RDT Standards Transmittal

Hanford Engineering Development Laboratory

DISTRIBUTION	DATE JUN 20 1974		NO. 192
	RETURN COMMENTS TO	TYPE SUBMISSION	TYPE ACTION
	S. W. Schoon Westinghouse Hanford Company P. O. Box 1970 Richland, WA 99352	☐ 1. PRELIMINARY ☐ 2. DRAFT ☐ 3. TENTATIVE ☐ 4. FINAL ☒ 5. Revision	☐ A. APPROVAL ☐ B. INFORMATION ☐ C. COMMENTS ☒ D. TRIAL USE ☐ E.
	NOT LATER THAN		
List 1	NUMBER	DESCRIPTION	ACTION
	RDT E 4-6T	Intermediate Heat Exchanger for Liquid Metal Systems, May 1974. Supersedes RDT E 4-6T, January 1972 This revision incorporates Amendments 1, 2, and 3 to RDT E 4-6T dated January 1972 and additional directed changes based on comments on the draft revision (D. R. Riley to A. G. Fremling, "RRD Review of HEDL Revision of E 4-6T, 'IHX for Liquid Metal System', and Approval with Comments", 5-30-74, RRD:PP:164) Due to extensive reorganization of the standard to improve the format and to give visibility to the Code design specification requirements, marginal notation of changes have not been included.	D
		MASTER Release for Announcement in Nuclear Science Abstracts	

SIGNATURE

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

RD T E 4-6T

Supersedes
RD T E 4-6T, January 1972

RD T Standard

INTERMEDIATE HEAT EXCHANGER FOR LIQUID METAL SYSTEMS

MAY 1974

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Any further distribution by any holder of this document or of the data therein to third parties representing foreign interests, foreign governments, foreign companies, and foreign subsidiaries or foreign divisions of U.S. companies should be coordinated with the Director, Division of Reactor Research and Development, U.S. Atomic Energy Commission.

Division of Reactor Research and Development
United States Atomic Energy Commission

MASTER

Release for Announcement in
Nuclear Science Abstracts

Send copy and distribution inquiries to:

RDT Standards Office
Oak Ridge National Laboratory
Building 1000, Room 120-C
P. O. Box X
Oak Ridge, TN 37830

Printed in the United States of America

USAEC Technical Information Center, Oak Ridge, Tennessee

R D T S T A N D A R D

UNITED STATES ATOMIC ENERGY COMMISSION
DIVISION OF REACTOR RESEARCH AND DEVELOPMENT

RDT E 4-6T

DATE May 1974

PAGE 1 OF 1

INTERMEDIATE HEAT EXCHANGER FOR LIQUID METAL SYSTEMS

TABLE OF CONTENTS

	<u>Page</u>
1. SCOPE	1
1.1 Definitions	1
2. APPLICABLE DOCUMENTS	4
2.1 Exceptions	4
2.2 RDT Standards	5
2.3 American National Standards (ANSI)	6
2.4 American Society of Mechanical Engineers (ASME)	6
2.5 Other Documents	6
3. TECHNICAL REQUIREMENTS	6
3.1 General Requirements	6
3.2 Design Requirements	6
3.3 Materials of Construction	13
3.4 Fabrication	14
3.5 Drawings	18
3.6 Reports and Documentation	21
3.7 Installation and Field Services Requirements	24
4. QUALITY ASSURANCE REQUIREMENTS	25
4.1 Quality Assurance Program	25
4.2 Quality Assurance Documents	25
4.3 Marking and Identification	25
4.4 Nondestructive Examination Requirements	25
4.5 Examination of Materials	26
4.6 Examination of Fabricated Items	26
4.7 Testing	27
5. PREPARATION FOR DELIVERY	29
5.1 Delivery Requirements	29
6. NOTES AND ORDERING DATA CHECKLIST	30
6.1 Notes	30
6.2 Ordering Data Checklist	30

INTERMEDIATE HEAT EXCHANGER FOR LIQUID METAL SYSTEMS

1. SCOPE

This standard delineates the requirements for liquid metal-to-liquid metal heat exchangers constructed in accordance with the Class 1 requirements of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components, and special requirements that are additive or more restrictive. This standard applies to shell-and-tube "intermediate" heat exchangers used to transfer heat between the primary and secondary liquid metal coolants of reactor heat transport systems.

1.1 Definitions.

1.1.1 Carbon Transport. The migration of carbon from material in one location of a loop to another because of a difference in carbon activity. In an all-austenitic steel loop that is undergoing preferential chromium removal, the carbon transport will be from the hot leg to the cold leg. If the loop has an austenitic hot leg and ferritic cold leg, the direction of carbon transport will be from the cold leg to the hot leg. If a large external carbon source is injected into the liquid metal, the direction of carbon transport will usually be from liquid metal to all the structural material in the loop.

1.1.2 Carburization. The addition of carbon to material in a region of a liquid metal loop from another source. The carbon may diffuse uniformly into the material, usually increasing strength and reducing ductility; or it may react with the material and form a carbide layer (often brittle) at the surface.

1.1.3 Caustic Stress-Corrosion Cracking. Failure by cracking under combined action of corrosion and stress in the presence of alkali metal hydroxides. A wide range of temperature, external or internal stress, and hydroxide concentrations can cause this phenomenon. Ferritic materials are more susceptible than austenitic materials.

1.1.4 Chloride Stress-Corrosion Cracking. Failure by cracking under combined action of corrosion and stress in the presence of chlorides (fluorides and bromides also can promote stress-corrosion cracking). A wide range of temperatures, external or internal stress, and chloride concentrations can cause this phenomenon. Austenitic materials are much more susceptible than ferritic materials. The best means of prevention is close control over trace amounts of halides in water, dye penetrants, solvents, etc., used in materials processing.

1.1.5 Decarburization. The removal of carbon from material in a region of a liquid metal loop. Decarburization of austenitic stainless steel reduces strength, may increase ductility, and may promote the

formation of sigma phase during elevated temperature service.

1.1.6 Fouling. The deposition and collection of impurities on heat transfer surfaces.

1.1.7 Fouling Resistance. The increase in thermal resistance or reciprocal of the heat transfer conductance due to fouling of the heat transfer surfaces.

1.1.8 Hands-on-Maintenance. The direct handling of tools by personnel, rather than through the use of remote manipulators or slave devices. High radiation fields, high temperatures, toxic gases, or interposed mechanical structures are among the conditions that interfere with hands-on maintenance.

1.1.9 Intermediate Heat Exchanger (IHX). The component that exchanges heat between primary and secondary liquid metal in a reactor heat transport system (See Figure 1).

1.1.10 Maintainability. Those inspection, servicing, testing, and repair characteristics of an item which affect the operating continuity of the facility and affect the effort required to restore the function of the item to its in-tolerance state.

1.1.11 Natural Frequency. The frequency of the periodic motion which takes place when an elastic system is displaced from its equilibrium position and released. The forces acting on the system after its release are dependent only on the motion of the system.

1.1.12 Radiation Damage. The deleterious changes in the physical properties or mechanical characteristics (or both) of a material resulting from interaction of radiation with the material.

1.1.13 Remote Manual Maintenance. Operations that require the use of tools that extend the normal reach of the operator and that transmit the action of the operator's hand to the work-piece. Each action of the tool requires a direct action of the operator. Slave devices such as master-slave manipulators and simple extended shanks on tools such as wrenches are examples of devices used for remote manual operations that permit personnel to work through shielding, enclosures, and greater than normal distances.

1.1.14 Remote Machine - Manual Setup Maintenance. Remote machine operations that are controlled by the mechanical design or programmed controls of the machine and that do not require operator action during execution of the task and where the machine is set up in the work location and prepared for the performance of the task by personnel having direct access and control.

1.1.15 Remote Machine - Remote Setup Maintenance. Machine operations that are controlled by the mechanical design or programmed controls of the machine and that do not require operator action during execution of the task and where the machine is set up in the work location and prepared for the performance of the task without direct personnel access or direct control.

Fig. 1. Schematic of IHX for Sodium Systems

1.1.16 Seal Membrane. A thin metallic member used to seal liquid metal or cover gas at a closure. The seal membrane is welded to the flange by seal welding.

1.1.17 Sensitization. The intergranular precipitation of chromium carbide in austenitic stainless steel when exposed to temperatures in the approximate range of 800°F to 1600°F. The depletion of chromium content in the thin envelope surrounding each grain promotes susceptibility to corrosive attack.

1.1.18 Shadow Shielding. A radiation shield that partially surrounds a radioactive source and is located between the source and the position to be protected. The shadow shield attenuates the direct radiation from the source and can reduce the field at the protected position to the level established by scatter around the shield.

1.1.19 Sodium-Water Reaction. Chemical reaction between sodium and water, steam, or water vapor, which produces sodium hydroxide and hydrogen. The reaction may be slow or fast, depending on the concentrations of sodium and water. If the reaction is fast, the heat of reaction and accumulated hydrogen present a possibility for high temperatures and explosions which can cause severe material damage. The residual sodium hydroxide, if not removed, is a potential source of caustic stress-corrosion cracking.

1.1.20 Spare Parts. Those parts determined to be necessary for the implementation of scheduled inservice maintenance operations, including those parts which are not designed for the full design life of the IHX.

1.1.21 Special Tools. Those nonstandard tools which are required to carry out access, repair, or replacement procedures.

1.1.22 Thermal Baffle. A baffle installed to reduce temperature gradients in parts.

1.1.23 Tube Plugging. A maintenance operation to seal a leaking tube from the tube-side fluid by the insertion of a plug in each end of the tube.

2. APPLICABLE DOCUMENTS

The following documents form a part of this standard to the extent specified in Sections 3 through 5. The issue of a document in effect on the date of invitation to bid, including any amendments or other published changes also in effect, shall apply unless otherwise specified. Where this standard appears to conflict with the requirements of a reference document, the supplier shall call it to the attention of the purchaser for resolution.

2.1 Exceptions. Where the materials or specifications to be employed in the manufacture of any part are not identified in this standard or the documents referenced herein, the supplier shall submit for purchaser approval the material specifications or other standards he proposes to use.

2.2 RDT Standards.

RDT C 7-6T	Thermocouple Material and Thermocouple Assembly, Chromel-P vs. Alumel, Stainless Steel Sheathed, Magnesium Oxide Insulated
RDT E 15-2T	Requirements for Nuclear Components (Supplement to ASME Boiler and Pressure Vessel Code, Section III)
RDT F 2-2	Quality Assurance Program Requirements
RDT F 3-2T	Calibration Program Requirements
RDT F 3-6T	Nondestructive Examination (Supplement to ASME Boiler and Pressure Vessel Code, Section V)
RDT F 3-15T	Requirements for Inspection of Dimensional Characteristics
RDT F 3-37T	Special Requirements for Metal Products
RDT F 4-20T	Operation and Maintenance Manuals
RDT F 5-1T	Cleaning and Cleanliness Requirements for Nuclear Components
RDT F 7-2T	Preparations for Sealing, Packaging, Packing, and Marking of Components for Shipment and Storage
RDT F 7-3T	Requirements for Identification Marking of Reactor Plant Components and Piping
RDT F 8-1T	Preloading Threaded Fasteners and Closures
RDT F 8-6T	Hoisting and Rigging of Critical Components and Related Equipment
RDT F 9-4T	Requirements for Design of Nuclear System Components at Elevated Temperatures (Supplement to ASME Code Case 1331)
RDT M 6-2T	Mechanical Locking Devices
RDT M 8-1T	Helical Age-Hardenable Nickel-Chromium-Iron Alloy Springs
RDT M 9-1T	Nickel-Chromium-Iron and Austenitic Chromium-Nickel Alloy Seals
RDT M 12-1T	Test Requirements for Thermal Insulating Materials for Use on Austenitic Stainless Steel
RDT M 12-2T	Calcium Silicate Block and Pipe Thermal Insulation (ASTM C 533 with Additional Requirements)

2.3 American National Standards (ANSI).

ANSI B1.1 Unified Screw Threads

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

ANSI Y14 Drafting Manual

2.4 American Society of Mechanical Engineers (ASME).

ASME Boiler and Pressure Vessel Code

Section III, Nuclear Power Plant Components

2.5 Other Documents.

Standards of Tubular Exchanger Manufacturers Association (TEMA)

3. TECHNICAL REQUIREMENTS

3.1 General Requirements.

3.1.1 Description of Plant Process System. A description of the plant process system of which the IHX is a component part will be provided in the Ordering Data.

