

PURCHASE SPECIFICATIONS

INQUIRY DATE: DECEMBER 5, 1979

PURCHASE DATE: MARCH 20, 1980

Type Equipment: AIR-COOLED HEAT EXCHANGER
Item Number of Identification: HPA3-E-679 & 680
Number Required: TWO (2)
Charge: 930-135-93-00006402
EON 37727

DETAIL SPECIFICATIONS:

PER ATTACHED AIR-COOLED HEAT EXCHANGER DATA SHEET (PAGE 1 OF 1),
COP-1-72 (PAGE 1-19),
COP-BI-72 (PAGE 1-2)
93838-296 (PAGE 1 OF 1)
ELS-1 (PAGE 1-4)
PCM-200

PLAINTIFF'S
EXHIBIT

16030.00

UCASB01648301

WV-17834

AIR-COOLED HEAT EXCHANGER DATA SHEET

UNION CARBIDE CORPORATION
ENGINEERING DEPARTMENT
TECHNICAL CENTER

1	PLANT LOCATION <u>SEADRIFT, TEXAS</u>				ITEM NO. <u>HPA3-E-679, E-680</u>			
2	SIZE AND TYPE <u>10' X 12'</u> INDUCED/ FORCED DRAFT				NO. OF BAYS <u>ONE</u>			
3	SURFACE PER UNIT - FINNED TUBE <u>1170 S</u> SQ FT BARE TUBE (ID) <u>481</u> SQ FT BARE TUBE (OD) <u>552</u> SQ FT							
4	PERFORMANCE DATA							
5	AIR SIDE							
6	AIR QUANTITY <u>68,900</u> (SCFM)		AIR QUANTITY/FAN <u>68,900</u> (SCFM)		ALTITUDE <u>50</u> FT			
7	APPROX. FACE VELOCITY <u>600</u> FPM (STD)		TEMPERATURE IN <u>35°C</u>		TEMPERATURE OUT <u>39.7°C</u>			
8	STATIC PRESSURE [†]		IN. WATER		TOTAL PRESSURE [†]		IN. WATER MINIMUM AMBIENT TEMPERATURE <u>32</u> °F	
9	DESIGN - MATERIALS - CONSTRUCTION							
10	TUBE BUNDLE				HEADER <u>REMOVABLE COVER PLATE</u>			
11	WIDTH <u>10'0" SHAFT THROUGH</u>				TYPE <u>REMOVABLE COVER PLATE</u> SPLIT <u>—</u>			
12	NO./BAY <u>ONE</u>				MATERIAL <u>STEEL</u> NO. OF SPLITS <u>—</u>			
13	ARRANGEMENT—				PASSES—NO. <u>1</u> ARRANGEMENT [†]			
14	BUNDLES <u>1</u> IN PARALLEL		<u>1</u> IN SERIES		PLUG-DESIGN: SHOULDER <u>—</u>			
15	BAYS <u>1</u> IN PARALLEL		<u>1</u> IN SERIES		MATERIAL <u>—</u>			
16	TUBE				GASKET MATERIAL <u>ASBESTOS</u>			
17	MATERIAL <u>STEEL</u> SEMI-WELDED				SIZE INLET NOZZLE <u>10</u> IN. - NO./BUNDLE <u>2</u>			
18	OD <u>1</u> IN. MIN. THICKNESS <u>16</u> BWS A.W.				SIZE OUTLET NOZZLE <u>10</u> IN. - NO./BUNDLE <u>2</u>			
19	NO./BUNDLE [†] <u>176</u> LENGTH <u>12</u> FT PITCH <u>2 1/2</u> IN Δ				SIZE VENT NOZZLE <u>3 1/4</u> IN. - NO./BUNDLE <u>1</u>			
20	FIN				RATING & FACING <u>150 & RF</u>			
21	TYPE: EXTRUDED - SEMI-WELDED - WELDED				MISCELLANEOUS			
22	MATERIAL: <u>ALUMINUM ALLOY 1100 OR EQUAL</u>				LOUVERS <u>REQUIRED</u> <u>100</u> % AUTO/ NOTE C <u>—</u>			
23	OD <u>2 1/4</u> IN. HEIGHT <u>5 1/8</u> IN.		NO./IN. <u>10</u>		SUPPORTS: BY OWNER/VENDOR			
24	MECHANICAL EQUIPMENT							
25	FAN		DRIVER		SPEED REDUCER			
26	MFR. & MODEL [†]		TYPE <u>ELECTRIC MOTOR</u>		TYPE <u>V-BELT/GEAR/PIPING BELT</u>			
27	NO./BAY <u>1</u> HP/FAN [†]		RPM [†]		NO./BAY [†] <u>1</u> HP/DRIVER [†]		NO./BAY [†]	
28	DIAMETER [†] FT. BLADE ANGLE [†]		RPM [†]		MODEL [†]			
29	NO. BLADES [†] PITCH <u>0</u> % AUTO. <u>100%</u> ADJ.		ENCLOSURE <u>TEFC CLASS I DIV 2 GRP C</u>		AGMA HP RATING CLASS <u>I</u> (IF USED)			
30	BLADE MATERIAL <u>PLASTIC</u>		VOLT/PHASE/CYCLE <u>460/3/60</u>		RATIO [†]			
31	HUB MATERIAL <u>BY MFR</u>		MFR. [†]		MFR. [†]			
32	MISCELLANEOUS							
33	VIBRAT. SWITCH: <u>NOT REQUIRED</u>				LATERAL BUNDLE MOVEMENT <u>NOT REQUIRED</u>			
34	CONTROL ACTION ON AIR FAILURE <u>—</u>				INSTALLED COST FACTOR <u>2</u> X PURCHASE COST			
35	FAN PITCH <u>—</u>		LOUVERS <u>OPEN/CLOSED</u>		INVESTMENT EQUIVALENT FOR POWER <u>2000</u> \$/HP			
36	WINTERIZATION: <u>NOT REQUIRED</u>				SLOPE BUNDLE: <u>—</u> IN/FT FOR DRAINAGE			
37	NOTES: *GIVE TUBE COUNT OF EACH PASS WHEN IRREGULAR				REFERENCES: <u>GENERAL SPECIFICATIONS</u>			
38	*VENDOR TO SUPPLY MISSING DATA				AIR-COOLED HEAT EXCHANGERS			
39								
40	<u>a) TUBES TO BE WELDED TO TUBESHEETS</u>							
41								
42	<u>b) TO BE PER UCC STD. SPEC'S. COP-1-72 & COP-B1-72</u>							
43								
44	<u>c) VENDOR TO PROVIDE PNEUMATIC OPERATOR WITH POSITIONER</u>							
45	<u>FOR AIR SUPPLY. AIR SUPPLY PRESSURE IS 22 PSIG.</u>							
46								
47								
48								
49								
50								
51	DESIGN BASIS		PRESSURE		TEMP.		HYDRO TEST	
52			PSI		100°F		PSI	
53	NAMEPLATE DATA		MAXIMUM ALLOWABLE WORKING PRESSURE				AIR TEST	
54			<u>75</u> PSI AT 30°F MIN		<u>450</u> °F MAX.			
55	PLOT AREA:							

UNION CARBIDE CORPORATION
ENGINEERING DEPARTMENT
TECHNICAL CENTER
SOUTH CHARLESTON, W. VA.

AIR-COOLED
HEAT EXCHANGER

EST. WT. (WET) _____ LB.

552 SQ. FT. (OD BASIS)

ITEM NO. HPA3-E-679, E-680

BY: GWS

DATE: 11/6/79 SK 37727-680

DESIGN # Z

UCASB01648302

FORMAT

This specification, designating general requirements for welded pressure vessels, is arranged into two sections - a fabrication section (Articles 1 thru 19), and a supplementary design section (Articles 40 thru 44). The fabrication section contains all the information necessary to provide properly executed approval (and certified) drawings; all specifications pertaining to the fabrication, inspection, testing, protection, and preparation for shipment of the vessel; and the requirements regarding certification and reports, for vessels for which a complete mechanical design has been furnished to the manufacturer. The supplementary design section contains supplementary design criteria and requirements for use in designing vessels or parts of vessels when a complete mechanical design has not been furnished to the manufacturer.

For the purpose of clarity, cross-references between the fabrication and design sections are used; however, when a complete mechanical design is provided by Buyer, or designated agent of Buyer, only the requirements of the fabrication section (Articles 1 thru 19) need be considered by the manufacturer.



GENERAL REQUIREMENTS FOR MATERIALS, DESIGN, FABRICATION, INSPECTION,
TESTING, AND CERTIFICATION OF WELDED PRESSURE VESSELS

TABLE OF CONTENTS

- 1 SCOPE
 - 1.1 Vessels covered by this specification.
 - 1.2 Definition of "Vessel Specifications".
 - 1.3 Design of vessels or parts of vessels not covered by the Vessel Specifications.
 - 1.4 Proposed exception by manufacturer.
- 2 CODES, STANDARDS, AND OTHER SPECIFICATIONS
 - 2.1 Reference specifications.
 - 2.2 Code and National Board inspection and stamping.
 - 2.3 Inspector qualifications.
- 3 WORKING DRAWINGS
 - 3.1 Information required to be noted on manufacturer's drawings.
 - 3.2 Special notes which may be required.
- 10 MATERIALS
 - 10.1 Unspecified materials.
 - 10.2 Tubing.
 - 10.3 Stainless steels.
 - 10.4 Flange standards.
 - 10.5 Gaskets.
- 11 FABRICATION DETAILS
 - 11.1 Butt welds required for joints of Categories A and B.
 - 11.2 Backing strip removal.
 - 11.3 Weld filler metal.
 - 11.4 Nozzle location with respect to welded joints.
 - 11.5 Nozzle corner joint examination.
 - 11.6 Flange drilling.
 - 11.7 Drain connections.
 - 11.8 Grounding clips.
 - 11.9 Intermediate head weld.
 - 11.10 Gasket surfaces.
 - 11.11 Heat treatment of rolled joints limited.
 - 11.12 Thickness of fixed tubesheets.
- 12 TOLERANCES
 - 12.1 Timing.
 - 12.2 Source.
- 13 MAGNETIC PARTICLE OR LIQUID PENETRANT EXAMINATION
 - 13.1 Welded joints requiring examination.
 - 13.2 Examination after heat treatment.

14 HYDROSTATIC TESTING

- 14.1 Vertically mounted vessels.
- 14.2 Horizontally mounted vessels.
- 14.3 Compartmented vessels.
- 14.4 Vessels having expansion joints.
- 14.5 Holding time.
- 14.6 Water temperature.
- 14.7 Water quality.
- 14.8 Blind flanges for test conditions.
- 14.9 Gaskets for test conditions.
- 14.10 Re-testing repaired vessels.
- 14.11 Opening flanged joints after testing.

15 AIR (PNEUMATIC) TESTING FOR LEAKS

- 15.1 Air tests required only when specified by Buyer.

16 NAMEPLATES

- 16.1 UCC nameplate.
- 16.2 Other nameplates.

17 REPORTS

- 17.1 Required information.
- 17.2 Reports to include dates.

18 CLEANING, PROTECTION, PAINTING, AND LOADING

- 18.1 Drying and cleaning.
- 18.2 Pre-shipment protection.
- 18.3 Painting.
- 18.4 Welded attachments limited.

19 APPENDED STANDARDS

- 19.1 Standard EQ-4
- 19.2 Standard EQ-15A
- 19.3 Standard EQ-181
- 19.4 Standard EQ-182

SUPPLEMENTARY DESIGN REQUIREMENTS

(For the design of vessels or parts of vessels not covered by Buyer's Vessel Specifications)

40 DESIGN CRITERIA

- 40.1 Design pressure and additional loadings.
- 40.2 Design temperature.
- 40.3 Operating liquid head.
- 40.4 Maximum allowable stress.
- 40.5 Designing for external pressure.



- 40.6 Internal pressure rating of vessels designed primarily for vacuum service.
- 40.7 Multiple-chamber vessels.
- 40.8 Wind or earthquake loads.
- 40.9 Increase thickness of all pressure-resisting components, if necessary, to withstand the computed equivalent design pressure at 37.8 C (100 F).

41 MISCELLANEOUS DESIGN REQUIREMENTS

- 41.1 Flanged joints.
- 41.2 Gasketed tubesheet joints.
- 41.3 Fixed tubesheet joints.
- 41.4 Pass partition plates.
- 41.5 Mitered 90-degree reducing elbows for calandrias.
- 41.6 Nozzle projection.
- 41.7 Support skirts.
- 41.8 Anchor bolt sizing and positioning.
- 41.9 Lifting lugs.

42 MATERIAL SELECTION

- 42.1 Carbon steel material acceptability without impact testing.
- 42.2 Low-alloy steel material acceptability.
- 42.3 Heat exchanger bolt material.
- 42.4 Vessel support materials.
- 42.5 External attachments on pressure parts.
- 42.6 Welded parts of dissimilar metals.
- 42.7 Bolted joints of dissimilar metals.
- 42.8 Gaskets.

43 HYDROSTATIC TEST PRESSURE DETERMINATION

- 43.1 Test pressures for vertical or horizontal vessels shop-tested in a horizontal position.
- 43.2 Test pressures for tall vertical vessels shop-tested in a horizontal position (Alternate permitting increased shell stress during test).
- 43.3 Test pressures for field-fabricated and field-tested vertical vessels.
- 43.4 Test pressures for specially-designated vessels having a corrosion allowance.

44 AIR (PNEUMATIC) TESTING FOR LEAKS



GENERAL REQUIREMENTS FOR MATERIALS, DESIGN, FABRICATION, INSPECTION,
TESTING, AND CERTIFICATION OF WELDED PRESSURE VESSELS

1 SCOPE

1.1 This specification designates general requirements for welded pressure vessels having design temperatures of minus 28.9 C (-20 F) and higher (except see Article 42.1.2) for which impact tests are generally not required for the material of construction or the weld metal. The requirements of this specification apply to all vessels having internal design pressures above 15 psig (0.011 kgf/mm²) but not exceeding 3000 psig (2.109 kgf/mm²) and those subject to external pressure, or for vacuum service (internal pressures less than atmospheric pressure). Special requirements are covered in the Vessel Specifications.

1.2 The term "Vessel Specifications" shall be understood to include any drawings, specifications, or data designated by Buyer for a particular vessel or group of vessels. The Vessel Specifications shall take precedence over this specification in all cases of disagreement.

1.3 The Vessel Specifications may contain drawings or other design data for a particular vessel or group of vessels which are relatively complete or only partially complete with respect to design and details. Parts or elements of the vessel which are not completely covered by the Vessel Specifications shall be designed by the manufacturer in accordance with the Supplementary Design Requirements section of this specification.

1.4 All quotations shall be submitted in strict accordance with this specification and/or the Vessel Specifications. Any proposed exceptions or alternates to these requirements shall be quoted as optional alternatives for Buyer's consideration and such exceptions or alternates shall be clearly and completely described in the proposal. No exceptions will be permitted without the written approval of Buyer.

2 CODES, STANDARDS, AND OTHER SPECIFICATIONS

2.1 Materials, design, fabrication, inspection, and testing shall be in accordance with Section VIII, Division 1, (Pressure Vessels) of the ASME Boiler and Pressure Vessel Code and, when applicable, the Standards of the Tubular Exchanger Manufacturers Association (TEMA), Class B, except as otherwise or additionally specified herein or in the Vessel Specifications. References to codes, standards, and other specifications are to the latest revisions in effect at the time of Buyer's request for quotation.

