shall not exceed one part in 1200 over the length of the rod or 0.015 inch in any one 12 inch span as compared with a straight edge.

3.7.4 Welded fuel rods shall contain not less than 95% helium in the free volume, and not more than 0.1% gaseous impurities other than argon as verified by process qualification tests.

3.7.5 Each rod shall be identified by a serial number stamped on the lower end cap. The serial number shall be unique to each rod and clearly visible after autoclaving.

3.7.6 Internal and external surfaces of fuel rods shall be clean, free of grease, oil, dust, dirt, moisture, finger marks, scale, flux, organic material (inserts, etc.) and other contaminants.

3.7.7 Contamination of UO_2 fuel rod exterior surfaces shall not exceed 10 dpm/100 cm^2 as determined by a wipe test.

3.7.8 After loading, individual rods shall be supported at all times to ensure that bowing will not exceed 1 inch over 3.5 feet of length.

4.0 RECORDS

4.1 Fabrication Records: Thorough fabrication and testing records including any special fuel rod characterization records shall be maintained. Rod history shall be traceable back to the initial feed materials. Records shall be cross referenced to the rod serial numbers.

4.2 Acceptance Testing Records: Acceptance testing records shall be maintained and the records shall be cross referenced to the rod serial numbers.

4.3 Process controls and records for each fuel rod shall be such as to assure traceability of each component of each rod including:

- each UO₂ pellet lot in the pellet column
- end cap lot(s)
- cladding lot
- insulator disc lot.
- enrichment level
- plenum spring lot

5.0 STORAGE

The rods shall be stored in such a manner that the rods remain clean, the identity is maintained, the rods are not damaged or contaminated with other materials (e.g., oil), and the rods retain conformity with this specification.

6.0 REWORK

Rods which exceed the allowable tolerances on dimensions but which would be reworked to meet the requirements of this specification may be so reworked and resubmitted, provided that the rework process has been reviewed and approved prior to use.

7.0 QUALITY ASSURANCE

Receiving and in-process inspection tests shall be conducted in sufficient numbers to assure that the finished fuel rods meet the following characteristics. Final inspection tests shall be conducted per RDT Standard E13-15T Section

3.7.3.1.

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Active fuel length	Major	3.2.4
Diametral gap	Critical	3.1
Overall Length	Major	3.1
OD	Major	3.1

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Rod Bow	Major	3.7.3
Rod Diameter at Welds	Major	3.3.6
Fuel Column Weight	Major	3.2.2
Fissile Content	Critical	3.2.2
Uranium Oxide Content	Major	3.2.2
Component Location	Major	3.5
Proper Pellet Location	Critical	3.5
Pellet Chips	Critical	3.5
Dryness of Pellets and Tubes	Critical	3.2.7 & 3.7.6
	(control by process procedure)	
Helium Atmosphere for Welding	Critical	3.3.1
	(control by process procedure)	
Joint Efficiency	Critical	3.3.7
	(control by process procedure)	
Weld Cover	Critical	3.3.2
Weld Cracks, Defects, and Appearance	Critical	3.3.3
Cladding and Weld Integrity	Critical	3.3.2
Etching	Major	3.4
Autoclaving	Major	3.6
Rod Cleanliness Before and After Autoclaving	Critical	3.7.6
Radioactive Surface & Weld Contamination	Major	3.7.7
Surface of Finished Rods	Critical	3.7.6
Serial Number	Critical	3.7.5
Serial Number, Depth and Appearance	Minor	3.7.5
Rod Handling	Major	3.7.8

APPENDIX A - GLOSSARY OF TERMS

Critical A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.

Major A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.

Minor A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - PELLET STACK COMPONENT WEIGHTS

		<u>Total Ceramic</u>	<u>Total U235</u>
Standard UO ₂ Rod (grams)	Nominal	1134	40.0
	Maximum	1157	41.2
	Minimum	1112	38.8

JERSEY NUCLEAR COMPANYPRODUCT SPECIFICATION

Title: STANDARD FUEL ROD - LOFT

Date Council Action:

Supersedes Issue Dated: NEW

Fuel Design Council MembersRecom-
mend
Approval:*George J. Cooper*
Manager, Product Design

Concur:

R. E. Smith, for
Manager, Quality Assurance
and Licensing

Accepted:

W. H. Smith
Manager, Plant Operation

Concur:

W. E. Smith
Technical Project
Coordinator

Accepted:

R. K. Wertz
Manager, Process Design

Accepted:

J. H. Smith
Manager, Fuel Management
ServicesOther Acceptances*W. E. Smith* 102 Council 2-10-72
Manager, Quality Control*W. E. Smith*
Manager, Materials

Approved:

J. P. Bupp
Manager, Research and Engineering

JERSEY NUCLEAR COMPANY

PRODUCT SPECIFICATION

1.0 TITLE: GUIDE TUBE ASSEMBLY

2.0 SCOPE

2.1 This specification describes the requirements for guide tube assemblies used in PWR fuel assemblies.

2.2 The functions and requirements of the guide tube assembly are to join the upper and lower tie plates, forming the basic structural skeleton of the fuel assembly and to support the spacer grid assemblies along the fuel assembly length, while resisting the applied axial loadings due to holddown forces, hydraulic forces, and handling.

2.3 A glossary of terms is given in Appendix A.

2.4 Procedure for passivation is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 Tubing

3.1.1 Method: Tubing shall be fabricated from 304L stainless steel conforming to the applicable material specification per the job parts list.

3.1.2 Dimensions: The tubing dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.1.3 Passivation: Tubing shall be passivated in accordance with the procedure specified in Appendix B.

3.2 Guide Tube Sleeve and End Fitting

3.2.1 Material: Guide tube sleeves and end fittings shall be fabricated from 304L rod and bar stock conforming to the applicable material specification per the job parts list except that EBC requirements are waived.

3.2.2 Dimensions: The guide tube sleeve and end fitting dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.2.3 Surface Defects: Guide tube sleeves and end fittings shall have a bright finish free of burrs or scale and shall have no surface mars, nicks, or scratches deeper than 0.005 inches.

3.2.4 Passivation: Finished guide tube sleeves and end fittings shall be passivated in accordance with the procedure specified in Appendix B.

3.3 Assembly

3.3.1 Components

The guide tube assembly shall be fabricated from the following components. The applicable assembly and component drawings and specifications are listed in the job parts list.

Tubing

Upper Guide Tube Sleeve

Lower Guide Tube End Fitting

3.3.2 Welding

The guide tube shall be assembled by welding using inert gas tungsten arc weld in conformance with the dimensions given on the applicable drawing per the job parts list.

3.3.3 Welds

All welds shall be well fused and free of splatter ejected metal, and slag. Based on metallographic examination during weld qualification and visual examination under low power magnification, the welds shall be free of undercuts, inclusions or folds greater than 0.005 inches deep, or cracks. The welds shall blend smoothly into the parent material and show no discontinuities due to lack of fusion. The lower end fitting weld shall be dressed if necessary to meet O.D. dimension tolerances. At the sleeve to guide tube weld, metal removal to meet plug gauging requirements is allowed, providing the maximum inner diameter envelope is not exceeded.

3.3.4 Testing

An axial tensile test of the sleeve to guide tube weld and the end fitting to guide tube weld shall yield joint efficiencies of 80% or greater based on the minimum ultimate strength of 70,000 psi for annealed tubing and the nominal guide tube area based on samples welded during weld qualification. Axial compression tests of the sleeve to guide tube weld and the end fitting to guide tube weld shall show symmetrical buckling of the guide tube without weld failure using tubing lengths of less than 3 inches.

3.3.5 Plug Gauging

The finished guide tube assembly shall be plug gauged with a 1.5 inch long plug having OD .0035 inches smaller than minimum allowed tube ID.

3.3.6 Identification

Each guide tube assembly shall be identified by a serial number electro-etched on the guide tube approximately 1.0

inch above the lower end fitting weld. The serial number shall be unique to each guide tube assembly.

3.3.7 Cleanliness

Internal and external surfaces of the guide tube assembly shall be clean, free of grease, oil, dust, dirt, finger marks or other contaminants.

4.0 REWORK

Guide tube assemblies which do not meet the allowable dimensional tolerances may be reworked provided the rework procedure has been reviewed and approved prior to use.

5.0 RECORDS

Complete fabrication and testing records shall be maintained. Traceability of the component parts to the initial material lots shall be maintained.

6.0 STORAGE

Guide tube assemblies shall be stored in a manner to protect the assembly from mechanical damage, corrosion, and to maintain conformance with this specification.

7.0 QUALITY ASSURANCE

Receiving, in-process, and final inspection tests shall be conducted in sufficient numbers to insure that the finished guide tubes meet the following characteristics:

<u>Item</u>	<u>Characteristics</u>	<u>Applicable Section</u>
Overall length	Major	3.3.1
Outside diameter	Major	3.3.1
Inside diameter (plug gauge)	Critical	3.3.5

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Component Dimensions	Major	3.2.2
Other Dimensions	Major	3.3.1
Weld Quality	Critical	3.3.3
Weld Tensile and Compressive Strength	Critical	3.3.4
Identification	Major	3.3.6
Cleanliness	Major	3.3.7
Serial Number	Critical	3.3.6
Serial Number Appearance, Depth	Minor	3.3.6
Component Materials	Critical	3.1.1, 3.2.1
Defects	Major	3.2.3
Passivation	Major	3.1.3, 3.2.4

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - PASSIVATION PROCEDURE

Immerse in a solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook)

JERSEY NUCLEAR COMPANY

PRODUCT SPECIFICATION

1.0 INSTRUMENTATION TUBE ASSEMBLY

2.0 SCOPE

2.1 This specification describes the requirements for instrumentation tube assemblies used in PWR fuel assemblies.

2.2 The function of the instrumentation tube assembly is to provide a longitudinal passageway in the fuel assembly for insertion of instrumentation.

2.3 A glossary of terms is given in Appendix A.

2.4 Procedure for passivation is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 Tubing

3.1.1 Method: Tubing shall be fabricated from 304L stainless steel conforming to the applicable material specification per the job parts list.

3.1.2 Dimensions: The tubing dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.1.3 Passivation: Tubing shall be passivated in accordance with the procedure specified in Appendix B.

3.2 Instrumentation Tube Sleeve

3.2.1 Material: Instrumentation tube sleeves shall be fabricated from 304L rod and bar stock conforming to the applicable material specification per the job parts list except that EBC requirements are waived.

3.2.2 Dimensions: The instrumentation tube sleeve dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.2.3 Surface Defects: Instrumentation tube sleeves shall have a bright finish free of burrs or scale and shall have no surface mars, nicks, or scratches deeper than 0.005 inch.

3.2.4 Passivation: Finished instrumentation tube sleeves shall be passivated in accordance with the procedure specified in Appendix B.

3.3 Instrumentation Tube Plug

3.3.1 Material: Instrumentation tube plugs shall be fabricated from 304L rod and bar stock conforming to the applicable material specification per the job parts list except that EBC requirements are waived.

3.3.2 Dimensions: The instrumentation tube plug dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.3.3 Surface Defects: Instrumentation plugs shall have a bright finish free of burrs or scale and shall have no surface mars, nicks or scratches deeper than 0.005 inch.

3.3.4 Passivation: Finished instrumentation tube plugs shall be passivated in accordance with the procedure specified in Appendix B.

3.4 Assembly

3.4.1 Components: The instrumentation tube assembly shall be fabricated from the following components. The applicable

assembly and component drawings and specifications are listed in the job parts list.

Tubing

Instrumentation Tube Sleeve

Instrumentation Tube Plug

3.4.2 Welding: The instrumentation tube shall be assembled by welding using inert gas tungsten arc weld in conformance with the dimensions given on the applicable drawing per the job parts list.

3.4.3. Welds: All welds shall be fused and free of splatter ejected metal, and slag. Based on metallographic examination during weld qualification and visual examination under low power magnification, the welds shall be free of undercuts, inclusions or folds greater than 0.005 inch deep or cracks. The welds shall blend smoothly into the parent material and show no discontinuities due to lack of fusion. At the sleeve to guide tube weld, metal removal to meet plug gauging requirements is allowed, providing the maximum inner diameter envelope is not exceeded.

3.4.4. Testing: An axial tensile test of the sleeve to instrumentation tube weld shall yield joint efficiencies of 80% or greater based on the minimum ultimate strength of 70,000 psi for annealed tubing and the nominal guide tube area based on samples welded during weld qualification. Axial compression tests of the sleeve to instrumentation tube weld shall show symmetrical buckling of the instrumentation tube without weld failure using tubing lengths of less than 3 inches.

3.4.5 Plug Gauging: The finished instrumentation tube assembly shall be plug gauged with 1.5 inch long plug having OD 0.0035 inches smaller than minimum allowed tube ID.

3.4.6 Identification: Each instrumentation tube assembly shall be identified by a serial number on the lower tube end. The serial number shall be unique to each instrumentation tube assembly. Upset metal may be removed by polishing to meet O.D. dimensional tolerances.

3.4.7 Cleanliness: Internal and external surfaces of the instrumentation tube assembly shall be clean, free of grease, oil, dust, dirt, finger marks or other contaminants.

4.0 REWORK

Instrumentation tubes which do not meet the allowable dimensional tolerances may be reworked provided the rework procedure has been reviewed and approved prior to use.

5.0 RECORDS

Complete fabrication and testing records shall be maintained. Traceability of the component parts to the initial material lots shall be maintained.

6.0 STORAGE

Instrumentation tube assemblies shall be stored in a manner to protect the assembly from mechanical damage, corrosion, and to maintain conformance with this specification.

7.0 QUALITY ASSURANCE

Receiving, in-process, and final inspection tests shall be conducted in sufficient numbers to insure that the finished instrumentation tubes meet the following characteristics:

JIL 30145, Revision 4

<u>Item</u>	<u>Characteristics</u>	<u>Applicable Section</u>
Overall Length	Major	3.4.1
Outside Diameter	Major	3.4.1
Inside Diameter(plug gauge)	Critical	3.4.5
Component Dimensions	Major	3.1.2, 3.2.2, 3.3.2
Other Dimensions	Major	3.4.1
Weld Quality	Critical	3.4.3
Weld Tensile and Compressive Strength	Critical	3.4.4
Identification	Major	3.4.6
Cleanliness	Major	3.4.7
Serial Number	Critical	3.4.6
Serial Number Appearance, Depth	Minor	3.4.6
Component Materials	Critical	3.1.1, 3.2.1, 3.3.1
Defects	Major	3.2.3, 3.3.3
Passivation	Major	3.1.3, 3.2.4, 3.3.4

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

JN-530145, Revision 4

APPENDIX B - PASSIVATION PROCEDURE

Immerse in a solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook, Vol. II, Page 605)

PRODUCT SPECIFICATION

1.0 TITLE: GRID SPACER ASSEMBLY - INTEGRAL INCONEL FRAME AND SPRINGS

2.0 SCOPE

2.1 This specification describes the requirements for Inconel grid spacer assemblies used in fuel assemblies.

2.2 The functions and requirements of the grid spacer assembly are:
To maintain an uniform spatial separation of the fuel rods conforming to the specified fuel rod pitch, and to restrain thermal bowing and/or flow-induced vibrations of the fuel rods which may induce fretting corrosion.

2.3 A glossary of terms is given in Appendix A.

3.0 TECHNICAL REQUIREMENTS

3.1 Structural Components

3.1.1 Material

All spacer components shall be fabricated from Inconel 718 strip conforming to the applicable material specification per the job parts list.

3.1.2 Surface Conditions

Finished parts shall be free of scale, burrs, (except as allowed by applicable drawings) and foreign materials. Surface roughness shall be per applicable drawings.

3.1.3 Dimensions:

Dimensions of the spacer components shall conform to those shown on the applicable drawings. No dimensional overcheck of components by Exxon Nuclear shall be required if the components and spacer assembly are fabricated by the same vendor.

3.1.4 Spring Characteristics:

The force-deflection characteristics of the spring after aging shall conform to the values given on the applicable support strip drawings.

3.2 Assembly

3.2.1 Dimensions:

3.2.1.1 Rod Cell:

The dimples and springs in each rod cell shall be dimensioned and positioned in compliance with the applicable assembly drawings.

3.2.1.2 Spacer Assembly:

The finished grid spacer assembly shall conform to the dimensions shown on the applicable drawing per the job parts list.

3.2.2 Welds:

Welds shall meet the following requirements:

3.2.2.1 Inert Gas Tungsten Arc Weld:

Welds must be well fused and free of spatter and ejected metal. Based on visual examination, under low power magnification, the welds shall be free of surface cracks. Metallographic examination during weld qualification shall show the weld well fused and free of internal cracks. Internal cracks are defined as transgranular cracks and not lack of fusion. Internal inclusions and porosity in excess of 0.006 inch shall be cause for rejection.

Welds shall be made under an inert gas (helium and/or argon) blanket or vacuum less than 1×10^{-3} torr which completely covers the weld

joint. This atmosphere shall cover the weld joint until the fused and heated metal cools sufficiently to avoid hydrogen and/or nitrogen absorption and oxidation. Weld parameters shall be selected to minimize distortion. There are two types of TIG welds involving structural components: (See spacer assembly drawing)

- a) Cross-Tab Welds: The intersections of structural components shall only be welded at the weld tabs as shown in the applicable drawing.
 - (1) Weld depth, exclusive of minor porosity (0.006") and inclusions, shall be as specified on the applicable drawing. Weld depth shall be measured from the top of the nugget to the bottom of the recast zone, and on the centerline of the tab cross members.
 - (2) The weld cover shall be as specified on the applicable drawing, exclusive of minor porosity (0.006") and inclusions. Welds shall be sectioned so the weld cover at the top of the slot in the structural strip can be measured.
 - (3) Up to 1% of the intersection welds can have only 2 of the 4 intersection-members fused. No two such intersections shall be adjacent nor shall they be at guide tube cell corners.
- b) End-Tab Welds: The end-tabs which penetrate the side plates shall be fused to the side plates as shown in the above reference drawing.

- (1) Weld penetration, exclusive of minor porosity (0.006") and inclusions, shall be as specified on the applicable drawing.
- (2) Up to 1% of the end tab welds can have the tab welded to only one side of the slot.

3.2.2.2 Resistance Spot Welds:

Qualification welds shall have a minimum diameter of bond area, exclusive of minor porosity as specified on the applicable drawing. Welds shall be free of cracks. These requirements shall be met based on metallographic and visual examinations, during weld qualification. Visual examination shall be with low power magnification.

Tension shear tests on qualification and in-process weld joint samples shall have a minimum joint strength as specified on the applicable drawing. One in-process weld joint sample shall be produced before and after the fabrication of each spacer assembly. The weld sample produced "after" a previous spacer assembly, may be used as a "before" sample on the subsequent assembly, provided the assemblies are fabricated by the same operator and with the same equipment.

3.2.2.3 Weld Visual Inspection:

After welding but prior to final heat treatment welds shall be inspected for discoloration to approved ENC visual standards. Welds may be cleaned by hand with a stainless steel brush to remove loose surface oxide prior to inspection for discoloration. Welds which do not meet the physical discoloration standards

shall be rejected. After final heat treatment all welds shall meet the approved visual discoloration standards and meet the configuration, per the applicable drawing.

3.2.3 Heat Treatment:

The assembled and welded spacer shall be annealed and precipitation heat treated, in a vacuum or suitable protective atmosphere, by the following procedure:

Hold at $1750 \pm 25^{\circ}\text{F}$ for 1 hour; cool at a rate $\geq$ air cooling to $1325^{\circ}\text{F} \pm 15^{\circ}\text{F}$; hold for 8 hours; cool at $100^{\circ}\text{F} \pm 15^{\circ}\text{F/hr}^*$ to $1150^{\circ}\text{F} \pm 15^{\circ}\text{F}$; hold for 8 hours and cool at a rate $\geq$ air cooling. Times at temperature shall be maintained to a tolerance of ± 10 per cent.

3.2.4 Identification:

Each spacer grid assembly shall be identified by a serial number on the outer surface (see applicable drawing for location). Serial numbers of scrapped spacer assemblies will not be reused.

3.2.5 Rework:

Repair or rework of any part of the assembly shall not impair the corrosion resistance or mechanical function procedures of any part of the assembly. Repair and rework procedures shall be reviewed and accepted by Materials and Mechanical Design and Process Engineering prior to rework. Records shall show which parts have

* Material may be furnace cooled at a slower rate provided the time at $1150 \pm 15^{\circ}\text{F}$ is adjusted to give a total aging time of 13 hours.

been reworked. After final assembly and heat treatment permanent deformation of dimples or springs to meet final assembly tolerances shall be limited to .020 inch at at the center of the spring and .010 inch at the center of the dimple. Tools for adjusting these components shall have contacting surfaces radiused within .030 of the surface radius to prevent local overstressing and shall provide positive limits so that components cannot be excessively deformed.

4.0 RECORDS

Complete fabrication records shall be maintained to assure traceability of each separate part to Heat Number and of each assembly to Heat Treatment Lot and Manufacturing Process. If all parts are not from the same material lot, an assembly map will be required which identifies each part as to its history and location in the spacer assembly. Acceptance inspection records shall be maintained.

5.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Mechanical Properties of Inconel 718	Major	3.1
Surface Condition and Finish	Major	3.1
Spring Dimensions	Major	3.1
Spring Characteristics	Critical	3.1
Heat Treat	Critical	3.2
Welds	Critical	3.2
Dimple Dimensions	Major	3.2
Assembly Envelope	Critical	3.2
Identification	Major	3.2

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification value, inspection criterion, test result, or defect measure, which if not properly controlled, could result in a reactor fuel failure. A critical defect, for example, is one that (judgment and experience indicate) is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or it is one that (judgment and experience indicate) is likely to prevent performance of the essential function of a components such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification value, inspection criterion, test result, or defect measure other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delay in shipping dates. Such a defect, for example, is likely to reduce materially the usability of a product such as a fuel rod or fuel assembly.
- Minor** A specification value, inspection criterion, test result or defect measure other than critical or major, which if not controlled, does not materially reduce the usability of the product, such as a fuel rod, for its intended purpose, or is not a departure from established standards significant to the effective use or operation of the product, or affects the appearance only to a minor degree where appearance is a significant characteristic.