3.1.2 IHX Type and Configuration. The IHX shall be a shell-and-tube heat exchanger of the general type and configuration specified in the Ordering Data. Any required design features and any restrictions on design configuration that result from consideration of the plant process system or reactor plant design will be specified in the Ordering Data. The installed position, limiting dimensions, dimensions of connecting piping, and other interface requirements will be specified in the Ordering Data.

3.1.3 Basis of Construction. The IHX shall be constructed in accordance with the Class 1 rules of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components (hereinafter referred to as the Code); the supplementary requirements of RDT E 15-2; and the Code Case Interpretations and Special Rulings specified in the Ordering Data. Where the metal temperature exceeds those for which allowable stress values are given by the Code, the requirements of the Code Case(s) specified in the Ordering Data as supplemented by RDT F 9-4 shall apply.

3.2 Design Requirements.

3.2.1 Functional Performance. The IHX shall be designed to meet the functional performance requirements specified in the Ordering Data.

3.2.2 Design Conditions.

3.2.2.1 Design Pressure. The internal and external design pressures for both the shell side and tube side of the IHX and the static and

dynamic pressure heads that apply shall be as specified in the Ordering Data.

3.2.2.2 Design Temperature. The design temperature for the shell side and the tube side of the IHX and the significant differential temperatures that pertain to each zone shall be as specified in the Ordering Data.

3.2.2.3 Design Mechanical Loads. The design mechanical loads shall be as specified in the Ordering Data. Earthquake data for the operating basis earthquake (3.2.3) shall be used where applicable to analysis of design conditions.

3.2.3 Operating Conditions. The IHX shall be designed for the normal, upset, emergency, and faulted conditions specified in the Ordering Data. The data required for the calculation of secondary and peak stress, for analysis of cyclic operation, and for assessing conformance to special stress limits of the Code will be provided in the Ordering Data for each operating condition.

3.2.4 Testing Conditions. The testing conditions shall be as specified in the Ordering Data.

3.2.5 Environmental Conditions. The IHX shall be designed for the environmental conditions specified in the Ordering Data. These conditions will include, but not be limited to, the following:

1. Pressure, temperature, and composition of the ambient external atmosphere.
2. Nuclear radiation intensity in the coolant and from plateout of radioactive materials.
3. Extent and type of liquid metal contaminants.
4. Exposure to neutron radiation.

3.2.5.1 Cover Gas. If a cover gas is required, the purchaser will provide information concerning type, temperature, and working pressure to be used by the supplier in designing component parts. If detrimental impurities are present in the gas, their identities and relative concentration will be specified in the Ordering Data.

3.2.6 Service Life. The IHX shall be designed for the service life specified in the Ordering Data.

3.2.7 Maintainability. The IHX shall be designed for accessibility to permit necessary inspections, leak location, maintenance, and repair in compliance with guidelines specified in the Ordering Data. Qualified techniques and procedures for inspection, leak location, tube plugging, seal welding, and other servicing operations covering all serviceable parts of the IHX and its auxiliary equipment shall be established. These procedures shall be included in the operation and maintenance manual (3.6.4). They shall describe the techniques and procedures for each maintenance task, emphasizing

the approach of hands-on-maintenance without precluding the application of remote techniques, such as remote manual; remote machine - manual setup; or remote machine - remote setup. The supplier shall design the IHX to provide access for surveillance and inservice inspection, including any shadow shielding required, as specified in the Ordering Data.

3.2.7.1 Tube Plugging. A procedure for sealing leaks that may result from the failure of a tube or tube-to-tubesheet joint shall be developed and qualified. The procedure shall incorporate the use of a plug that is welded or exploded into the tube holes in such a manner that the seal is not dependent upon the integrity of the original tube-to-tubesheet weld. Variations in tooling or techniques required to facilitate tube plugging - both with the bundle in situ and with the bundle removed to a maintenance area - shall be included in the procedure.

3.2.8 Thermal and Hydraulic Design. The IHX shall be designed to permit safe, stable, and predictable operation throughout the operating range. For these conditions, the IHX shall be designed for uniform flow distribution on the primary and the secondary sides and to prevent thermal stratification of liquid metal, internal recirculation, and reverse flow. Direct impingement of inlet liquid metal on the heat transfer tubes shall be avoided. Areas of low flow, or pockets of erosion product entrapment, shall be avoided to the maximum extent possible. When cover gas is used, the IHX design shall prevent local gas accumulations and entrainment of cover gas in the liquid metal.

3.2.8.1 Physical Properties of Liquid Metal. The physical properties of liquid metal to be used in the design of the IHX shall be as specified in the Ordering Data.

3.2.8.2 Heat Transfer Surface. The excess heat transfer surface included to account for repair by plugging tubes and any other factors which will reduce the effective heat transfer area during the IHX service life shall be recommended for approval by the purchaser.

When the IHX design uses a cover gas blanket, the effects of variations in the liquid level during normal operation on the effective heat transfer surface shall be incorporated in the calculation of the heat transfer surface. Requirements pertaining to liquid metal level and level changes, if any, will be specified in the Ordering Data (3.2.1).

3.2.8.3 Natural Circulation. The IHX heat transfer surface shall be arranged to promote natural circulation under the service conditions specified in the Ordering Data.

3.2.8.4 Pressure Drop. The primary and secondary side pressure drops shall not exceed the values specified in the Ordering Data under 3.2.1.

3.2.8.5 Flow Bypass. Flow bypass shall be kept to a minimum. Flow bypass of the heat transfer area and the possible resulting effects on the temperature distribution shall be accounted for in the design and shall be discussed in the design report (3.6.1).

3.2.8.6 Fouling. Unless otherwise specified in the Ordering Data, the fouling resistance used for calculations shall be zero.

3.2.8.7 Thermal Transients. An analysis to evaluate the response of the IHX to the inlet flow and temperature transients specified in 3.2.3 shall be performed. The analytical model employed shall be described in an interim report (3.6.2).

3.2.8.8 Flow Model Testing. The responsibility of the supplier for any experimental testing required to verify thermal-hydraulic characteristics shall be as specified in the Ordering Data.

3.2.9 Structural Design Requirements.

3.2.9.1 Material Degradation. In addition to satisfying the design rules of 3.1.3, the IHX shall be designed to accommodate the environmental degradation of material properties resulting from decarburization, carburization, radiation damage, and sodium-water reaction effects, and the loss of material due to erosion, corrosion, and other surface wastage effects that may occur under the specified service conditions and throughout the specified service life.

An allowance for all pressure boundaries of the IHX shall be established based upon criteria provided by the purchaser in the Ordering Data. The allowance with the bases and supporting data shall be included in the design report (3.6.1).

3.2.9.2 Differential Thermal Expansion. Under all steady state and transient conditions specified in 3.2.3, differential thermal expansion between individual tubes, tubes and shell, and between any connected parts of the IHX shall be accommodated without exceeding the allowable stresses or loads. Tube flexibility shall be adequate to preclude damage as a consequence of differential expansion between inactive tubes (which may have been plugged to seal leaks) and active tubes, and between active tubes subject to maldistribution or flow channeling. The analysis shall be included in the design report (3.6.1).

3.2.9.3 Vibration. The IHX and all its parts shall be designed so that they will not be damaged or caused to malfunction either by internally generated vibrations such as flow-induced vibrations, or by mechanical vibrations such as pump vibrations, check valve slam vibration, or vibrations or shocks caused by shipping.

Baffles and tube support plates, tie rods, impingement plates, etc., shall be provided so that natural frequencies of all unsupported tube spans are at least 50 percent higher than hydrodynamically generated frequencies in the flow range specified in the Ordering Data. Provisions shall be made to prevent damaging vibrations in areas where local fluid velocities are high.

Engineering vibration analyses of the tube bundle structural design, covering peak velocities over the range of flows as described in the Ordering Data, shall be included in the design report (3.6.1). The complete analytical

method shall be described in detail giving all references and assumptions in an orderly way to facilitate verification. The analyses shall show that the maximum amplitude of tube vibration will not exceed 25 percent of the nominal distance between the outer surfaces of adjacent tubes.

3.2.9.4 Seismic Criteria. The IHX shall be designed in accordance with the seismic loading criteria specified in the Ordering Data.

3.2.9.5 Thermal Transient Stresses. The IHX shall be designed for the flow and temperature transient conditions specified in 3.2.3. Design provisions such as thermal sleeves or thermal baffles may be used to reduce the effect of such transients on the structure. The thermal transient analysis shall be included in the design report. (3.6.1).

3.2.9.6 Mechanical and Hydraulic Shock. When specified in the Ordering Data, the IHX shall be designed for mechanical shock conditions such as those anticipated during shipping and handling and for hydraulic shock conditions such as system check valve slam.

3.2.10 Liquid Metal Drainage. The IHX design shall include provisions for draining the primary and secondary side liquid metal as specified in the Ordering Data. All surfaces in the IHX shall be designed for complete drainage. Drain ports shall be provided for draining regions behind thermal baffles or shields and other possible traps.

The design shall minimize areas of reduced flow or pockets that contribute to entrapment of erosion products. Residual liquid metal on necessary horizontal surfaces (such as baffles and tube sheets) is permissible, but shall be minimized by the design configuration.

3.2.11 Vents. The design shall include provisions for vents on the primary and secondary system sides of the IHX to facilitate filling and draining operations.

3.2.12 Preheater. The requirements for a preheating system for heating the IHX, dry or filled with liquid metal, at the rate and to the maximum temperature as specified in the Ordering Data shall be determined by the supplier. The preheat means shall not cause damage to the IHX shell or internal components.

3.2.13 Insulation. Insulation requirements shall be determined by the supplier based on the use of the insulating materials specified in 3.3.2. The IHX conditions to be achieved through use of insulation will be specified in the Ordering Data.

3.2.14 Design of Internals.

3.2.14.1 Crevices. Dead spaces, crevices, or areas of fluid or particle entrapment shall be eliminated or held to an absolute minimum. This requirement does not specifically prohibit crevices between interfacing surfaces of tube-to-tubesheet joints, provided that the supplier can conclusively demonstrate through operating experience, developmental testing, or both that

such crevices are not detrimental to IHX reliability.

3.2.14.2 Ligament Thickness. The nominal ligament width between adjacent tube holes in the tubesheet shall not be less than 0.25 inch.

3.2.14.3 Baffles and Support Plates. When circular holes are employed, the thickness of cross-flow baffles and tube support plates and the tube hole clearance shall, as a minimum, conform to the TEMA requirements for Class R heat exchangers. For noncircular holes, the supplier shall submit his design for approval by the purchaser.

3.2.15 Radiation Shield Plug. A radiation shield plug shall be provided by the supplier if the plug is designed as an integral part of the IHX. The radiation shield plug shall attenuate the gamma radiation and neutron flux to the levels specified in the Ordering Data. The IHX supplier shall provide the cooling elements for the radiation shield plug if cooling is necessary to control the temperature. Any requirement for redundant cooling elements will be specified in the Ordering Data. The Ordering Data will also specify any interface requirements which the IHX supplier must meet to permit connection of the cooling elements to a plant radiation shielding cooling system. When necessary, thermal shields shall be used to reduce the temperatures to acceptable limits.

3.2.16 Seals. Unless otherwise specified in the Ordering Data all liquid metal pressure boundary seals shall be of the seal welded type conforming to the requirements of RDT M 9-1. Seal membranes shall be designed to accommodate the loads due to internal pressure and due to the relative motion of mating parts under all expected operating and transient conditions with the closure fully secured.

Seal welds in radioactive areas or potentially radioactive areas shall be designed to permit the use of an automatic welding process and of special machines for seal weld cutting, weld preparation, and seal welding. The seal design shall permit both manual and remote application of tooling, and the supplier shall physically demonstrate to the purchaser's satisfaction that these operations can be performed remotely. A qualified seal weld procedure for the tungsten-inert-gas process shall be furnished by the supplier as part of the operations and maintenance manual (3.6.4).

Subject to purchaser approval, gasketed joints may be used as internal seals in the primary to secondary liquid metal boundary. These shall be of a design proven in liquid metal service. The design shall provide for leak detection between primary and secondary systems. The description, function, analysis, materials, instrumentation, auxiliary equipment and services required for the seal shall be included in the design report (3.6.1).

3.2.17 Threaded Elements and Bolts. Threaded connections shall conform to the following requirements:

1. Unless otherwise specified in the Ordering Data, all screwthreads shall be in accordance with ANSI B1.1 and the thread fits shall be Class 2A or 2B.

