

ENGINEERING AND MATERIAL STANDARD
FOR
SHELL AND TUBE HEAT EXCHANGERS

CONTENTS :

PAGE No.

0. INTRODUCTION	3
1. GENERAL	4
1.1 Scope	4
1.2 References	4
1.3 Units	5
1.4 Conflicting Requirements	5
SECTION 2 (F)HEAT EXCHANGER FABRICATION TOLERANCES	
F-1 External Dimension, Nozzles and support Locations.....	6
F-3 Tubsheets, Partitions, Covers and Flanges.....	6
F-4 Interchangeable Parts	6
SECTION 3 (G)GENERAL FABRICATION AND PERFORMANCE INFORMATION	
G-1 Shop Operation.....	7
G-3 Nameplates	7
G-4 Drawings and ASME Code Data Reports.....	7
G-5 Guarantees	9
G-6 Preparation of Heat Exchangers for shipment.....	9
G-7 General Construction Features of TEMA Standard Heat Exchangers.....	10
SECTION 4 (E)INSTALLATION, OPERATION AND MAINTENANCE	
E-4 Maintenance of Heat Exchangers	11
SECTION 5 (RCB)MECHANICAL STANDARDS TEMA CLASS RCB	
RCB-1 Scope and General Requirements.....	12
RCB-2 Tubes.....	14
RCB-3 Shells and Shell Covers.....	16
RCB-4 Baffels and Support Plates.....	17
RCB-5 Floating and Construction.....	18
RCB-6 Gaskets	18
RCB-7 Tubesheets	18
RCB-9 Channels, covers and bonnets.....	19
RCB-10 Nozzles	19
RCB-12 Inspection and Test	19
SECTION 7 (T)THERMAL RELATIONS	
T-1 Scope and Basic Relations.....	20

***APPENDICES:**

*APPENDIX A ENQUIRIES AND QUOTATIONS	21
*APPENDIX B HEAT EXCHANGER SPECIFICATION SHEET	22
*APPENDIX C SCOPE OF INSPECTION AND TESTING	23
*APPENDIX D MANUFACTURER'S NONDESTRUCTIVE EXAMINATION RECORDS	24

Note:

Only sections number that have been supplemented are mentioned here.

* This Appendices have been added to the edition of TEMA being supplemented by this Standard.

0. INTRODUCTION

Shell and tube heat exchangers are designed and fabricated to the standards of the "Tubular Exchanger Manufacturing Associations (TEMA)". The TEMA Standards list three mechanical standard classes of exchanger constructions; R, C and B of these classes R and C are usually considered. (class B is very similar to class C). Equipment fabricated in accordance with the requirements of class R will adequately meet the heavy duty service requirements of refinery units.

Steam surface condensers shall be designed and fabricated in accordance with the standard for steam surface condensers published by the Heat Exchange Institute unless specified otherwise. However, there are numerous applications which do not require this type of construction. They are characterized by low fouling and corrosivity tendencies, requiring fouling factors not exceeding 0.00 and corrosion allowances not exceeding 3.2 mm for the unit under consideration.

Such units would be considered low-maintenance items. Services falling in this category are water-to-water exchangers, air coolers and similar non-hydro-carbon applications, as well as some light duty hydrocarbon services such as light ends exchangers, offsite lube oil heaters and some tank suction heaters. For such services, class C construction should be considered. Although units fabricated to either class R or class C standards comply with all the requirements of the pertinent codes, (ASME or other national codes), class C units are designed for maximum economy and may result in a cost saving of up to 5% over class R.

This Material and Engineering Standard gives the supplement to TEMA Standard Seventh Edition 1988 "Standards of the Tubular Exchanger Manufacturers Association " with its 1990 ERRATA. For ease of reference, the clauses or sections numbering of TEMA Standard, has been used throughout this Specification with the exception of Section 1 "General" at the beginning of this Standard which is added to the TEMA Standard.

Clauses in TEMA Standard not mentioned here remain unaltered.

For the purpose of this Standard, the following definitions shall hold:

Sub. (Substitution) : The TEMA Standard clause is deleted and replaced by a new clause.

