

**PLAINTIFF'S
EXHIBIT**

CHV-11

MANUFACTURING DEPARTMENT

ENGINEERING SPECIFICATION 391-J
3-4-59

HEAT EXCHANGE EQUIPMENT

1.0 Scope

- 1.1 Describes materials, fabrication, inspection and testing of shell and tube type heat exchangers with carbon steel shell and shell heads for common refinery services that will produce metal temperatures between 30F and 775F.
- 1.2 The 775F limit is applied because welds in seamless carbon steel pipe and carbon steel castings are susceptible to deterioration by graphitization above this temperature. Welds in plate and forgings are usually not susceptible to this deterioration below 900F.
- 1.3 Refer to Engineering Specification 392 for Low Alloy Steel Heat Exchanger Requirements. Refer to Engineering Department Specification EG-1338 for Stainless Steel Heat Exchanger Requirements.

2.0 General Requirements

- 2.1 Selection of Materials is based on best available knowledge of corrosion characteristics of stocks and cooling media. Supplier shall assume full responsibility for incorporating materials for each specific design that will have completely adequate strength to withstand the specified maximum pressure and temperature conditions. Company assumes responsibility only for corrosion or other deterioration caused by stock or cooling media on materials it specifies. Supplier may submit a completely adequate alternative for approval.
- 2.2 The required performance conditions, fabrication requirements and materials selection given in this Specification and the Design Data Sheets (Form EF-18) attached to the order are mandatory for each unit of exchange listed, unless changes are mutually agreed to by the Company and Supplier.

3.0 Code Compliance

All heat exchange equipment except that used for steam generation shall conform to the requirements of Section VIII of the ASME Boiler & Pressure Vessel Code latest edition. Unfired steam generating equipment used in California shall be classed as unfired steam boilers and shall be so constructed under the applicable provisions of sections I, V, or VIII of the Code.

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4.0 Materials

4.1 Plate

- 4.11 Carbon steel plate for process pressure containing parts shall be Firebox quality and have 55,000 psi minimum tensile strength. The following Code permissible plate does not meet the above requirements and shall not be used for pressure containing parts:

ASTM A7	All Grades
ASTM A30	Flange and Grade B Firebox
ASTM A113	All Grades
ASTM A129	All Grades
ASTM A283	All Grades
ASTM A285	Flange and Grades A & B Firebox

4.2 Pipe

- 4.21 Use of bessemer steel is not permitted.
- 4.22 All pipe shall be seamless or fusion welded. Carbon steel seamless pipe shall be selected from one of the following:

ASTM A53	(Grade B preferred)
ASTM A106	(Grade B preferred)

4.3 Nozzles

- 4.31 For nominal sizes 1-1/2" and smaller, bosses shall be welding grade hot rolled steel meeting ASTM A306 Grade 55 or forgings.

- 4.32 For nominal sizes 2" and larger, use any of the following materials:

Seamless pipe, not less than Schedule 80 for sizes 8" and smaller and not less than 1/2" wall for sizes 10" and larger.

Forged welding type nozzles.

Fusion welded pipe fabricated of same material and in same manner as shell or channel or meeting ASTM A155.

4.4 Tube Sheets

- 4.41 Carbon Steel - any commercial grade permitted by Section 4.11 above.
- 4.42 Chrome Moly - ASTM A182.
- 4.43 Austenitic Steel - ASTM A167 or A240.