2. The use of cap bolts for closures is not permitted.
3. All threaded fasteners shall have a minimum nominal diameter of 1/2 inch.
4. Lubricants applied to threaded parts not exposed to liquid metal shall be in accordance with RDT F 8-1. Lubricants applied to threaded parts exposed to liquid metal shall be approved by the purchaser.
5. Mechanical and thermal straining shall be in accordance with RDT F 8-1.
6. All threaded fasteners shall have locking devices in accordance with RDT M 6-2. Class A locking devices shall be used for the primary side of the IHX. Class B locking devices may be used on the secondary side of the IHX.
7. All stainless steel fasteners shall be designed to prevent galling.
8. Lugs and other devices, such as jacking bolts, to assist in lifting and moving shall be designed as part of the IHX shield plug or head, IHX tube bundle, and IHX shell.

3.2.18 Surface Roughness. Unless otherwise specified in the Ordering Data, the maximum surface roughness shall not exceed:

1. 63 microinch (AA) for heat transfer tubing.
2. 125 microinch (AA) for tubesheet holes.
3. 63 microinch (AA) for mating surfaces.
4. 250 microinch (AA) for all other surfaces.

3.2.19 Plating. Surfaces in contact with liquid metal shall not be plated. Plating shall not be used for other applications unless purchaser approval has been obtained.

3.2.20 Interchangeability. The IHX shall be designed to assure the interchangeability and replaceability of the parts, subassemblies, and other items listed in the Ordering Data.

3.2.21 Connections and Appurtenances.

3.2.21.1 Piping Connections. All piping connections shall be prepared by the supplier in accordance with ANSI B16.25 for butt welding to pipe of the sizes specified in the Ordering Data.

3.2.21.2 Auxiliary Systems. Available auxiliary systems for shield plug cooling, if required, or cooling of other component parts of the IHX, will be described by the purchaser in the Ordering Data.

3.2.21.3 Auxiliary Lines. Venting, cover gas, and drain connections shall be as specified in the Ordering Data.

3.2.21.4 IHX Supports. The necessary supports to match the plant foundation drawings furnished by the purchaser shall be provided.

3.2.21.5 Seismic Ties. Interface data for any required seismic ties will be specified in the Ordering Data.

3.2.21.6 Insulation Supports. Provisions for supporting the insulation on the exterior of the IHX shall be as specified in the Ordering Data.

3.2.21.7 Preheater Supports. Provisions for supporting the preheater system on the exterior of the IHX shall be as specified in the Ordering Data.

3.2.21.8 Lifting Provisions. The IHX and each part or sub-assembly weighing more than 50 pounds and which must be handled individually shall be designed for, or provided with, means for lifting and handling using standard cranes and hoisting equipment. All lifting lugs and handling fixtures shall meet the requirements of RDT F 8-6.

3.2.22 Instrumentation.

3.2.22.1 General. Provisions shall be made for incorporation of the instrumentation specified in Ordering Data. Supplementary instrumentation shall be recommended by the supplier for approval by the purchaser.

3.2.22.2 Liquid Metal Level Indication. Continuous monitoring of the primary side liquid metal level shall be provided for units that are designed to operate with a cover gas blanket and under conditions of possible level fluctuation as defined in 3.2.1. When liquid metal level instrumentation is required, the type shall be as specified in the Ordering Data.

3.2.22.3 Leak Detection. Provisions to detect leaks to the external environment shall be as specified in the Ordering Data. Methods of detecting and locating leaks in tubes, tube-tubesheet welds, seals, and tube bundles shall be defined by the supplier.

3.2.22.4 Thermocouples. Thermocouples shall be in accordance with RDT C 7-6.

3.3 Materials of Construction. The specific material to be used for each part or component, including type and grade and any additional material requirements - such as optional requirements of the material standard or limitations on chemical composition that are to apply - shall be as specified in the Ordering Data or as recommended by the supplier and approved by the purchaser.

3.3.1 Pressure-Retaining Boundary and Sodium-Containing Parts. All

materials for parts within the boundaries of Code jurisdiction or in contact with sodium shall be in accordance with the Code and the supplemental requirements of RDT E 15-2. Material specifications to be used shall be limited to those RDT standards listed in Tables NNB-2120-1 and NNB-2120-2 of RDT E 15-2 and RDT M 8-1. Unless otherwise specified, all parts of the IHX that form part of the pressure-retaining boundaries or that are exposed to liquid sodium or sodium-containing environments shall be fabricated from either 304 or 316 austenitic stainless steel. Specified selection of alternate materials shall be based on the mechanical properties, metallurgical stability, sodium compatibility, and response to radiation under the applicable design and environmental conditions. When recommending the use of alternate materials, the supplier shall document the justification, which shall include, as a minimum, a summary of available test or experience data and discussion of the adequacy of the recommended material(s) relative to 304 or 316 stainless steel or other purchaser-specified alternate.

3.3.2 Other Applications. Materials used for other applications not within the scope of 3.3.1 shall be as specified in the Ordering Data or as recommended by the supplier and approved by the purchaser, except that insulation shall be in accordance with RDT M 12-1 and RDT M 12-2.

3.3.3 Tubing. The heat exchanger tubing shall be as specified in the Ordering Data. The nominal inside tube diameter shall be not less than 0.50 inch. Straight tubing is to be supplied with tube camber not to exceed 0.030 inch in 3 feet. The surface of the tubing shall be free of surface irregularities or imperfections which produce liquid penetrant indications.

3.3.4 Traceability and Archive Samples. Samples of materials used in fabricating the IHX and samples of insulating materials used thereon shall be selected from parent material lots and in-process parts as specified in the Ordering Data. Such samples shall be accumulated, individually identified as to source material and location, and preserved to maintain the material characteristics prevailing at the time of sampling.

Records shall be maintained on all parts of the IHX to provide traceability of all materials to the material certifications.

3.4 Fabrication.

3.4.1 Fabrication Release. The fabrication of component parts and assemblies shall not be initiated without prior purchaser approval.

3.4.2 Welding and Thermal Cutting. All welding, brazing, hard surfacing, and thermal cutting shall be in accordance with the Code as supplemented by RDT E 15-2. Structural welds which are not governed by the requirements of the Code or RDT E 15-2 shall be designed to permit meaningful radiographic examinations per RDT E 15-2 whenever practicable. Purchaser approval is required for all such structural welds that cannot be radiographed.

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

3.4.2.2 Weld Repair. Purchaser approval is required to make weld repairs to remove defects that recur:

1. After the first cycle of weld repair of defects in the fusion zone or the adjacent base metal where welds are not heat treated following repair.
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 does not require purchaser approval.

A continuous, cumulative record of all weld repairs shall be maintained. Weld repair records and drawings showing the location and extent of weld repair referenced to the applicable weld repair record shall be submitted to the purchaser as specified in the Ordering Data.

3.4.2.3 Partial Penetration Welds. Partial penetration welds may be used for attachment welds of clips and support brackets for nameplates, insulation, and electrical heaters provided such joints will meet all other design requirements of this standard. Use of partial penetration welds for applications other than those cited is subject to purchaser approval.

The joint configuration of all partial penetration welds shall be shown on the design drawings.

3.4.2.4 Tube-to-Tubesheet Welds. All tube-to-tubesheet welding shall be in accordance with RDT E 15-2.

3.4.2.5 Temporary Welds. Temporary welds shall be machined or ground flush with the base material surface. The affected area shall be examined by the liquid penetrant method in accordance with the method requirements and acceptance criteria of RDT F 3-37 for welds and weld-clad plate.

3.4.3 Sensitization. Austenitic stainless steel which has become sensitized during heat treatment, welding, or forming shall be solution annealed per the applicable standard or be protected against corrosion and moisture during all subsequent manufacturing, testing, and storage operations. The method of protecting sensitized material which is not solution annealed subsequent to heat treatment, welding, or forming shall be recommended by the supplier and subject to the approval of the purchaser. Sensitization of materials by such means as stress-relieving heat treatments shall be avoided wherever possible.

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 after the bending and forming operations shall be not 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 for stress relief or material structure improvement following bending or forming operations. After bending or cold straightening which causes plastic deformation, austenitic stainless steel tubing shall be solution annealed. Such solution annealing shall be conducted on the entire tube.

3.4.5 Tubesheet Fabrication.

3.4.5.1 Tubesheet Tube Holes. The tubesheet tube holes shall be consistent with the type of tube-to-tubesheet weld employed. If the tube-to-tubesheet joint is fabricated by a combination of welding and tube expansion processes, the tolerance on the diameter of tubesheet holes shall be in accordance with the "Special Close Fit" requirements for TEMA Class C heat exchangers.

Longitudinal tool marks in the tube holes of tubesheets shall be removed and the surface of the holes shall be subject to the finish requirements of 3.2.18. Where deviations exist with respect to the tolerance and conditions for tube holes, they shall be evaluated on an individual basis and the indicated action shall be approved by the purchaser.

3.4.5.2 Tubesheet Ligaments. The minimum tubesheet ligament thickness shall be within 0.050 inch of the nominal ligament thickness or shall be the minimum thickness required by structural design, whichever is greater.

3.4.5.3 Tube Rolling Procedure Qualification. Where tubes are installed in tubesheets by a rolling or expansion process, the procedure shall be approved by the purchaser. The procedure shall be qualified by expanding a sample of at least 20 tubes in a tubesheet section that has the same thickness and tube hole configuration to be used for the actual tubesheet and in which the tube holes are drilled using the intended manufacturing procedure. The materials of the sample shall have the same physical characteristics and properties as the materials used in the intermediate heat exchanger. The inspection techniques and acceptance criteria to be used for this procedure qualification sample shall be recommended by the supplier and subject to the approval of the purchaser. The procedure shall be qualified for each combination of tube and tubesheet size and material.

3.4.6 Cleaning. The fabrication of a part, combination of parts, subassembly, or complete IHX assembly shall be conducted so as to facilitate cleaning and inspection for cleanliness, and to minimize contamination during fabrication.

Surfaces shall be cleaned to meet the cleanliness requirements of RDT F 5-1 and shall be maintained in a clean condition up to and including all assembly procedures. When any part or assembly that contains crevices is cleaned using water, the removal of all residual water shall be ensured by such means as vacuum evaporation or oven drying.

An IHX cleaned in accordance with the above will be suitable for installation into nuclear systems without additional cleaning. The IHX supplier

shall be responsible for insuring that all items furnished by his subcontractors conform to the same cleanliness requirements.

Where used, external carbon steel structural support members of the IHX shall be protected from atmospheric corrosion by suitable methods in accordance with the supplier's practices. Machined mating surfaces shall be protected from corrosion and damage by suitable passivation and protective devices to be approved by the purchaser.

3.4.7 Assembly. Component parts shall be assembled in accordance with a detailed assembly procedure prepared by the supplier. The procedure shall contain as a minimum:

1. Assembly sequence.
2. Cleaning procedures, sequence, and precautionary rules.
3. Any special machining or fitting-at-assembly instructions.
4. Intermediate and final inspection criteria and hold points.
5. Handling and storage methods and procedures.
6. Tightening torques for threaded parts.
7. Procedures for the locking of locking devices or lock welding.
8. Drawings or photographs required to illustrate assembly problem areas or assembly techniques.

3.4.8 Identification Marking. The marking of materials, parts, components, and assemblies for both in-process and permanent identification shall be in accordance with RDT F 7-3. In addition to the identification data required to meet the traceability requirements of the Code and RDT F 2-2, the identification marking shall include part numbers, serial numbers, etc., as specified in the Ordering Data. A nameplate which conforms to the following requirements shall be permanently attached to the IHX:

1. The plate shall be of a corrosion-resistant material compatible with the surface to which it is fastened.
2. Caustic-resistant enamel shall be used to fill the markings on the nameplate.
3. The nameplate shall be attached to the component in accordance with the requirements of the Code and RDT E 15-2 and in a location approved by the purchaser.
4. The nameplates shall contain all data required by the Code and any additional information specified in the Ordering Data.
5. Nameplates shall not be painted over or otherwise covered or

concealed by insulation or adjacent parts.

3.4.9 Precautionary Measures. Shop practices and restrictions on the use of materials shall be in accordance with RDT F 5-1. Assembled portions of the tube bundle shall be protected against inadvertent contamination by examination materials during liquid penetrant examination of localized areas during fabrication. Hoisting and rigging of items and subassemblies designated as "critical" in the Ordering Data shall comply with RDT F 8-6. The appropriate instructions and restrictions shall be included in fabrication procedures and other documents defining acceptable shop practices.