2.2 Each pressure vessel shall be inspected and stamped in accordance with the ASME Code and National Board, unless exempted by the provisions of Article 2.2.1. Stamping shall be in accordance with Article 16.2. Certified reports, from Buyer approved insurance companies, that the vessels meet the requirements of the ASME Code are required for vessels from manufacturers in those countries where ASME and National Board stamping are not obtainable.

2.2.1 ASME Code inspection is not required when exempted by Code paragraph U-1(h) for vessels qualifying for and to be stamped with the Code UM-symbol. National Board inspection and stamping is not applicable for vessels to be marked with the Code UM-symbol.

2.3 Competency determination for inspectors of equipment constructed in accordance with rules other than the ASME Code, or for equipment on which National Board stamping has been waived, shall be by written agreement between Buyer and the manufacturer.

3 WORKING DRAWINGS

3.1 INFORMATION REQUIRED - The manufacturer shall provide certified, complete assembly and working drawings for all pressure vessels. Drawings submitted to Buyer for approval shall be complete and shall include, but not necessarily be limited to, the following information:

- (1) Buyer's item number, purchase order number, and property number.

*The metric equivalents of U. S. Customary units in this specification are in general agreement with the ASTM Metric Practice Guide (E380).

(2) Reference to specifications. The manufacturer shall include on his drawings a reference to all applicable codes, standards, and specifications, including date of issue. References shall include all applicable UCC specifications and standards, and any applicable manufacturer standards. When reference is made to the manufacturer's own standards, copies of such standards shall be included with the submitted working drawings.

- (3) National Board number.
- (4) Maximum allowable working pressure.
- (5) Maximum design temperature.
- (6) Minimum design temperature.
- (7) Weld joint efficiencies used in design.
- (8) Corrosion allowance. If none, so state.
- (9) Relevant fabrication, inspection, and testing requirements such as heat treatment, degree of radiography or other nondestructive examinations.
- (10) Hydrostatic test pressure. Indicate whether test will be conducted in horizontal or vertical position. If tested in vertical position, test pressure shall apply (be referenced) to the top of the vessel.
- (11) Pneumatic (e.g., air) leak tests, if any.
- (12) Estimated weight of vessel, empty and full of water.
- (13) Thickness of all components or elements.
- (14) Material specifications for all components and parts (including ASME standard specifications for product forms, as applicable).
- (15) Weld details. All welds shall be either detailed or identified by use of the Standard Welding Symbols of the American Welding Society (AWS A2.0); (approved as AWS Standard Y32.3).
- (16) External surface preparation and protective coating material and thickness specifications.
- (17) All pertinent dimensions, including location of weld seams, nozzle location and projection, location of vessel supports, insulation supports, and others necessary for a complete description of the vessel.

3.2 SPECIAL NOTES

3.2.1 Increased Test Stress Note - Drawings for vessels designed for increased test stress in accordance with Article 40.9.2 of this specification shall be marked conspicuously with special notes as described in Article 40.9.2.4.

3.2.2 Clad-Steel Vessel Thickness Note - Drawing notes shall specify whether or not credit has been taken for the cladding thickness in the design calculations for the vessel.

3.2.3 Balance Point Note - For all horizontal heat exchangers and vessels larger than 36 inch (approx. 915 mm) diameter which have a significant non-uniform weight distribution, the manufacturer shall show on a certified drawing the balance point location of the assembled unit, measured from a permanent reference point (e.g., face of main flange or tubesheet, large nozzle centerline, etc.). The balance point shall be determined by successive lifts of the completed and assembled unit.

10. MATERIALS

10.1 UNSPECIFIED MATERIALS - Materials not completely defined in the Vessel Specifications shall conform to the requirements of the ASME Code, Section II.

10.2 TUBING

10.2.1 Tubing Thickness - Average wall tubing (tubing with a plus-or-minus variation from specified wall thickness) may be used provided the under-tolerance will not permit wall thicknesses less than the required minimum for design conditions. The tolerance for average wall tubing shall be not more than the smaller of the allowable tolerance for average (nominal) wall tube given in the applicable tube specification or plus-or-minus 10 percent of the specified wall thickness.

10.2.2 Welded Tubing - All welded tubing shall be subjected to both the hydrostatic and nondestructive electric testing procedures, conducted in accordance with applicable ASME Code tubing specifications and Sections 9 and 10 of Specification SA-450. Both tests shall be performed after final heat treatment of the tubing. For stainless steel welded tubing, see also Article 10.3.3.

10.3 STAINLESS STEELS

10.3.1 Carbon Content - For design temperatures over 537.8 C (1000 F), regular grades of austenitic chromium-nickel stainless steels shall have not less than 0.04 percent carbon.

10.3.2 Welded Pipe with Filler Metal - The addition of filler metal to the weld in the manufacturing of austenitic stainless steel welded pipe having a wall thickness in excess of 0.165 inches (4.2 mm) shall be acceptable provided the joints are full-penetration welds of Type (1) ASME Code Table UW-12, and are made in accordance with procedures and by operators qualified in accordance with the ASME Boiler and Pressure Vessel Code, Section IX. The finished pipe shall comply in all other respects with the applicable requirements of Specification ASME SA-312 for welded pipe.

10.3.3 Cold Drawing for Welded Tubing - Molybdenum bearing grades of stainless steel welded tubing (e.g., Types 316, 316L, 317, 318 and EBR 26Cr-1Mo) through 2 inches (50.8 mm) nominal diameter shall be purchased to Specification ASME SA-249 (to SA-268 for EBR 26Cr-1Mo) with the added requirement that they shall be cold-reduced a minimum of 15 percent reduction in wall thickness after welding and prior to the final anneal, unless otherwise specified or approved by Buyer.

10.4 FLANGE STANDARDS - All external nozzles and nozzle flanges shall be ANSI standard unless otherwise specified or approved by Buyer.

10.4.1 Threaded Flanges Excluded - Threaded flanges shall not be used without Buyer's prior approval.

10.5 GASKETS

10.5.1 Continuous Gaskets - Gaskets shall be continuous. Metal gaskets made integral by welding and non-metallic gaskets with abutting ends suitably joined (dovetailed, scarfed, sniplapped) shall be considered as being continuous. Means shall be provided for holding (centering) the gasket in position during joint make-up.

10.5.2 Gaskets for Spacer-Ring Flanges - Unless otherwise specified, gaskets for flat face, spacer-ring type flanged joints (when such joints are specified or approved by Buyer) shall be of neoprene impregnated, brass wire inserted asbestos cloth, folded construction, 3 ply, 1/8 inch (3.2 mm) minimum total thickness. For vessels having design temperatures not exceeding 121.1 C (250 F), Garlock Style 8240, Johns-Manville Style 119, or approved equals are acceptable.

10.5.3 Asbestos Gasket Thickness - Compressed asbestos sheet gaskets shall be 1/16 inch (approx. 1.6 mm) thick unless otherwise specified or approved by Buyer.

10.5.4 Asbestos Gasket Material - When compressed asbestos gaskets are specified, one of the following products shall be provided unless otherwise approved by Buyer:

Durabla
 Garlock No. 900
 Johns-Manville No. 61
 Nicolet No. 226
 Raybestos-Manhattan No. 73

All compressed asbestos gaskets shall be ordered with a release agent to prevent sticking to the flange faces. All gaskets and gasket material shall be contained within a suitable package both for shipping and storage.

10.5.5 Spare Gaskets - A spare gasket shall be provided for each flanged joint, and shall be suitably packaged, marked, and shipped with the vessel, except that spare gaskets shall not be provided for nozzles having ANSI Standard flanges nor for any flanged joint using a compressed asbestos sheet gasket, unless otherwise specified in the Vessel Specifications.

10.5.6 Test Gaskets - See Articles 14.9 and 14.11.

11 FABRICATION DETAILS

11.1 BUTT WELDS REQUIRED - Welded pressure joints of Categories A & B (Paragraph UW-3 of ASME Code Section VIII/1) shall be butt welds having full penetration and fusion for their entire length. Longitudinal and circumferential welds in support skirts shall also meet these requirements.

11.2 BACKING STRIP REMOVAL REQUIRED - Backing strips, if used, shall be removed unless otherwise specified or approved in writing by Buyer.

11.3 WELD FILLER METAL - Deposited weld metal shall be essentially of the same strength and ductility as the material joined and, unless otherwise approved by Buyer, shall have essentially the same chemical composition as the material joined.

11.4 NOZZLE LOCATION - Nozzles or other openings preferably shall be located so that no part of the neck, added reinforcement or attachment welds intersects any welded joint, but may, if necessary, be located in circumferential joints (except neck-to-shell joints). Openings shall not be located in other welded joints unless approved by Buyer and noted on the manufacturer's drawing.

11.5 NOZZLE CORNER JOINT EXAMINATION - For nozzles attached per Fig. UW-16.1(a) or (b) of the ASME Code, the cut edge of the openings in plate thicker than 1/2 inch (12.7 mm) shall be examined in accordance with ASME Code Par. UG-93(b)(3).

11.6 FLANGE DRILLING - Bolt holes in all fixed flanges and stud holes in pads shall straddle the natural centerlines. For all nozzles in necks, bolt holes shall straddle centerlines parallel to or coincident with the natural vessel centerlines. Bolt holes in flanges shall be 1/8 inch (3.2 mm) larger than the diameter of the bolts.

11.7 DRAIN CORRECTIONS - Drain connections shall be trimmed flush with the inside contour of the vessel.

11.8 GROUNDING CLIPS - A 2-1/2 inch (63.5 mm) square by 3/8-5/8 inch (9.5-15.9 mm) thick grounding clip, having a 9/16 inch (14.3 mm) diameter hole centered in the clip 1-3/8 inches (35 mm) from the attached edge, is required for each vessel. The clip shall be edge-welded with a 1/4 inch (6.4 mm) continuous fillet weld, preferably to the support skirt, a lug, or other attachment, rather than to the pressure containing enclosure. For vessels constructed of impact-tested materials, the grounding clip shall not be attached directly to a pressure containing part. The material of the clip shall be similar to the material of the part to which it is to be welded, except clips to be joined to ferritic steel members shall be of austenitic stainless steel. Inconel A, Inco 182, or type 310 filler metal shall be used to weld the stainless steel to carbon steel.

11.9 INTERMEDIATE HEAD WELD - For compartmented tanks having a flanged and dished intermediate head, the outer end of the intermediate head skirt shall be seal-welded to the shell of the compartment. [See Fig. UW-13.1(f) of the ASME Code.]

11.10 GASKET SURFACES - All gasket seating surfaces shall be plane and true. Gasket surfaces of all fabricated flanges and bolted tubesheet joints (including pass-ribs) shall be machined, or re-machined if necessary, after welding or other fabrication steps which result in warpage or other distortion from a plane and true surface.

11.11 HEAT TREATMENT OF ROLLED JOINTS LIMITED - When heat exchangers or other vessels which contain rolled tube-to-tubesheet joints are required to be postweld heat treated, the tubes shall not be rolled until after heat treatment except that local heat treatment of the vessel may be performed provided that the temperature of the rolled tube joints shall not exceed 204.4 C (400 F).

11.12 THICKNESS OF FIXED TUBESHEETS - The tolerance on the specified thickness of fixed tubesheets shall be plus 1/8 inch (3.2 mm) minus zero. Tubesheet thickness in excess of 1/8 inch (3.2 mm) greater than the specified thickness is not acceptable for fixed tubesheets unless approved by Buyer.

12 TOLERANCES

12.1 TIMING - All applicable tolerances shall apply to the completed vessel after final pressure test(s).

12.2 SOURCE - Tolerances shall conform to Buyer's applicable standard from the following:



12.2.1 Pressure Vessels and Tanks - Buyer's Engineering Standard EQ-4.

12.2.2 Distillation Columns - Buyer's Engineering Standard EQ-181.

12.2.3 Heat Exchangers - Buyer's Engineering Standard EQ-182.

13 MAGNETIC PARTICLE OR LIQUID PENETRANT EXAMINATION

13.1 WELDED JOINTS REQUIRING EXAMINATION - Welded joints of the following categories (as defined in Paragraph UM-3, ASME Code Section VIII/1) shall be inspected by either magnetic particle or liquid penetrant examination in accordance with ASME Code Appendix VI or Appendix VIII, respectively, in the following cases:

13.1.1 Category D Welded Joints - All non-butt welds of Category D for vessels designed on a full-radiography basis.

13.1.2 Category A and B Welded Joints - The root pass of all Category A and B butt welds when the joint thickness exceeds 2 inches (50.8 mm).

13.2 EXAMINATION AFTER HEAT TREATMENT - When completed welds are required to be examined by the magnetic particle or liquid penetrant method and the vessel or part is to be heat treated, the examination shall be made after heat treatment in the following cases.

13.2.1 For vessels covered by Buyer's Standard Specification COP-2.

13.2.2 For vessels fabricated from non-impact-tested low-alloy steels over 1-1/4 inches (31.8 mm) thick.

13.2.3 For vessels fabricated from carbon steels over 2 inches (50.8 mm) thick.

13.2.4 When required by the ASME Code.

14 HYDROSTATIC TESTING

14.1 VERTICALLY MOUNTED VESSELS - All vertically mounted vessels shall be tested in their normal operating position if practicable. If vessels designed in accordance with Articles 40.9.1 and 40.9.2 are to be shop-tested in the horizontal position, the test pressure referenced to the vessel centerline shall be equal to the pressure which would exist at the bottom of the vessel if it were tested in the vertical position, and the recorded test pressure shall be noted with the suffix "H" or other suitable notation.

14.2 HORIZONTALLY MOUNTED VESSELS - Horizontally mounted vessels shall be tested on their supports without additional temporary supports or shoring. All supporting lugs, rings, saddles, or other types of supports that are to be permanently attached to the vessel shall be attached prior to the test. The test pressure shall be referenced to the vessel centerline.

14.3 COMPARTMENTED VESSELS - For vessels which consist of two or more compartments (e.g., heat exchangers), each compartment shall be given a separate and individual test with no pressure in the adjacent compartments. Mating surfaces of flanged joints shall be tested together unless otherwise specified or approved by Buyer.

14.4 VESSLS HAVING EXPANSION JOINTS - Temporary ties or supports which restrict or prevent the normal expansion or contraction of expansion joints shall be removed or loosened during the hydrostatic test.

14.5 HOLDING TIME - The hydrostatic test pressure shall be maintained for one hour per inch (25.4 mm) of maximum shell thickness with a one hour minimum and a five hour maximum.

14.6 WATER TEMPERATURE - The temperature of the water shall be sufficient to ensure that the vessel metal temperature (for the entire duration of the test) is not less than the minimum design temperature plus 16.6 C (°F + 30), but in no case less than 15.6 C (60 F).

14.7 WATER QUALITY - Water used in testing austenitic stainless steel vessels or components shall have a chloride ion content not greater than 125 ppm.

14.8 BLIND FLANGES FOR TEST CONDITIONS - The manufacturer shall provide all blind flanges and gaskets (or other types of blanking covers as may be required) necessary for testing. See Article 14.11.3.