Issue Date 4/1/72JERSEY NUCLEAR COMPANYPRODUCT SPECIFICATION

Title: GRID SPACER ASSEMBLY - INTEGRAL INCONEL FRAME AND SPRINGS

Supersedes Issue Dated: New

Fuel Design Council MembersPrepared
By:Charles J. [Signature]
Manager, Product Design

Accepted:

[Signature] for
Manager, Quality Assurance
and Licensing

Accepted:

[Signature]
Manager, Plant Operation

Accepted:

A. E. Neumann 4/1/72
Customer Project
Coordinator

Accepted:

[Signature] for
Manager, Process Engineering

Accepted:

[Signature]
Manager, Fuel Management
Services

Accepted:

RHP
D. L. Lowell 4/1/72
Manager, Quality Control

Accepted:

[Signature]
Manager, Materials

Approved:

A. E. Neumann for [Signature]
Manager, Research and Engineering

JN-530155, Revision 2

Issue Date 10/4/73

PRODUCT SPECIFICATION

1.0 TITLE: Machined Tie Plates

2.0 SCOPE

- 2.1 This specification describes stainless steel upper and lower fuel assembly tie plates which are fabricated from plate and sheet stock or forgings.
- 2.2 The function of the lower tie plate is to support the fuel assembly in the vertical position, correctly position the lower end of the fuel rods within the assembly and provide mating surfaces to correctly position the fuel assembly within the reactor, support tube, and channel assemblies, and to channel coolant flow into the fuel assembly in a hydraulically efficient manner.
- 2.3 The function of the upper tie plate is to correctly position the upper end of the fuel rods, provide mating surfaces to correctly position the fuel assembly within the reactor channel and to provide a point of attachment to allow movement of the fuel assembly in and out of the core with an overhead hoist.
- 2.4 A glossary of terms is given in Appendix A.
- 2.5 Pertinent references are listed in Appendix B.
- 2.6 Procedure for passivation is given in Appendix C.

3.0 TECHNICAL REQUIREMENTS

- 3.1 Material: Tie plates shall be fabricated from 304L stainless steel sheet and plate stock produced to ASTM A240-70, solution annealed, or forgings produced to ASTM A473-70*. The intergranular corrosion test, Section 3.6, shall also be required.
- 3.2 Defects: Internal defects in the machined part such as porosity, inclusions, cold shuts, and laminations shall be acceptable provided the defect is less than 0.060 inch in any dimensions, does not reduce the section thickness by more than 20%, and machining does not expose the defect.

Defects in excess of acceptable limits may be opened by machining or grinding and repaired by welding in accordance with Section 3.3 of this specification. Tie plates which are repair welded shall be radiographed to ascertain suitable repair. Repaired tie plates shall be clearly identifiable and records shall be provided showing the nature, extent, and location of the repair.

- 3.3 Welding: Welding shall be done with stainless steel conforming to the compositional requirements of AWS (ASTM) ER 308L except that carbon content shall be limited to 0.025% maximum. Weld type and configuration shall conform to the applicable drawing. Welds will be qualified per Jersey Nuclear Quality Control Procedures. Weld defects may be reworked in accordance with Section 3.7 of this specification.
- 3.4 Radiography: All tie plates shall be radiographed to ascertain internal quality as defined by Section 3.2 of this specification. Radiography shall be performed in accordance with ASTM E94 and ASTM E142 at a 2-2T quality level. Radiographs, the radiographic technique, and the shooting sketch shall be sent to the Buyer.

* Equivalent specification may be substituted with Buyer's prior approval.

3.5 Surface Quality

- 3.5.1 Finish: Except as specified by the applicable drawing, all machined surfaces shall be finished to 63 microinches or less per ANSI B46.1, 1962. EDM surfaces shall be 250 microinches or less.
- 3.5.2 Deburring: Deburring shall be performed only with carbide or equivalent abrasives or tooling. Wire brushing shall be done only with stainless steel brushes not previously used on materials other than stainless steel.
- 3.5.3 Contaminants: Solvents containing halides shall not be used at any time during manufacture. Lead or materials containing lead in excess of trace amounts (90 ppm) shall not contact the tie plates at any time.

3.6 Inspection and Testing

- 3.6.1 Visual: Each tie plate shall be 100% visually inspected for surface defects and irregularities. Attention shall be given to the presence of burrs, discontinuities such as cracks, and potential stress risers such as tool marks, recesses, sharp corners and voids. When advisable, magnification shall be used to aid visual inspection. Tie plates exhibiting surface discontinuities or cracks in excess of the requirements of 3.2, 3.5 or applicable drawings, shall be rejected or repaired in accordance with 3.2 or 3.7.
- 3.6.2 Dye Penetrant: Dye penetrant examination shall be in accordance with ASTM E165-65. All tie plate components shall be 100% examined for exposed defects. All welds shall be inspected for cracks or voids.

3.6.3 Intergranular Corrosion test: A representative sample from the material lot shall be corrosion tested in accordance with ASTM A262-70, Practice C. The target corrosion rate shall be less than 0.002 inch per month as determined by the average of five 48 hour test periods. The maximum permissible limit is 0.005 inch per month as determined by the average of five 48 hour periods, with no single period rate exceeding 0.006 inch per month.

3.7. Rework

Weld defects may be repaired in accordance with procedures proposed by the Seller and approved by the Buyer. Repair welding shall conform to Section 3.3 of this specification. Tie plates which are repair welded shall be clearly identifiable and records shall be provided showing the nature, extent, and location of rework performed.

3.8. Identification

The identity of each tie plate shall be maintained at all times with respect to material lot number. This identity shall be stamped or engraved on the finished tie plate.

3.9. Passivation

Finished tie plates shall be passivated in accordance with the procedure given in Appendix C.

4.0 RECORDS

Process control and fabrication records as specified by Quality Control shall be maintained to assure traceability of each tie plate as to heat number, heat treatment lot, and manufacturing process. Testing and inspection records shall be retained.

5.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Outside Dimension	Critical	Drawing
Rod Spacing	Critical	Drawing
Squareness of Outside Dimension	Critical	Drawing
Passivation	Major	3.9
Threads	Major	Drawing
Visual Inspection	Major	3.6
Finish	Minor	3.5
Dye Penetrant Inspection	Critical	3.6
Material	Critical	3.1

APPENDIX A- GLOSSARY OF TERMS

Critical	A specification value, inspection criterion, test result, or defect measure, which if not properly controlled, could result in a reactor fuel failure. A critical defect, for example, is one that (judgment and experience indicate) is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or it is one the (judgment and experience indicate) is likely to prevent performance of the essential function of a component such as a fuel rod, fuel assembly, or fuel reload core.
Major	A specification value, inspection criterion, test result, or defect measure other than critical, which if not properly controlled could result in excessive costs, defect rates, rework, or delays in shipping dates. Such a defect, for example, is likely to reduce materially the usability of a product such as a fuel rod or fuel assembly.
Minor	A specification value, inspection criterion, test result or defect measure other than critical or major, which if not controlled, does not materially reduce the usability of the product, such as a fuel rod, for its intended purpose, or is not a departure from established standards significant to the effective use of operation of the product, or affects the appearance only to a minor degree where appearance is significant characteristic.
Buyer	Jersey Nuclear Company
Seller	Supplier of Stainless Steel Sheet Material
Lot	A quantity of metal originating from one heat and processed under the same specified conditions to the finished plate, sheet or forging.

APPENDIX B - REFERENCES

Specifications

ASTM-E165-65

ANSI B46.1 1962

AWS (ASTM) ER 308L

ASTM A240-70

ASTM A473-70

ASTM E94-68

ASTM E142-68

ASTM A262-70

Liquid Penetrant Inspection

American Standard for Surface
Texture

Weld Filler Metal

Stainless Steel Plate, Sheet,
and Strip

Stainless and Heat-Resisting
Steel forgings

Recommended Practice for Radiographic
Testing

Standard Method for Controlling
Quality of Radiographic Testing

Detecting Susceptability to
Intergranular Attack in Stainless
Steel

JH 530155, Revision 2

APPENDIX C - PASSIVATION PROCEDURE

Immerse in solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook, Vol. II, Page 605)

JERSEY NUCLEAR COMPANYPRODUCT SPECIFICATION

1.0 TITLE: LOFT Fuel Assembly, Types D and E

2.0 SCOPE:

- 2.1 This specification describes the product requirements for the LOFT Types D and E fuel assemblies. Type D is a square, non-instrumented control assembly with stainless steel guide tubes. Type E is a triangular, non-instrumented corner assembly.
- 2.2 The scope of this specification excludes discussion of, or provision for, preventing criticality incidents, for health and safety requirements, and for hazards avoidance. In addition to the requirements of this specification, the requirements imposed by the Jersey Nuclear Criticality Safety Specifications and Radiation Work Procedures, plus all regulations pertaining to shipping must be observed.
- 2.3 A glossary of terms is given in Appendix A.
- 2.4 Pertinent specifications and drawings are listed in the latest revision of the applicable Parts List.
- 2.5 A table of rod fuel column weights is given in Appendix B.
- 2.6 The assembly sequence is given in Appendix C.
- 2.7 The welding requirements are listed in Appendix D.

3.0 TECHNICAL REQUIREMENTS

3.1 Components

The fuel assembly shall consist of those subassemblies and components specified in the latest revision of the assembly Parts List.

3.2 Design and Construction

- 3.2.1 The fuel assembly and its components shall conform to the latest revision of the applicable drawing. The absolute measurement system is to be used.
For purposes of determining conformance with these specifications, all dimensions and tolerances are in accordance with ANSI Y14.5-1966.
- 3.2.2 The bundle assembly sequence shall be in accordance with Appendix C of this specification.
- 3.2.3 The grid spacer assemblies shall be captured by locking rings welded to the guide tubes at each guide tube-spacer intersection with four welds, in accordance with Appendix D of this specification.
- 3.2.4 Conformance to fuel assembly dimensions shall be determined with the fuel assembly freestanding in a vertical position resting on a flat surface.
- 3.2.5 The minimum spacing between any two adjacent fuel rods shall be not less than 0.120 inch. The axially integrated average spacing over the fuel rod length shall not be less than 0.131 inch. The minimum spacing between a fuel rod

JN-530193, Revision 4

and guide tube shall not be less than 0.059 inches. The axially integrated average spacing over the fuel rod length shall not be less than 0.070 inches.

3.2.6 The outward bow of peripheral fuel rods shall not exceed 0.010 inch between adjacent spacers.

3.2.7 Finished fuel bundle assembly handling and positioning equipment must be such that the relative lateral displacements and twisting of the plates and spacers shall not exceed 0.063 inch and 0.5 degree* respectively.

3.2.8 The Type D fuel assembly shall be checked for fit up with a fuel assembly by actual insertion of a completed control rod cluster assembly or an equivalent gauge. An assembly which required a drag force in excess of 10 pounds for vertical insertion shall be rejected or reworked.

3.2.9 The individual rods shall be supported at all times prior to assembly to insure bowing does not exceed 1 inch in 3.5 feet.

*~35 mils measured at corner extremities

JN 530193, Revision 4

- 3.2.10 The weights of fillile material in a fuel assembly shall be within the limits specified in Appendix B.
- 3.2.11 For shipping and/or storage the fuel assembly shall be externally supported on a rigid surface (i.e., strong-back) aligned to within 0.030 inch of the nominal assembly envelope. During shipping the fuel assembly shall be supported horizontally at the tie plate and spacer locations with additional support between tie plate and spacers to withstand maximum vertical accelerations of 10 g without affecting fuel clad or spacer integrity.

3.3 Cleanliness and Workmanship

During insertion of fuel rods into the assembly, care shall be exercised to minimize scratching of the fuel rods. Scratches caused by assembly must not exceed a depth of 0.002 inch. The completed assembly shall be free of lint, fingerprints, metal cuttings, and all foreign materials which may impair corrosion resistance or reactivity. During and after assembly only reagent grade ethyl alcohol or reagent grade acetone may be used for cleaning. Tools used for assembly shall be stainless steel, chrome plated, or plastic. If plastic, the material used shall be free of sulfur or halides. Inspection gauges are exempted from this requirement.

3.4 Identification

Each fuel assembly shall be identified with a permanent serial

number applied on the top and side of the upper tie plate. The character size and location shall be in accordance with the assembly drawing.

4.0 RECORDS

4.1 Records shall be maintained for each fuel assembly so that all parts and subassemblies can be traceable to fabrication and/or source lots. Included in the records shall be a cross-section map which identifies each fuel rod by type and enrichment.

5.0 STORAGE

Fuel assemblies shall be packaged and stored in a manner that ensures compliance with this specification, prevents contamination by foreign materials and moisture, protects the assembly from physical damage, deterioration or corrosion and avoid criticality when stored in proximity with other fuel assemblies.

6.0 SHIPPING

6.1 Fuel assemblies shall be shipped only in AEC licensed and DOT shipping containers for shipping enriched uranium bearing fuel assemblies.

6.2 Each shipping container shall bear appropriate identification, including: Container manufacturer's nameplate bearing drawing

and container serial number; and proper labeling of outer container including type of shipment, radiation levels (units) and DOT Permit No.

- 6.3 Each loaded shipping package shall incorporate a seal, which is not readily breakable, and which, while intact, will be evidence that the package has not been illicitly opened.
- 6.4 In transit, the fuel assemblies shall be oriented so that the lower end of the assembly is in the forward direction. (This requires that the outer container be identified as to the orientation of the contained assemblies.)
- 6.5 Each shipment shall be accompanied by properly completed shipping papers, which will include:
 - Drawing and Serial Number of each assembly
 - Specification Number, Revision Number and date
 - Weight of fuel assembly (gross and tare weights)
 - Weight and enrichments of contained fissile material
 - Maximum radiation level at three feet from surface of outer container
 - Special instructions involved (e.g., maximum number of packages allowed per shipment, escort requirements, sole vehicle use, route restrictions, storage and/or layover limitations, etc.)
 - License numbers of shipper and receiver
 - Signature of shipper
 - Radiation level and spacing required for storage with other fissile materials
 - Initials of labeler.
- 6.6 During shipment, fuel assemblies shall be supported at tie plate and spacer positions. The support shall be in compliance with Section 3.2.11 above.

7.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Assembly and Component Envelopes	Critical	3.2.1, 3.2.8
Plug Weld	Critical	App. D.
Spacer Orientation	Critical	3.2.1
Guide Tube Axial Adjustment	Critical	3.2.2
Torque on Assembly Nuts	Major	3.2.2
Lock Welding of Nuts	Critical	3.2.2
Locking of Spacer to Guide Tube	Critical	3.2.3
Fuel Rod Separation	Critical	3.2.5
Peripheral Rod Bow	Major	3.2.6
Fuel Rod Support During Assembly and Shipping	Critical	3.2.8, 3.2.11
Fissile Weights	Critical	3.2.10
Cleanliness and Workmanship	Major	3.3
Identification	Major	3.4
Records - Assembly	Major	4.1
Storage	Major	5.0
Shipping	Major	6.0

APPENDIX A - GLOSSARY OF TERMS

Critical A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.

Major A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.

Minor A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - ASSEMBLY FUEL WEIGHTS

	Type D	Type E
UO ₂ , kg Nominal	231.3	79.4
Maximum	233.7	80.2
Minimum	229.0	78.6
U ²³⁵ , kg Nominal	8.16	2.80
Maximum	8.28	2.84
Minimum	8.04	2.76

APPENDIX C - BUNDLE ASSEMBLY SEQUENCE

- The procedures outlined in this specification are to be followed in conjunction with the applicable drawings and specifications per the job parts list. Performance of some operations in parallel is satisfactory.
- Welding shall be performed by qualified welders and welding procedures as developed during weld qualification.
 - Mount the grid spacer assemblies in a fixture in accordance with the dimensions indicated on the applicable drawings, square and align grid spacer assemblies.
 - Insert a batch of guide tube assemblies through the spacers with the upper alignment gauge block in place.
 - Install the gauge block bushing over the guide tube sleeves and lock into alignment, install guide tube nuts and torque to 50 ± 10 inch pounds.
 - Weld the locking rings to the guide tubes at each spacer location per Appendix D. For Assembly D, plug gauge full length of guide tube.
 - Insert the next batch of guide tube assemblies and repeat sequence until all guide tubes are installed.
 - Install nuts on guide tube lower end fitting.
 - Mount the lower tie plate or alignment gauge block in accordance with the dimensions indicated on the applicable drawings, square, align and clamp in position.

APPENDIX C - CONTINUED

- Adjust each lower guide tube nut to contact with the lower tie plate or gauge block.
- Remove lower tie plate or gauge block.
- Weld nuts to guide tube lower end fitting.
- Remove upper gauge block, install upper tie plate with thermocouple cover, install nuts, torque to 25 ± 5 inch pounds, and lock weld nuts to the guide tube sleeve and to the thermocouple cover plate.
- Install standard fuel rods through the bottom of the assembly.
- Insert the instrument tube assembly through the bottom of the assembly.
- Install lower tie plate seating it against the lower guide tube adjusting nuts. Install the attachment nuts and torque to 25 ± 5 inch pounds. Attach instrumentation tube to lower tie plate and torque nut to 50 ± 10 inch pounds, release and retorque to 25 ± 5 inch pounds.
- Lock nuts in place by welding to guide tube.
- Install the upper end box assembly, align, insert dowel pins, make the plug weld, and then weld dowel pins.

APPENDIX D- WELDING REQUIREMENTS

D-1 Spacer to Guide Tube Weld

- D.1.1 The guide tube to locking ring weld shall be accomplished using an inert gas tungsten arc weld.
- D.1.2 The weld parameters shall be adjusted to achieve a fusion weld between the guide tube and locking ring.
- D.1.3 After welding, the locking ring shall be in contact with the spacer on at least one side of the spacer guide tube cell, (contact being defined as not admitting a 0.001 inch feeler) and shall have not more than 0.005 clearance with at least one of the other three sides of the spacer guide tube cell. It is acceptable for one locking ring at each spacer to have no spacer contact provided it has a maximum of 0.005 clearance with at least one side of the spacer guide tube cell.
- D.1.4 Tension shear tests of production sample welds shall have ultimate strengths greater than 400 pounds.
- D.1.5 The minimum diameter of the bonded area shall be 0.060 inch based on destructive examination of representative welds.
- D.1.6 Representative welds shall show no evidence of cracking or metal expulsion.
- D.1.7 Metallographic examination of representative welds shall show full penetration through the weld interface.

D-2 Upper End Box to Grid Plate Welding

- D.2.1 The upper end box shall be joined to the grid plate by welding to form the upper tie plate assembly.
- D.2.2 The welds shall be accomplished by gas tungsten arc welding.
- D.2.3 The upper end box shall be attached to the grid plate assembly, with the grid assembly in place and aligned per the

APPENDIX D - CONTINUED

applicable drawing. Sixteen plug welds are required for the square assemblies, eight with alignment dowels in place. Ten welds are required for the triangular assemblies, four with dowels in place.

D.2.4 Weld filler metal shall be ER 308L per AWS A5.9-69 except that the carbon content shall be less than .025 percent.

D.2.5 Based on examination of representative welds during weld qualification, the welds at dowel pin locations shall have a penetration of 0.060 inch. The plug welds without dowel pins shall be full penetration and show a surface concavity of less than .060 inch.

D.2.6 Welds shall be free of cracks, overlaps, or undercuts. The welds shall blend smoothly into the parent material and show no discontinuities due to lack of fusion.

D.2.7 Welds may be dressed by grinding to meet the final tie plate envelope dimensions.

D.3 Lock Welds

D.3.1 Welds used for locking threaded fasteners shall be accomplished by gas tungsten arc welding.

D.3.2 A minimum of two welds on opposite sides of the fastener shall be used.

D.3.3 The welds shall be a minimum .125 inch long with minimum .030 penetration as determined by weld qualification samples.

D.3.4 Welds shall be visually examined for complete fusion of the mating components, and freedom from cracks.

D.3.5 Lock weld parameters shall be based on representative welds during weld qualification which show complete fusion and no significant porosity.

JERSEY NUCLEAR COMPANY

PRODUCT SPECIFICATION1.0 TITLE: Control Rod End Fittings2.0 SCOPE:

2.1 This specification describes requirements for the control rod end fittings to be used in fuel assemblies.

2.2 The functions of the control rod end fittings are to seal the rod and isolate the control material from the reactor coolant and to provide a means of attaching the control rod to the control rod spider.

2.3 A glossary of terms is given in Appendix A.

3.0 TECHNICAL REQUIREMENTS

3.1 Alloy Composition: Control rod end fittings shall be fabricated from 304L stainless steel rod or bar stock in accordance with the applicable material specification.

3.2 Dimensions: The dimensions, tolerances, and surface finish of the control rod end fittings shall conform to the applicable drawing per the job parts list.

3.3 Surface Condition: Control rod end fittings shall have a bright finish, free of burrs or scale, and shall have no surface mars, nicks or scratches deeper than 0.005 inch. All surfaces shall be clean and free of extraneous materials.

3.4 Dye Penetrant: Each finished end fitting shall be dye penetrant inspected. Indications other than burrs and scratches shall be cause for rejection.

3.5 Rework: Mechanical rework shall be allowed, where necessary, to meet these specifications. No repair by welding, or weld metal build-up shall be allowed.