Del. (Deletion) : The TEMA Standard clause is deleted without any replacement.

Add. (Addition) : A new clause with a new number is added.

Mod. (Modification): Part of the TEMA Standard clause is modified, and/or a new description and/or condition is added to that clause.

1. GENERAL

1.1 Scope

This Standard covers the minimum requirements for design and fabrication of shell and tube heat-exchangers, based on TEMA Standard seventh edition, 1988 and its 1990 ERRATA. This Standard is supplemented to the TEMA Standard.

Deviations from this Standard or the TEMA Standard are not permitted without the prior written approval of the Company. Such approval shall be valid only for a specific case, and shall not be construed as having general validity for wider application.(Add)

1.2 References

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this standard shall, to the extent specified herein, form a part of this standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Consultant/Vendor.

TEMA (TUBULAR EXCHANGER MANUFACTURING ASSOCIATION)

Seventh Edition, 1988 and its 1990 ERRATA

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Section VIII "Pressure Vessel Code" 1989
 Section II "Material Specification" 1989
 Section IX "Welding and Brazing Qualifications" 1989

API (AMERICAN PETROLEUM INSTITUTE)

RP. 521 "Guide for Pressure and Depressuring System"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

Serv-	A-193	"Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature ice"
	A-194	"Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service"
	A-320	"Specification for Alloys-Steel Bolting Materials for Low Pressure Service"

IPS (IRANIAN PETROLEUM STANDARDS)

E-PR-770 "TEMA Type Shell and Tube Heat Exchangers"
 G-ME-150 "Standard for towers ,Reactors pressure Vessels and Internals" 1372

HEI (HEAT EXCHANGE INSTITUTE)

"Standard for Steam Surface Condensers"

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

MR-01-75 "Sulfide Stress Cracking Resistance Material for Oil Field Equipment"(Add)

1.3 Units

This standard is based on International System of Units, (SI) except where otherwise specified. (Add.)

1.4 Conflicting Requirements

In case of conflict between documents relating to the inquiry or order, the following priority shall apply:

- 1) First Priority : The Purchase order
- 2) Second Priority : The data/requisition sheets and drawings referred to
- 3) Third Priority : This Standard Specification.
- 4) Fourth Priority : The referenced standards, codes and publications.

The "Company" shall be consulted in writing in every case of conflict. (Add.)

SECTION 2 (F)
HEAT EXCHANGER FABRICATION TOLERANCES

F-1 External Dimension, Nozzles and support Locations

F-1.1 For stacked exchangers having interconnecting nozzles, in no case shall the gasket faces of mating flanges be out of parallel by more than 1 mm. (Add)

F-3 Tubsheets, Partitions, Covers and Flanges

The plus tolerance on dimension R4 shall not be greater than 5 mm, see Note 1 to Fig. F-3 of TEMA. (Mod.)

F-4 Interchangeable Parts

Tolerances on interchangeable parts between exchangers shall be identical. (Add.)

SECTION 3 (G)

GENERAL FABRICATION AND PERFORMANCE INFORMATION

G-1 Shop Operation

G-1.1 All welding shall conform to ASME code requirements. Pressure holding seams, nozzle attachments and similar joints shall be full penetration butt joints. (Add.)

G-1.2 Welds attaching other nonpressure attachments (such as lugs or structural steel supports) shall be continuous. (Add.)

G-1.3 Welds attaching insulation support rings need not be continuous. (Add.)

G-3 Nameplates

G-3.1 Each exchanger shall be provided with a stainless steel namplate securely attached to the nameplate bracket which is welded to exchanger shell in an accessible and visible position near the channel end. Where the exchanger is to be lagged the nameplate shall be mounted so that it will not be obscured by the lagging. (Mod.)

G-3.11 The namplate shall indicate :

- a) Manufacturer's name.
- b) Manufacturer's serial number.
- c) Design code.
- d) Design pressure, Shell
 Tube
- e) Design temperature, Shell
 Tube
- f) Test pressure, Shell
 Tube
- g) Weight of heat exchanger and tube bundle,
- h) The letter SR, if stress relieved.
- i) The letter "Full" if completely radiographed and "Spot" if Partially Radiographed.
- j) User's Tag No. and exchanger name and Order No.
- k) Year built.
- l) Shell and tube bundle material.
- m) Any additional information required by the Company. (Mod.)