14.9 GASKETS FOR TEST CONDITIONS - Test gaskets shall be the same (type, materials of construction, and dimensions) as the service gaskets specified in the Vessel Specifications. If service gaskets are not specified, test gaskets shall be of compressed asbestos in accordance with Articles 10.5.3 and 10.5.4, unless otherwise approved by Buyer. No dope or gasket compound other than a light oil shall be used on gasketed or threaded joints except when a compound is specified or approved by Buyer for service conditions. Test gaskets of compressed asbestos thicker than 1/16 inch (1.6 mm) shall not be substituted for 1/16 inch (1.6 mm) thick gaskets. If the joint will not hold the test pressure with the specified test gasket, the gasket surfaces shall be re-machined to a true and plane surface. Where gasketed joints are broken following the specified tests, new gaskets shall be provided except for those ANSI standard flanged nozzles which are not specified to be furnished with blind flanges.

14.10 RETESTING REPAIRED VESSELS - Repairs to cracks or defects revealed during or subsequent to pressure testing shall be tested by reapplying the original pressure test(s).

14.11 OPENING FLANGED JOINTS AFTER TESTING

14.11.1 Main Flange Joints - Main flange joints between compartments of heat exchangers or other pressure vessels shall be left unbroken (undisturbed and assembled) after testing, if practicable. When necessary to ship such compartments separately, a new gasket for field installation shall be suitably packaged, marked, and shipped with the vessel. This gasket shall be in addition to spare gaskets required by Article 10.5.4.

14.11.2 Blind-Flanged Connections - All manways, handholes, and those nozzles which are specified to be provided with blind flanges, shall be shipped with cover plates or blind flanges left unbroken after testing, if drainage and drying are otherwise effected. If such joints are broken after testing, they shall be reassembled for shipment using new gaskets. This gasket shall be in addition to spare gaskets required by Article 10.5.5.

14.11.3 Other Connections - For connections (nozzles) which are not specified to be provided with blind flanges, the blind flanges (or other types of blanking covers as may be required) may be removed after testing and remain the property of the manufacturer.

15 AIR (PNEUMATIC) TESTING FOR LEAKS

15.1 Air tests shall be required only when specified by Buyer. They shall be conducted after the hydrostatic test (except for preliminary low-pressure leak tests as specified or approved by Buyer), and with the interior of the vessel completely drained and judged thoroughly dry by Buyer's Inspector or other authorized representative.

15.1.1 Tube-to-tubesheet joints manually welded with covered electrodes shall be sandblasted prior to air testing.

16 NAMEPLATES

16.1 UCS NAMEPLATE - Buyer's standard nameplate shall be filled out by the manufacturer for each pressure chamber of a vessel and attached in the designated location. The nameplate and the information to be stamped on the nameplate will be supplied to the manufacturer by Buyer's Vendor Inspection-Expediting Department. For the method of attaching the mounting clip and the nameplate, see Buyer's Standard EQ-15A.

16.2 OTHER NAMEPLATES - Code, National Board, and other required non-Carbide stamping shall be on a nameplate attached to the vessel in conformance with Par. UG-119 of the ASME Code. Where stamping or punchmarking upon the vessel itself is unavoidable, the stamps or punches shall be specifically ground with rounded edges or points. When possible, such markings shall be located in relatively unstressed areas, such as on the edge of a flange. All nameplates shall indicate the maximum allowable working pressure and



the coincident maximum design temperature, and also the minimum design temperature. Other ratings, such as the equivalent design pressure at 37.3 C (100 F) or the basis-for-test pressure, may be stamped in addition to, but not in lieu of, the maximum allowable working pressure and coincident maximum design temperature.

17 REPORTS

17.1 REQUIRED INFORMATION - The manufacturer shall provide Buyer with four copies of each of the Manufacturer's Data Reports as specified in Par. UG-120 of the ASME Code, heat charts, certified mill test reports or certificates of compliance for materials used, and Buyer's nameplate, Code and National Board stamping ruboffs. Four copies of the Manufacturer's Certificate of Compliance, ASME Code Form U-3, shall be provided for vessels to be marked with the Code UM-symbol. See Article 2.2.1.

17.1.1 Foreign-Built Vessels - Manufacturers in those countries where ASME Code and National Board stamping are not obtainable shall furnish six copies each of the reports described herein and two clear copies (in English) of design criteria and the design calculations for each vessel.

17.2 REPORTS TO INCLUDE DATES - Reports shall note the date of issue of this specification and the year of issue of the ASME or ASTM Specifications, ASME Code, TEMA Standards, and ANSI Standards under which the vessel and vessel components were fabricated, manufactured, and/or tested.

18 CLEANING, PROTECTION, PAINTING, AND LOADING

18.1 DRYING AND CLEANING - After hydrostatic testing, the interior of all vessels shall be completely drained, and thoroughly dried and cleaned of foreign matter. Austenitic stainless steel and high alloy vessels shall be free from scale.

18.2 PRE-SHIPMENT PROTECTION - The following protection procedures shall be performed by the manufacturer before vessel is shipped:

18.2.1 Machined Surfaces - All gasket and other machined surfaces shall be cleaned with solvent and coated with "Rust Veto" No. 700, a heavy duty rust-preventive grease, manufactured by the E. F. Houghton Company.

18.2.2 Blind-Flanged Connections - Manways and nozzles which are to be furnished with blind flanges or covers shall be shipped with the flange joint unbroken or reassembled as specified in Article 14.11.2.

18.2.3 Other Connections - All other connection (nozzle) openings shall be provided with covers to ensure protection from mechanical damage and to exclude foreign material. All threaded openings shall be capped or plugged after the threads have been coated with "Rust Veto" No. 700.

18.2.4 Other Protection Requirements - When more complete protection of a vessel is necessary, additional or alternate instructions will be included in the Vessel Specifications.

18.3 PAINTING - Vessels shall not be painted unless otherwise specified in the Vessel Specifications.

18.4 WELDED ATTACHMENTS LIMITED - Welding of attachments to the vessel for shipping purposes is not permitted unless specific approval in writing is granted by Buyer.

19 APPENDED STANDARDS

19.1 Standard EQ-4: Dimensional Tolerances for Pressure Vessels and Tanks, May 1972.

19.2 Standard EQ-15A: Nameplate Mounting Clip, 4-1-71.

19.3 Standard EQ-181: Dimensional Tolerances for Distillation Columns, May 1972.

19.4 Standard EQ-182: Fabrication Notes and Dimensional Tolerances for Heat Exchangers, May 1972.



SUPPLEMENTARY REQUIREMENTS FOR THE DESIGN OF VESSELS OR PARTS OF VESSELS
NOT COVERED BY BUYER'S VESSEL SPECIFICATIONS

40 DESIGN CRITERIA

40.1 DESIGN PRESSURE AND ADDITIONAL LOADINGS - All pressure vessels shall be designed to withstand the design pressure at both the maximum and minimum design temperatures, including any additional loadings outlined in Paragraph UG-22 of the ASME Code, and as required by this specification and the Vessel Specifications. The design pressure shall be considered to apply to the top of the vessel in its normal operating position as defined in ASME Code Paragraph UA-60(b), and may be used in place of the maximum allowable working pressure as permitted in ASME Code Paragraph UA-60(a). The design pressure shall be considered to apply to the vessel in its corroded condition when a corrosion allowance is required by applicable codes or specified by Buyer. When the design pressure is not specified by Buyer in the Vessel Specifications, it shall be calculated to be not less than the maximum anticipated operating (including upset, start-up, and shut-down conditions) pressure divided by 0.90. For determining thickness of all components, see additional requirements for "Equivalent Design Pressure" in Article 40.9.

40.2 DESIGN TEMPERATURE - Each vessel shall have both a maximum and a minimum design temperature rating, and both shall be marked on the vessel nameplate. When the maximum and minimum design temperatures for a vessel are not specified by Buyer in the Vessel Specifications, they shall be determined in accordance with the following:

40.2.1 Maximum Design Temperature - All pressure vessels for warm service [minus 1.1 C (30 F) to 398.9 C (750 F), inclusive] shall have a maximum design temperature rating at least equal to the maximum anticipated (considering start-up, normal operating, upset, and shut-down conditions) temperature plus 13.9 C (°F + 25) but in no case less than 148.9 C (300 F). Vessels fabricated from materials whose allowable stress does not decrease below a specified temperature shall be rated at the highest temperature compatible with the vessel design.

40.2.2 Minimum Design Temperature - All pressure vessels shall have a minimum design temperature rating equal to or lower than the minimum anticipated (considering start-up, normal operating, upset, and shut-down conditions) temperature, but in no case greater than minus 1.1 C (30 F) unless otherwise approved by Buyer. For vessels whose metal temperature in normal service is dependent on ambient temperature, the minimum design temperature shall be taken as the lowest one-day mean temperature based on National Weather Service or other official records for the specified plant location. Each non-impact-tested carbon steel component shall have an impact test exemption temperature equal to or less than the minimum design temperature for the vessel. The impact test exemption temperature for carbon steel materials shall be determined as specified in Article 42.1. The minimum design temperature rating for all vessels shall be taken as the highest of the minimum temperatures permitted for any component.

40.3 OPERATING LIQUID HEAD - The hydrostatic head considered to apply in addition to and coincident with the design pressure shall be the hydrostatic pressure on each component when the vessel is filled to its maximum operating depth with a liquid having a specific gravity equal to that of the operating liquid, but in no case less than 1.0. All pressure vessels (except gas absorption and distillation columns) shall be assumed to operate completely filled with liquid unless otherwise specified or approved by Buyer.

40.4 MAXIMUM ALLOWABLE STRESS - The maximum allowable stress used for the design of all components shall be in accordance with the ASME Code, Section VIII/1. Where two allowable stress values are given for the same type of stainless steel, the lower value shall be used in the design of tubesheets and flanges.

40.5 DESIGNING FOR EXTERNAL PRESSURE - Vessels subjected to partial vacuum operating pressures of 6 ounces per square inch (2.637×10^{-4} kgf/mm²) or more shall be designed for full vacuum unless otherwise approved by Buyer. If a vessel will not be operated under vacuum at any time except when a vacuum is inadvertently drawn under upset or other emergency conditions, the vessel need not be designed for vacuum conditions provided that the vessel (as designed and ASME Code-stamped for internal pressure) can safely withstand the emergency vacuum condition on a short-time basis. In determining the maximum safe vacuum which may be drawn, ASME Code rules for external pressure design shall be used with additional consideration given to maximum out-of-roundness tolerance.

40.6 INTERNAL PRESSURE RATING OF VESSELS DESIGNED FOR VACUUM SERVICE - For vessels designed primarily for vacuum service, if no internal pressure rating is specified by Buyer, the internal design pressure shall be taken to be 25 psig (0.018 kgf/mm²) at the maximum design temperature specified for vacuum service.



40.7 MULTIPLE-CHAMBER VESSELS - The common component(s) or element(s) of multi-chamber or compartmented heat exchangers and other pressure vessels shall be designed for the most severe combinations of pressure, temperature, and other loadings which may occur during operation (including upset, start-up, and shut-down conditions) and test conditions. Design on the basis of simultaneous action of internal pressure in adjacent compartments is not acceptable to Buyer.

40.8 WIND OR EARTHQUAKE LOADS - Vessels shall be designed to resist wind pressures or seismic loadings without guys or bracing from other structures. The wind shall be assumed to act on the total projected area of the vessel including allowance for insulation, attached piping, ladders, platforms, and all other external attachments.

40.8.1 Design wind loads shall comply with Table 1 for the location at which the vessel will be installed unless otherwise specified in the Vessel Specifications.

40.8.2 Vertical pressure vessels having a height-to-diameter ratio of 15 or greater and all top-heavy vessels shall be checked as dynamic structures. The seismic analogy method (using a seismic factor of 0.20) shall be followed in checking the adequacy of the design of the vessel and vessel supports (excluding anchor bolts). For vessels to be located in Canada, vessels shall additionally conform to the requirements of the Canadian Structural Design Manual (Supplement No. 4, National Building Code of Canada).

40.8.3 When specified in the Vessel Specifications, vessels (including the anchor bolting) shall be designed to resist earthquake forces. Earthquake loadings shall be calculated according to the requirements of the Uniform Building Code as applicable for the Earthquake Zone Number specified in the Vessel Specifications.

40.8.4 Wind loads and earthquake loads are not to be considered as occurring at the same time. The vessel supports and anchor bolts shall be designed to withstand the greater of the wind or seismic moments when acting simultaneously with other loadings imposed upon the vessel during normal operation.

TABLE 1 - DESIGN WIND LOADS

Location Group	Locality	Height Above Ground, Ft. (4)	Plane Vertical Surfaces, Lbs. per Sq. Ft. (3)				Cylindrical Surfaces (1) and Ladders, Cages, & Platforms Lbs. per Sq. Ft. (3) on Projected Area			
			Up to 30	30 to 60	60 to 120	120 to 250	Up to 30	30 to 60	60 to 120	120 to 250
1	Continental USA coastal or inland areas not subject to hurricanes and tornadoes. (Includes Kanawha River Valley and Ohio River Valley upstream from Cincinnati.)		15	20	25	35	15	20	25	35
1A	Montreal, Canada (2)		16	17	19	22	11	12	14	16
2	USA areas in proximity of Great Lakes		25	30	40	55	20	25	35	50
3	Areas subject to hurricanes. (Includes USA Gulf Coast and Puerto Rico.)		30	40	50	70	25	30	40	55

(1) Tabular loads are for uniform diameter vessels having an h/D ratio equal to or less than 25 (where h = height of vessel and D = outside diameter). For vessels of non-uniform diameter or those having an h/D ratio greater than 25, design loads shall be as given in the Vessel Specifications.

(2) Wind loads are in accordance with the National Building Code of Canada, 1970 Edition, including supplements 1 and 4, using 1 in 30 annual probability data.

(3) One lb. per sq. ft. = 4.883×10^{-6} kgf/mm².

(4) One ft. = 304.8 mm.

40.9 EQUIVALENT DESIGN PRESSURE - In addition to the requirements of Articles 40.1 through 40.8, the thickness of all vessel components shall be further checked and increased, if necessary, to conform with the requirements of this article as follows:

All pressure-resisting components of all pressure vessels (except as permitted in Articles 40.9.2 and 40.9.3) shall be designed to withstand an equivalent design pressure at 37.8 C (100 F) equal to the greater of P_{ED} or P_{ET} as specified in Article 40.9.1, formula (1) or (2). If the thickness (before any corrosion allowance is added) of any component(s) is not adequate to withstand the greater of the two equivalent design pressures, the thickness of the component(s) shall be increased. In computing thickness required to withstand equivalent design pressures, the ASME Code allowable stresses at 37.8 C (100 F) and the applicable joint efficiency shall be used; and no additional loadings other than those inherent in the equivalent design pressure formulas need be considered. For the purpose of computing equivalent design pressures only, where two ASME Code allowable stress values are given for the same type of stainless steel, the higher value may be used for all components. (Also see Article 40.4) When specified by Buyer for a particular vessel or group of vessels, the thickness of all components shall be further checked for conformance with Article 40.9.4.