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- 4.44 Non-Ferrous - Rolled Naval Brass - ASTM B171
Rolled Admiralty Metal - ASTM B171
Rolled Aluminum Bronze, Alloy D-ASTM B171
Rolled Copper Nickel - ASTM B171
Rolled Monel - ASTM B127
- 4.5 Gaskets
- 4.51 For Flat and Raised Face Flanges. Use compressed asbestos sheet.
- 4.52 For Tongue and Groove Flanges. Use double jacketed asbestos.
- 4.53 For Male & Female Flanges. Either of above or solid metal gaskets may be used, except that compressed asbestos may not be used above 300 lb. rating or 450F operating temperature. Nubbins shall not be used with compressed asbestos or metal clad asbestos gaskets but are required for solid metal gaskets.
- 4.54 For Tube Sheet to Shell Gaskets. Use only metal clad asbestos or solid metal.
- 4.55 Material for solid metal or jackets for metal clad asbestos gaskets shall be non-ferrous when used against non-ferrous surfaces.
- 4.56 Tape - shall not be used to retain gaskets in place during final assembly.
- 4.6 Bolting
- 4.61 Pressure containing parts. Unless a material of different composition and properties is required by design and/or service conditions, stud bolts for pressure containing parts shall be ASTM A193 Grade B7. Nuts shall be Grade 2 or 2H per ASTM A194.
- 4.62 Floating Heads. The bolts used for attaching floating heads may be threaded with National Fine Threads.
- 4.63 Internals. Machine bolts may be used for non-pressure containing parts.
- 4.64 Lubrication. Apply a brand of high temperature thread lubricant of a quality recognized and approved by the Purchaser's Inspector prior to installing bolts, e.g., Led-Plate manufactured by Armite Laboratories, Fel-Amo C5 manufactured by Felt Products Mfg. Co., John Crane Thred-Gard manufactured by Crane Packing Company.

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- 4.65 Monel and "K" Monel. Do not use lead bearing cutting oils, grease, or thread lubricants on these alloys.

4.7 Tubes4.71 Steel

Carbon steel seamless	ASTM A83 or A179
Low and intermediate chrome molybdenum seamless	ASTM A199 or A213
High chrome alloy seamless or welded.	ASTM A213 or A268
Austenitic steel seamless or fusion welded only	ASTM A213 or A249

4.72 Non-Ferrous Seamless Annealed Full Length

Admiralty, Types A,B,C, or D	ASTM B111
Aluminum Brass, Types B,C, or D	ASTM B111
Aluminum Bronze	ASTM B111
70-30 Copper Nickel	ASTM B111
Monel	ASTM B165

4.8 Floating heads, Channels and Channel covers for water service

Cast Bronze	ASTM B143 Grade 2A (Case 1190 or B148 Grade 9D (Case 1233)
Fabricated Monel (Channels)	Refer to Dwg. GC-E-99643
Cast Iron	Any class of ASTM A278
Steel	Any weldable Code specified grade.

- 4.9 Welding electrodes, automatic or manual, shall deposit a composition corresponding to the material being welded. Where applicable, electrodes shall meet ASTM Specifications; for example, carbon steel electrodes shall be of the E60 series of ASTM A233. Welding electrodes and other welding materials may be of any recognized brand approved by the Purchaser's Inspector.

5.0 Design5.1 General

- 5.11 Base the design of each exchanger unit on the maximum design pressures and temperatures shown on the attached Design Data Sheet.
- 5.12 Proportion minor components such as nozzle attachments, so that they do not limit the test pressure.

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5.13 Staybolts as a means to stiffen tube sheets, channel covers and floating heads are not acceptable.

5.14 Through-bolts are required for all nozzle, shell, and head flanges. Studs tapped into flanges are not acceptable.

5.2 Shell, Channel and Heads

5.21 Standard shell and tube units shall be equipped with stock inlet impingement plates at least as large as the nozzle that will provide sufficient distribution to prevent excessive heating of the tubes in the area of the inlet. The design of these plates shall be such that they can be relocated when the bundle is rotated 180° on its longitudinal axis.

5.22 Channels and floating heads attached by means of clamp rings shall be fitted with sturdy dowels to assure alignment.

5.23 Cold formed flanged and dished heads shall be normalized or annealed before attachment to shells, flanges, or other parts. This does not include carbon steel floating heads having a simple dish without knuckle radius.

5.24 The actual measured minimum thickness of formed heads, and distributor plates, shall be recorded on the Manufacturer's Data Report.

5.3 Nozzle Connections

5.31 Cutting of nozzle openings through the principal welded shell, channel or shell head joints shall be avoided.

5.32 Reinforce openings in shell, channel, and heads so that these openings do not limit the test pressure.

5.33 Tell-tale holes in reinforcing pads shall be tapped 1/8" pipe size, left unplugged and sealed with cup grease unless otherwise specified on the order.

