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Westinghouse
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Specification for

Forced Circulation Cold Trap Assemblies
for Removal of Sodium Impurities from
FFTF Closed Loop Systems

HWS-1880, Rev. 2
Addendum 1
Data Type 2

Hanford Engineering Development Laboratory

BUILDING: 337

PROJECT: FFTF

ENGINEERING RELEASE
BY HEDL
REV. 2 DATE 11-18-75
ERO A1339 A

PREPARED BY:

D. B. Klos

APPROVED BY:

M. K. Mahaffey [signature] DATE 11/13/75

F. C. Smith [signature] DATE 11/13/75

DATE

RELEASE AUTHORIZATION

Document Number:	HWS-1880, Rev. 2
Document Title:	Forced Circulation Cold Trap Assemblies for Removal of Sodium Impurities from FFTF Closed Loop Systems

This document, reviewed in accordance with DOE Order 241.1, "Scientific and Technical Information Management," and DOE G 241.1-1, "Guide to the Management of Scientific and Technical Information," does not contain classified or sensitive unclassified information and is:

APPROVED FOR PUBLIC RELEASE

Christine Willingham
C. Willingham

12/1/99
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Hanford Engineering Development Laboratory	Westinghouse Hanford Company A subsidiary of Westinghouse Electric Corporation P. O. Box 1970 Richland, Wa. 99352	IDENTIFICATION NO. HWS-1880 REV. 2
		APPROVAL / DATE
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TITLE	
Forced Circulation Cold Trap Assemblies for Removal of Sodium Impurities from FFTF Closed Loop Systems	CONTRACT NO. AT(45-1) - 2170
	CONTRACTOR
	AUTHOR D. B. Klos

INITIAL RELEASE AND CHANGE CONTROL RECORD

REVISION NUMBER	DATE	REPLACE PAGE NUMBERS	PAGE ADDITIONS
Rev. 2 Addendum1	10/21/75	Addendum 1 to HWS-1880, Rev. 2 a) Correct Paragraph 3.2.11 b) Delete ASME, Section III, Class I requirements on economizer tube side sodium. Addendum 2 to this Specification is hereby certified to be correct and complete with respect to the specified functions and operating conditions in compliance with Paragraph NA-3255 of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components. Frank R La Salle 11-13-75 Registered Professional Engineer - Date Civil 20295 California Registration State FR La Salle 11-13-75 REGISTERED PROFESSIONAL ENGINEER FRANK R. LA SALLE No. 20295 CIVIL STATE OF CALIFORNIA	

This addendum forms part of Specification HWS-1880, Rev. 2. The following changes are to be made:

a. Following subparagraph "c" in Paragraph 3.2.11, correct "80 Btu/hr-ft^2-°F" to read "80 Btu/hr-ft^2."

b. Table I, "Cold Trap Design Conditions," under "Economizer," Tube Side Sodium column, and row 10, "Code Design Requirements, ASME", delete "Section III, Class I " and add "**". Add footnote to Table I as follows: "** All external primary pressure boundaries are to be designed to Section III, Class I requirements."

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HWS-1880
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Hanford Engineering Development Laboratory

ORDERING DATA 1-56 July 11, 1975

Supplements RDT Standard E4-5T in establishing the requirements for forced circulation cold trap assemblies in the Fast Flux Test Facility.

ENGINEERING RELEASE
BY HEDL
REV. 2 DATE 7/11/75
ERO A1116 A

This is to certify that Revision 2 of Design Specification HWS 1880 has been reviewed and state that to the best of my knowledge and belief that this specification complies with the requirements of subarticle NA-3250 of the ASME Boiler and Pressure Vessel Code, Section III-1971, Nuclear Power Plant Components

REGISTERED PROFESSIONAL ENGINEER
FRANK R. LA SALLE
No. 20295
CIVIL
STATE OF CALIFORNIA

7-11-75

Signature Frank R La Salle
Title Professional Engineer
Registration No. 20295
State California

Hanford Engineering Development Laboratory
Operated for the U. S. Energy Research and Development Admin.
By
The Westinghouse Hanford Company, Richland, Washington

Hanford Engineering Development Laboratory	Westinghouse Hanford Company A subsidiary of Westinghouse Electric Corporation P. O. Box 1970 Richland, Wa. 99352	IDENTIFICATION NO. HWS 1880 REV. 2
		APPROVAL / DATE
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TITLE	CONTRACT NO.
Forced Circulation Cold Trap Assemblies for Removal of Sodium Impurities from FFTF Closed Loop Systems	AT(45-1) - 2170
	CONTRACTOR HEDL
	AUTHOR

INITIAL RELEASE AND CHANGE CONTROL RECORD

REVISION NUMBER	DATE	REPLACE PAGE NUMBERS	PAGE ADDITIONS
2	7/11/75	The following new pages have been added to the Ordering Data: 15A, 35A through 35M, 36B, 38A through 38E, 39A, 39B, 40A, 40B, 43 through 56. This revision incorporates Addenda 2 and 3, Addendum 1 was determined to be unnecessary by HEDL. The changes detailed below constitute Revision 2 to this Specification. These changes include editorial corrections, corrections of errors, modifications to RDT standards, and incorporations of updated design conditions, transients, seismic curves, histograms and nozzle loads. 1. Modification to RDT E4-5T, Section 3.4.4 The requirement for stress relief of tubing U-bends is deleted. 2. Modifications to RDT # 15-2T, Paragraphs NNB-3365.1 and RDT F6-5T, Part D - Special requirements are waived for tube-to-tubesheet welds in the economizers. 3. Ordering Data, Section 2.1 (pages 5 and 5-A) The issue dates of the following RDT standards are changed as shown: RDT F5-1T February 1972 RDT M2-5T April 1972 RDT M3-6T June 1972 RDT M5-1T January 1972 4. Ordering Data, Section 3.1.2 (page 6) The requirement that the Supplier provide a blower for each secondary coolant system cold trap is deleted. 5. Ordering Data, Section 3.2.1 (page 7); Sections 3.2.3 and 3.2.4 (page 10); and Section 3.2.5 (page 11) Appropriate references to Table IC (new, page 36B) are added to the text.	

BD-7320-005 (6-72)
AEC-GL RICHLAND, WASH.

Hanford Engineering Development Laboratory	Westinghouse Hanford Company A subsidiary of Westinghouse Electric Corporation P. O. Box 1970 Richland, Wa. 99352	IDENTIFICATION NO. HWS 1880 REV. APPROVAL / DATE APPROVAL / DATE
TITLE	Forced Circulation Cold Trap Assemblies for Removal of Sodium Impurities from FFTF Closed Loop Systems	CONTRACT NO. AT(45-1) - 2170 CONTRACTOR HEDL AUTHOR

INITIAL RELEASE AND CHANGE CONTROL RECORD

REVISION NUMBER	DATE	REPLACE PAGE NUMBERS	PAGE ADDITIONS
		6. <u>Ordering Data, Section 3.2.1-4 (page 7)</u> The footnote on page 7, promising histograms and updated transients, is deleted. Reference to Table VIII (new) as the source of histogram information is added. 7. <u>Ordering Data, Section 3.2.1-4.A(2) (page 8)</u> The text of this section has been expanded to provide more information, i.e., normal thermal transients. Reference is made to Tables III-IIIC (new) which provide additional thermal transient information. 8. <u>Ordering Data, Section 3.2.1-4A (4) (page 7)</u> This new section provides pressure transient information and makes reference to Table III D (new). 9. <u>Ordering Data, Section 3.2.1-4.B (1&2)(page 8)</u> This section is rewritten to provide additional seismic analysis and flow-and-thermal transients information for upset conditions. Reference is added to seismic response curves 18-29 (new), to Tables IV through IV B (revised or new) and to Figures 4 through 17. 10. <u>Ordering Data, Section 3.2.1-4.B (3) (page 8)</u> Reference to Figure 17 is added to paragraph b. 11. <u>Ordering Data, Section 3.2.1-4.D (page 9)</u> References to Table IV and Figure 7 are added. 12. <u>Ordering Data, Section 3.2.1-4.E (1) (page 9)</u> (a) This section is rewritten to provide additional seismic analysis information for faulted conditions. Reference is added to seismic response curves 24-29 (new). (b) Reference is added to Figure 17. 13. <u>Ordering Data, Section 3.2.1.1 (page 9)</u> This section (Seismic Criteria) is deleted. 14. <u>Ordering Data, Section 3.2.1.2 (page 9)</u> This section is updated to provide missing information regarding environmental vibrations and degree of analysis required.	

BD-7320-005 (5-72)
AEC-RL RICHLAND, WASH.

Hanford Engineering Development Laboratory	Westinghouse Hanford Company A subsidiary of Westinghouse Electric Corporation P. O. Box 1970 Richland, Wa. 99352	IDENTIFICATION NO. HWS-1880	REV.
		APPROVAL	DATE
		APPROVAL	DATE

TITLE	
FORCED CIRCULATION COLD TRAP ASSEMBLIES FOR REMOVAL OF SODIUM IMPURITIES FROM FFTF CLOSED LOOP SYSTEMS	CONTRACT NO. AT(45-1) – 2170 CONTRACTOR HEDL AUTHOR

INITIAL RELEASE AND CHANGE CONTROL RECORD

REVISION NUMBER	DATE	REPLACE PAGE NUMBERS	PAGE ADDITIONS
		15. Ordering Data, Section 3.2.1.3 (page 9) Reference is added to Tables VA and VB (new). 16. Ordering Data, Section 3.2.5 (page 11) Reference is made to Figure 30 (new). 17. Ordering Data, Section 3.2.11 (page 12) The entire section on preheaters is rewritten to redefine supplier responsibility and to update requirements. 18. Ordering Data, Section 3.2.13 (page 13) The requirement for bolted construction of the support frame is deleted. 19. Ordering Data, Section 3.3 (page 14) The materials requirements for cold trap internals are clarified; and RDT M2-2 (forgings) and RDT M3-6 (pipe) are added. The footnote is changed to delete the 0.10 percent maximum carbon content requirement. 20. Ordering Data, Section 3.4.5 (page 14) Requirement is added for a chloride contamination test. 21. Ordering Data, Section 3.4.5.2 (page 15) The requirement for ultra-violet light inspection of the wire mesh is clarified. 22. Ordering Data, Figures 1 and 2 (pages 18 and 19) These figures are updated. 23. Ordering Data, Figures 4-17 (pages 21-34) These temperature transient curves are updated. 24. Ordering Data, Figures 18-29 (pages 35-35K) Seismic response curves (new) are provided. 25. Ordering Data, Figure 30 (page 35L) Conceptual design for the sodium inlet nozzle (new) is provided. Ordering Data, Figure 31 (page 35M) Curve for TSMDA pressure pulse is added.	

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		APPROVAL	DATE
		APPROVAL	DATE

TITLE	CONTRACT NO. AT(45-1) - 2170
Forced Circulation Cold Trap Assemblies for Removal of Sodium Impurities from FFTF Closed Loop Systems	CONTRACTOR HEDL
	AUTHOR

INITIAL RELEASE AND CHANGE CONTROL RECORD

REVISION NUMBER	DATE	REPLACE PAGE NUMBERS	PAGE ADDITIONS
		26. Ordering Data, Table I (page 36) The operating pressure drop requirement for a plugged trap is added (line 5); and the "H" is deleted from "316 H" in line 11. 27. Ordering Data, Table IC (page 36-b) Table (new) showing additional alternate operating conditions is provided. 28. Ordering Data, Table II (page 37) The original Table II is replaced to provide updated steady state operating conditions. 29. Ordering Data, Tables III-IIIC (pages 38-38C) The original Table III is replaced, to provide updated normal thermal transients. 30. Ordering Data, Table IIID (page 38D & E) Table (new) showing pressure transients is provided. 31. Ordering Data, Tables IV - IVB (pages 39-39B) The original Table IV is replaced, providing additional design transient information. 32. Ordering Data, Tables V-VB (pages 40-40B) The original Table V is replaced, to provide updated nozzle load information. 33. Ordering Data, Table VI (page 41) Item 2 is changed, to require submittal of detail drawings to Purchaser for information rather than approval. 34. Ordering Data, Pages 44-56 (new) Histograms (new) and Table VIII (new) are provided. Released per ERO A1116.	

BD-7320-005 (5-72)
AEC-RL RICHLAND, WASH.

SPECIFICATION CONTENTS

"RDT M 3-2T Stainless and Alloy Steel Seamless Tubes (ASME SA-213 with additional Requirements)"

"RDT M 5-1T Stainless Steel Plate, Sheet, and Strip (ASME SA-240 with Additional Requirements)"

Delete the date from all remaining standards.

4. Page 3, Para. 2.2: Delete the date, -1964, from ANSI B 16.25.

5. Page 3, Para. 2.3: Change to read as follows:

   "ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components, and applicable Code Cases"

6. Page 3, Para. 2.4: Delete the words "Fifth Edition, 1968."

7. Page 4, Para. 3.1: In the last sentence, change the words "Nuclear Vessels" to "Nuclear Power Plant Components."

8. Page 4, Para. 3.2.1: In the first sentence, change the words "Code Case 1331-4" to "RDT E 15-2"; in line 3, delete the words "and Code Case 1331-4."

9. Page 9, Para. 3.4.1: In the first sentence, change the words "Section III of the ASME Boiler and Pressure Vessel Code" to read as follows: "The Code, as supplemented by RDT E 15-2."

10. Page 9, Para. 3.4.2: Change to read as follows:

    "All welding, hardsurfacing, brazing, and thermal cutting procedures shall be in accordance with RDT E 15-2 for all classes of vessels."

11. Page 10, Para. 3.4.7.1: Change to read "Raw materials and in-process marking shall be in accordance with the applicable material standard and Paragraph NB-4122 of the Code."

12. Page 11, Para. 3.4.7.2: In the last paragraph change the words "RDT F 6-1, Appendix C, par. 7.1" to "NA-8300 and NB-4435 of the Code." Add as the last three sentences to the paragraph:

    "Nameplates shall not be attached directly to the vessel, pipe, or component. A standoff using the same base material, shall be welded to the item using full penetration welds. The standoff height shall be equal to the insulation thickness plus 1/4 inch."

13. Page 12, Para. 3.7.1: In the last sentence of the first paragraph, change the words "Class A" to "Class 1." In item 4, change the words "N-142 of the ASME Boiler and Pressure Vessel Code, Section III" to "NA 3350 of the Code." In the last sentence of this paragraph, change "Class C" to "Class 2" and "Class A" to "Class 1."

FORCED-CIRCULATION COLD TRAP ASSEMBLY FOR REMOVAL OF SODIUM IMPURITIES

AMENDMENT 1

This amendment forms a part of RDT E 4-5T, dated December 1970

1. Page 1, Para. 1.2: Delete this paragraph.

2. Page 2, Para. 2: Delete paragraph as written and substitute the following under the heading, APPLICABLE DOCUMENTS:

   "The following documents are a part of this standard to the extent specified herein. The issue in effect on the date of invitation to bid, together with any amendments or addenda also in effect on that date, shall apply unless otherwise specified. Any conflicts between the requirements of referenced documents shall be brought to the attention of the purchaser for resolution."

3. Page 2, Para. 2.1: Delete the following standards: RDT F 3-2T, RDT F 3-3T, RDT F 3-4T, RDT F 3-5T, RDT F 3-8T, RDT F 6-1T.

   Add the following standards:

   "RDT E 15-2T Requirements for Nuclear Components (Supplement to ASME Boiler and Pressure Vessel Code, Section III)"

   "RDT F 3-37T Special Requirements for Metal Products"

   "RDT F 6-5T Welding Qualifications (Supplement to ASME Boiler and Pressure Vessel Code, Section IX)"

   "RDT F 6-10T Repair of Materials by Welding"

   "RDT F 6-14T Brazing Fabrication Requirements"

   Change the titles of the following standards to read:

   "RDT M 1-1T Stainless Steel Covered Welding Electrodes (ASME SFA-5.4 with Additional Requirements)"

   "RDT M 1-2T Stainless Steel Welding Rods and Bare Electrodes (ASME SFA-5.9 with Additional Requirements)"

   "RDT M 2-2T Stainless and Low Alloy Steel Forgings (ASME SA-182 with Additional Requirements)"

14. Page 14, Para. 3.7.2.9: Change "Paragraph IX-225, Section III" to "Paragraph NA-4900."

15. Page 15, Para. 4.4.2: In the first sentence, change the words "RDT Standards" to "RDT F 3-6."

16. Page 16, Table I: Replace the deleted standards RDT F 3-3, RDT F 3-4, RDT F 3-5, and RDT F 3-8 with RDT F 3-6.

17. Page 17, Para. 4.4.3: In the first sentence, change "RDT F 6-1" to "RDT F 6-10."

18. Page 17, Para. 4.5: Change "RDT F 6-1, Part 1," to "RDT E 15-2."

19. Page 17, Para. 4.5.2: Revise this paragraph to read as follows:

    "Liquid Penetrant Examination — Nonmagnetic materials shall be examined by liquid penetrant methods. Welds shall be examined in accordance with the requirements of RDT E 15-2 by liquid penetrant. The use of liquid penetrant materials from aerosol spray cans using halogenated compounds as propellants is prohibited. Following liquid penetrant examination, weld areas shall be cleaned in accordance with the requirements of RDT F 5-1."

20. Page 17, Para. 4.5.4: Change "RDT F 6-1" to "RDT E 15-2."

21. Page 18, Para. 4.6.1: In the second sentence, change "Paragraph N-713" to "Paragraph NB-6300." In the fourth sentence, change "Table N421," to "Table I of Appendix I."

    In the third paragraph, change "RDT F 3-2" to "RDT F 2-2."

22. Page 20, Para. 6: Immediately under the paragraph title, add the following statement:

    "Compliance. When this standard is used as a basis for procurement, the purchase specification will be certified by a registered Professional Engineer representing the purchaser to be in compliance with the rules for a design specification of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components."

23. Page 21, Para. 6: In Item 29, change "Class C" to "Class 2."

RDT E 4-5T

RDT Standard

FORCED-CIRCULATION COLD TRAP ASSEMBLY FOR REMOVAL OF SODIUM IMPURITIES

December 1970

Division of Reactor Development and Technology
United States Atomic Energy Commission

R D T S T A N D A R D		RDT	E 4-5T
UNITED STATES ATOMIC ENERGY COMMISSION DIVISION OF REACTOR DEVELOPMENT AND TECHNOLOGY		Date	December 1970

FORCED-CIRCULATION COLD TRAP ASSEMBLY FOR REMOVAL OF SODIUM IMPURITIES

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FORCED-CIRCULATION COLD TRAP ASSEMBLY FOR REMOVAL OF SODIUM IMPURITIES

1. SCOPE

This standard delineates the requirements for the design, materials, fabrication, examination, acceptance testing, and delivery of a cold trap assembly to remove impurities from liquid sodium by crystallization.

1.1 Classification - Cold trap assemblies covered by this standard shall be classified according to type of cooling system used (liquid or gaseous) and by the characteristics of the cooling and crystallization zones.

1.2 Compliance - The Ordering Data for the cold trap shall be certified by a registered Professional Engineer in accordance with the requirements of Paragraph N-141, Section III of the ASME Boiler and Pressure Vessel Code.

1.3 Definitions

Cold Trap - An assembly of an economizer plus a crystallizer tank.

Cold Trapping - The crystallization of impurities from liquid sodium by cooling a portion of the sodium system below the saturation temperature of the impurity in the system.

Crystallization Element - The knitted wire mesh packing used to fill the annular sodium cooling zone, or the sodium return line, of the crystallizer tank, or both. The element serves as nucleation sites for impurities crystallizing out of the cooling sodium, and as a filter to trap suspended impurity crystals.

Crystallizer Tank - That vessel of the cold trap which provides low temperature and extended surfaces for promoting precipitation of dissolved sodium impurities. The processes of cooling, crystallization, settling and filtration occur in this tank.

Crystallizer Tank Cooling System - An auxiliary cooling system, gas or liquid, used to remove heat from cold traps.

Economizer - A regenerative heat exchanger used as part of a forced-circulation cold trap assembly to minimize system heat losses, reduce thermal shock, and reduce total heat removal requirements of the trap.

Residence Time, Crystallizer Tank - The average time in minutes that an element of fluid remains within the packed zone of the crystallizer tank. It is determined by dividing the crystallizer tank volume packed with knitted wire mesh, by the sodium flow rate.

Residence Time, Economizer - The average time in seconds that an element of fluid remains within the shell side of the economizer. It is determined by dividing the economizer shell side volume by the sodium flowrate.

2. APPLICABLE DOCUMENTS

The following documents of the exact issue shown form a part of this standard to the extent specified herein. Where the contents of this document conflict with any document referenced herein, this standard takes precedence.

2.1 AEC-Reactor Development and Technology (RDT) Standards

RDT F 2-2T* June 1969	Quality Assurance Program Requirements
RDT F 3-2T February 1969	Calibration System Requirements
RDT F 3-3T February 1969	Ultrasonic Examination of Heavy Steel Forgings (Modified ASTM A388)
RDT F 3-4T February 1969	Ultrasonic Shear-Wave Examination of Plates (Modified ASTM A577)
RDT F 3-5T February 1969	Longitudinal-Wave Ultrasonic Examination of Plain and Clad Steel Plates (Modified ASTM A578)
RDT F 3-6T March 1969	Nondestructive Examination
RDT F 3-8T February 1969	Ultrasonic Examination of Metal Pipe and Tubing for Longitudinal Discontinuities (Modified ASTM E213)
RDT F 5-1T March 1969	Cleaning and Cleanliness Requirements for Nuclear Reactor Components
RDT F 6-1T February 1969	Welding
RDT F 7-2T February 1969	Preparations for Sealing, Packaging, Packing, and Marking of Components for Shipment and Storage
RDT M 1-1T February 1969	Corrosion Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes (Modified ASTM A298)
RDT M 1-2T February 1969	Corrosion Resisting Chromium and Chromium-Nickel Steel Welding Rods and Bare Electrodes (Modified ASTM A371)

*The letter "T" which appears at the end of RDT Standard numbers designates approval for use as "tentative" standard.

RDT M 2-2T February 1969	Stainless and Heat-Resisting Steel Forgings (Modified ASTM A182)
RDT M 2-4T February 1969	Alloy Steel Forgings (Modified ASTM A336)
RDT M 2-5T February 1969	Factory Made Wrought Austenitic Steel Welding Fittings (Modified ASTM A403)
RDT M 3-2T February 1969	Seamless Ferritic and Austenitic Alloy Steel Tubes (Modified ASTM A213)
RDT M 3-3T February 1969	Seamless Austenitic Stainless Steel Pipe (Modified ASTM A376)
RDT M 3-5T May 1969	Welded Austenitic Stainless Steel Tubing (Modified ASTM A249)
RDT M 3-6T May 1969	Seamless and Welded Austenitic Stainless Steel Pipe (Modified ASTM A312)
RDT M 3-7T May 1969	Welded Large Diameter Stainless Steel Pipe (Modified ASTM A358)
RDT M 4-2T February 1969	Austenitic Stainless Steel Castings for High Temperature Service (Modified ASTM A351)
RDT M 5-1T February 1969	Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip (Modified ASTM A240)
RDT M 7-3T February 1969	Stainless and Heat-Resisting Steel Bars and Shapes (Modified ASTM A479)

2.2 American National Standards Institute (ANSI) Standards

ANSI B16.25-1964 Buttwelding Ends for Pipe, Valves, Flanges, and Fittings

ANSI Y14 Standard Drafting Manual

2.3 American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code, 1968 Edition, and Addenda

Section III Nuclear Vessels, and Code Case 1331-4

2.4 Others

Standards of Tubular Exchanger Manufacturers Association (TEMA) Fifth Edition, 1968

American Institute of Steel Construction (AISC) Specifications:

Specification for Design, Fabrication and Erection of Structural Steel for Buildings

Code of Standard Practice for Steel Buildings and Bridges

3. TECHNICAL REQUIREMENTS

3.1 General - The sodium forced-circulation cold trap assembly is part of a sodium purification system. The cold trap is used to remove dissolved impurities from radioactive or nonradioactive sodium. An economizer is used as a regenerative heat exchanger to lower the inlet sodium temperature to the crystallizer tank within design conditions and thereby require a smaller load for the cold trap coolant. Each cold trap assembly will include piping, structural supports, heaters, lifting lugs, insulation clips, and special tools required to install or service the unit.

Schematics, typical of cold trap assemblies that have been designed and operated successfully are shown in Figure 1. Detailed envelope dimensions, drawings and system descriptions for the cold trap assembly are presented in the Ordering Data.

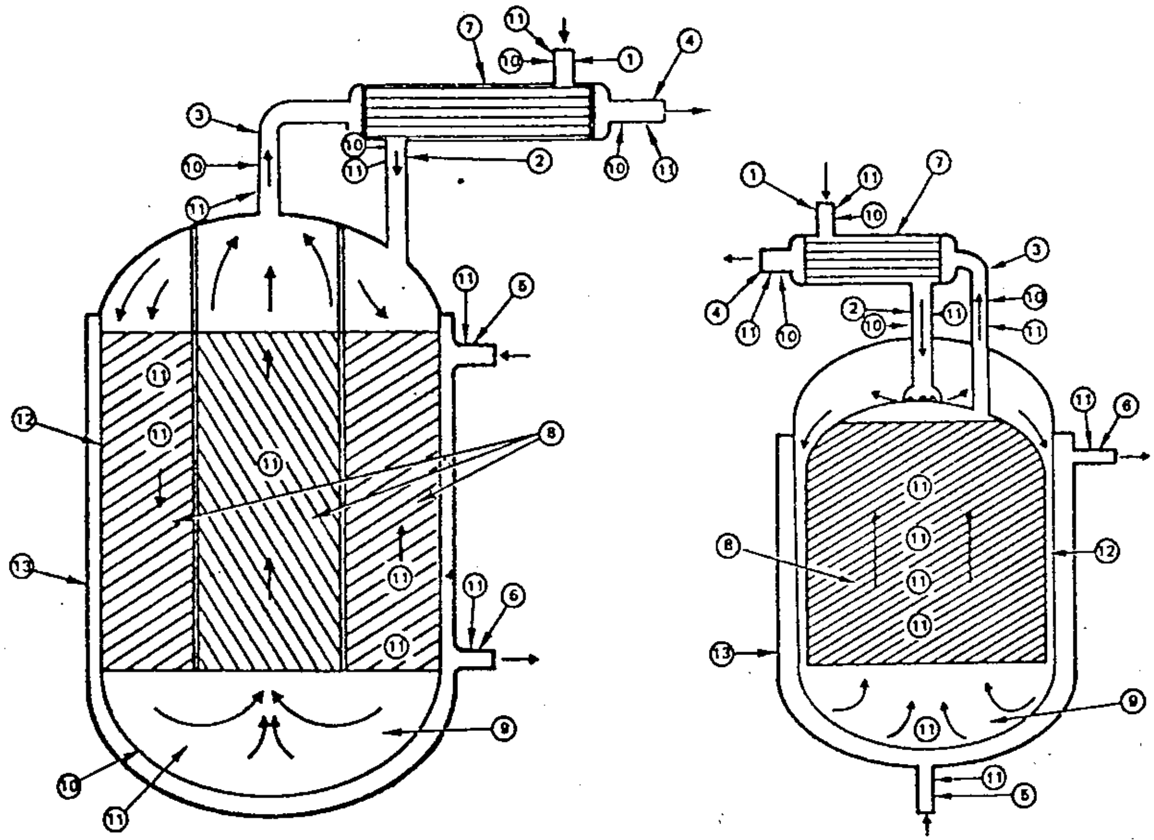
The design, fabrication and assembly of the cold trap shall be in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Vessels (hereinafter referred to as "the Code"), and the cold traps shall be code stamped.

3.2 Design Parameters

3.2.1 Structural Design Requirements - The design of the cold trap assembly shall be in accordance with Section III of the Code and Code Case 1331-4. The method of determining allowable stresses supplementing the Code and Code Case 1331-4 will be specified in the Ordering Data. The classification of the cold trap assembly under Section III of the Code will be specified in the Ordering Data. The cold trap assembly shall be designed for operation under the normal, upset, emergency, and faulted conditions as defined in Section III of the Code. Operating temperatures, pressures, and thermal transients for all operating conditions shall be as specified in the Ordering Data.

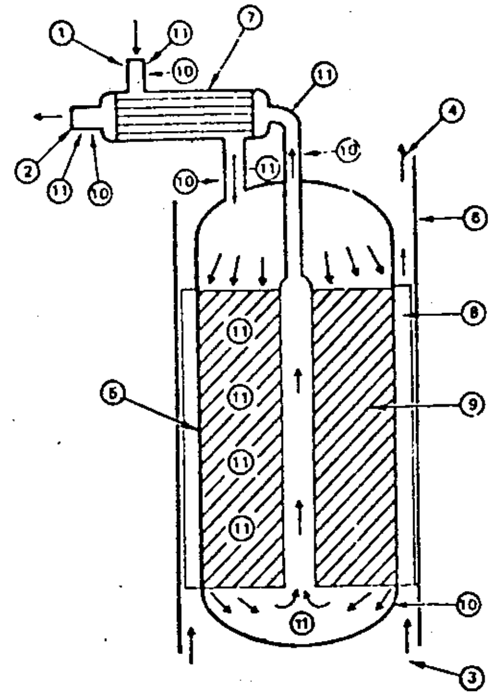
3.2.1.1 Seismic Criteria - The cold trap assembly shall be designed for the seismic loading criteria specified in the Ordering Data, and shall be designed to resist the combined effect of horizontal and vertical seismic loadings together with external loads, pressure loads, and temperature loads.

3.2.1.2 Vibration - The cold trap and all its parts shall be analyzed and designed so that they will not be damaged or caused to malfunction by internally generated vibrations, such as flow-induced vibrations or by environmental vibrations. Baffles and tube support plates, tie rods, impingement plates, etc. shall be provided so that the natural frequencies of all unsupported tube spans are sufficiently removed from both hydrodynamically and environmentally generated fluid pulsations to avoid damage.



① SODIUM INLET
② COOLED SODIUM INLET TO CRYSTALLIZER TANK
③ PURIFIED SODIUM OUTLET FROM CRYSTALLIZER TANK
④ SODIUM OUTLET
⑤ LIQUID COOLANT INLET
⑥ LIQUID COOLANT OUTLET
⑦ ECONOMIZER
⑧ CRYSTALLIZER ELEMENT
⑨ SETTLING REGION
⑩ PRESSURE SENSOR
⑪ PROCESS THERMOCOUPLE
⑫ CRYSTALLIZER TANK
⑬ COOLANT JACKET

TYPES OF LIQUID COOLED COLD TRAPS



① SODIUM INLET
② SODIUM OUTLET
③ COOLING GAS INLET
④ COOLING GAS OUTLET
⑤ CRYSTALLIZER TANK
⑥ COOLANT JACKET
⑦ ECONOMIZER
⑧ COOLING FINS
⑨ CRYSTALLIZER ELEMENT (WIRE MESH)
⑩ PRESSURE SENSOR
⑪ PROCESS THERMOCOUPLE

TYPICAL GAS-COOLED COLD TRAP

Fig. 1 Cold Trap Assemblies

3.2.1.3 Piping Reactions - The cold trap assembly shall be designed to accommodate the forces and moments exerted by the piping on the economizer and crystallizer tank cooling jacket (if applicable) as specified in the Ordering Data and Figure 2.

3.2.1.4 Corrosion Allowance - Corrosion allowances for both sodium-containing materials and coolant-containing materials shall be as specified in the Ordering Data.

3.2.1.5 Life - The cold trap assembly shall be structurally capable of operating for the life specified in the Ordering Data.

3.2.2 Size and Weight - Weight and overall dimensions shall be the minimum consistent with the requirements specified herein. Overall dimensions of the cold trap assembly shall not exceed the limitations specified in the Ordering Data.

3.2.3 Thermal and Hydraulic Design - The cold trap piping shall be designed so that the average velocities and pressure losses will be within limits specified in the Ordering Data. The cold trap assembly shall be designed to permit freezing and programmed melting of its contents without being damaged.

3.2.3.1 Residence Time - Maximum economizer residence time shall be 30 seconds, and minimum residence time in the crystallizer tank shall be 5 minutes.

3.2.3.2 Pressure Drop - The pressure drop through the cold trap assembly shall be a minimum consistent with the requirements of this standard, and shall not exceed the maximum value specified in the Ordering Data.

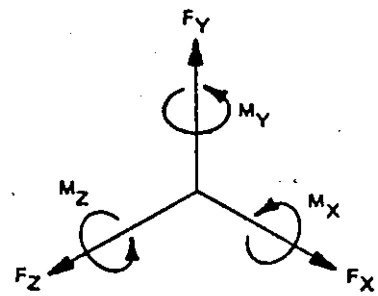
√ 3.2.3.3 Sodium Temperature - The cold trap assembly shall be capable of cooling the design flow of sodium to a temperature at the coldest part of the crystallizer tank of 230 F. The temperature drop in the crystallizer tank shall be a maximum of 100 F.

3.2.3.4 Flow Rate - The cold trap assembly shall be capable of processing sodium at the flow rate specified in the Ordering Data.

3.2.4 Economizer - The economizer (tubular heat exchanger) shall be designed in conformance with TEMA Class R requirements. The economizer shall be external to the crystallizer tank. Detailed design requirements for the economizer shall conform to the requirements of the Ordering Data and the following:

1. Nozzles and connections shall be of the size, type, and orientation specified in the Ordering Data.
2. Supports shall be adequate for supporting the unit when filled and subjected to the seismic loading of 3.2.1.1.
3. The system sodium inlet stream shall be on the shell side.

DESIGN TEMPERATURE F



NOZZLE IDENTIFICATION		FORCES (lb)			MOMENTS (ft-lb)		
		F_X	F_Y	F_Z	M_X	M_Y	M_Z
ECONOMIZER SHELL SIDE:	SODIUM INLET						
	SODIUM OUTLET						
ECONOMIZER TUBE SIDE:	SODIUM INLET						
	SODIUM OUTLET						
CRYSTALLIZER TANK:	SODIUM INLET						
	SODIUM OUTLET						
	COOLANT INLET						
	COOLANT OUTLET						

Figure 2. Piping Reactions at Nozzles

3.2.5 Crystallizer Tank - The crystallizer tank shall be designed to give the fluid residence time specified in 3.2.3.1. The physical properties, pressure, and temperature of the coolant to be used in the cooling system will be specified in the Ordering Data.

3.2.5.1 Crystallization Element - The crystallization element shall be made with continuous-strand stainless steel knitted wire mesh; the wire shall be 0.003 to 0.015 inch in diameter. The mesh shall be wound in spiral pads forming right circular cylinders with dimensions as specified in the Ordering Data, and shall be packed to a density of 10 to 25 lb/ft^3 to give the surface area per unit volume specified in the Ordering Data. The compacted mesh pads shall be stacked to give the total thickness, in the direction of sodium flow, specified in the Ordering Data. The packing shall be supported by a rigid framework designed to hold it in place against the maximum specified pressure drop.