3.5 Drawings. Drawings shall be prepared in accordance with ANSI Y14. As a minimum, the supplier shall prepare the following types of drawings for each component required by the equipment specification. The time and approval requirements for drawings to be submitted to the purchaser and the number of copies required shall be as specified in the Ordering Data.

3.5.1 Preliminary Drawings. When required by the Ordering Data, preliminary engineering drawings shall be submitted for the purchaser's information with the supplier's initial bid. These drawings shall depict component configuration, design features, engineering concepts, interface data, etc., proposed as a basis for meeting the requirements of the specification.

3.5.2 Design Evaluation Drawings. Design evaluation drawings shall be submitted to the purchaser for approval prior to initiation of manufacture. These drawings, which may include design layout drawings, interface control drawings, etc., shall provide a complete basis for independent design review prior to detailing. The drawings shall include, but not be limited to:

1. Overall and critical interface dimensions that establish size, shape, fit, and clearances of each major part. Identification and consideration of interface with adjacent components and environment, including weights, center of gravity, space envelopes for insulation, heaters, maintenance services, etc.
2. A nozzle schedule showing nozzle sizes, material type, function, operating temperature, etc.
3. Minimum material design thickness of all pressure boundary parts.
4. The selected materials in common groupings (i.e., plate, forgings, etc.) including the specification to which the material is to be procured.
5. Referenced mandatory or special fabrication processes, heat treatment, etc.
6. The position and type of welds using simplified drafting notation. Notes shall be included to classify the welds by common groupings to cover specified general weld type and identify the type of examination to be performed.

7. Referenced nondestructive examination requirements.
8. The positions of required instrumentation. All instruments, including types, locations, and points of attachment shall be shown.
9. Pertinent design features, including design provisions for maintainability.
10. Design parameters for any structural member to accommodate differential thermal expansion (3.2.9.2) including dimensions, type of construction, material, design pressure, design limit of extension, normal operating extension, etc.
11. Identification of all component parts, if any, which will not be manufactured to RDT standards.
12. Identification of all component parts, if any, which will not be subjected to RDT cleanliness requirements.
13. Size and location of all connections and fittings, lifting lugs and any other handling or shipping features.

3.5.3 Detail Drawings. Detail drawings shall define all features of each part shown including, as applicable:

1. Tolerance block, including geometric tolerances.
2. Detailed dimensions, tolerances, and maximum roughness of each surface.
3. Material specification and any special requirements including nondestructive examination, heat treatment, hardness, and corrosion protection.
4. Fabrication instructions, including welding, hard surfacing, and cleaning instructions; inspection symbols; and references to assembly procedure requirements.
5. Such additional information required to adequately describe equipment having special features or characteristics.
6. Location and description of all lifting lugs, seismic connections, and any other handling or shipping features.
7. A listing of all documents required to supplement the drawing through definition of material, fabrication, inspection, and test requirements.

3.5.4 Assembly Drawings. The assembly drawings shall include the following information, as applicable:

1. A bill of material which includes location, identity (drawing and

part numbers), and material type of each part.

2. Lubricants to be used during assembly, and where permitted.
3. The location of final closure welds and seal welds, with appropriate procedures.
4. Dimensions establishing the assembled relationship of all components and parts including size, shape, fits, and clearances of each major part.
5. Pressure and temperature data, including design pressure and temperature, and test pressure.
6. Pertinent references to cleaning, marking, torquing, locking, handling, and packaging instructions.
7. Weights and center of gravity (3.5.8).
8. Reference to pertinent operation and maintenance manuals (3.6.4).

3.5.5 As-Built Drawings. The supplier shall provide both assembly and detail drawings revised to show the final configuration of the components and parts at the time of acceptance by the purchaser for shipment. Actual measured values of overall dimensions and critical interface dimensions related to assembly of major parts and components of the IHX and installation of the IHX in the purchaser's facility shall be shown on the drawings in addition to the design dimensions and tolerances. Measurements shall be made with the part, component, or complete IHX in the intended assembly position or intended installed position.

3.5.6 Drawing and Specification Lists. A current listing of all drawings associated with the components of this standard shall be maintained by the supplier. Each drawing number shall include the current revision number.

A current list of specifications shall be maintained. This list of specifications shall include as applicable, requirements for design, material, fabrication, construction, installation, testing, inspection, maintenance, cleaning, packaging, shipping, storage, operation, and quality assurance.

3.5.7 Parts List. A complete list of parts organized by assemblies shall be prepared by the supplier. Each referenced drawing number shall include the current revision number. A copy of the parts list which shall serve as a baseline against which further changes may be monitored shall be provided.

3.5.8 Weights and Centers of Gravity. The outline drawings and assembly drawings shall indicate the following:

1. The dry weight and center of gravity of the IHX.

2. The weight and center of gravity of the assembly when filled with liquid metal.
3. The dry weight and center of gravity of the IHX tube bundle assembly.
4. The weights and centers of gravity of the subassemblies into which the IHX would be divided for shipping purposes.

3.6 Reports and Documentation. The time and approval requirements of submittals to the purchaser and the number of copies required shall be as specified in the Ordering Data.

3.6.1 Design Report. A design report shall be prepared and submitted at the time of request for approval of the IHX design by the purchaser. As a minimum, the design report shall include the following:

1. A design description of the IHX including operating characteristics, operational limitations, and safety considerations.
2. Heat transfer and fluid flow analyses.
3. Curves of primary and secondary side pressure drops (including nozzle losses) from 0 to 100 percent flow.
4. A thermal analysis of the response of the IHX to the inlet flow and temperature transients specified in the Ordering Data (3.2.8.7).
5. A thermal transient stress analysis of regions of discontinuities and thick sections (3.2.9.5).
6. A stress report in accordance with Code requirements which is prepared in accordance with the guidelines presented in Appendix C of the Code.
7. Vibration analyses (3.2.9.3).
8. Differential thermal expansion analysis including calculation of the magnitude of the expansion and analysis of any structural member required to accommodate this expansion (3.2.9.2).
9. If a design or fabrication procedure is chosen which is not widely accepted by industry, the reasons for using this design or fabrication procedure shall be provided.
10. The procedure for locating and sealing tube leaks (3.2.7 and 3.2.7.1).
11. Weight and center of gravity calculations of the IHX and its component parts.
12. Seal type and removal and replacement description (3.2.16).
13. Effects of flow bypass (3.2.8.5).

14. Corrosion allowance used in analysis (3.2.9.1).
15. Materials of construction (3.3).
16. Material degradation due to carburization, decarburization, radiation damage, sodium-water reaction products, etc.
17. Transient pressure variation analysis, including effects of check valve slam, sodium-water reactions, etc., on the IHX.
18. Any information previously submitted in an interim design report.

All information furnished in the design report shall be in sufficient detail to permit independent checking. The references from which data or formulae are taken shall be identified. The validity of the data and the conclusions which support the recommended design shall be discussed. All computer programs used shall be properly 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 suitably numbered and dated, and shall be submitted to the purchaser for approval.

3.6.2 Interim Design Reports. An interim design report shall be submitted for review if early approval by the purchaser is necessary for proceeding with the design or manufacture.

As a minimum, interim design reports shall cover the following:

1. Design analysis plan and interim reports as required by RDT F 9-4 (3.1.3).
2. Heat transfer and fluid flow analyses.
3. A thermal analysis of the response of the IHX to the inlet flow and temperature transients specified in 3.2.8.7.
4. Any new or unusual analytical techniques or fabrication procedures.
5. Preheater and insulation requirements (3.2.12 and 3.2.13).
6. Any additional items specified in the Ordering Data.

3.6.3 Periodic and Progress Reports. Reports of progress in design, fabrication, inspection, testing, and shipping shall be made at intervals specified in the Ordering Data. These reports shall relate the progress made since the last report with only enough repetition of previously reported events to frame the contents of the present report. These periodic reports shall also include difficulties encountered (such as failures and malfunctions) and the efforts made or planned for overcoming them. Problems foreseen as possible disruptions of the schedule shall be brought to the

attention of the purchaser as early as possible. Breakthroughs of significance shall be completely discussed.

3.6.4 Operation and Maintenance Manual. An IHX operation and maintenance manual in accordance with the applicable sections of RDT F 4-20 specified in the Ordering Data shall be provided by the supplier. This manual shall reflect the as-built configuration of the delivered item. Information shall include, but not be limited to, the following:

1. A detailed description of the IHX and associated components, and instructions for installation, operation, preventive maintenance, and repair, such as draining the tube bundle, locating leaking tubes, tube plugging, cutting, cleaning and rewelding of seal welds, removing IHX head and tube bundle. These instructions shall include a description of the tools required to make these repairs with the unit installed in the plant.
2. Procedures for replacing seals, tube bundle, and other replaceable components.
3. Instructions for use of all lifting and handling fixtures, and special tools and equipment.
4. Reduced size drawings for operation, maintenance, and instructional purposes, including assembly and detail drawings and drawings of special tools and equipment.
5. Instructions for disassembly, cleaning, preparation for shipment, and for crating constituent parts.
6. A list of recommended spare parts.
7. Inservice inspection requirements and procedures.

3.6.5 Special Tool List. A list of all special tools, including gages, required for this contract shall be prepared and kept current by the supplier. The list shall identify each tool by name, drawing number, function, and operations for which it is required and whether it is an in-process tool or a deliverable item.

3.6.6 Spare Parts List. A list of spare parts to be stocked at the plant site shall be recommended by the supplier. This list is to contain those parts and tools likely to be damaged or expended during installation and plant operation. When approved, the supplier shall process and deliver these spares in accordance with the requirements for deliverable items.

3.6.7 Final Report. A final report shall be provided by the supplier. The final report shall present the complete history of the design, development, fabrication, testing, and shipping of the IHX and its auxiliary equipment. Proprietary information on analysis or fabrication is neither sought nor desired. The final report should include, in addition to detailed accounts of

the areas listed above, the following:

1. The analyses specified throughout this standard, including design, stress, shipping, and any others. These may appear as appendices.
2. Copies of drawings specified in this standard of the as-built configuration, reduced to convenient sizes for binding with the final report.
3. Illustrations, sketches, schematic diagrams, and photographs of major stages of fabricating, assembling, inspecting, cleaning, testing, repairing, packing, and shipping.

3.6.8 Project Plan. A project plan shall be provided by the supplier. The project plan is intended to present an overview of the project and to define and schedule specific activities that are required for the successful and timely execution of the contract work scope. The plan shall include the supplier's project organization, including resumes of pertinent project individuals; a project schedule showing all supplier approval hold points; and definition of principal tasks with associated objectives and milestones.

3.7 Installation and Field Services Requirements. The supplier shall provide technical advice and assistance and shall monitor quality assurance implementation during the installation and subsequent repair, replacement, and alteration of equipment to the extent specified herein and in the Ordering Data.

3.7.1 Unloading. Written procedures for unloading deliverable items from the carrier at the designated site shall be provided. All special lifting devices, supports, and fixtures necessary to unload the components from the carrier and to transport them to a designated storage area shall be provided.

3.7.2 Storage. Items that will be stored at the designated site for a significant period of time before use will be listed in Ordering Data. Written storage procedures for all such items shall be provided.

3.7.3 Handling. The supplier shall be responsible for providing equipment as required by this standard, instructions for handling all major components which he has supplied, and for monitoring these operations as specified in the Ordering Data. Handling instructions shall be in accordance with RDT F 8-6.

3.7.4 Unpacking. Written procedures for removing all packaging from major items shall be provided.

3.7.5 Installation Instructions. Written installation instructions for all delivered items including seal weld procedures, pipe cutting and rewelding procedures, and nondestructive examination procedures necessary to requalify the unit shall be provided.

3.7.6 Preoperational Testing. All preinstallation and preoperational tests required for the delivered equipment shall be described in the technical manuals. During such testing, the supplier shall provide technical assistance to verify that all equipment performs in the manner intended.

3.7.7 Field Modification Services. Engineering services and technical direction for any field modification of delivered items shall be provided. All field modifications shall be performed in accordance with the requirements of this standard and the Ordering Data.

4. QUALITY ASSURANCE REQUIREMENTS

4.1 Quality Assurance Program. The supplier shall plan, establish, implement, and maintain a documented quality assurance program that fulfills all requirements of Sections 1, 2, 3, 4, 5 and 8 of RDT F 2-2, the Code, and the additional quality assurance requirements of this standard.