5.34 Design nozzles to comply with Section 4.2 and 4.3 above. Above 8" nominal size, nozzle thicknesses shall be at least as thick as the shell or designed with the corrosion allowance specified in the attached Design Data Sheets.

5.35 Pipe shall not be used for nozzles 1-1/2" and smaller. Minimum size for all small nozzles shall be 3/4" I.P.S. Openings 3/4" to 1-1/2" incl. on castings shall be tapped integral bosses and on plate and forgings shall be welding bosses made per Drawing GD-L31368. These bosses shall be beveled and full penetration welds made at the vessel attachment.

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- 5.36 Provide each exchanger unit with adequate permanent connections for testing both shell and tube sides. Place vents at the highest point and drains at the lowest point on both shell and tube sides with respect to the position of the unit when installed for service. Channels in sea water service shall have 3/4" or larger vents at the highest point for releasing entrapped air, excepting those designed with top nozzles.
- 5.37 Equip the nozzles of each unit with a temperature and pressure connection. These are in addition to vents and drains per 5.36 above.
- 5.38 Fit all threaded connections including vent, drain, pressure and temperature connections with solid bar stock pipe plugs of the same material as the connection, except that steel shall be used in cast iron parts. Plugs shall have a length of shank equal to at least twice the diameter.

5.4 Flanges5.41 General

- a) Slip-on type steel hubbed or rolled ring flanges shall not be used in any service over 750F unless throughwelded per sketch 7 of figure UA-48 paragraph UA-48 of the Code.
- b) Flat faced flanges are limited to bronze or cast iron parts. On sizes 12" and over, they shall be equipped with jack screws for parting.

5.42 Nozzle Flanges

- a) Flanges shall be ASA forged steel welding neck, lap joint or slip-on type.
- b) For 150 lb. and 300 lb. ASA rating, use 1/16" raised face for all stocks at temperatures to 450F unless otherwise specified on Design Data Sheets. Use ASA small groove for LPG and other hazardous services and for stock temperatures over 450F in 300 lb. or higher rating unless otherwise specified on Design Data Sheets.
- c) For all flanges 400 lb. ASA rating and higher, use small groove unless otherwise specified on Design Data Sheets.
- d) When shells of units flange together or are connected with a short straight spool, the connection shall be fitted with a spectacle blind. Refer to Std. Dwg. GC-L31452 and GC-L87309 for design of blind. Blind will be furnished and installed by Purchaser.

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- e) When tongue and groove facing is required on stacked units that flange together on the shell side or are connected with a spool, the tongue shall be on the upper flange so that the gasket can be properly positioned in the groove.

5.43 Shell and Head Flanges

Use confined gasket type steel flanges such as male and female or tongue and groove for all services over 450F, and for hazardous services so designated on attached Design Data Sheets. Raised face may be used in other services at 450F and below. When tongue and groove flanges are used, the tongue shall be on the removable part, such as the head, channel, channel cover and the back of the fixed tube sheet.

5.5 Tube Bundle

- 5.51 Except for particular services when permitted by the order, each tube bundle shall be a removable type, floating head design with the tubes readily accessible for inspection, cleaning and replacement.
- 5.52 When it is proposed to furnish bundles with bent tubes, "U" return bends, etc., they shall be stress relieved after assembly in the bend section including a minimum length of three feet beyond the tangents of the bends. Circumferentially welded jointers shall also be included in the stress relief. The tube sheet shall not be heated. Stress relief of carbon steel shall be as prescribed in the Code. Supplier's proposed stress relief temperature and time at temperature for other materials, whether ferrous or non-ferrous, shall be submitted to the Purchaser for approval.
- 5.53 Tube sheets shall not be less than 1" thick.
- 5.54 Deburr all tube holes in cross baffles and support plates to avoid damage to tubes.
- 5.55 There shall be sufficient clearance between tube bundles and shell to permit insertion and removal of the bundle without difficulty. The Purchaser's inspector shall be present at the time the bundle is inserted in the shell to collaborate in checking clearances and fits.
- 5.56 It is preferred that condensers and coolers for sea water service shall be designed so that the tube bundle can be rotated 90° or 180° around its longitudinal axis and remain operable. If bundle cannot be rotated, Supplier shall so state in his bid.