3.2.6 Venting - The cold trap assembly shall be self-venting with vent locations approved by the purchaser.

3.2.7 Instrumentation Provisions - A minimum of two thermowells shall be provided in the crystallizer tank, extending from the top of the tank through the knitted wire mesh into the lower plenum. The number and locations of other thermowells shall be as specified in the Ordering Data. If the thermocouples are to be provided by the supplier, their requirements will be specified in the Ordering Data.

3.2.8 Connections and Appurtenances - All connections (heaters, thermocouples, insulation supports, sodium and crystallizer tank coolant piping) shall be as specified in the Ordering Data.

There shall be no interconnection between systems that could result in the mixing of the sodium with the crystallizer tank coolant.

All cold trap assembly piping stub connections shall extend to the assembly interface boundary specified in the Ordering Data, and shall be designed for buttwelding in accordance with ANSI B16.25.

3.2.9 Insulation - The supplier shall provide any internal insulation and shall provide clips where required on the exterior of the equipment for support of external insulation. The supplier shall recommend the required insulation thickness to provide a maximum external temperature of 140 F, and shall provide the value used for sizing system heaters.

3.2.10 Handling Fixtures - Lifting lugs, supports, handling fixtures, and framing shall be as specified in the Ordering Data.

3.2.11 Heaters - The supplier shall recommend size and location of all heaters required for a programmed preheat of the cold trap assembly, full of solid sodium, from ambient to preheat temperature as specified in the Ordering Data. Heaters shall be designed to operate at one-half their rated voltage.

The use of electrical heaters in contact with sodium shall not be permitted.

3.2.12 Environmental Conditions - Normal ambient conditions to which the cold trap assembly will be exposed are specified in the Ordering Data, and include temperature and pressure ranges, humidity, wind, precipitation, and other conditions which could influence the operation of the assembly.

3.2.13 Structural Supports - The cold trap assembly shall be supported from a steel structure as specified in the Ordering Data. Structural steel design, fabrication, and erection shall be in accordance with the AISC "Specification for Design, Fabrication and Erection of Structural Steel for Buildings" and the AISC "Code of Standard Practice for Steel Buildings and Bridges." Structural members shall be designed to exclude field welding. Bolted structures are preferred.

3.3 Materials of Construction - Sodium containment materials shall be Type 304 or Type 316 stainless steel, and shall conform to the requirements of the appropriate RDT material standards as specified in the Ordering Data. Knitted wire mesh used in the crystallization element shall be continuous strand austenitic stainless steel wire mesh.

Structural supports may be of carbon steel construction.

3.4 Fabrication

3.4.1 Fabrication Criteria - Detailed fabrication procedures meeting the requirements of Appendix IX of Section III of the ASME Boiler and Pressure Vessel Code shall be submitted by the supplier to the purchaser for his review prior to the start of fabrication. The fabrication procedures shall include the proposed sequences and procedures for material procurement, fabrication, cleaning, maintaining cleanliness, examination, in-process inspection, and testing of all parts of the cold trap assembly that are to be provided by the supplier.

3.4.2 Welding and Thermal Cutting - All welding, brazing, hardsurfacing, and thermal cutting procedures shall be in accordance with RDT F 6-1, Part 1, for all classes of vessels.

3.4.2.1 Dissimilar Metal Welds - Carbon or low alloy steel parts shall not be welded directly to a stainless steel pressure containment part.

3.4.2.2 Weld Repair - Purchaser approval shall be required to make weld repairs to remove defects that recur:

1. After the first cycle of weld repair of defects at the fusion zone and/or adjacent base metal.

2. After the second cycle of weld repair in welds that are heat treated after each repair cycle.

Repair of crater cracks restricted to the crater of the weld pass shall not require purchaser approval.

3.4.3 Heat Treatment - All heat treatment including stress relieving shall be in accordance with the requirements of the applicable material standards.

3.4.3.1 Sensitization - Austenitic stainless steel which has become sensitized during heat treatment, welding, or forming shall be solution annealed in accordance with the applicable material standard; or, sensitized austenitic stainless steel, which has not been solution annealed in accordance with the applicable standard, shall be maintained in a dry, controlled, monitored environment subsequent to sensitization. Alternate techniques for handling sensitized materials shall require the written concurrence of the purchaser.

3.4.4 Bending and Forming - Bending and forming procedures for shaping tubes, shells, heads, etc., shall be in accordance with the applicable standards or procedures prepared by the supplier and approved by the purchaser. The wall thickness at the outer radius of the bend after the bending and forming operations shall not be less than the minimum design thickness. The out-of-roundness in any circular cross section of pipes and tubes after bending shall not exceed 8 percent of the outside diameter. The supplier shall evaluate the need for heat treatment to ensure dimensional stability following bending or forming operations.

3.4.5 Cleaning - Surfaces shall be clean and free of pitting, corrosion products, and oxides. The cleaning of materials and the degree of cleanliness shall be in accordance with RDT F 5-1, as specified in the Ordering Data. Before conducting cleaning operations, the supplier shall submit the following for purchaser's approval: (1) general cleaning procedures to be employed, (2) flushing procedures, (3) acceptance standards for contamination, (4) drying methods to be employed on cleansed equipment, and (5) inhibitors employed for minimizing corrosion when applicable and procedures for their removal.

3.4.6 Assembly - The assembly of component parts including economizer and crystallizer tank assembly shall be in accordance with a detailed assembly procedure prepared by the supplier. The procedure shall contain as a minimum:

1. Any special machining or fitting-at-assembly instructions.

2. Intermediate and final inspection criteria and hold points.

3.4.7 Identification - Identification procedures shall conform to the following requirements.

3.4.7.1 Marking - Raw materials and in-process marking shall be in accordance with the applicable material standard and Appendix IX to Section III of the Code. When raw material is cut or sectioned, all markings shall be transferred to the unmarked portion of the material.

3.4.7.2 Nameplates - Permanent nameplates shall be attached to the crystallizer tank and economizer. The nameplate shall show the following information as a minimum:

1. Code class
2. Manufacturer's name
3. Manufacturer's drawing or part number
4. Manufacturer's serial number
5. Purchase order or contract number
6. RDT E 4-5T
7. Design pressure, ____ psig at coincident temperature ____ F
8. Design temperature, F
9. Design sodium flowrate, ____ lb/hr at design temperature
10. Material of construction
11. Year built

The nameplates shall be of a corrosion resistant material compatible with the surface to which they are fastened. Caustic resistant enamel shall be used to fill the markings on the nameplate. The plate support brackets shall be attached by welding in accordance with RDT F 6-1, Appendix C, par. 7.1. Nameplates shall not be painted over or otherwise covered.

3.5 Drawings - Drawings shall be prepared in accordance with ANSI Y14 and submitted to the purchaser. The submittal time, approval requirements, and number of copies shall be as specified in the Ordering Data.

3.5.1 Assembly Drawings - These drawings shall include the following information, where applicable.

1. Information required for the preparation of mechanical supports.
2. Size and location of all connections and fittings.
3. Thermal and pressure movement of all connections with respect to the equipment support.
4. Dry weight and center of gravity locations.
5. A complete list of reference drawings.
6. A bill of material which includes location, identity (drawing and part numbers), and material type of each part.

7. Dimensions establishing size, shape, fits and clearances of each major part.

8. Pressure and temperature data, including design pressure and temperature, and test pressure.

9. Actual dimensions in critical areas as specified in Ordering Data.

10. Pertinent references to cleaning, marking, torque, locking, handling, and packaging instructions.

3.5.2 Detail Drawings - Detail drawings shall include, as appropriate, the following information:

1. Detailed dimensions, tolerances, and maximum roughness of each surface.

2. Material specification and any special requirements including non-destructive testing, heat treatment, and hardness.

3. Fabrication instructions, including welding, hardsurfacing, cleaning, inspection symbols, and references to assembly procedure requirements.

3.5.3 Drawing and Specification Lists - The supplier shall maintain a current listing of all drawings associated with the components of this standard. Each drawing number shall include the current revision number.

The supplier shall maintain a current list of specifications. This list of specifications shall include as applicable, requirements for design, materials, fabrication, construction, installation, testing, inspection, maintenance, cleaning, packaging, shipping, storage, operation, and quality assurance.

The drawings and specifications lists shall be maintained for the time specified in the Ordering Data.

3.6 Special Tools - One set of special tools required in operating and maintaining the equipment shall be supplied. The tools shall be new and unused.

3.7 Reports and Documentation

3.7.1 Design Report - The supplier shall prepare a design report related to the design of the cold trap and its component parts. The time and approval requirements of submittals to the purchaser and the number of copies required shall be as specified in the Ordering Data. The design report shall be submitted as the basis for approval of the cold trap assembly design by the purchaser. As a minimum for Section III Class A requirements of the Code, this design report shall include the following:

1. A design description of the cold trap including operating characteristics, operational limitations, and safety considerations.

2. Heat transfer and fluid flow analyses.

3. A thermal transient stress analysis of regions of discontinuities and thick sections.

4. A stress report satisfying the rules of Paragraph N-142 of the ASME Boiler and Pressure Vessel Code, Section III. This report shall include a discussion of the employed high-temperature design criteria.

5. Vibration analyses.

6. Differential thermal expansion analysis.

7. Weight and center of gravity calculations of the cold trap and its component parts.

8. Corrosion allowance used in analysis.

9. Materials of construction.

All information furnished in the design report shall be in sufficient detail to permit independent checking. The references from which data or formulas are taken shall be identified. The validity of the data and the conclusion, which support the recommended design, shall be discussed. All computer programs used shall be identified and described in the report to enable independent verification.

The supplier shall be responsible for making such additions or corrections to the report as are required to keep the information current. These revisions shall be numbered and dated, and shall be submitted to the purchaser for approval.

For Section III Class C requirements of the Code, the design report shall include those items from the above Class A listing that are specified in the Ordering Data.

3.7.2 <u>Quality Assurance Documents</u> - The supplier shall prepare the following documents based on the requirements of RDT F 2-2. The time and approval requirements of submittals to the purchaser and the number of copies required shall be as specified in the Ordering Data.

3.7.2.1 <u>Quality Assurance Program Plan</u> - The supplier shall prepare a quality assurance program plan in accordance with RDT F 2-2, Paragraphs 2.2.2, 3.2, and 4.2.

3.7.2.2 <u>Inspection and Test Plan</u> - The supplier shall prepare an inspection and test plan in accordance with RDT F 2-2, Paragraph 5.3.

3.7.2.3 Special Process Control and Nondestructive Examination Procedures - The supplier shall prepare and qualify procedures and equipment for special processes and nondestructive examinations and test in accordance with RDT F 2-2, Paragraph 5.5.

3.7.2.4 Inspection and Test Procedures - The supplier shall prepare inspection and test procedures in accordance with RDT F 2-2, Paragraph 5.6.2. These procedures shall include the details of any sampling plans proposed by the supplier and the basis for selection of the proposed sampling plan in accordance with RDT F 2-2, Paragraph 5.9.

3.7.2.5 Nonconforming Item Documentation - The supplier shall document all nonconformances including corrective action and proposed rework, repair, and retest procedures in accordance with RDT F 2-2, Paragraph 5.10.

3.7.2.6 Handling, Preservation, Packaging and Storage Procedures - The supplier shall prepare handling, preservation, packaging, and storage procedures in accordance with RDT F 2-2, Paragraph 5.12.

3.7.2.7 Proposed New Design Criteria - The supplier shall propose new design criteria in accordance with RDT F 2-2, Paragraph 3.3.2.

3.7.2.8 Design Descriptions - The supplier shall prepare design descriptions in accordance with RDT F 2-2, Paragraph 3.3.5.

3.7.2.9 Quality Records - As a minimum, the supplier shall maintain a file of code records as required by Paragraph IX-225, Section III of the Code and shall submit the following documents to the purchaser pertinent to each cold trap assembly:

1. Parts List - List of items by part number, drawing number and revision, part name, serial number or lot or heat number.

2. Drawings - A reproducible set of assembly drawings.

3. Special Processes and Nondestructive Test Qualifications - Certifications of special processes and nondestructive testing procedures and equipment qualifications as specified in RDT F 2-2, Paragraph 5.5.

4. Nonconformance Records - A copy of each nonconformance and corrective action record including rework, repair, and retest procedures.

5. Certification - Certification of conformance as specified in RDT F 2-2, Paragraph 5.6.5 including:

    a. Material Certifications - Chemical and physical test results, nondestructive test results, heat treatment data, and test results of the test coupons.

b. Nondestructive Fxamination - Certified results of final nondestructive examinations including radiographic films, recorder charts, and photographs.

c. Test Reports - Certified copy of test results including analysis of test results, test fluid temperature, and metal temperatures, including temperature corrections made to test pressure.

d. Final Inspection - A copy of final inspection data and results.

4. QUALITY ASSURANCE REQUIREMENTS

4.1 Quality Assurance Program - The supplier shall submit for purchaser's acceptance, prior to cold trap fabrication and assembly, a quality assurance program plan and procedures which provide for compliance with the requirements of Sections 1 through 5 and Section 8 of RDT F 2-2.

4.2 Inspection - The supplier shall be responsible for the performance of all inspections, including visual examinations.

Cold trap assemblies furnished to this standard shall be subject to verification or inspection at the supplier's facility by a purchaser representative. All such inspections shall be scheduled in advance. Such inspection may include, at purchaser's option, witnessing of various processes, inspections, tests, preservation, cleaning, marking, packaging, and any associated inspection of other records pertaining to this standard.

Source inspection by the purchaser or his designated representative shall in no way relieve the supplier of his responsibility for meeting requirements of this standard.

Evidence of source inspection shall be shown on shipping documents.

4.3 Nondestructive Examination - All nondestructive examinations shall be in accordance with the applicable material and process standards and RDT F 3-6. If alternate or additional acceptance standards are needed, the supplier shall recommend criteria to the purchaser for his written approval prior to proceeding with the examinations.

4.4 Examination of Materials - Acceptance standards and calibration levels shall be as specified in the applicable material standard.

4.4.1 Visual Examination of Materials - All raw materials shall be examined visually for defects and state of cleanliness in accordance with the requirements of the applicable material standards.

4.4.2 Nondestructive Examination of Materials - When requirements for examination of materials are specified by nondestructive testing, examinations shall be accomplished using RDT Standards as shown in Table I.

TABLE 1

REQUIREMENTS FOR EXAMINATION OF MATERIALS

Material Form	Examination Method		Radiographic
	Ultrasonic (Notes 1 and 2)	Liquid Penetrant (Note 3)	
Plate	RDT F 3-5 and RDT F 3-4, 100% of the surface by both longitudinal and shear wave technique (Notes 4 and 5)	RDT F 3-6, 100% of the surfaces of both sides of the material that will contact reactor sodium coolant or cover gas (Notes 4 and 5)	
Forgings	RDT F 3-3	Same as above	
Pipe and tubing	RDT F 3-8	RDT F 3-6, All external and accessible internal surfaces of the material that will contact reactor sodium coolant or cover gas (Notes 4 and 5)	
Cast components		Same as above	RDT F 3-6, Fully examined regardless of thickness (Note 6)

NOTES:

1. Procedural requirements and methods and production scanning techniques shall be as specified in the applicable RDT material standard for the product form.
2. Questionable indications located by ultrasonic test shall be supplemented with a nondestructive test method other than ultrasonic test where possible and as determined on a case basis by the supplier and purchaser.
3. Austenitic stainless steel materials shall be examined by liquid penetrant testing using a solvent removable penetrant.
4. Examination on any formed sections shall be performed after final forming operations and any heat treatment that directly follows forming, but prior to welding.
5. Material subject to accelerated cooling shall be examined after the cooling operation.
6. Radiographic quality level shall be 2-2 T for material thickness 3 inches or less, and 1-2 T for material thickness greater than 3 inches. Density of the individual film in the area to be examined shall be between 1.5 and 3.3.

4.4.3 Material Repairs - Where the applicable material standard and procurement specification allows the use of welding processes for repair of defects in the material, the quality assurance provisions of the repair weld shall be accomplished in accordance with the requirements of RDT F 6-1.

The examination of the weld repair shall be in accordance with the requirements of RDT F 3-6. The weld repaired area shall be re-examined by the inspection method(s) which revealed the original defect and in addition, where necessary, other nondestructive test methods which will ensure that the quality of the material has been maintained.

4.5 Examination During Fabrication - Examinations of welds, both visual and dimensional, and nondestructive testing, shall be in accordance with the requirements of RDT F 6-1, Part 1, and RDT F 3-6.

4.5.1 Visual and Dimensional Examination - All items shall be subject to visual and dimensional examination to verify conformance with approved drawings. After forming operations, any shells or heads shall be 100 percent examined for conformance to prescribed shape and thickness. Nozzles and attachments shall be examined for proper fit to the curvature of the shell surface.

4.5.2 Liquid Penetrant Examination - Nonmagnetic materials shall be examined by liquid penetrant methods.

Welds shall be examined in accordance with the requirements of RDT F 6-1 by liquid penetrant. As a minimum, the root and final layers of all welds shall be examined in accordance with RDT F 3-6 by liquid penetrant examination. If radiographic examination of the weld is not possible, all weld layers shall be examined by the liquid penetrant method. Following nondestructive test examination, weld areas shall be thoroughly cleaned in accordance with the requirements of RDT F 5-1 before proceeding to the next weld pass.

4.5.3 Radiographic Examination - All completed welds that are required to be radiographed shall be examined by radiography in accordance with the requirements of RDT F 3-6.

4.5.4 Examination of Weld Repairs - Weld repairs shall be examined in accordance with the requirements of RDT F 6-1.

4.5.5 Examination of Lifting, Handling, and Shipping Fixtures - Following proof load testing of lifting, handling, and shipping fixtures, and attachment lugs, all structural welds of these items shall be examined by the magnetic particle or liquid penetrant method depending upon material in accordance with the requirements of RDT F 3-6.

All slings and hooks, not containing structural welds, used in lifting the cold trap assembly shall, as a minimum, be visually examined for structural defects.

4.6 Acceptance Tests

4.6.1 Strength Tests - The strength test performed shall be pneumatic, using a test gas of purity specified in the Ordering Data. Pneumatic tests shall be based upon Paragraph N-713, "Pneumatic Test," of Section III of the Code. The supplier's procedure shall include all requirements of that paragraph plus those of this section.

Prior to and during the performance of the strength test, the material temperature shall be maintained at least 60 F above the highest of the impact test temperatures required to meet the impact values of Section III of the Code, Table N421, taking into account materials and welds at the fluid and gas boundary and the materials of the parts welded directly to either the inside or the outside surfaces.

The temperatures of the cold trap material and gas shall be continuously monitored during the test. Instruments used to monitor and record pressure and temperatures shall be calibrated in accordance with RDT F 3-2 for the overall system accuracy of ±2 percent in the range of the test unless otherwise specified in the Ordering Data. Temperature corrections shall be made to the test pressure.

Upon completion of the pneumatic tests, the cold trap assembly shall be protected from contamination by maintaining the sealed conditions and by keeping the internal environment of test gas at 5 to 7 psig pressure, until the helium leak test, if required, is performed.

4.6.2 Helium Leak Test - Helium leak testing of the cold trap assembly pressure boundaries shall be performed in accordance with RDT F 3-6. The type of helium leak test to be used and the maximum permissible helium leak rate are specified in the Ordering Data.

The completed economizer, the crystallizer tank (both before and after cooling jacket welding) and the completed cold trap assembly shall be helium leak tested after the strength test of 4.6.1 has been completed.

4.6.3 Repair and Retest - Upon failure of either the pneumatic or helium leak test, and with prior purchaser approval, the defect shall be repaired and the cold trap assembly retested.

4.7 Functional Tests - Requirements for functional tests, test provisions, and test equipment shall be as specified in the Ordering Data.

5. PREPARATION FOR DELIVERY

5.1 Delivery Requirements - The supplier shall deliver the cold trap assembly to the site designated in the Ordering Data.

5.1.1 Preparation - Upon completion of all shop testing and inspection, the supplier shall prepare the cold trap assembly for delivery to the designated site. This shall include, but not be limited to, recleaning (if necessary), surface preparation, and examination.

5.1.2 Packaging and Packing - All sealing, packaging, packing, and identification marking shall be in accordance with RDT F 7-2. Packaging shall be adequate to protect the item from corrosion and damage while at the supplier's facilities, during transportation to the designated site, and at the designated site, as specified in the Ordering Data.

5.1.3 Shipping - The supplier shall identify all technical documentation, instructions, drawings, reports, and manuals that are to accompany the cold trap during shipment.

5.1.4 Handling - All handling, lifting, supporting, and shipping fixtures shall comply with the following requirements.

1. If shipment is scheduled for the winter months (October through March inclusive) and the anticipated ambient temperature may be less than -10 F, the supplier shall take special precautions to prevent brittle fracture of ferritic material.

2. Lifting points shall be provided on all shipping devices.

3. If the component to be handled requires upending, points of attachments for chain falls, trunnions, or other features shall be provided so that upending can be done in a safe, controlled manner.

4. All handling equipment, shipping containers and fixtures shall be adequate to prevent any damage due to shock or vibration. Dynamic loadings for use as a reference basis shall be recommended by the supplier. Proof tests shall be performed on, and documented for, all critical lifting, handling, supporting, and shipping fixtures prior to use on components to ensure safe handling of these components. All lifting, handling, and shipping fixtures and attachment lugs shall be tested statically to 150 percent of the total load to be lifted at the speeds and motions which would be expected during actual handling operations. If painted, these items shall be stripped to base metal prior to testing by a suitable method which will not interfere with the interpretation of the non-destructive examination required by 4.5.5 of this standard.

5.2 Caution Labels and Special Marking - When shipping containers or components are packed with desiccant and humidity indication card, a special caution notice label shall be applied.

Warning notices placed on the component or container shall indicate the location and quantity of desiccant in the unit and the location of the humidity indication card.

6. NOTES AND ORDERING DATA

The following technical and procurement data will be furnished by the purchaser.

1. Title, number and date of this standard.
2. Number of units required.
3. Detailed envelope dimensions, system descriptions (3.1).
4. Methods of determining allowable stresses supplementary to the Code (3.2.1).
5. Classification of the cold trap under section III of the Code (3.2.1).
6. Operating temperatures, pressures, and thermal transients for all applicable operating conditions (3.2.1).
7. Seismic loading criteria (3.2.1.1).
8. Piping reactions (3.2.1.3).
9. Corrosion allowances (3.2.1.4).
10. Life (3.2.1.5).
11. Limiting overall dimensions (3.2.2).
12. Sodium velocity (3.2.3).
13. Residence times (3.2.3.1).
14. Pressure drop (3.2.3.2).
15. Flow rate of sodium to be purified (3.2.3.4).
16. Economizer nozzle details (3.2.4).
17. Coolant physical properties, pressure and temperature (3.2.5).
18. Dimensions and packing density of crystallization element (3.2.5.1).
19. Extra thermowells and thermocouples (3.2.7).
20. Details of connections (3.2.8).
21. Length of piping stub connections (3.2.8).
22. Details of handling fixtures (3.2.10).

23. Preheat temperature, time to reach it, program for rate of temperature rise (3.2.11).

24. Normal ambient conditions (3.2.12).

25. Materials of construction and their RDT material standards (3.3).

26. Cleaning criteria from RDT F 5-1 (3.4.5).

27. Drawings, Design Report, and Quality Assurance Documents submittal time, approval requirements and number of copies (3.5, 3.7.1, and 3.7.2).

28. Time to maintain drawing and specification lists (3.5.3)

29. Design report requirements for Class C vessels (3.7.1).

30. Purity of test gas for pneumatic strength test (4.6.1).

31. Type of helium leak test, leak rate (4.6.2).

32. Requirements for functional tests (4.7).

33. Delivery site (5.1).

34. Storage conditions at delivery site (5.1.2).

COLD TRAP REQUIREMENTS	CRYSTALLIZER TANK SODIUM	COOLANT JACKET	ECONOMIZER	
			SHELL SIDE SODIUM	TUBE SIDE SODIUM
1 FLUID CIRCULATED DENSITY: THERMAL CONDUCTIVITY: SPECIFIC HEAT: VISCOSITY:				
2. TOTAL FLOW RATE, lb/hr. SYSTEM STARTUP/CLEANUP. SYSTEM MAINTENANCE/POLISHING				
3. RESIDENCE TIME: **ECONOMIZER (SHELL SIDE):** **CRYSTALLIZER TANK:**				
4. OPERATING TEMPERATURES, F: INLET: OUTLET: MINIMUM:				
5. OPERATING PRESSURE (ATM. PSIA______):				
6. OPERATING PRESSURE DROP, PSI:				
7. DESIGN TEMPERATURE, F:				
8. DESIGN PRESSURE, PSIG:				
9. CORROSION ALLOWANCE:				
10. FOULING FACTOR:				
11. CODE DESIGN REQUIREMENTS:				
12. MATERIALS OF CONSTRUCTION:				
13. NOZZLES, SIZE AND TYPE:				
14. HELIUM LEAKAGE RATE.				

DEVELOPMENT LABORATORY
WADCO CORPORATION

ORDERING DATA

SUPPLEMENTS RDT E 4-5T DATED DECEMBER 1970
and Amended September 1971

FORCED CIRCULATION
COLD TRAP ASSEMBLIES
FOR
REMOVAL OF SODIUM
IMPURITIES FROM FFTF
CLOSED LOOP SYSTEMS

AEC-RL RICHLAND, WASH.

HANFORD ENGINEERING
DEVELOPMENT LABORATORY
WADCO CORPORATION

HWS-1880
REVISION 2

SPECIFICATION FOR

FORCED CIRCULATION
COLD TRAP ASSEMBLIES
FOR REMOVAL OF SODIUM
IMPURITIES FROM FFTF
CLOSED LOOP SYSTEMS

BUILDING: 703

PROJECT: FFTF

PREPARED BY:

D. B. KLOS

APPROVED BY:

__________ DATE

__________ DATE

__________ DATE

AEC-GE RICHLAND, WASH.

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COLD TRAP ASSEMBLIES FOR FFTF CLOSED LOOP SYSTEM
ORDERING DATA

Note: This Ordering Data supplements RDT E-4-5, dated December 1970 as revised by Amendment 1 dated August 1971, in establishing the requirements for specific cold trap assemblies. The paragraph numbering system used in this Ordering Data parallels the numbering system of RDT E4-5. Omission of paragraphs from this Ordering Data indicates that no supplemental requirements to RDT E4-5 are required.

1. SCOPE

This document contains the Ordering Data to be used for the procurement of gas cooled cold trap assemblies for the 2.3 megawatt thermal Fast Flux Test Facility (FFTF) closed loop primary and secondary systems.

1.1 Classification - The cold trap assemblies described herein shall use gaseous nitrogen and ambient air* as the coolants and shall be classified as Class 1 under the Code (Reference 3.2.1, Item 2 herein). The primary cold trap will be operated in a nitrogen (99%) atmosphere and will be cooled by gaseous nitrogen.

* Note: The secondary cold trap will be operated in ambient air and cooled by forced ambient air cooling. These differences need not be considered in either design or fabrication of the trap.

2. APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, shall be a part of this Ordering Data to the extent specified below and in Sections 3, 4 and 5 of this Ordering Data.

2.1 AEC-Reactor Development & Technology (RDT) Standards

RDT E 4-5T	Forced Circulation Cold Trap Assembly for Removal of Sodium Impurities, December 1970 and Amendment 1, September 1971.
RDT E 15-2T	Requirements for Nuclear Components (supplement to ASME Boiler and Pressure Vessel Code, Section III) - July 1971 and Amendment 1, July 1971.
RDT F 2-2T	Quality Assurance Program Requirements - June 1969 and Amendment 1, July 1971, Amendment 2, September 1971, Amendment 3, October 1971, Amendment 4, October 1971, Amendment 5, November 1971.
RDT F 3-6T	Nondestructive Examination - July 1971.
RDT F 3-37T	Special Requirements for Metal Products - July 1971.
RDT F 5-1T	Cleaning and Cleanliness Requirements for Nuclear Reactor Components - February, 1972 [2]
RDT F 6-5T	Welding Qualification (supplement to ASME Boiler and Pressure Vessel Code, Section III) - July 1971 and Amendment 1, July 1971.
RDT F 6-10T	Repair of Materials by Welding - July 1971.
RDT F 6-14T	Brazing Fabrication Requirements - July 1971.
RDT F 7-2T	Preparation for Sealing, Packaging, Packing and Marking of Components for Shipment and Storage - February 1969. and Amendment 1, October 1971.
RDT M 1-1T	Stainless Steel Covered Welding Electrodes (ASME SFA-5.4 with additional requirements) - July 1971.
RDT M 1-2T	Stainless Steel Welding Rods and Bare Electrodes (ASME SFA-5.9 with additional requirements) - July 1971.
RDT M 2-2T	Stainless and Low Alloy Steel Forgings (ASME SA-182 with additional requirements) - July 1971.
RDT M 2-4T	Alloy Steel Forgings (ASME SA-336 with additional requirements) - July 1971.

RDT M 2-5T	Austenitic Stainless Steel Weld Fittings (ASME SA-403 with additional requirements) - July 1971.
RDT M 3-2T	Stainless and Alloy Steel Seamless Tubes (ASME SA-213 with additional requirements) - July 1971.
RDT M 3-3T	Austenitic Stainless Steel Seamless Pipe (ASME SA-376 with additional requirements) - July 1971.
RDT M 3-6T	Austenitic Stainless Steel Pipe (ASME SA-312 with additional requirements) - July 1971.
RDT M 5-1T	Stainless Steel Plate, Sheet, and Strip (ASME SA-240 with additional requirements) - July 1971.
RDT M 7-3T	Stainless Steel Bars and Shapes (ASME SA-479 with additional requirements) - July 1971.

2.2 <u>American National Standards Institute (ANSI) Standards</u>

ANSI B 16.25	1964 Buttwelding Ends for Pipe, Valves, Flanges and Fittings.
ANSI Y-14 Series	Standard Drafting Manual - Most recent editions.

2.3 <u>American Society of Mechanical Engineers (ASME)</u>

ASME Boiler and Pressure Vessel Code, Section III - Nuclear Power Plant Components - 1971 Edition.

2.4 <u>Others</u>

HEDL-TME 71-32	Liquid Metal Fast Breeder Reactor Materials Handbook.
JABE-WADCO-02	Seismic Design Criteria for FFTF Site, Richland, Washington, by John A. Blume and Associates, dated November 1970.
ASTM 4-478-67	Specifications for Chromium-Nickel Stainless Steel and Heat Resisting Steel Weaving Wire.
	Standards of Tubular Exchanger Manufacturers (TEMA) Fifth Edition 1968

3. TECHNICAL REQUIREMENTS

3.1 General. The cold traps to be furnished shall bedesigned and fabricated to function in accordance with the requirements of this specification. The Supplier shall complete detailed design and design calculations, including stress analysis as required by the Code and covering all design conditions specified herein.

Any appurtenances for which requirements are not specified in detail shall be designed and fabricated in accordance with applicable nationally recognized codes and standards and with such additional requirements as may be specified by the Purchaser prior to final contract negotiations.

Components and services to be provided shall include the following items:

1. A complete cold trap assembly for primary and secondary coolant system service consisting of an economizer, crystallizer tank with mesh packing, cooling jacket, lifting lugs and handling fixture and support frame. Design of the primary and secondary cold traps assemblies shall be identical. The quantity of each category of units shall be as specified in the request for proposal. [2]

2. Drawings, plans, instruction manuals.

3. Design and Analysis reports.

4. Quality Assurance Procedures and Documentation.

The following equipment and services are not covered by this Ordering Data:

1. Field installation labor.

2. Remote readout instrumentation.

3. Thermocouples or remote readout instrumentation.

4. Electrical heaters.

5. Thermal insulation.

Envelope dimensions are shown in Figures 1 and 2. A simplified schematic showing the system in which the cold trap assemblies will be installed is shown in Figure 3.

3.2.1 Structural Design Requirements

1. The allowable stresses for both primary and secondary cold trap assemblies shall be in accordance with Class 1 of the Code and Code Case Interpretation 1331-5.

2. Both the economizers and the crystallizer tanks shall be classified as Class 1 under the Code.

3. The design conditions are listed in Tables I, I-A, I-B, and I-C.

4. The normal, upset, testing, emergency, and faulted conditions, as defined in the Code, for design of the cold trap assemblies shall be in accordance with the following:

   A. Normal Conditions

      1. Normal steady-state operating range in accordance with Table II.

      2. Normal thermal transients due to startup and shutdown will be in accordance with Table III. The normal startup and shutdown transient for each operating conditions is listed in Tables III-A through III-C for various locations of the trap. Preheating transients with the system dry are also listed in Tables III-A through III-C. These preheat transients are part of the Sodium Refill Sequence. At 350°F, sodium is removed from the system, which is purged with argon. The temperature is lowered to ambient for cell maintenance. Next, the temperature is increased to 350°F and the pressure is reduced to 0.0 psia. Fresh sodium at 350°F is put into the system completing the sequence (the pressure returns to 14.7 psia). [2]

      3. During steady-state operation, sodium temperatures may vary cyclically ± 10°F within a two-hour period.

      4. The pressure transients during normal startups and shutdowns are given in Table III-D. The time required for the change requires a minimum of five minutes for normal transients. [2

B. Upset Conditions

1. Operating Basis Earthquake (OBE)

a. Seismic analysis shall be based upon response spectra presented in JABE-WADCO-02. The response spectra curves shall be corrected by building and structural amplification factors which will be provided by the Purchaser.

b. See Figure 16 for flow and thermal transients.

c. Number of occurrences* = 3

2. Upset, flow, thermal, and pressure transients are specified in Tables IV, IV-A, and IV-B. The special pressure transients listed as items 13 (TSMDA) and 26 (IHX Leak) in Table IV are additionally specified in subparagraph 3) below. Item 21 (HCDA) in Table IV is not a design event for the cold traps. [2]

3. Closed Loop Test Specimen Meltdown Accident (TSMDA)

a. TSMDA analysis shall be performed using the pressure/time histories shown in Figure 31. The curve for the pressure pulse is applicable at any location within the cold trap assembly. Note that the lower curve is the pressure <u>differential</u> across the tubesheets.

b. See Figure 17 for flow and thermal transients.

c. Number of occurrences* = 4. **

C. Testing Conditions

No testing beyond the ten (10) tests allowed by paragraph NB-6000 and NC-6000 of the Code have been identified.

5. A load history (histogram) specifying the sequence to assume for transient events is provided in Table VIII. [2]

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* The number of events listed in Table IV does not include these events.
** Number of TSMDA events is 3. One occurrence is added for analysis purposes to account for the IHX Leak transient.