40.9.1 Equivalent Design Pressure for Shop-Fabricated Vertical and Horizontal Vessels Shop-Tested in Horizontal Position - For vessels which are to be installed in a vertical position, but are to be shop-tested in a horizontal position, and for all horizontally-mounted vessels, the thickness of all vessel components (before any corrosion allowance is added) shall be adequate to withstand the larger of the equivalent design pressures P_{ED} or P_{ET} . The equivalent design pressures P_{ED} and P_{ET} for all vessel components, regardless of elevational position in the vessel, shall be determined by formulas (1) and (2).

$$P_{ED} = \frac{S_A}{S_D} (P_D + H_D + V) \quad (1)$$

$$P_{ET} = \frac{S_A}{S_D} (P_D + V) + \frac{2H_T}{3} \quad (2)$$

where P_D = Internal design pressure at top of vessel in its normal operating position at maximum design temperature (nameplate rating), in psi.

P_{ED} = Equivalent design pressure at 37.8 C (100 F) based on design (operating) liquid head, in psi.

P_{ET} = Equivalent design pressure at 37.8 C (100 F) based on test liquid head, in psi.

H_D = Hydrostatic head at the bottom of the vessel in its normal operating position when filled to its normal operating depth with a liquid having a specific gravity equal to that of the operating liquid, but in no case less than 1.0. Vessels (except gas absorption and distillation columns) shall be assumed to operate completely filled with liquid unless otherwise specified or approved by Buyer.

H_T = Hydrostatic head at the bottom of the vessel in its normal operating position when completely filled with water.

$\frac{S_A}{S_D}$ = Highest ratio (for the materials of which the vessel is constructed) of the ASME Code allowable stress at 37.8C (100 F) (S_A) for any pressure-resisting component of the vessel, to the ASME Code allowable stress at design temperature (S_D) for the same component. For shell-and-tube heat exchangers, the tubesheet material and the tube material are exempted from this requirement.

V = Design vacuum on adjacent chamber, if any, in psi (for heat exchangers and other multi-compartment vessels).

40.9.2 Equivalent Design Pressure for Shop-Fabricated Vertical Vessels Shop-Tested in Horizontal Position: Alternate Permitting Increased Shell Stress During Test - For tall, vertical, cylindrical, shop-fabricated vessels (such as distillation columns) which are designed for a relatively low operating liquid head, and which are to be shop-tested in a horizontal position, the thickness of all vessel components (before any corrosion allowance is added) shall be adequate to withstand the larger of equivalent design pressures P_{ED} or P_{ET} as required by Article 40.9.1, except that, when approved by Buyer, the thickness of the cylindrical shell only (at all elevational positions and before any corrosion allowance is added) shall be adequate to withstand the larger of the two equivalent design pressures P_{EDS} or P_{ETS} . The equivalent design pressures P_{EDS} and P_{ETS} for the shell only, subject to the restrictions below, shall be determined by formulas (3) and (4):

$$P_{EDS} = \frac{S_A}{S_D} (P_D + H_0) \quad (3)$$

$$P_{ETS} = \frac{1.5}{K} \left[P_D \left(\frac{S_A}{S_D} \right) + \frac{2H_T}{3} \right] \quad (4)$$

where P_{EDS} = Equivalent design pressure at 37.8 C (100 F) based on design (operating) liquid head, in psi.

P_{ETS} = Equivalent design pressure at 37.8 C (100 F) for cylindrical shells (including reinforcement for coatings) permitted to have an increased test stress, in psi.

K = The lesser of 80 percent of the specified minimum yield strength at 37.3 C (100 F) divided by S_A , or 1.75; but in no case shall K be less than 1.5.

and other terms are as defined in Article 40.9.1. Shell thicknesses based on the equivalent design pressure P_{ETS} permit a maximum shell stress during hydrostatic test equal to the lesser of 80 percent of the specified minimum yield strength at 37.3 C (100 F) or 175 percent of the ASME Code allowable stress at 37.3 C (100 F).

40.9.2.1 The increased test stress may also be permitted for nozzle walls and reinforcement of nozzle openings in the shell provided that the finished inside diameter of the nozzle (or major inside dimension, if the nozzle is elliptical) is not larger than the limiting size of openings listed in ASME Code Par. UA-7 for reinforcement of openings for which ASME Code Pars. UG-36 through UG-44 are primarily intended to apply. The thickness of nozzles and reinforcement of nozzle openings shall be adequate to withstand the larger of equivalent design pressures P_{EDS} or P_{ETS} as given in formulas (3) and (4) above. Material used for nozzles and reinforcement shall have a specified minimum yield strength equal to or greater than that of the material used in the vessel wall, except that when such material is not available, lower strength material may be used, provided the thickness of nozzle wall and area of reinforcement is increased in inverse proportion to the ratio of the specified minimum yield strengths of the two materials to compensate for the lower yield strength of the nozzle or reinforcement material.

40.9.2.2 The increased test stress is not permissible in those portions of the shell immediately adjacent to the junction with other pressure components such as conical transitions, which affect the strength of the junction with such other components. Those portions of the shell shall be designed in accordance with Article 40.9.1.

40.9.2.3 The increased test stress shall be acceptable only for carbon steels (or low-alloy steels approved by Buyer) with transition properties such that the material in the thickness under consideration has an impact test exemption temperature as determined from Figure 1 at least 16.7 C (30 F) lower than the minimum temperature of the vessel during the hydrostatic test.

40.9.2.4 When vessels are designed in accordance with Article 40.9.2, the design drawings shall be marked conspicuously with a note referring to that article. The shell test stress, or the ratio of shell test stress to ASME Code allowable stress, shall also be noted on the vessel drawings. The manufacturer shall make known to Buyer any proposed exceptions to this article at the time the manufacturer's quotation is submitted to Buyer. No exceptions will be permitted without the written approval of Buyer.

40.9.3 Equivalent Design Pressure for Field-Fabricated and Field-Tested Vertical Vessels - For vertical vessels which are to be fabricated in the field and tested in their normal operating position, the thickness of all vessel components (before any corrosion allowance is added) shall be adequate to withstand the larger of equivalent design pressures P_{EDV} or P_{ETV} . The equivalent design pressures P_{EDV} and P_{ETV} for all vessel components, based on their elevational position, shall be determined by formulas (5) and (6):

$$P_{EDV} = \frac{S_A}{S_D} (P_D + H_{OV}) - \frac{2}{3} (H_T - H_{TE}) \quad (5)$$

$$P_{ETV} = \frac{S_A}{S_D} (P_D) + \frac{2H_{TE}}{3} \quad (6)$$

where

P_{EDV} = Equivalent design pressure at the elevation of the element under consideration at 37.8 C (100 F) based on design (operating) liquid head, in psi.

P_{ETV} = Equivalent design pressure at the elevation of the element under consideration at 37.8 C (100 F) based on test (filled with water) liquid head, in psi.

H_{OV} = Hydrostatic head at the bottom of the vessel in its normal operating position when filled to its maximum operating depth with a liquid having a specific gravity equal to that of the operating liquid but in no case less than 0.67.

H_{TE} = Hydrostatic head at the elevation of the element under consideration when the vessel is completely filled with water.

and P_D , H_T and $\frac{S_A}{S_D}$ are as defined in Article 40.9.1.

If $\left(\frac{S_A}{S_D}\right) H_{OV} = \frac{2H_T}{3}$, then $P_{EDV} = P_{ETV}$

If $\left(\frac{S_A}{S_D}\right) H_{OV} = \frac{2H_T}{3}$, then $P_{EDV} = P_{ETV}$

40.9.4 Supplementary Design Requirement for Specially-Designated Vessels Having a Corrosion Allowance - When specified by Buyer for a particular vessel or group of vessels, the thickness of vessel components shall be further checked and increased, if necessary, to conform with the requirements of this Article as follows:

The highest permissible internal pressure for the principal component as determined by the ASME Code design formulas, using nominal thickness with corrosion allowance included and using ASME Code allowable stresses at 37.8 C (100 F), shall be considered to be the pre-determined "basis for calculated test pressure" as defined in ASME Code Par. UA-60(e). All other components (elements) shall be of such thickness that the "basis for calculated test pressure" will be not less than the "basis for calculated test pressure" of the principal component. The principal component shall be taken as that shell or formed head element having the greatest ratio of corrosion allowance to the thickness required for the design conditions as specified in Articles 40.1 to 40.8 inclusive.

41 MISCELLANEOUS DESIGN REQUIREMENTS

41.1 FLANGED JOINTS

41.1.1 Confined Joints - Gaskets and gasketed flange joint designs for all pressure vessels (including heat exchangers) for main shell joints and for nozzle flange joints greater than 24 inch (609.6 mm) nominal diameter shall be of the fully confined type (except for spiral-wound gaskets with compression gage rings) for any of the following conditions:



- (1) Design pressures 300 psig (0.211 kgf/mm²) or higher.
- (2) Design temperatures exceeding 260 C (500 F).
- (3) Design temperatures less than minus 29.9 C (-20 F).
- (4) Joint requires metallic or semi-metallic gaskets.
- (5) Cyclic pressure or temperature service.

41.1.2 Unconfined Joints - Flange faces for unconfined joints shall have a raised face of at least 1/16 inch (1.6 mm).

41.1.3 Lap Joints - Joints for stainless steel and non-ferrous components shall be of the lap-joint type with carbon steel flanges, unless otherwise specified or approved by Buyer.

41.1.3.1 The nominal outside diameter of shop-fabricated laps shall correspond to ANSI B16.9 standard diameters when used with ANSI standard flanges. When shop-fabricated laps are to be used with flanges having other than ANSI standard diameters and drilling, the nominal outside diameter of the lap shall not exceed the flange bolt circle diameter less one bolt hole diameter, and the finished flat width of the lap shall comply with the following:

(1) The unsupported radial width of the lap, at the back of the lap, shall not exceed the minimum required thickness of the nozzle or shell.

(2) For an assembled joint, after all permissible clearances have been considered, the radial width of the lap in contact with the flange shall be not less than the finished thickness of the lap less corrosion allowance.

41.1.3.2 The finished thickness of shop-fabricated laps shall be not less than the nominal thickness (including corrosion allowance) of the nozzle or shell to which it is attached, but in no case less than 1/4 inch (6.4 mm) (plus corrosion allowance) for nominal sizes 14 inch (355.6 mm) and larger nor less than 3/16 inch (4.8 mm) (plus corrosion allowance) for nominal sizes less than 14 inches (355.6 mm). Additionally, laps made of low-carbon stainless steel grade materials shall have a finished lap thickness not less than 110 percent of the nominal thickness of the nozzle or shell.

41.2 GASKETED TUBESHEET JOINTS

41.2.1 Gaskets at Pass-Ribs - Confining grooves shall be provided for all pass-rib gasketed joints except those for exchangers having a nominal diameter of 12 inches (304.8 mm) or smaller and a maximum allowable working pressure of 300 psig (0.211 kgf/mm²) or less.

41.2.2 Bolting Area Calculations - The pass-rib gasket area shall be added to the circumferential gasket area in obtaining the total gasket area to be compressed and the bolting required.

41.2.3 Alloy steel bolts shall be used as specified in Article 42.3.

41.3 FIXED TUBESHEET JOINTS - Welded tubesheet-to-shell joints shall be in accordance with ASME Code Figure UW-13.2 (a), (b), (f), or (k). For the purpose of determining required weld sizes [as specified in Code Par. UW-13 (e) (3)] a tubesheet shall be considered to be supported (80 percent or more of the pressure load on the tubesheet is carried by the tubes, stays, or braces) if

$$\frac{A_t E_t}{A_s E_s} \geq 4$$

where

A_t = total cross-sectional metal area of tubes, sq. ins.

E_t = modulus of elasticity of tube material at design temperature, psi.

A_s = cross-sectional metal area of shell based on actual thickness less corrosion allowance, sq. ins.

E_s = modulus of elasticity of shell material at design temperature, psi.

41.3.1 When an expansion joint is provided for heat exchangers with fixed tubesheets, the joint attachment weld shall be located not less than $2.5 \sqrt{Rt}$ from the back of the tubesheet, where R = outside radius of shell, ins., and t = actual thickness of shell less corrosion allowance, ins.

41.4 PASS PARTITION PLATES - Pass partition plates for heat exchanger channels shall be designed for the maximum anticipated differential pressure and coincident temperature (including start-up, upset, and shut-down conditions) as specified by Buyer.

41.5 MITERED 90-DEGREE REDUCING ELBOWS FOR CALANDRIAS - Inlet and outlet mitered reducing elbows shall have dimensions as specified or approved by Buyer and shall conform to the following requirements:

(1) The minimum number of sections shall be 5, with not less than 3 changes in direction at both the inside and outside contour.

(2) Meridian (change of direction) angles between adjacent sections shall be approximately equal for gradual flow transition.

(3) No re-entrant angles are permitted, and the general contours shall be similar to those of commercial forged reducing welding elbows.

(4) All welded joints shall be full-penetration butt welds, double-welded unless otherwise approved by Buyer.

41.6 NOZZLE PROJECTION - Nozzle projections (outside of wall to nozzle face) for each vessel or group of vessels shall be as specified or approved by Buyer, and shall in no case be less than the greater of the following:

41.6.1 5 inches (127 mm) for pipe sizes $\leq$ 2 inches (50.8 mm).

5-1/2 inches (139.7 mm) for pipe sizes 2-4 inches (50.8-101.6 mm), inclusive.

6-1/2 inches (165.1 mm) for pipe sizes $\geq$ 4 inches (101.6 mm), or

41.6.2 The flange thickness (including lap thickness for lapped flanges), plus 1-1/2 times the nut thickness, plus the reinforcing pad thickness, plus the insulation thickness [3 inches (76.2 mm), max.], or

41.6.3 The length through the hub of welding neck flanges plus the reinforcing pad thickness plus

1 inch (25.4 mm) for pipe sizes up to 4 inches (101.6 mm), inclusive.

1-1/2 inches (38.1 mm) for pipe sizes over 4 inches (101.6 mm) to 8 inches (203.2 mm), inclusive.

2 inches (50.8 mm) for pipe sizes over 8 inches (203.2 mm).

41.7 SUPPORT SKIRTS

41.7.1 Support skirts for vessels with bottom head having a knuckle radius shall be welded to the straight flange (cylindrical) portion of the head unless otherwise approved by Buyer. Skirt materials shall be in accordance with Articles 42.4 and 42.6.5.

41.8 ANCHOR BOLT SIZING AND POSITIONING

41.8.1 The minimum size of anchor bolts for pressure vessels shall be 3/4 inch (19 mm). The orientation of anchor bolt holes shall be as specified or approved by Buyer.

41.8.2 The anchor bolt circle shall be selected to provide radial clearance for the tensioning device specified in the Vessel Specifications when post-tensioned anchor bolts are required.



- (1) Design pressures 300 psig (0.211 kgf/mm²) or higher.
- (2) Design temperatures exceeding 260 C (500 F).
- (3) Design temperatures less than minus 28.9 C (-20 F).
- (4) Joint requires metallic or semi-metallic gaskets.
- (5) Cyclic pressure or temperature service.

41.1.2 Unconfined Joints - Flange faces for unconfined joints shall have a raised face of at least 1/16 inch (1.6 mm).

41.1.3 Lap Joints - Joints for stainless steel and non-ferrous components shall be of the lap-joint type with carbon steel flanges, unless otherwise specified or approved by Buyer.