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- 5.57 Where shell side fouling is anticipated use half-moon-side baffles. Under fouling conditions, disc and donut, orifice and half-moon top to bottom baffles are unsatisfactory.
- 5.58 Where shell side fouling is expected to be severe, square pitch with adequate spacing is required for mechanical cleaning.

5.6 Supports

- 5.61 Design all supports to withstand, under normal operating conditions, an earthquake force of 0.2 times the acceleration of gravity. This shall receive special consideration when units are to be stacked.

5.7 Handling Attachments

Channels, channel covers, shell covers and floating heads shall be provided with drilled lugs, attached by welding or integrally cast for use in dismantling and reassembly. These are not required on floating heads of the through bolt design where a bolt hole can be used for a handling attachment. The use of eye bolts for handling large heavy parts is not recommended. Special consideration shall be given to providing safe lifting attachments for parts of vertical reboilers including tube bundles. Lifting lugs shall be provided on the sides of parts when units are stacked to permit handling the parts with a bridle.

5.8 Welded attachments

All attachments such as clip pads, support pads, etc., shall be continuously welded to the exchanger.

6.0 Fabrication6.1 Shells, Channels and Shell Heads

Fabrication by casting, forging or fusion welding is permitted. When 100% radiographing is not a Code requirement, fusion welds shall be radiographed at positions designated by the Purchaser's inspector. At least one radiograph shall be taken of each longitudinal and circumferential joint showing not less than 14" of weld whenever possible.

- 6.11 All radiographs shall be made and interpreted in conformity with paragraph UW-51 of the Code. Should the radiographs disclose defects other than those allowed by the Code, the Supplier shall, if requested by the Purchaser's inspector, radiograph the full length of all such welded joints. The Purchaser will pay for the radiographs requested by his inspector at the price quoted in the Supplier's bid. The Supplier shall make all repairs at his expense, all in conformity with paragraph UW-38 of the Code. The parts that thereby become fully radiographed and repaired shall be recorded as required by the Code.

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6.12 Before commencement of fabrication and as prescribed in paragraphs UW-28 and UW-29 of the Code, the Supplier shall make available for review by the Purchaser's inspector, satisfactory evidence showing the Qualification of Welding Procedures and Welding Operators, and sufficient details giving the types and thicknesses of materials and the types of joints to be used in the fabrication.

6.13 Welded longitudinal and girth joints shall be double butt welded. Any other procedure selected by the Supplier shall be fully described in his bid and specifically approved by the Purchaser in writing before being used.

7.0 Special Bid Requirements

7.1 Gaskets

The Supplier shall furnish quotes as an extra for two spare sets of shell head, floating head and channel cover gaskets and one spare set of channel tube sheet and shell tube sheet gaskets for each exchanger unit.

7.2 Test Rings

The supplier shall furnish quotes, as an extra, for test rings for each exchanger unit or group of identical exchanger units except kettle type. Floating head rings shall be quoted for all floating head units. Channel rings shall be quoted only for units designed so that the tube ends cannot be seen when the channel cover is removed. Quote shall show separate prices for channel and floating head rings. All test rings shall withstand without deformation, a hydrostatic test of 1-1/2 times max. allowable working pressure as defined in Section 9.2 below.

7.3 Radiographing

When the design is such that the Code does not require 100% radiographing, the Supplier shall quote prices with and without radiographing as required by Section 6.1 above, or quote radiographing as an additive.