D. Emergency Conditions

1. OBE plus SCRAM with full primary flow

a. See 3.2.1.4.B.1.a for earthquake loadings.

b. Emergency flow and thermal transients are specified in Table IV and figures 6 and 7. [2]

c. Number of occurrences* = 1

E. Faulted Conditions

1. Design Basis Earthquake (DBE)

a. Seismic analysis shall be based upon criteria presented in JABE-WADCO-02. The response spectrum curves are provided in figures 24-29, inclusive. Figures 24-26, for the HTS South building, elevation 550'-0", apply to the primary cold trap. Figures 27-29, for the HTS East and West buildings at elevation 530'-0", apply to the secondary cold traps. Since both cold traps are to be the same design, the most severe conditions of either location shall be used for design purposes. [2]

b. Select worst case flow and thermal transients from figures 16 and 17. [2]

c. Number of occurrences = 1*

3.2.1.1 Seismic Criteria

Paragraph deleted. [2]

3.2.1.2 Vibrations. An engineering vibration analysis of the cold trap assemblies shall be performed in accordance with the requirements of paragraph 3.2.1.2 of RDT E4-5T and the following: The analysis shall consider the effects of flow and seismic-induced vibrations, and of continuous environmental vibration levels to 0.05 g peak in the range 2 to 200 Hz. The supplier shall specify the environmental vibration limits permissible for continuous operation of the cold trap assemblies for the design life speicifed in paragraph 3.2.1.5.

3.2.1.3 Piping Reactions. Piping reactions shall be in accordance with Table V. [2]

3.2.1.4 Corrosion Allowance. The minimum corrosion allowance for sodium-wetted surface shall be 0.010" for intergranular penetration plus 0.003" for metal loss. No corrosion allowance is required for surfaces contacted by air/nitrogen.

* The number of events listed in Table IV does not include these events.

3. Technical Requirements

3.2.1.5 Life. The structural service life of the cold trap assembly shall be ten (10) years when operated and maintained within the design limits of RDT E 4-5 and this Ordering Data.

3.2.2 Size and Weight. The envelope dimensions of the cold trap assembly are shown in Fig. 1. These dimensions include heaters, insulation and supports.

3.2.3 Thermal and Hydraulic Design. The cold trap piping shall be designed so that the average sodium velocity shall not exceed 7 ft/sec. Other requirements shall be as specified in Tables I, I-A,I-B and I-C. The cold trap assemblies shall be designed to the conditions in Table 1 and the supplier [2]
shall verify that the designs will meet the operating conditions specified in Tables I-A, I-B, and I-C.

3.2.3.2 Pressure Drop. The pressure drop through the cold trap assembly is specified in Table I.

3.2.3.4 Flow Rate. The nominal flow rate of sodium through the cold trap assembly is specified in Tables I, I-A, I-B and I-C. [2]

3.2.4 Economizer. Interface piping for the economizer is shown on the cold trap assembly schematics, Figures 1 and 2. The pipes shall be carried to the top of the defined envelope (see Figure 1). The pipe ends shall be designed for buttwelding in accordance with ANSI 16.25. Both interface and economizer-crystallizer inter-connection pipe nominal sizes shall be one-inch Schedule 40, and the material shall be type 316 H stainless steel.

The sodium inlet and outlet nozzle orientation is as shown on Figure 2. The air/nitrogen inlet nozzle location and orientation shall be as shown in Figure 2. The economizers shall fit within the circle defined by the maximum envelope, as shown in Figure 1; length of the torus, if used, may be up to a 3/4 circle.

The economizers shall be designed to the specifications given in Tables I, I-A, I-B, and I-C. The economizer tubing nominal inside diameter shall [2]
not be less than 0.50 inch.

3.2.5 Crystallizer Tank. Fluid residence time of sodium, and the pressure and temperature of the coolant to be used in the cooling system are specified in Tables I, I-A, I-B & I-C. The sodium velocity throughout the crystallizer shall be constant. The sodium inlet to the crystallizer tank shall be designed for uniform flow distribution through the cross section of the down flow annulus. The design for a sodium inlet nozzle which promotes uniform flow distribution is shown in Figure 30. [2]

The nominal chemical and thermophysical sodium properties shall be as defined in HEDL TME-71-32, Sodium Section.

Shrouds for cooling gas flow shall be removable for installation of thermocouples and heaters.

3.2.5.1 Crystallization Element. The crystallizer tank shall contain knitted wire mesh packed to 250 ft^2/ft^3 specific surface area and shall conform to the wire size and density limits specified in the Standard. The maximum pressure drop across the crystallizer tank shall be as specified in Table 1. The total thickness of the stacked mesh pads shall be as required by the design to give the specified residence time. The wire mesh shall conform to the requirements of ASTM-A-478-67, Specification for Chromium Nickel Stainless Steel and Heat Resisting Steel Weaving Wire.

3.2.7 Instrument Provisions. Four thermowells for thermocouples are required, as shown in Figures 1 and 2. The thermowells shall be constructed from 1/2 inch Sch 40 pipe. Thermowells shall be accessible from the top of the cold trap assembly and the thermocouple vertical position in the thermowells shall be adjustable to any packing depth. Two thermowells shall be positioned in the outer annulus region and two in the central sodium return region.

Other thermocouples shall be furnished to provide necessary temperature monitoring as required for preheat and operation of the cold trap assembly. The distribution, location, attachment and final specification of the sensors shall be determined by cold trap design, and submitted to the purchaser for approval. Two or more redundant thermocouples shall be installed in locations where a sensor cannot be replaced or serviced without extensive disassembly of the cold trap. Thermocouples will be supplied by the purchaser. [2]

3.2.8 Connections and Appurtenances. Piping shall be carried to interface boundaries defined in Figures 1 and 2. Electrical and heater terminal connections shall be accessible from the top of the cold trap assembly.

3.2.9 Insulation. Insulation and insulation supports shall be selected and provided by the supplier in accordance with the requirements of HWS-2160.

3.2.10 Handling Fixtures. Lifting lugs shall be attached to the cold trap assembly to allow vertical handling of the cold trap assembly when it is filled with sodium. Lifting lugs shall permit use of standard hooks. The structural supports shall provide support to prevent damage during handling.

3.2.11 Preheater. The supplier shall specify the design of an electrical resistance type preheating system to perform the following functions:

a) Preheat the dry (argon filled) cold trap assembly from 100°F to 350°F at a rate of 25°F per hour.

b) Preheat the sodium filled economizer assembly from 350°F to 1050°F at the rate of 50°F per hour.

c) Melt sodium, and preheat sodium filled trap to 700°F at a rate of 50°F per hour after a condition in which the sodium filled crystallizer assembly has cooled below the freezing point of sodium. The supplier shall recommend to the Purchaser the procedure to be followed.

Design of the preheating system shall be based on a cold trap insulated in accordance with the requirements of paragraph 3.2.9 above, using 80 BTU/hr-ft^2-°F heat loss and an insulation surface temperature of 140°F with the cold trap assemblies at the design temperature specified in Table I.

The distribution, location, attachment and final specification of the heaters shall be determined by cold trap design, and submitted to the Purchaser for approval. The entire cold trap shall be trace heated. The economizer and crystallizer tanks shall be in separate heater zones for temperature control purposes. Interconnecting pipe shall be included in the economizer zone. Heaters and insulation will be procured and installed by the Purchaser. Supports for heaters and insulation shall be provided and installed by the Supplier. Heater requirements will be specified by the Purchaser prior to final contract negotiations.

3.2.12 Environmental Conditions. The cold trap assemblies will be exposed to the following environmental conditions after installation and during operation:

Atmosphere	Nitrogen (99%) /Air*
Temperature	60°F - 100°F
Pressure (nominal)	14.7 psia
Relative Humidity	10%
Radiation (gamma)	1×10^5 R/hr

3.2.13 Structural Supports. All cold trap assemblies shall be provided with a support frame structurally adequate to withstand the specified piping, seismic upset, and handling loads and reactions.

3.3 Materials of Construction. With the exception of components welded to the cold trap, the structural framing shall be of carbon steel.

Sodium containing materials shall be of 316 austenitic stainless steel and shall conform to the following standards*:

Type	RDT Standard Number	
Weld Rods	RDT M 1-2, RDT M 1-1	
Forgings	RDT M 2-2T, RDT M 2-4T	[2]
Fittings	RDT M 2-5	
Tube	RDT M 3-2	
Pipe	RDT M 3-3T, RDT M 3-6T	[2]
Plate, Sheet, Strip	RDT M 5-1	
Bars and Shapes	RDT M 7-3	

3.4.5 Cleaning. The cold trap assemblies shall be suitable for installation into nuclear systems without additional cleaning. Cleaning shall be in accordance with RDT Standard F5-1. The supplier shall include the appropriate instructions and restrictions in his fabrication procedures and other documents defining acceptable shop practices. As a minimum, [2] the supplier's procedures and other documents shall include the requirements of paragraphs 4.4.1, 4.4.2, 4.4.3, and 4.4.4 of RDT F5-1. The supplier shall be responsible for ensuring that all items furnished by his subcontractors conform to the same cleanliness requirements.

Assurance that residual chloride contamination is within acceptable [2] limits shall be demonstrated by procedures provided by the supplier and approved by the purchaser.

3.4.5.1 Precautionary Measures. Maintaining the cleanliness of stainless steel is of particular importance. The following precautions shall be observed for stainless steels:

a. Only stainless steel wire brushes shall be used.
b. Grinding wheels shall be resin bonded aluminum oxide.
c. Rotary files shall be faced with tungsten carbide.
d. Cleaning solutions, solvents, machining fluids, etc., shall not consist of halogenated compounds.

* For temperatures in excess of 1000°F, the carbon content shall be 0.06 percent minimum. [2]

or contain halogenated compounds that contain in excess of 5000 ppm residual halides except when specific purchaser approval is obtained.

e. Marking materials such as marking dyes and layout fluids shall meet the above requirements for solutions and solvents except that where permanent marking is permitted, the residual halide content of the marking fluids shall not exceed 200 ppm.

f. Carbon tetrachloride fire extinguishers shall not be located near or used in the vicinity of fabrication or storage.

g. Surface contamination by personnel from perspiration, food particles, smoking materials, etc., shall be avoided.

3.4.5.2 Mesh Cleanliness Inspection. The mesh packing shall be inspected with ultraviolet light for the presence of thin oil films and other transparent films that are not detectable under white light. The ultraviolet light inspection shall be performed before the mesh [2] is inserted into the crystallizer tank. The ultraviolet light inspection will be conducted in an area that is blacked out to white light. Fluorescence of the surface indicates the presence of contaminants and is unacceptable and requires cleaning.

3.5 Drawings. Drawing submittal requirements are as presented in Table VI.

3.7 Reports and Documentation.

3.7.1 Design Reports. A final Report (Item 16, Table VII) shall be prepared by the supplier to document pertinent aspects of the design and manufacture of the cold traps. The Final Report is intended to present a complete history of the design, fabrication, testing, and shipping of the Cold Traps. As such, it should include the following: [2]

a) A chronological, summary description of significant events associated with the above categories of activities that highlights such items as difficulties or problems encountered, their causes and solutions, recommendations for changes or improvements in the specification, design, and fabrication techniques for future similar units, and other information deemed by the supplier to be pertinent to an understanding of the successes, failures, or difficulties associated with designing and supply these components.

b. The analysis specified by applicable specification (s), including design, stress, testing, shipping, or any others that are performed. The final design report, as amended and updated to reflect the results of any changes to the design subsequent to original completion and submittal of the report, will normally constitute the major part of this item.

c. A complete set of the "As-Built" drawings of the component.

d. All pertinent illustrations, sketches, schematic diagrams, and photographs of major stages of fabricating, assembling, inspecting, cleaning, testing, repairing, packaging, and shipping.

Where more than one type of trap is provided under a single procurement action, and subject to Purchaser approval, a single Final Report, appropriately subdivided by trap types, may be submitted to cover all units supplied under a given contract.

3.7.2 Quality Assurance Documents. The time and approval requirements and the number of copies required shall be as specified in Table VII.

4. QUALITY ASSURANCE REQUIREMENTS

4.6.1 Pneumatic Strength Test. The Supplier shall use pre-purified grade nitrogen to conduct the pneumatic strength test.

4.6.2. Helium Leak Tests. The methods of testing which can be used to check the helium leak tightness of the cold trap assembly are the Hood Method and the Probe Method as specified in RDT F 3-6.

The Hood Method shall be used as a final check on the overall helium leak tightness of the cold trap assembly.

The helium leakage rate shall not exceed 1 x 10^{-7} atmospheric cc/sec of helium.

4.7 Functional Tests - No sodium flow functional tests are planned. Functional tests of blowers, and blower controls shall be performed at the Supplier's shop. Procedures to be used for these tests shall be submitted to the Purchaser for approval.

5. PREPARATION FOR DELIVERY

5.1 Delivery Requirements. The point of delivery for the cold trap assembly is given in the purchase order.

5.1.2 Packaging and Packing. All sealing, packaging, packing, and identification marking shall be in accordance with the requirements of RDT F 7-2, and the following instructions:

1. The cold trap assembly shall be purged with inert gas (nitrogen) prior to sealing the opening for shipment. Purging shall be continued until the purged gas leaving the assembly has a dew point of minus 40°F or colder. The assembly shall then be pressurized with purge gas at 4 to 6 psig and sealed. A visual gage will be installed for monitoring the pressure.

2. Desiccants and humidity indication cards are not required.

3. Sealed metal containers are not required.

4. Pre-production model packs for rough handling tests are not required.

5. Special warehouse storage and structural markings are not required.

6. No sodium acceptance performance tests are required.

6. Notes and Ordering Data

Compliance - This Ordering Data is hereby certified to be correct and complete with respect to the specified functions and operating conditions in compliance with paragraph NA-3255 of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components.

Charles J. Packingpaugh

Registered Professional Engineer

M12921 CALIF

Registration Number State

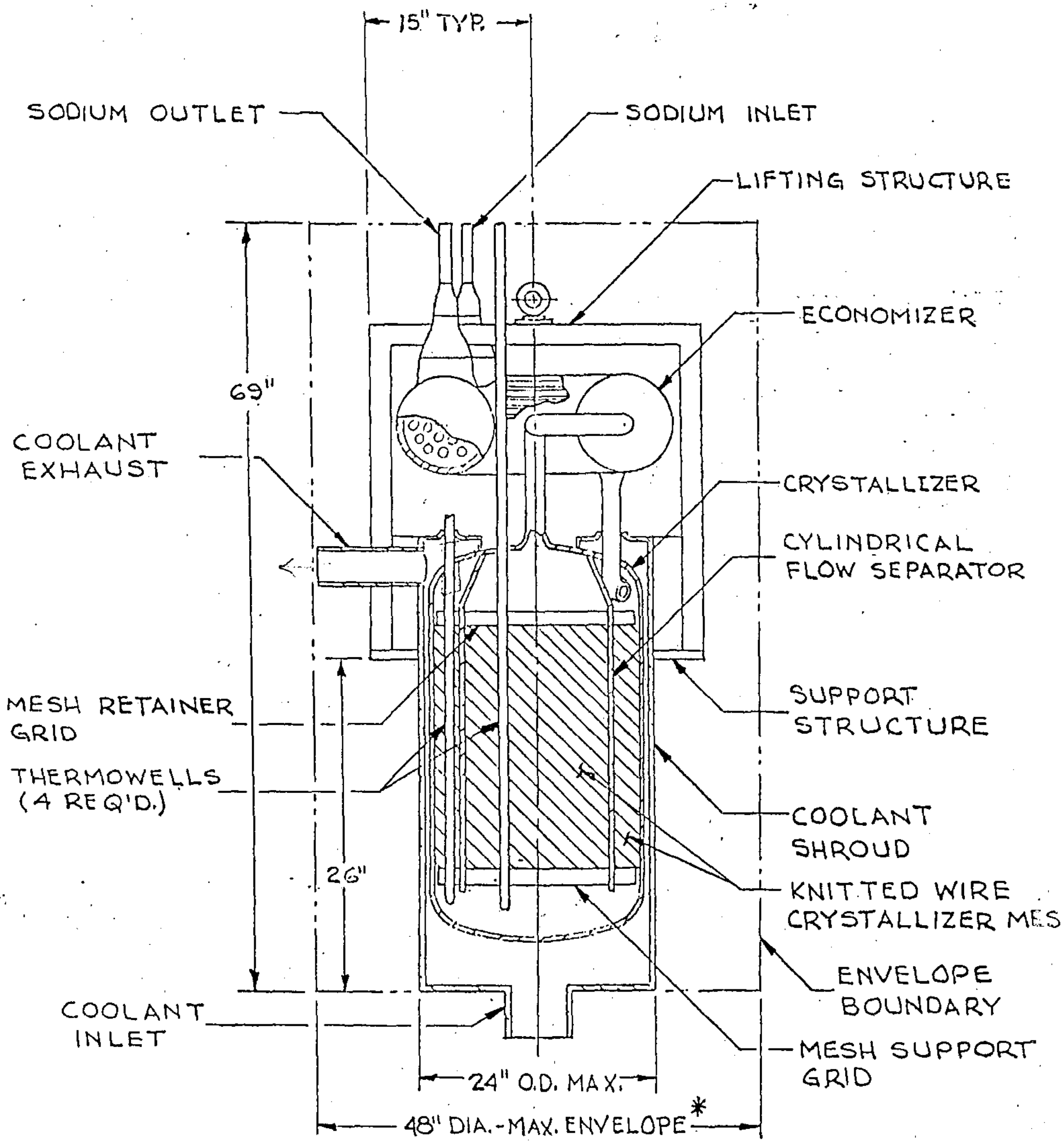


FIGURE 1 - ELEVATION - COLD TRAP ASSEMBLY (SCHÉMATIC)

* INCLUDES 9" THICK CA-SILICATE INSULATION

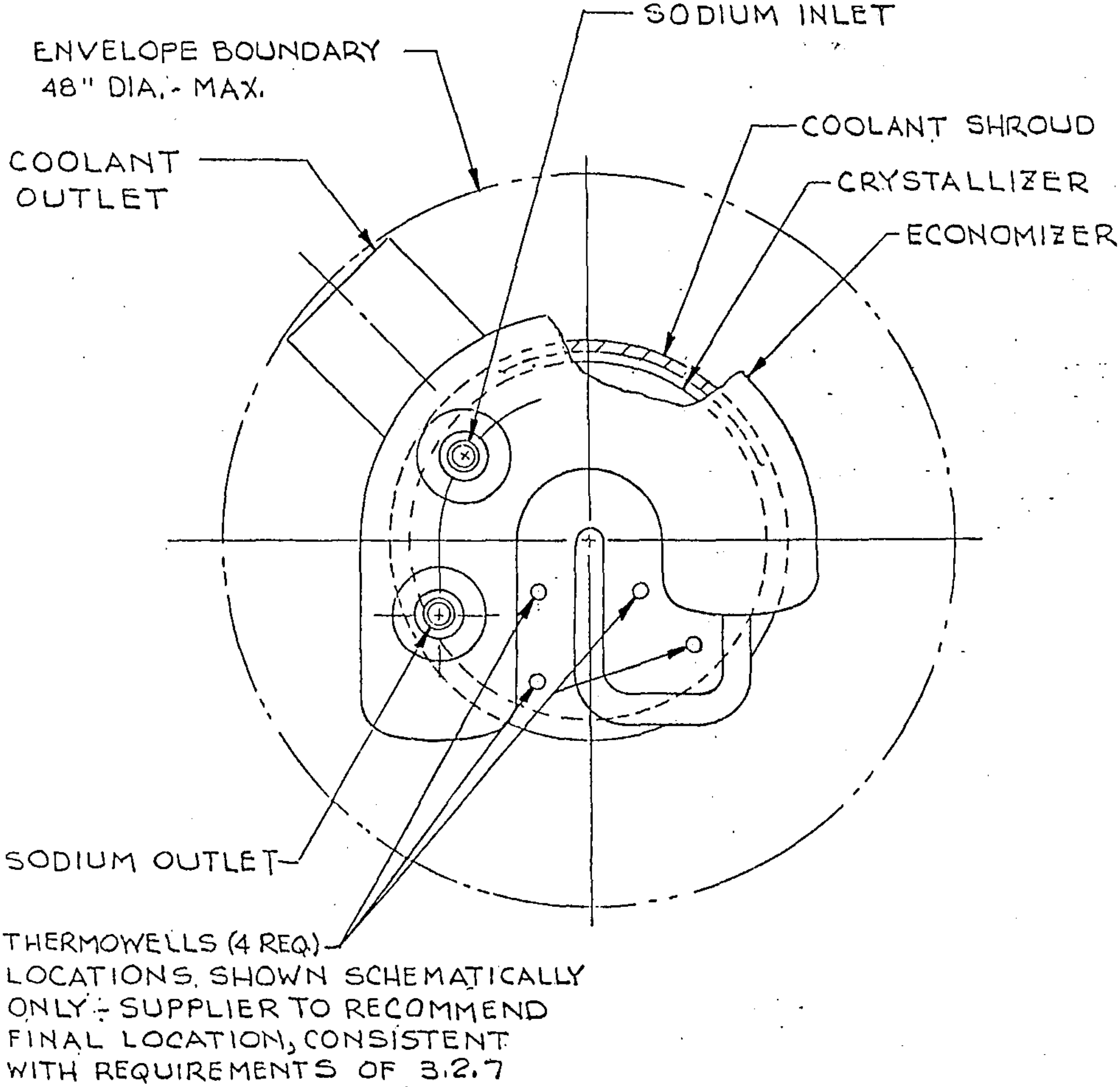


FIGURE 2 - PLAN - COLD TRAP ASSEMBLY
(SCHEMATIC)

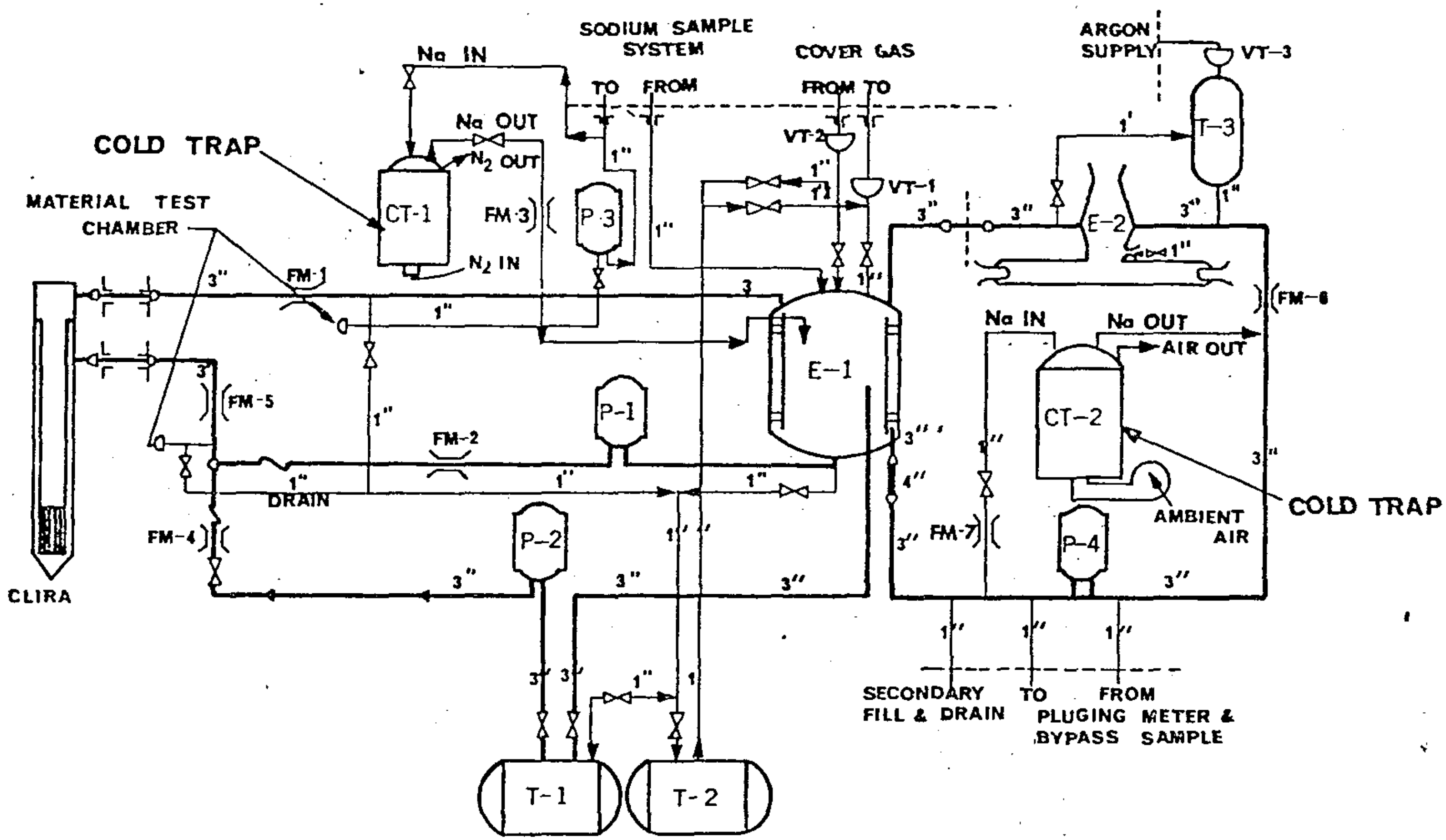
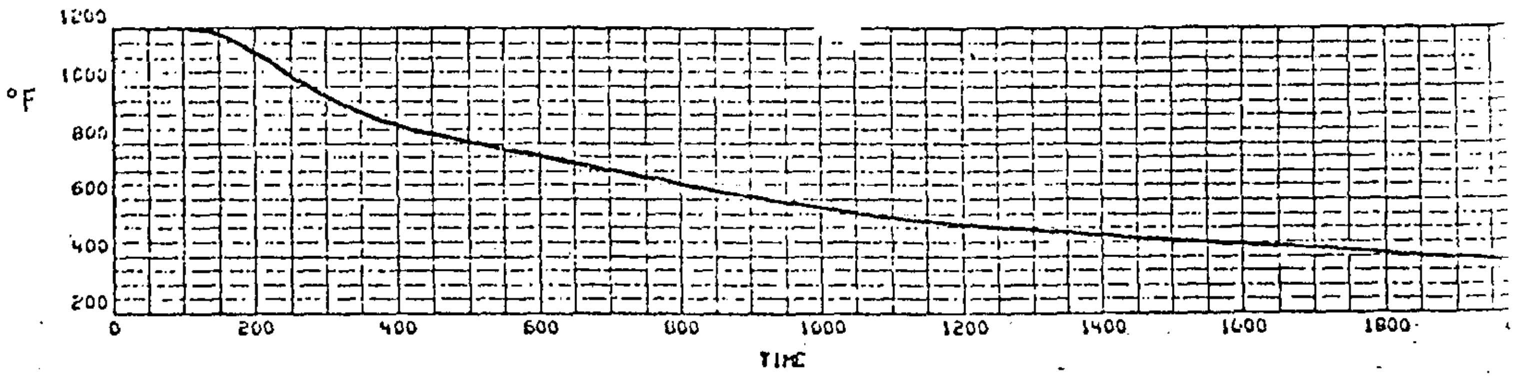
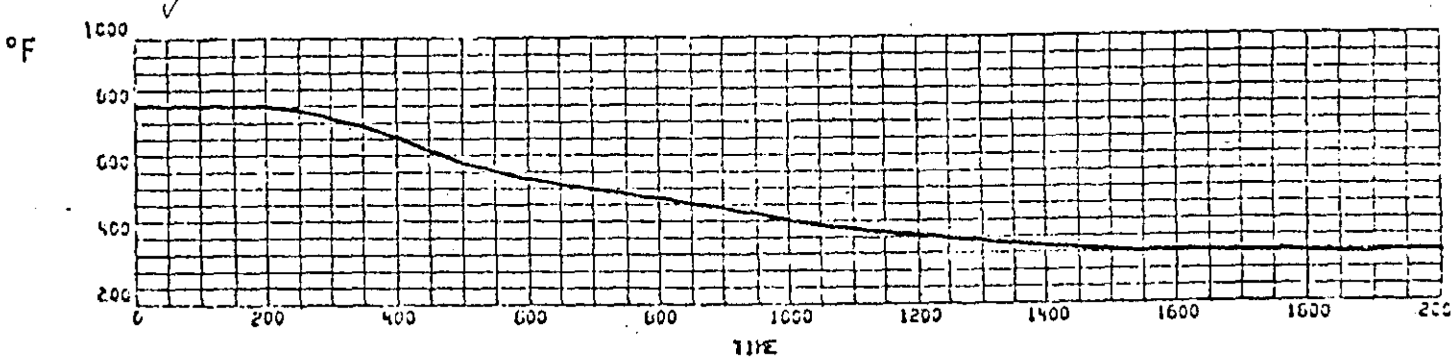


FIGURE 3 SIMPLIFIED SCHEMATIC DIAGRAM SHOWING COLD TRAP ASSEMBLY IN FFTF CLOSED LOOP SYSTEM

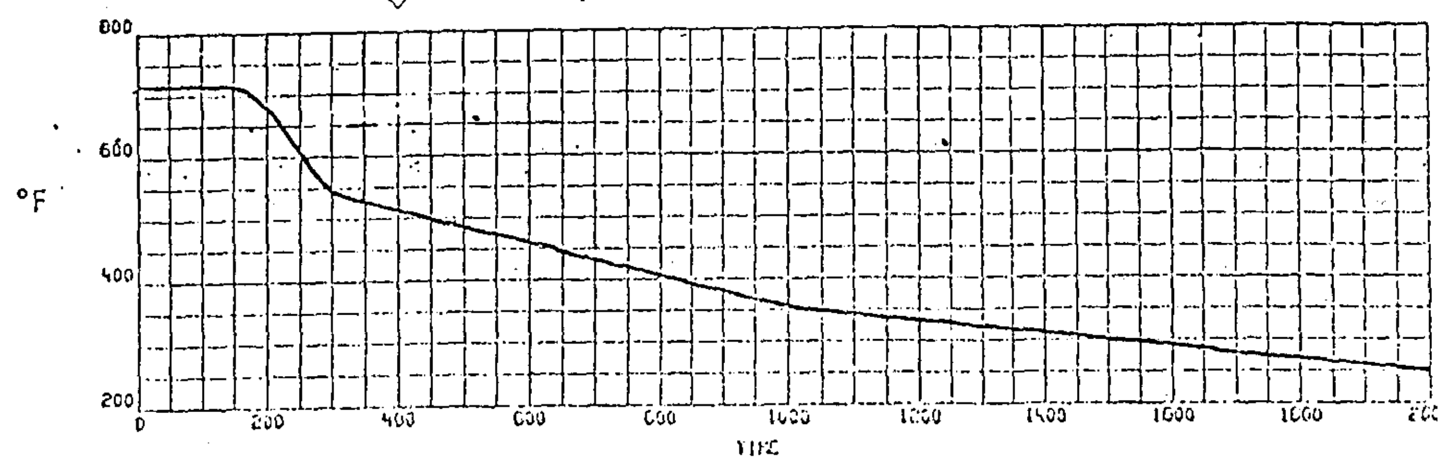
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



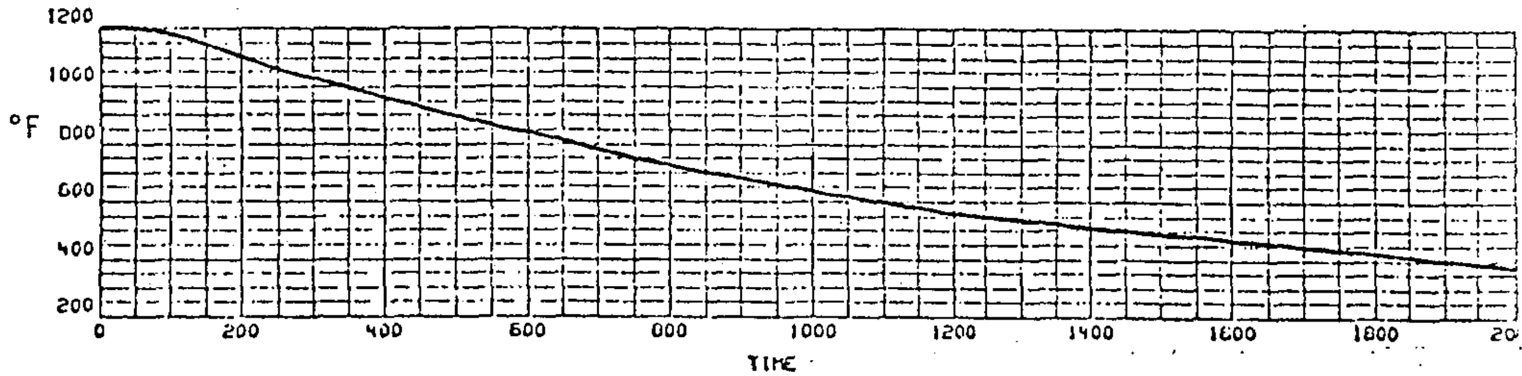
PRIMARY LOCATION II
(PRIMARY COLD LEG)



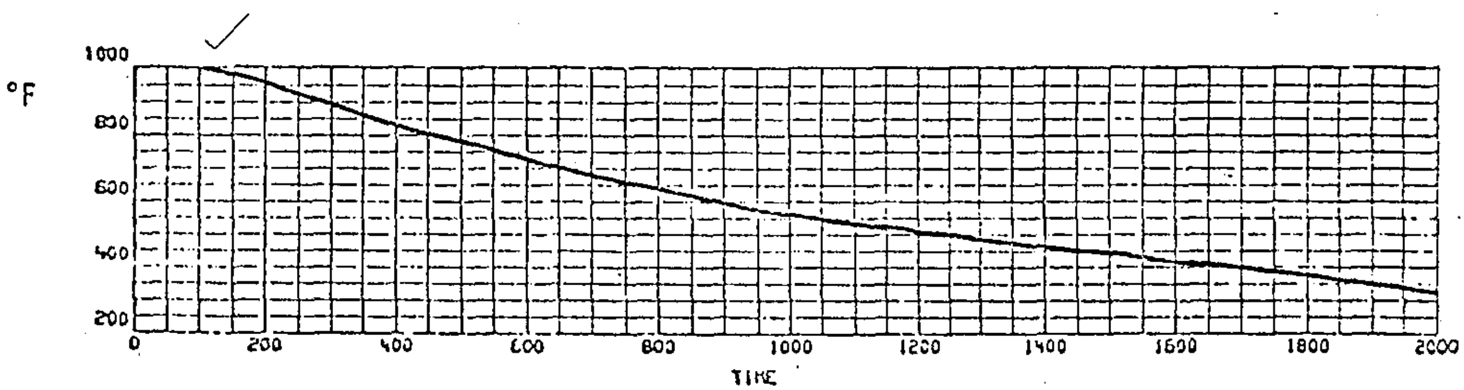
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 4. TRANSIENT U1 SCRAM WITH FULL FLOW
400°F AT CASE