41.1.3.1 The nominal outside diameter of shop-fabricated laps shall correspond to ANSI B16.9 standard diameters when used with ANSI standard flanges. When shop-fabricated laps are to be used with flanges having other than ANSI standard diameters and drilling, the nominal outside diameter of the lap shall not exceed the flange bolt circle diameter less one bolt hole diameter, and the finished flat width of the lap shall comply with the following:

(1) The unsupported radial width of the lap, at the back of the lap, shall not exceed the minimum required thickness of the nozzle or shell.

(2) For an assembled joint, after all permissible clearances have been considered, the radial width of the lap in contact with the flange shall be not less than the finished thickness of the lap less corrosion allowance.

41.1.3.2 The finished thickness of shop-fabricated laps shall be not less than the nominal thickness (including corrosion allowance) of the nozzle or shell to which it is attached, but in no case less than 1/4 inch (6.4 mm) (plus corrosion allowance) for nominal sizes 14 inch (355.6 mm) and larger nor less than 3/16 inch (4.8 mm) (plus corrosion allowance) for nominal sizes less than 14 inches (355.6 mm). Additionally, laps made of low-carbon stainless steel grade materials shall have a finished lap thickness not less than 110 percent of the nominal thickness of the nozzle or shell.

41.2 GASKETED TUBESHEET JOINTS

41.2.1 Gaskets at Pass-Ribs - Confining grooves shall be provided for all pass-rib gasketed joints except those for exchangers having a nominal diameter of 12 inches (304.8 mm) or smaller and a maximum allowable working pressure of 300 psig (0.211 kgf/mm²) or less.

41.2.2 Bolting Area Calculations - The pass-rib gasket area shall be added to the circumferential gasket area in obtaining the total gasket area to be compressed and the bolting required.

41.2.3 Alloy steel bolts shall be used as specified in Article 42.3.

41.3 FIXED TUBESHEET JOINTS - Welded tubesheet-to-shell joints shall be in accordance with ASME Code Figure UW-13.2 (a), (b), (f), or (k). For the purpose of determining required weld sizes [as specified in Code Par. UW-13 (e) (3)] a tubesheet shall be considered to be supported (80 percent or more of the pressure load on the tubesheet is carried by the tubes, stays, or braces) if

$$\frac{A_t E_t}{A_s E_s} \geq 4$$

where

A_t = total cross-sectional metal area of tubes, sq. ins.

E_t = modulus of elasticity of tube material at design temperature, psi.

A_s = cross-sectional metal area of shell based on actual thickness less corrosion allowance, sq. ins.

E_s = modulus of elasticity of shell material at design temperature, psi.

41.3.1 When an expansion joint is provided for heat exchangers with fixed tubesheets, the joint attachment weld shall be located not less than $2.5 \sqrt{Rt}$ from the back of the tubesheet, where R = outside radius of shell, ins., and t = actual thickness of shell less corrosion allowance, ins.

41.4 PASS PARTITION PLATES - Pass partition plates for heat exchanger channels shall be designed for the maximum anticipated differential pressure and coincident temperature (including start-up, upset, and shut-down conditions) as specified by Buyer.

41.5 MITERED 90-DEGREE REDUCING ELBOWS FOR CALANDRIAS - Inlet and outlet mitered reducing elbows shall have dimensions as specified or approved by Buyer and shall conform to the following requirements:

- (1) The minimum number of sections shall be 5, with not less than 3 changes in direction at both the inside and outside contour.
- (2) Meridian (change of direction) angles between adjacent sections shall be approximately equal for gradual flow transition.
- (3) No re-entrant angles are permitted, and the general contours shall be similar to those of commercial forged reducing welding elbows.
- (4) All welded joints shall be full-penetration butt welds, double-welded unless otherwise approved by Buyer.

41.6 NOZZLE PROJECTION - Nozzle projections (outside of wall to nozzle face) for each vessel or group of vessels shall be as specified or approved by Buyer, and shall in no case be less than the greater of the following:

- 41.6.1 5 inches (127 mm) for pipe sizes - 2 inches (50.8 mm),
 5-1/2 inches (139.7 mm) for pipe sizes 2-4 inches (50.8-101.6 mm), inclusive,
 6-1/2 inches (165.1 mm) for pipe sizes - 4 inches (101.6 mm), or

41.6.2 The flange thickness (including lap thickness for lapped flanges), plus 1-1/2 times the nut thickness, plus the reinforcing pad thickness, plus the insulation thickness [3 inches (76.2 mm), max.], or

- 41.6.3 The length through the hub of welding neck flanges plus the reinforcing pad thickness plus
 1 inch (25.4 mm) for pipe sizes up to 4 inches (101.6 mm), inclusive,
 1-1/2 inches (38.1 mm) for pipe sizes over 4 inches (101.6 mm) to 8 inches (203.2 mm), inclusive,
 2 inches (50.8 mm) for pipe sizes over 8 inches (203.2 mm).

41.7 SUPPORT SKIRTS

41.7.1 Support skirts for vessels with bottom head having a knuckle radius shall be welded to the straight flange (cylindrical) portion of the head unless otherwise approved by Buyer. Skirt materials shall be in accordance with Articles 42.4 and 42.6.5.

41.8 ANCHOR BOLT SIZING AND POSITIONING

41.8.1 The minimum size of anchor bolts for pressure vessels shall be 3/4 inch (19 mm). The orientation of anchor bolt holes shall be as specified or approved by Buyer.

41.8.2 The anchor bolt circle shall be selected to provide radial clearance for the tensioning device specified in the vessel specifications when post-tensioned anchor bolts are required.

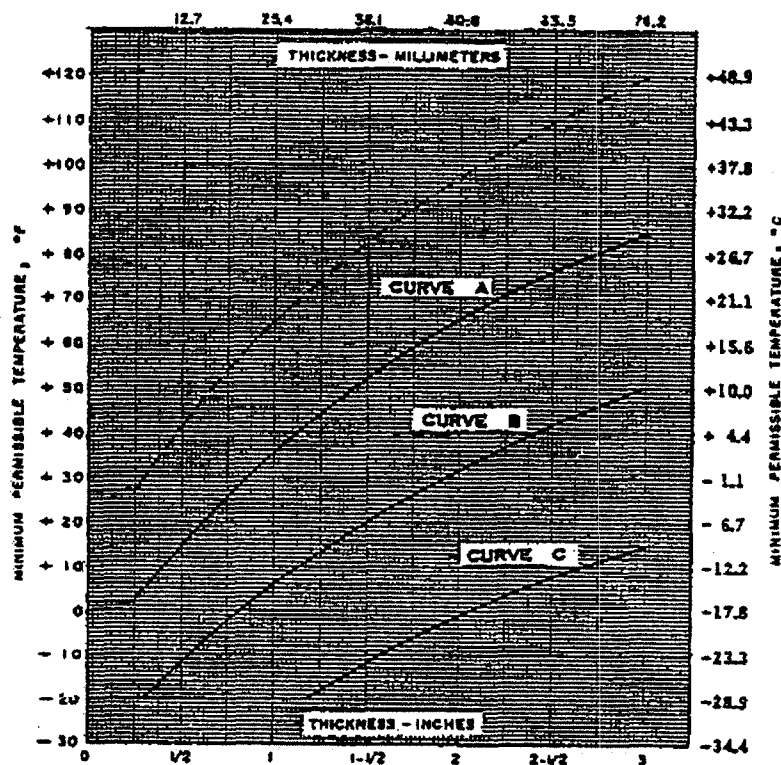


FIGURE 1 — IMPACT TEST EXEMPTION CURVES FOR CARBON STEEL

(FOR PRESSURE PARTS AND NON-PRESSURE PARTS WELDED TO PRESSURE PARTS AS NOTED, SEE ARTICLES 4.1, 1 AND 4.3.)

NOTES ON USE OF FIGURE 1 (Specifications listed are ASME Specifications):

- CURVE A:** Plates: SA-285 and SA-515; SA-442 $\leq$ 1 inch thickness; SA-283 (for non-pressure parts only)
- CURVE B:** Non-normalized plate: SA-442 $>$ 1 inch thickness; SA-516 $\leq$ 1-1/2 inch thickness
 Pipe: SA-53 and SA-106
 Forgings: SA-181 and SA-105
 Tubing: Heat exchanger tubing conforming to any of the carbon steel (P-1) tubing specifications listed in ASME Code Tables UCS-23 and UCS-27.
 Non-Pressure Parts of Product Forms Other Than Plate conforming to SA-36 or any of the carbon steel (P-1) materials listed in ASME Code Tables UCS-23 and UCS-27.
- CURVE C:** Plate: SA-516 normalized (Notes: Plates $\leq$ 1-1/2 inch thickness are not normalized unless normalizing is specified by the purchaser)
 Pipe: SA-524
 Forgings: SA-105 made to fine grain practice and normalized (See Alternate Forgings).
- DOTTED CURVE:** For UCC use only in evaluating existing vessels made of obsolete Specification SA-285-C flange quality.
- ALL CURVES:** The thickness of plate and other product forms shall be defined as the thickness of the thickest part. For thicknesses greater than 3 inches impact tests shall be made according to ASME Code Par. UG-84, except as otherwise permitted for tubesheets and flanges below.
- EXCEPTIONS:** For Tubesheets and Special Flanges Only (other than standard flanges conforming to ANSI Std. B16.5), the following materials may be used for minimum design temperatures 30°F or above without impact testing:
- (1) SA-285 and SA-515 to 2 inches thick, inclusive
 - (2) SA-181 to 3 inches thick, inclusive
 - (3) SA-516 and SA-105 to 6 inches thick, inclusive
- Standard Flanges conforming to ANSI Standard B16.5 may be used without impact testing as follows:
- (1) SA-181 and SA-105 for minimum design temperatures 30°F or above.
 - (2) SA-105 made to fine grain practice and normalized for minimum design temperatures minus 20°F or above. (See Alternate Forgings)
- ALTERNATE FORGINGS:** For all thicknesses, impact tested SA-350-LF1 or LF2, or ASME Code Case 1285, except impact test temperature need not be lower than minimum design temperature.



41.8.3 Design stresses for anchor bolts as calculated on the tensile stress area of the threaded portion, unless otherwise specified or approved by Buyer, shall not exceed the following:

For low-alloy steel - 25,000 psi (17,577 kgf/mm²) for bolt diameters $\leq$ 2-1/2 inches (63.5 mm), and 23,000 psi (16,171 kgf/mm²) for bolt diameters $>$ 2-1/2 inches (63.5 mm) through 4 inches (101.6 mm), or

For carbon steel - 15,000 psi (10,546 kgf/mm²). Carbon steel anchor bolts shall not exceed 1-1/2 inches (38.1 mm) in diameter.

41.8.4 The tensile stress area of the threaded portion of anchor bolts shall be determined in accordance with the following:

For low-alloy steel - ANSI 8-Pitch Thread Series (8-UN).

For carbon steel - ANSI Course Thread Series (UNC).

41.9 LIFTING LUGS

41.9.1 Vessel lifting lugs shall be provided for all vertical pressure vessels having a diameter of 5'-0" or larger, or a length greater than 6'-6". Lifting lugs in accordance with Buyer's Standard EQ-36 (copies furnished upon request) are acceptable within the limitations of the Standard. For taller, larger diameter, or otherwise heavier vessels than those shown on Standard EQ-36, lugs of a similar design shall be provided unless otherwise approved by Buyer. The effect of handling and erection shall be considered in the design of the vessel and the lifting lugs.

41.9.2 Lifting lugs of the general type shown on Buyer's Standard EQ-34A (copies furnished upon request) shall be provided for all removable vessel covers and manway covers. For heat exchangers, lifting lugs shall be provided for handling channel covers and shell covers.

42 MATERIAL SELECTION

42.1 Carbon Steel materials are acceptable without impact testing for all pressure and non-pressure parts only under the following conditions:

42.1.1 For Minimum Design Temperatures Down to minus 28.9 C (-20 F), provided that the impact test exemption temperature as shown in Figure 1 for the thickness of the material under consideration is equal to or below the minimum design temperature rating of the vessel as defined in Article 40.2.2.

42.1.2 For Minimum Design Temperatures Down to minus 45.6 C (-50 F), provided that the maximum stress in any component for the design pressure and any other applicable design loadings does not exceed either 0.4 times the ASME Code allowable stress for the material of any component, or 6300 psi (4,210 kgf/mm²).

42.2 LOW-ALLOY STEELS shall be as specified or approved by Buyer.

42.3 HEAT EXCHANGER BOLT MATERIAL - Code approved low-alloy steel bolts shall be used for all flanged joints which contain a tubesheet. Carbon steel bolts shall not be used.

42.4 VESSEL SUPPORT MATERIALS - All components of skirts and other vessel supports shall be of ASME Code approved materials.

42.5 EXTERNAL ATTACHMENTS ON PRESSURE PARTS - All external attachments welded to pressure parts shall be of the same type material (ASME Code P-number) as the part to which they are attached except as noted in Article 42.6, or except as otherwise specified or approved by Buyer. All material for such attachments shall be Code approved material and all carbon steel shall be in accordance with Article 42.1. When austenitic stainless steel welded attachments are required, regular grade stainless steels may be substituted for similar AISI types of low-carbon stainless steels.



42.5 WELDED PARTS OF DISSIMILAR METALS - Parts of vessels or external attachments welded to pressure parts of vessels shall be of material having essentially the same coefficient of expansion as the vessel material unless otherwise specified or approved by Buyer, except as follows:

42.6.1 Nozzle reinforcing pads for austenitic stainless steel vessels or vessel compartments may be of carbon steel provided that:

- (1) The maximum design temperature does not exceed 232.2 C (450 F).
- (2) The minimum design temperature is not less than minus 28.9 C (-20 F) and the material satisfies the requirements of Article 42.1.
- (3) The difference between the maximum and minimum design temperatures does not exceed 198.9 C (390 F).
- (4) The total number of temperature fluctuations of more than 93.3 C (200 F) does not exceed 3000 (= 12 times per month for 20 years).
- (5) The vessel is not postweld heat treated.
- (6) The vessel is not for lethal service.

42.6.2 External stiffening rings for austenitic stainless steel vessels may be of carbon steel for vessels designed for full vacuum at maximum design temperatures not exceeding 148.9 C (300 F) or minimum design temperatures not less than minus 12.2 C (10 F) with internal pressure rating not exceeding 25 psig (0.018 kgf/mm²) with the same temperature limitations, or provided that the use of carbon steel rings is justified by a complete stress analysis and is approved by Buyer. Additionally, the material for carbon steel rings shall satisfy the requirements of Article 42.1.

42.6.3 Clios, clip back-up pads, insulation supports, and other welded attachments on austenitic stainless steel vessels may be of carbon steel subject to the limitations specified in Article 42.6.1 (1), (2), (3), (4), and (5) for reinforcing pads. For vessel supports, see Articles 42.6.4 and 42.6.5.

42.6.4 Lugs, saddles, or other vessel supports except skirts, welded to austenitic stainless steel vessels may be of carbon steel subject to the limitations specified in Article 42.6.1 (1), (2), (3), (4), and (5) for reinforcing pads, except that the supports shall be welded to a stainless steel back-up pad (rather than directly onto the vessel) for design temperatures higher than 65.6 C (150 F).

42.6.5 Support skirts welded to austenitic stainless steel vessels shall be of austenitic stainless steel except as permitted in Articles 42.6.5.1, 42.6.5.2, and 42.6.5.3. Exceptions or alternates to these requirements shall be justified by a complete stress analysis and approved by Buyer.