8.0 Name Plates

Each exchanger unit shall be identified by a securely attached 18-8% chrome nickel or brass name plate so mounted that it will not inadvertently be covered by insulation. In addition to the data required by the Code, the name plate shall give the following information:

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Max. Allow. working press. shell side)	}	As controlled by the limits for the materials and design used. Where compressed asbestos gaskets are used or where gaskets are not confined, 450F shall be given as the max. allow. temperature.
Max. allow. working press. tube side)		
Max. allow. temperature shell side		
Max. allow. temperature tube side		
Max. allow. temperature tube sheets		
Purchaser's order number	)	

9.0 Tests

- 9.1 Paint or other coatings shall not be applied to exchanger units prior to final testing.
- 9.2 To all tube sides and to all shells, apply a hydrostatic test equal to one and one-half times the maximum allowable pressure at the test temperature calculated for the nominal thickness as constructed. This test shall be applied as prescribed in paragraph UG-99(c) of the Code 1958 addenda.
- 9.3 Report separately in the Manufacturer's Data Report any thickness of steel in the shell or channel which is in excess of required minimum thickness plus specified corrosion allowance.
- 9.4 When required by the order, the following additional test on each exchanger shall be made:

Each complete exchange unit shall be heated with steam to a temperature equal to the designed inlet temperature of the hot stream, or if this is not possible, to the maximum temperature possible with the Supplier's facilities. However, if the designed inlet temperature of the hot stream is less than 300F, the tube bundle shall be heated to 300F. After the unit has cooled and without tightening of bolts, it shall withstand, without leaking, the standard hydrostatic test applied to the shell side and also to the tube side as described in Section 9.2.

- 9.5 Use normal service gaskets for all final hydrostatic tests. Special test gaskets shall not be used except by permission of the Purchaser.
- 9.6 The Purchaser's inspector shall witness the final required tests as described above.

10.0 Prints and Data Report

- 10.1 The Supplier shall furnish preliminary outline prints upon receipt of the order. Before delivery of the equipment, he shall furnish corrected certified outline prints, gasket prints, cross sectional prints of all major components and tube bundle details sufficiently complete so that the Purchaser can fabricate and assemble a replacement tube bundle. They shall include tube sheet layout, baffles, devices

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for sealing baffles to shell, special studs, etc. All such prints shall include the changes desired by the Purchaser. The number of such prints will be specified on the order. The following information shall be included.

Purchaser's item and order number.
Name plate numbers.
Number and size of units for each item.
Service (per Design Data Sheets).
Max. allowable working temperatures when new (tubes & Shell).
Max. allowable working pressures when new (tubes & shell).
Number of passes (tubes & shell).
Tubes, number, size, material, square feet of total transfer surface per unit, spacing and pitch.
Baffles spacing, thickness, and material.
Materials and thicknesses of floating heads, tube sheets, channels, channel covers, shells and shell heads.
Minimum thicknesses are required for all steel dished, ellipsoidal and hemispherical heads & formed distrib. plates.
Corrosion allowances on floating heads, tube sheets, channels, channel covers, shells and shell heads which have been proved by tests.
Design heat duty in BTU per hour.
Complete gasket description.
Strength test pressures applied (tubes & shell).

10.2 Prior to release of exchange units for shipment Supplier shall furnish ASME Code Manufacturer's Data Report Form No. U-1 which has been signed by an Inspector licensed by the National Board of Boiler and Pressure Vessel Inspectors or by the California Department of Industrial Relations. The number of such reports on each exchange unit will be specified on the order.

11.0 Preparation for Shipment

11.1 Protect flanged connections for piping against corrosion by the application of a suitable heavy protective grease, and bolt wood or steel cover plates in place to protect the faces during shipment. Those equipped with permanent blind flanges or covers shall be bolted up with specified gaskets in place, ready for service.

11.2 Protect threaded connections on outside of heat exchanger from damage, see section 5.38.

11.3 Plug tell-tale holes in reinforcing pads with nothing but stiff grease.

11.4 The fabricator shall load and block the vessel in a manner to avoid damage during shipment.

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12.0 Inspection by Purchaser

The inspection clause, Form PD-37 attached to the purchase order, constitutes a part of this Specification.

13.0 Alternate Bids

The Supplier shall bid in strict conformity with the provision of this Specification. However, in the event that any of these provisions is contrary to the Supplier's standard practice, the Supplier may offer an alternate quote indicating where his standard practice deviates from this Specification, together with a statement of the saving to be realized by such deviation, and the reasons why the Supplier considers his standard practice superior to the provisions of this Specification.