4.0 RECORDS

4.1 Purchase Lots: Control rod end fittings shall be lotted on the basis of units originating from the same rod stock lot.

5.0 STORAGE AND SHIPPING

Control rod end fittings shall be sorted, handled, packaged and shipped in a manner to maintain conformance with this specification and to protect these parts from mechanical damage and from deterioration of surface finish or corrosion resistance, and to provide traceability.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material	Major	3.1
Dimensions	Major	3.2
Surface Condition	Major	3.3
Dye Penetrant	Critical	3.4

APPENDIX A - GLOSSARY OF TERMS

Critical	A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
Major	A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
Minor	A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

JN-S30196, Revision 0

Issue Date 5/26/72

PRODUCT SPECIFICATION

1.0 TITLE: Guide Tube Flow Restrictor

2.0 SCOPE

- 2.1 This specification describes requirements for the guide tube flow restrictors used in PWR fuel assemblies.
- 2.2 The function of the guide tube flow restrictor is to hydraulically simulate a partially inserted control rod. The flow restrictor must provide the flow restriction without complete blockage while resisting the hydraulic forces.
- 2.3 A glossary of terms is given in Appendix A.
- 2.4 Procedure for passivation is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

- 3.1 Alloy Composition: The flow restrictor shall be fabricated from 304L stainless steel stock in accordance with the applicable material specification.
- 3.2 Dimensions: The dimensions, tolerances, and surface finish of flow restrictor shall conform to the applicable drawing per the job parts list.
- 3.3 Surface Condition: Flow restrictors shall have a bright finish, free of burrs or scale, and shall have no surface mars, nicks or scratches deeper than 0.005 inch.
- 3.4 Passivation: Finished flow restrictors shall be passivated in accordance with the procedure specified in Appendix B.

4.0 RECORDS

- 4.1 Purchase Lots: Flow restrictors shall be lotted on the basis of units originating from the same rod stock lot.

5.0 STORAGE AND SHIPPING

Flow restrictors shall be stored, handled, packaged and shipped in a manner to maintain conformance with this specification and to protect these parts from mechanical damage and from deterioration of surface finish or corrosion resistance, and to provide traceability.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material	Major	3.1
Dimensions	Major	3.2
Threads	Major	3.2
Surface Defects	Major	3.3
Passivation	Critical	3.4

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - PASSIVATION PROCEDURE

Immerse in solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook, Vol. II, Page 605.)

JH-530192, Revision 1

Issue Date 10/9/72

PRODUCT SPECIFICATION1.0 TITLE: INSTRUMENTED FUEL ROD - LOFT2.0 SCOPE

- 2.1 This specification describes the product requirements for the LOFT instrumented fuel rods to be used in LOFT fuel assemblies.
- 2.2 The functions of the instrumented fuel rods are to hermetically contain the fuel material and resulting fission products, to isolate the fuel material from the reactor coolant, to provide an adequate heat transfer surface, and to supply its appropriate share of the fuel assembly design energy. In addition, thermocouples are attached to the rod surface to provide temperature data during reactor operation and testing.
- 2.3 A glossary of terms is given as Appendix A.
- 2.4 Pellet stack component weights are given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

- 3.1 The fuel rod assembly shall be fabricated from the following components. The specific drawing number for each component is listed on the rod assembly drawing. The rod assembly drawings are listed in the job parts list and on the fuel assembly drawing. Applicable specifications for each component are listed along with the drawing number in the job parts list.

UO₂ Fuel Pellet

Insulator Disc

Lower End Cap

Plenum Spring

Cladding

Upper End Cap

Thermocouple Leads, Active
and Dummy

3.2 Pellet Stack

- 3.2.1 The active pellet stack shall be included between two insulator pellets (one placed on each end of the stack) in accordance with the applicable drawings.
- 3.2.2 The active pellet stack and component weights shall be as specified in Appendix B. The following tolerances apply to the various components:
Total Oxide	$\pm 2\%$
Fissile Content	$\pm 3\%$
- 3.2.3 Each rod pellet stack shall be weighed to an accuracy of 0.1 percent. Stack weight and pellet lot(s) shall be recorded and remain traceable by individual rod identification.
- 3.2.4 The length of the active pellet column (excluding insulator discs) shall be as specified on the applicable drawing and shall be measured prior to loading of the pellets into the clad tube.
- 3.2.5 A short dished pellet, minimum length 0.20 inches, may be used at either or both ends of the fuel column to adjust the fuel column length. A pellet shortened by grinding may be used at the plenum end of the column.
- 3.2.6 Pellet enrichment is of critical importance and must be controlled by process procedure to insure proper loading and identification.
- 3.2.7 Pellets shall be vacuum outgassed prior to loading in conformance with the approved applicable Process Specification.

3.3 Welding

- 3.3.1 The end cap to cladding weld shall be accomplished in an atmosphere at nominally atmospheric pressure containing a minimum of 95% helium, balance argon, and a minimum of 99.9% inert gas (helium plus argon). The helium used shall be Bureau of Mines grade A, and the argon of comparable purity.
- 3.3.2 The rod to end cap weld shall have a minimum accumulative solid metal path from rod interior to exterior (leak free path) of 0.020 inches after correction for distance across voids, inclusions or areas of non-bond indication in the path. Fusion zone beta grains shall have a Wedmanstätten structure indicating uniform second phase distribution and the existence of alpha crystals within beta grains. The heat affected zone shall exhibit no columnar grains. The heat affected zone of the clad shall not extend beyond the end cap.
- 3.3.3 The weld shall be free of cracks, overlaps, or undercuts.
- 3.3.4 The weld shall contain no porosity (a group of pores) or inclusions in any cross section in which an individual pore or inclusion exceeds 0.004 inches in the greatest dimensions.
- 3.3.5 The weld shall blend smoothly into the parent material and show no discontinuities due to lack of fusion.
- 3.3.6 The lower and upper end cap welds shall not exhibit a surface convexity (e.g., weld overhang) greater than 0.005 inches on the rod diameter. Weld overhang may be altered by careful hand filing or dressing in order to meet the specified dimensions.

- 3.3.7 An axial tensile test of representative welds on cladding samples conducted at room temperature during initial weld qualification shall yield joint efficiencies of 80% or greater based on the minimum specified ultimate strength and nominal specified clad thickness.
- 3.3.8 Metallographic destructive examination of the closure weld area shall be used to verify that at a confidence level of 95%, 95% of the end cap welds meet the requirements of paragraph 3.3.2 above.
- 3.3.9 Each end cap weld shall be radiographed to further verify the weld quality.
- 3.3.10 Rework - Rods having reject or non-conforming welds may be reworked, provided that the rework process or procedure has been reviewed and approved prior to use.
- 3.4 Etching: All outer surfaces of the finished fuel rod shall be etched. The total amount of metal to be removed from a single surface by etching shall be at least 0.0005 inches and no more than 0.0015 inches.
- 3.5 Pellet Location and Plenum Length: A sampling plan shall be established for full length radiography after final closure welding to verify that fuel rods retain their proper plenum lengths and pellet seating, and to ascertain the absence of gross pellet chipping.
- 3.6 Instrumentation
- 3.6.1 The thermocouples attached to the fuel rod shall be small diameter sheathed cables with crushed magnesium oxide insulation as supplied by ANC.

- 3.6.2 The thermocouple locations and points of attachment shall be in accordance with the applicable drawing per the job parts list.
- 3.6.3 Attachment of the thermocouple cable to the fuel rod shall be by laser welding using procedures in accordance with ANC Procedure 60081. The hot junction shall be welded directly to the outside surface of the cladding using titanium filler wire. The thermocouple cable shall be fastened by welding along the fuel rod length using titanium filler metal.
- 3.6.4 The fuel rod cladding surface shall be as etched. Autoclave corrosion testing shall be omitted for the instrumented fuel rods.
- 3.6.5 Dummy sections of thermocouple cable shall be attached to provide a degree of symmetry for the thermocouple system. See the applicable drawing.
- 3.6.6 A means of identifying each individual thermocouple lead shall be provided. The identification shall be compatible with routing requirements during assembly of the fuel bundle and during installation of the fuel bundle in the reactor core.
- 3.6.7 Thermocouple continuity and leak testing shall be in accordance with ANC 60040 and ASTM E-235-67.

3.7 Miscellaneous

- 3.7.1 The rods shall be helium leak tested. The leak rate shall not exceed 1×10^{-8} std cc/sec of helium and the chamber shall be evacuated to 50 microns or less. The leak rate shall be measured within 8 days after welding.

- 3.7.2 Rods shall have no marks greater than 0.002 inch deep.
- 3.7.3 The maximum allowable bow for the rod shall not exceed that specified in the applicable drawing.
- 3.7.4 Welded fuel rods shall contain not less than 95% helium in the free volume, and not more than 0.1% gaseous impurities other than argon as verified by process qualification tests.
- 3.7.5 Each rod shall be identified by a serial number stamped on the lower end cap. The serial number shall be unique to each rod and clearly visible.
- 3.7.6 Internal and external surfaces of fuel rods shall be clean, free of grease, oil, dust, dirt, moisture, finger marks, scale, flux, organic material (inserts, etc.) and other contaminants.
- 3.7.7 Contamination of UO_2 fuel rod exterior surfaces shall not exceed 10 dpm/100 cm^2 as determined by a wipe test.
- 3.7.8 After loading, individual rods shall be supported at all times to ensure that bowing will not exceed 1 inch over 3.5 feet of length.

4.0 RECORDS

- 4.1 Fabrication Records: Thorough fabrication and testing records including any special fuel rod characterization records shall be maintained. Rod history shall be traceable back to the initial feed materials. Records shall be cross referenced to the rod serial numbers.

4.2 Acceptance Testing Records: Acceptance testing records shall be maintained and the records shall be cross referenced to the rod serial numbers.

4.3 Process controls and records for each fuel rod shall be such as to assure traceability of each component of each rod including:

- each UO_2 pellet lot in the pellet column
- end cap lot(s)
- cladding lot
- insulator disc lot
- enrichment level
- plenum spring lot

5.0 STORAGE

The rods shall be stored in such a manner that the rods remain clean, the identity is maintained, the rods are not damaged or contaminated with other materials (e.g., oil), and the rods retain conformity with this specification.

6.0 REWORK

Rods which exceed the allowable tolerances on dimensions but which could be reworked to meet the requirements of this specification may be so reworked and resubmitted, provided that the rework process has been reviewed and approved prior to use.

7.0 QUALITY ASSURANCE

Receiving and in-process inspection tests shall be conducted in sufficient numbers to assure that the finished fuel rods meet the following characteristics. Final inspection tests shall be consistent with RDT Standard E13-15T Section 3.7.3.1.

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Active fuel length	Major	3.2.4

JN-530198, Revision 1

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Diametral gap	Critical	3.1
Overall Length	Major	3.1
OD	Major	3.1
Rod Bow	Major	3.7.3
Rod Diameter at Welds	Major	3.3.6
Fuel Column Weight	Major	3.2.2
Fissile Content	Critical	3.2.2
Uranium Oxide Content	Major	3.2.2
Component Location	Major	3.5
Proper Pellet Location	Critical	3.5
Pellet Chips	Critical	3.5
Dryness of Pellets and Tubes	Critical	3.2.7 and 3.7.6
(Control by process procedure)		
Helium Atmosphere for Welding	Critical	3.3.1
(Control by process procedure)		
Joint Efficiency	Critical	3.3.7
(Control by process procedure)		
Weld Cover	Critical	3.3.2
Weld Cracks, Defects, and Appearance	Critical	3.3.3
Cladding and Weld Integrity	Critical	3.3.2
Etching	Major	3.4
Rod Cleanliness	Critical	3.7.6

JN-S30198, Revision 1

Item	Characteristic	Applicable Section
Radioactive Surface and Weld Contamination	Major	3.7.7
Surface of Finished Rods	Critical	3.7.6
Serial Number	Critical	3.7.5
Serial Number, Depth and Appearance	Minor	3.7.5
Rod Handling	Major	3.7.8
Thermocouple Weld	Major	3.6.3
Thermocouple Leak Check	Major	3.6.7
Thermocouple Location	Major	3.6.2
Thermocouple Continuity	Major	3.6.6

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

JN-S30198, Revision 1

APPENDIX B - PELLET STACK COMPONENT WEIGHTS

		<u>Total Ceramic</u>	<u>Total U²³⁵</u>
Standard UO ₂ Rod (grams)	Nominal	1134	40.0
	Maximum	1157	41.2
	Minimum	1112	38.8

Issue Date 12/15/72

JERSEY NUCLEAR COMPANY

PRODUCT SPECIFICATION

1.0 TITLE: CONTROL ROD SPIDER

2.0 SCOPE

- 2.1 This specification describes the requirements for the control rod spider used in rod cluster control assemblies in PWR's.
- 2.2 The function of the control rod spider is to suspend the individual control rods in a cluster and connect the cluster and the control rod drive mechanism.
- 2.3 A glossary of terms is given in Appendix A.
- 2.4 Procedure for passivation is given in Appendix B.
- 2.5 Pertinent references are given in Appendix C.

3.0 TECHNICAL REQUIREMENTS

- 3.1 Material: Spiders shall be fabricated from 304L stainless steel plate stock produced to ASTM A240-70*, solution annealed, or forgings produced to ASTM A473-70* except that maximum carbon content shall be 0.025 percent and maximum cobalt content shall be 0.15 percent. The intergranular corrosion test, Section 3.6.3, shall also be required.
- 3.2 Defects: Internal defects in the machined part such as porosity, inclusions, cold shuts, and laminations shall be acceptable provided the defect is less than 0.060 inch in any dimension, does not reduce the section thickness by more than 20%, and machining does not expose the defect.

* Equivalent specification may be substituted with Buyer's prior approval.

Defects in excess of acceptable limits may be opened by machining or grinding and repaired by welding in accordance with Section 3.3 of this specification. Spiders which are repair welded shall be radiographed and dye penetrant inspected (Section 3.4 and 3.6.2) to ascertain suitable repair. Repaired spiders shall be clearly identifiable and records shall be provided showing the nature, extent, and location of the repair.

- 3.3 Welding: Welding shall be done with stainless steel conforming to the compositional requirements of AWS (ASTM)ER 308L except that carbon content shall be limited to 0.025% maximum. Weld type and configuration shall conform to the applicable drawing. Welds will be qualified per Jersey Nuclear Quality Control Procedures. Weld defects may be reworked in accordance with Section 3.2 of this specification.
- 3.4 Radiography: All spiders shall be radiographed to ascertain internal quality as defined by Section 3.2 of this specification. Radiography shall be performed in accordance with ASTM E94 and ASTM E142 at a 2-2T quality level. Radiographs, the radiographic technique, and the shooting sketch shall be approved by and furnished to the Buyer.

3.5 Surface Quality

- 3.5.1 Finish: Except as specified by the applicable drawing, all machined surfaces shall be finished to 63 microinches or less per ANSI B46.1, 1962. EDM surfaces shall be 125 microinches or less.
- 3.5.2 Deburring: Deburring shall be performed only with carbide or equivalent abrasives or tooling. Wire brushing shall be done only with stainless steel brushes not previously used on materials other than stainless steel.

3.5.3 Contaminants: Solvents containing halides shall not be used at any time during manufacture. Lead or materials containing lead in excess of trace amounts (50 ppm) shall not contact the spiders at any time. All surfaces shall be clean and free of contaminants such as grease, oil, and dirt.

3.6 Inspection and Testing

3.6.1 Visual: Each spider shall be 100% visually inspected for surface defects and irregularities. Attention shall be given to the presence of burrs, discontinuities such as cracks, and potential stress risers such as tool marks, recesses, sharp corners and voids. When advisable, magnification shall be used to aid visual inspection. Spiders exhibiting surface discontinuities or cracks in excess of the requirements of 3.2, 3.5 or applicable drawings shall be rejected or repaired in accordance with 3.2 or 3.7.

3.6.2 Dye Penetrant: Dye penetrant examination shall be in accordance with ASTM E165-65. All cell spider components shall be 100% examined for exposed defects. All welds shall be inspected for cracks and voids. Indications other than burrs or scratches shall be cause for rejection or rework.

3.6.3 Intergranular Corrosion Test: A representative sample from the material lot shall be corrosion tested in accordance with ASTM A262-70, Practice C. The target corrosion rate shall be less than 0.002 inch per month as determined by the average of five 48 hour test periods. The maximum permissible limit is 0.005 inch per month as determined by the average of five 48 hour periods, with no single period rate exceeding 0.006 inch per month.

3.7 Rework

Weld repairs and dimensional adjustments may be made provided the rework procedure has been reviewed and approved by the Buyer. Repair welding shall be in accordance with Section 3.3 of this specification.

3.8 Identification

The identity of each spider shall be maintained at all times with respect to material lot number. This identity shall be stamped or engraved on the finished spider.

3.9 Passivation

Finished spiders shall be passivated in accordance with the procedure given in Appendix B.

4.0 RECORDS

Process control and fabrication records as specified by Quality Control shall be maintained to assure traceability of each spider as to heat number, heat treatment lot or forging number, and manufacturing process. Testing and inspection records shall be retained.

5.0 QUALITY ASSURANCE

Receiving, in-process, and final inspection tests shall be conducted in sufficient numbers to insure that the finished spiders meet the following characteristics.

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material	Critical	3.1
Defects	Major	3.2
Welding	Critical	3.3
Radiography	Critical	3.4
Surface Quality	Major	3.5
Inspection	Major	3.6
Identification	Major	3.8
Passivation	Major	3.9

APPENDIX A - GLOSSARY OF TERMS

Critical	A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
Major	A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
Minor	A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.
Buyer	Jersey Nuclear Company
Seller	Supplier of RCC spiders
Lot	A quantity of metal originating from one heat and processed under the same specified conditions to the finished plate, sheet or forging.

APPENDIX B - PASSIVATION PROCEDURE

Immerse in solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook, Vol. II, Page 605)

APPENDIX C - REFERENCES

Specifications

ASTM A240-70

Stainless steel plate, Sheet,
and Strip

ASTM A473-70

Stainless and Heat-Resisting
Steel forgings

AWS (ASTM) ER 308L

Weld Filler Metal

ASTM E94-68

Recommend Practice for Radiographic
Testing

ASTM E142-68

Standard Method for Controlling
Quality of Radiographic Testing

ANSI B46.1, 1962

American Standard for Surface
Texture

ASTM E165-65

Liquid Penetrant Inspection

ASTM A262-70

Detecting Susceptibility to
Intergranular Attack in Stainless
Steel.

JERSEY NUCLEAR COMPANYPRODUCT SPECIFICATION1.0 TITLE: GUIDE TUBE INSTRUMENTATION ASSEMBLIES - LOFT2.0 SCOPE

- 2.1 This specification describes the requirements for guide tube instrumentation assemblies used in LOFT fuel assemblies.
- 2.2 The functions and requirements of the guide tube instrumentation assemblies are to provide support for the differential pressure tube, for the thermocouple leads, both coolant and guide tube, and/or the neutron detector, from the point of attachment to the top of the guide tube just above the upper tie plate grid, while resisting hydraulic forces and accommodating differential thermal expansions.
- 2.3 A glossary of terms is given in Appendix A.
- 2.4 Procedure for passivation is given in Appendix B.
- 2.5 A list of elements significant in the determination of equivalent boron content is given in Appendix C.

3.0 TECHNICAL REQUIREMENTS3.1 Instrumentation Support

- 3.1.1 Material: Instrumentation supports shall be fabricated from 304L stainless steel or Zircaloy-4 rod or bar stock conforming to the applicable material specification per the job parts list.
- 3.1.2 Dimensions: The support dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.
- 3.1.3 Surface Defects: Supports shall be free of burrs, sharp edges or scale and shall have no surface mars, nicks or scratches deeper than 0.005 inch.

- 3.1.4 Passivation: Instrumentation supports fabricated from stainless steel shall be passivated in accordance with the procedure given in Appendix B.
- 3.1.5 Etching: Instrumentation supports fabricated from zircaloy 4 shall be etched before final assembly. The total amount of metal to be removed from a single surface by etching shall be at least .00025 and no more than .001 inch.

3.2 Clips and Springs

- 3.2.1 Material: Clips and springs shall be fabricated from Inconel 718 sheet stock conforming to the applicable material specification per the job parts list.
- 3.2.2 Dimensions: Clip and spring dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.
- 3.2.3 Surface Defects: Clips and springs shall be free of scale, burrs or sharp edges. The parts shall have no nicks or scratches greater than 0.0001 inch.
- 3.2.4 Heat Treatment: Clips and springs shall be precipitation heat treated to yield age hardened characteristics after forming per paragraph 5.7 of AMS 5596C.

3.3 Thermocouple Leads

- 3.3.1 Material: The thermocouple leads shall be stainless steel sheathed or titanium sheathed per the applicable job parts list. Insulation shall be crushed magnesium oxide. The thermocouple leads shall be supplied by the customer.
- 3.3.2 Attachment: The weld attachment of thermocouples to the guide tubes shall be by gas tungsten arc or laser beam procedures in accordance with the applicable instrumented fuel assembly product and process specifications.

3.3.3 Integrity: Continuity checks before and after assembly shall be in accordance with INC 60040.

3.4 Neutron Detector

3.4.1 Material: Neutron detectors shall be of the self-powered cobalt emitter type per INC-60040, supplied by ANC.

3.4.2 Integrity: Inspection and tests shall be in accordance with INC-60040.

3.5 Tubing

3.5.1 Material: Tubing shall be fabricated from 304L or Zircaloy 4 conforming to the applicable material specification per the job parts list.

3.5.2 Dimensions: Tubing dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.5.3 Passivation: Finished tubing fabricated from stainless steel shall be passivated in accordance with the procedure specified in Appendix B.