42.6.5.1 For vessels having a design temperature of 55.6-232.2 C (150-450 F), the skirt shall be stainless steel for a distance of $1.5 \sqrt{Rt}$ (where R = mean skirt radius, and t = skirt thickness, in inches) below the attachment weld, but not less than the following:

8 inches (approx. 200 mm) for vessels $\leq$ 78 inches (approx. 2.0 m), diameter.

12 inches (approx. 300 mm) for vessels $>$ 78 inches (approx. 2.0 m), but $\leq$ 138 inches (approx. 3.5 m), diameter.

18 inches (approx. 450 mm) for vessels $>$ 138 inches (approx. 3.5 m), diameter.

The rest of the skirt may be of carbon steel.

42.6.5.2 For vessels having a design temperature higher than 232.2 C (450 F), the minimum length of stainless steel skirt below the attachment weld shall be as specified in the Vessel Specifications.

42.6.5.3 For vessels having a design temperature between minus 28.9 C (-20 F) and 65.6 C (150 F), inclusive, and having a height to diameter ratio of 5 or less, the entire skirt may be of carbon steel subject to the requirements of Article 42.1.

42.6.6 Nozzles for steel vessels clad with austenitic stainless steel shall be of similarly clad material for nozzles larger than 12 inch (304.8 mm) nominal diameter. Nozzles of 12 inches (304.8 mm) nominal diameter and smaller may be of solid stainless steel subject to the limitations specified in Article 42.6.1 (1), (2), (3), (4), and (5) for reinforcing pads. Loose liners shall not be used for nozzles of any size unless specified or approved by Buyer.

42.6.7 Tubesheets which are to be fixed by welding to a carbon steel shell shall be of carbon steel or clad carbon steel except that solid stainless steel tubesheets may be used provided that:

(1) The intended use of tubesheets of stainless steel (or other materials having a coefficient of expansion which differs from that of the shell material by more than 15 percent) is justified by a complete stress analysis and is approved by Buyer, or the tubesheet is welded to a relatively short shell section of the same material and the junction of the alloy and carbon steel shell sections is justified by a complete stress analysis and is approved by Buyer.

(2) The tubesheet material is approved by Buyer.

42.7 BOLTED JOINTS OF DISSIMILAR METALS - Austenitic stainless steel or non-ferrous alloy tubesheets or flanges may be bolted to carbon steel flanges provided that the differential diametral expansion will not result in diametral interference of recessed (e.g., male and female) joints but in no case exceeds 1/32 inch (0.79 mm), and further provided that the tubesheet material is approved by Buyer. Bolts joining a carbon steel flange to a stainless steel flange or tubesheet shall be of low-alloy steel unless otherwise specified or approved by Buyer.

42.8 GASKETS

42.8.1 Spiral-wound Gaskets - Spiral-wound gaskets, except those for standard ANSI flanges and facings, shall be ordered giving complete information including flange dimensions, flange facing dimensions, and bolting as recommended by the gasket manufacturer.

42.8.1.1 Compression Rings Required - All spiral-wound gaskets for raised face or other unconfined gasket joints shall be furnished with an outside compression limiting ring.

42.8.1.2 Asbestos Filled Spiral-Wound Gaskets shall not be used for joints requiring the outside diameter of the gasket to be larger than 44 inches (approx. 1118 mm).

42.8.1.3 Teflon Filled Spiral-Wound Gaskets shall not be used for joints larger than 24 inches (approx. 610 mm) nominal diameter.

42.8.2 Maximum Pressure and Temperature for Asbestos Gaskets - For design pressures less than 300 psig (0.21 kgf/mm²), compressed asbestos sheet gaskets may be used for external, bolted flanged joints with facings other than ring joint, except as required in Article 10.5.2, unless otherwise stated in the Vessel Specifications. The maximum design temperature for asbestos gaskets shall be 260 C (500 F) unless otherwise approved by Buyer.

42.8.3 Gasket Seating Stresses for all gasket materials shall be in accordance with the ASME Code and, in addition, shall be not less than the minimum nor more than the maximum values recommended by the gasket manufacturer.

43 HYDROSTATIC TEST PRESSURE DETERMINATION

43.1 TEST PRESSURE FOR VERTICAL OR HORIZONTAL VESSELS SHOP-TESTED IN A HORIZONTAL POSITION - For vessels designed in accordance with Article 40.9.1, the hydrostatic test pressure shall be determined as follows:

43.1.1 Vessels having no specified corrosion allowance - For testing in the horizontal position, the test pressure referenced to the centerline of the vessel shall be taken as 1.5 times the larger of equivalent design pressures P_{ED} or P_{ET} . If a vertical vessel is tested in a vertical position (as for a field test), the test pressure referenced to the top of the vessel shall be 1.5 times the larger of equivalent design pressures P_{ED} or P_{ET} , minus the hydrostatic head of the testing liquid.

43.1.2 Vessels having a specified corrosion allowance - For testing in either the vertical or horizontal position, the hydrostatic test pressure shall be determined in accordance with ASME Code Par. UG-99(c), except as follows:

43.1.2.1 Heat exchangers having standard TEMA corrosion allowance on carbon steel parts shall be tested in accordance with Article 43.1.1 unless otherwise specified by Buyer.

43.2 TEST PRESSURES FOR VERTICAL VESSELS SHOP-TESTED IN A HORIZONTAL POSITION (Alternate Permitting Increased Snell Stress During Test) - For vessels designed in accordance with Article 40.9.2, the hydrostatic test pressure shall be determined as follows:

43.2.1 Vessels having no specified corrosion allowance - For testing in the horizontal position, the test pressure referenced to the vessel centerline shall be the greater of $1.5 P_{EDS}$ or $K P_{ETS}$. If the vessel is tested in a vertical position (as for a field test), the test pressure referenced to the top of the vessel shall be the greater of $1.5 P_{EDS}$ or $K P_{ETS}$, minus the hydrostatic head of the testing liquid.

43.2.2 Vessels having a specified corrosion allowance - For testing in either the vertical or horizontal position, the hydrostatic test pressure shall be determined in accordance with ASME Code Par. UG-99(c).

43.3 TEST PRESSURES FOR FIELD-FABRICATED AND FIELD-TESTED VERTICAL VESSELS - For vessels designed in accordance with Article 40.9.3, the hydrostatic test pressure shall be determined as follows:

43.3.1 Vessels having no specified corrosion allowance - The hydrostatic test pressure referenced to the top of the vessel shall be 1.5 times the larger of equivalent design pressures P_{EDV} or P_{ETV} , computed for the top of the vessel.

43.3.2 Vessels having a specified corrosion allowance - The hydrostatic test pressure shall be determined in accordance with ASME Code Par. UG-99(c).

43.4 TEST PRESSURES FOR SPECIALLY-DESIGNATED VESSELS HAVING A CORROSION ALLOWANCE - For vessels checked for conformance with Article 40.9.4, the hydrostatic test pressure shall be determined in accordance with ASME Code Par. UG-99(c).

44 AIR (PNEUMATIC) TESTING FOR LEAKS - Air tests, when specified by Buyer, shall be conducted after the hydrostatic test (except for preliminary low-pressure leak tests as specified or approved by Buyer), and with the vessel completely drained and judged thoroughly dry by Buyer's Inspector or other authorized representative. The air test pressure shall be 1.25 times the maximum allowable working pressure, except where limited by law (as in Canada) to the maximum allowable working pressure, or unless otherwise specified or approved by Buyer. Preliminary low-pressure leak tests of internal joints (such as tube-to-tubesheet joints), when required, shall be as agreed upon between Buyer and the manufacturer.

DIMENSIONAL TOLERANCES FOR PRESSURE VESSELS AND TANKS

NOZZLES

The circumferential location of nozzles shall be within $\pm \frac{1}{2}$ in. of the specified angle as measured circumferentially at the face of the nozzle.

The axial-squareness of nozzle faces, as measured just inside the bolt holes, in any plane, shall be within $\frac{1}{8}$ in. for connections 8 in. and under, and within $3/32$ in. for connections over 8 in.

The tolerance on the outside diameter of nozzles rolled from plate and welded shall be $\pm \frac{1}{8}$ in. for connections 12 in. and under, and $\pm \frac{1}{4}$ in. for connections over 12 in.

FLANGES, SHOP-FABRICATED

Bolt circle diameter $\pm \frac{1}{8}$ in.

Bolt hole spacing: $\frac{1}{8}$ in. minimum difference

Eccentricity of bolt circle with respect to bore:

$\pm \frac{1}{8}$ in., maximum, for nominal diameters ≤ 24 in.
 $\frac{1}{4}$ in., maximum, for nominal diameters > 24 in.

Outside diameter: $\pm \frac{1}{8}$ in. for nominal diameters ≤ 24 in.
 Outside diameter: $\pm \frac{1}{4}$ in. for nominal diameters > 24 in.

Thickness: $\pm \frac{1}{8}$ in., ± 0 in.

Recess face outside diameter: $\pm \frac{1}{8}$ in.

Height of tongue, depth of groove, and inside and outside diameters for tongue and groove or male and female fittings: $\pm \frac{1}{8}$ in.

For same flanges, the clearance between the inside diameter of the flange and the outside diameter of the nozzle or shell shall not exceed:

$\frac{1}{8}$ in. for nominal diameters ≤ 12 in.
 $\frac{1}{4}$ in. for nominal diameters > 12 in. but ≤ 48 in.
 $\frac{3}{8}$ in. for nominal diameters > 48 in.

INSULATION SUPPORT AND VACUUM STIFFENING RINGS

Location from reference line to first ring: $\pm \frac{1}{8}$ in.

Distance between any two: $\pm \frac{1}{8}$ in.

SHELL

The outside circumference of shell shall be within the following limits:

$\pm \frac{1}{8}$ in. for nominal diameters 48 in. and under,
 $\pm \frac{1}{4}$ in. for nominal diameters over 48 in. through 96 in.,
 $\pm \frac{3}{8}$ in. for nominal diameters over 96 in.

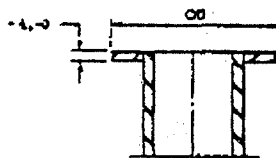
Shells shall be straight within $\frac{1}{8}$ inch ($\pm \frac{1}{8}$ inch) along any longitudinal element over a distance not less than the length of the longest shell course, except that at circumferential joints and at nozzles an additional variation equal to the offset permitted by the ASME code for circumferential welded joints will be

BASE OR SUPPORTS

Clearance between the outside of head and the inside of skirt shall not exceed $\frac{1}{8}$ in.

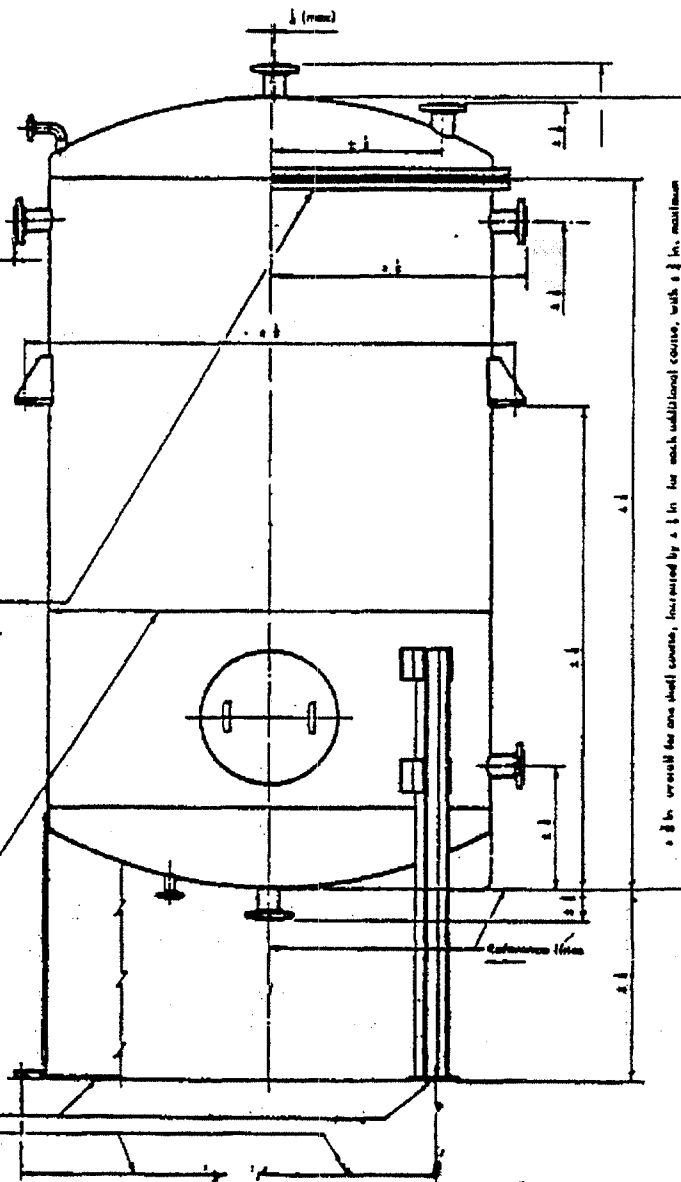
Face of skirt, of legs, or of support brackets shall be true and square with respect to the reference line, within the following limits:

$\pm \frac{1}{8}$ in. for nominal diameters 64 in. and under
 $\pm \frac{1}{4}$ in. for nominal diameters over 64 in. through 120 in.
 $\pm \frac{3}{8}$ in. for nominal diameters over 120 in.,
 $\pm \frac{1}{2}$ in. for bolt circles (to base of skirt or legs)



OD: $\pm \frac{1}{8}$ in., ± 0 in. for nominal diameters ≤ 24 in.
 OD: $\pm \frac{1}{4}$ in., ± 0 in. for nominal diameters > 24 in. but ≤ 24 in.
 OD: $\pm \frac{1}{2}$ in., ± 0 in. for nominal diameters > 24 in.

SHOP-FABRICATED LAPS



NOTE:

All tolerances not indicated shall be in accordance with the ASME Code, Section VIII/1.

Tolerances shown are intended to apply to both vertical and horizontal nodes.

Tolerances on angular dimensions expressed in degrees shall be based upon the equivalent inches of arc.

Thicknesses specified for machined parts are maximum.

Tolerances on cumulative dimensions may not be cumulative where prohibited by the tolerance on an overall dimension, or where interference between parts would result.

All dimensions given in inches



STANDARD
CHEMICALS AND PLASTICS

EQ-15A
PROCESS EQUIPMENT
4-1-71

NAME PLATE MOUNTING CLIP

Continuous, 1/8-in. min.
3/16-in. max; avoid
excessive fusion and
undercutting of shell.
For method of attachment,
see table.

Metal Clip for Name
Plate (See note. For
material see table.)

Drill four
0.052-in.
dia holes

Longitudinal Axis of Cylinder

Rotate Name Plate only, 90°
for Horizontal Vessels

Standard Name Plate
(see note)

Four No. 00 x 3/16-in. long
R. H. Stainless Steel Type U
Parker-Kalon Drive Screws, or
approved equal.