4.2 Quality Assurance Documents. Quality assurance documents required by RDT F 2-2 shall be submitted by the supplier for purchaser approval as specified in the Ordering data. Other documents required by RDT F 2-2 for which submittal is not required shall be prepared and maintained by the supplier.

4.3 Marking and Identification.

4.3.1 Materials. All materials used in the manufacture of items shall be examined to ensure compliance with the requirements of 3.4.8.

4.3.2 Permanent Marking. All finished components, spare parts and special handling fixtures to be delivered as part of the contractual requirements shall be examined to ensure that they are permanently marked for purposes of identification in accordance with 3.4.8. Material samples shall be examined for conformance to the marking requirements of 3.3.4.

4.4 Nondestructive Examination Requirements.

4.4.1 Required Examinations, Methods, and Acceptance Criteria. Materials and fabricated items shall be nondestructively examined as required by and in accordance with the Code as supplemented by RDT E 15-2 and the additional requirements of this standard. Acceptance criteria shall be in accordance with the Code as supplemented by RDT E 15-2.

4.4.2 Equipment Calibration. Instrumentation, reference blocks and other physical standards, and measuring equipment used in conjunction with nondestructive examinations shall be calibrated and controlled in accordance with RDT F 3-2.

4.4.3 Designation of Certification Level. Each written examination procedure shall specify the certification level (Levels I, II, or III) required of personnel who:

1. Perform the nondestructive examination.

2. Interpret and evaluate the results of the examination.

4.4.4 Post Examination Cleaning. Following any nondestructive examination in which examination materials remain on the surface, the part shall be thoroughly cleaned to satisfy the cleanliness requirements of RDT F 5-1 before proceeding to the next weld pass, fabrication, or inspection step. When any part or assembly that contains crevices is cleaned using water, the removal of all residual water shall be ensured by such means as vacuum evaporation or oven drying.

4.5 Examination of Materials. Prior to use in fabrication, all materials shall be:

1. Visually examined for conformance to cleanliness requirements and to detect obvious defects.
2. Nondestructively examined in accordance with the requirements of paragraph 4.4.1 and any additional requirements specified in 3.3.

4.6 Examination of Fabricated Items.

4.6.1 General. All items shall be visually examined and measured to verify conformance to purchaser-approved drawings (3.5). Inspection of dimensional characteristics shall conform to the requirements of RDT F 3-15. Any requirements for recording measurements other than required by RDT F 3-15, shall be as specified in the Ordering Data (3.5.5). All dimensional limits depicted on the approved drawings shall be interpreted as absolute as defined by RDT F 3-15. After forming operations, all shells and heads shall be 100 percent examined for conformance to the required shape and thickness. Nozzles and attachments shall be examined for proper fit to the curvature of the shell surface.

4.6.2 Welds. Visual, dimensional, and nondestructive examination of welds and weld repairs shall be in accordance with the Code as supplemented by RDT E 15-2 and the additional requirements of this standard.

4.6.2.1 Structural welds which are not governed by the requirements of the Code or RDT E 15-2 and that cannot be adequately examined by radiography (3.4.2) shall be 100 percent examined by ultrasonic methods in accordance with RDT F 3-6. Such welds which cannot be adequately examined by either radiography or ultrasonics, or a combination of both, shall be progressively examined by a liquid penetrant or magnetic particle method. The progressive liquid penetrant (or magnetic particle) examination shall be performed after the root pass and each successive 1/2 inch or 1/3 T (whichever is smaller) of deposited weld metal, where T is the thickness of the finished weld. The applicable acceptance criteria of RDT E 15-2 shall apply.

4.6.3 Examination of Lifting, Handling and Shipping Fixtures. All lifting, handling, and shipping fixtures and lifting lugs shall be load tested and inspected in accordance with RDT F 8-6.

4.6.4 Seal Membranes. Seal membranes shall be examined in accordance with RDT M 9-1.

4.7 Testing.

4.7.1 Helium Leak Tests. All seal welds and all single pass welds shall be helium leak tested in accordance with RDT F 3-6 and as specified in the Ordering Data. When a pneumatic pressure test is used (4.7.2), the helium leak test shall be performed after the pressure test is completed. When a hydrostatic pressure test is used (4.7.1), a helium leak test shall be performed prior to the hydrostatic test. The type of helium leak test to be used and the maximum permissible helium leak rate shall be as specified in the Ordering Data.

4.7.1.1 Helium Leak Test of Tube-to-Tubesheet Welds. If the tube-to-tubesheet joint is fabricated by a combination of welding and tube expanding processes, the tube-to-tubesheet welds shall be helium leak tested prior to performing any final tube expansion to ensure the welds are leak free. If required to position the tube, a tack roll may be performed prior to welding. After all the welds have been leak tested and final rolling has been completed, a second helium leak test shall be performed.

If the tube-to-tubesheet joint is fabricated by full penetration butt welding, the tube-to-tubesheet welds shall be helium leak tested prior to proceeding with the next operation which could prevent repair.

After all tube-to-tubesheet welds have been completed, a final helium leak test shall be performed.

4.7.2 Pressure Test. Either a pneumatic or hydrostatic pressure test shall be conducted in accordance with the Code and the supplementary requirements of RDT E 15-2. Hydrostatic testing, however, shall not be used for components or assemblies such as tube bundles that contain crevices which may trap and hold water or that may not readily be dried. The type of pressure test to be conducted shall be as specified in the Ordering Data or recommended by the supplier and approved by the purchaser. A detailed test procedure shall be submitted for the purchaser's approval.

Prior to testing, the inside and outside surfaces shall be cleaned to meet the cleanliness requirements of RDT F 5-1.

Prior to and during the performance of the pressure test, the material temperature of materials for which the Code requires impact testing shall be maintained at least 60°F above the applicable RT_{NDT}, 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 studs, bolts, nuts, washers and other closure members furnished with the IHX shall not be used for pressure tests unless specified in the Ordering Data.

The temperatures of the IHX material shall be monitored during the test. Instruments used to monitor and record pressure and temperatures shall be calibrated in accordance with RDT F 2-2 for an overall system accuracy of

± 2 percent in the range of the test unless specified otherwise in the Ordering Data.

4.7.2.1 Pneumatic Pressure Test Requirements. The pneumatic pressure test shall be performed in accordance with the Code.

Upon completion of the pneumatic tests, the tested items shall be protected from contamination by maintaining the sealed condition and by keeping the internal environment of test gas at 5 to 7 psig pressure until the helium test is performed, if applicable.

4.7.2.2 Hydrostatic Pressure Test Requirements. Hydrostatic pressure tests shall be performed in accordance with the Code as supplemented by RDT E 15-2. The water used for hydrostatic pressure tests shall conform to the RDT F 5-1 requirements for Grade A water. Post-test drying shall be in accordance with RDT F 5-1.

4.7.3 Stress Verification Test. When required by the Ordering Data, a test shall be performed in conjunction with the pressure test to verify stress calculations and design methods. Strain gages shall be installed in locations recommended by the supplier to verify his stress calculations and design methods.

4.7.4 Special Tests. When required by the Ordering Data, the supplier shall propose a testing program to perform applicable vibration, shock, or other special tests. For each test proposed and approved, the supplier shall recommend test conditions such as environment and loading for purchaser approval. For each test performed, a test report that includes the test data, analyses of the data, and interpretation of the data relative to design objectives shall be submitted to the purchaser.

4.7.5 Test Instruments. Instruments commonly used in test and research laboratories shall be used in testing the IHX and the component parts with the following limitations:

1. No mercury or mercury-containing instruments shall be used during manufacturing or testing.
2. Soft metals, such as lead, copper, and aluminum shall not be brought in direct contact with IHX parts.
3. Halogens and halogenous materials shall not be used.
4. Sulphur and sulphur compounds shall not be used.

4.7.6 Prototype Test. Full scale tests of a prototype IHX may be required to achieve full understanding of the design. The conditions of temperature, flow, pressure, liquid metal and cover gas quality, and thermal and pressure transients for any required prototype tests will be specified in the Ordering Data.

5. PREPARATION FOR DELIVERY

5.1 Delivery Requirements. The supplier shall be responsible for the delivery of all items to be provided to the delivery point specified in the Ordering Data. A packaging and shipment plan presenting the practices, procedures, and instructions to be followed in meeting the requirements of 5.1.1, 5.1.2, 5.1.3, and 5.1.4 and any additional requirements specified in the Ordering Data shall be submitted for the purchaser's approval.

5.1.1 Preparation. Upon completion of all shop testing and inspection, all items shall be prepared for delivery to the designated site. This shall include, but is not limited to, all disassembly (as required), recleaning (if necessary), surface preparation, examination, etc. Following preparation, all deliverable items shall be packaged in accordance with the requirements of 5.1.2.

5.1.2 Packaging and Packing. Items subject to deterioration, corrosion, or damage shall be packaged in a manner to preserve them. All sealing, packaging, packing, and identification marking shall be in accordance with RDT F 7-2. Unless otherwise specified in the Ordering Data, major subassemblies or complete heat exchangers shall be purged, pressurized, and sealed in accordance with RDT F 7-2. Packaging shall be adequate to protect the item while at the supplier's facilities, during transportation to the designated site, and at the designated site.

If field fabrication or field assembly of any component is required, these requirements shall apply to the components being shipped to the field as well as to the final movement of the component to its in-place position.

5.1.3 Shipping. The supplier shall be responsible for the delivery of all items covered by this standard to the delivery point. These responsibilities include, but are not limited to, the following:

5.1.3.1 Routing. Routing for all deliverable items shall be recommended for the purchaser's approval. When approved, the supplier shall make all arrangements necessary to ship those materials and components in accordance with the requirements of this standard.

5.1.3.2 Shipping Instructions. Instructions to the shipper for handling, shipping, in-transit storage, and storing of all major deliverable items shall be provided by the supplier.

5.1.3.3 Loading. Required shipping position, supports, and crating shall be determined by the supplier. Supervision for loading the components on a suitable vehicle shall be provided by the supplier. All handling equipment shall be adequate to prevent any damage to components during handling and shipping operations in accordance with 5.1.4.

5.1.4 Handling. Hoisting and rigging of major parts during preparation for delivery and loading shall meet the requirements of RDT F 8-6. All tackle and handling fixtures shall meet the requirements of RDT F 8-6. Lifting points and tie down points that satisfy the requirements of RDT F 8-6

shall be provided for shipping fixtures.

6. NOTES AND ORDERING DATA CHECKLIST

6.1 Notes. The specification for the intermediate heat exchanger which will consist of this standard, modifications (if any), and the Ordering Data, must be certified by a registered professional engineer representing the purchaser to be correct, complete, and in compliance with the Design Specification requirements of subsubarticle NA-3250 of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components.

6.2 Ordering Data Checklist. The detailed requirements and conditions necessary to design, fabricate, examine, test, and deliver an intermediate heat exchanger in accordance with this standard are to be included in the Ordering Data. These requirements are also indicated in the following Ordering Data checklist. The list includes topics to which the standard makes specific reference and as other supplemental information needing definition by the purchaser.

The applicable paragraph number of the standard is used herein to identify information and its location. Any omission of a paragraph number in this checklist indicates that the particular paragraph of the standard is believed to adequately specify the requirement.

1. Scope. This section should include a statement indicating that this document is the Ordering Data which supplements this standard. In addition, include a brief presentation of basic information which will aid the supplier in performing his work. Coverage should include:
 - a. Application, a brief description of the nature of the application.
 - b. The location of the installation site as may be required for Code purposes.
 - c. Summary of the components and services to be furnished.
2. Applicable Documents. List all documents which are specifically called out in Section 3, 4, or 5 of the Ordering Data and this standard. Identify the applicable issues, amendments, addenda, etc., as required to clarify what documents are in effect or are to apply. List applicable drawings.
3. Technical Requirements.
 - 3.1.1 Description of the plant process system.
 - 3.1.2 The IHX type and configuration, design features, interface requirements.
 - 3.2.1 Performance requirements. As a minimum, the following

process performance requirements shall be specified:

1. Heat load.
2. Primary liquid metal flow rate.
3. Secondary liquid metal flow rate.
4. Primary liquid metal inlet pressure.
5. Secondary liquid metal inlet pressure.
6. Primary side pressure drop.
7. Secondary side pressure drop.
8. Primary liquid metal inlet temperature.
9. Secondary liquid metal inlet temperature.
10. Minimum liquid metal level.
11. Allowable change of liquid metal level.