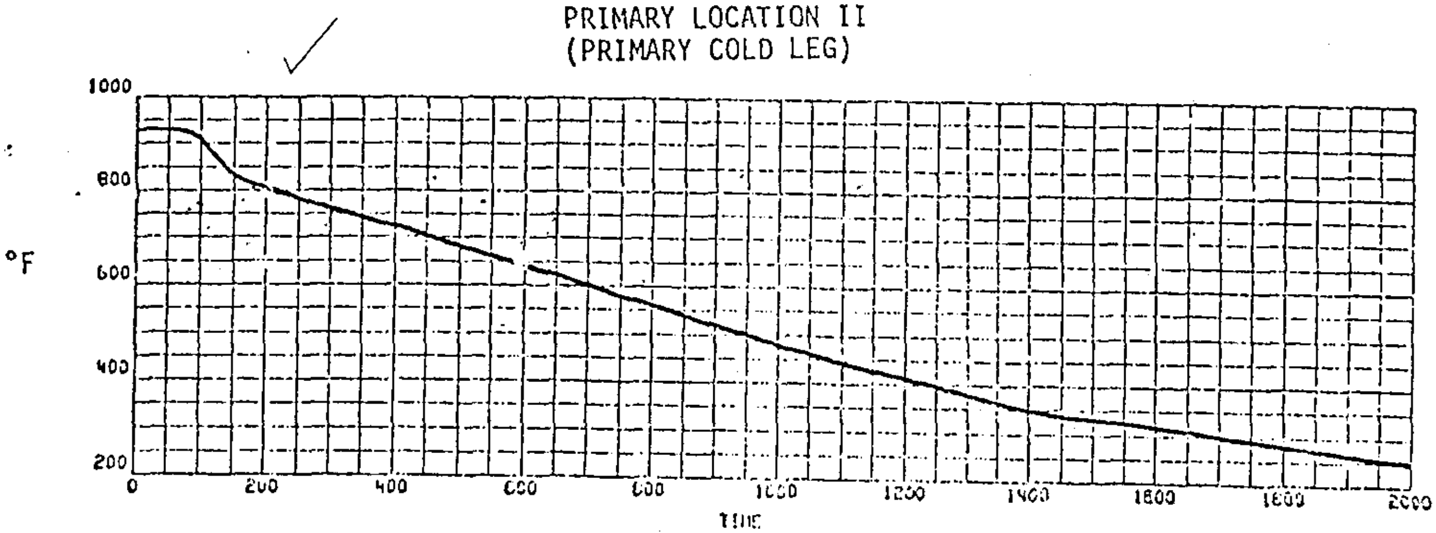
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



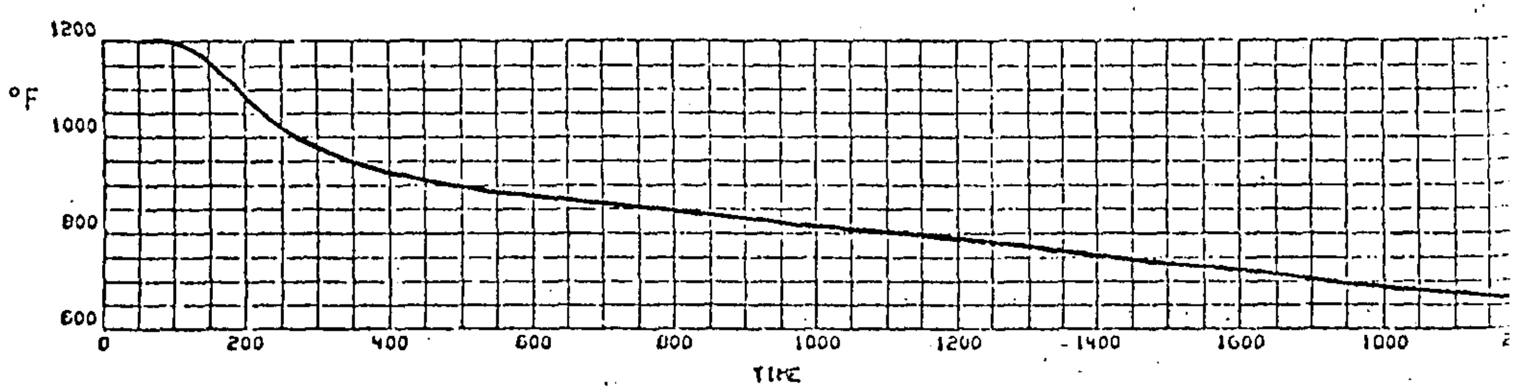
PRIMARY LOCATION II
(PRIMARY COLD LEG)



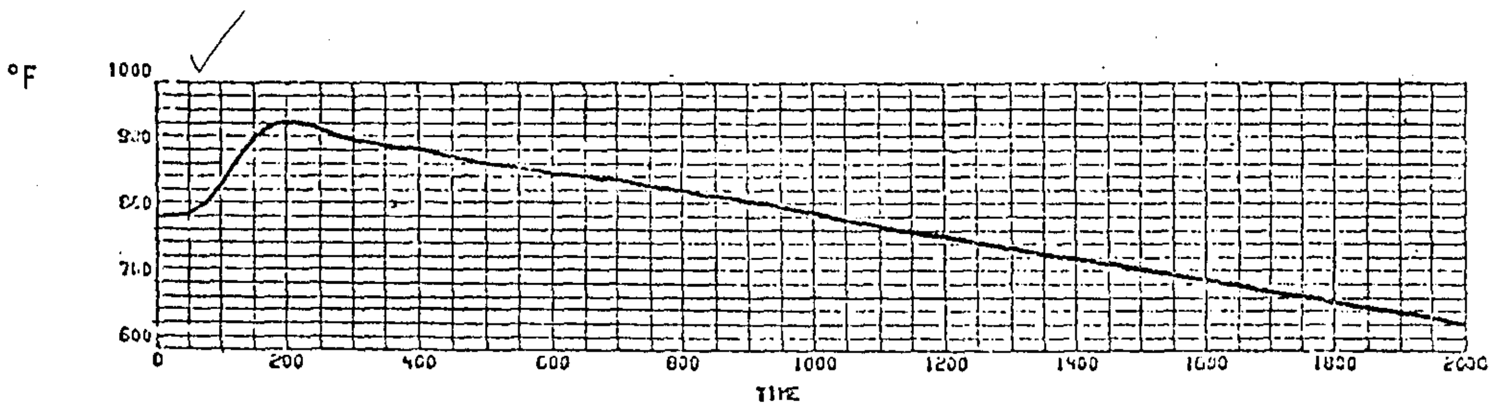
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 5. TRANSIENT U2 SCRAM WITH FULL FLOW
200°F ΔT AT CASE

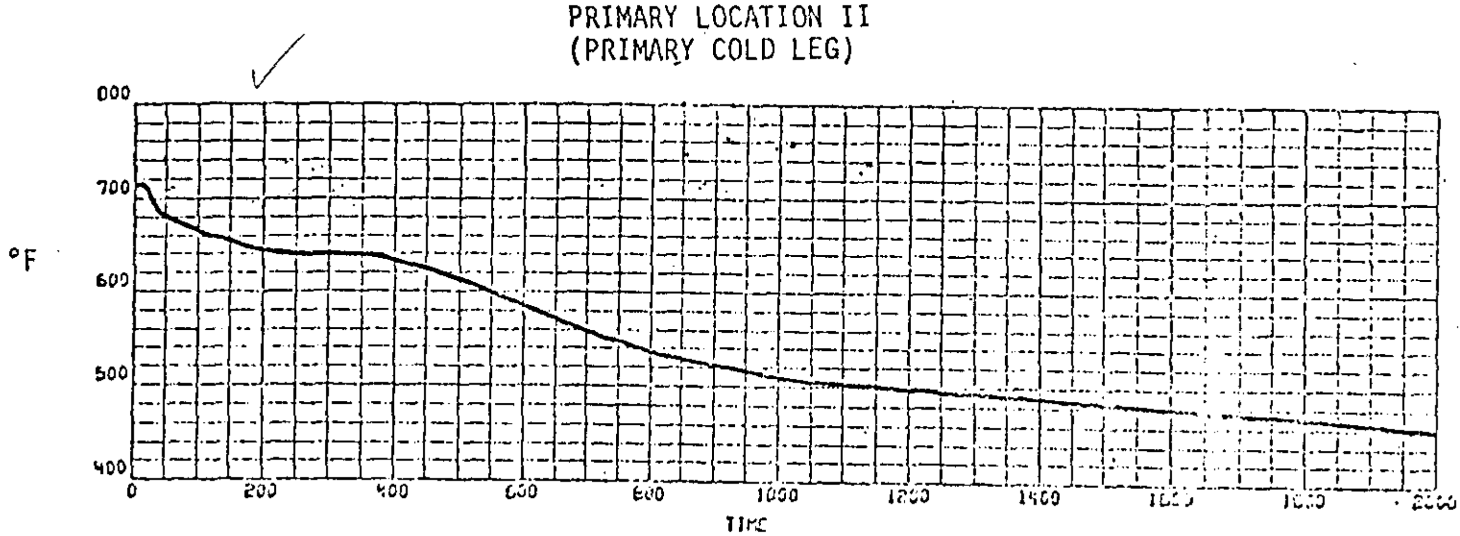
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



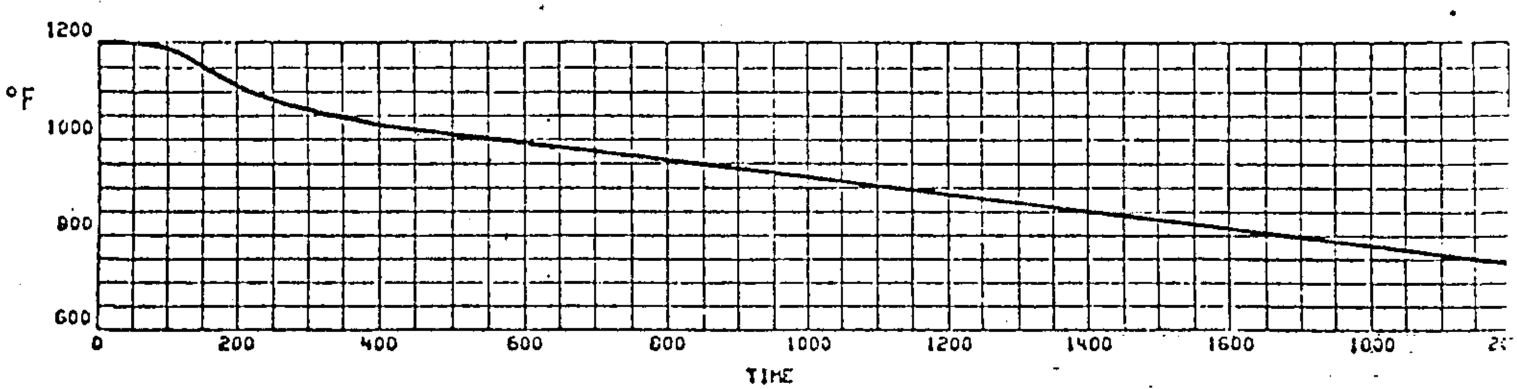
PRIMARY LOCATION II
(PRIMARY COLD LEG)



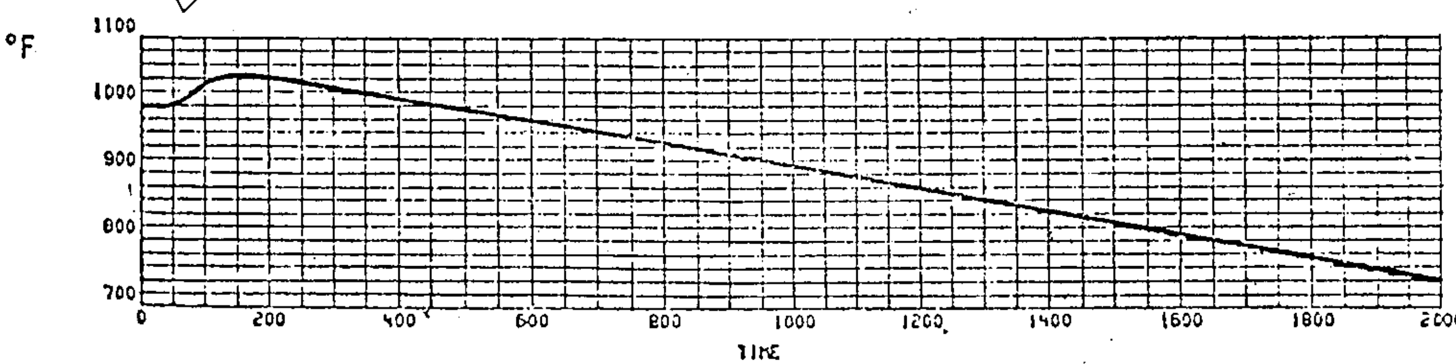
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 6. TRANSIENT U3 SCRAM WITH FULL PRIMARY FLOW
400°F ΔT CASE

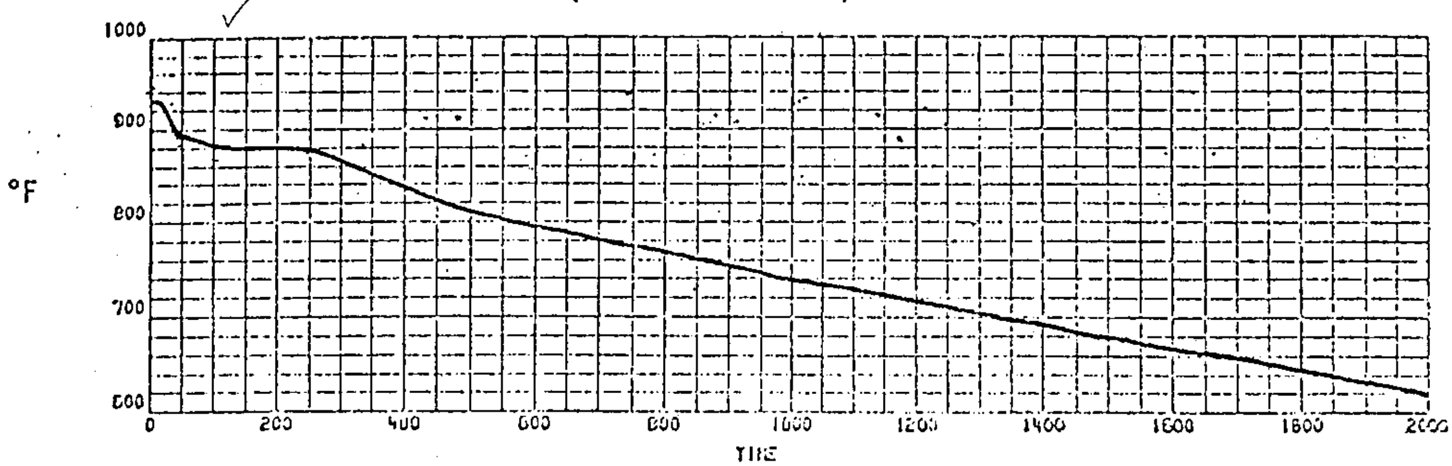
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



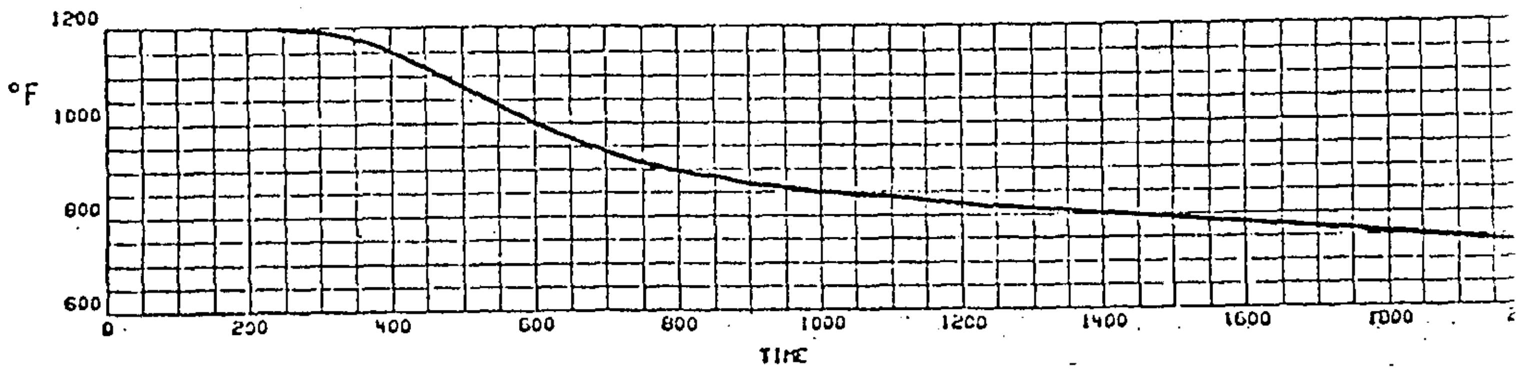
PRIMARY LOCATION II
(PRIMARY COLD LEG)



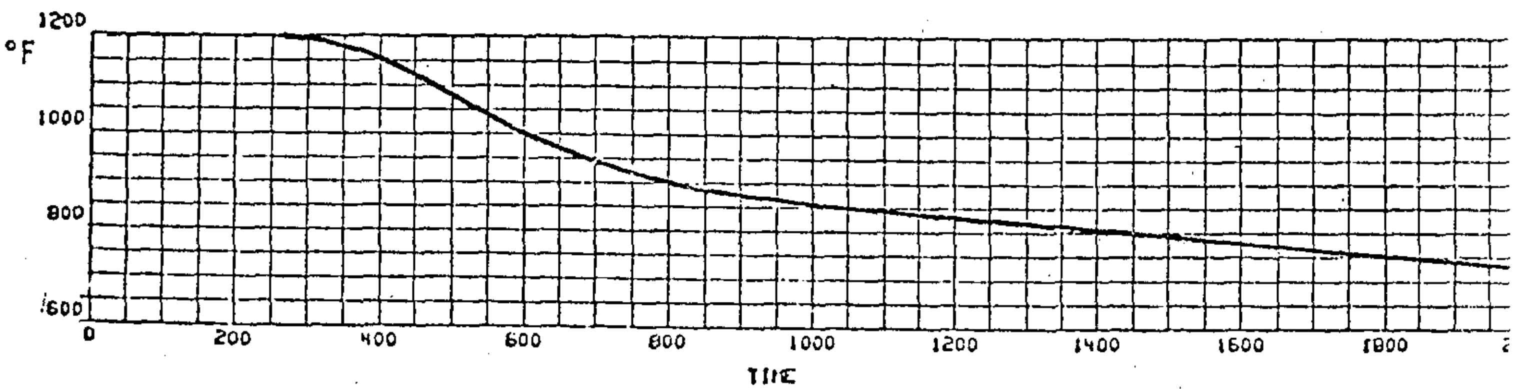
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 7. TRANSIENT U4 SCRAM WITH FULL PRIMARY FLOW
200°F ΔT CASE

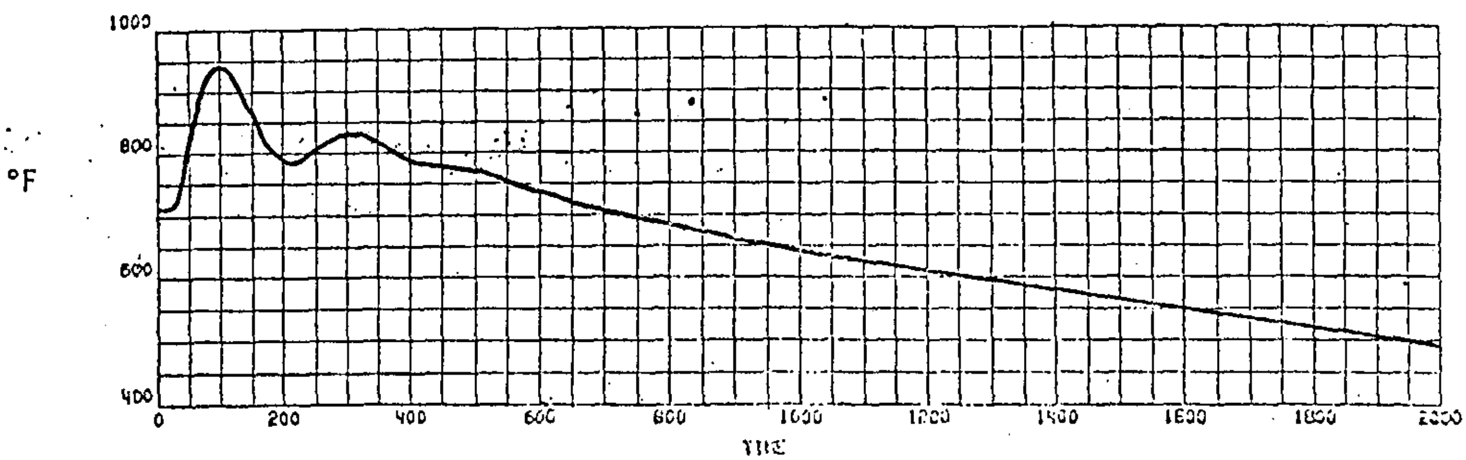
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



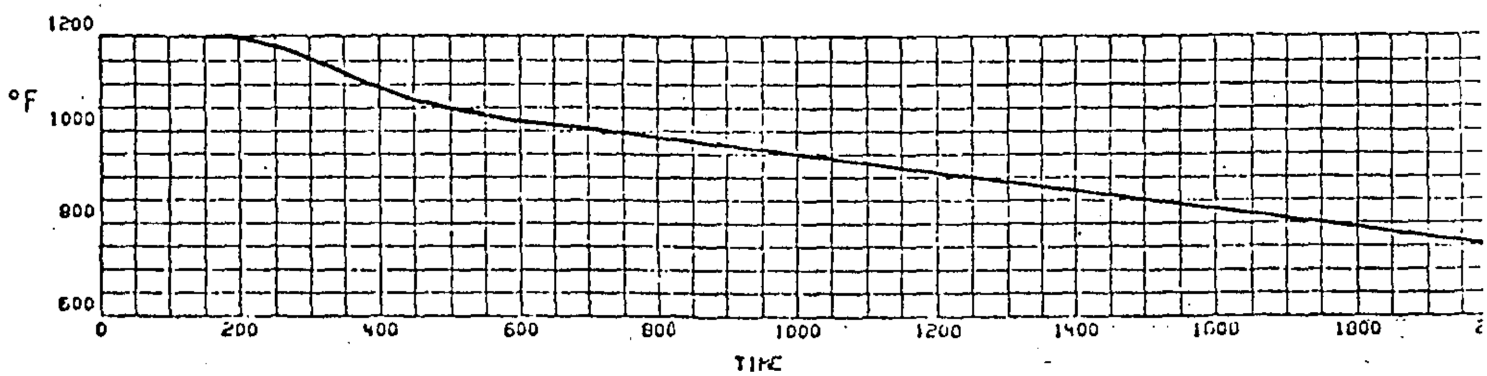
PRIMARY LOCATION II
(PRIMARY COLD LEG)



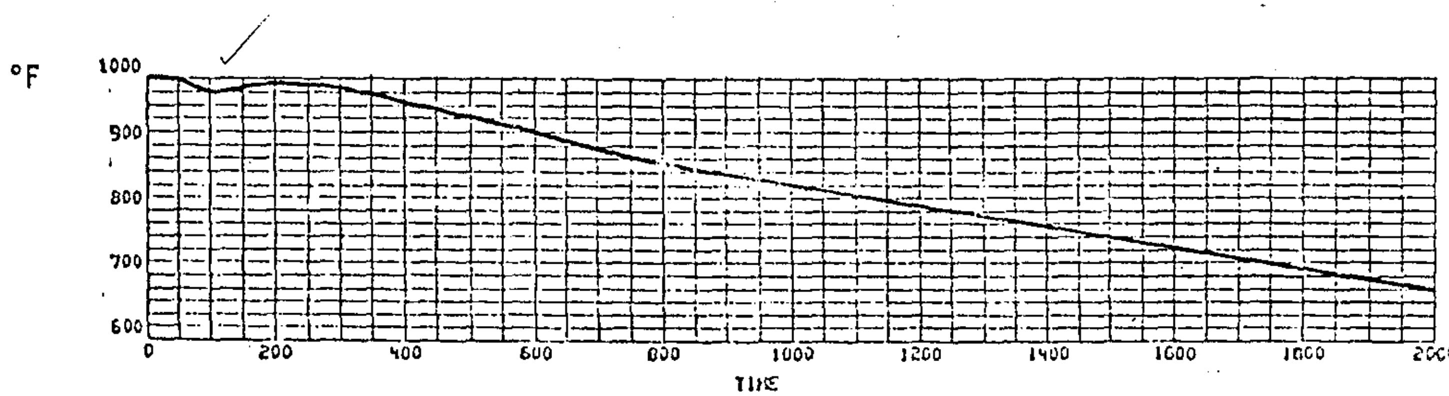
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 8. TRANSIENT U5 SCRAM WITH FULL SECONDARY FLOW
400°F ΔT CASE

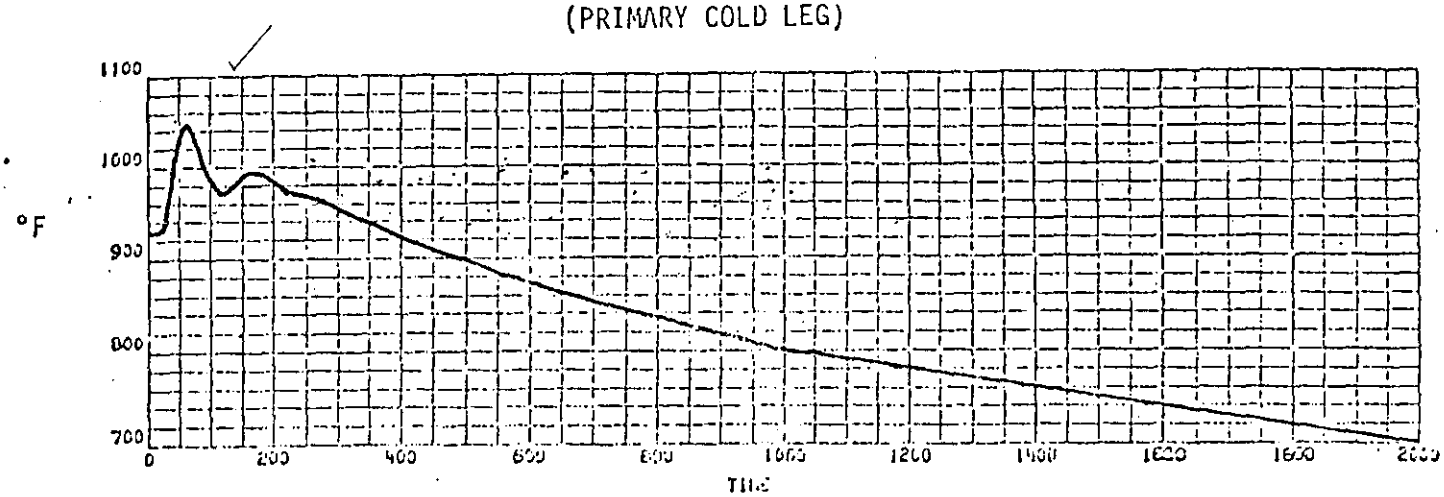
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



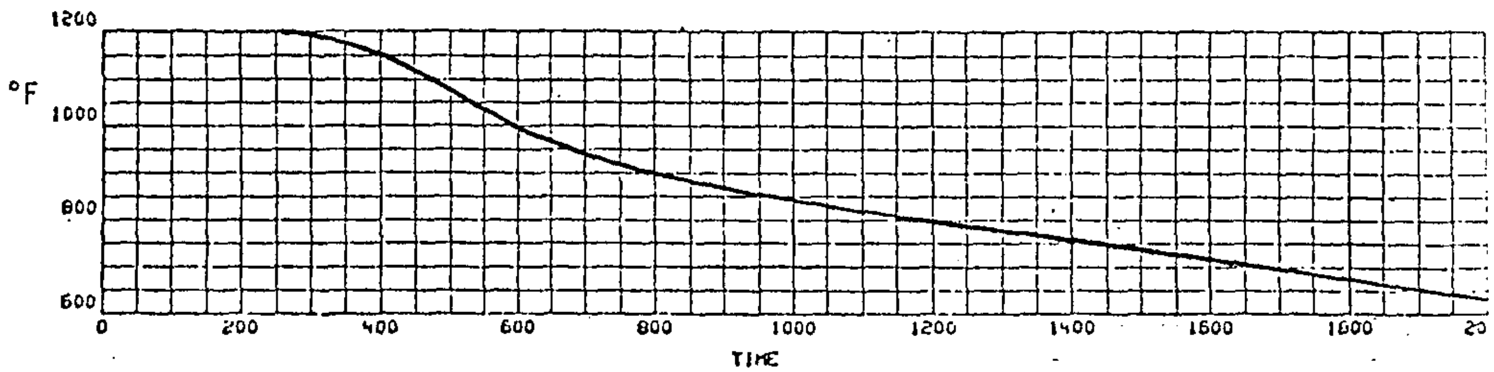
PRIMARY LOCATION II
(PRIMARY COLD LEG)



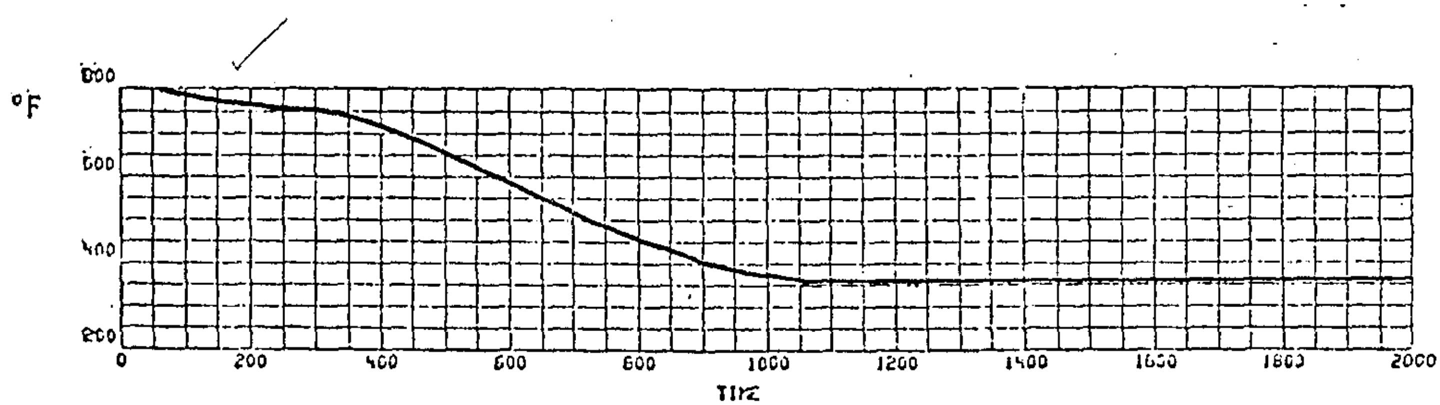
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 9. TRANSIENT U6 SCRAM WITH FULL SECONDARY FLOW
200°F ΔT CASE

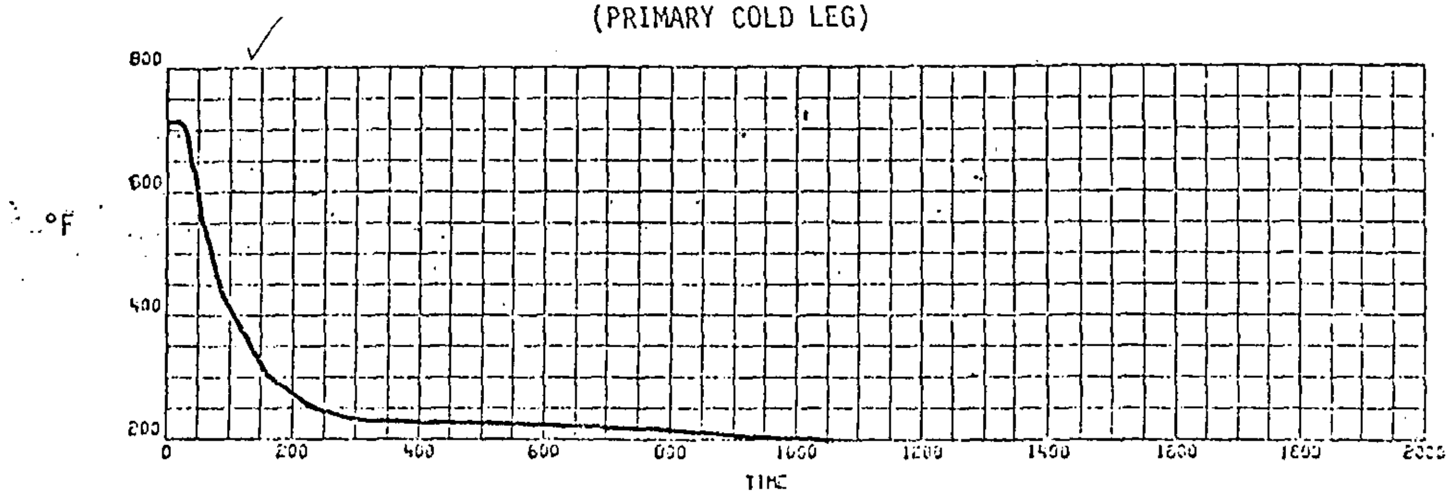
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



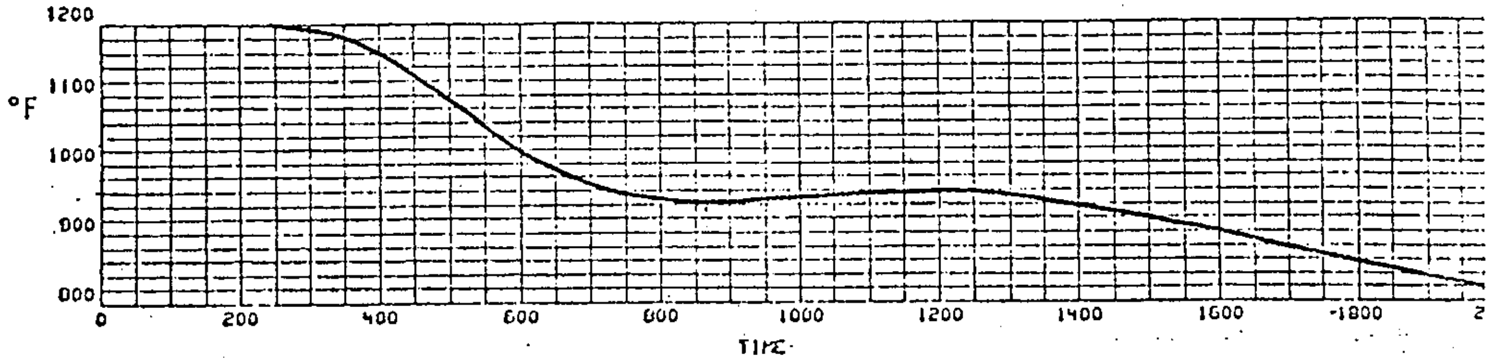
PRIMARY LOCATION II
(PRIMARY COLD LEG)



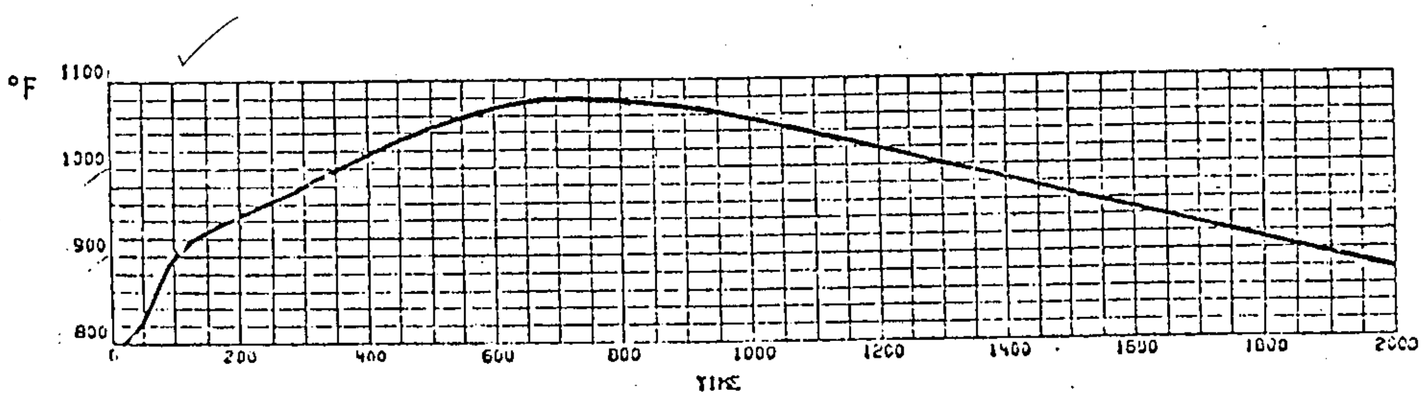
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 10. TRANSIENT U7 SCRAM WITH FULL AIR FLOW

COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



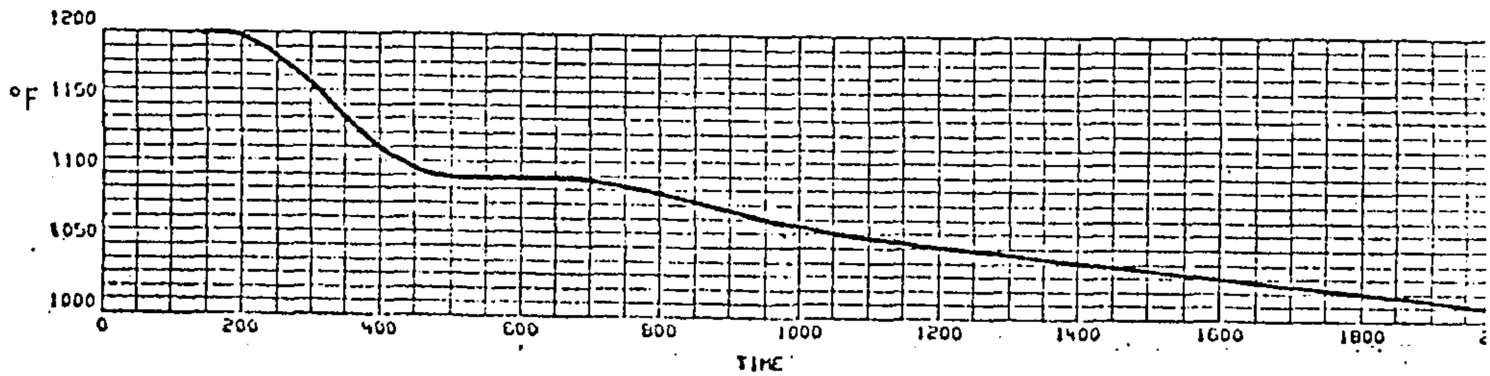
PRIMARY LOCATION II
(PRIMARY COLD LEG)

Use thermal transients for "U13 SECONDARY LOCATION I" for analysis of U8 in the secondary cold leg.