Vessel Material	Carbon Steel, Alloy Steel, or Stainless Clad Steel	Aluminum	Monel or Nickel	Copper or Copper Silicon Alloy	Austenitic Stainless Steel
Clip Material	Carbon Steel	Aluminum	Carbon Steel	Copper Silicon Alloy	Carbon Steel
Method of Attaching Clip to Vessel	Metal Arc Weld, Carbon Steel Rod	HELLARC Weld, Aluminum Rod	Metal Arc Weld, International Nickel Co. No. 190 Monel Rod	HELLARC Weld, Copper Silicon Alloy Rod	Metal Arc Weld, Inco No. 92 or No. 182 Electrode or T310 Stainless Steel Rod

NOTE:

Name plate shall be attached to all fabricated equipment and apparatus in accordance with this Standard. Name plate will be furnished by Purchaser. Mounting clip shall be furnished and attached by fabricator. Attachment of clip shall be in location and position shown on assembly drawing. Name plate shall be filled out and attached to clip by fabricator. Mount nameplate for best viewing. Plates containing special serial numbers or other special information shall be placed below the standard name plate.

All dimensions given in inches

24.6.1.1 19.6.2.1

MULTIPLE DISTRIBUTION

UCASB01648329

DIMENSIONAL TOLERANCES FOR DISTILLATION COLUMNS

FLANGES, SHOP - FABRICATED

BOLT CIRCLE DIAMETER $\pm 1/8"$
 BOLT HOLE SPACING $\pm 1/4"$ MAXIMUM DIFFERENCE
 ECCENTRICITY OF BOLT CIRCLE WITH RESPECT TO AXIS
 $1/8"$ MAXIMUM FOR NOMINAL DIAMETERS $\leq 14"$
 $1/4"$ MAXIMUM FOR NOMINAL DIAMETERS $> 14"$
 OUTSIDE DIAMETER

$1/8"$ FOR NOMINAL DIAMETERS $\leq 14"$
 $1/4"$ FOR NOMINAL DIAMETERS $> 14"$

WELDED: $\pm 1/8"$, $-0"$

WELD FACE OUTSIDE DIAMETER: $\pm 1/8"$

HEIGHT OF VOLUME, DEPTH OF GROOVE, AND HOLE AND OUTSIDE DIAMETERS FOR TONGUE AND GROOVE OR MALE AND FEMALE FLANGES: $\pm 1/16"$

FOR LOCKE FLANGES, THE CLEARANCE BETWEEN THE INSIDE DIAMETER OF THE FLANGE AND OUTSIDE DIAMETER OF THE NOZZLE OR BELL SHALL NOT EXCEED:

$1/16"$ FOR NOMINAL DIAMETERS $\leq 14"$
 $1/8"$ FOR NOMINAL DIAMETERS $> 14"$
 $1/4"$ FOR NOMINAL DIAMETERS $> 14"$

FLANGE BRACES AND OUTSIDE DIAMETER: $\pm 1/8"$, $-0"$

SHOP - FABRICATED LUGS



OD $\pm 1/16"$, $-0"$ FOR NOMINAL DIAMETERS $\leq 8"$
 OD $\pm 1/8"$, $-0"$ FOR NOMINAL DIAMETERS $> 8"$ BUT $\leq 14"$
 OD $\pm 1/4"$, $-0"$ FOR NOMINAL DIAMETERS $> 14"$

THE OUTSIDE CIRCUMFERENCE OF BELL SHALL BE WITHIN THE FOLLOWING LIMITS:

$\pm 1/16"$ FOR NOMINAL DIAMETERS $\leq 14"$ AND UNDER
 $\pm 1/8"$ FOR NOMINAL DIAMETERS $> 14"$ THROUGH $16"$
 $\pm 1/4"$ FOR NOMINAL DIAMETERS OVER $16"$

NOZZLES

THE ELEVATION OF FLANGE CONNECTIONS SHALL BE WITHIN $\pm 1/8"$ OF THE DIMENSION FROM THE REFERENCE LINE. STAMPING AND THE HOOKUP CONNECTIONS SHALL BE WITHIN $\pm 1/8"$ OF THE DIMENSION FROM THE TOP FINISHED TRAY SUPPORT SURF.

THE OUT-OF-SQUARENESS OF NOZZLE FACES, AS MEASURED JUST INSIDE THE BOLT HOLES, IN ANY PLANE, SHALL BE WITHIN $1/16"$ FOR CONNECTIONS $\leq 14"$ NOMINAL DIAMETER AND UNDER, AND WITHIN $1/8"$ FOR CONNECTIONS OVER $14"$ NOMINAL DIAMETER.

INLET AND OUTLET CONNECTIONS FOR NATURAL GAS JALATION CALORIMETERS SHALL BE LOCATED EXACTLY TO THE COLUMN.

THE TOLERANCES ON THE OUTSIDE DIAMETER OF NOZZLES BOLDED FROM PLATE AND WELDED SHALL BE $\pm 1/16"$ FOR CONNECTIONS $\leq 14"$ AND UNDER AND $\pm 1/8"$ FOR CONNECTIONS OVER $14"$.

MINIMUM SUPPORT AND VERTICAL STIFFENING RINGS

LOCATION FROM REFERENCE LINE TO FIRST RING: $\pm 1/4"$
 DISTANCE BETWEEN ANY TWO: $\pm 1/8"$

NOTE

ALL TOLERANCES NOT INDICATED SHALL BE IN ACCORDANCE WITH THE ASME CODE. ALL TOLERANCES ARE BASED UPON THE DIMENSIONS AS SPECIFIED ON THE DRAWING, EXCEPT THAT THE TOLERANCES ON ANGULAR DIMENSIONS EXPRESSED IN DEGREES SHALL BE BASED UPON THE EQUIVALENT INCHES OF ARC.

TOLERANCES ON CONSECUTIVE DIMENSIONS MAY NOT BE CUMULATIVE UNLESS INDICATED BY THE TOLERANCE ON AN OVERALL DIMENSION, WHERE INTERFERENCE BETWEEN PARTS WOULD RESULT, OR WHERE THE INTENDED FUNCTION OF ANY PART WOULD BE RESTRICTED. TOLERANCES SHOWN WITH THE DIMENSION LINE SHALL BE MEASURED FROM THE REFERENCE LINE.

TRAYS

AFTER INSTALLATION ALL TRAYS SHALL BE LEVEL AND PLANE WITHIN THE FOLLOWING LIMITS (SEE COLUMN SPECIFICATIONS FOR TOLERANCE CLASSES).

FOR COLUMN TRAYS, DIMENSIONS IN INCHES

	CLASS A	CLASS B
≥ 44	$1/16"$	$1/8"$
≥ 44 BUT ≤ 14	$1/16"$	$1/16"$
≥ 16	$1/16"$	$1/8"$

TOLERANCE ON WEIR HEIGHT: $\pm 1/16"$ MEASURED AT HIGH POINT OF WEIR. WEIRS SHALL BE LEVEL WITHIN $\pm 1/16"$ FROM A LEVEL PLANE AT THE MID-POINT OF THE WEIR FOR COLUMNS OF ALL DIAMETERS.

TOLERANCE ON HORIZONTAL CLEARANCE BETWEEN DOWNCOMER AND TOP OF WEIR: $\pm 1/16"$

TOLERANCE ON DOWNCOMER LENGTH: $\pm 1/16"$

TOLERANCE ON VERTICAL CLEARANCE UNDER THE DOWNCOMER FOR INSTALLED TRAYS: $\pm 1/16"$. NONWELDED RAYLES SHALL BE DESIGNED AND FABRICATED WITH ADEQUATE ADJUSTABILITY TO MEET THIS TOLERANCE AT THE MAXIMUM TRAY AND SUPPORT LEVELS TOLERANCE.

FOR POST-SUPPORTED TRAYS, THE CLEARANCE BETWEEN THE TRAY COLLAR AND THE SHELL SHALL NOT EXCEED $0.015"$ OVER 95 PERCENT OF THE CIRCUMFERENCE, OVER THE MEASUREMENT IN PERCENT OF THE CIRCUMFERENCE IT SHALL NOT EXCEED $1/16"$.

TRAY SUPPORTS

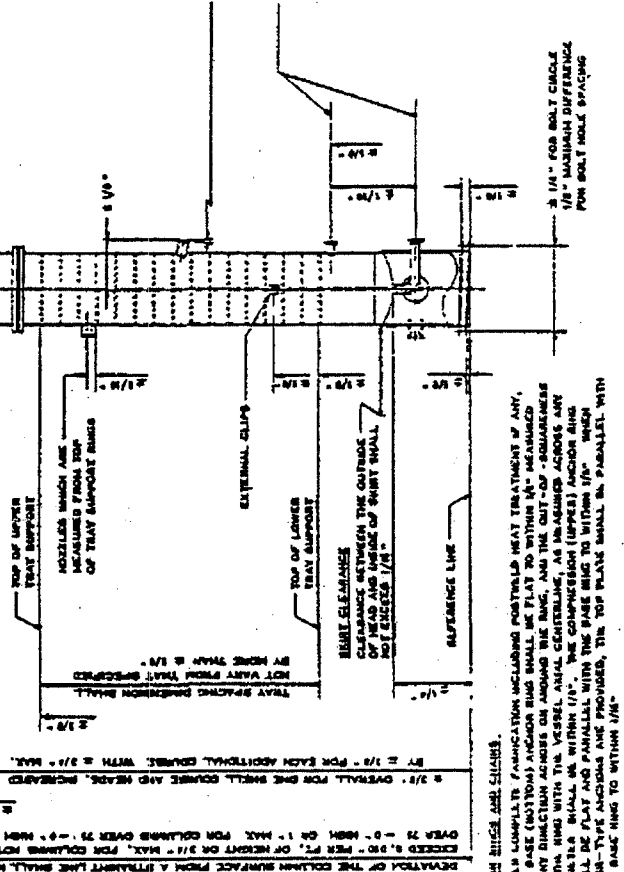
THE DIFFERENCE IN HEIGHT MEASURED FROM A LEVEL PLANE BETWEEN THE HIGHEST AND LOWEST POINTS OF ANY SUPPORTING MEMBER SHALL NOT EXCEED THE FOLLOWING (SEE COLUMN SPECIFICATIONS FOR TOLERANCE CLASSES).

FOR COLUMN TRAYS, DIMENSIONS IN INCHES

	CLASS A	CLASS B
≥ 44	$1/16"$	$1/8"$
≥ 44 BUT ≤ 14	$1/16"$	$1/16"$
≥ 16	$1/16"$	$1/8"$

FOR COLUMN TRAYS, DIMENSIONS IN INCHES

	CLASS A	CLASS B
≥ 44	$1/16"$	$1/8"$
≥ 44 BUT ≤ 14	$1/16"$	$1/16"$
≥ 16	$1/16"$	$1/8"$



ANCHOR RINGS AND CLIPS

AFTER COMPLETE FABRICATION INCLUDING POSTWELD HEAT TREATMENT OF ANY, THE BASE (BOTTOM) ANCHOR RING SHALL BE FLAT TO WITHIN $1/8"$ MEASURED IN ANY DIRECTION ACROSS OR AROUND THE RING, AND THE OUT-OF-SQUARENESS OF THE RING SHALL BE WITHIN $1/16"$ MEASURED IN ANY DIRECTION. THE ANCHOR RINGS SHALL BE FLAT AND PARALLEL WITH THE BASE RING TO WITHIN $1/16"$ WHEN CHAIN-TYPE ANCHORS ARE PROVIDED, THE TOP PLATE SHALL BE PARALLEL WITH THE BASE RING TO WITHIN $1/16"$.



MATERIAL SPECIFICATIONS FOR THREADED ALLOY-STEEL FASTENERS

1 SCOPE

1.1 This specification covers threaded alloy-steel fasteners (bolting) for bolted joints of pressure vessels for low-, medium-, and high-temperature services.

1.2 This specification shall be strictly adhered to except as it may be amended in the Vessel Specifications or as may be otherwise mutually agreed upon in writing between Buyer and the manufacturer. The term "Vessel Specifications" shall be understood to include any drawings, specifications, or data designated by Buyer for a particular vessel or group of vessels. The Vessel Specifications shall take precedence over this specification in all cases of disagreement.

2 REFERENCE SPECIFICATIONS

2.1 Fasteners required to meet this specification shall also meet the applicable requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, the specified ASME Material Specifications, and the designated ANSI Standards, except as modified herein.

2.2 References to codes, standards, and other specifications are to the latest revisions in effect at the time of Buyer's request for quotation.

3 MATERIALS

3.1 The materials for each class of Fasteners shall be as specified in Table 1.

3.2 Steel to which lead has been added shall not be used.

TABLE 1 - MATERIALS FOR FASTENERS

Class of Fastener	Design Temperature Range ⁽⁵⁾		Bolting Material	Nut Material
	Minimum	Maximum		
<u>FERRITIC STEELS</u>				
IB ⁽⁴⁾	-29C(-20F)	538C(1000F)	ASME SA-193, Gr B16	ASME SA-194, Gr 7
I	-29C(-20F)	399C(750F)	ASME SA-193, Gr B7 ⁽¹⁾	ASME SA-194, Gr 2 or 2H
II	-29C(-20F)	427C(800F)	ASME SA-193, Gr B7 ⁽¹⁾	ASME SA-194, Gr 3 or 4
III	-29C(-20F)	538C(1000F)	ASME SA-193, Gr B16	ASME SA-194, Gr 4
IV	-103C(-150F)	204C(400F)	ASME SA-320 Gr L7 or L43 ⁽²⁾	ASME SA-194, Gr 7 (Qualified by impact tests per SA-320)
<u>AUSTENITIC STEELS</u>				
X	-198C(-325F)	260C(500F)	ASME SA-193, Gr B8, Class 1 or 1A ⁽³⁾	ASME SA-194, Gr 8
XI	-198C(-325F)	538C(1000F)	ASME SA-453, Gr 660 ⁽³⁾	Same as bolting

¹ For Class I and II fasteners, Grade B16 may be substituted for Grade designated for sizes 2-1/2 inch (63.5mm) diameter and smaller where design temperature will not exceed 371C (700F).

² For Class IV fasteners, in diameters 2 inch (50.8mm) and smaller, the impact requirements of ASME SA-320 may be applied. For diameters larger than 2 inch, the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, paragraph UG-84 shall apply.

³ See Article 4.1.

⁴ See Article 6.1.

⁵ Actual temperature of fasteners.

(19.5.2.1)

EXTERNALLY THREADED FASTENERS

1 Class X and XI fasteners shall be lubricated before assembly in the flanged joint with an approved lubricant applied in accordance with the manufacturer's recommendations. The following products are currently approved for lubricating austenitic stainless steel threads.

Markal SR-2
Markal SR-3

Markal Company
3052 W. Carroll Avenue
Chicago, Illinois

Whytakote 505

Alona Holykote Company
65 Howard Avenue
Stamford, Connecticut

Lubricants containing copper, silver, or alloys or compounds containing these metals, shall not be used.

2 Both ends of studs shall be pointed (See Standards of the Industrial Fasteners Institute). The point shall be flat (straight cut) and chamfered. Buyer considers length of studs to be the length from first thread to first thread.

3 When the Vessel Specifications require stud ends to be countersunk, use combined drill and countersink, Size No. 4, in accordance with Twist Drill Standard ANSI B94.11.

NUTS

All fasteners shall be equipped with nuts conforming to the dimensions of Heavy Hex Nuts per ANSI Standard B18.2.2.