3.6 Sleeve

3.6.1 Material: Sleeves shall be fabricated from 304L stainless steel or Zircaloy 4 rod and bar stock conforming to the applicable material specification per the job parts list except that the EBC requirements are waived.

3.6.2 Dimensions: The sleeve dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.6.3 Surface Defects: Sleeves shall have a bright finish free of burrs or scale and shall have no surface mars, nicks, or scratches deeper than 0.005 inch.

3.6.4 Passivation: Finished sleeves fabricated from stainless steel shall be passivated in accordance with the procedure specified in Appendix B.

3.6.5 Etching: Finished sleeves fabricated from zircaloy 4 shall be etched before final assembly. The total amount of metal to be removed from a single surface by etching shall be at least .00025 and no more than .001 inch.

3.7 Equivalent Boron Content: The total equivalent boron content (EBC) of 304L stainless steel used for supports (including impurities), shall not exceed 850 ppm; the total equivalent boron content (EBC) of Zircaloy 4 used for supports (including impurities), shall not exceed 40 ppm, based on either a comparative reactivity test using an analyzed standard of the same general composition, or a quantitative analysis for the elements listed in Appendix C and a summation of their contribution to the equivalent boron content. Factors for converting constituent concentrations to equivalent boron concentrations are given in the Equivalent Boron Content Specification (See JN-S30100).

3.8 Assembly

3.8.1 Components

The guide tube instrumentation assemblies shall be fabricated from the following components. The applicable assembly and component drawings and specifications are listed in the job parts list.

Instrumentation support	Spring
Spring clip	Tubing
Thermocouple leads	Sleeve
Neutron detector and leads	Locking ring

3.8.2 Dimensions

The instrumentation guide tube assembly dimensions and tolerances shall conform to the applicable drawing per the job parts list.

3.8.3 Identification

Each guide tube instrumentation assembly shall be identified by a serial number on the uppermost support. The serial number shall be unique to each guide tube instrumentation assembly. Upset metal may be removed by polishing to meet O.D. dimensional tolerances.

3.8.4 Cleanliness

Internal and external surfaces of the guide tube instrumentation assembly shall be clean, free of grease, oil, dust, dirt, finger marks or other contaminants.

4.0 REWORK

Guide tube instrumentation assemblies which do not meet the requirements of this specification may be reworked provided the rework procedure has been reviewed and approved prior to use.

5.0 RECORDS

Complete fabrication and testing records shall be maintained. Traceability of the component parts to the initial material lots shall be maintained.

6.0 STORAGE

Guide tube instrumentation assemblies shall be stored in a manner to protect the assembly from mechanical damage, corrosion, and to maintain conformance with this specification.

7.0 QUALITY ASSURANCE

Receiving, in-process, and final inspection tests shall be conducted in sufficient numbers to insure that the finished assemblies meet the following characteristics:

JN-S30203, Revision 2

<u>Item</u>	<u>Characteristics</u>	<u>Applicable Section</u>
ComponentsMaterials	Critical	3.1.1, 3.2.1, 3.3.1 3.4.1
Defects	Major	3.1.3, 3.2.3
Passivation	Major	3.1.4, 3.5.3, 3.6.4
Heat Treatment	Major	3.2.4
Outside Diameter	Major	3.5.1
Component Dimensions	Major	3.5.1
Other Dimensions	Major	3.5.1
Identification	Major	3.5.3
Cleanliness	Major	3.5.4
Serial Number	Major	3.5.6
Etching	Major	3.1.5, 3.6.5

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - PASSIVATION PROCEDURE

Immerse in a solution of 6 to 15 volume percent 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinse in deionized water and dry.

(Reference: ASM Metals Handbook)

APPENDIX C- IMPURITY SPECIFICATIONS

In lieu of a comparative reactivity test, the concentration of each of the elements listed below may be determined and used to calculate the total equivalent boron content.

Alloying Elements

Chromium

Iron

Nickel

Impurity Elements

Boron

Cadmium

Cobalt

Dysprosium

Europium

Gadolinium

Manganese

Samarium

Issue Date 9/21/72

PRODUCT SPECIFICATION

1.0 TITLE: Dummy Half-Rods

2.0 SCOPE

2.1 This specification describes requirements for dummy half rods to be used in fuel assemblies.

2.2 The function of the dummy half rods is to occupy peripheral positions in the fuel rod array of triangular corner assemblies which cannot be filled with standard fuel rods and thus yield a more uniform coolant flow distribution.

2.3 A glossary of terms is given in Appendix A.

2.4 Procedure for passivation is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 Alloy Composition: Dummy half rods shall be fabricated from 304L (or 304) stainless steel rod or bar stock in accordance with the applicable material specification.

3.2 Dimensions: The dimensions, tolerances, and surface finish of dummy half rods shall conform to the applicable drawing per the job parts list.

3.3 Surface Condition: Dummy half rods shall be free of burrs or scale, and shall have no surface marks, nicks or scratches deeper than 0.005 inch.

3.4 Passivation: Finished dummy half rods shall be passivated in accordance with the procedure specified in Appendix B.

3.5 Fabrication: The dummy half rods shall be machined from rod or bar stock. Straightening to meet drawing requirements is allowed if followed by a vacuum stress relief anneal at $750^{\circ}\text{F} \pm 25^{\circ}\text{F}$ for a minimum of 12 hours.

3.6 Handling: The dummy half rod shall be handled in such a way that the bow does not exceed one inch in three and one-half feet.

4.0 RECORDS

4.1 Purchase Lots: Dummy half rods shall be lotted on the basis of units originating from the same rod stock lot.

5.0 STORAGE AND SHIPPING

Dummy half rods shall be stored, handled, packaged and shipped in a manner to maintain conformance with this specification and to protect these parts from mechanical damage and from deterioration of surface finish or corrosion resistance, and to provide traceability.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material	Major	3.1
Dimensions	Major	3.2
Surface Defects	Major	3.3
Passivation	Critical	3.4
Fabrication	Major	3.5
Handling	Major	3.6

APPENDIX A - GLOSSARY OF TERMS

Critical A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.

Major A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.

Minor A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - PASSIVATION PROCEDURE

Immerse in solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook, Vol. II, Page 605.)

PRODUCT SPECIFICATION

1.0 TITLE: 304L STAINLESS STEEL NUT

2.0 SCOPE

- 2.1 This specification describes requirements for the nut to be used in fuel assemblies.
- 2.2 The functions of the nuts to mechanically fix the guide tubes to the upper tie plate, to carry the full weight of the fuel assembly when the assembly is suspended by the upper tie plate and to carry the full holddown load when the assembly is installed in the reactor.
- 2.3 A glossary of terms is given in Appendix A.
- 2.4 Procedure for passivation is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

- 3.1 Material: Nuts shall be fabricated from 304L stainless steel stock conforming to the applicable material specification per the job parts list.
- 3.2 Dimensions: The dimensions, tolerances, and surface finish of nuts shall conform to the latest revision of the applicable drawings per the job parts list.
- 3.3 Surface Condition: Nuts shall have a bright finish, free of burrs or scale, and shall have no surface mars, nicks or scratches deeper than 0.005 inch.

3.4 Passivation: Finished nuts shall be passivated in accordance with the procedure specified in Appendix B. After passivation, the parts shall be thoroughly rinsed in deionized water and dried.

4.0 CERTIFICATION

The fabricator shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation.

5.0 SHIPPING AND STORAGE

5.1 Nuts shall be stored, handled, packaged, and shipped in a manner that assures conformance to this specification and prevents damage or deterioration and provides traceability.

5.2 The fabricator shall be responsible for all details of packing, crating, and shipping and for identification of parts and shipping cartons.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material	Major	3.1
Dimensions	Minor	3.2
Threads	Major	3.2
Surface Condition	Major	3.3
Passivation	Major	3.4

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - PASSIVATION PROCEDURE

Immerse in a solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook, Vol. II, Page 605)

JERSEY NUCLEAR COMPANYPRODUCT SPECIFICATION

1.0 TITLE: Instrumented Rod Nut

2.0 SCOPE:

2.1 This specification describes requirements for the nut to be used to attach instrumented fuel rods.

2.2 The function of the instrumentation rod nuts is to mechanically fix the instrumented fuel rods to the upper tie plate.

2.3 A glossary of terms is given in Appendix A.

2.4 Pertinent references are listed in Appendix C.

3.0 TECHNICAL REQUIREMENTS

3.1 Material: Nuts shall be fabricated from Zircaloy-4 rod or bar conforming to the applicable material specification per the job parts list.

3.2 Dimensions: The dimensions, tolerances, and surface finish of nuts shall conform to the latest revision of the applicable drawings per the job parts list.

3.3 Surface Condition: Nuts shall be free of burrs or scale, and shall have no surface marks, nicks or scratches deeper than 0.005 inch. All surfaces shall be clean and free of extraneous materials.

3.4 Corrosion Resistance: Samples of finished instrumented rod nuts shall be corrosion tested in accordance with the steam corrosion test of ASTM B351-67. Maximum weight gain shall not exceed the limits listed in ASTM B351-67.

3.5 Rework: Mechanical rework shall be allowed, where necessary, to meet these specifications.

4.0 CERTIFICATION

The fabricator shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation.

5.0 SHIPPING AND STORAGE

5.1 Nuts shall be stored, handled, packaged, and shipped in a manner that assures conformance to this specification and prevents damage or deterioration and provides traceability.

5.2 The fabricator shall be responsible for all details of packing, crating, and shipping and for identification of parts and shipping cartons.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material	Major	3.1
Dimensions	Minor	3.2
Threads	Major	3.2
Surface Condition	Major	3.3
Corrosion Resistance	Major	3.4

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - REFERENCES

Specifications

ASTM B351-67

Hot-Rolled and Cold-Finished
Zirconium and Zirconium Alloy
Bars, Rod, and Wire for Nuclear
Applications.

JH-530221, Revision 2

Issue Date 10/9/72

JERSEY NUCLEAR COMPANYPRODUCT SPECIFICATION1.0 TITLE CONTROL ROD CLUSTER2.0 SCOPE

2.1 This specification describes the requirements for control rod cluster assemblies.

2.2 The functions and requirements of the control rod cluster assembly are to provide a means of controlling the reactor core by neutron absorption, while resisting the applied loadings due to insertion and withdrawal forces, hydraulic forces, and handling.

2.3 A glossary of terms is given in Appendix A.

2.4 Procedure for passivation is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 Upper Shaft

3.1.1 Material

Upper shafts shall be fabricated from 304L rod and bar stock conforming to the applicable material specification per the job parts list.

3.1.2 Dimensions

Shaft dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.1.3 Surface Defects

Shafts shall have a bright finish free of burrs or scale and shall have no surface mars, nicks, or scratches deeper than 0.005 inch.

3.2 Handling Knob

3.2.1 Material

Handling knobs shall be fabricated from 304L rod and bar stock conforming to the applicable material specification per the job parts list.

3.2.2 Dimensions

The handling knob dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.2.3 Surface Defects

Handling knobs shall have a bright finish free of burrs or scale and shall have no surface mars, nicks, or scratches deeper than 0.005 inch except for spherical surfaces where none shall be deeper than 0.003 inch.

3.3 Spring Retainer

3.3.1 Material

Spring retainers shall be fabricated from 304L rod and bar stock conforming to the applicable material specification per the job parts list.

3.3.2 Dimensions

Spring retainer dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.3.3 Surface Defects

Spring retainers shall have a bright finish (before passivation) free of burrs or scale and

shall have no surface mars, nicks, or scratches deeper than 0.005 inch.

3.3.4 Liquid Penetrant

Finished spring retainers shall be liquid penetrant inspected in accordance with ASTM E165-65. Retainers with cracks, pits, or surface porosity shall be rejected.

3.3.5 Passivation

Finished retainers shall be passivated in accordance with the procedure specified in Appendix B.

3.4 Bolt

3.4.1 Material

Bolts shall be fabricated from 304L rod and bar stock conforming to the applicable material specification per the job parts list.

3.4.2 Dimensions

The bolt dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.4.3 Surface Defects

Bolts shall have a bright finish (before passivation) free of burrs or scale and shall have no surface mars, nicks, or scratches deeper than 0.005 inch.

3.4.4 Passivation

Finished bolts shall be passivated in accordance with the procedure specified in Appendix B.

3.4.5 Liquid Penetrant

Finished bolts shall be liquid penetrant inspected in accordance with ASTM E165-65. Bolts with cracks,

pits, or surface porosity shall be rejected.

3.4.6 X-Ray

Finished bolts will be radiographed for internal defects.

Bolts which give any indication of voids or pores shall be rejected.

3.5 Lock Pins

3.5.1 Material

Lock pins shall be fabricated from 304L rod and bar stock conforming to the applicable material specification per the job parts list.

3.5.2 Dimensions

Pin dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.6 Assembly

3.6.1 Components

The control rod cluster assembly shall be fabricated from the following components. The applicable assembly and component drawings are listed in the job parts list.

Component product and material specifications are listed above and on the applicable job parts list.

Control Rod Spider	Control Rods (20)
Coil Springs (2)	Upper Shaft
Handling Knob	Spring Retainer
Bolt	Lock Pins (21)

3.6.2 Structure Welds

The control rod cluster shaft to handling knob and shaft to spider welds shall be made using inert gas tungsten arc welds in conformance with the dimensions given on the applicable

drawing per the job parts list. All welds shall be well fused and free of splatter, ejected metal, and slag. Based on metallographic examination during weld qualification and visual examination under 3 to 6X magnification, the welds shall be free of undercuts, cracks, inclusions or folds greater than 0.005 inch deep. The welds shall blend smoothly into the parent material and show no discontinuities due to lack of fusion. Welds will be 100% radiographed for internal defects. Indications of voids, pores, or lack of fusion greater than 0.060 inches total in any cross section shall be cause for rejection. The welds shall be liquid penetrant inspected in conformance with ASTM E165-65 after the root pass and after final welding and dressing. Indications of cracks shall be cause for rejection.

3.6.3 Attachment of Control Rods

The threaded connection shall be made with an initial torque of 15 inch-pounds, relaxed back to zero torque, and re-torqued to 7 to 10 inch-pounds. After final torquing, the hole for the locking pin shall be drilled.

3.6.4 Lock Pin Welds

After press fitting of locking pins into place, lock welds shall be made using inert gas tungsten arc welds without filler metal. The weld shall extend around the complete pin circumference. The weld shall blend smoothly into the parent material and show no indications of discontinuity due to lack of fusion.

3.6.5 Passivation

After the assembly of the handling knob, upper shaft and spider, the handling knob, shaft and both weld regions shall be passivated.

(Appendix 3). The balance of this subassembly shall not be passivated. The total assembly including control rods shall not be passivated again.

3.6.6 Identification

Each cluster assembly shall be identified by the serial number on the spider.

3.6.7 Cleanliness

The control rod cluster assembly shall be clean, free of grease, oil, dust, dirt, finger marks or other contaminants.

3.6.8 Mating Dimensions

Each control rod cluster shall be checked for fit up with a fuel assembly by actual insertion into a completed assembly. The insertion shall be made with assembly meeting specifications mounted in a vertical position, and gauged to measure insertion drag. A control rod cluster which exhibits a drag force in excess of 10 pounds during insertion shall be rejected or reworked (Section 4.0).

4.0 REWORK

Control rod cluster assemblies which do not meet the allowable dimensional tolerances may be reworked provided the rework procedure has been reviewed and approved prior to use.

5.0 RECORDS

Complete fabrication and testing records shall be maintained. Traceability of the component parts to the initial material lots shall be maintained.

6.0 STORAGE

Control rod cluster assemblies shall be stored in a manner to protect the assembly from mechanical damage, corrosion and to maintain conformance with this specification.

7.0 QUALITY ASSURANCE

Receiving, in-process, and final inspection tests shall be conducted in sufficient numbers to insure that the control rod cluster assemblies meet the following characteristics: Final inspection tests shall be conducted for RDT Standard E13-15T, Section 3.7.3.6.

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Component Materials	Critical	3.0
Liquid Penetrant	Critical	3.3.4, 3.4.5
Dimensions	Major	3.6.1
Weld Quality	Critical	3.6.2, 3.6.4
Torque of Rods	Major	3.6.3
Passivation	Major	3.6.5
Identification	Major	3.6.6
Cleanliness	Major	3.6.7
Insertion Test	Critical	3.6.8

APPENDIX A - GLOSSARY OF TERMS

Critical

A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.

Major

A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.

Minor

A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - PASSIVATION PROCEDURE

Immerse in a solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook)

JN-530231, Revision 4

Issue Date 9/21/73PRODUCT SPECIFICATION1.0 TITLE: CONTROL ROD - LOFT2.0 SCOPE

2.1 This specification describes the product requirements for the LOFT control rods to be used in LOFT control rod cluster assemblies

2.2 The functions of the control rods are to hermetically contain the control material to provide an adequate heat transfer surface, and to provide the proper neutron absorption characteristic for reactor control. The control rod shall perform all of these functions throughout irradiation.

2.3 A glossary of terms is given as Appendix A.

2.4 Procedure for passivation is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 The control rod assembly shall be fabricated from the following components. The specific drawing number for each component is listed on the rod assembly drawing. The rod assembly drawing is listed in the job parts list. Applicable specifications for each component are listed along with the drawing number in the job parts list.

Poison Rod

Lower End Fitting

Cladding

Plenum Spring

Upper End Fitting

3.2 Welding

3.2.1 The end fitting to cladding weld shall be accomplished using an inert gas tungsten arc in an atmosphere at nominally atmospheric pressure containing a minimum

of 95% helium, balance argon, and a minimum of 99.9% inert gas (helium plus argon). The helium used shall be Bureau of Mines grade A, and the argon of comparable purity.

- 3.2.2 The rod to end cap weld shall have a minimum cumulative solid metal path from rod interior to exterior (leak free path) of 0.015 inch after correction for distance across voids, inclusions or areas of non-bond indication in the path. This requirement applies after finishing to specified diameter.
- 3.2.3 The weld shall be free of cracks, overlaps, or undercuts.
- 3.2.4 The weld shall contain no porosity (a group of pores) or inclusions in any cross section in which an individual pore or inclusion exceeds 0.003 inch in the greatest dimension.
- 3.2.5 The weld shall blend smoothly into the parent material and show no discontinuities due to lack of fusion. Weld fusion and heat affected zones shall show no intergranular attack.
- 3.2.6 The upper and lower fitting welds may be dressed to meet the maximum diameter requirements.
- 3.2.7 An axial tensile test of representative welds conducted at room temperature during initial weld qualification shall yield joint efficiencies of 70% or greater based on the minimum specified clad ultimate strength and nominal specified clad thickness.
- 3.2.8 Metallographic destructive examination of the closure weld area shall be used to verify that at a confidence level of 95%, 95% of the end cap welds meet the requirements of paragraph 3.2.2 and 3.2.4 above.

3.2.9 Each end cap weld shall be radiographed to further verify the weld quality.

3.2.10 Rework

Rods having reject or non-conforming welds may be reworked, provided that the rework process or procedure has been reviewed and approved prior to use.

3.3 Passivation

Finished control rods shall be passivated in accordance with the procedure specified in Appendix B.

3.4 Miscellaneous

- 3.4.1 The rods shall be helium leak tested before passivation within eight days after welding. The leak rate shall not exceed 1×10^{-8} std cc/sec of helium and the chamber shall be evacuated to 50 microns or less.
- 3.4.2 Finished rods shall have no mars greater than 0.002 inch deep.
- 3.4.3 Welded control rods shall contain not less than 95% helium in the free volume, and not more than 0.1% gaseous impurities other than argon as verified by process qualification tests.
- 3.4.4 Each rod shall be identified by a serial number electro-etched on the upper end fitting. The serial number shall be unique to each rod and clearly visible.
- 3.4.5 Internal and external surfaces of control rods shall be clean, free of grease, oil, dust, dirt, moisture, finger marks, scale, flux, organic material and other contaminants.
- 3.4.6 After loading, individual rods shall be supported at all times to ensure that bowing will not exceed 1 inch over any 3.5 foot length.

3.5 Absorber Weight

The weight of the absorber (silver indium cadmium alloy) in each control rod shall be less than 3.02 pounds and greater than 2.79 pounds.

4.0 RECORDS

4.1 Fabrication Records

Thorough fabrication and testing records shall be maintained.

Rod history shall be traceable back to the initial feed materials.

Records shall be cross referenced to the rod serial numbers.

4.2 Inspection Testing Records

Inspection testing records shall be maintained and the records shall be cross referenced to the rod serial numbers.

4.3 Process Controls and Records

Process controls and records for each fuel rod shall be such as to assure traceability of each component of each rod including:

- end fitting lot(s)
- poison rod lot
- cladding lot
- plenum spring lot

5.0 STORAGE

The rods shall be stored in such a manner that the rods remain clean, the identity is maintained, the rods are not damaged or contaminated with other materials (e.g., oil), and the rods retain conformity with this specification.

6.0 REWORK

Rods which exceed the allowable tolerances on dimensions but which would be reworked to meet the requirements of this specification may be so reworked and resubmitted, provided that the rework process has been reviewed and approved prior to use.

7.0 QUALITY ASSURANCE

Receiving and in-process inspection tests shall be conducted in sufficient numbers to assure that the finished control rods meet the following characteristics. Final inspection tests shall be conducted per RDT Standard E13-15T Section 3.7.3.2.