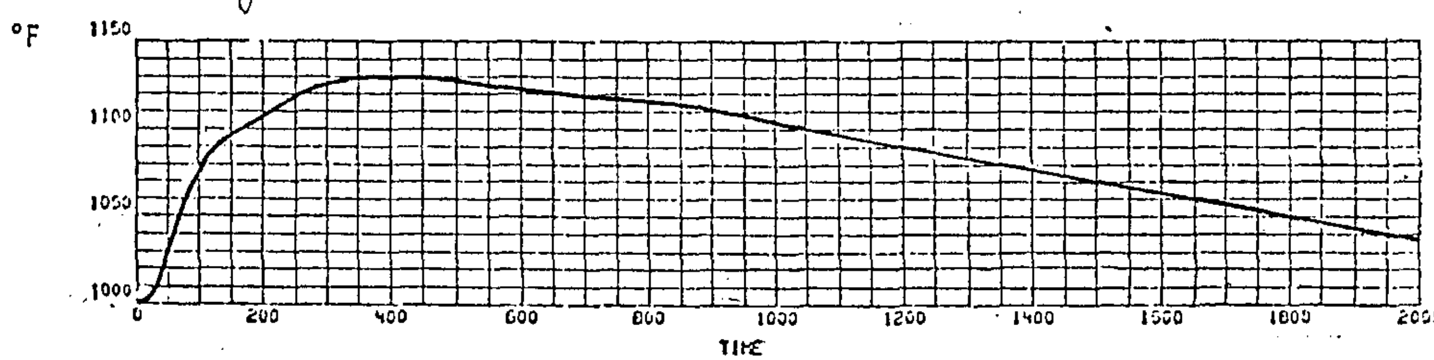
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 11. TRANSIENT U8 LOSS OF SECONDARY FLOW
400°F ΔT TEST

COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



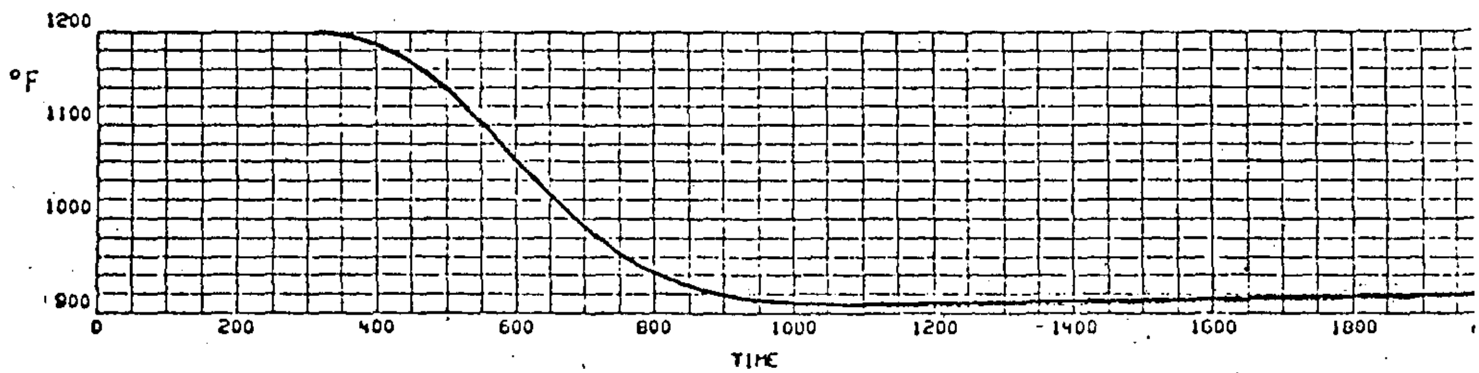
PRIMARY LOCATION II
(PRIMARY COLD LEG)

Use thermal transients for "U14 SECONDARY LOCATION I" for analysis of U9 in the secondary cold leg.

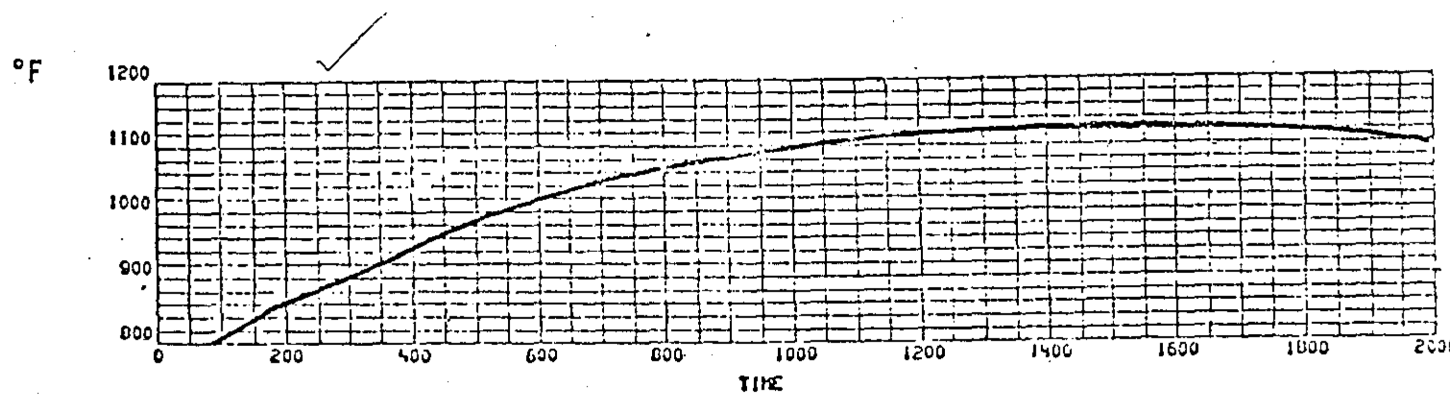
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 12. TRANSIENT U9 LOSS OF SECONDARY FLOW
200°F ΔT CASE

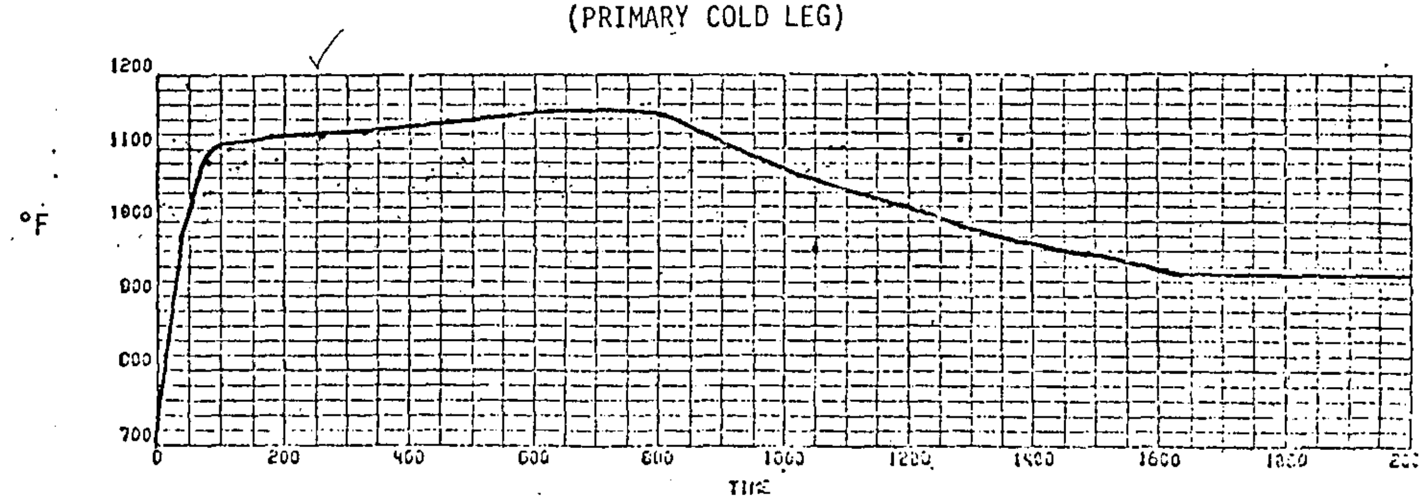
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



PRIMARY LOCATION II
(PRIMARY COLD LEG)

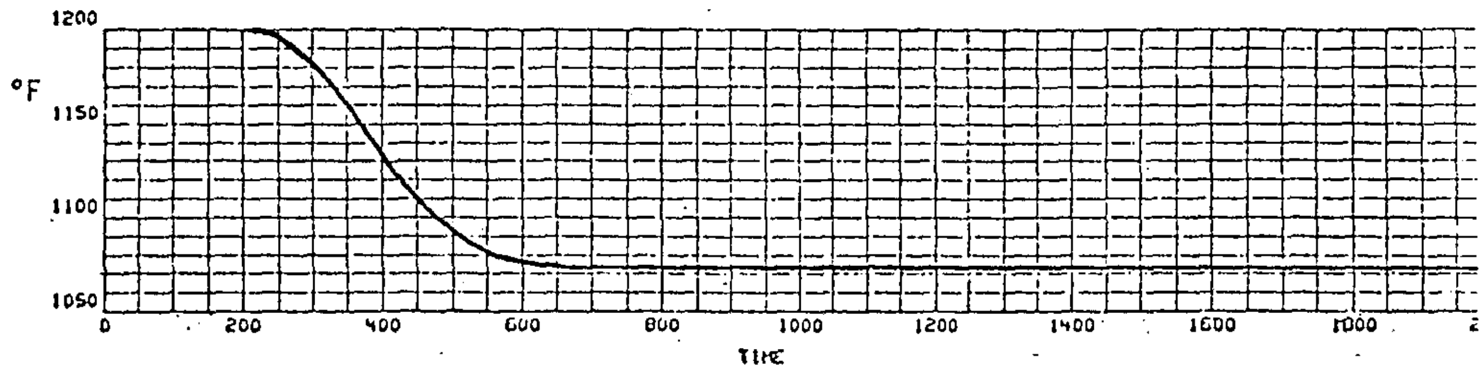


SECONDARY LOCATION I
(SECONDARY COLD LEG)

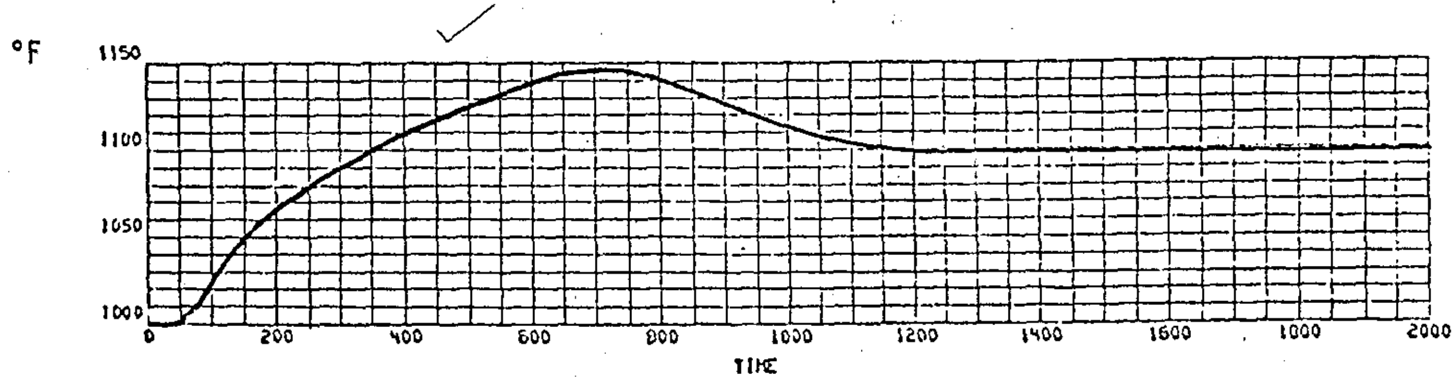
FIGURE 13. TRANSIENT U10 LOSS OF AIR FLOW

400°F ΔT CASE

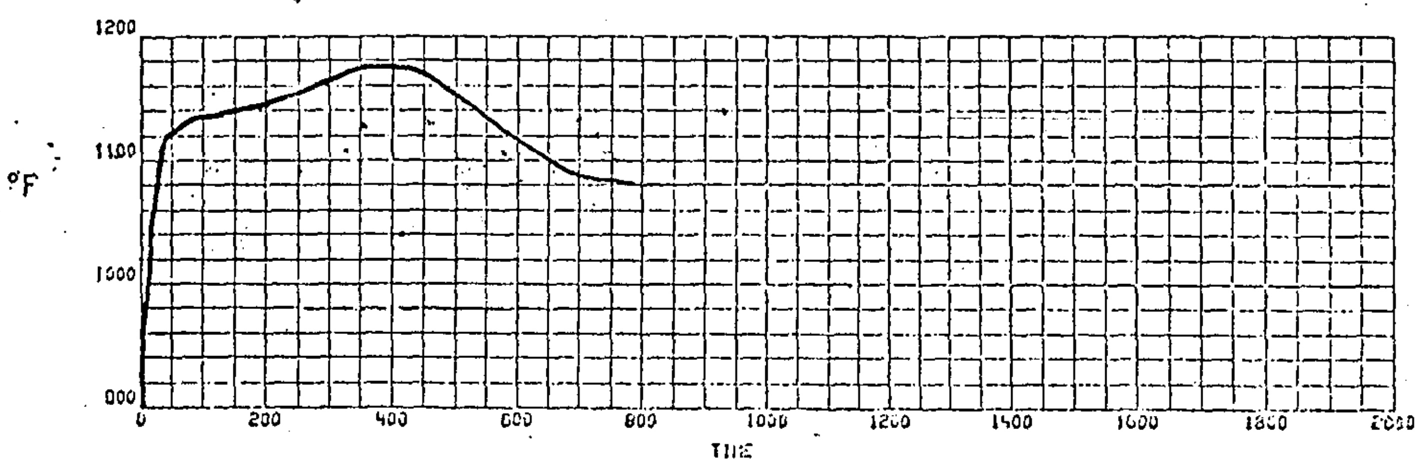
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



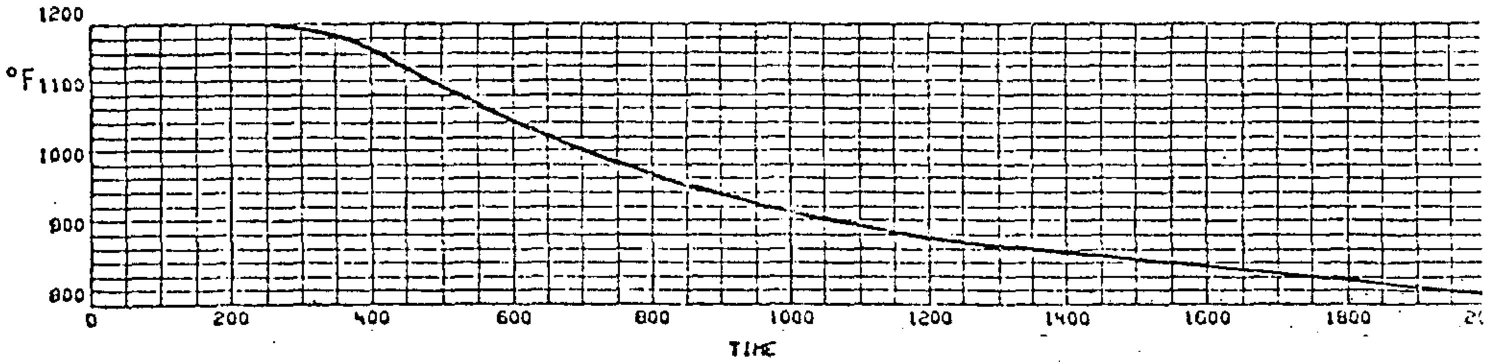
PRIMARY LOCATION II
(PRIMARY COLD LEG)



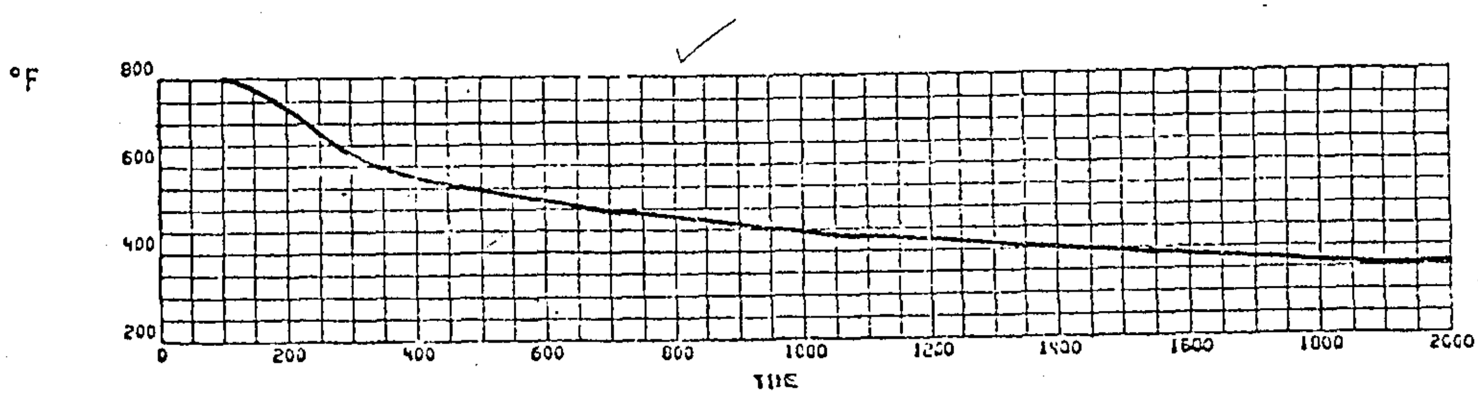
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 14. TRANSIENT U11 LOSS OF AIR FLOW
200°F ΔT CASE

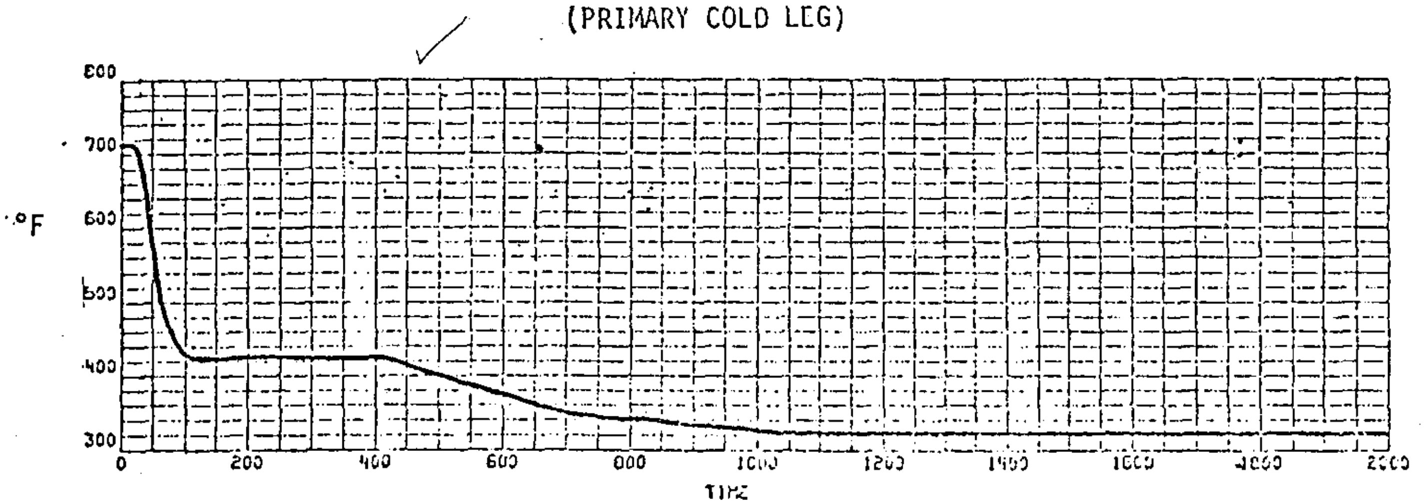
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



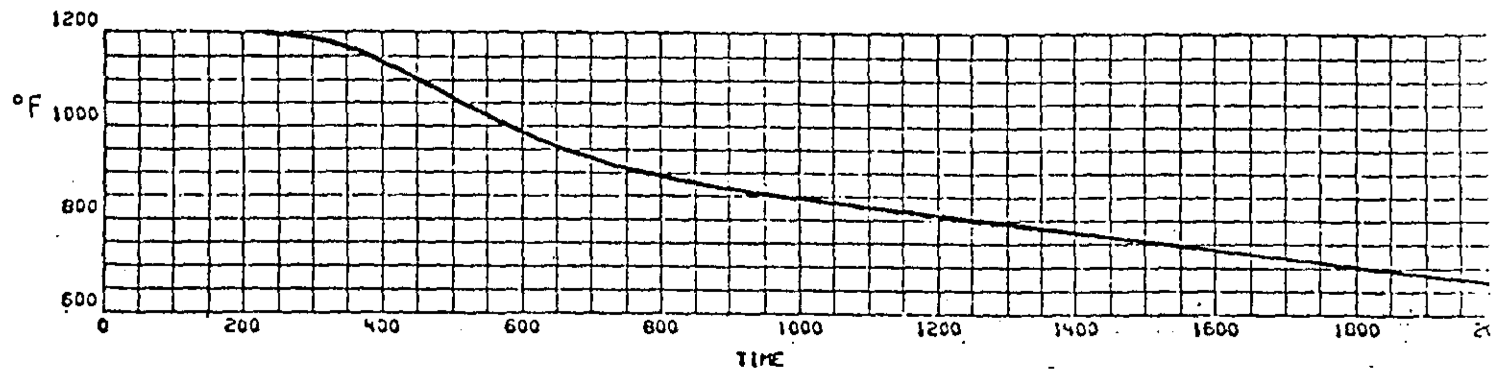
PRIMARY LOCATION II
(PRIMARY COLD LEG)



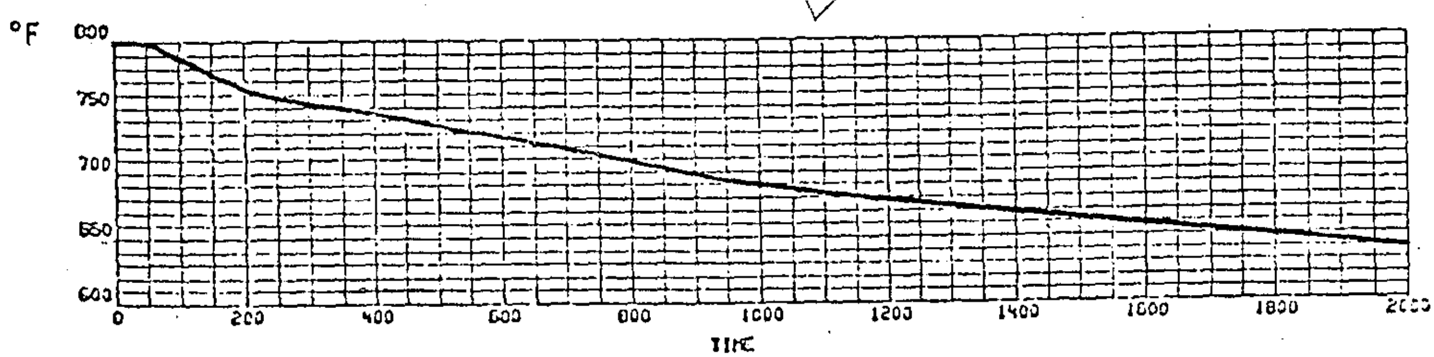
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 15. TRANSIENT U12 INCREASE OF AIR FLOW

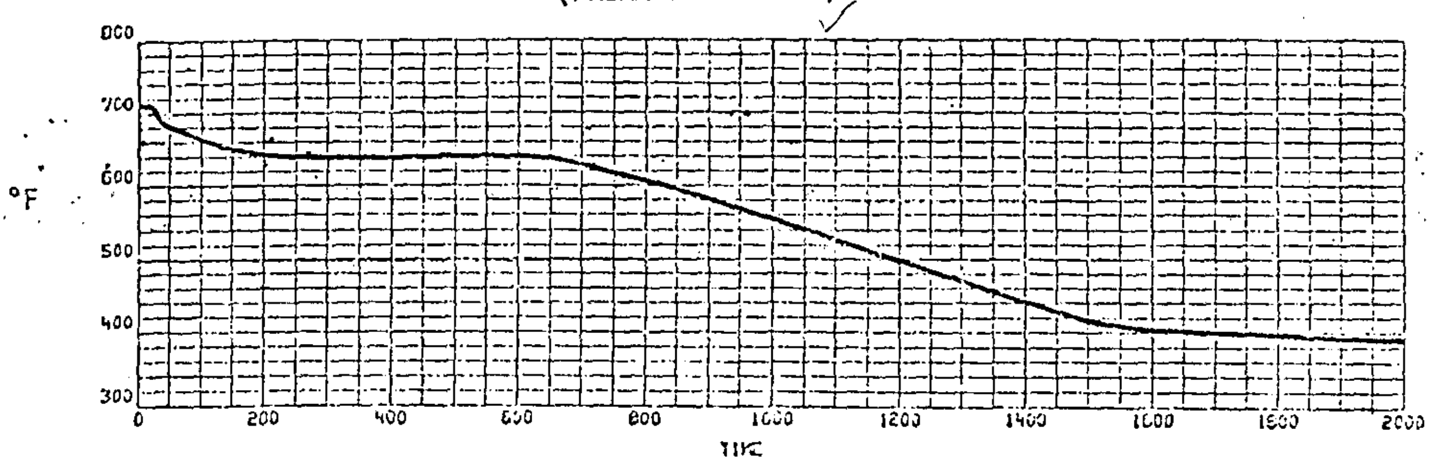
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



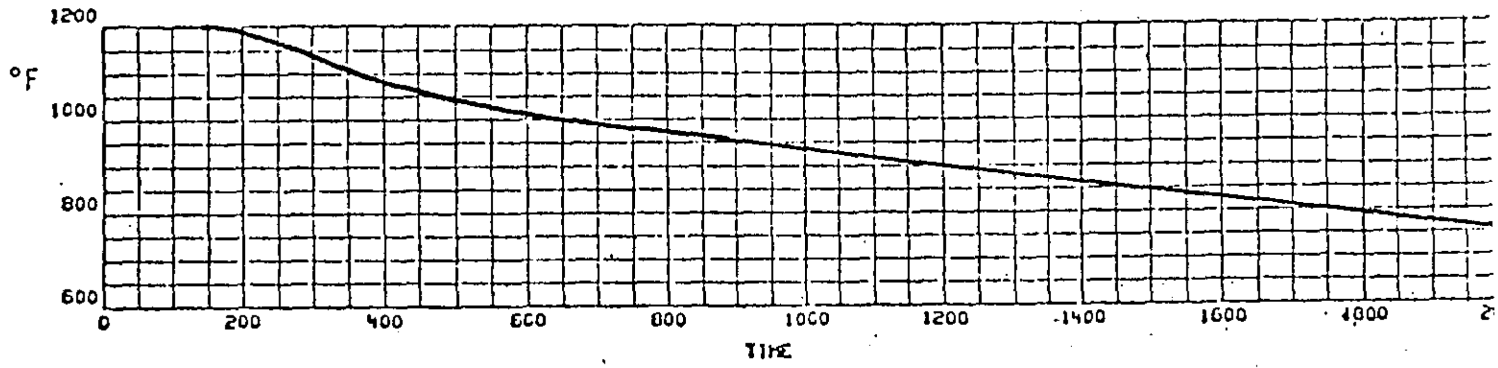
PRIMARY LOCATION II
(PRIMARY COLD LEG)



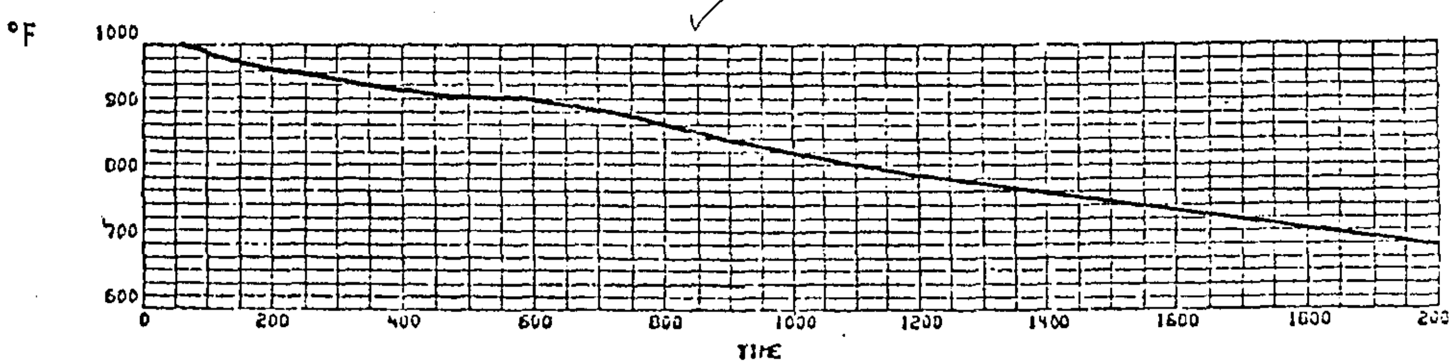
SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 16. TRANSIENT U13 NORMAL REACTOR SCRAM
400°F ΔT CASE

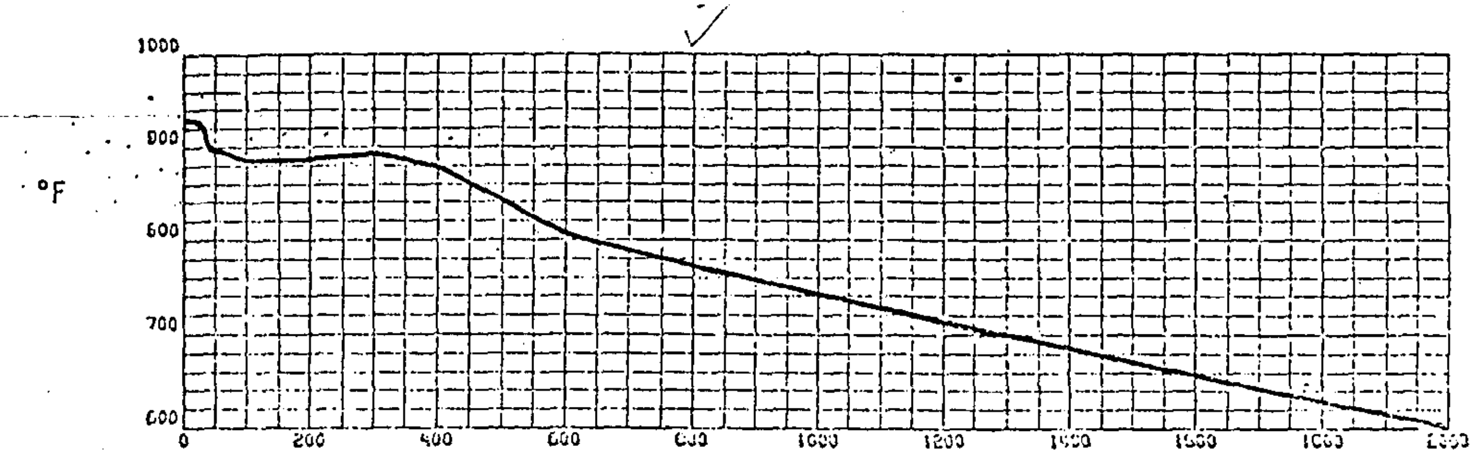
COLD TRAP INLET TEMPERATURE



PRIMARY LOCATION I
(PRIMARY HOT LEG)