3.2.2 Design conditions.

3.2.3 Operating conditions.

3.2.4 Test conditions (if any).

3.2.5 Environmental conditions.

3.2.5.1 Cover gas data (where applicable).

3.2.6 Service life.

3.2.7 Maintainability.

3.2.8.1 Liquid metal properties.

3.2.8.2 Liquid level requirements (if any).

3.2.8.3 Service conditions requiring natural circulation.

3.2.8.6 Fouling factor (if required).

3.2.8.7 Flow model testing.

3.2.9.1 Material allowance criteria.

3.2.9.3 Vibration analysis data.

3.2.9.4 Seismic analysis.

3.2.9.6 Mechanical and hydraulic shock (if required).

3.2.10 Liquid metal drainage.

3.2.12 Preheating requirements.

3.2.13 Insulation criteria.

-
- 3.2.15 Radiation shield plug.
 - 3.2.16 Seals.
 - 3.2.17 Alternate threaded fastener requirements (if any).
 - 3.2.18 Alternate surface finish requirements (if any).
 - 3.2.20 Interchangeability.
 - 3.2.21.1 Connecting piping.
 - 3.2.21.2 Available auxiliary systems.
 - 3.2.21.3 Auxiliary connections.
 - 3.2.21.4 IHX supports.
 - 3.2.21.5 Seismic ties.
 - 3.2.21.6 Insulation supports.
 - 3.2.21.7 Preheater supports.
 - 3.2.22 Instrumentation
 - 3.2.22.1 Liquid metal level monitoring (if required).
 - 3.2.22.2 Leak detection.
 - 3.3 Specific material choices, material requirements, applicable optional provisions.
 - 3.3.3 Heat exchanger tubing.
 - 3.3.4 Material samples.
 - 3.4.2.2 Weld repair record and weld map submittal.
 - 3.4.8 Item identification.
 - 3.4.9 Designate "critical" items (F 8-6).
 - 3.5 Time and approval requirements and number of copies of drawings required.
 - 3.5.5 Critical dimensions to be recorded.
 - 3.6 Time and approval requirements and number of copies required for technical documentation.
 - 3.6.2 Additional items to be covered in interim reports, (if any).

- 3.6.3 Periodic and progress report intervals.
- 3.6.4 Operation and maintenance manual requirements.
- 3.7 Extent of technical services and assistance to be provided by the supplier.
 - 3.7.2 Identification of long-storage items.
 - 3.7.3 Requirements for monitoring by the supplier of handling operations during construction, installation, and testing.
 - 3.7.8 Requirements for field modifications to be performed by the supplier.

4. Quality Assurance Requirements.

- 4.2 Quality assurance document submittal requirements.
 - 4.7.1 The type of helium leak test and the maximum permissible helium leak rate.
 - 4.7.2 Type of pressure test, alternate test requirements.
 - 4.7.3 Stress verification test requirements (if any).
 - 4.7.4 Special test requirements (if any).
 - 4.7.6 Prototype test conditions (if any).
- 5.1 Delivery point.
 - 5.1.2 Alternate packaging requirements.

Operated by
Westinghouse
Hanford Company
for the USAEC

A subsidiary of
Westinghouse Electric
Corporation

RDT Standards Transmittal

Please File in Master

Hanford Engineering Development Laboratory

DISTRIBUTION	DATE	May 5, 1975		NO.	210
	RETURN COMMENTS TO	TYPE SUBMISSION		TYPE ACTION	
	List 1 H. L. Barton Westinghouse Hanford Company P. O. Box 1970 Richland, WA 99352	☐ 1. PRELIMINARY		☐ A. APPROVAL	
		☐ 2. DRAFT		☐ B. INFORMATION	
	☒ 3. TENTATIVE		☐ C. COMMENTS		
	☐ 4. FINAL		☒ D. TRIAL USE		
	NOT LATER THAN	☒ 5. Amendment		☐ E.	
	NUMBER	DESCRIPTION			ACTION
	<u>RDT E 4-6T,</u>	Intermediate Heat Exchanger for Liquid Metal Systems, Amendment 1 dated 4-23-75.			D
		<u>Note:</u> This amendment consists of replacement pages to the May 1974 issue of RDT E 4-6T. See the amendment control sheet for instructions.			

SIGNATURE

[Signature]

AMENDMENT CONTROL SHEET FOR RDT E 4-6T

The changes incorporated in the May 1974 issue of RDT E 4-6T are identified by the following marginal notations:

C	Change
D	Deletion
E	Editorial
N	Addition

The number suffix following the letter code on the amendment pages corresponds to the number of the amendment in which the change was made.

Amendment 1 (4/23/75) replaces pages of the May 1974 issue as follows:

Old Pages

Cover page
5 and 6
Page 11
13 and 14
15 and 16
17 and 18
21 and 22
25 and 26
27 and 28

New Pages

Cover page
5, 6, and 6A
11 and 11A
13 and 14
15, 15A and 16
17, 17A and 18
21, 22, and 22A
25 and 26
27 and 28

RDT E 4-6T

Supersedes
RDT E 4-6T, January 1972

RDT Standard

INTERMEDIATE HEAT EXCHANGER FOR LIQUID METAL SYSTEMS

MAY 1974

Any further distribution by any holder of this document or of the data therein to third parties representing foreign interests, foreign governments, foreign companies, and foreign subsidiaries or foreign divisions of U. S. companies should be coordinated with the Director, Division of Reactor Research and Development, U. S. Energy Research and Development Administration.

***U. S. Energy Research and Development Administration**

Division of Reactor Research and Development

***Cover Amended**

Send copy and distribution inquiries to:

RDT Standards Office
Holifield National Laboratory
Building 1000, Room 118-C
P. O. Box X
Oak Ridge, Tennessee 37830

Printed in the United States of America
USERDA Technical Information Center, Oak Ridge, Tennessee

2.2 RDT Standards.

RDT C 7-6T	Thermocouple Material and Thermocouple Assembly, Chromel-P vs. Alumel, Stainless Steel Sheathed, Magnesium Oxide Insulated.	
RDT E 15-2NB-T	Class 1 Nuclear Components (Supplement to ASME Boiler and Pressure Vessel Code, Section III, Subsections NA and NB)	C1
RDT F 2-2	Quality Assurance Program Requirements	D1
RDT F 3-15T	Requirements for Inspection of Dimensional Characteristics	D1
RDT F 4-20T	Operation and Maintenance Manuals	
RDT F 5-1T	Cleaning and Cleanliness Requirements for Nuclear Components	
RDT F 7-2T	Preparations for Sealing, Packaging, Packing, and Marking of Components for Shipment and Storage	
RDT F 7-3T	Marking of Components and Parts	E1
RDT F 8-1T	Preloading Threaded Fasteners and Closures	
RDT F 8-6T	Hoisting and Rigging of Critical Components and Related Equipment	
RDT F 9-4T	Requirements for Construction of Nuclear System Components at Elevated Temperatures (Supplement to ASME Code Cases 1592, 1593, 1594, 1595, and 1596)	C1
RDT M 6-2T	Mechanical Locking Devices	
RDT M 8-1T	Helical Age-Hardenable Nickel-Chromium-Iron Alloy Springs	
RDT M 12-1T	Test Requirements for Thermal Insulating Materials for Use on Austenitic Stainless Steel	D1
RDT M 12-2T	Calcium Silicate Block and Pipe Thermal Insulation (ASTM C 533 with Additional Requirements)	

2.3 American National Standards (ANSI).

ANSI B1.1 Unified Screw Threads

ANSI B16.25 Buttwelding Ends

E1

ANSI Y14 Drafting Manual

2.4 American Society of Mechanical Engineers (ASME).

ASME Boiler and Pressure Vessel Code

Section III, Nuclear Power Plant Components

Code Case 1592, Class 1 Components in Elevated Temperature Service.
Section III.

N1

Code Case 1593, Fabrication and Installation of Elevated Temperature
Components. Section III, Class 1.

Code Case 1594, Examination of Elevated Temperature Components. Sec-
tion III, Class 1.

Code Case 1595, Testing of Elevated Temperature Components. Section
III, Class 1.

Section V, Nondestructive Examination

2.5 Other Documents.

Standards of Tubular Exchanger Manufacturers Association (TEMA)

3. TECHNICAL REQUIREMENTS

3.1 General Requirements.

3.1.1 Description of Plant Process System. A description of
the plant process system of which the IHX is a component part, including
the system provisions for protection against overpressure, will be pro-
vided in the Ordering Data.

C1

3.1.2 IHX Type and Configuration. The IHX shall be a shell-
and-tube heat exchanger of the general type and configuration specified
in the Ordering Data. Any required design features and any restrictions
on design configuration that result from consideration of the plant pro-
cess system or reactor plant design will be specified in the Ordering
Data. The installed position, limiting dimensions, dimensions of con-
necting piping, and other interface requirements will be specified in
the Ordering Data.

3.1.3 Basis of Construction. The IHX shall be constructed in accordance with the Class 1 rules of the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Nuclear Power Plant Components (hereinafter referred to as the Code); the supplementary requirements of RDT E 15-2NB; and the Code Case Interpretations and Special Rulings specified herein and in the Ordering Data. Where the metal temperature exceeds those for which allowable stress values are given by the Code, the requirements of Code Cases 1592, 1593, 1594, and 1595 and the supplemental requirements of RDT F 9-4 shall apply.

C1

3.2 Design Requirements.

3.2.1 Functional Performance. The IHX shall be designed to meet the functional performance requirements specified in the Ordering Data.

3.2.2 Design Conditions.

3.2.2.1 Design Pressure. The internal and external design pressures for both the shell side and tube side of the IHX and the static and

(End of Amendment Page)

such crevices are not detrimental to IHX reliability.

3.2.14.2 Ligament Thickness. The nominal ligament width between adjacent tube holes in the tubesheet shall not be less than 0.25 inch.

3.2.14.3 Baffles and Support Plates. When circular holes are employed, the thickness of cross-flow baffles and tube support plates and the tube hole clearance shall, as a minimum, conform to the TEMA requirements for Class R heat exchangers. For noncircular holes, the supplier shall submit his design for approval by the purchaser.

3.2.15 Radiation Shield Plug. A radiation shield plug shall be provided by the supplier if the plug is designed as an integral part of the IHX. The radiation shield plug shall attenuate the gamma radiation and neutron flux to the levels specified in the Ordering Data. The IHX supplier shall provide the cooling elements for the radiation shield plug if cooling is necessary to control the temperature. Any requirement for redundant cooling elements will be specified in the Ordering Data. The Ordering Data will also specify any interface requirements which the IHX supplier must meet to permit connection of the cooling elements to a plant radiation shielding cooling system. When necessary, thermal shields shall be used to reduce the temperatures to acceptable limits.

3.2.16 Seals. Unless otherwise specified in the Ordering Data or approved by the purchaser, mechanical joints in the pressure retaining boundary shall be sealed by seal welding or the use of welded seal membranes. Seal membranes shall be designed to accommodate the loads due to internal pressure and due to the relative motion of mating parts under all expected operating and transient conditions with the closure fully secured.

E1

Seal welds in radioactive areas or potentially radioactive areas shall be designed to permit the use of an automatic welding process and of special machines for seal weld cutting, weld preparation, and seal welding. The seal design shall permit both manual and remote application of tooling, and the supplier shall physically demonstrate to the purchaser's satisfaction that these operations can be performed remotely. A qualified seal weld procedure for the tungsten-inert-gas process shall be furnished by the supplier as part of the operations and maintenance manual (3.6.4).

Subject to purchaser approval, gasketed joints may be used as internal seals in the primary to secondary liquid metal boundary. These shall be of a design proven in liquid metal service. The design shall provide for leak detection between primary and secondary systems. The description, function, analysis, materials, instrumentation, auxiliary equipment and services required for the seal shall be included in the design report (3.6.1).

3.2.17 Threaded Elements and Bolts. Threaded connections shall conform to the following requirements:

1. Unless otherwise specified in the Ordering Data, all screw-threads shall be in accordance with ANSI B1.1 and the thread fits shall be Class 2A or 2B.