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Active poison length	Major	3.1
OD, including weld overhang	Critical	3.1
Other dimensions	Major	3.1
Helium Atmosphere for welding	Critical (control by process procedure)	3.2.1, 3.4.3
Weld cover	Critical	3.2.2
Weld cracks, defects, and appearance	Critical	3.2.3, 3.2.4, 3.2.5
Cladding and weld integrity	Critical	3.4.1
Joint efficiency	Critical	3.2.7
Passivation	Major	3.3
Surface of finished rods	Critical	3.4.2
Serial number	Critical	3.4.4
Serial number, depth and appearance	Minor	3.4.4
Rod cleanliness	Critical	3.4.5
Rod handling	Major	3.4.6

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - PASSIVATION PROCEDURE

Immerse in a solution of 6 to 15 volume percent 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinse in deionized water and dry.

(Reference: ASM Metals Handbook)

JN-S30232, Revision 4

Issue Date 9/21/73JERSEY NUCLEAR COMPANYPRODUCT SPECIFICATION1.0 TITLE LOFT Fuel Assembly, Types A, B and C2.0 SCOPE

- 2.1 This specification describes the product requirements for the LOFT Types A, B and C fuel assemblies. Type A is a square, instrumented center assembly with stainless steel guide tubes. Type B is a square instrumented control assembly. Type C is a triangular, instrumented corner assembly.
- 2.2 The scope of this specification excludes discussion of, or provision for, preventing criticality incidents, for health and safety requirements, and for hazards avoidance. In addition to the requirements of this specification, the requirements imposed by the Jersey Nuclear Criticality Safety Specifications and Radiation Work Procedures, plus all regulations pertaining to shipping must be observed.
- 2.3 A glossary of terms is given in Appendix A.
- 2.4 Pertinent specifications and drawings are listed in the latest revision of the applicable Parts List.
- 2.5 A table of rod fuel column weights is given in Appendix B.
- 2.6 The assembly sequence is given in Appendix C.
- 2.7 The welding requirements are listed in Appendix D.
- 2.8 Instrumentation requirements are given in Appendix E.

3.0 TECHNICAL REQUIREMENTS3.1 Components

The fuel assembly shall consist of those subassemblies and components specified in the latest revision of the fuel assembly Parts List.

3.2 Design and Construction

3.2.1 The fuel assembly and its components shall conform to the latest revision of the applicable drawing. The absolute measurement system is to be used.

For purposes of determining conformance with this specifications, all dimensions and tolerances are in accordance with ANSI Y14.5-1966.

3.2.2 The bundle assembly sequence shall be in accordance with Appendix C of this specification.

3.2.3 The grid spacer assemblies shall be captured by locking rings welded to the guide tubes at each guide tube-spacer intersection with four welds, in accordance with Appendix D of this specification.

3.2.4 Conformance to fuel assembly dimensions shall be determined with the fuel assembly free standing in a vertical position resting on a flat surface.

3.2.5 The minimum spacing between any two adjacent fuel rods shall be not less than 0.120 inch. The axially integrated average spacing over the fuel rod length shall not be less than 0.131 inch. The minimum spacing between a fuel rod and guide tube shall not be less than 0.059 inch. The axially integrated average spacing over the fuel rod length shall not be less than 0.070 inch.

3.2.6 The outward bow of peripheral fuel rods shall not exceed 0.010 inch between adjacent spacers.

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- 3.2.7 Finished fuel bundle assembly handling and positioning equipment must be such that the relative lateral displacements and twisting of tie plates and spacers shall not exceed 0.063 inch and 0.5 degree* respectively.
- 3.2.8 The type B fuel assembly shall be checked for fit up with a fuel assembly by actual insertion of a completed control rod cluster assembly or an equivalent gage. An assembly which requires a drag force in excess of 10 pounds for vertical insertion shall be rejected or reworked.
- 3.2.9 The individual rods shall be supported at all times prior to assembly to insure bowing does not exceed 1 inch in 3.5 feet.
- 3.2.10 The weights of fissile material in a fuel assembly shall be within the limits specified in Appendix B.
- 3.2.11 For shipping and/or storage the fuel assembly shall be externally supported on a rigid surface (i.e., strongback) aligned to within 0.030 inch of the nominal assembly envelope. During shipping the fuel assembly shall be supported horizontally at the tie plate and spacer locations, with additional support provided between tie plates and spacers to withstand maximum vertical accelerations of 10g without affecting fuel clad or spacer integrity.
- 3.2.12 See Appendix E for instrumentation requirements.

3.3 Cleanliness and Workmanship

During insertion of fuel rods into the assembly, care shall be exercised to minimize scratching of the fuel rods. Scratches

* ~ 35 mils, measured at corner extremities.

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caused by assembly must not exceed a depth of 0.002 inch. The completed assembly shall be free of lint, fingerprints, metal cuttings, and all foreign materials which may impair corrosion resistance or reactivity. During and after assembly only reagent grade ethyl alcohol or reagent grade acetone may be used for cleaning. Tools used for assembly shall be stainless steel, chrome plated, or plastic. If plastic, the material used shall be free of sulfur or halides. Inspection gages are exempted from this requirement.

3.4 Identification

Each fuel assembly shall be identified with a permanent serial number applied on the top and side of the upper tie plate. The character size and location shall be in accordance with the assembly drawing.

4.0 RECORDS

4.1 Records shall be maintained for each fuel assembly so that all parts and subassemblies can be traceable to fabrication and/or source lots. Included in the records shall be a cross-section map which identifies each fuel rod by type and enrichment.

5.0 STORAGE

Fuel assemblies shall be packaged and stored in a manner that ensures compliance with this specification, prevents contamination by foreign materials and moisture, protects the assembly from physical damage, deterioration or corrosion and avoids criticality when stored in proximity with other fuel assemblies.

6.0 SHIPPING

- 6.1 Fuel assemblies shall be shipped only in AEC licensed and DOT shipping containers for shipping enriched uranium bearing fuel assemblies.
- 6.2 Each shipping container shall bear appropriate identification, including: container manufacturer's nameplate bearing drawing and container serial number; and proper labeling of outer container including type of shipment, radiation levels (units) and DOT Permit No.
- 6.3 Each loaded shipping package shall incorporate a seal, which is not readily breakable, and which, while intact, will be evidence that the package has not been illicitly opened.
- 6.4 In transit, the fuel assemblies shall be oriented so that the lower end of the assembly is in the forward direction. (This requires that the outer container be identified as to the orientation of the contained assemblies.)
- 6.5 Each shipment shall be accompanied by properly completed shipping papers, which will include:
 - Drawing and serial number of each assembly.
 - Specification number, revision number and date.
 - Weight of fuel assembly (gross and tare weights).
 - Weight and enrichments of contained fissile material.
 - Maximum radiation level at three feet from surface of outer container.
 - Special instructions involved (e.g., maximum number of packages allowed per shipment, escort requirements, sole vehicles use, route restrictions, storage and/or layover limitations, etc.)

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- Signature of shipper.
- Radiation level and spacing required for storage with other fissile materials.
- Initials of labeler.

6.6 During shipment, fuel assemblies shall be supported at tie plate and spacer positions. The support shall be in compliance with Section 3.2.11 above.

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7.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Assembly and Component Envelopes	Critical	3.2.1
Plug Weld	Critical	App. D
Spacer Orientation	Critical	3.2.
Guide Tube Axial Adjustment	Critical	3.2.2
Torque on Assembly Nuts	Major	3.2.2
Lock Welding of Nuts	Critical	3.2.2
Attachment of Spacer to Guide Tube	Critical	3.2.3
Fuel Rod Separation	Critical	3.2.5
Peripheral Rod Bow	Major	3.2.6
Fuel Rod Support During Assembly and Shipping	Critical	3.2.8, 3.2.9
Fissile Weights	Critical	3.2.10
Cleanliness and Workmanship	Major	3.3
Identification	Major	3.4
Records - Assembly	Major	4.1
Storage	Major	5.0
Shipping	Major	6.0
Instrumentation Continuity	Major	App.E

APPENDIX A - GLOSSARY OF TERMS

Critical	A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
Major	A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
Minor	A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

APPENDIX B - ASSEMBLY FUEL WEIGHTS

	<u>Types A and B</u>	<u>Type C</u>
UO ₂ , kg Nominal	231.3	79.4
Maximum	233.7	80.2
Minimum	229.0	78.6
U ²³⁵ , kg Nominal	8.16	2.80
Maximum	8.28	2.84
Minimum	8.04	2.76

APPENDIX C - BUNDLE ASSEMBLY SEQUENCE

- The procedures outlined in this specification are to be followed in conjunction with the applicable drawings and specifications per the job parts list.
- Welding shall be performed by qualified welders and welding procedures as developed during weld qualification.
 - Mount the grid spacer assemblies in a fixture in accordance with the dimensions indicated on the applicable drawings, square and align grid spacer assemblies.
 - Insert a batch of guide tube assemblies through the spacers with the alignment gauge block in place.
 - Install the gauge block bushing over the guide tube sleeves and lock into alignment, install guide tube nuts and torque to 50 ± 10 inch pounds.
 - Weld the locking rings to the guide tubes at each spacer location per Appendix D and plug gauge.
 - Insert the next batch of guide tube assemblies and repeat sequence until all guide tubes are installed.
 - Install liquid level detector guide tubes where applicable using the sequence above except that the guide tube to spacer weld is omitted.
 - Install nuts on guide tube lower end fitting.
 - Mount the lower tie plate on alignment gauge block in accordance with the dimensions indicated on the applicable drawings, square, align and clamp in position.

- Adjust each lower guide tube nut to contact with the lower tie plate.
- Remove lower tie plate.
- Weld nuts to guide tube lower end fitting.
- Remove gauge block and install upper tie plate without thermocouple cover, install instrumented guide tube supports and complete welds, install nuts and torque to 25 ± 5 inch pounds.
- Install instrumented fuel rods through the bottom of the assembly, install cap screw, torque to 9 - 10 inch pounds, release, and torque to 9 - 10 inch pounds. Lock screw by deforming the cap into the recesses provided for locking. Route thermocouple leads through the tie plate slots. Check instrument lead resistance after final routing for each rod.
- Install standard fuel rods through the bottom of the assembly.
- Insert the instrument tube assembly through the bottom of the assembly.
- Install lower tie plate seating it against the lower guide tube adjusting nuts. Install the attachment nuts and torque to 25 ± 5 inch pounds. Attach instrumentation tube to lower tie plate and torque nut to 50 ± 10 inch pounds, release and retorque to 25 ± 5 inch pounds.
- Lock nuts in place by welding to guide tube.
- Route lower coolant thermocouple through slots in lower tie plate, position hot junction and stake, and weld thermocouple cover plate in position.
- Route upper coolant thermocouples and stake.

- Remove guide tube nuts, attach thermocouple cover plate and routing fixtures where applicable, torque to 25 ± 5 inch pounds and lock weld nuts and fixtures to the guide tube sleeve and to the thermocouple cover plate.
- Complete routing of all thermocouples.
- Install the upper end box assembly, threading thermocouple cables through the routing hole in the end box, align, insert dowel pins, make the plug weld, and then weld dowel pins.
- Check instrument lead continuity.

APPENDIX D - WELDING REQUIREMENTSD-1 Spacer to Guide Tube Weld

- D.1.1 The guide tube to locking ring weld shall be accomplished using an inert gas tungsten arc weld.
- D.1.2 The weld parameters shall be adjusted to achieve a fusion weld between the guide tube and locking ring.
- D.1.3 After welding, the locking ring shall be in contact with the spacer on at least one side of the spacer guide tube cell, (contact being defined as not admitting a 0.001 inch feeler) and shall have not more than 0.005 clearance with at least one of the other three sides of the spacer guide tube cell. It is acceptable for one locking ring at each spacer to have no spacer contact provided it has a maximum of 0.005 clearance with at least one side of the spacer guide tube cell.
- D.1.4 Tension shear tests of production sample welds shall have ultimate strengths greater than 400 pounds.
- D.1.5 The minimum diameter of the bonded area shall be 0.060 inch based on destructive examination of representative welds.
- D.1.6 Representative welds shall show no evidence of cracking or metal expulsion.
- D.1.7 Metallographic examination of representative welds shall show full penetration through the weld interface.

D-2 Upper End Box to Grid Plate Welding

- D.2.1 The upper end box shall be joined to the grid plate by welding to form the upper tie plate assembly.

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- D.2.2 The welds shall be accomplished by gas tungsten arc welding.
- D.2.3 The upper end box shall be attached to the grid plate assembly, with the grid assembly in place and aligned per the applicable drawing. Sixteen plug welds are required for the square assemblies, eight with alignment dowels in place. Ten welds are required for the triangular assemblies, four with dowels in place.
- D.2.4 Weld filler metal shall be ER 308L per AWS A5.0-69 except that the carbon content shall be less than 0.025 percent.
- D.2.5 Based on examination of representative welds during weld qualification, the welds at dowel pin locations shall have a penetration of 0.060 inch. The plug welds without dowel pins shall be full penetration and show a surface concavity of less than 0.060 inch.
- D.2.6 Welds shall be free of cracks, overlaps, or undercuts. The welds shall blend smoothly into the parent material and show no discontinuities due to lack of fusion.
- D.2.7 Welds may be dressed by grinding to meet the final tie plate envelope dimensions.

D.3 Lock Welds

- D.3.1 Welds used for locking threaded fasteners shall be accomplished by gas tungsten arc welding.
- D.3.2 A minimum of two welds on opposite sides of the fastener shall be used.
- D.3.3 The welds shall be a minimum 0.125 inch long with minimum 0.030 penetration as determined by weld qualification samples.

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D.3.4 Welds shall be visually examined for complete fusion of the mating components, and freedom from cracks.

D.3.5 Lock weld parameters shall be based on representative welds during weld qualification which show complete fusion and no significant porosity.

APPENDIX E - INSTRUMENTATION DETAILS

- E.1 The fuel assembly instrumentation shall be in conformance with the requirements of INC-60007 and INC-60040. In addition, the instrumentation will conform to the specifications below.
- E.2 Instrumentation routing shall be in conformance with the applicable assembly drawing per the job parts list.
- E.3 All instrumentation shall be fully installed, completely routed, except for attachment of the end box, and all continuity checks made before final installation and welding of the upper end box to the gird.
- E.4 Except for the initial bend out of the flow channel, all fuel rod thermocouples and bends shall be made using a forming mandrel of the proper diameter.
- E.5 Routing of thermocouples across the grid plate must be in the slotted recesses. Packing of multiple leads within a slot shall be such that the thermocouple cover plate will lie flat over any slot with hand pressure alone.
- E.6 Coolant thermocouples shall be pre-formed near the hot junction so as to control extension into the coolant stream per the applicable drawing.
- E.7 Coolant thermocouples shall be formed so that before installation of the cover plate a part of the thermocouple within 0.25" and 0.38" of the hot junction extends above the slot a minimum of .032 inch and must be forced into position by the cover plate.
- E.8 For bundles incorporating liquid level detectors, a torque of 30 to 50-inch pounds may be used for final tightening and orienting of the instrumentation routing fixture. If the proper orientation cannot be achieved within the specification limits, grinding or filing may be used to adjust engagement and orientation.

EXXON NUCLEAR COMPANY, INC.

PRODUCT SPECIFICATION

1.0 TITLE: GUIDE TUBE ASSEMBLY (ZIRCALOY-4)

2.0 SCOPE

2.1 This specification describes the requirements for guide tube assemblies used in PWR fuel assemblies.

2.2 The functions and requirements of the guide tube assembly are to join the upper and lower tie plates, forming the basic structural skeleton of the fuel assembly and to support the spacer grid assemblies along the fuel assembly length, while resisting the applied axial loadings due to holddown forces, hydraulic forces, and handling.

2.3 A glossary of terms is given in Appendix A.

3.0 TECHNICAL REQUIREMENTS

3.1 Tubing

3.1.1 Material: Tubing shall be fabricated from Zircaloy-4 conforming to the applicable material specification per the job parts list.

3.1.2 Dimensions: The tubing dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.2 Guide Tube Sleeve and End Fitting

3.2.1 Material: Guide tube sleeves and end fittings shall be fabricated from Zircaloy-4 rod and bar stock conforming to the applicable material specification per the job parts list except that EBC requirements are waived.

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- 3.2.2 Dimensions: The guide tube sleeve and end fitting dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.
- 3.2.3 Surface Defects: Guide tube sleeves and end fittings shall be free of burrs or scale and shall have no surface marks, nicks, or scratches deeper than 0.005 inch.
- 3.2.4 Cleanliness: All surfaces of the sleeve and end fitting shall be clean and free of extraneous materials. Components such as oils, greases, rubber and plastics containing sulfur and halides shall not ordinarily be used in contact with corrosion resistant surfaces. Where use of such components is necessary, the surfaces shall be cleaned prior to operations which involve heating the parts such as welding and heat treating. Such materials shall not be used under circumstances where they may become entrapped in areas of crevices that will become inaccessible to further direct contact cleaning.
- 3.2.5 Etching: All surfaces of the sleeve and end fitting shall be etched before final assembly. The total amount of metal to be removed from a single surface by etching shall be at least 0.00025 and no more than 0.001 inch.

3.3 Assembly

3.3.1 Components

The guide tube assembly shall be fabricated from the following components. The applicable assembly and components

drawings and specifications are listed in the job parts list:

Tubing

Upper Guide Tube Sleeve

Lower Guide Tube End Fitting

3.3.2 Welding:

The guide tube shall be assembled by welding using inert gas tungsten arc weld in conformance with the dimensions given on the applicable drawing per the job parts list.

3.3.3 Welds

All welds shall be well fused and free of splatter, ejected metal, and slag. Based on metallographic examination during weld qualification and visual examination under low power magnification, the welds shall be free of undercuts, inclusions or folds greater than 0.005 inch deep, or cracks. The welds shall blend smoothly into the parent material and show no discontinuities due to lack of fusion. The lower end fitting weld shall be dressed if necessary to meet O.D. dimension tolerances. Up to 0.002 inch may be removed from the inner surface at the sleeve to tube weld to meet dimensional requirements.

3.3.4 Testing

An axial tensile test of the sleeve to guide tube weld and the end fitting to guide tube weld shall yield joint efficiencies of 80% or greater based on the minimum ultimate strength

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of 60,000 psi for annealed tubing and the nominal guide tube area based on samples welded during weld qualification. Axial compression tests of the sleeve to guide tube weld and the end fitting to guide tube weld shall show symmetrical buckling of the guide tube without weld failure using tubing lengths of less than 3 inches.

3.3.5 Plug Gauging

The finished guide tube assembly shall be plug gauged with a 1.5 inch long plug having an O.D. 0.0035 inch smaller than the minimum allowed tube I.D.

3.3.6 Identification

Each guide tube assembly shall be identified by a serial number electro-etched on the guide tube approximately 1.0 inch above the lower end fitting weld. The serial number shall be unique to each guide tube assembly.

3.3.7 Cleanliness

Internal and external surfaces of the guide tube assembly shall be clean, free of grease, oil, dust, dirt, finger marks or other contaminants.

4.0 REWORK

Guide tube assemblies which do not meet the allowable dimensional tolerances may be reworked provided the rework procedure has been reviewed and approved prior to use.

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5.0 RECORDS

Complete fabrication and testing records shall be maintained.

Traceability of the component parts to the initial material lots shall be maintained.

6.0 STORAGE

Guide tube assemblies shall be stored in a manner to protect the assembly from mechanical damage, corrosion, and to maintain conformance with this specification.

7.0 QUALITY ASSURANCE

Receiving, in-process, and final inspection tests shall be conducted in sufficient numbers to insure that the finished guide tubes meet the following characteristics:

<u>Item</u>	<u>Characteristics</u>	<u>Section</u>
Overall length	Major	3.3.1
Outside diameter	Major	3.3.1
Inside diameter (plug gauge)	Critical	3.3.5
Component Dimensions	Major	3.1.2 3.2.2
Other dimensions	Major	3.3.1
Weld Quality	Critical	3.3.3
Weld tensile and compressive strength	Critical	3.3.4
Identification	Major	3.3.6
Cleanliness	Major	3.2.4 3.3.7
Serial number	Critical	3.3.6
Serial number appearance, depth	Minor	3.3.6
Component materials	Critical	3.1.1 3.2.1
Defects	Major	3.2.3
Etching	Major	3.2.5

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

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Issue Date 12/13/76

PRODUCT SPECIFICATION

1.0 TITLE: INSTRUMENTATION TUBE ASSEMBLY (ZIRCALOY-4)

2.0 SCOPE

2.1 This specification describes the requirements for instrumentation tube assemblies used in PWR assemblies.

2.2 The function of the instrumentation tube assembly is to provide a longitudinal passageway in the fuel assembly for insertion of instrumentation.

2.3 A glossary of terms is given in Appendix A.

3.0 TECHNICAL REQUIREMENTS

3.1 Tubing

3.1.1 Material: Tubing shall be fabricated from Zircaloy-4 conforming to the applicable material specification per the job parts list.

3.1.2 Dimensions: The tubing dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.2 Instrumentation Tube Sleeve

3.2.1 Material: Instrumentation tube sleeves shall be fabricated from Zircaloy-4 rod and bar stock conforming to the applicable material specification per the job parts list, except that EBC requirements are waived.

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- 3.2.2 Dimensions: The instrumentation tube sleeve dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.
- 3.2.3 Surface Defects: Instrumentation tube sleeves shall be free of burrs or scale and shall have no surface marks, nicks, or scratches deeper than 0.005 inch.
- 3.2.4 Cleanliness: All surfaces of the sleeve shall be clean and free of extraneous materials. Components such as oils, greases, rubber and plastics containing sulfur, and halides shall not ordinarily be used in contact with corrosion resistant surfaces. Where use of such components is necessary, the surfaces shall be cleaned prior to operations which involve heating the parts such as welding and heat treating. Such materials shall not be used under circumstances where they may become entrapped in areas or crevices that will become inaccessible to further direct contact cleaning.
- 3.2.5 Etching: All surfaces of the components shall be etched before final assembly. The total amount of metal to be removed from a single surface shall be nominally .0005 with a maximum of .001 inch.