PRIMARY LOCATION II
(PRIMARY COLD LEG)



SECONDARY LOCATION I
(SECONDARY COLD LEG)

FIGURE 17. TRANSIENT U14 NORMAL REACTOR SCRAM
200°F ΔT CASE

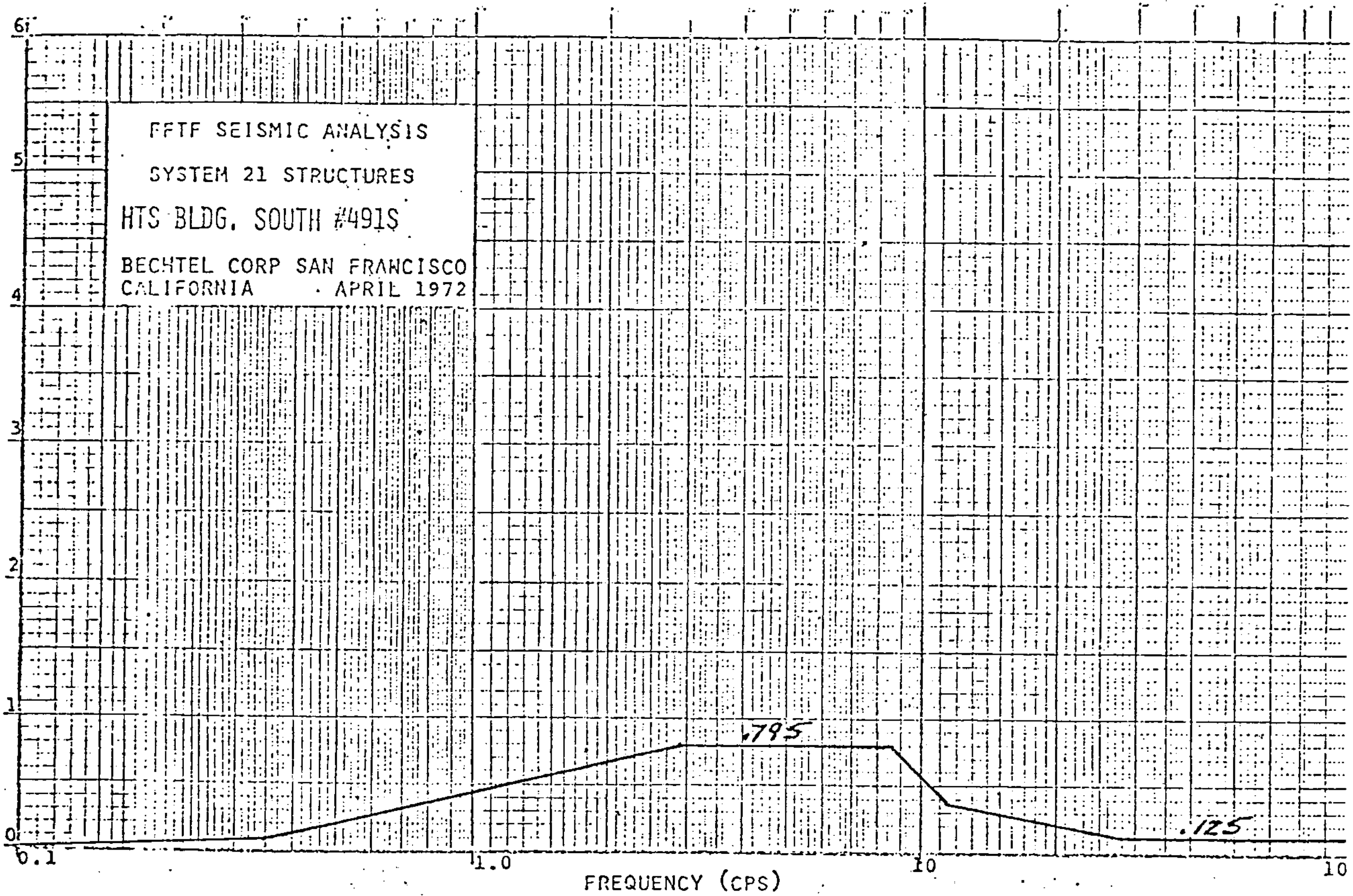


FIGURE 18. OBE HORIZONTAL E-W RESPONSE SPECTRUM AT EL. 550' & 539' 1% DAMPING

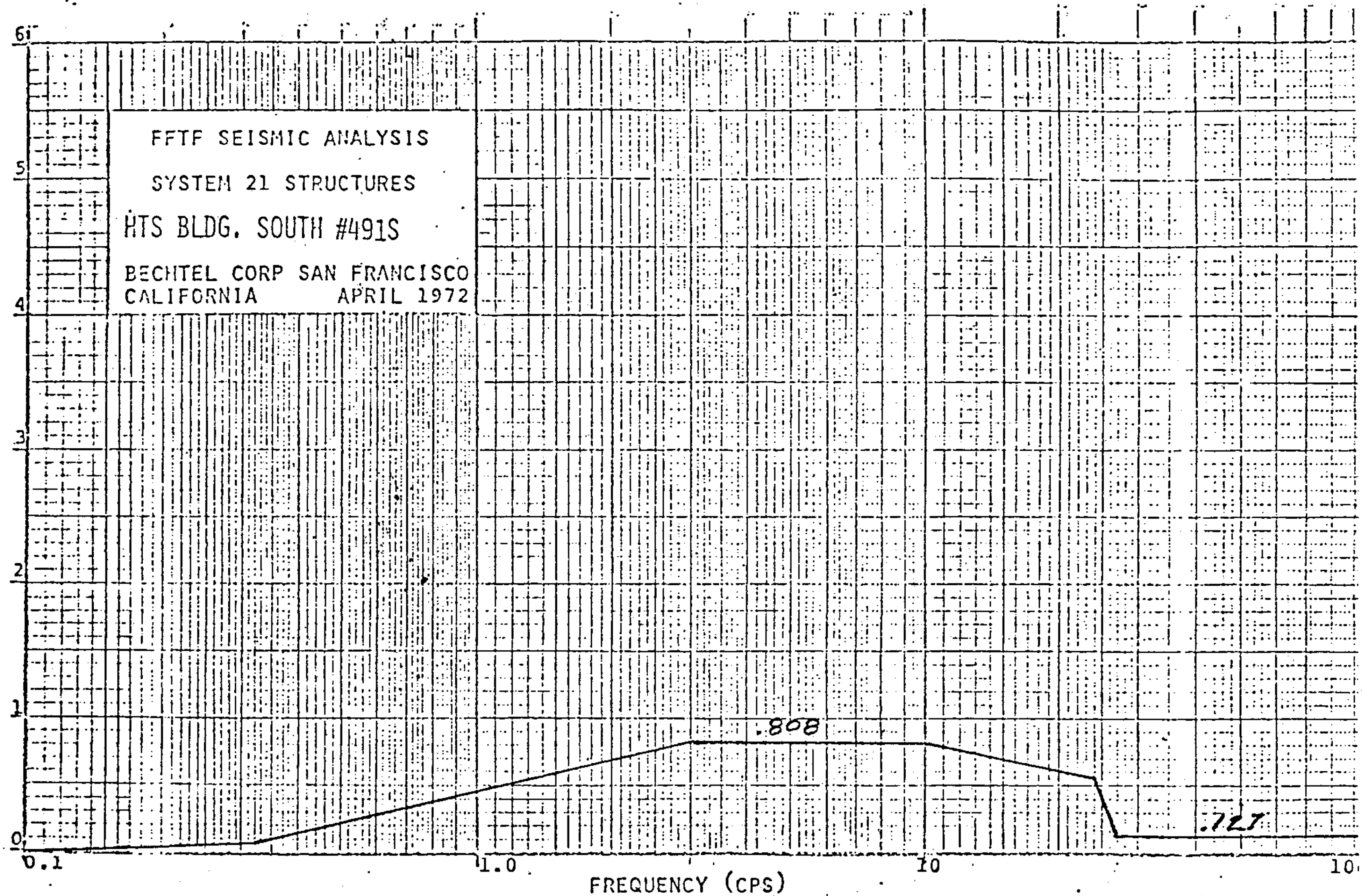


FIGURE 19. OBE HORIZONTAL N-S RESPONSE SPECTRUM AT EL. 550'-0", 1% DAMPING

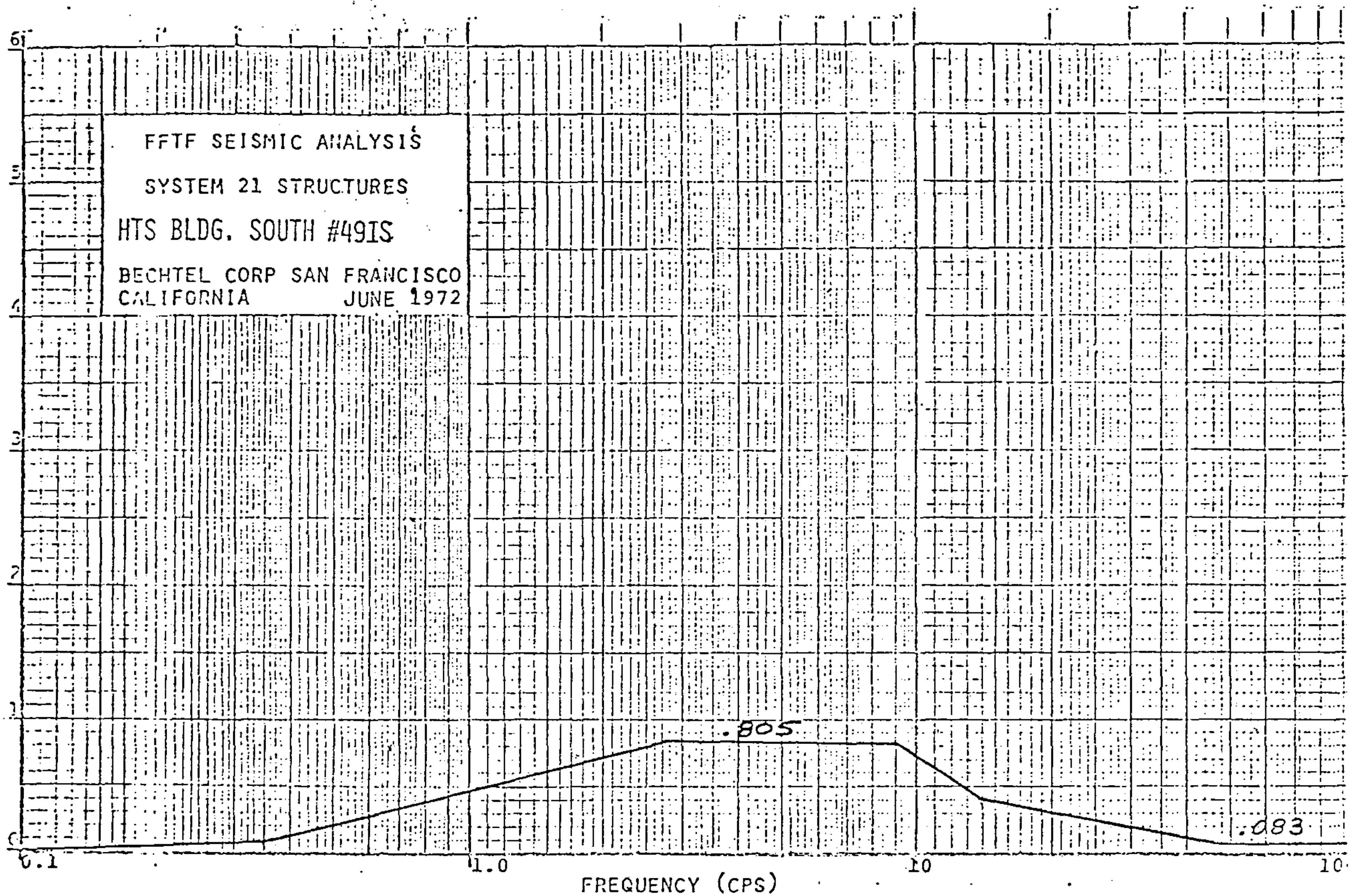


FIGURE 20. OBE VERTICAL RESPONSE SPECTRUM AT EL. 550'-0", 1% DAMPING

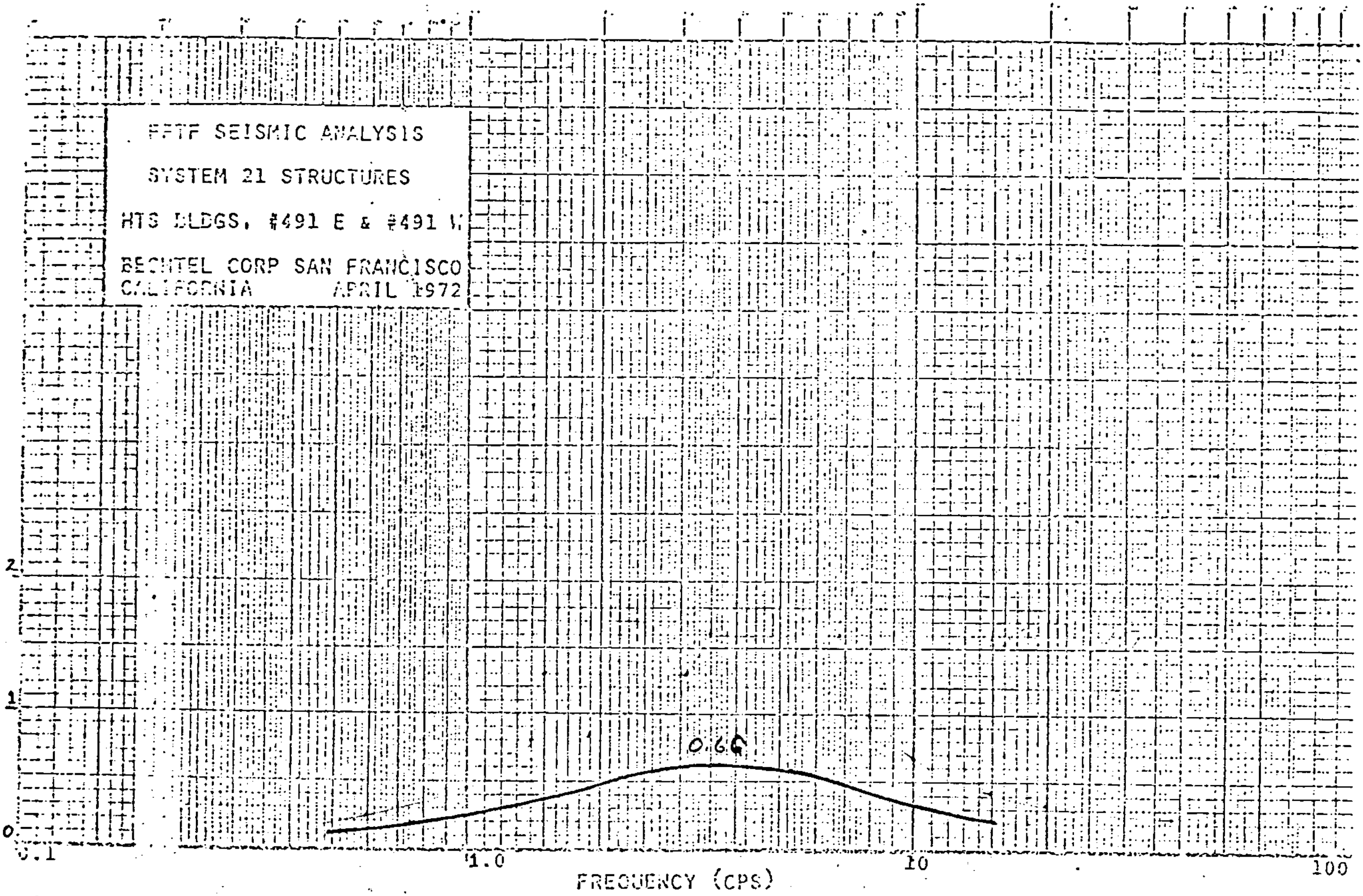


FIGURE 21. OBE HORIZONTAL E-W RESPONSE SPECTRUM AT EL. 530'-0", 1% DAMPING

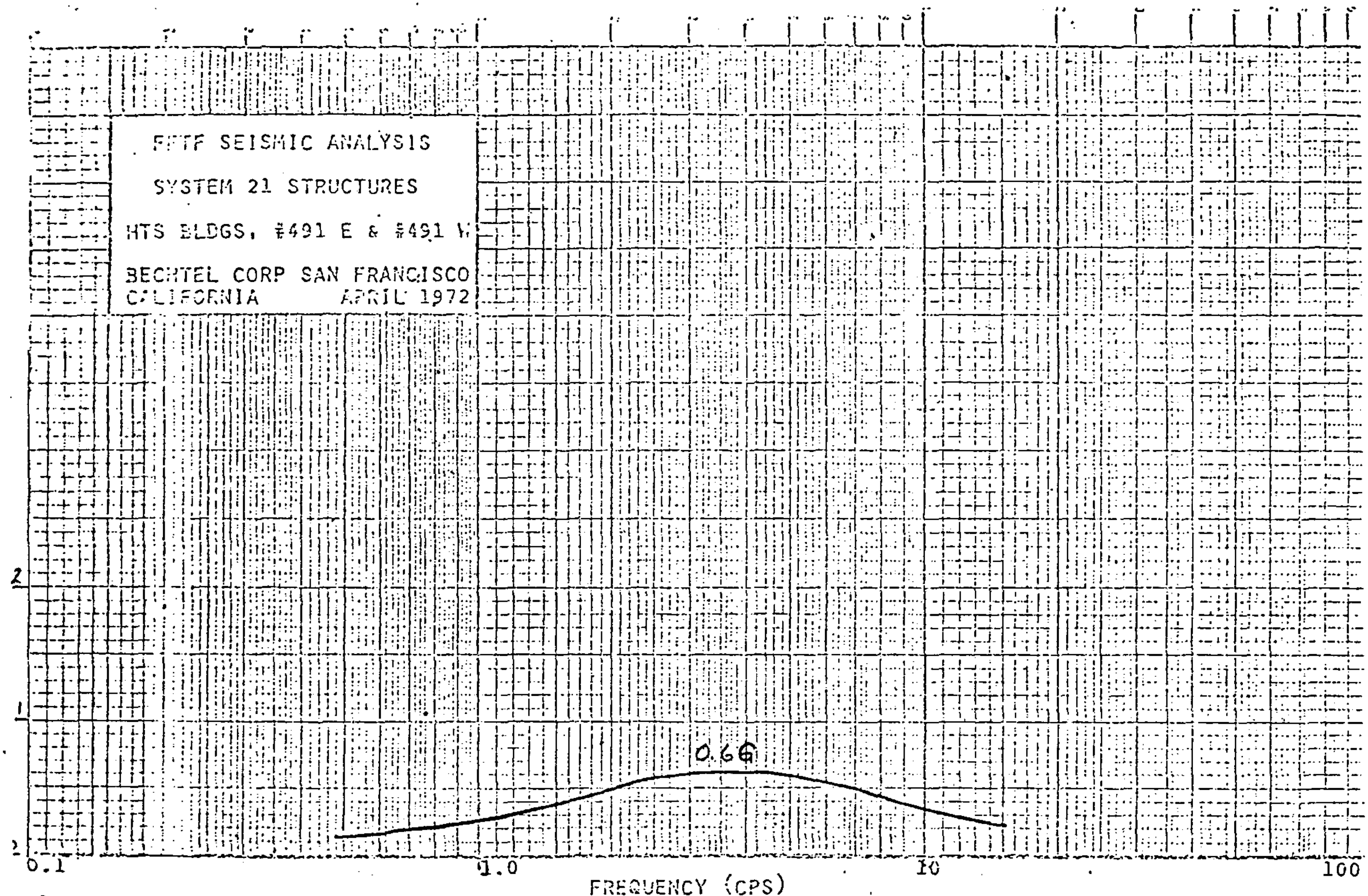


FIGURE 22. OBE HORIZONTAL N-S RESPONSE SPECTRUM AT EL. 530'-0", 1% DAMPING

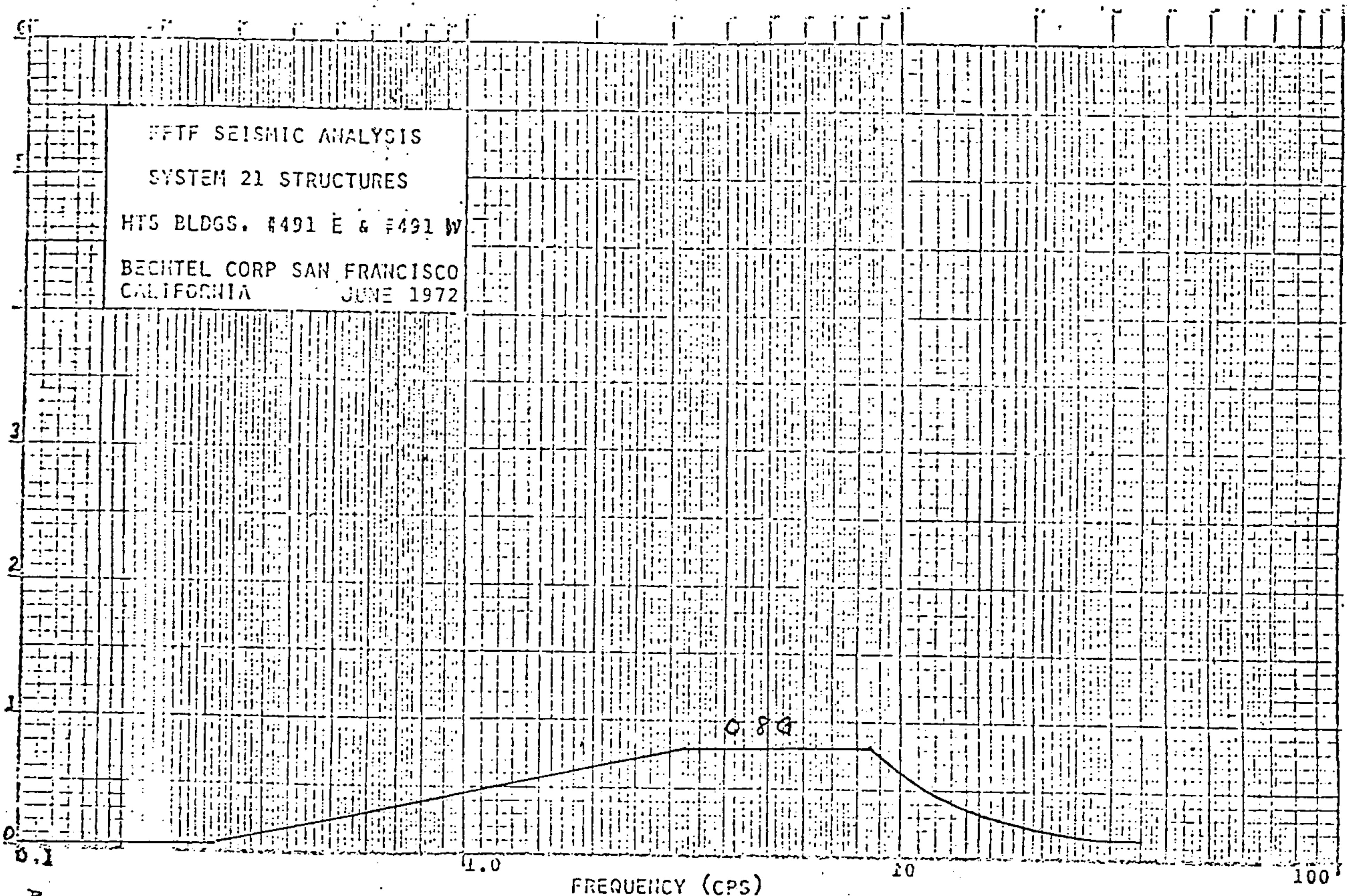


FIGURE 23. OBE VERTICAL RESPONSE SPECTRUM AT EL. 530'-0", 1% DAMPING

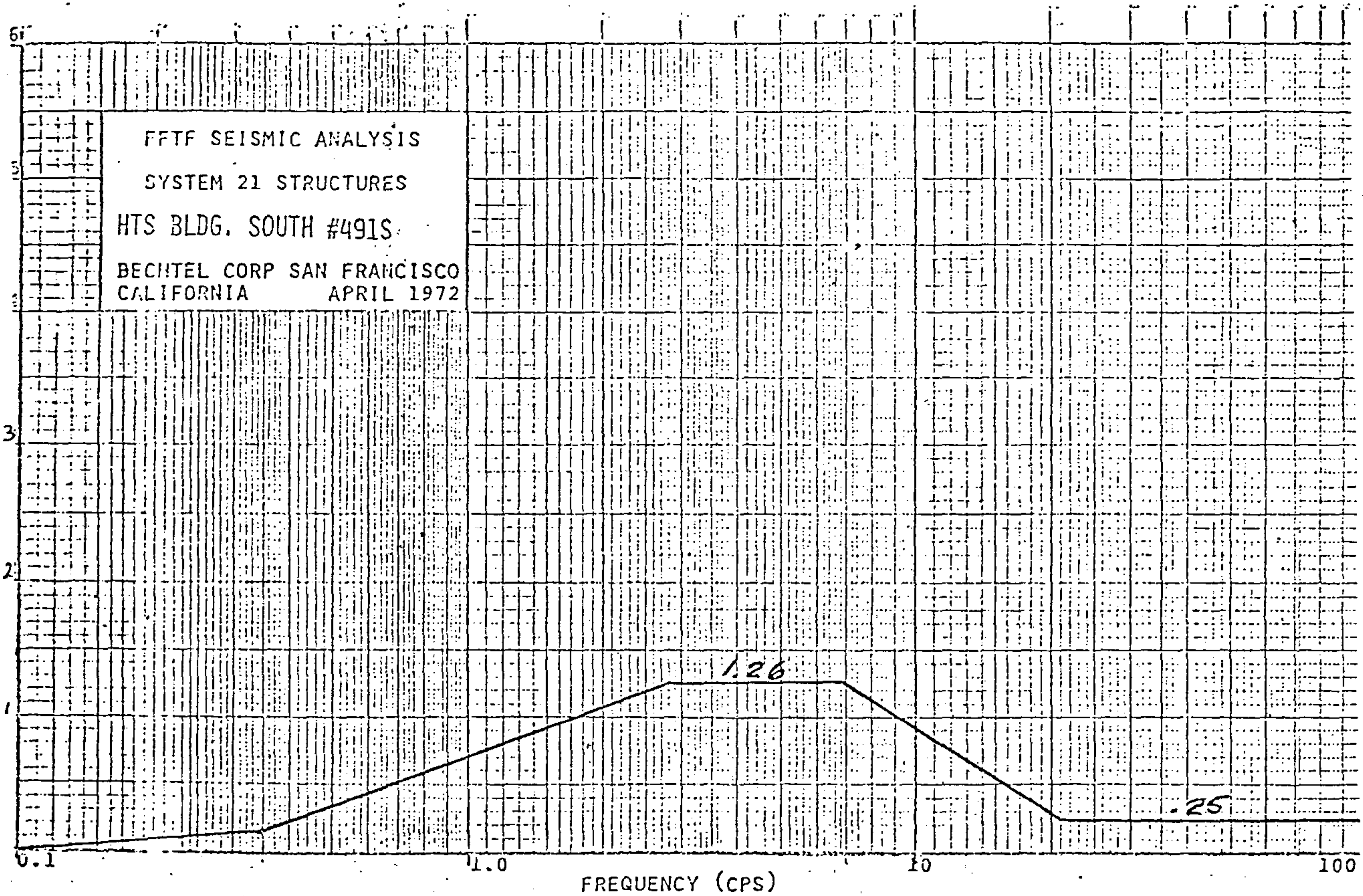


FIGURE 24. DBE HORIZONTAL E-W RESPONSE SPECTRUM AT EL.550 & 539 2% DAMPING

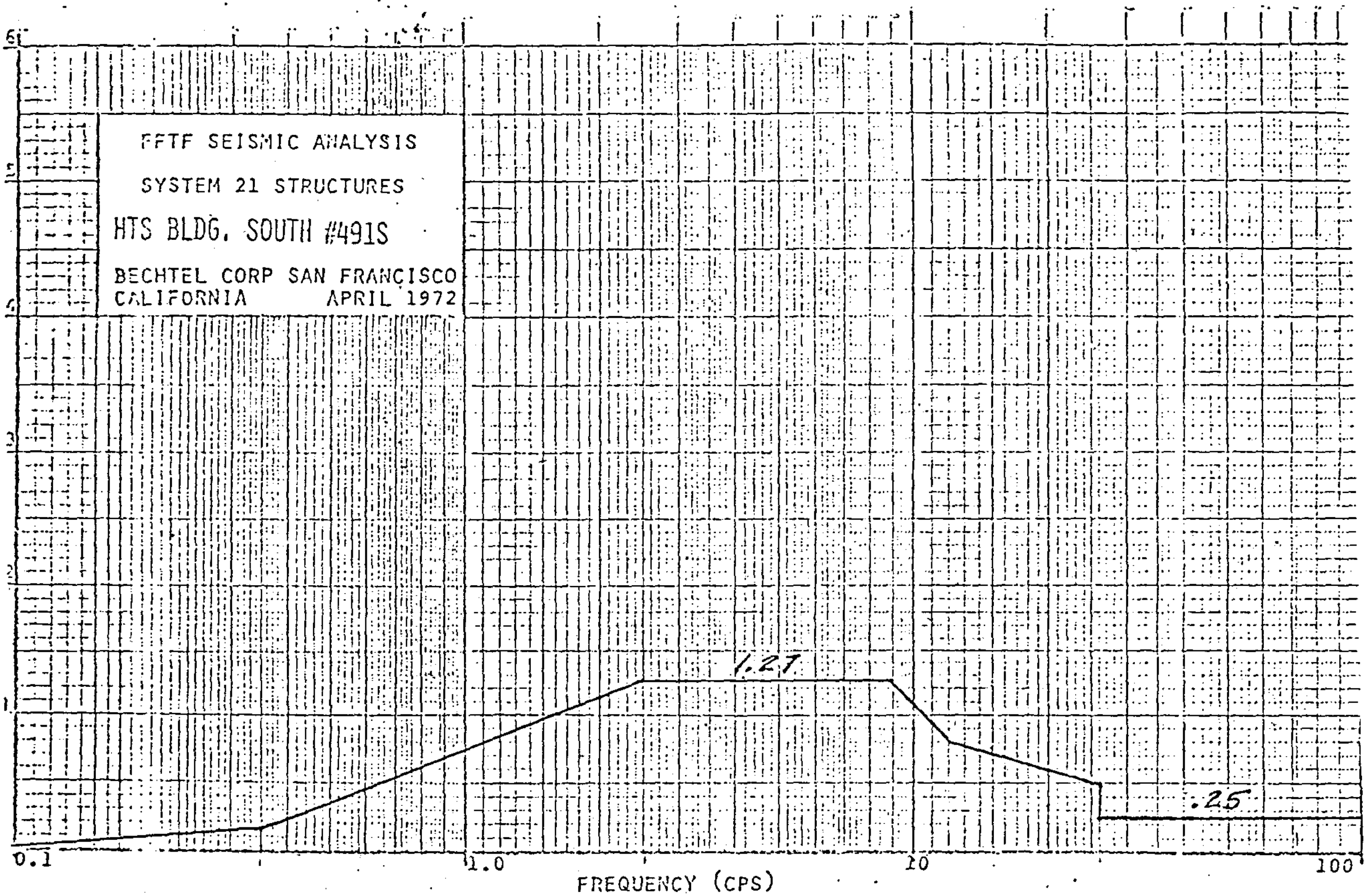


FIGURE 25. DBE HORIZONTAL N-S RESPONSE SPECTRUM AT EL. 550'-0", 2% DAMPING

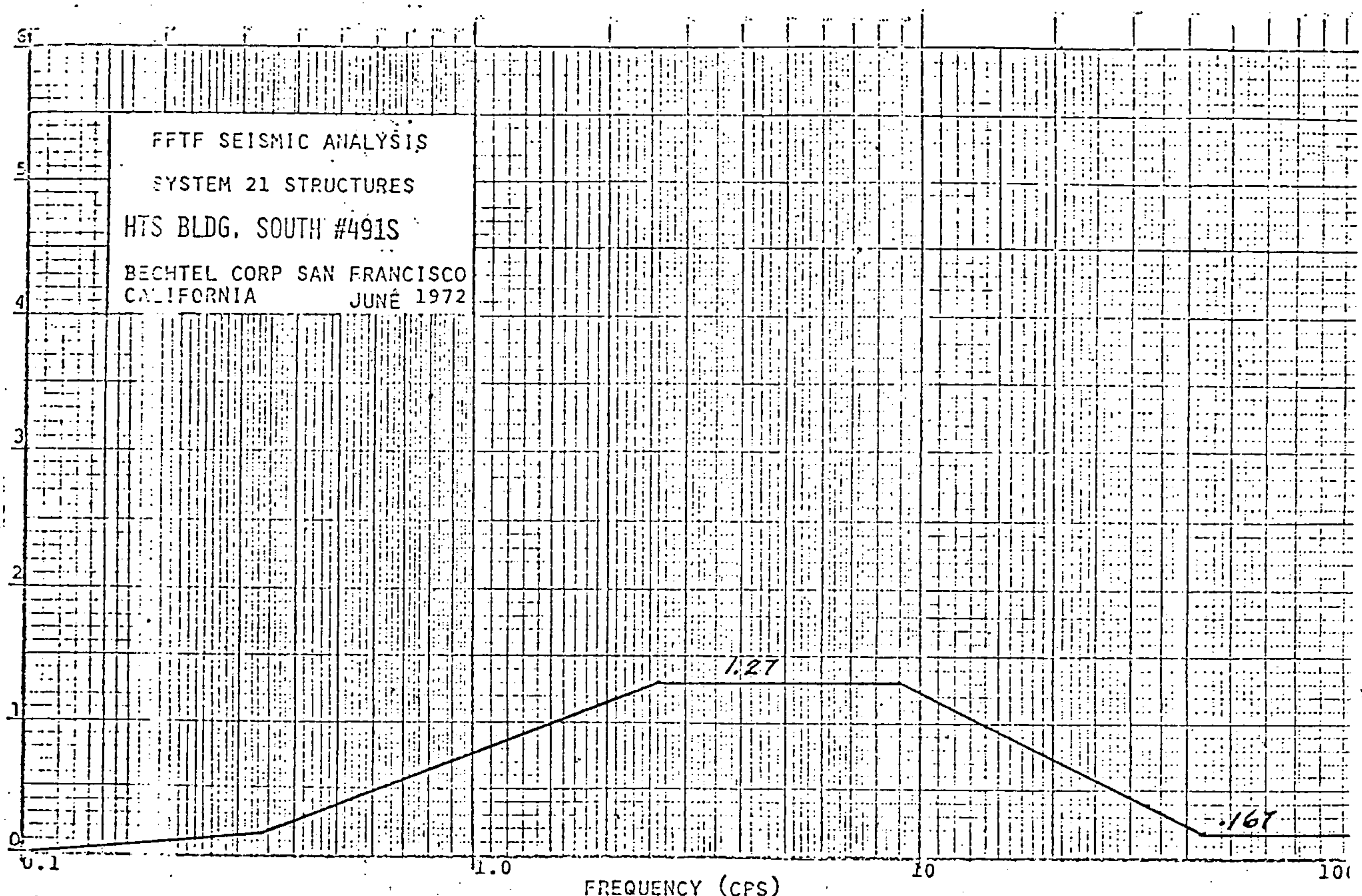


FIGURE 26. DBE VERTICAL RESPONSE SPECTRUM AT EL. 550'-0", 2% DAMPING

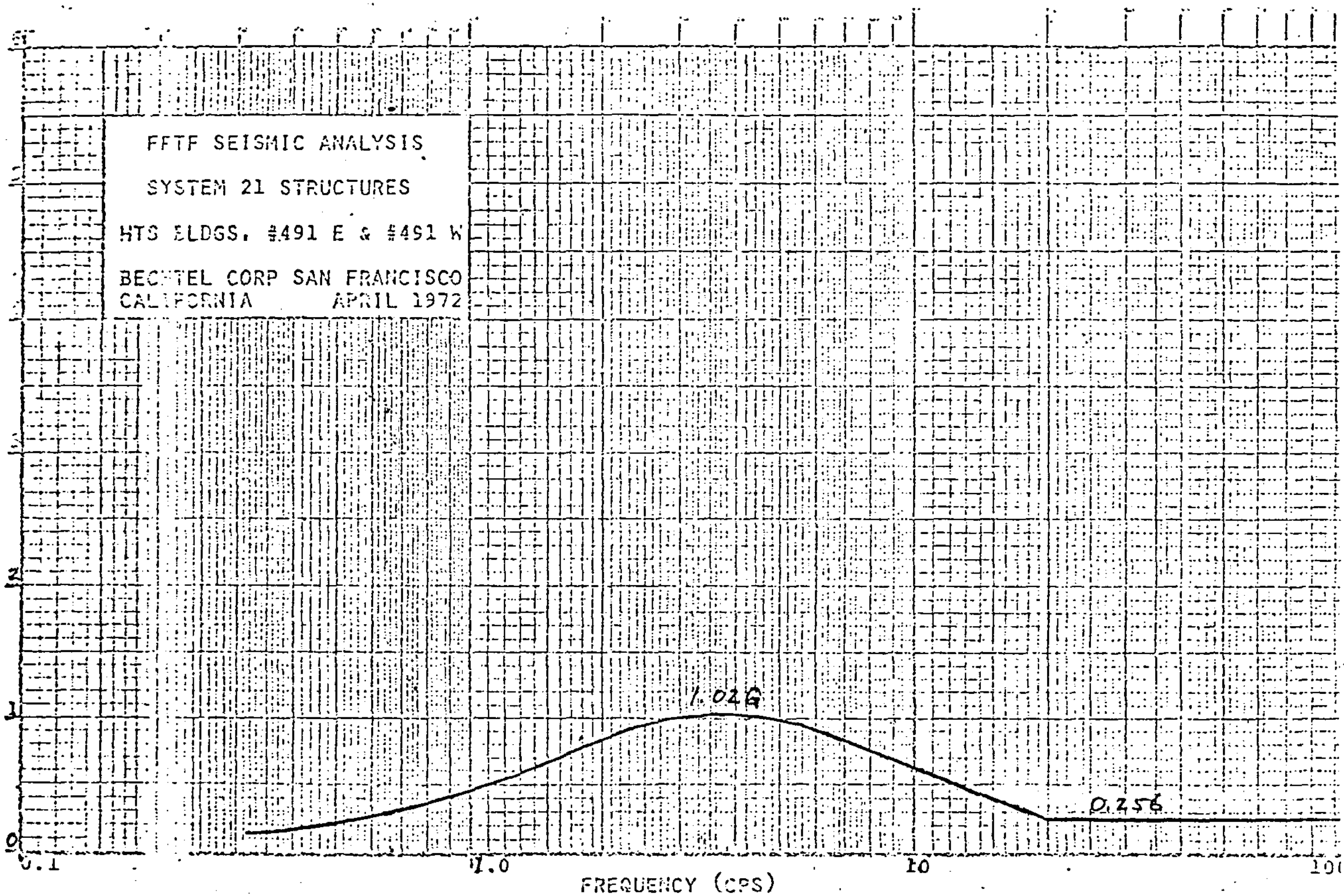


FIGURE 27. DBE HORIZONTAL E-W RESPONSE SPECTRUM AT EL. 530'-0", 2% DAMPING

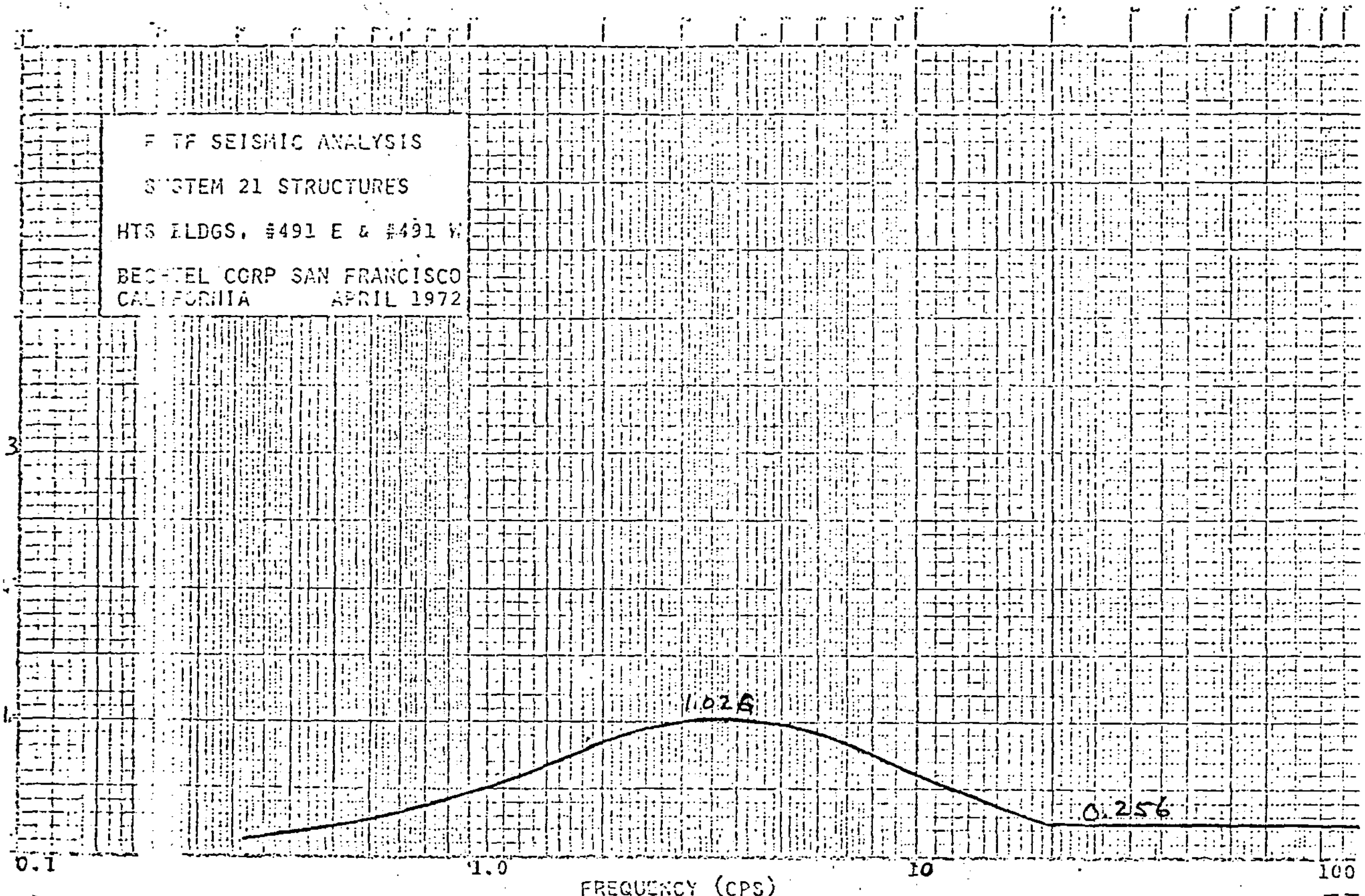


FIGURE 28. DBE HORIZONTAL N-S RESPONSE SPECTRUM AT EL. 530'-0", 2% DAMPING

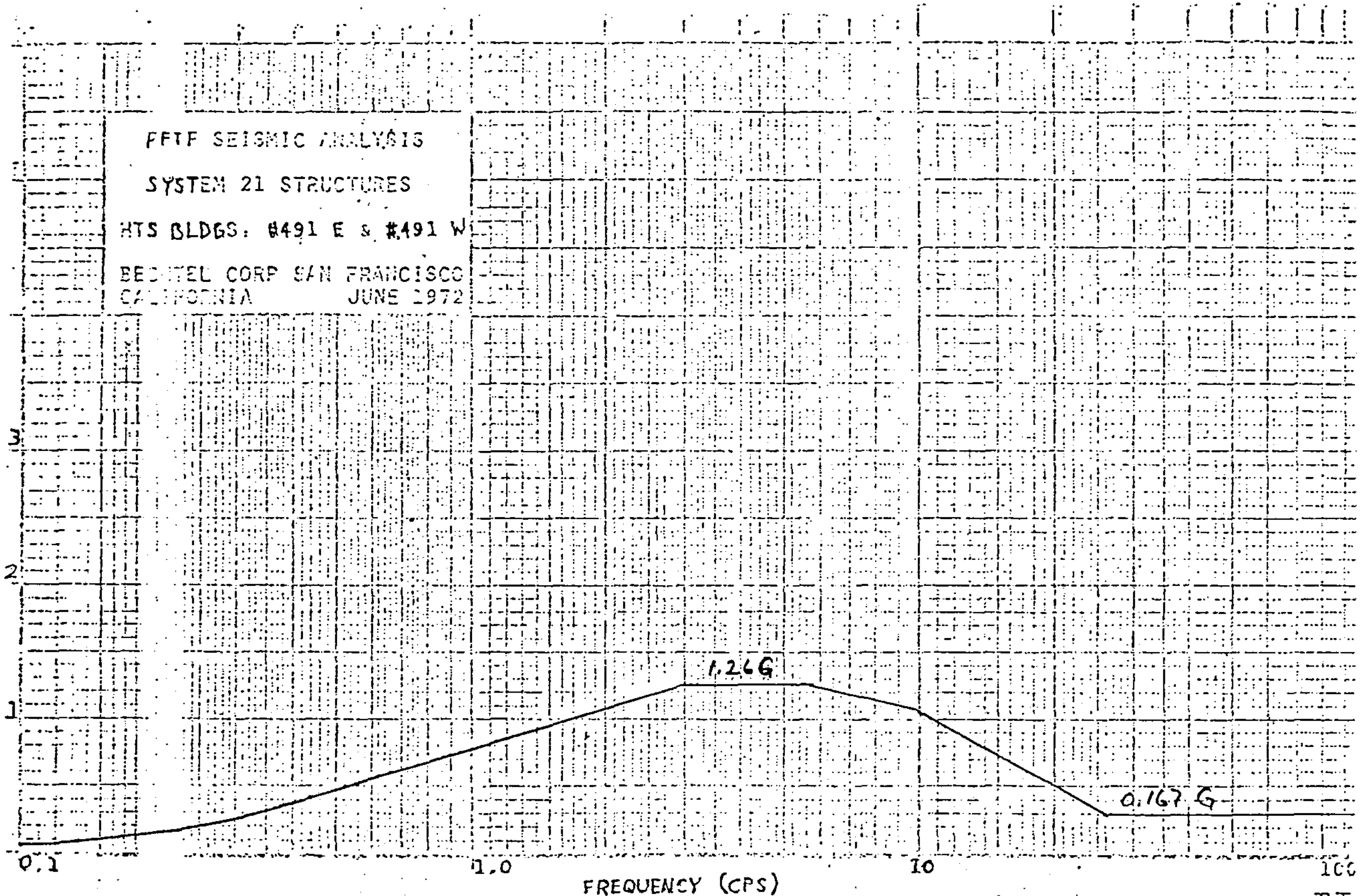


FIGURE 29. DBE VERTICAL RESPONSE SPECTRUM AT EL. 530'-0" 2% DAMPING

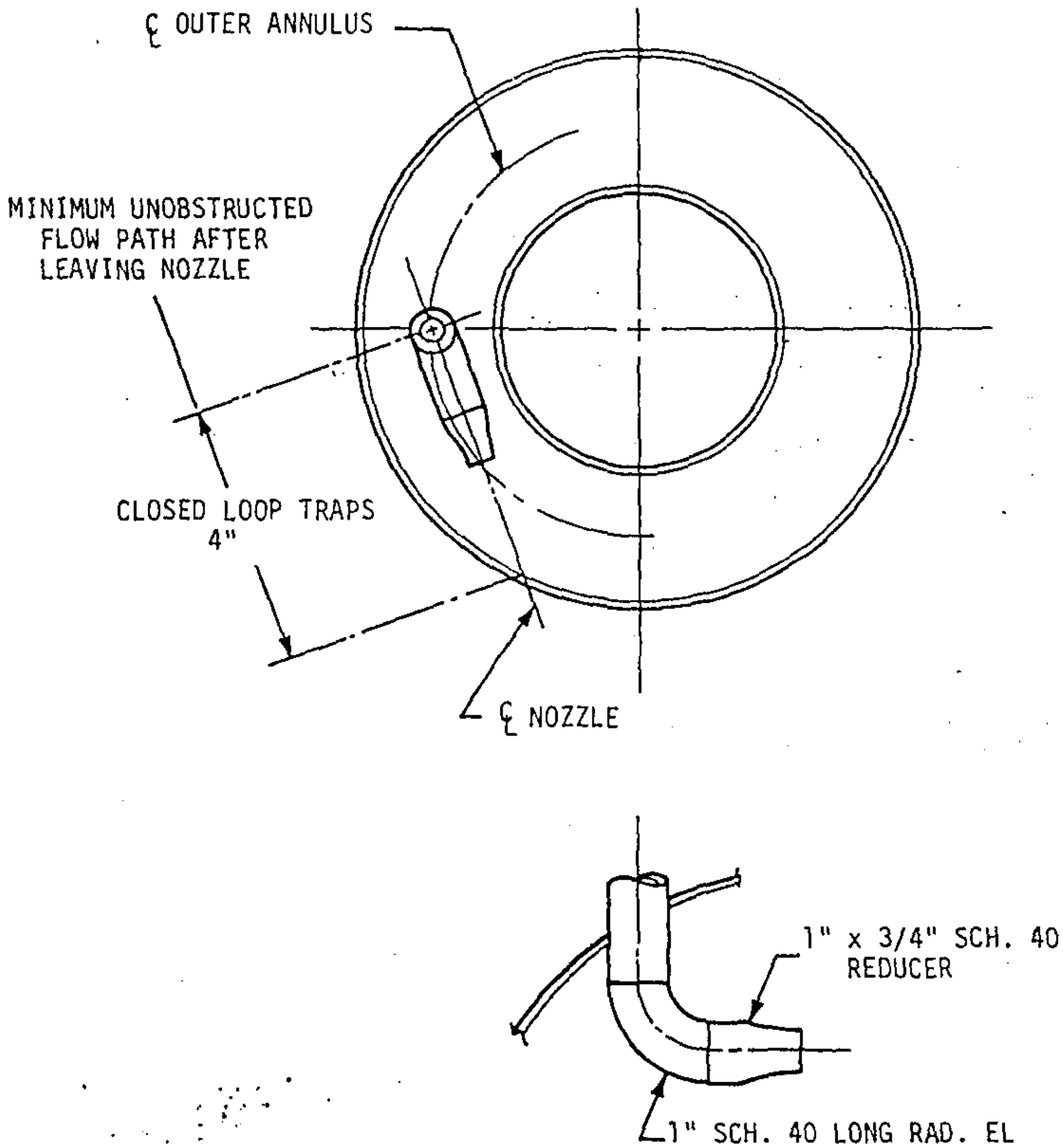


FIGURE 30. SODIUM INLET NOZZLE.

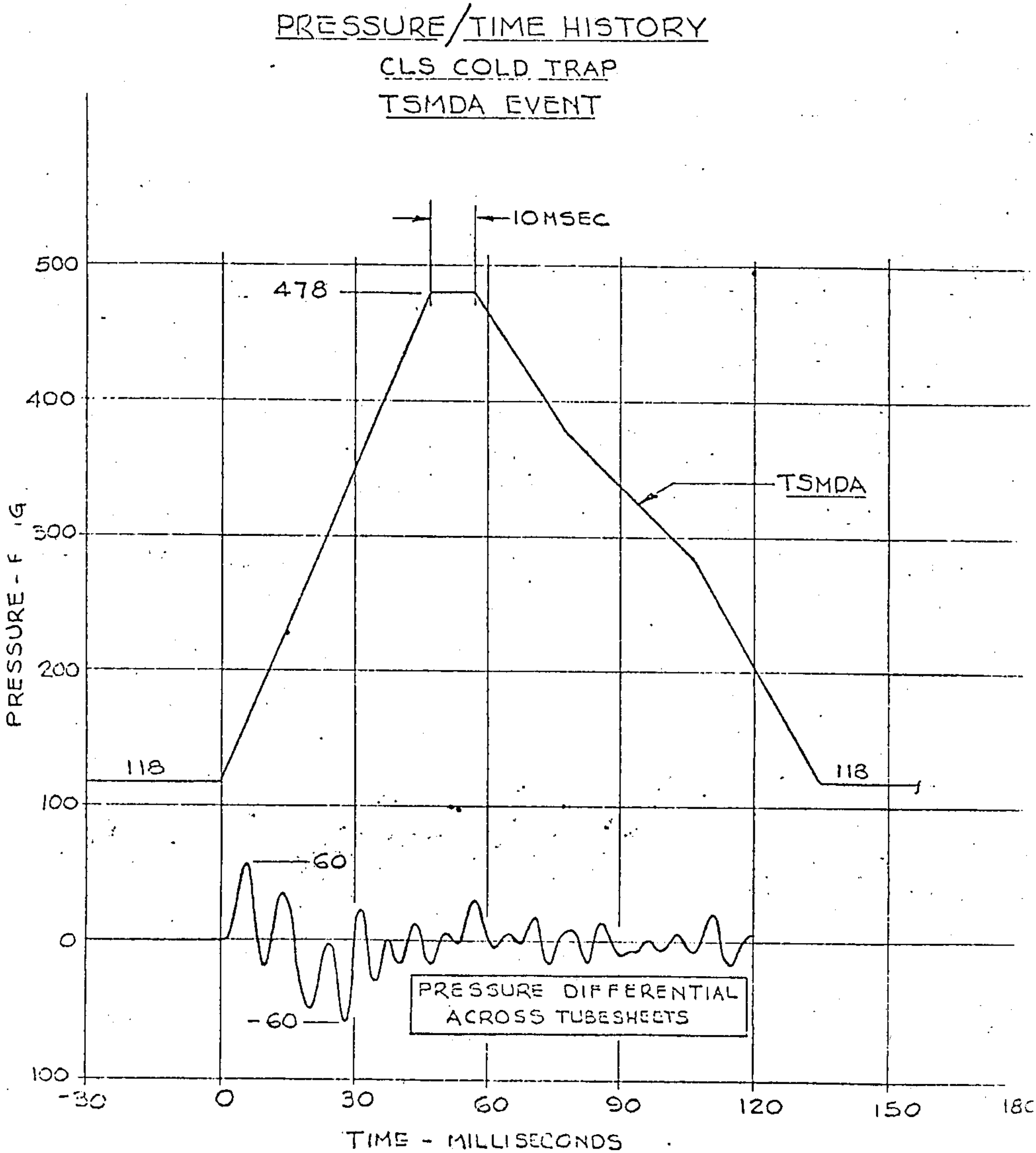

PRESSURE/TIME HISTORY
CLS COLD TRAP
TSMDA EVENT
10 MSEC
478
TSMDA
118
118
60
-60
PRESSURE DIFFERENTIAL ACROSS TUBESHEETS
500
400
300
200
100
0
100
PRESSURE - F IG
-30
0
30
60
90
120
150
180
TIME - MILLISECONDS

FIGURE 31

TABLE I [2]

COLD TRAP DESIGN CONDITIONS

COLD TRAP REQUIREMENTS	CRYSTALLIZER TANK SODIUM	COOLANT JACKET AIR	ECONOMIZER SHELL SIDE SODIUM	ECONOMIZER TUBE SIDE SODIUM
1. Total Flow Rate lb/hr	1390	(2300 max.) 2015*	1390	1390
2. Residence Time (min.)	> 5 Min.	---	Less than 30 sec.	---
3. Operating Temperatures, (°F)				
Inlet	295 (min)	60	1200	259*
Outlet	259*	92*	295 (min.)	1161*
Minimum	230			
4. Operating Pressure (psig)	118	---	118	118
5. Operating Pressure Drop (psig)				
Clean Trap	5	10 in. WG	--	--
Plugged Trap	20	10 in WG	--	--
6. Design Temperature, (°F)	1220	---	1220	1220
7. Design Pressure, PSIG				
Pressure at Design Temp.	150	---	150	150
Vacuum at 600°F	-15	---	-15	-15
8. Corrosion Allowance (in.)	See 3.2.1.4	---	See 3.2.1.4	See 3.2.1.4
9. Fouling Factor				
10. Code Design Requirements: ASME	Section III Class I	---	Section III Class I	Section III Class I
11. Materials of Construction	316 SS	316SS	316 SS	316 SS [2]
12. Nozzles, Size and Type	2 - 1"	---	2 - 1"	2 - 1"
13 Helium Leakage Rate Atm cc/sec	10^{-7}	10^{-7}	10^{-7}	10^{-7}

* Guidline Value Only - For Vendor Information

TABLE 1A

COLD TRAP ALTERNATE OPERATING CONDITION A

Cold Trap Requirements	Crystallizer Tank Sodium	Coolant Jacket Air	Economizer Shell Side Sodium	Economizer Tube Side Sodium
1. Total Flow Rate lb/hr	1390	(2300 max.) 675*	1390	1390
2. Residence Time	> 5 min.	--	Less than 30 sec.	--
3. Operating Temperatures:				
Inlet	255 (min.)	60	600	242*
Outlet	242*	96*	255 (min.)	586*
Minimum	230	--	--	--

TABLE 1B

COLD TRAP ALTERNATE OPERATING CONDITION B

Cold Trap Requirements	Crystallizer Tank Sodium	Coolant Jacket Air	Shell Side Sodium	Tube Side Sodium
1. Total Flow Rate lb/hr	2080	(2300 max.) 1770*	2080	2080
2. Residence Time	> 5 min.	--	Less than 30 sec.	--
3. Operating Temperatures:				
Inlet	261 (min.)	60	600	241*
Outlet	241*	91*	261 (min.)	579*
Minimum	230	--	--	--

* Guideline Only - for Vendor Information

TABLE 1 C

COLD TRAP ALTERNATE OPERATING CONDITIONS

	Cold Trap Requirements	Crystallizer Tank Sodium	Coolant Jacket Air	Shell Side Sodium	Tube Side Sodium
1.	Total Flow Rate (lb/hr)	1390	(2300 max) 2100*	1390	1390
2.	Residence Time	>5 min.	--	Less than 30 sec	--
3.	Operating Temp. (°F)				
	Inlet	282 (min.)	100	1000	254*
	Outlet	254*	124*	282 (min)	969*
	Minimum	230	--	--	--

*Guideline Only - for Vendor Information

TABLE II [2]

NORMAL STEADY STATE OPERATING CONDITIONS FOR COLD TRAP*

	Condition A	Condition B	Condition C	Condition D&E
Time at Condition (hrs)	13,250	39,800	6,625	28,625
Sodium Flow Rate (lb/hr)	1390	1390	1390	1390
Primary Location I				
Sodium Inlet Nozzle				
Temperature (°F)	1200	1200	1200	1000
Pressure (psig)	118	118	118	118
Sodium Outlet Nozzle				
Temperature (°F)	1165	1165	1165	965
Pressure (psig)	113	113	113	113
Primary Location II				
Sodium Inlet Nozzle				
Temperature (°F)	1020	820	1020	1020
Pressure (psig)	95	95	95	95
Sodium Outlet Nozzle				
Temperature (°F)	965	765	965	965
Pressure (psig)	90	90	90	90
Secondary Location I				
Sodium Inlet Nozzle				
Temperature (°F)	950	735	1015	1020
Pressure (psig)	97	97	97	97
Sodium Outlet Nozzle				
Temperature (°F)	895	680	960	965
Pressure (psig)	92	92	92	92

*During steady state operation the sodium temperatures and pressure will vary cyclically ± 10°F and ± 13.0 psi within a 2 hour period.

TABLE III [2]

TOTAL SHUTDOWNS FOR 10 YEARS

I.	SCRAMS		
	A. External to CLS		
	Reactor Scrams		247
	Upset and Emergency Scrams		63
	B. CLS Initiated Scrams		
	Normal	24	
	CLS Malfunction	19	
		43	43
II.	CONTROL ROD DROPS		10
III.	NORMAL SHUTDOWNS		59
IV.	TOTAL SHUTDOWNS		422
V.	NUMBER OF NON-NORMAL SHUTDOWNS		363

TABLE III-A [2]

NORMAL TRANSIENTS FOR: PRIMARY LOCATION I

(Primary Hot Leg Branch - Arm and Pipeway Piping; Cell primary Hot Leg. Piping, Outlet FM, IHX Inlet, Primary Sample Line Piping and Pump, Primary Cold Trap)

Event+	Temperature: °F Start	End	Operating ** Conditions	Maximum Rate and Duration of Transient
Normal	1200	350	A,B,C	-100°F/hr for full temperature difference
	1000	350	D, E	-100°F/hr for full temperature difference
Shutdown	350	Ambient	Preheat*	- 25°F/hr for full temperature difference
Normal	Ambient	350	Preheat*	+ 25°F/hr for full temperature difference
	350	1000	D, E	+100°F/hr for full temperature difference
Startup	350	1200	A,B,C	+100°F/hr for full temperature difference

* System Dry

\+ Each startup and shutdown above 350°F include a 1.0 °F/sec ramp for 50 seconds during any hour giving a to temperature change of 50°F such that the average rate of change over the entire startup or shutdown remains at 100°F/hr magnitude.

**References to operating conditions A, B, C, D, and E refer to the conditions listed in Table II.

TABLE III-B [2]

NORMAL TRANSIENTS FOR: PRIMARY LOCATION II