(End of Amendment Page)

2. The use of cap bolts for closures is not permitted.
3. All threaded fasteners shall have a minimum nominal diameter of 1/2 inch.
4. Lubricants applied to threaded parts not exposed to liquid metal shall be in accordance with RDT F 8-1. Lubricants applied to threaded parts exposed to liquid metal shall be approved by the purchaser.
5. Mechanical and thermal straining shall be in accordance with RDT F 8-1.
6. All threaded fasteners shall have locking devices in accordance with RDT M 6-2. Class A locking devices shall be used for the primary side of the IHX. Class B locking devices may be used on the secondary side of the IHX.
7. All stainless steel fasteners shall be designed to prevent galling.
8. Lugs and other devices, such as jacking bolts, to assist in lifting and moving shall be designed as part of the IHX shield plug or head, IHX tube bundle, and IHX shell.

3.2.18 Surface Roughness. Unless otherwise specified in the Ordering Data, the maximum surface roughness shall not exceed:

1. 63 microinch (AA) for heat transfer tubing.
2. 125 microinch (AA) for tubesheet holes.
3. 63 microinch (AA) for mating surfaces.
4. 250 microinch (AA) for all other surfaces.

3.2.19 Plating. Surfaces in contact with liquid metal shall not be plated. Plating shall not be used for other applications unless purchaser approval has been obtained.

3.2.20 Interchangeability. The IHX shall be designed to assure the interchangeability and replaceability of the parts, subassemblies, and other items listed in the Ordering Data.

3.2.21 Connections and Appurtenances.

3.2.21.1 Piping Connections. All piping connections shall be prepared by the supplier in accordance with ANSI B16.25 for butt welding to pipe of the sizes specified in the Ordering Data.

3.2.21.2 Auxiliary Systems. Available auxiliary systems for shield plug cooling, if required, or cooling of other component parts of the IHX, will be described by the purchaser in the Ordering Data.

3.2.21.3 Auxiliary Lines. Venting, cover gas, and drain connections shall be as specified in the Ordering Data.

3.2.21.4 IHX Supports. The necessary supports to match the plant foundation drawings furnished by the purchaser shall be provided.

3.2.21.5 Seismic Ties. Interface data for any required seismic ties will be specified in the Ordering Data.

3.2.21.6 Insulation Supports. Provisions for supporting the insulation on the exterior of the IHX shall be as specified in the Ordering Data.

3.2.21.7 Preheater Supports. Provisions for supporting the preheater system on the exterior of the IHX shall be as specified in the Ordering Data.

3.2.21.8 Lifting Provisions. The IHX and each part or sub-assembly weighing more than 50 pounds and which must be handled individually shall be designed for, or provided with, means for lifting and handling using standard cranes and hoisting equipment. All lifting lugs and handling fixtures shall meet the requirements of RDT F 8-6.

3.2.22 Instrumentation.

3.2.22.1 General. Provisions shall be made for incorporation of the instrumentation specified in the Ordering Data. Supplementary instrumentation shall be recommended by the supplier for approval by the purchaser.

3.2.22.2 Liquid Metal Level Indication. Continuous monitoring of the primary side liquid metal level shall be provided for units that are designed to operate with a cover gas blanket and under conditions of possible level fluctuation as defined in 3.2.1. When liquid metal level instrumentation is required, the type shall be as specified in the Ordering Data.

3.2.22.3 Leak Detection. Provisions to detect leaks to the external environment shall be as specified in the Ordering Data. Methods of detecting and locating leaks in tubes, tube-tubesheet welds, seals, and tube bundles shall be defined by the supplier.

3.2.22.4 Thermocouples. Thermocouples shall be in accordance with RDT C 7-6.

3.3 Materials of Construction. The specific material to be used for each part or component, including type and grade and any additional material requirements - such as optional requirements of the material standard or limitations on chemical composition that are to apply - shall be as specified in the Ordering Data or as recommended by the supplier and approved by the purchaser.

3.3.1 Pressure Retaining Parts and Parts in Contact with Sodium.

Materials for parts of pressure retaining components and parts in contact with sodium or sodium vapor shall be in accordance with the Code and the supplemental requirements of RDT E 15-2NB. Only those materials permitted by the applicable Code Cases specified in 3.1.3 shall be used for parts for elevated temperature service. Except where the use of Code material specifications is specified or approved by the purchaser, the RDT material standards listed in Tables NNB-2120-1 and NNB-2120-2 of RDT E 15-2NB and RDT M 8-1 shall be used. Unless otherwise specified, all parts of the IHX that form part of the pressure retaining boundaries or that are exposed to liquid sodium or sodium-containing environments shall be fabricated from either 304 or 316 austenitic stainless steel. Specified selection of alternate materials shall be based on the mechanical properties, metallurgical stability, sodium compatibility and response to radiation under the applicable design and environmental conditions. When recommending the use of alternate materials, the supplier shall document the justification, which shall include, as a minimum, a summary of available test or experience data and discussion of the adequacy of the recommended material(s) relative to 304 or 316 stainless steel or other purchaser-specified alternate.

|C1

|C1

3.3.2 Other Applications. Materials used for other applications not within the scope of 3.3.1, including any Code materials

required for components supports, shall be as specified in the Ordering Data or as recommended by the supplier and approved by the purchaser, except that insulation shall be in accordance with RDT M 12-1 and RDT M 12-2.

|N1

3.3.3 Tubing. The heat exchanger tubing shall be as specified

in the Ordering Data. The nominal inside tube diameter shall be not less than 0.50 inch. Straight tubing is to be supplied with the tube camber not to exceed 0.030 inch in 3 feet. The surface of the tubing shall be free of surface irregularities or imperfections which produce liquid penetrant indications.

3.3.4 Traceability and Archive Samples. Samples of materials

used in fabricating the IHX and samples of insulating materials used thereon shall be selected from parent material lots and in-process parts as specified in the Ordering Data. Such samples shall be accumulated, individually identified as to source material and location, and preserved to maintain the material characteristics prevailing at the time of sampling.

Records shall be maintained on all parts of the IHX to provide traceability of all materials to the material certifications.

3.4 Fabrication.

3.4.1 Fabrication Release. The fabrication of component parts

and assemblies shall not be initiated without prior purchaser approval.

3.4.2 Welding and Thermal Cutting. Welding, brazing, hard surfacing, and thermal cutting of pressure retaining components shall be in accordance with the Code as supplemented by RDT E 15-2NB. Similar processes used for component support fabrication shall be in accordance with the Code.

C1

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

3.4.2.2 Weld Repair. Purchaser approval is required to make weld repairs to remove defects that recur:

1. After the first cycle of weld repair of defects in the fusion zone or the adjacent base metal where welds are not heat treated following repair.
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 does not require purchaser approval.

A continuous, cumulative record of all weld repairs shall be maintained. Weld repair records and drawings showing the location and extent of weld repair referenced to the applicable weld repair record shall be submitted to the purchaser as specified in the Ordering Data.

3.4.2.3 Partial Penetration Welds. Partial penetration welds may be used for attachment welds of clips and support brackets for nameplates, insulation, and electrical heaters provided such joints will meet all other design requirements of this standard. Use of partial penetration welds for applications other than those cited is subject to purchaser approval.

The joint configuration of all partial penetration welds shall be shown on the design drawings.

3.4.2.4 Tube-to-Tubesheet Welds. All tube-to-tubesheet welding shall be in accordance with RDT E 15-2NB.

C1
D1

3.4.3 Sensitization. Austenitic stainless steel which has become sensitized during heat treatment, welding, or forming shall be solution annealed per the applicable standard or be protected against corrosion and moisture during all subsequent manufacturing, testing, and storage operations. The method of protecting sensitized material which is not solution annealed subsequent to heat treatment, welding, or forming shall be recommended by the supplier and subject to the approval of the purchaser. Sensitization of materials by such means as stress-relieving heat treatments shall be avoided wherever possible.

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 after the bending and forming operations shall be not 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

(End of Amendment Page)

outside diameter. The supplier shall evaluate the need for heat treatment for stress relief or material structure improvement following bending or forming operations. After bending or cold straightening which causes plastic deformation, austenitic stainless steel tubing shall be solution annealed. Such solution annealing shall be conducted on the entire tube.

3.4.5 Tubesheet Fabrication.

3.4.5.1 Tubesheet Tube Holes. The tubesheet tube holes shall be consistent with the type of tube-to-tubesheet weld employed. If the tube-to-tubesheet joint is fabricated by a combination of welding and tube expansion processes, the tolerance on the diameter of tubesheet holes shall be in accordance with the "Special Close Fit" requirements for TEMA Class C heat exchangers.

Longitudinal tool marks in the tube holes of tubesheets shall be removed and the surface of the holes shall be subject to the finish requirements of 3.2.18. Where deviations exist with respect to the tolerance and conditions for tube holes, they shall be evaluated on an individual basis and the indicated action shall be approved by the purchaser.

3.4.5.2 Tubesheet Ligaments. The minimum tubesheet ligament thickness shall be within 0.050 inch of the nominal ligament thickness or shall be the minimum thickness required by structural design, whichever is greater.

3.4.5.3 Tube Rolling Procedure Qualification. Where tubes are installed in tubesheets by a rolling or expansion process, the procedure shall be approved by the purchaser. The procedure shall be qualified by expanding a sample of at least 20 tubes in a tubesheet section that has the same thickness and tube hole configuration to be used for the actual tubesheet and in which the tube holes are drilled using the intended manufacturing procedure. The materials of the sample shall have the same physical characteristics and properties as the materials used in the intermediate heat exchanger. The inspection techniques and acceptance criteria to be used for this procedure qualification sample shall be recommended by the supplier and subject to the approval of the purchaser. The procedure shall be qualified for each combination of tube and tubesheet size and material.

3.4.6 Cleaning. The fabrication of a part, combination of parts, subassembly, or complete IHX assembly shall be conducted so as to facilitate cleaning and inspection for cleanliness, and to minimize contamination during fabrication.

Surfaces shall be cleaned to meet the cleanliness requirements of RDT F 5-1 and shall be maintained in a clean condition up to and including all assembly procedures. When any part or assembly that contains crevices is cleaned using water, the removal of all residual water shall be ensured by such means as vacuum evaporation or oven drying.

An IHX cleaned in accordance with the above will be suitable for installation into nuclear systems without additional cleaning. The IHX supplier

BLANK PAGE

shall be responsible for ensuring that all items furnished by his sub-contractors conform to the same cleanliness requirements.

Where used, external carbon steel structural support members of the IHX shall be protected from atmospheric corrosion by suitable methods in accordance with the supplier's practices. Machined mating surfaces shall be protected from corrosion and damage by suitable passivation and protective devices to be approved by the purchaser.

3.4.7 Assembly. Component parts shall be assembled in accordance with a detailed assembly procedure prepared by the supplier. The procedure shall contain as a minimum:

1. Assembly sequence.
2. Cleaning procedures, sequence, and precautionary rules.
3. Any special machining or fitting-at-assembly instructions.
4. Intermediate and final inspection criteria and hold points.
5. Handling and storage methods and procedures.
6. Tightening torques for threaded parts.
7. Procedures for the locking of locking devices or lock welding.
8. Drawings or photographs required to illustrate assembly problem areas or assembly techniques.

3.4.8 Identification Marking. The marking of materials, parts, components, and assemblies for both in-process and permanent identification shall be in accordance with RDT F 7-3. In addition to the identification data required to meet the traceability requirements of the Code and RDT F 2-2, the identification marking shall include part numbers, serial numbers, etc., as specified in the Ordering Data. A nameplate which conforms to the following requirements shall be permanently attached to the IHX:

1. The plate shall be of a corrosion-resistant material compatible with the surface to which it is fastened.
2. Caustic-resistant enamel shall be used to fill the markings on the nameplate.
3. The nameplate shall be attached to the component in accordance with the requirements of the Code and in a location approved by the purchaser. |D1
4. The nameplates shall contain all data required by the Code and any additional information specified in the Ordering Data.

5. Nameplates shall not be painted over or otherwise covered or

(End of Amendment Page)

concealed by insulation or adjacent parts.

3.4.9 Precautionary Measures. Shop practices and restrictions on the use of materials shall be in accordance with RDT F 5-1. Assembled portions of the tube bundle shall be protected against inadvertent contamination by examination materials during liquid penetrant examination of localized areas during fabrication. Hoisting and rigging of items and subassemblies designated as "critical" in the Ordering Data shall comply with RDT F 8-6. The appropriate instructions and restrictions shall be included in fabrication procedures and other documents defining acceptable shop practices.

3.5 Drawings. Drawings shall be prepared in accordance with ANSI Y14. As a minimum, the supplier shall prepare the following types of drawings for each component required by the equipment specification. The time and approval requirements for drawings to be submitted to the purchaser and the number of copies required shall be as specified in the Ordering Data.