3.3 Instrumentation Tube Plug

- 3.3.1 Material: Instrumentation tube plugs shall be fabricated from Zircaloy-4 rod and bar stock conforming to the applicable material specification per the job parts list except that EBC requirements are waived.

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- 3.3.2 Dimensions: The instrumentation tube plug dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.
- 3.3.3 Surface Defects: Instrumentation plugs shall be free of burrs or scale and shall have no surface mars, nicks or scratches deeper than 0.005 inch.
- 3.3.4 Cleanliness: All surfaces of the plug shall be clean and free of extraneous materials. Components such as oils, greases, rubber and plastics containing sulfur and halides shall not ordinarily be used in contact with corrosion resistant surfaces. Where use of such components is necessary, the surfaces shall be cleaned prior to operations which involve heating the parts such as welding and heat treating. Such materials shall not be used under circumstances where they may become entrapped in areas or crevices that will become inaccessible to further direct contact cleaning.
- 3.3.5 Etching: All surfaces of the components shall be etched before final assembly. The total amount of metal to be removed from a single surface shall be nominally .0005 and with a maximum of .001 inch.
- 3.4 Assembly
- 3.4.1 Components: The instrumentation tube assembly shall be fabricated from the following components. The applicable assembly and component drawings and specifications are listed in the job parts list.
- Tubing
 - Instrumentation Tube Sleeve
 - Instrumentation Tube Plug

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3.4.2 Welding: The instrumentation tube shall be assembled using both resistance spot welds and inert gas tungsten arc welds. (See Sections 3.4.3.1 and 3.4.3.2, below).

3.4.3 Welds: Weld requirements listed below shall be met as established by weld qualification tests:

3.4.3.1 Resistance Spot Weld (Tubing-Sleeve)

- a) Compression shear of welds shall have an ultimate joint strength greater than 1000 pounds per guide tube.
- b) The minimum diameter of the bonded area shall be 0.040 inch based on destructive examination of representative welds.
- c) Welds shall show no evidence of cracking.
- d) Metallographic examination of in process test welds shall show full penetration through the weld interface.

3.4.3.2 Inert Gas Tungsten Arc Weld (Tubing-Plug)

- a) Welds shall be in conformance with the dimensions given on the applicable drawing per the job parts list.
- b) Welds shall be free of splatter, ejected metal, slag, and blend smoothly into the parent material while showing no discontinuities due to lack of fusion.

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- c) Based on metallographic and visual examination, the weld shall be free of undercuts, inclusions or folds greater than 0.005 inch deep or evidence of cracking. Visual examination shall be with low power magnification.

3.4.4 Plug Gauging: The finished instrumentation tube assembly shall be plug gauged with a 1.5 inch long plug having an O.D. .0035 inch smaller than the minimum allowed tube I.D.

3.4.5 Handling: The instrumentation tube components shall not be etched subsequent to being assembled, therefore, extreme care in handling throughout the manufacturing process is necessary to prevent surface contamination.

3.4.6 Identification: Each instrumentation tube assembly shall be identified by a serial number electroetched on the lower tube end. The serial number shall be unique to each instrumentation tube assembly. Upset metal may be removed by polishing to meet O.D. dimensional tolerances.

3.4.7 Cleanliness: Internal and external surfaces of the instrumentation tube assembly shall be clean, free of grease, oil, dust, dirt, finger marks or other contaminants. One test assembly per group of 40 guide tube assemblies (maximum) shall be autoclaved in steam at times and temperatures specified in approved Process Specifications to assure cleanliness is maintained. The autoclave finish shall have a black lustrous oxide film acceptable per Quality Control visual standards.

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4.0 REWORK

Instrumentation tubes which do not meet the allowable dimensional tolerances may be reworked provided the rework procedure has been reviewed and approved prior to use.

5.0 RECORDS

Complete fabrication and testing records shall be maintained. Traceability of the component parts to the initial material lots shall be maintained.

6.0 STORAGE

Instrumentation tube assemblies shall be stored in a manner to protect the assembly from mechanical damage, corrosion, and to maintain conformance with this specification.

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7.0 QUALITY ASSURANCE

Receiving, in-process, and final inspection tests shall be conducted in sufficient numbers to ensure that the finished instrumentation tubes meet the following characteristics:

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Overall Length	Major	3.4.1
Outside Diameter	Major	3.4.1
Inside Diameter (plug gauge)	Critical	3.4.4
Component Dimensions	Major	3.1.2, 3.2.2 3.3.2
Other Dimensions	Major	3.4.1
Weld Quality	Critical	3.4.2, 3.4.3.1, 3.4.3.2
Weld Tensile and Compressive Strength	Critical	3.4.3.1 3.4.3.2
Identification	Major	3.4.6
Cleanliness	Major	3.2.4, 3.3.4, 3.4.7
Serial Number	Critical	3.4.6
Serial Number Appearance Depth	Minor	3.4.6
Component Materials	Critical	3.1.1, 3.2.1, 3.3.1
Defects	Major	3.2.3, 3.3.3
Handling	Major	3.4.5
Etching	Major	3.2.5, 3.3.5

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APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

PRODUCT SPECIFICATION

PRODUCT SPECIFICATION

1.0 TITLE: Uranium Dioxide Pellets - LOFT

2.0 SCOPE

2.1 This specification describes the UO_2 fuel pellets to be used in fuel assemblies.

2.2 The function of the UO_2 pellets is to produce a specific quantity of heat energy for a specific length of time.

2.3 Requirements of the UO_2 pellets are:

(a) To perform all required functions without causing more than 3/4% nonelastic cladding strain.

(b) To perform all required functions without resulting in fuel melting.

2.4 A glossary of terms is given in Appendix A.

2.5 Impurity content specifications are listed in Appendix B.

2.6 The inspection and testing program for uranium dioxide pellets shall be such that it can be established with 95% confidence that the critical characteristics among the chemical requirements, density and dimensions (except maximum diameter and stoichiometry) of 95% of the pellets in each pellet lot meet the required values. Alternately, for the product to be acceptable, there shall be 95% confidence that the true value of the mean of the total population lies within the specification limits and no single sample value shall exceed 80% of the maximum limits. Pellets shall be 100% inspected for maximum diameter. Stoichiometry shall be determined on one sample per pellet lot and result reported to two decimal places.

2.7 The enrichment values and tolerances are specified on the applicable drawings per the job parts list.

2.8. The technical requirements given below shall be applicable to the loaded fuel pellets.

3.0 TECHNICAL REQUIREMENTS

3.1 Material: Sinterable uranium dioxide powder as specified in the applicable material specification.

3.2 Process: Cold-press and sinter.

3.3 Nuclear Requirements

3.3.1 Isotopic Content: The ^{235}U content shall be as specified on the applicable drawings. The uranium isotopic composition (including ^{232}U , ^{234}U , ^{235}U , ^{236}U , and ^{238}U) of the starting material (UF_6) shall be measured and reported. The isotopic composition shall not be changed during processing. In the event that blending shall be necessary, a modified specification shall be written and approved prior to application.

3.3.2 Equivalent Boron Content: The total equivalent boron content (EBC), based on a summation of the contributions from each of the elements indicated in Appendix B, shall not exceed 4.0 ppm on a uranium weight basis. An alternate acceptable equivalent boron content is a summation of less than 3.0 ppm based on the contribution from the abridged list of Appendix B. Factors for converting constituent concentrations are given in the Specification for Equivalent Boron Content.

3.4 Chemical Requirements

3.4.1 Uranium Content: The uranium content shall be a minimum of 87.7% by weight of the uranium dioxide on a dry weight basis.

3.4.2 Stoichiometry: The oxygen to uranium ratio of the sintered fuel pellets shall be within the limits of 2.00 and 2.02.

3.4.3 Impurity Content: The impurity content shall not exceed the individual element and total content limits specified in Appendix B.

on a uranium weight basis.

3.4.4 Gas Content: The total gas* release shall not exceed 0.10 cc/g of pellet weight at standard temperature and pressure. The average gas release for a group of pellets normally contained within a single lot shall not exceed 0.05 cc/g on a total weight basis. The gas release shall be measured by vacuum outgassing at a temperature of $3000^{\circ} \pm 90^{\circ}\text{F}$.

3.4.5 Moisture: The moisture content of a given pellet shall not exceed 20 ppm on a pellet weight basis. The average moisture content of a lot of UO_2 pellets shall not exceed 10 ppm on a total weight basis.

3.5 Physical Characteristics

3.5.1 Dimensions: The dimensional requirements are given in the applicable drawing per the job parts list.

3.5.2 Density: Sintered pellets shall have a density in conformance with the applicable drawing. The theoretical density is taken to be 10.96 g/cc.

3.5.3 Pellet Chips: Pellet chip limits shall be:

End Chip, Dished End: The chipped area of any single chip shall not exceed 10% of the land area and extend no deeper than 0.005 inches beyond the dish depth. The total chipped area shall not exceed 20% of the land area.

End Chip, Non-Dished End: The chipped area of any single chip shall not exceed 4% of the pellet end area and extend no deeper than 0.020 inches along the pellet length. The total chipped area shall not exceed 8% of the land area.

Circumferential Chip: The chipped area of any single chip shall not exceed 3% of the circumferential area and penetrate no deeper than 0.025 inches. The total chipped area shall not exceed 10% of the circumferential area.

*Including moisture

3.5.4 Pellet Cracks: Cracks and fissures on pellet surfaces shall not exceed the following limits:

- radial cracks on end surfaces .10 in.
- circumferential cracks
 - a) $<60^\circ$ within .10 in. of end surface
 - b) $<180^\circ$ mid-body crack
- axial cracks .125 inches
- micro-cracking is acceptable
- end capping is not acceptable

3.5.5 Cleanliness: Finished pellets shall be free of dirt, grease, lint, loose powder, abrasive grit, residual film from lubricants, cleaning agents and other foreign materials.

3.5.6 Identification: Each finished pellet shall have a mark centered on the end of the pellet that clearly identifies the pellet enrichment. The enrichment symbol shall consist of two arabic numerals. The two arabic numerals on the punch shall be enclosed within an area no greater than .150 inches square. The letters shall be raised no more than .010 inches above the face of the punch.

3.5.7 Pellet Microstructure: The pellet structure shall be monitored by sampling and metallographic examination of a longitudinal section. The metallographs shall be retained as a part of the job record.

4.0 RECORDS

4.1 Fabrication Records: Process control and fabrication records as specified by Quality Control shall be maintained and shall be such as to assure the traceability of each UO_2 pellet lot in each fuel rod pellet column to the UF_6 lot.

4.2 Acceptance Testing Records: Acceptance testing records shall be maintained.

5.0 STORAGE

Finished fuel pellets shall be stored in conformance with the appropriate Criticality Safety Specifications and in such a manner that the fuel pellets remain clean and dry, the identity is maintained, the pellets are not damaged or contaminated with other materials, (e.g., oil), and the pellets retain conformity with this specification.

6.0 REWORK

Pellets which exceed the allowable tolerances but which could be reworked to meet the requirements of this specification may be so reworked and resubmitted, provided that the rework process has been reviewed and approved through authorized procedures. Rework procedures authorized in the applicable process specification do not require further approval. Regrinding and reoutgassing to meet the requirements of this specification may be performed without further review.

7.0 QUALITY ASSURANCE

	<u>Characteristic</u>	<u>Applicable Section</u>
Uranium Isotopic Content	Critical	3.3
Equivalent Boron Content	Major	3.3
Uranium Content	Major	3.4
Oxygen-to-Uranium Ratio	Critical	3.4
Impurity Content	See Appendix B	3.4
Gas Content	Critical	3.4
Moisture Content	Critical	3.4
Length	Minor	3.5.1
Maximum Diameter	Critical	3.5.1
Minimum Diameter	Major	3.5.1
Perpendicularity	Major	3.5.1
Surface Cracks	Minor	3.5.4
Dish Depth	Major	3.5.1
Dish Diameters	Major	3.5.1
Dish Angles	Minor	3.5.1
Chips	Major	3.5.3
Surface Appearance	Minor	3.5.4/3.5.3
Maximum Density	Critical	3.5.2
Minimum Density	Major	3.5.2
Legible Identification	Critical	3.5.6
Identification Mark Size	Minor	3.5.6
Minimum Land Width	Major	3.5.1

APPENDIX A - GLOSSARY OF TERMS

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- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.
- Pellet Lot** A pellet lot is defined as a group of pellets, not exceeding 3000 pounds, from a single UO_2 powder lot, which have undergone identical sintering procedures. See also the applicable material specification for UO_2 powder.
- End Capping** A continuous conically shaped crack at the end of a pellet, usually caused by excessive pressing pressures.

PRODUCT SPECIFICATION1.0 TITLE: LOFT FUEL ASSEMBLY, TYPE F2.0 SCOPE

- 2.1 This specification describes the product requirements for the LOFT Type F fuel assembly. Type F is a square, instrumented center assembly with zircaloy guide tubes.
- 2.2 The scope of this specification excludes discussion of, or provision for, preventing criticality incidents, for health and safety requirements and for hazards avoidance. In addition to the requirements of this specification, the requirements imposed by the Exxon Nuclear Criticality Safety Specifications and Radiation Work Procedures, plus all regulations pertaining to shipping must be observed.
- 2.3 A glossary of terms is given in Appendix A.
- 2.4 Pertinent specifications and drawings are listed in the latest revision of the applicable Parts List.
- 2.5 A table of rod fuel column weights is given in Appendix B.
- 2.6 The assembly sequence is given in Appendix C.
- 2.7 The welding requirements are listed in Appendix D.
- 2.8 Instrumentation requirements are given in Appendix E.

3.0 TECHNICAL REQUIREMENTS

3.1 Components

The fuel assembly shall consist of those subassemblies and components specified in the latest revision of the fuel assembly parts list.

3.2 Design and Construction

3.2.1 The fuel assembly and its components shall conform to the latest revision of the applicable drawing. The absolute measurement system is to be used.

For purposes of determining conformance with these specifications, all dimensions and tolerances are in accordance with ANSI Y14.5-1966.

3.2.2 The bundle assembly sequence shall be in accordance with Appendix C of this specification.

3.2.3 The grid spacer assemblies shall be captured by locking rings welded to the guide tubes at each guide tube-spacer intersection with four welds, in accordance with Appendix D of this specification.

3.2.4 Conformance to fuel assembly dimensions shall be determined with the fuel assembly free standing in a vertical position resting on a flat surface.

3.2.5 The minimum spacing between any two adjacent fuel rods shall not be less than 0.120 inch. The axially integrated average spacing over the fuel rod length shall not be less than 0.131 inch. The minimum spacing between a fuel rod and guide tube shall not be less than 0.59 inch. The axially integrated average spacing over the fuel rod length shall not be less than .070 inch.

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- 3.2.6 The outward bow of peripheral fuel rods shall not exceed 0.010 inch between adjacent spacers.
 - 3.2.7 Finished fuel bundle assembly handling and positioning equipment must be such that the relative lateral displacements and twisting of tie plates and spacers shall not exceed 0.063 inch and 0.5 degree*, respectively.
 - 3.2.8 The individual rods shall be supported at all times prior to assembly to ensure bowing does not exceed 1 inch in 3.5 feet.
 - 3.2.9 The weights of fissile material in a fuel assembly shall be within the limits specified in Appendix B.
 - 3.2.10 For shipping and/or storage the fuel assembly shall be externally supported on a rigid surface (i.e., strong-back) aligned to within .030 inch of the nominal envelope. During shipping the fuel assembly shall be supported horizontally at the tie plate and spacer locations, with additional support provided between tie plates and spacers to withstand maximum vertical accelerations of 10 g without affecting fuel clad or spacer integrity.
 - 3.2.11 See Appendix E for instrumentation requirements.
- 3.3 Cleanliness and Workmanship
- During insertion of fuel rods into the assembly, care shall be exercised to minimize scratching of the fuel rods. Scratches caused by assembly must not exceed a depth of 0.002 inch. The

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completed assembly shall be free of lint, fingerprints, metal cuttings, and all foreign materials which may impair corrosion resistance or reactivity. During and after assembly only reagent grade ethyl alcohol or reagent grade acetone may be used for cleaning. Tools used for assembly shall be stainless steel, chrome-plated or plastic.

3.4 Identification

Each fuel assembly shall be identified with a permanent serial number applied on the top and side of the upper tie plate. The characters shall be in accordance with the assembly drawing.

4.0 RECORDS

4.1 Records shall be maintained for each fuel assembly so that all parts and subassemblies can be traceable to fabrication and/or source lots. Included in the records shall be a cross-section map which identifies each fuel rod by type and enrichment.

5.0 STORAGE

Fuel assemblies shall be packaged and stored in a manner that ensures compliance with this specification, prevents contamination by foreign materials and moisture, protects the assembly from physical damage, deterioration or corrosion and avoids criticality when stored in proximity with other fuel assemblies.

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6.0 SHIPPING

6.1 Fuel assemblies shall be shipped only in NRC licensed and DOT shipping containers for shipping enriched uranium bearing fuel assemblies.

6.2 Each shipping container shall bear appropriate identification, including:

Container manufacturer's nameplate bearing drawing and container serial number; and proper labeling of outer container including type of shipment, radiation levels (units) and DOT Permit No.

6.3 Each loaded shipping package shall incorporate a seal, which is not readily breakable, and which, while intact, will be evidence that the package has not been illicitly opened.

6.4 In transit, the fuel assemblies shall be oriented so that the lower end of the assembly is in the forward direction. (This requires that the outer container be identified as to the orientation of the contained assemblies.)

6.5 Each shipment shall be accompanied by properly completed shipping papers, which will include:

- o Drawing and Serial Number of each assembly
- o Specification Number, Revision Number and Date
- o Weight of fuel assembly (gross and tare weights)
- o Weight and enrichments of contained fissile material
- o Maximum radiation level at three feet from surface of outer container
- o Special instructions involved (e.g., maximum number of packages allowed per shipment, escort requirements, sole vehicles use, route restrictions, storage and/or layover limitations, etc.)

- o Signature of shipper
- o Radiation level and spacing required for storage with other fissile materials.
- o Initials of labeler.

6.6 During shipment, fuel assemblies shall be supported at tie plate and spacer positions. The support shall be in compliance with Section 3.2.10, above.

7.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Assembly and Component Envelopes	Critical	3.2.1
Plug Weld	Critical	App. D
Spacer Orientation	Critical	3.2.2
Guide Tube Axial Adjustment	Critical	3.2.2
Torque on Assembly Nuts	Major	3.2.2
Lock Welding of Nuts	Critical	3.2.2
Attachment of Spacer to Guide Tube	Critical	3.2.3
Fuel Rod Separation	Critical	3.2.5
Peripheral Rod Bow	Major	3.2.6
Fuel Rod Support During Assembly and Shipping	Critical	3.2.7, 3.2.8
Fissile Weights	Critical	3.2.9
Cleanliness and Workmanship	Major	3.3
Identification	Major	3.4
Records - Assembly	Major	4.1
Storage	Major	5.0
Shipping	Major	6.0
Instrumentation Continuity	Major	App. E

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APPENDIX A - GLOSSARY OF TERMS

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Major A specification, inspection, test or defect, other than critical which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.

Minor A specification, inspection, test or defect, other than Critical or major, which if not controlled, does not materially reduce the intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

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APPENDIX B - ASSEMBLY FUEL WEIGHTSType F

UO ₂ , kg	Nominal	231.3
	Maximum	233.7
	Minimum	299.0
U-235, kg	Nominal	8.16
	Maximum	8.28
	Minimum	8.04

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APPENDIX C - BUNDLE ASSEMBLY SEQUENCE

- o The procedures outlined in this specification are to be followed in conjunction with the applicable drawings and specifications per the job parts list.
- o Welding shall be performed by qualified welders and welding procedures as developed during weld qualification.
- o Mount the grid spacer assemblies in a fixture in accordance with the dimensions indicated on the applicable drawings, square and align grid spacer assemblies.
- o Insert a batch of guide tube assemblies through the spacers with the alignment gauge block in place.
- o Install the gauge block bushing over the guide tube sleeves and lock into alignment, install guide tube nuts and torque to 50 ± 10 inch pounds.
- o Weld the locking rings to the guide tubes at each spacer location per Appendix D and plug gauge.
- o Insert the next batch of guide tube assemblies and repeat sequence until all guide tubes are installed.
- o Install liquid level detector guide tubes where applicable using the sequence above except that the guide tube to spacer weld is omitted.
- o Install nuts on guide tube lower end fitting.
- o Mount the lower tie plate on alignment gauge block in accordance with the dimensions indicated on the applicable drawings, square, align, and clamp in position.

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APPENDIX C (Continued)

- o Adjust each lower guide tube nut to contact with the lower tie plate.
- o Remove lower tie plate.
- o Weld nuts to guide tube lower end fitting.
- o Remove gauge block, and install upper tie plate without thermocouple cover, install instrumented guide tube supports and complete welds.
- o Install nuts and torque to 25 ± 5 inch pounds.
- o Install instrumented fuel rods through the bottom of the assembly, install cap screw, torque to 9-10 inch pounds, release, and torque to 9-10 inch pounds. Lock screw by deforming the cap into the recesses provided for locking. Route thermocouple leads through the tie plate slots. Check instrument lead resistance after final routing for each rod.
- o Install standard fuel rods through the bottom of the assembly.
- o Insert the instrument tube assembly through the bottom of the assembly.
- o Install lower tie plate, seating it against the lower guide tube adjusting nuts. Install the attachment nuts and torque to 15 ± 5 inch pounds. Attach instrumentation tube to lower tie plate, install locking pin, and torque nut to 50 ± 10 inch pounds, release and retorque to 25 ± 5 inch pounds.
- o Lock nuts in place by welding to lower tie plate.