(IHX to Auxiliary Supply Tank: Line, Valve, and Tank Inlet; IHX Primary Outlet Nozzle; Primary Expansion Volume Tank; Cold Leg Main Line: Piping, Main Pump, FM Inlet and Mixing Tee, Check Valve; Cold Leg Auxiliary Line: Piping, FM, Auxiliary Pump, Check Valve, Inlet to Mixing Tee; Auxiliary Tank Outlet Nozzle; Inlet Nozzle; Cell Primary Cold Leg: Piping, Line Strainer, Inlet FM: Pipeway and Cold Leg Branch Arm Piping).

Event+	Temperature °F Start	End	Operating** Condition	Maximum Rate and Duration of Transient
Normal	1000	350	A,C,D,E	-100°F/hr for full temperature difference
Shutdown	800	350	B	-100°F/hr " " " "
	350	Ambient	Preheat*	- 25°F/hr " " " "
Normal	Ambient	350	Preheat	+ 25°F/hr for full temperature difference
Startup	350	800	B	+100°F/hr " " " "
	350	1000	A,C,D,E	+100°F/hr " " " "

* System Dry

\+ (See Primary Hot Leg)

** References to operating conditions A, B, C, D & E refer to the conditions listed in Table II.

TABLE III-C [2]

NORMAL TRANSIENTS FOR: SECONDARY LOCATION I

(DHX Sodium Outlet, Secondary Cold Leg: Piping, FM, Pump; Secondary IHX Inlet; Secondary Sample Line and Pump; Secondary Cold Trap and Cold Trap Line)

Event+	Temperature, °F Start	End	Operating** Condition	Maximum Rate and Duration of Transient
Normal	1000	350	D, E	-100°F/hr for full temperature difference
Shutdown	995	350	C	-100°F/hr for full temperature difference
	930	350	A	-100°F/hr for full temperature difference
	715	350	B	" " " " " "
	350	Ambient	Preheat*	- 25°F/hr " " " "
Normal	350	1000	D, E	+100°F/hr for full temperature difference
Startup	350	995	C	" " " " " " "
	350	930	A	" " " " " " "
	350	715	B	" " " " " " "
	Ambient	350	Preheat*	+ 25°F/hr " " " "

* System Dry
\+ (See Primary Hot Leg)
** Operating conditions A, B, C, D, and E refer to the conditions listed in Table II.

NOTE: The transients associated with conditions C and A may be assumed identical with those of conditions D, E for elastic analysis.

TABLE III-D [2]

PRESSURE TRANSIENTS

I. GENERAL PRESSURE TRANSIENTS

		Startup Start (PSIG)	Startup End (PSIG)	Shutdown Start (PSIG)	Shutdown End (PSIG)	# of Occurrences
	A. Primary System					
	1. Primary piping from CLIRA outlet to IHX inlet and sample line pump inlet, exit flow meter	0	92	92	0	422
PRIMARY LOCATION I	2. Sample line pump exit,	0	118	118	0	422
	3. Main line from IHX to main line pump, auxiliary line from IHX to auxiliary line pump, auxiliary tank; auxiliary line valves	0	65	65	0	422
	4. Main line from pump to mixing tee; main line FM and check valve; auxiliary line from pump to mixing tee; auxiliary line FM and check valve; ~~inlet FM; line from~~ mixing tee to CLIRA	0	333	333	0	422
PRIMARY LOCATION 2	5. Cold trap line from cold trap to IHX inlet	0	113	113	0	422
	6. PST	0	57	57	0	422
	B. Secondary System					
	1. Secondary line IHX	0	102	102	0	422
	2. Secondary line DHX outlet to pump inlet, secondary surge tank, secondary sample line pump inlet.	0	67	67	0	422

TABLE III-D (Con't)

GENERAL PRESSURE TRANSIENTS (Continued)

			Pressure (PSIG)				
			Startup		Shutdown		
			Start	End	Start	End	# of Occurrences
	3.	Secondary line from pump to IHX inlet	0	130	130	0	422
SECONDARY LOCATION II	4.	Secondary sample line pump exit, secondary cold trap inlet	0	97	97	0	422
	5.	Secondary cold trap outlet	0	92	92	0	422

C. Primary System Fill

		Pressure (PSIG)		
		Vacuum	Na Fill	# of Occurrences
1.	Primary system except auxiliary tank, drain tank, and cold trap	0 to -14.7	-14.7 to 0	59

TABLE IV [2]
CLS DESIGN EVENTS

Item	Event	Classification	Number of Occurrences	Does Event Result in Shutdown	Number of Non-Normal Shutdowns	Reference † *** for Thermal and Flow Transient	Reference for Pressure Transient
1	Reactor power signal failure resulting in low test flow (scram on power to flow ratio)	Upset	1	yes	1	Appendix I, U13 or U14	Table VII, I
2	Scram with full primary flow	Upset	1	yes	1	Appendix I, U3 or U4	Table VII, I
3	Scram with full secondary flow	Upset	1	yes	1	Appendix I, U5 or U6	Table VII, I
4	Scram with full air flow	Upset	1	yes	1	Appendix I, U7	Table VII, I
5	Scram with full flows	Upset	1	yes	1	Appendix I, U1 or U2	Table VII, I
6	Increase in air flow	Upset	1	yes	1	Appendix I, U12	Table VII, I
7	Control rod drop	Upset	10	yes	10	Appendix I, U13 or U14	Table VII, I
8	Loss of air flow	Upset	4	yes	4	Appendix I, U10 or U11	Table VII, I
9	Loss of secondary flow	Upset	8	yes	8	Appendix I, U8 or U9	Table VII, I
10	Normal Scram	Upset	321	yes	321	Appendix I, U13 or U14	Table VII, I
11	Partial flow blockage in primary	Upset	1	yes	1	Appendix I, U13 or U14	Table VII, I
12	Leak in CLIRA flow tube	Upset	1	yes	1	Appendix I, U13 or U14	Table VII, I
13	Fuel Meltdown (TSMDA)	Upset*	3	yes	3	Appendix I, U13 or U14	Table VII, II 1
14	Loss of one Primary Pump with Check Valve Failure	Upset	1	yes	1	Appendix I, Page 2 and U13 or U14	Table VII, I
15	Loss of one Primary Pump	Upset	4	no	NA	NA	Table VII, II 2
16	Loss of DHX Preheater	Upset	1	no	NA	NA	NA
17	OBE + Normal Scram	Upset	3	yes	3	Appendix I, U13 or U14	Table VII, I
18	DBE + Normal Scram	Faulted**	1	yes	NA	Appendix I, U13 or U14	Table VII, I
19	OBE + Scram with full Primary Flow	Emergency	1	yes	1	Appendix I, U3 or U4	Table VII, I
20	Tornado	Faulted**	1	yes	NA	Appendix I, U8 or U9	Table VII, I
21	HCDA	Faulted**	1	yes	NA	Appendix I, U13 or U14	Table VII, II 4
22	Hot Drain Primary and Secondary	Upset	3	yes	3	Appendix I, Page 2 and U13 or U14	Table VII, I
23	Freezing and Remelting in Primary Plus Drain Tank Overheating Accident	Upset	1	no	NA	Appendix II	NA
24	Freezing and Remelting in Secondary	Upset	1	no	NA	Appendix II	NA
25	Maintenance in Primary (System is dry at ambient and drain and auxiliary tanks contain frozen sodium)	Upset	5	no	NA	Appendix II	NA
26	IHX Leak	Upset	1	yes	1	Appendix I, U13 or U14	Table VII, II 3
	TOTAL				363		

* The TSMDA is classified as an upset condition to allow operation of the system after a TSMDA without downtime for repair and requalification. If an undue penalty is put on any component such as the IHX, the event may be reclassified as emergency provided technical data on analysis is available to support such a recommendation. It must be recognized that this will impose availability penalties on the system if and when a TSMDA occurs.

** These events are terminal events and must be considered in design. The system is required to be leak tight after Items 18 and 20. They are not listed as causing non-normal shutdowns and they are not listed in the load history (Table VII).

*** When a choice is given between "U" number, the worst case should be used for analysis.

† Internal CLIRA transients are calculated by ARD.

TABLE IV-A [2]

REDUCED SYSTEM EVENTS

Because of the similarity of transient curves in the system piping and components, the following events listed in Table IV may be combined and analyzed for thermal considerations as normal scrams:

Item (from Table IV)	Number of Occurrences
1	1
7	10
11	1
12	1
13	3
14	1
26*	1

Item 22 has no special characteristics for cold traps and is included in Item 10.