3.5.1 Preliminary Drawings. When required by the Ordering Data, preliminary engineering drawings shall be submitted for the purchaser's information with the supplier's initial bid. These drawings shall depict component configuration, design features, engineering concepts, interface data, etc., proposed as a basis for meeting the requirements of the specification.

3.5.2 Design Evaluation Drawings. Design evaluation drawings shall be submitted to the purchaser for approval prior to initiation of manufacture. These drawings, which may include design layout drawings, interface control drawings, etc., shall provide a complete basis for independent design review prior to detailing. The drawings shall include, but not be limited to:

1. Overall and critical interface dimensions that establish size, shape, fit, and clearances of each major part. Identification and consideration of interface with adjacent components and environment, including weights, center of gravity, space envelopes for insulation, heaters, maintenance services, etc.
2. A nozzle schedule showing nozzle sizes, material type, function, operating temperature, etc.
3. Minimum material design thickness of all pressure boundary parts.
4. The selected materials in common groupings (i.e., plate, forgings, etc.) including the specification to which the material is to be procured.
5. Referenced mandatory or special fabrication processes, heat treatment, etc.
6. The position and type of welds using simplified drafting notation. Notes shall be included to classify the welds by common groupings to cover specified general weld type and identify the type of examination to be performed.

BLANK PAGE

2. The weight and center of gravity of the assembly when filled with liquid metal.
3. The dry weight and center of gravity of the IHX tube bundle assembly.
4. The weights and centers of gravity of the subassemblies into which the IHX would be divided for shipping purposes.

3.6 Reports and Documentation. The time and approval requirements of submittals to the purchaser and the number of copies required shall be as specified in the Ordering Data.

3.6.1 Design Report. A design report shall be prepared and submitted at the time of request for approval of the IHX design by the purchaser. As a minimum, the design report shall include the following:

1. A design description of the IHX including operating characteristics, operational limitations, and safety considerations.
2. Heat transfer and fluid flow analyses.
3. Curves of primary and secondary side pressure drops (including nozzle losses) from 0 to 100 percent flow.
4. A thermal analysis of the response of the IHX to the inlet flow and temperature transients specified in the Ordering Data (3.2.8.7).
5. A thermal transient stress analysis of regions of discontinuities and thick sections (3.2.9.5).
6. A stress report in accordance with Code requirements which is prepared in accordance with the guidelines presented in Appendix C of the Code.
7. Vibration analyses (3.2.9.3).
8. Differential thermal expansion analysis including calculation of the magnitude of the expansion and analysis of any structural member required to accommodate this expansion (3.2.9.2).
9. If a design or fabrication procedure is chosen which is not widely accepted by industry, the reasons for using this design or fabrication procedure shall be provided.
10. The procedure for locating and sealing tube leaks (3.2.7 and 3.2.7.1).
11. Weight and center of gravity calculations of the IHX and its component parts.
12. Seal type and removal and replacement description (3.2.16).
13. Effects of flow bypass (3.2.8.5).

14. Corrosion allowance used in analysis (3.2.9.1).
15. Materials of construction (3.3).
16. Material degradation due to carburization, decarburization, radiation damage, sodium-water reaction products, etc.
17. Transient pressure variation analysis, including effects of check valve slam, sodium-water reactions, etc., on the IHX.
18. Any information previously submitted in an interim design report.

All information furnished in the design report shall be in sufficient detail to permit independent checking. The reference from which data or formulae are taken shall be identified. The validity of the data and the conclusions which support the recommended design shall be discussed. All computer programs used shall be properly 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 suitably numbered and dated, and shall be submitted to the purchaser for approval.

3.6.2 Interim Design Reports. An interim design report shall be submitted for review if early approval by the purchaser is necessary for proceeding with the design or manufacture.

As a minimum, interim design reports shall cover the following:

1. Structural evaluation plan and interim reports as required by RDT F 9-4 (3.1.3). |C1
2. Heat transfer and fluid flow analyses.
3. A thermal analysis of the response of the IHX to the inlet flow and temperature transients specified in 3.2.8.7.
4. Any new or unusual analytical techniques or fabrication procedures.
5. Preheater and insulation requirements (3.2.12 and 3.2.13).
6. Any additional items specified in the Ordering Data.

3.6.3 Periodic and Progress Reports. Reports of progress in design, fabrication, inspection, testing, and shipping shall be made at the intervals specified in the Ordering Data. These reports shall relate the progress made since the last report with only enough repetition of previously reported events to frame the contents of the present report.

These periodic reports shall also include difficulties encountered (such as failures and malfunctions) and the efforts made or planned for overcoming them. Problems foreseen as possible disruptions of the schedule shall be brought to the

(End of Amendment Page)

BLANK PAGE

3.7.6 Preoperational Testing. All preinstallation and preoperational tests required for the delivered equipment shall be described in the technical manuals. During such testing, the supplier shall provide technical assistance to verify that all equipment performs in the manner intended.

3.7.7 Field Modification Services. Engineering services and technical direction for any field modification of delivered items shall be provided. All field modifications shall be performed in accordance with the requirements of this standard and the Ordering Data.

4. QUALITY ASSURANCE REQUIREMENTS

4.1 Quality Assurance Program. The supplier shall plan, establish, implement, and maintain a documented quality assurance program that fulfills all requirements of Sections 1, 2, 3, 4, 5, and 8 of RDT F 2-2, the Code, and the additional quality assurance requirements of this standard.

4.2 Quality Assurance Documents. Quality assurance documents required by RDT F 2-2 shall be submitted by the supplier for purchaser approval as specified in the Ordering data. Other documents required by RDT F 2-2 for which submittal is not required shall be prepared and maintained by the supplier.

4.3 Marking and Identification

4.3.1 Materials. All materials used in the manufacture of items shall be examined to ensure compliance with the requirements of 3.4.8.

4.3.2 Permanent Marking. All finished components, spare parts, and special handling fixtures to be delivered as part of the contractual requirements shall be examined to ensure that they are permanently marked for purposes of identification in accordance with 3.4.8. Material samples shall be examined for conformance to the marking requirements of 3.3.4.

4.4 Nondestructive Examination Requirements

4.4.1 Required Examinations, Methods, and Acceptance Criteria. Materials and fabricated items that are part of the pressure retaining component shall be nondestructively examined in accordance with the Code as supplemented by RDT E 15-2NB. Materials and fabricated parts of the component supports shall be nondestructively examined in accordance with the Code.

4.4.2 Equipment Calibration. Instrumentation, reference blocks and other physical standards, and measuring equipment used in conjunction with nondestructive examinations shall be calibrated and controlled in accordance with RDT F 2-2.

|C1
|D1

4.5 Examination of Materials. Prior to use in fabrication, all materials shall be:

|D1

1. Visually examined for conformance to cleanliness requirements and to detect obvious defects.
2. Nondestructively examined in accordance with the requirements of paragraph 4.4.1 and any additional requirements specified in 3.3. If the examinations were performed and properly documented by the material supplier, they need not be repeated.

|N1

4.6 Examination of Fabricated Items.

4.6.1 General. All items shall be visually examined and measured to verify conformance to purchaser-approved drawings (3.5). Inspection of dimensional characteristics shall conform to the requirements of RDT F 3-15. Any requirements for recording measurements other than required by RDT F 3-15, shall be as specified in the Ordering Data (3.5.5). All dimensional limits depicted on the approved drawings shall be interpreted as absolute as defined by RDT F 3-15. After forming operations, all shells and heads shall be 100 percent examined for conformance to the required shape and thickness. Nozzles and attachments shall be examined for proper fit to the curvature of the shells and heads shall be 100 percent examined for conformance to the required shape and thickness. Nozzles and attachments shall be examined for proper fit to the curvature of the shell surface.

4.6.2 Welds. Visual, dimensional, and nondestructive examination of welds, weld repairs, and hard surfacing deposits in the pressure retaining components shall be in accordance with the Code as supplemented by RDT E 15-2NB. Examination of welds, weld repairs, and hard surface deposits in component supports shall be in accordance with the Code.

|C1

4.6.3 Examination of Lifting, Handling, and Shipping Fixtures. All lifting, handling, and shipping fixtures and lifting lugs shall be load tested and inspected in accordance with RDT F 8-6.

|D1

4.7 Testing.

4.7.1 Helium Leak Tests. Unless otherwise specified in the Ordering Data, the completed tube bundle and the completely assembled IHX shall be helium leak tested using the hood method of Section V of the ASME Boiler and Pressure Vessel Code. The maximum permissible helium leak rates for the tube bundle and for the assembled heat exchanger shall be as specified in the Ordering Data. These helium leak tests shall be performed after pressure testing has been completed.

|C1

4.7.1.1 Helium Leak Test of Tube-to-Tubesheet Welds. If the tube-to-tubesheet joint is fabricated by a combination of welding and tube expanding processes, the tube-to-tubesheet welds shall be helium leak tested prior to performing any final tube expansion to ensure the welds are leak free. If required to position the tube, a tack roll may be performed prior to welding. After all the welds have been leak tested and final rolling has been completed, a second helium leak test shall be performed.

If the tube-to-tubesheet joint is fabricated by full penetration butt welding, the tube-to-tubesheet welds shall be helium leak tested prior to proceeding with the next operation which could prevent repair.

After all tube-to-tubesheet welds have been completed, a final helium leak test shall be performed.

4.7.2 Pressure Test. Either a pneumatic or hydrostatic pressure test shall be conducted in accordance with the Code and the supplementary requirements of RDT E 15-2NB. Hydrostatic testing, however, shall not be used for components or assemblies such as tube bundles that contain crevices which may trap and hold water or that may not readily be dried. The type of pressure test to be conducted shall be as specified in the Ordering Data or recommended by the supplier and approved by the purchaser. A detailed test procedure shall be submitted for the purchaser's approval. |C1

Prior to testing, the inside and outside surfaces shall be cleaned to meet the cleanliness requirements of RDT F 5-1.

Prior to and during the performance of the pressure test, the material temperature of materials for which the Code requires impact testing shall be maintained at least 60°F above the applicable RT_{NDT}, 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 studs, bolts, nuts, washers and other closure members furnished with the IHX shall not be used for pressure tests unless specified in the Ordering Data.

The temperatures of the IHX material shall be monitored during the test. Instruments used to monitor and record pressure and temperature shall be calibrated in accordance with RDT F 2-2 for an overall system accuracy of

(End of Amendment Page)

± 2 percent in the range of the test unless specified otherwise in the Ordering Data.

4.7.2.1 Pneumatic Pressure Test Requirements. The pneumatic pressure test shall be performed in accordance with the Code.

Upon completion of the pneumatic tests, the tested items shall be protected from contamination by maintaining the sealed condition and by keeping the internal environment of test gas at 5 to 7 psig pressure until the helium test is performed, if applicable.

4.7.2.2 Hydrostatic Pressure Test Requirements. Hydrostatic pressure tests shall be performed in accordance with the Code as supplemented by RDT E 15-2. The water used for hydrostatic pressure tests shall conform to the RDT F 5-1 requirements for Grade A water. Post-test drying shall be in accordance with RDT F 5-1.

4.7.3 Stress Verification Test. When required by the Ordering Data, a test shall be performed in conjunction with the pressure test to verify stress calculations and design methods. Strain gages shall be installed in locations recommended by the supplier to verify his stress calculations and design methods.

4.7.4 Special Tests. When required by the Ordering Data, the supplier shall propose a testing program to perform applicable vibration, shock, or other special tests. For each test proposed and approved, the supplier shall recommend test conditions such as environment and loading for purchaser approval. For each test performed, a test report that includes the test data, analyses of the data, and interpretation of the data relative to design objectives shall be submitted to the purchaser.

4.7.5 Test Instruments. Instruments commonly used in test and research laboratories shall be used in testing the IHX and the component parts with the following limitations:

1. No mercury or mercury-containing instruments shall be used during manufacturing or testing.
2. Soft metals, such as lead, copper, and aluminum shall not be brought in direct contact with IHX parts.
3. Halogens and halogenous materials shall not be used.
4. Sulphur and sulphur compounds shall not be used.

4.7.6 Prototype Test. Full scale tests of a prototype IHX may be required to achieve full understanding of the design. The conditions of temperature, flow, pressure, liquid metal and cover gas quality, and thermal and pressure transients for any required prototype tests will be specified in the Ordering Data.