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APPENDIX C (Continued)

- o Route lower coolant thermocouple through slots in lower tie plate, position hot junction and stake, and weld thermocouple cover plate in position.
- o Route upper coolant thermocouple and stake.
- o Remove guide tube nuts, attach thermocouple cover plate and locking cups. Lock weld locking cups to thermocouple cover plate, torque nuts to 25 ± 5 inch pounds and crimp locking cups to lock nuts.
- o Complete routing of all thermocouples.
- o Install the upper end box assembly, threading thermocouple cables through the routing hole in the end box, align, insert dowel pins, and weld.
- o Check instrument lead continuity.

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APPENDIX D - WELDING REQUIREMENTSD-1 Locking Ring to Guide Tube Weld (Spacer Attachment)

- D.1.1 The locking ring to guide tube weld shall be accomplished using either resistance spot or inert gas tungsten arc welds. Both welding processes may be used in a single fuel bundle assembly.
- D.1.2 Resistance Spot Weld -
- The minimum diameter of the bonded area shall be 0.035 inch based on destructive examination of representative welds.
 - Welds shall show no evidence of cracking.
- D.1.3 Inert Gas Tungsten Arc Welds -
- The minimum diameter of the bonded area shall be 0.060 inch based on destructive examination of representative welds.
 - Welds shall show no evidence of cracking.
- D.1.4 Tension shear tests of production sample welds shall have an ultimate joint strength greater than 1000 pounds per locking sleeve.
- D.1.5 Metallographic examination of in process test welds shall show full penetration through the weld interface.
- D.1.6 After welding, the locking ring shall be in contact with the spacer on at least one side of the spacer guide tube cell, (contact being defined as not admitting a .001 feeler) and shall have not more than .005 clearance with at least

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APPENDIX D (Continued)

one of the other three sides of the spacer guide tube cell. It is acceptable for one locking ring at each spacer to have no spacer contact provided it has a maximum of .005 clearance with at least one side of the spacer guide tube cell.

D-2 Upper End Box to Grid Plate Welding

- D.2.1 The upper end box shall be joined to the grid plate by welding to form the upper tie plate assembly.
- D.2.2 The welds shall be accomplished by gas tungsten arc welding.
- D.2.3 The upper end box shall be attached to the grid plate assembly, with the grid assembly in place and aligned per the applicable drawing. Sixteen plug welds are required for the square assemblies. Eight with alignment dowels in place.
- D.2.4 Weld filler metal shall be ER 308L per AWS A5.9-69, except that the carbon content shall be less than .025 percent.
- D.2.5 Based on examination of representative welds during weld qualification, the welds at dowel pin locations shall have a penetration of 0.060 inch. The plug welds without dowel pins shall be full penetration and show a surface concavity of less than .060 inch.
- D.2.6 Welds shall be free of cracks, overlaps, or undercuts. The welds shall blend smoothly into the parent material and show no discontinuities due to lack of fusion.
- D.2.7 Welds may be dressed by grinding to meet the final tie plate envelope dimensions.

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APPENDIX D (Continued)

D-3 Lock Welds

- D.3.1 Welds used for locking threaded fasteners shall be accomplished by gas tungsten arc welding.
- D.3.2 A minimum of two welds on opposite sides of the fastener shall be used.
- D.3.3 The welds shall be a minimum .125 inch long with a minimum .030 penetration as determined by weld qualification samples.
- D.3.4 Welds shall be visually examined for complete fusion of the mating components and freedom from cracks.
- D.3.5 Lock weld parameters shall be based on representative welds during weld qualification which show complete fusion and no significant porosity.

APPENDIX E - INSTRUMENTATION DETAILS

- E.1 The fuel assembly instrumentation shall be in conformance with the requirements of INC-60007 and INC-60040. In addition, the instrumentation will conform to the specifications below.
- E.2 Instrumentation routing shall be in conformance with the applicable assembly drawing per the job parts list.
- E.3 All instrumentation shall be fully installed, completely routed, except for attachment of the end box, and all continuity checks made before final installation and welding of the upper end box to the grid.
- E.4 Except for the initial bend out of the flow channel, all fuel rod thermocouples and bends shall be made using a forming mandrel of the proper diameter.
- E.5 Routing of thermocouples across the grid plate must be in the slotted recesses. Packing of multiple leads within a slot shall be such that the thermocouple cover plate will lie flat over any slot with hand pressure alone.
- E.6 Coolant thermocouples shall be pre-formed near the hot junction so as to control extension into the coolant stream per the applicable drawing.
- E.7 Coolant thermocouples shall be formed so that before installation of the cover plate a part of the thermocouple within 0.25 inch and 0.38 inch of the hot junction extends above the slot a minimum of .032 inch and must be forced into position by the cover plate.
- E.8 For bundles incorporating liquid level detectors, a torque of 30 to 50 inch-pounds may be used for final tightening and orienting of the instrumentation routing fixture. If the proper orientation cannot be achieved within the specification limits, grinding or filing may be used to adjust engagement and orientation.

JN-S30279, Revision 0

Issue Date 9-11-72PRODUCT SPECIFICATION1.0 TITLE: 304L LOCKING RING2.0 SCOPE

- 2.1 This specification describes requirements for the locking ring to be used to connect guide tubes to spacers in fuel assemblies.
- 2.2 The function of the locking rings is to mechanically correct the guide tubes to the spacers providing support for the guide tubes and axially locating the spacers.
- 2.3 A glossary of terms is given in Appendix A.
- 2.4 Procedure for passivation is given in Appendix B.
- 2.5 A list of elements significant in the determination of equivalent boron content is given as Appendix C.

3.0 TECHNICAL REQUIREMENTS

- 3.1 Material: The locking ring shall be fabricated from 304L stainless steel conforming to the requirements of ASTM A213-70*, except as amended by this specification.
- 3.2 Equivalent Boron Content: The total equivalent boron content (EBC) of material used for locking rings (including impurities), shall not exceed 850 ppm, based on either a comparative reactivity test using an analyzed standard of the same general composition, or a quantitative analysis for the elements listed in Appendix C and a summation of their contribution to the equivalent boron content. Factors for converting constituent concentrations to equivalent boron concentrations are given in the Equivalent Boron Content Specification (See JN-S30100).

3.3 Grain Size: Two metallographic specimens, one longitudinal and one transverse section, shall be selected at random from each lot for grain size determination. The maximum grain size shall be ASTM Micro-Grain Size Number 7.0, as specified in ASTM-E-112-63, "Estimating the Average Grain Size of Metals".

3.4 Surface Condition: The locking ring shall be free of burrs or scale, and shall have no surface mars, nicks or scratches deeper than 0.005 inch.

3.5 Corrosion Resistance: Two representative samples per lot shall be corrosion tested in accordance with ASTM-262-70, Practice C. The target corrosion rate shall be less than 0.002 inch per month as determined by the average of five 48-hour test periods. The maximum permissible limit is 0.005 inch per month as determined by the average of five 48-hour periods, with no single period rate exceeding 0.006 inch per month.

3.6 Dimensions: The dimensions, tolerances, and surface finish of the locking ring shall conform to the latest revision of the applicable drawings per the job parts list.

3.7 Passivation: The finished locking ring shall be passivated in accordance with the procedure specified in Appendix B.

4.0 CERTIFICATION

The fabricator shall certify that he has complied with all parts of this specification and shall provide inspection and test results as required in the purchase order documentation.

5.0 SHIPPING AND STORAGE

5.1 The locking rings shall be stored, handled, packaged, and shipped in a manner that assures conformance to this specification and prevents damage or deterioration and provides traceability.

5.2 The fabricator shall be responsible for all details of packing, crating, and shipping and for identification of parts and shipping cartons.

6.0 QUALITY ASSURANCE

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Material	Major	3.1
Equivalent Boron Content	Major	3.2
Grain Size	Major	3.3
Surface Condition	Major	3.4
Corrosion Resistance	Major	3.5
Dimensions	Minor	3.6
Passivation	Major	3.7

JN-530279, Revision 0

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

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APPENDIX B - PASSIVATION PROCEDURE

Immerse in a solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook, Vol. II, Page 605)

APPENDIX C - IMPURITY SPECIFICATIONS

In lieu of a comparative reactivity test, the concentration of each of the elements listed below may be determined and used to calculate the total equivalent boron content.

Alloying Elements

Chromium

Iron

Nickel

Impurity Elements

Boron

Cadmium

Cobalt

Dysprosium

Europium

Gadolinium

Manganese

Samarium

XN-S30306, Revision 2

Issue Date: 06/22/77

PRODUCT SPECIFICATION

1.0 TITLE: NEUTRON SOURCE ASSEMBLY - LOFT

2.0 SCOPE

- 2.1 This specification describes the requirements for the neutron source assembly for the LOFT reactor.
- 2.2 The functions of the neutron source assembly are: (1) to provide a primary finite flux of neutrons to facilitate start-up, control, and flux monitoring; (2) to hermetically contain the source material; and (3) to provide a means of attachment to the core structure.
- 2.3 The requirements of the neutron source assemblies are to maintain the integrity and position of the source under normal design conditions.
- 2.4 A glossary of terms is given in Appendix A.
- 2.5 Procedure for passivation is given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 Neutron Source

3.1.1 Source Strength

The neutron source shall provide a minimum neutron source strength of $1.2 \times 10^9 \pm 10\%$ neutrons per second at time of delivery to the customer.

3.1.2 Encapsulation

The neutron source shall be doubly encapsulated in 304 or 304L stainless steel conforming to the requirements of ASTM A-213-71, or A-276-75, or a Purchaser approved equivalent specification.

3.1.3 Corrosion Resistance

A representative sample of the encapsulating material shall be tested in accordance with ASTM A-262-70, Practice C, as amended by specification XN-S30378, Revision 1.

3.1.4 Helium Leak Detection

The source shall be helium leak tested after final encapsulation weld. The leak rate shall not exceed 1×10^{-8} standard cc/sec of helium and the chamber shall be evacuated to 50 microns or less.

3.1.5 Dimensions

The dimensions of the encapsulated neutron source shall approximate a right circular cylinder with a maximum length of 1.50 inches and a maximum diameter of 0.371 inches.

3.1.6 Auto-Radiography

The external encapsulation weld shall be auto-radiographed on a "best efforts" basis and shall not be cause for acceptance or rejection.

3.1.7 Integrity

The neutron source shall be capable of withstanding a pressure of 3150 psia at room temperature, and an operating pressure of 2300 psia at 600°F, as demonstrated by hydrostatic testing or Purchaser approved analysis, prior to fabrication.

3.2 Sleeves, Shaft, Collar, Pin, Washer, End Fitting and Tube

3.2.1 Material

The locking, threaded, and retaining sleeves, shaft, collar, pin, washer, end fitting and tube shall be fabricated from 304 or 304L rod or tubing and bar stock in conformance with the applicable material specification per the job parts list.

3.2.2 Dimensions

Component dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

3.2.3 Surface Defects

All components shall have a bright finish (before passivation) free of burrs or scale and shall have no surface mars, nicks or scratches deeper than 0.005 inch.

3.2.4 Passivation

Finished components shall be passivated in accordance with the procedure specified in Appendix B.

3.3 Coil Springs

3.3.1 Material

Coil springs shall be fabricated from Inconel X-750, in accordance with the applicable specification per the job parts list.

3.3.2 Dimensions

The spring dimensions, surface finish and tolerances shall conform to the applicable drawing per the job parts list.

3.4 Assembly

3.4.1 Components

The neutron source assembly shall be fabricated from the following components. The applicable assembly and component drawings are listed in the job parts list. Component product and material specifications are listed above and/or in the applicable job parts list.

Neutron Source	Tube
Locking Sleeve	Collar
Retaining Sleeve	Pin
Threaded Sleeve	Plenum Spring
Shaft	Outer Spring
End Fitting	Inner Spring

XN-S30306, Revision 2

3.4.2 Welding

The encapsulation and the neutron source assembly welds shall be accomplished in an atmosphere at nominally atmospheric pressure containing a minimum of 95% helium, balance argon, and a minimum of 99.9% inert gas (helium plus argon). The helium used shall be Bureau of Mines Grade A, and the argon of comparable purity.

Prior to production welding, the vendor shall qualify his welding procedures, equipment, and personnel. The weld qualification results and the qualified weld procedure shall be submitted to the Purchaser for approval.

3.4.3 Cleanliness

The surfaces of the neutron source assembly shall be clean and free of dirt, grease, moisture, oil, dust and all other foreign material.

3.4.4 Visual Inspection

Each component and the assembly shall be 100% visually inspected to ensure compliance with the applicable requirements of this specification.

3.4.5 Dimensions

The neutron source assembly dimensions shall conform to the applicable drawing per the job parts list.

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4.0 REWORK

Individual components or assemblies which exceed the allowable tolerances on dimensions but which could be reworked to meet the requirements of this specification may be so reworked and resubmitted, provided that the rework process has been reviewed and approved prior to use.

5.0 SHIPPING AND STORAGE

The neutron source assembly shall be handled, stored, packaged, and shipped in a manner which assures compliance with this specification and prevents surface contamination that may impair corrosion resistance, or damage to, or deterioration of the source. The neutron source assembly shall be shipped in a shipping container that meets the appropriate U.S. D.O.T. shipping regulations for radiation shielding and conforms to all requirements of applicable state and federal regulations with regard to the transport of radioactive sources. The shipping container shall be the responsibility of, and provided by the Vendor.

6.0 RECORDS

Complete fabrication and testing records, including data confirming the neutron source strength, shall be maintained. Traceability of the component parts to the initial material lots shall be maintained.

7.0 QUALITY ASSURANCE

Receiving, in-process and final inspection tests shall be conducted in sufficient numbers to insure that the neutron source assemblies meet the following characteristics:

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Neutron Source Strength	Critical	3.1.1
Component Materials	Major	3.1.2, 3.2.1, 3.3.1
Corrosion Resistance	Major	3.1.3
Helium Leak Test	Critical	3.1.4
Dimensions	Major	3.1.5, 3.2.2, 3.3.2, 3.4.5
Auto-Radiography	Minor	3.1.6
Surface Defects	Major	3.2.3
Passivation	Major	3.2.4
Weld Quality	Critical	3.4.2
Cleanliness	Major	3.4.3

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APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as a fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

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APPENDIX B - PASSIVATION PROCEDURE

Immerse in a solution of 6 to 15 volume percent of 70% nitric acid in water for a minimum of 30 minutes at room temperature, thoroughly rinsed in deionized water and dried.

(Reference: ASM Metals Handbook)

XN-S30353, Revision 1

Issue Date 9/21/73

PRODUCT SPECIFICATION

1.0 TITLE: STANDARD PRESSURIZED FUEL ROD - LOFT

2.0 SCOPE

- 2.1 This specification describes the product requirements for the LOFT standard fuel rods to be used in LOFT fuel assemblies.
- 2.2 The functions of the standard fuel rods are to hermetically contain the fuel material and resulting fission products, to isolate the fuel material from the reactor coolant, to provide an adequate heat transfer surface, and to supply its appropriate share of the fuel assembly design energy. The fuel rod shall perform all of these functions throughout irradiation.
- 2.3 A glossary of terms is given as Appendix A.
- 2.4 Pellet stack component weights are given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

- 3.1 The fuel rod assembly shall be fabricated from the following components. The specific drawing number for each component is listed on the rod assembly drawing. The rod assembly drawings are listed in the job parts list and on the fuel assembly drawing. Applicable specifications for each component are listed along with the drawing number in the job parts list.

UO₂ Fuel Pellet

Plenum Spring

Insulator Disc

Cladding

Lower End Cap

Upper End Cap

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3.2 Pellet Stack

3.2.1 The active pellet stack shall be included between two insulator pellets (one placed on each end of the stack) in accordance with the applicable drawings.

3.2.2 The active pellet stack and component weights shall be as specified in Appendix B. The following tolerances apply to the various components:

Total Oxide $\pm 2\%$

Fissile Content $\pm 3\%$

3.2.3 Each rod pellet stack shall be weighed to an accuracy of 0.1 percent. Stack weight and pellet lot(s) shall be recorded and remain traceable by individual rod identification.

3.2.4 The length of the active pellet column (excluding insulator discs) shall be as specified on the applicable drawing and shall be measured prior to loading of the pellets into the clad tube.

3.2.5 A short dished pellet, minimum length 0.20 inches, may be used at either or both ends of the fuel column to adjust the fuel column length. A pellet shortened by grinding may be used at the plenum end of the column.

3.2.6 Pellet enrichment is of critical importance and must be controlled by process procedure to insure proper loading and identification.

3.2.7 Pellets shall be vacuum outgassed prior to loading in conformance with the approved applicable Process Specification.

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3.3 Welding

- 3.3.1 The end cap to cladding weld shall be accomplished in an atmosphere at nominally atmospheric pressure containing a minimum of 95% helium, balance argon, and a minimum of 99.9% inert gas (helium plus argon). The helium used shall be Bureau of Mines Grade A, and the argon of comparable purity.
- 3.3.2 The rod to end cap weld shall have a minimum accumulative solid metal path from rod interior to exterior (leak free path) of 0.020 inches after correction for distance across voids, inclusions or areas of non-bond indication in the path. Fusion zone beta grains shall have a Widmanstatten structure indicating uniform second phase distribution and the existence of alpha crystals within beta grains. The heat affected zone shall exhibit no columnar grains. The heat affected zone of the clad shall not extend beyond the end cap.
- 3.3.3 The weld shall be free of cracks, overlaps, or undercuts.
- 3.3.4 The weld shall contain no porosity (a group of pores) or inclusions in any cross section in which an individual pore or inclusion exceeds 0.004 inches in the greatest dimension.
- 3.3.5 The weld shall blend smoothly into the parent material and show no discontinuities due to lack of fusion.
- 3.3.6 The lower and upper end cap welds shall not exhibit a surface convexity (e.g., weld overhang) greater than 0.005 inches on

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the rod diameter. Weld overhang may be altered by careful hand filing or dressing order to meet the specified dimension.

- 3.3.7 An axial tensile test of representative welds on cladding samples conducted at room temperature during initial weld qualification shall yield joint efficiencies of 80% or greater based on the minimum specified ultimate strength and nominal specified clad thickness.
- 3.3.8 Metallographic destructive examination of samples of the closure weld area shall be used to verify that at a confidence level of 95%, 95% of the end cap welds meet the requirements of paragraph 3.3.2 above.
- 3.3.9 Each end cap weld shall be radiographed to further verify the weld quality.
- 3.3.10 Rework - Rods having reject or non-conforming welds may be reworked, provided that the rework process or procedure has been reviewed and approved prior to use.

3.4 Pressurization

- 3.4.1 Fill gas pressurization of the fuel rods shall be accomplished by the laser method of drilling a hole through the upper end cap and seal welding.
- 3.4.2 Metallographic destructive examination of samples of the seal weld area shall be used to verify a minimum solid metal path from rod interior to rod exterior of 0.024 inch with a confidence level of 95% that 95% of the end caps meet this requirement. Fusion zone beta grains shall have a Widmanstätten

structure indicating uniform second phase distribution and the existence of alpha crystals within beta grains. The heat affected zone shall exhibit no columnar grains. The weld shall be free of cracks. The weld shall contain no porosity (a group of pores) or inclusions in any cross section in which an individual pore or inclusion exceeds 0.004 inches in the greatest dimension.

- 3.4.3 The atmosphere for pressurization must contain a minimum of 95% helium, balance argon, and a minimum of 99.9% inert gas (helium plus argon). The helium used shall be Bureau of Mines Grade A, the inert gases of comparable purity.
- 3.4.4 The fill gas pressure used in the rod pressurization shall be maintained at the pressure specified on the fuel rod assembly drawing during seal welding. Rod pressurization shall be verified by an acoustical and pressure transducer process or other approved method.
- 3.5 Etching: All outer surfaces of the finished fuel rod shall be etched. The total amount of metal to be removed from a single surface by etching shall be at least .0005 inch and no more than 0.0015 inch.
- 3.6 Pellet Location and Plenum Length: A sampling plan shall be established for full length radiography after final closure welding to verify that fuel rods retain their proper plenum lengths and pellet seating, and to ascertain the absence of gross pellet chipping.
- 3.7 Corrosion Testing: The finished fuel rods shall be corrosion tested by autoclaving for a period of 24 ± 1 hours in steam at $389 \pm 10^\circ \text{C}$ and 1500 psia, nominal. After treatment the fuel rods shall have a continuous black, lustrous oxide film and be free from either or both white and brown corrosion products in excess of quality control visual standards.

3.8 Miscellaneous

- 3.8.1 The autoclaved rods shall be helium leak tested. The leak rate shall not exceed 1×10^{-8} std cc/sec of helium and the chamber shall be evacuated to 50 microns or less. The leak rate shall be measured within 8 days after welding, and again subsequent to prefilming.
- 3.8.2 Rods shall have no mars greater than 0.002 inch deep.
- 3.8.3 The maximum allowable bow for the rod, after autoclaving, shall not exceed one part in 1200 over the length of the rod or 0.015 inch in any one 12 inch span as compared with a straight edge.
- 3.8.4 Welded fuel rods shall contain not less than 95% helium in the free volume, and not more than 0.1% gaseous impurities other than argon as verified by process qualification tests.
- 3.8.5 Each rod shall be identified by a serial number stamped on the lower end cap. The serial number shall be unique to each rod and clearly visible after autoclaving.
- 3.8.6 Internal and external surfaces of fuel rods shall be clean, free of grease, oil, dust, dirt, moisture, finger marks, scale, flux, organic material (inserts, etc.) and other contaminants.
- 3.8.7 Contamination of UO_2 fuel rod exterior surfaces shall not exceed 10 dpm/100 cm^2 as determined by a wipe test.
- 3.8.8 After loading, individual rods shall be supported at all times to ensure that bowing will not exceed 1 inch over 3.5 feet of length.