Thus number of normal scrams for thermal considerations for the CLS is:

$$321 + 18 = 339$$

Consequently, no separate thermal transients are given in Appendix I for the above items. Transient curves U13 and U14 shall be used.

---

* Event includes pressure pulse as identified in Table III-D.

TABLE IV-B [2]

DESIGN TRANSIENTS FOR COLD TRAP INLET NOZZLE

Item		Number of Occurrences	Category
2	Scram with Full Primary Flow U3, U4	1	Upset
3	Scram with Full Secondary Flow U5, U6	1	Upset
4	Scram with Full Air Flow U7	1	Upset
5	Scram with Full Flows U1, U2	1	Upset
6	Increase in Air Flow U12	1	Upset
8	Loss of Air Flow U10, U11	4	Upset
9	Loss of Secondary Flow U8, U9*	9	Upset
10	Normal Scram U13, U14	339	Upset
17	Normal Scram + OBE	2	Upset
18	DBE + Normal Scram	1	Faulted
19	OBE + Scram with Full Primary Flow	1	Emergency
23, 24, 25	Freezing and Remelting (See below)	6	Upset

NOTE: Transient information is listed in Appendix I as follows:

Location	Temperature	Sample Pump Flow(GPM)	Cold Trap Flow (lb/hr)
Primary Loc. I		13	1390
Primary Loc. II		13	1390
Sec. Loc. I		13	1390

* The tornado case was combined with loss of secondary flow for thermal transient specification.

Item	Transient
15	Included in normal shutdown - See histogram
16	Included in normal shutdown - See historgram
20	Combined with loss of secondary flow Item 9
21	Not required for cold traps
22	Included in Item 10
23,24 & 25	A freezing and remelting procedure is specified as follows: trap at 350°F with liquid sodium; trap cooled to ambient (sodium freezes), trap heated back to 350°F, rate up or down will not exceed 50°F/hour
26	IHX leak (pressure transient) See Table V.

TABLE V [2]

NOZZLE LOADS FOR DESIGN CONDITIONS

Nozzle Description	Pipe Nom. Dia. (in.)	Pipe Schd.	Mat'l	DESIGN MECHANICAL LOADS: Thermal Expansion Loads					Other Mechanical Loads			
				Temp. Range	Lbs.		In. Lbs.		Lbs.		In. Lbs.	
				70°F-___°F	F_A	F_L	M_T	M_B	F_A	F_L	M_T	M_B
Cold Trap Economizer Inlet	1.0	40	316SS	1220	224	173	387	651	10	10	40	70
Cold Trap Economizer Outlet	1.0	40	316SS	1220	289	215	504	835	10	10	50	90

NOZZLE LOAD NOTES

1. The loads given are the end loads imposed on the nozzle or component by the piping.
   The following is an explanation of the application of the loads.
   a. F_A is the axial force on the nozzle or component.
   b. F_L is the lateral force on the nozzle or component in the lateral direction which will produce the worst design condition. i.e., $F_L = \sqrt{F_{L_1}^2 + F_{L_2}^2}$
   c. M_T is the torsional moment applied around the axis of the nozzle or component.
   d. M_B is the bending moment on the nozzle or component applied in the direction which will produce the worst design condition, i.e., $M_B = \sqrt{M_{B_1}^2 + M_{B_2}^2}$
   e. The direction ($\pm$) of each load must be chosen so as to produce the worst design condition.
2. The effect of the longitudinal pressure stress is not included in the load table. Add $F_A = 0.7854\ PD^2$, where P = Pressure (Psi) D = I.D (inches).

TABLE VB [2]

NOZZLE LOADS FOR NORMAL OPERATING, UPSET AND EMERGENCY CONDITIONS

Nozzle Description	Pipe Nom. Dia. (in.)	Pipe Schd.	Mat'l	MECHANICAL LOADS: Thermal Expansion Loads (3): Temp. Range 70°F-___°F	Thermal Expansion Loads (3): lbs. F_A	lbs. F_L	in. lbs. M_T	in. lbs. M_B	Dead Weight Loads: lbs. F_A	lbs. F_L	in. lbs. M_T	in. lbs. M_B	OBE Seismic Loads (4): lbs. F_A	lbs. F_L	in. lbs. M_T	in. lbs. M_B
Cold Trap Economizer Inlet	1.0	40	316SS	1200	220	170	350	640	10	10	40	70	60	80	130	210
Cold Trap Economizer Outlet	1.0	40	316SS	1165	275	205	480	795	10	10	50	90	70	100	160	265

NOZZLE LOAD NOTES

1. The loads given are the end loads imposed on the nozzle or component by the piping.

   The following is an explanation of the application of the loads.

   a. F_A is the axial force on the nozzle or component.

   b. F_L is the lateral force on the nozzle or component in the lateral direction which will produce the worst design condition, i.e., $F_L = \sqrt{F_{L_1}^2 + F_{L_2}^2}$

   c. M_T is the torsional moment applied around the axis of the nozzle or component.

   d. M_B is the bending moment on the nozzle or component applied in the direction which will produce the worst design condition, i.e., $M_B = \sqrt{M_{B_1}^2 + M_{B_2}^2}$

   e. The direction (±) of each load must be chosen so as to produce the worst design condition.

2. The effect of the longitudinal pressure stress is not included in the load table. Add $F_A = 0.7854\ PD^2$, where P = Pressure (Psi) D = I.D. (inches).

3. Restrained thermal expansion loads for ranges of temperature other than the normal operating temperature shall be obtained by linear extrapolation,

   E.G., $L_2 = \frac{\Delta T_2}{\Delta T_1} L_1$ where:

   ΔT_1 and L_1 are the temperature range and force or moment given in the table and ΔT_2 and L_2 are the new temperature range and the corresponding load. The nozzle loads due to dead weight and seismic effects are independent of temperature. The nozzle loads given in the table shall apply for primary loads at temperature less than normal operating temperature.

4. Nozzle loads due to seismic effects are not to be included in evaluating the nozzle for Normal Operating Conditions.

TABLE VA [2]

NOZZLE LOADS FOR FAULTED CONDITIONS

Nozzle Description	Pipe Nom. Dia. (in.)	Pipe Schd.	Mat'l	MECHANICAL LOADS: Thermal Expansion Loads (3): Temp. Range 70°F-___°F	Thermal Expansion: lbs. F_A	Thermal Expansion: lbs. F_L	Thermal Expansion: in. lbs. M_T	Thermal Expansion: in. lbs. M_B	Dead Weight Loads: lbs. F_A	Dead Weight: lbs. F_L	Dead Weight: in. lbs. M_T	Dead Weight: in. lbs. M_B	DBE Seismic Loads: lbs. F_A	DBE Seismic: lbs. F_L	DBE Seismic: in. lbs. M_T	DBE Seismic: in. lbs. M_B
Cold Trap Economizer Inlet	1.0	40	316SS	1200	220	170	380	640	10	10	40	70	108	144	234	378
Cold Trap Economizer Outlet	1.0	40	316SS	1165	275	205	480	795	10	10	50	90	126	180	288	477

NOZZLE LOAD NOTES

1. The loads given are the end loads imposed on the nozzle or component by the piping.

   The following is an explanation of the application of the loads.

   a. F_A is the axial force on the nozzle or component.

   b. F_L is the lateral force on the nozzle or component in the lateral direction which will produce the worst design condition, i.e., $F_L = \sqrt{F_{L_1}^2 + F_{L_2}^2}$

   c. M_T is the torsional moment applied around the axis of the nozzle or component.

   d. M_B is the bending moment on the nozzle or component applied in the direction which will produce the worst design condition, i.e., $M_B = \sqrt{M_{B_1}^2 + M_{B_2}^2}$

   e. The direction (±) of each load must be chosen so as to produce the worst design condition.

2. The effect of the longitudinal pressure stress is not included in the load table. Add $F_A = 0.7854\ PD^2$, where P = Pressure (Psi) D = I.D. (inches).

3. Restrained thermal expansion loads for ranges of temperature other than the normal operating temperature shall be obtained by linear extrapolation

   E.G., $L_2 = \frac{\Delta T_2}{\Delta T_1} L_1$ where:

   ΔT_1 and L_1 are the temperature range and force or moment given in the table and ΔT_2 and L_2 are the new temperature range and the corresponding load. The nozzle loads due to dead weight and seismic effects are independent of temperature. The nozzle loads given in the table shall apply for primary loads at temperature less than normal operating temperature.

TABLE VI

DRAWING SUBMITTAL REQUIREMENTS OF HWS-1880

1. The following documents shall be submitted to the purchaser for the indicated purpose at the time indicated.
2. The listed documents do not include all documentation required to be generated by the supplier.
3. Documentation not required for submittal shall be made available to the purchaser upon request.

ITEM	DESCRIPTION	NO. OF REPRODUCIBLE DOCUMENTS REQUIRED	COPIES	REFERENCE PARAGRAPH OF RDT E4-5	SUBMIT TO PURCHASER FOR APPROVAL	SUBMIT TO PURCHASER FOR INFO.	TIME FOR SUBMITTAL TO PURCHASER
1	Assembly Drawings	2	4	3.5.1			
	Initial Submittal				X		2 months after contract award
	Final Submittal				X		1 month after completion of final design
2	Detail Drawings	2	4	3.5.2		X*	4 weeks prior to start of fabrication [2
3	Drawings and Specification List	2	4	3.5.3		X	Monthly
4	Outline Drawings (Major Drawings)	6				X	6 weeks after award of contract

* Although detail drawings are to be submitted to Purchaser "for information", Purchaser reserves right of approval.

TABLE VII

REPORTS AND DOCUMENTS SUBMITTAL REQUIREMENTS OF HWS-1880

1. The following documents shall be submitted to the purchaser for the indicated purpose at the time indicated.
2. The listed documents do not include all documentation required to be generated by the supplier.
3. Documentation not required for submittal shall be made available to the purchaser upon request.

ITEM	DESCRIPTION	NO. OF REPRODUCIBLE DOCUMENTS REQUIRED	COPIES	REFERENCE PARAGRAPH OF RDT E4-5	SUBMIT TO PURCHASER FOR APPROVAL	SUBMIT TO PURCHASER FOR INFO.	TIME FOR SUBMITTAL TO PURCHASER
1	Assembly Procedures	2	4	3.4.6		X	1 month prior to use
2	Design Reports						
	(a) Preliminary	2	4	3.7.1	X		2 months after contract award
	(b) Final	2	4	3.7.1	X		Prior to fabrication for that part
3	QA Program Plan	2	4	3.7.2.1	X		1 month after contract award
4	Inspection and Test Plan	2	4	3.7.2.2	X		1 month Prior to fabrication release
5	Special Process Control and Nondestructive Examination Procedures	2	4	3.7.2.3	X		1 month prior to use
6	Inspection and Test Procedures	2	4	3.7.2.4	X		1 month prior to use
7	Nonconforming Item Documentation	2	4	3.7.2.5	X		1 month Prior to proceeding

TABLE VII (continued)

ITEM	DESCRIPTION	NO. OF REPRODUCIBLE DOCUMENTS REQUIRED	COPIES	REFERENCE PARAGRAPH OF RDT E4-5	SUBMIT TO PURCHASER FOR APPROVAL	SUBMIT TO PURCHASER FOR INFO.	TIME FOR SUBMITTAL TO PURCHASER
8	Handling, Preservation, Packaging, and Storage Procedures	2	4	3.7.2.6	X		1 month prior to use
9	Proposed New Design Criteria	2	4	3.7.2.7	X		Upon identification
10	Design Descriptions	2	4	3.7.2.8	X		At the completion of final design
11	Quality Records	2	4	3.7.2.9	X		Prior to purchaser acceptance for shipment
12	Parts List	6		3.7	X		Start of fabrication of individual Parts
13	Progress Report			3.7	X		Monthly
14	Operation & Maintenance Instructions Outline	6		3.7	X		Prior to Purchaser acceptance for shipment
15	Repair Parts and Special Tools List	6		3.7	X		At completion of final design
16	Final Report				X		Two months after final acceptance
17	Project Plan				X		One month after contract award

TABLE VIII LOAD HISTORY FOR CLOSED LOOP SYSTEM FOR 10 YEARS

t < 0.0

Event[+] #	Description	t	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
0.1	Component Testing	0					
0.2	Component Shipping	0					
0.3	System Test Pneumatic	0					
0.4	Closed Loop Module Shipping & Installation	0					
0.5	Preheat	0	Ambient, Argon in System	Ambient Vacuum	negligible	T = 350 Vacuum	1
0.6	Na Fill	0	T = 350 Vacuum	Sodium Fill	negligible	T = 350 Sodium at 14.7 psia	1

NOTE: PCLDI testing has not been included. This load history is for plant units only.

+ The number preceding the decimal indicates the year number. The events are listed in chronological order.

t = 0.0 -- 1.0 yrs

NSU = Normal Startup
NSD = Normal Shutdown
NS_c = Normal Scram

a		b	c	d	e	f	g
Event #	Description+	Initiation Time (Yrs)	Starting Condition	Intermediate Condition**	Duration at Intermediate Condition	Final Condition	# of Occurrence
1.1	NSU #7	0.	T = 350°	A/B/C/D	Each normal	T = 350	1
1.2	NSU #8	0.	T = 350	A/B/C/D	startup to	T = 350	1
1.3	NSU #9	0.	T = 350	A/B/C/D	Conditions	T = 350	1
1.4	NSU #13	0.	T = 350	A/B/C/D	A, B, C or	T = 350	1
1.5	NSU #17 (OBE)	0.	T = 350	A/B/C/D	D is followed	T = 350	1
1.6	NSU #15 (NSD)	0.	T = 350	A/B/C/D + press. trans.	by 177 hrs of operation.	T = 350	1
1.7	NSU #22	0.	T = 350	A/B/C/D		T = 350 sec pri & drained	1
1.8	Na Fill Secondary	0.	T = 350 pri & sec.drained	--		T = 350	1
1.9	NSU #10	0.	T = 350	A/B/C/D		T = 350	1
..10	Na Fill Primary	0.	T = 350 pri.drained	--		T = 350	1
1.11	#25	0.	T = 350	Pipes dry, T = amb. Tanks frozen, T = amb.		T = 350 Pipes Full	1
1.12	NSU NS_c (#10)	0.	T = 350	A/B/C/D		T = 350	1
1.13	Na Refill Seq.*	0.	T = 350	Pri.Dry Amb. Sec T = 350		T = 350	1
1.14	NSU NSD	0.	T = 350	A/B/C/D		T = 350	1
1.15	Na Refill Seq.*	0.	T = 350	Pri.Dry Amb. Sec T = 350		T = 350	1
1.16	NSU NSD	0.	T = 350	A/B/C/D		T = 350	1
1.17	Na Refill Seq.*	0.	See above	--		T = 350	1
1.18	NSU NSD	0.	T = 350	A/B/C/D		T = 350	1
1.19	Na Refill Seq.*	0.	See above	--		T = 350	1
1.20...							
.28	NSU NS_c(#10)	0.	T = 350	A/B/C/D	↓	T = 350	9
1.29...							

t = 0.0 1.0 yrs

NSU = Normal Startup
NSD = Normal Shutdown
NS_c = Normal Seram

Event #	Description+		Initiation Time (Yrs)	Starting Condition	Intermediate Condition**	Duration at Intermediate Condition	Final Condition	# Occurrences
1.55	NSU	NS_c(#10)	0.	T = 350	A/B/C/D	Each normal	T = 350	27
1.56	NSU	NSD	0.	T = 350	A/B/C/D	startup to	T = 350	1
1.57	Na Refill Seq.*		0.	See above	---	Conditions	T = 350	1
1.58	NSU	NSD	0.	T = 350	A/B/C/D	A, B, C or	T = 350	1
1.59	Na Refill Seq.*		1.00	See above	---	D is followed by 177 hrs of operation.	T - 350	1

* See discussion under Normal Transients.

** Each normal startup should terminate at the worst operating condition. In some cases this will be the highest temperature or pressure. However, severe transients for a particular component or location may start at a lower temperature or pressure. The normal startup for this event should be to the operating condition corresponding to the lower temperature or pressure.

\+ The number listed refers to Table V.

= 1.0 ⟶ 2.0 yrs

NSU = Normal Startup
NSD = Normal Shutdown
NS_c = Normal Scram

Event #	Description		Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
2.1	NSU	#7	1.	T = 350	A/B/C/D	Each normal	T = 350	1
2.2	NSU	#9	1.	T = 350	A/B/C/D	startup to	T = 350	1
2.3	NSU	NS_c(#10)	1.	T = 350	A/B/C/D	conditions	T = 350	1
2.4	Na Refill Seq.*		1.	T = 350	Pri: Dry Amb Sec: T = 350	A, B, C, or D is followed	T = 350	1
2.5	NSU	NSD	1.	T = 350	A/B/C/D	by 220 hrs of	T = 350	1
2.6	Na Refill Seq.*		1.	T = 350	Pri: Dry Amb Sec: T = 350	operation.	T = 350	1
2.7	NSU	NSD	1.	T = 350	A/B/C/D	↓	T = 350	1
2.8	Na Refill Seq.*		1.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
2.9	NSU	NSD	1.	T = 350	A/B/C/D		T = 350	1
10	Na Refill Seq.*		1.	See above	--		T = 350	1
2.11	NSU	NSD	1.	T = 350	A/B/C/B		T = 350	1
2.12	Na Refill Seq.*		1.	See above	--		T = 350	1
2.13...2.20	NSU	NS_c(#10)	1.	T = 350	A/B/C/D		T = 350	8
2.21...2.43	NSU	NS_c(#10)	1.	T = 350	A/B/C/D		T = 350	23
2.44	NSU	NSD	1.	T = 350	A/B/C/D		T = 350	1
2.45	Na Refill Seq.*		1.	See above	--		T = 350	1
2.46	NSU	NSD	1.	T = 350	A/B/C/D		T = 350	1
2.47	Na Refill Seq.*		2.00	See above	--	↓	T = 350	1

t = 2.0 → 3.0 yrs

Event #	Description		Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
3.1	NSU	#7	2.	T = 350*	A/B/C/D	Each normal	T = 350	1
3.2	NSU	#9	2.	T = 350	A/B/C/D	startup to	T = 350	1
3.3	#25		2.	T = 350	Pipes Dry: T = Amb. Tank Frozen, T = Amb.	Conditions A, B, C, or D is followed	T = 350 Pipes Full	1
3.4	NSU	NS_c (#10)	2.	T = 350	A/B/C/D	by 220 hrs of	T = 350	1
3.5	Na Refill Seq.*		2.	T = 350	Pri: Dry Amb Sec: T = 350	operation. ↓	T = 350	1
3.6	NSU	NSD	2.	T = 350	A/B/C/D		T = 350	1
3.7	Na Refill Seq.*		2.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
3.8	NSU	NSD	2.	T = 350	A/B/C/D		T = 350	1
3.9	Na Refill Seq.*		2.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
3.10	NSU	NSD	2.	T = 350	A/B/C/D		T = 350	1
3.11	Na Refill Seq.*		2.	See above	--		T = 350	1
3.12	NSU	NSD	2.	T = 350	A/B/C/D		T = 350	1
3.13	Na Refill Seq.*		2.	See above	--		T = 350	1
3.14... 3.21	NSU	NS_c (#10)	2.	T = 350	A/B/C/D		T = 350	8
3.22... 3.44	NSU	NS_c (#10)	2.	T = 350	A/B/C/D		T = 350	23
3.45	NSU	NSD	2.	T = 350	A/B/C/D		T = 350	1
3.46	Na Refill Seq.*		2.	See above	--		T = 350	1
3.47	NSU	NSD	2.	T = 350	A/B/C/D		T = 350	1
3.48	Na Refill Seq.*		3.00	See above	--	↓	T = 350	1

t = 3.0 → 4.0 yrs

Event #	Description	Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
4.1	NSU #7	3.	T = 350	A/B/C/D	Each normal	T = 350	1
4.2	NSU #8	3.	T = 350	A/B/C/D	startup to	T = 350	1
4.3	NSU #15 NSD	3.	T = 350	A/B/C/D + press.trans.	Conditions A, B, C or	T = 350	1
4.4	NSU NS_c (#10)	3.	T = 350	A/B/C/D	D is followed	T = 350	1
4.5	Na Refill Seq.*	3.	T = 350	Pri: Dry Amb Sec: T = 350	by 220 hrs of	T = 350	1
4.6	NSU NSD	3.	T = 350	A/B/C/D	operation.	T = 350	1
4.7	Na Refill Seq.*	3.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
4.8	NSU NSD	3.	T = 350	A/B/C/D		T = 350	1
4.9	Na Refill Seq.*	3.	See above	--		T = 350	1
4.10	NSU NSD	3.	T = 350	A/B/C/D		T = 350	1
4.11	Na Refill Seq.*	3.	See above	--		T = 350	1
4.12...4.19	NSU NS_c (#10)	3.	T = 350	A/B/C/D		T = 350	8
4.20...4.42	NSU NS_c (#10)	3.	T = 350	A/B/C/D		T = 350	23
4.43	NSU NSD	3.	T = 350	A/B/C/D		T = 350	1
4.44	Na Refill Seq.*	3.	See above			T = 350	1
4.45	NSU NSD	3.	T = 350	A/B/C/D		T = 350	1
4.46	Na Refill Seq.*	4.00	See above	--		T = 350	1

t = 4.0 → 5.0 yrs

Event #	Description	Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
5.1	NSU #7	4.	T = 350	A/B/C/D	Each normal	T = 350	1
5.2	NSU #9	4.	T = 350	A/B/C/D	startup to	T = 350	1
5.3	NSU NS_c (#10)	4.	T = 350	A/B/C/D	Conditions	T = 350	1
5.4	Na Refill Seq.*	4.	T = 350	Pri: Dry Amb Sec: T = 350	A, B, C or D is followed	T = 350	1
5.5	NSU NSD	4.	T = 350	A/B/C/D	by 220 hrs of	T = 350	1
5.6	Na Refill Seq.*	4.	T = 350	Pri: Dry Amb Sec: T = 350	operation.	T = 350	1
5.7	NSU NSD	4.	T = 350	A/B/C/D	↓	T = 350	1
5.8	Na Refill Seq.*	4.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
5.9	NSU NSD	4.	T = 350	A/B/C/D		T = 350	1
5.10	Na Refill Seq.*	4.	See above	--		T = 350	1
5.11	NSU NSD	4.	T = 350	A/B/C/D		T = 350	1
5.12	Na Refill Seq.*	4.	See above	--		T = 350	1
5.13...5.20	NSU NS_c (#10)	4.	T = 350	A/B/C/D		T = 350	8
5.21...5.43	NSU NS_c (#10)	4.	T = 350	A/B/C/D		T = 350	23
5.44	NSU NSD	4.	T = 350	A/B/C/D		T = 350	1
5.45	Na Refill Seq.*	4.	See above	--		T = 350	1
5.46	NSU NSD	4.	T = 350	A/B/C/D		T = 350	1
5.47	Na Refill Seq.*	5.0	See above	--	↓	T = 350	1

t = 5.0 → 6.0 yrs

Event #	Description		Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
6.1	NSU	#1	5.	T = 350°	A/B/C/D	Each normal	T = 350	1
6.2	NSU	#2	5.	T = 350	A/B/C/D	startup to	T = 350	1
6.3	NSU	#3	5.	T = 350	A/B/C/D	Conditions	T = 350	1
6.4	NSU	#4	5.	T = 350	A/B/C/D	A, B, C, or	T = 350	1
6.5	NSU	#5	5.	T = 350	A/B/C/D	D is followed	T = 350	1
6.6	NSU	#6	5.	T = 350	A/B/C/D	by 180 hrs of	T = 350	1
6.7	NSU	#7	5.	T = 350	A/B/C/D	operation.	T = 350	1
6.8	NSU	#9	5.	T = 350	A/B/C/D	↓	T = 350	1
6.9	NSU	#11	5.	T = 350	A/B/C/D		T = 350	1
6.10	NSU	#12	5.	T = 350	A/B/C/D		T = 350	1
6.11	NSU	#13	5.	T = 350	A/B/C/D		T = 350	1
6.12	NSU	#14	5.	T = 350	A/B/C/D		T = 350	1
6.13	NSU	NSD #16	5.	T = 350	A/B/C/D		T = 350	1
6.14	NSU	#19(ODE + #2)	5.	T= 350	A/B/C/D		T = 350	1
6.15	NSU	#10	5.	T = 350	A/B/C/D		T = 350	1
6.16	NSU	#17	5.	T = 350	A/B/C/D		T = 350	1
6.17	NSU	#22	5.	T = 350	A/B/C/D		T = 350 Sec Pri. & Drained	1
6.18	Na Fill Sec.		5.	T = 350 Pri. & Sec Drained	--		T = 350	1
6.19	NSU	#26	5.	T = 350	A/B/C/D		T = 350	1
6.20	Na Fill Primary		5.	T = 350 Pri Drained	--		T = 350	1
6.21	#25		5.	T = 350	Pipes Dry: T = Amb. Tanks Frozen T = Amb.		T = 350 Pipes Full	1
6.22	#23		5.	T = 350	All Pri. Na Frozen		T = 350	1
6.23	#24		5.	T = 350	All Sec. Na Frozen		T = 350	1
24	NSU	NS_c (#10)	5.	T = 350	A/B/C/D		T = 350	1
6.25	Na Refill Seq.*		5.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
6.26	NSU	NSD	5.	T = 350	A/B/C/D		T = 350	1
6.27	Na Refill Seq.*		5.	T = 350	Pri: Dry Amb Sec: T = 350	↓	T = 350	1

Event #	Description		Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
6.28	NSU	NSD	5.	T = 350	A/B/C/D	Each normal	T = 350	1
6.29	Na Refill Seq.*		5.	See above	--	startup to	T = 350	1
6.30	NSU	NSD	5.	T = 350	A/B/C/D	Conditions	T = 350	1
6.31	Na Refill Seq.*		5.	See above	--	A, B, C, or	T = 350	1
6.32...6.37	NSU	NS_c (//10)	5.	T = 350	A/B/C/D	D is followed by 180 hrs of	T = 350	6
6.38...6.56	NSU	NS_c (//10)	5.	T = 350	A/B/C/D	operation.	T = 350	19
6.57	NSU	NSD	5.	T = 350	A/B/C/D	↓	T = 350	1
6.58	Na Refill Seq.*		5.	See above	--	↓	T = 350	1
6.59	NSU	NSD	5.	T = 350	A/B/C/D	↓	T = 350	1
6.60	Na Refill Seq.*		6.	See above	--	↓	T = 350	1

t = 6.0 → 7.0 yrs

Event #	Description	Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
7.1	NSU #7	6.	T = 350	A/B/C/D	Each normal	T = 350	1
7.2	NSU #8	6.	T = 350	A/B/C/D	startup to	T = 350	1
7.3	NSU #15 NSD	6.	T = 350	A/B/C/D + Press.Trans.	Conditions	T = 350	1
7.4	NSU NS_c(#10)	6.	T = 350	A/B/C/D	A, B, C, or D is followed	T = 350	1
7.5	Na Refill Seq.*	6.	T = 350	Pri: Dry Amb Sec: T = 350	by 220 hrs of	T = 350	1
7.6	NSU NSD	6.	T = 350	A/B/C/D	operation.	T = 350	1
7.7	Na Refill Seq.*	6.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
7.8	NSU NSD	6.	T = 350	A/B/C/D		T = 350	1
7.9	Na Refill Seq.*	6.	See above	--		T = 350	1
7.10	NSU NSD	6.	T = 350	A/B/C/D		T = 350	1
7.11	Na Refill Seq.*	6.	See above	--		T = 350	1
7.12...7.19	NSU NS_c(#10)	6.	T = 350	A/B/C/D		T = 350	8
7.20...7.42	NSU NS_c(#10)	6.	T = 350	A/B/C/D		T = 350	23
7.43	NSU NSD	6.	T = 350	A/B/C/D		T = 350	1
7.44	Na Refill Seq.*	6.	See above	--		T = 350	1
7.45	NSU NSD	6.	T = 350	A/B/C/D	↓	T = 350	1
7.46	Na Refill Seq.*	7.0	See above	--		T = 350	1

t = 7.0 → 8.0 yrs

Event #	Description		Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
8.1	NSU	#7	7.	T = 350°	A/B/C/D	Each normal	T = 350	1
8.2	NSU	#9	7.	T = 350	A/B/C/D	startup to	T = 350	1
8.3	#25		7.	T = 350	Pipes Dry: T = Amb. Tank Frozen, T = Amb.	Conditions A, B, C, or D is followed	T = 350 Pipes Full	1
8.4	NSU	NS_c(#10)	7.	T = 350	A/B/C/D	by 220 hrs of	T = 350	1
8.5	Na Refill Seq.*		7.	T = 350	Pri: Dry Amb Sec: T = 350	operation.	T = 350	1
8.6	NSU	NSD	7.	T = 350	A/B/C/D	↓	T = 350	1
8.7	Na Refill Seq.*		7.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
8.8	NSU	NSD	7.	T = 350	A/B/C/D		T = 350	1
8.9	Na Refill Seq.*		7.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
8.10	NSU	NSD	7.	T = 350	A/B/C/D		T = 350	1
8.11	Na Refill Seq.*		7.	See above	--		T = 350	1
8.12	NSU	NSD	7.	T = 350	A/B/C/D		T = 350	1
8.13	Na Refill Seq.*		7.	See above	--		T = 350	1
8.14...8.21	NSU	NS_c(#10)	7.	T = 350	A/B/C/D		T = 350	8
8.22...8.44	NSU	NS_c(#10)	7.	T = 350	A/B/C/D		T = 350	23
8.45	NSU	NSD	7.	T = 350	A/B/C/D		T = 350	1
8.46	Na Refill Seq.*		7.	See above	--		T = 350	1
8.47	NSU	NSD	7.	T = 350	A/B/C/D		T = 350	1
8.48	Na Refill Seq.*		8.	See above	--	↓	T = 350	1

t = 8.0 → 9.0 yrs

Event #	Description		Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
9.1	NSU	#7	8.	T = 350°	A/B/C/D	Each normal	T = 350	1
9.2	NSU	#9	8.	T = 350	A/B/C/D	startup to	T = 350	1
9.3	NSU	NS_c (#10)	8.	T = 350	A/B/C/D	Conditions	T = 350	1
9.4	Na Refill Seq.*		8.	T = 350	Pri: Dry Amb Sec: T = 350	A, B, C, or	T = 350	1
						D is followed		
9.5	NSU	NSD	8.	T = 350	A/B/C/D	by 220 hrs of	T = 350	1
9.6	Na Refill Seq.*		8.	T = 350	Pri: Dry Amb Sec: T = 350	operation.	T = 350	1
9.7	NSU	NSD	8.	T = 350	A/B/C/D	↓	T = 350	1
9.8	Na Refill Seq.*		8.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
9.9	NSU	NSD	8.	T = 350	A/B/C/D		T = 350	1
9.10	Na Refill Seq.*		8.	See above	--		T = 350	1
.11	NSU	NSD	8.	T = 350	A/B/C/D		T = 350	1
9.12	Na Refill Seq.*		8.	See above	--		T = 350	1
9.13...9.20	NSU	NS_c (#10)	8.	T = 350	A/B/C/D		T = 350	8
9.21...9.43	NSU	NS_c (#10)	8.	T = 350	A/B/C/D		T = 350	23
9.44	NSU	NSD	8.	T = 350	A/B/C/D		T = 350	1
9.45	Na Refill Seq.*		8.	See above	--		T = 350	1
9.46	NSU	NSD	8.	T = 350	A/B/C/D		T = 350	1
9.47	Na Refill Seq.*		9.	See above	--	↓	T = 350	1

t = 9.0 ⟶ 10.0 yrs

Event #	Description	Initiation Time (Yrs)	Starting Condition	Intermediate Condition	Duration at Intermediate Condition	Final Condition	# of Occurrence
10.1	NSU #7	9.	T = 350°	A/B/C/D	Each normal	T = 350	1
10.2	NSU #8	9.	T = 350	A/B/C/D	startup to	T = 350	1
10.3	NSU #9	9.	T = 350	A/B/C/D	Conditions	T = 350	1
10.4	NSU #15 NSD	9.	T = 350	A/B/C/D + Press. Trans.	A, B, C, or D is followed	T = 350	1
10.5	NSU #13	9.	T = 350	A/B/C/D	by 205 hrs of	T = 350	1
10.6	NSU #17(OBE)	9.	T = 350	A/B/C/D	operation.	T = 350	1
10.7	NSU #22	9.	T = 350	A/B/C/D		T = 350 Sec and Pri Drained	1
10.8	Na Fill Sec.	9.	T = 350 Pri. & Sec Drained	--	--	T = 350	1
10.9	NSU #10	9.	T = 350	A/B/C/D		T = 350	1
10.10	Na Fill Pri.	9.	T = 350 Pri Drained	--		T = 350	1
10.11	#25	9.	T = 350	Pipes Dry: T = Amb. Tanks Frozen, T = Amb.		T = 350 Pipes Full	1
10.12	NSU NS_c(#10)	9.	T = 350	A/B/C/D		T = 350	1
10.13	Na Refill Seq.*	9.	T = 350	Pri: Dry Amb Sec: T = 350		T = 350	1
10.14	NSU NSD	9.	T = 350	A/B/C/D		T = 350	1
10.15	Na Refill Seq.*	9.	See above	--		T = 350	1
10.16	NSU NSD	9.	T = 350	A/B/C/D		T = 350	1
10.17	Na Refill Seq.*	9.	See above	--		T = 350	1
10.18 ... 10.24	NSU NS_c(#10)	9.	T = 350	A/B/C/D		T = 350	7
10.25 ... 10.46	NSU NS_c(#10)	9.	T = 350	A/B/C/D		T = 350	23
10.47	NSU NSD	9.	T = 350	A/B/C/D		T = 350	1
10.48	Na Refill Seq.*	9.	See above	--		T = 350	1
10.49	NSU NSD	9.	T = 350	A/B/C/D		T = 350	1
10.50	Na Refill Seq.*	10.	See above	--		T = 350	1
10.51	Na Drain	10.0	T = 350	Drain		Ambient Argon	1

9-75

TYPE CT COLD TRAP LOADS

LINE DESIG.	NOZZLE	TEMP	FX	FY	FZ	MX	MY	MZ
1" GEA 61124	N1 (INLET)	1000	-25	-1	8	96	660	360
61125	N2 (OUTLET)	965	-15	-4	3	72	0	348
61224	N1 (INLET)	1000	-24	-1	8	108	660	336
61225	N2 (OUTLET)	965	-15	-3	2	48	0	132
61324	N1 (INLET)	1000	-25	-1	8	120	672	324
61325	N2 (OUTLET)	1000	-11	-2	2	12	84	48
61424	N1 (INLET)	1000	-22	-1	8	132	648	26
61425	N2 (OUTLET)	965	-31	-12	-1	48	408	840

COORDINATES: X = EAST
Y = VERTICAL
Z = SOUTH