COATING

Class 1D fasteners shall be coated by the Bethlehem Steel Company's Bethalume process. A supplemental Bethalume C coating shall be applied to threads in nuts. Minimum mechanical properties after coating shall not be less than that specified in the designated ASME Material Specifications for the bolting material. The Brinell hardness range for the nuts in the finished condition may be 212 to 352.

WASHERS

Washers specified for use with fasteners supplied to this specification shall be through-hardened and shall meet the physical and mechanical property requirements of ASME Specification SA-325 for temperatures not exceeding 204C(400F). For temperatures higher than 204C(400F), washers shall be in accordance with ASME Specification SA-541 (any grade having minimum yield strength of 120,000 psi or greater).

REPORTS

The manufacturer shall furnish copies of certified mill test reports for, or certificates of compliance with, the designated ASME Specifications including any amendments or additions herein. The number of copies shall be as specified in the Material Specifications or in Buyer's purchase order.

Test reports shall note the date of issue of this specification and the year of issue of the ASME Specifications, ASME Standards, and ANSI Standards under which the fasteners were manufactured and tested.



AC INTEGRAL HORSEPOWER T FRAME HORIZONTAL, POLYPHASE INDUCTION MOTORS
60 HERTZ 200 THROUGH 575 VOLTS

(ELS-10, Pages 1 through 3 are the data sheets for ELS-1)

1 SCOPE

This specification covers requirements for continuous-duty, totally-enclosed fan-cooled or explosion proof fan cooled, random-wound, squirrel-cage, three-phase, T frame, horizontal induction motors in voltage ratings of 200, 230/460, 460 and 575 volts, 60 hertz.

2 APPLICABLE STANDARDS AND CODES

The design of this equipment shall satisfy the intent of all applicable codes, standards and regulations noted below.

The National Electrical Manufacturers Association Standards Publication MG-1. (NEMA)

The Institute of Electrical and Electronics Engineers Standards Publication, 112A Test Procedures for Polyphase Induction Motors and Generators. (IEEE)

American National Standards Institute (ANSI)

The National Electrical Code (NEC)

3 SERVICE CONDITIONS

Motors shall perform satisfactorily when operated indoors or outdoors either intermittently or continuously in an atmosphere typical of chemical and plastic plants. Unless otherwise noted on the order, motors shall be for use in a 40°C (104°F) or lower ambient temperature and at an altitude of 3300 feet or lower.

4 DESIGN AND MATERIAL

4.1 ENCLOSURES

4.1.1 Totally Enclosed Fan Cooled Motors shall be cast iron frame including stator yoke, end brackets, fan cover and rotatable conduit box. Conduit box shall have threaded conduit opening, water seal between box and motor frame and a gasketed cover. A threaded (NPT) drain hole (or holes) with corrosion resistant plug shall be drilled at the lowest accessible part of the motor case.

4.1.2 Explosion Proof Fan Cooled Motors shall be suitable for Class I, Division 1, Group D Locations and shall be corrosion resistant cast iron frame, including stator yoke, end brackets, fan cover and conduit box with threaded conduit connection. A threaded (NPT) drain hole (or holes) with corrosion resistant plug shall be drilled at the lowest accessible part of the motor case. Explosion proof motors shall have the UL label attached to the motor frame.

4.1.3 All metal to metal end bracket and conduit box fits shall be treated with preservative by the manufacturer before final assembly.

4.1.4 A non-sparking, non-corrosive water seal/slinger ring shall be installed on the drive end of the motor shaft.

4.1.5 Lifting eyebolts or cast hooks shall be furnished with all motors. Eyebolts shall be located at balance point. Drilled and tapped holes in the enclosure case shall be dead-ended or permanently sealed against water entry.

4.2 COOLING FANS

The cooling fan shall be corrosion resistant, non-sparking material. (Note: aluminum is not acceptable) When plastic fans are provided they shall be of reinforced thermosetting plastic and shall be sufficiently conductive to prevent the accumulation of static charges.

4.3 BEARINGS AND LUBRICATION

4.3.1 Bearing Specification - Manufacturers' standard antifriction bearings are acceptable provided they are designed for two-year minimum AFPM 8-10 life under continuous operation at the motors' rated load. Bearing housing shall be designed and equipped with drain plugs to allow regreasing while motor is operating. Install grease fitting if motor does not have sealed life-time bearing.

4.3.2 V-Belt Load Calculations - Belt pull shall be considered to be twice the resultant belt load as determined in sub section 4.3.2.1. Manufacturers are required to submit calculated bearing life with approval drawings.

4.3.2.1 Method for Calculation of Resultant V-Belt Loads -

A. Tension in Tight Side of Belt

$$T_1 = 0.031 W V^2 + \frac{550}{V} \text{ HP (C.F.)}$$

Where: W = Belt weight, lb/ft
 V = Belt velocity, ft/sec
 HP = Motor rated horsepower
 C.F. = Correction factor from table below
 T_1 = Tension in tight side of belt, lb force

Angle of Wrap (Small Sheave)	C.F. = Correction Factor
160°	1.009
150°	1.015
140°	1.023
130°	1.033
120°	1.047
110°	1.064
100°	1.087
90°	1.118
80°	1.160
70°	1.217
60°	1.299
50°	1.420

(Interpolate for intermediate values)

B. Tension in Slack Side of Belt

$$T_2 = T_1 - \frac{550 \text{ HP}}{V}$$

Where: T_2 = Tension in slack side of belt, lb force
 ($T_2 = 0$ for timing belts)
 T_1 = Tension in tight side of belt, lb force
 HP = Motor rated horsepower
 V = Belt velocity, ft/sec



Resultant Belt Load

$$= \left[[T_1 + T_2 \cos (180 - \alpha)]^2 + [T_2 \sin (180 - \alpha)]^2 \right]^{1/2}$$

$$\text{OR}$$

$$= \left[[T_1 - T_2 \cos \alpha]^2 + [T_2 \sin \alpha]^2 \right]^{1/2}$$

Where α = Angle of wrap (small sheave), degree T_1 = Tension in tight side of belt, lb force T_2 = Tension in slack side of belt, lb force

NOTE: AFBMA B-10 bearing life for all fan shaft and motor bearings shall be calculated using twice the resultant load as determined above.

4.3.3 Antifriction Bearing Lubricant Specification (Minimum)

General Description: Industrial quality, multipurpose, lithium base grease with mineral oil formulated from refined base stock and containing additives which inhibit oxidation and corrosion.

NLGI Grade:	2	Mineral Oil
Thickener:	Lithium	Viscosity, SUS at 100°F (38°C): 800/1000
Dropping Point:	350°F (177°C)	Viscosity, SUS at 210°F (99°C): 60/80
Water Resistance, % Max. ASTM D 1264:	10	Flash Point, Min: 475°F (246°C)
Corrosion Resistance, ASTM D 1743:	Pass	Pour Point, Max: 10°F (-12°C)
		Oxidation Inhibitor: Yes

Note: Polyurea-thickened greases may be used when bearing operating temperatures are between 120°C and 150°C.

4.4 INSULATION AND TEMPERATURE RISE

4.4.1 Stator insulation shall be Class F non-hygroscopic, highly moisture and chemical resistant. The motor leads shall be Class B or Class F non-hygroscopic material.

4.4.2 The total temperature rise, of the various parts shall not exceed 80°C (176°F) as measured by resistance when motor is tested at its rating with a maximum ambient temperature of 40°C (104°F).

4.5 MOTOR LEADS

Three leads only shall be brought into the conduit box through a moisture resistant seal.

4.6 NEMA DESIGN

4.6.1 Motors shall be NEMA Design B unless otherwise specified on the data sheet, ELS-1D.

4.7 NAMEPLATE

4.7.1 It shall be easy to read and made of a non-corrosive material, and include the "T" ratings as specified in the National Electrical Code, Article 500.

4.7.2 The front and rear bearing manufacturers name and bearing number shall be stamped on the nameplate.

4.7.3 Uni-directional motors shall have a rotation arrow plate on the motor frame.

4.8 HARDWARE

All hardware including frame bolts, conduit box bolts, nameplate fasteners, grease caps or plugs, fan clamp and bolt, drain plugs or fittings, etc., shall be corrosion resistant materials or be plated or treated with corrosion resistant materials. All bolt heads and nuts shall be hexagon and/or allen head shaped.

4.9 COATINGS

4.9.1 The inside of motor frame, stator and rotor air gap surfaces shall be sealed with a moisture resistant long life coating.

4.9.2 The exterior surfaces including all air flow passages shall be coated with a rust inhibiting primer and finished with an alkyd or epoxy enamel.

5 SPACE HEATERS

Space heaters, when requested on the data sheet, shall be arranged to provide the optimum attainable uniform heating of the stator windings. The heaters shall maintain the temperature of the motor windings approximately 5°C (9°F) above ambient. Heaters shall be for operation on a single-phase 115 or 230 volt, 60 Hertz system. Surface temperature of the heater elements or the motor enclosure shall not exceed temperatures, as specified in NEC Table 500-2(b).

5.1 CONNECTION BOX - Separate connection box shall be provided for connections to motor heaters.

6 INSPECTION AND TEST

Motors shall be capable of meeting prototype and standard production tests as defined under 2 above. Particular emphasis shall be placed on:

6.1 THE STATOR WINDING INSULATION SYSTEM shall be capable of passing high potential test, as defined under NEMA MG1-12.02.

6.2 VIBRATION when measured in accordance with NEMA MG 1-12.06 procedures, shall not exceed values stated in NEMA MG 1-12.05.

6.3 MOTOR NOISE LEVELS shall not exceed the values tabulated in NEMA MG 1-12.49C when tested in accordance with IEEE Publication No. 85.

6.5.1.1



INORGANIC ZINC PAINT

IZ

1. **DESCRIPTION:** One package or two package, high purity zinc powder in alcohol base vehicle. Use: shop or field applied primer for compatible finish coats; the two package paint may be used as a one-coat paint system in non-aggressive environments.
2. **SURFACES:** Carbon steel. Do not apply to stainless steel or nickel alloy surfaces.
3. **SURFACE PREPARATION:** Steel Structures Painting Council Surface Preparation Specification (SSPC-SP-10). Near-white blast cleaned surface finish. Commercial blast (SP-6) is not acceptable. Pickling according to SSPC-SP-8 is acceptable alternate to abrasive blasting with prior approval of the Protective Coatings Engineer.
4. **SYSTEM - SCHEDULE AND APPLICATION DATA:**

Coat No.	Paint Type	Application Method	Film Thickness MILs			Approx. Coverage(1)	Pot Life Hours	Drying Time at 70 - 75°F		
			Wet Max	Dry Min.	Max.			Touch Minutes	Handle Hours	Recoat Hours
1	IZ	Air Spray ⁽²⁾	8-9	2½	4	190 ⁽³⁾ 200 ⁽⁴⁾	8 ⁽³⁾ none ⁽⁴⁾	60 ⁽⁵⁾	1-2	24 ⁽⁶⁾
Total				2½	4					

5. **MIXING AND THINNING:** According to manufacturer's instructions and Steel Structures Painting Council Application Specifications, SSPC-PA-1. Only manufacturer's recommended thinner may be used. Mixing of powder and liquid must be done by mechanical agitation; slowly and thoroughly. Strain through 30-60 meshscreen.
6. **APPLICATION:** According to manufacturer's instructions and Steel Structures Painting Council Application Specifications, SSPC-PA-1. Use double regulated pot equipped with agitator and short ½" material hose. Typical gun set up: Devilbiss MBC with "E" tip and needle and No. 64 cap equipped with leather packing and mastic spring. Keep pot at close to same level as gun.
7. **PAINT MATERIALS:** See LOAM, Page 2, over.
8. **COLORS:** Manufacturer's standard; in one-coat systems, a natural zinc gray color may be specified.
9. **NOTES:**
 - (1) Coverage is practical coverage at 20% loss - square feet/gallon at average thickness.
 - (2) Some IZ paints with fine zinc powder may be applied by airless spray. Consult with paint manufacturer
 - (3) Two-Package
 - (4) One-Package
 - (5) Water insolubility
 - (6) Follow manufacturer's instructions
 - (7) For cold temperature application.



LOAM

Item 7. PAINT MATERIALS (Cont'd):

One Package

<u>Manufacturer</u>	<u>Description</u>
Ameron	Dimetecote EZ-II
Bywater	Zincguard 102-SP-92
Carboline	Carboxinc SP-81
Devco/Prufcoat	Catha-Coat 306
International	Interzinc QHA-004
Mobil	UniPak 13-G-10W
Reliance	Rel-Zinc 101

Two Package

Ameron	Dimetecote	D-6
Ameron	Dimetecote	D-9(7)
Carboline	Carboxinc	11
Cook	Inorganic Zinc	411-A-105 or 108
Devco/Prufcoat	Catha-Coat	304
DuPont	Ganicin	347-931
Imperial	Durazinc	555
International	Interzinc	1
Jones-Blair	Chem-D-2	99310
Matcote	Inorganic Zinc	289-1
Mobil	Mobilzinc	7
Porter	Zinc Lock	351
PPG	Metalhide	1000
Reliance	Rel-Zinc	100

UNION CARBIDE CORPORATION
CHEMICALS AND PLASTICS

QUALIFICATION OF HORIZONTAL ELECTRIC MOTORS

UNDER

ELECTRICAL STANDARD ELS-1 - INTEGRAL HORSEPOWER MOTORS

The following motors have been determined by Buyer to conform to the requirements of ELS-1 when furnished with the options indicated:

<u>Manufacturer</u>	<u>Model</u>	<u>Options to be Specified and Limitations (As Noted)</u>
General Electric	*Severe duty TEFC & exp. proof	Request G.E. Engineering Authority OSM-13 No option to specifications required. Please see notes below.
Westinghouse	*Mill and chemical TEFC & exp. proof	No option to specifications required. Please see notes below.
Reliance	*Duty Master TEFC-XT *Duty Master FXCP-XT exp. proof	140 series frame sizes <u>do not</u> meet ELS-1 specs. Three leads to be specified. Please see notes below.
U. S. Motors	*Corroduty Type TC TEFC & exp. proof	140 series frame sizes <u>do not</u> meet ELS-1 specs. Plastic fan to be specified. Please see notes below.
Allis-Chalmers	*RGZ-CH TEFC *RGZZ-CH exp. proof	No options to be specified for frame size 326T and smaller. Above 326T phenolic instead of aluminum fans to be specified. Please see notes below.
Louis Allis	TEFC & exp. proof	Request MA Spec. No. 257. No option to specifications required. Please see note below.
Delco Products Div. General Motors Corp.	*C.I.M. TEFC only	No option to specifications required. Please see notes below.

*Manufacturer's model identification to be included by specifier with motor description.

Motors other than those listed above will be accepted by Buyer provided it can be substantiated by Seller that they conform to Electrical Standard ELS-1.

NOTES:

- The following horsepower/speed combinations are available to meet ELS-1 Standard
3/4 hp, 1200 rpm, Frame 143T
1 hp, 1800 rpm, Frame 143T
1 hp, 1200 rpm, Frame 145T
- All 1/2 hp motors and below are classified as Fractional Horsepower Motors and are not required to meet ELS-1 Standard.
- In sizing motor for driven load do not use 1.15 service factor, assume motor has 1.0 service factor.