4.0 RECORDS

4.1 Fabrication Records: Thorough fabrication and testing records including any special fuel rod characterization records shall be maintained. Rod history shall be traceable back to the initial feed materials. Records shall be cross-referenced to the rod serial numbers.

4.2 Acceptance Testing Records: Acceptance testing records shall be maintained and the records shall be cross-referenced to the rod serial numbers.

4.3 Process controls and records for each fuel rod shall be such as to assure traceability of each component of each rod including:

- each UO_2 pellet lot in the pellet column
- insulator disc lot
- end cap lot(s)
- enrichment level
- cladding lot
- plenum spring lot

5.0 STORAGE

The rods shall be stored in such a manner that the rods remain clean, the identity is maintained, the rods are not damaged or contaminated with other materials (e.g., oil), and the rods retain conformity with this specification.

6.0 REWORK

Rods which exceed the allowable tolerances on dimensions but which would be reworked to meet the requirements of this specification may be so reworked and resubmitted, provided that the rework process has been reviewed and approved prior to use.

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7.0 QUALITY ASSURANCE

Receiving and in-process inspection tests shall be conducted in sufficient numbers to assure that the finished fuel rods meet the following characteristics. Final inspection tests shall be consistent with RDT Standard E13-15T, Section 3.7.3.1.

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Active fuel length	Major	3.2.4
Diametral gap	Critical	3.1
Overall Length	Major	3.1
O.D.	Major	3.1
Rod Bow	Major	3.8.3
Rod Diameter at Welds	Major	3.3.6
Fuel Column Weight	Major	3.2.2
Fissile Content	Critical	3.2.2
Uranium Oxide Content	Major	3.2.2
Component Location	Major	3.6
Proper Pellet Location	Critical	3.6
Pellet Chips	Critical	3.6
Dryness of Pellets and Tubes	Critical	3.2.7 and 3.8.6
	(Control by process procedures)	
Helium Atmosphere for Welding	Critical	3.3.1
	(Control by process procedures)	
Joint Efficiency	Critical	3.3.7
	(Control by process procedures)	
Weld Cover	Critical	3.3.2
Weld Cracks, Defects, and Appearance	Critical	3.3.3
Cladding and Weld Integrity	Critical	3.3.2
Etching	Major	3.5
Gas Fill Pressure and Rod Pressurization	Critical	3.4
Pressurization Weld	Critical	3.4
Radioactive Surface and Weld Contamination	Major	3.8.7

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<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Autoclaving	Major	3.7
Rod Cleanliness Before and After Autoclaving	Critical	3.8.6
Surface of Finished Rods	Critical	3.8.6
Serial Number	Critical	3.8.5
Serial Number, Depth and Appearance	Minor	3.8.5
Rod Handling	Major	3.8.8

APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which is not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

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APPENDIX B - PELLET STACK COMPONENT WEIGHTS

		<u>Total Ceramic</u>	<u>Total U²³⁵</u>
Standard UO ₂ Rod (grams)	Nominal	1134	40.0
	Maximum	1157	41.2
	Minimum	1112	38.8

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Issue Date 9/21/73PRODUCT SPECIFICATION

1.0 TITLE: INSTRUMENTED PRESSURIZED FUEL ROD - LOFT

2.0 SCOPE

2.1 This specification describes the product requirements for the LOFT instrumented fuel rods to be used in LOFT fuel assemblies.

2.2 The functions of the instrumented fuel rods are to hermetically contain the fuel material and resulting fission products, to isolate the fuel material from the reactor coolant, to provide an adequate heat transfer surface, and to supply its appropriate share of the fuel assembly design energy. In addition, thermocouples are attached to the rod surface to provide temperature data during reactor operation and testing.

2.3 A glossary of terms is given as Appendix A.

2.4 Pellet stack component weights are given in Appendix B.

3.0 TECHNICAL REQUIREMENTS

3.1 The fuel rod assembly shall be fabricated from the following components. The specific drawing number for each component is listed on the rod assembly drawing. The rod assembly drawings are listed in the job parts list and on the fuel assembly drawing. Applicable specifications for each component are listed along with the drawing number in the job parts list.

UO₂ Fuel Pellet

Plenum Spring

Insulator Disc

Cladding

Lower End Cap

Upper End Cap

Thermocouple Leads,
Active and Dummy

3.2 Pellet Stack

3.2.1 The active pellet stack shall be included between two insulator pellets (one placed on each end of the stack) in accordance with the applicable drawings.

3.2.2 The active pellet stack and component weights shall be as specified in Appendix B. The following tolerances apply to the various components:

Total Oxide $\pm 2\%$

Fissile Content $\pm 3\%$

3.2.3 Each rod pellet stack shall be weighed to an accuracy of 0.1 percent. Stack weight and pellet lot(s) shall be recorded and remain traceable by individual rod identification.

3.2.4 The length of the active pellet column (excluding insulator discs) shall be as specified on the applicable drawing and shall be measured prior to loading of the pellets into the clad tube.

3.2.5 A short dished pellet, minimum length 0.20 inch, may be used at either or both ends of the fuel column to adjust the fuel column length. A pellet shortened by grinding may be used at the plenum end of the column.

3.2.6 Pellet enrichment is of critical importance and must be controlled by process procedure to insure proper loading and identification.

3.2.7 Pellets shall be vacuum outgassed prior to loading in conformance with the approved applicable Process Specification.

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3.3 Welding

- 3.3.1 The end cap to cladding weld shall be accomplished in an atmosphere at nominally atmospheric pressure containing a minimum of 95% helium, balance argon, and a minimum of 99.9% inert gas (helium plus argon). The helium used shall be Bureau of Mines Grade A, and the argon of comparable purity.
- 3.3.2 The rod to end cap weld shall have a minimum accumulative solid metal path from rod interior to exterior (leak free path) of 0.020 inches after correction for distance across voids, inclusions or areas of non-bond indication in the path. Fusion zone beta grains shall have a Widmanstatten structure indicating uniform second phase distribution and the existence of alpha crystals within beta grains. The heat affected zone shall exhibit no columnar grains. The heat affected zone of the clad shall not extend beyond the end cap.
- 3.3.3 The weld shall be free of cracks, overlaps, or undercuts.
- 3.3.4 The weld shall contain no porosity (a group of pores) or inclusions in any cross section in which an individual pore or inclusion exceeds 0.004 inches in the greatest dimension.
- 3.3.5 The weld shall blend smoothly into the parent material and show no discontinuities due to lack of fusion.
- 3.3.6 The lower and upper end cap welds shall not exhibit a surface convexity (e.g., weld overhang) greater than 0.005 inches on

the rod diameter. Weld overhang may be altered by careful hand filing or dressing order to meet the specified dimension.

- 3.3.7 An axial tensile test of representative welds on cladding samples conducted at room temperature during initial weld qualification shall yield joint efficiencies of 80% or greater based on the minimum specified ultimate strength and nominal specified clad thickness.
- 3.3.8 Metallographic destructive examination of samples of the closure weld area shall be used to verify that at a confidence level of 95%, 95% of the end cap welds meet the requirements of paragraph 3.3.2 above.
- 3.3.9 Each end cap weld shall be radiographed to further verify the weld quality.
- 3.3.10 Rework - Rods having reject or non-conforming welds may be reworked, provided that the rework process or procedure has been reviewed and approved prior to use.

3.4 Pressurization

- 3.4.1 Fill gas pressurization of the fuel rods shall be accomplished by the laser method of drilling a hole through the upper end cap and seal welding.
- 3.4.2 Metallographic destructive examination of samples of the seal weld area shall be used to verify a minimum solid metal path from rod interior to rod exterior of 0.024 inch with a confidence level of 95% that 95% of the end caps meet this requirement. Fusion zone beta grains shall have a Widmanstatten structure indicating uniform second phase distribution and the existence of alpha crystals within beta grains. The heat

affected zone shall exhibit no columnar grains. The weld shall be free of cracks. The weld shall contain no porosity (a group of pores) or inclusions in any cross section in which an individual pore or inclusion exceeds 0.004 inches in the greatest dimension.

3.4.3 The atmosphere for pressurization must contain a minimum of 95% helium, balance argon, and a minimum of 99.9% inert gas (helium plus argon). The helium used shall be Bureau of Mines Grade A, the inert gases of comparable purity.

3.4.4 The fill gas pressure used in the rod pressurization shall be maintained at the pressure specified on the fuel rod assembly drawing during seal welding. Rod pressurization shall be verified by an acoustical and pressure transducer process or other approved method.

3.5 Etching: All outer surfaces of the finished fuel rod shall be etched. The total amount of metal to be removed from a single surface by etching shall be at least 0.0005 inch and no more than 0.0015 inch.

3.6 Pellet Location and Plenum Length: A sampling plan shall be established for full length radiography after final closure welding to verify that fuel rods retain their proper plenum lengths and pellet seating, and to ascertain the absence of gross pellet chipping.

3.7 Instrumentation

3.7.1 The thermocouples attached to the fuel rod shall be small diameter sheathed cables with crushed magnesium oxide insulation as supplied by ANC.

3.7.2 The thermocouple locations and points of attachment shall be in accordance with the applicable drawing per the job parts list.

- 3.7.3 Attachment of the thermocouple cable to the fuel rod shall be by laser welding using procedures in accordance with ANC Procedure 60081. The hot junction shall be welded directly to the outside surface of the cladding using titanium filler wire. The thermocouple cable shall be fastened by welding along the fuel rod length using titanium filler metal.
- 3.7.4 The fuel rod cladding surface shall be as etched. Autoclave corrosion testing shall be omitted for the instrumented fuel rods.
- 3.7.5 Dummy sections of thermocouple cable shall be attached to provide a degree of symmetry for the thermocouple system. See the applicable drawing.
- 3.7.6 A means of identifying each individual thermocouple lead shall be provided. The identification shall be compatible with routing requirements during assembly of the fuel bundle and during installation of the fuel bundle in the reactor core.
- 3.7.7 Thermocouple continuity and leak testing shall be in accordance with ANC 60040 and ASTM E-235-67.

3.8 Miscellaneous

- 3.8.1 The rods shall be helium leak tested. The leak rate shall not exceed 1×10^{-8} std cc/sec of helium and the chamber shall be evacuated to 50 microns or less. The leak rate shall be measured within eight days after welding.

- 3.8.2 Rods shall have no mars greater than 0.002 inch deep.
- 3.8.3 The maximum allowable bow for the rod shall not exceed that specified in the applicable drawing.
- 3.8.4 Welded fuel rods shall contain not less than 95% helium in the free volume, and not more than 0.1% gaseous impurities other than argon as verified by process qualification tests.
- 3.8.5 Each rod shall be identified by a serial number stamped on the lower end cap. The serial number shall be unique to each rod and clearly visible.
- 3.8.6 Internal and external surfaces of fuel rods shall be clean, free of grease, oil, dust, dirt, moisture, finger marks, scale, flux, organic material (inserts, etc.) and other contaminants.
- 3.8.7 Contamination of UO_2 fuel rod exterior surfaces shall not exceed 10 dpm/100 cm^2 as determined by a wipe test.
- 3.8.8 After loading, individual rods shall be supported at all times to ensure that bowing will not exceed 1 inch over 3.5 feet of length.

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4.0 RECORDS

4.1 Fabrication Records: Thorough fabrication and testing records including any special fuel rod characterization records shall be maintained. Rod history shall be traceable back to the initial feed materials. Records shall be cross-referenced to the rod serial numbers.

4.2 Acceptance Testing Records: Acceptance testing records shall be maintained and the records shall be cross-referenced to the rod serial numbers.

4.3 Process controls and records for each fuel rod shall be such as to assure traceability of each component of each rod including:

- each UO₂ pellet lot in the pellet column
- insulator disc lot
- end cap lot(s)
- enrichment level
- cladding lot
- plenum spring lot

5.0 STORAGE

The rods shall be stored in such a manner that the rods remain clean, the identity is maintained, the rods are not damaged or contaminated with other materials (e.g., oil), and the rods retain conformity with this specification.

6.0 REWORK

Rods which exceed the allowable tolerances on dimensions but which would be reworked to meet the requirements of this specification may be so reworked and resubmitted, provided that the rework process has been reviewed and approved prior to use.

7.0 QUALITY ASSURANCE

Receiving and in-process inspection tests shall be conducted in sufficient numbers to assure that the finished fuel rods meet the following characteristics. Final inspection tests shall be consistent with RDT Standard E13-15T, Section 3.7.3.1.

<u>Item</u>	<u>Characteristic</u>	<u>Applicable Section</u>
Active fuel length	Major	3.2.4
Diametral gap	Critical	3.1
Overall Length	Major	3.1
O.D.	Major	3.1
Rod Bow	Major	3.8.3
Rod Diameter at Welds	Major	3.3.6
Fuel Column Weight	Major	3.2.2
Fissile Content	Critical	3.2.2
Uranium Oxide Content	Major	3.2.2
Component Location	Major	3.6
Proper Pellet Location	Critical	3.6
Pellet Chips	Critical	3.6
Dryness of Pellets and Tubes	Critical	3.2.7 and 3.8.6
	(Control by process procedures)	
Helium Atmosphere for Welding	Critical	3.3.1
	(Control by process procedures)	
Joint Efficiency	Critical	3.3.7
	(Control by process procedures)	
Weld Cover	Critical	3.3.2
Weld Cracks, Defects, and Appearance	Critical	3.3.3
Cladding and Weld Integrity	Critical	3.3.2
Etching	Major	3.5
Rod Cleanliness	Critical	3.8.6
Gas Fill Pressure and Rod Pressurization	Critical	3.4
Pressurization Weld	Critical	3.4
Radioactive Surface and Weld Contamination	Major	3.8.7

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Item	Characteristic	Applicable Section
Surface of Finished Rods	Critical	3.8.6
Serial Number	Critical	3.8.5
Serial Number, Depth and Appearance	Minor	3.8.5
Rod Handling	Major	3.8.8
Thermocouple Weld	Major	3.7.3
Thermocouple Leak Check	Major	3.7.7
Thermocouple Location	Major	3.7.2
Thermocouple Continuity	Major	3.7.6

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APPENDIX A - GLOSSARY OF TERMS

- Critical** A specification, inspection, test or defect, which if not properly controlled, could result in a reactor fuel failure. Such a defect, for example, is one that judgment and experience indicate is likely to result in hazardous or unsafe conditions for individuals using or depending upon the product or is one that judgment and experience indicate is likely to prevent performance of the function of an end item such as fuel rod, fuel assembly, or fuel reload core.
- Major** A specification, inspection, test or defect, other than critical, which is not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
- Minor** A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the usability of the product or an end item such as a fuel rod for its intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.

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APPENDIX B - PELLET STACK COMPONENT WEIGHTS

		<u>Total Ceramic</u>	<u>Total U²³⁵</u>
Standard UO ₂ Rod (grams)	Nominal	1134	40.0
	Maximum	1157	41.2
	Minimum	1112	38.8

XN-530603, Revision 0

Issue Date: 12/13/76

PRODUCT SPECIFICATION

1.0 TITLE: LOFT GUIDE TUBE ASSEMBLY (ZIRCALOY-4)

2.0 SCOPE

- 2.1 This specification describes the requirements for guide tube assemblies used in LOFT fuel assemblies.
- 2.2 The functions and requirements of the guide tube assembly are to join the upper and lower tie plates, forming the basic structural skeleton of the fuel assembly and to support the spacer grid assemblies along the fuel assembly length, while resisting the applied axial loadings due to holdown forces, hydraulic forces, and handling.
- 2.3 A glossary of terms is given in Appendix A.

3.0 TECHNICAL REQUIREMENTS

3.1 Tubing

- 3.1.1 Method: Tubing shall be fabricated from Zircaloy-4 conforming to the applicable material specification per the job parts list.
- 3.1.2 Dimensions: The tubing dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.

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3.2 Guide Tube Sleeve and End Fitting

- 3.2.1 Material: Guide tube sleeves and end fittings shall be fabricated from Zircaloy-4 rod and bar stock conforming to the applicable material specification per the job parts list except that EBC requirements are waived.
- 3.2.2 Dimensions: The guide tube sleeve and end fitting dimensions, tolerances and surface finish shall conform to the applicable drawing per the job parts list.
- 3.2.3 Surface Defects: Guide tube sleeves and end fittings shall be free of burrs or scale and shall have no surface marks, nicks, or scratches deeper than 0.005 inch.
- 3.2.4 Cleanliness: All surfaces of the sleeve and end fitting shall be clean and free of extraneous materials. Components such as oil, grease, rubber and plastics containing sulfur and halides shall not be used in contact with corrosion resistant surfaces. Where use of such components is necessary, the surfaces shall be cleaned prior to operations which involve heating the parts such as welding and heat treating. Such materials shall not be used under circumstances where they may become entrapped in areas of crevices that will become inaccessible to further direct contact cleaning.
- 3.2.5 Etching: All surfaces of the components shall be etched before final assembly. The total amount of metal to be removed from a single surface shall be nominally .0005 with a maximum .001 inch.

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3.3 Assembly

3.3.1 Components

The guide tube assembly shall be fabricated from the following components. The applicable assembly and component drawings and specifications are listed in the job parts list.

Tubing

Upper Guide Tube Sleeve

Lower Guide Tube End Fitting

3.3.2 Welding: The guide tube shall be assembled using both resistance spot welds and inert gas tungsten arc welds. (See Sections 3.3.3.1 and 3.3.3.2, below).

3.3.3 Welds: Weld requirements listed below shall be met as established by weld qualification tests.

3.3.3.1 Resistance Spot Welds (Guide Tube-Upper Sleeve Attachment)

- a) Compression shear of welds shall have an ultimate joint strength greater than 1800 pounds per guide tube.
- b) The minimum diameter of the bonded area shall be 0.040 inch based on destructive examination of representative welds.
- c) Welds shall show no evidence of cracking.
- d) Metallographic examination of in process test welds shall show full penetration through the weld interface.

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3.3.3.2 Inert Gas Tungsten Arc Weld (Guide Tube-End Fitting Attachment)

- a) Welds shall be in conformance with the dimensions given on the applicable drawing per the job parts list.
- b) Axial tensile strength of the weld shall yield joint efficiencies of 80% or greater based on the minimum ultimate strength specified in the applicable material specification and the nominal guide tube area.
- c) Welds shall be free of splatter, ejected metal, slag and blend smoothly into the parent material while showing no discontinuities due to lack of fusion.
- d) Based on metallographic and visual examination, the welds shall be free of undercuts, inclusions or folds greater than 0.005 inch deep or evidence of cracking. Visual examination shall be with low power magnification.

3.3.4 Plug Gauging: The finished guide tube assembly shall be plug gauged with a 1.5 inch long plug having an OD of .0035 inch smaller than the minimum allowed ID.

3.3.5 Handling: The guide tube components shall not be etched subsequent to being assembled, therefore, extreme care in handling throughout the manufacturing process is necessary to prevent surface contamination.

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3.3.6 Identification: Each guide tube assembly shall be identified by a serial number electro-etched on the guide tube approximately 1.0 inch above the lower end fitting weld. The serial number shall be unique to each guide tube assembly.

3.3.7 Cleanliness: Internal and external surfaces of the guide tube assembly shall be clean, free of grease, oil, dust, dirt, finger marks or other contaminants. One test assembly per group of 40 guide tube assemblies (maximum) shall be autoclaved in steam at times and temperatures specified in approved Process Specifications to assure cleanliness is maintained. The autoclave finish shall have a black lustrous oxide film acceptable per Quality Control visual standards.

4.0 REWORK

Guide tube assemblies which do not meet the allowable dimensional tolerances may be reworked provided the rework procedure has been reviewed and approved prior to use.

5.0 RECORDS

Complete fabrication and testing records shall be maintained. Traceability of the component parts to the initial material lots shall be maintained.

6.0 STORAGE

Guide tube assemblies shall be stored in a manner to protect the assembly from mechanical damage, corrosion, and to maintain conformance with this specification.

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7.0 QUALITY ASSURANCE

Receiving, in-process, and final inspection tests shall be conducted to ensure that the finished guide tubes meet the following characteristics:

<u>Item</u>	<u>Characteristics</u>	<u>Section</u>
Overall Length	Major	3.3.1
Outside Diameter	Major	3.3.1
Inside Diameter (Plug Gauge)	Critical	3.3.4
Component Dimensions	Major	3.1.2 3.2.2
Other Dimensions	Major	3.3.1
Weld Quality	Critical	3.3.3 3.3.3.1 3.3.3.2
Weld Tensile and Compressive Strength	Critical	3.3.3.1 3.3.3.2
Identification	Major	3.3.6
Cleanliness	Major	3.2.4 3.3.7
Serial Number	Critical	3.3.6
Serial Number Appearance, Depth	Minor	3.3.6
Component Materials	Critical	3.1.1 3.2.1
Defects	Major	3.2.3
Etching	Major	3.2.5
Handling	Major	3.3.5

APPENDIX A - GLOSSARY OF TERMS

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Major	A specification, inspection, test or defect, other than critical which if not properly controlled, could result in excessive costs, defect rates, rework, or delays in scheduled shipping dates. Such a defect, for example, is likely to reduce materially the usability of the product or an end item such as a fuel rod or fuel assembly.
Minor	A specification, inspection, test or defect, other than critical or major, which if not controlled, does not materially reduce the intended purpose, or is a departure from established standards having no significant bearing on the effective use or operation of the unit, or affects the appearance in a minor degree where appearance is a significant characteristic.