G-4 Drawings and ASME Code Data Reports

G-4.11 Welding procedure specifications and procedure qualifications records shall be submitted by the fabricator for Purchaser's review and approval prior to the start of fabrication.

Welder's performance qualification records shall be made available for Purchaser's review , upon request. (Add.)

G-4.12 Within the time specified after receipt of the purchase order, the vendor shall submit general arrangement and/or detailed workshop drawings and design calculations for Company's approval.

These drawings shall show the complete unit to be supplied and shall give the following technical information:

- The service, the company's items number, project name and location, purchase order number and vendor's shop order number.
- Design code(s)
- The design pressure, design temperature, test pressure, and any restrictions on testing or operation of the exchanger.
- The nozzles and connection size, location, orientation, projection, direction of flow, and if flanged, the rating and facing.
- The dimensions and location of supports, including bolt holes and slots, and the stacking arrangement.
- The overall dimensions of the exchanger.
- The tube bundle removal clearance.
- The weight of the exchanger, empty and full of water, and of the tube bundle.
- Tube pitch.
- Tube to tubesheet attachment.
- Number of tubes.
- The specified corrosion allowance for each side of the exchanger.
- Total heat transfer surface area.
- ASTM number or specification number of the material,
- Heat treatment required.
- Tolerances.
- Non-destructive test requirements.
- The requirements for material impact testing, if any.
- Surface preparation and painting. (Add.)

G-4.13 Shop fabrication of the parts shall not be started before the relevant vendor's and/or sub-contractor's drawings have been approved by the Company. (Add.)

G-4.21 After fabrication and inspection have been completed, the vendor shall furnish the purchaser with four copies of the following documents:

- AS-built specification sheet that includes material specifications and grades for all pressure parts.
- AS- built drawings.
- Manufacturer's data report (see Form U-1, Section VIII, Division 1 of the ASME code).
- Nameplate rubbing.
- Certified material test reports or certificates of compliance, as required by the ASME code.

- The temperature-recorder charts made during post-weld heat treatment.
- Inspection records and reports (see Appendix C and D).(Add.)

G-4.3 Unless otherwise agreed, the drawings, specification and the design are to be considered the property of the company and the company shall have the right to use these drawings, etc., for any purpose without obligation to the vendor. (Sub.)

G-5 Guarantees

G-5.1 Suppliers shall guarantee that the finished materials and accessories furnished will be free from any inherent defects in workmanship and material and that they will give proper and continuous service under the operating and design conditions specified, for a period of one year reckoned from the day on which the equipment is commissioned, but not more than 18 months from the delivery date. (Mod.)

G-5.2 In the event of failure covered by suppliers guarantee, after the exchanger has been commissioned, purchaser shall notify the supplier thereof as soon as possible. Supplier will have the following choices:

- a) Having the material returned to their works for repair.
- b) Effecting the repair at the site where the equipment is located.
- c) Authorizing the purchaser to repair on Vendor's responsibility and account.(Mod.)

G-5.4 Manufacturer's Guarantee shall provide coverage for any deterioration due to corrosion,erosion, flow-induced tube vibration or any other causes, where as the equipment is operated at the design conditions specified by the Company in his order or shown on the exchanger specification sheet. (Sub.)

G-6 Preparation of Heat Exchangers for shipment

G-6.2 Water,oil,or other liquids used for cleaning or hydrostatic testing are to be completely drained from all units before shipment. (Mod.)

G-6.3 Connections that are beveled for welding shall be suitably covered to protect the bevel from damage. (Mod.)

G-6.5 Apart from any special stipulations on packing and shipping as laid down in the requisition or order, all parts shall be packed in such a way as to prevent damage during transport to its destination. (Sub.)

G-6.6 The following parts shall be stamped with the serial number of the exchanger:

Shell flange	Floating tubesheet
Shell cover flange	Floating head cover flange
Channel flange	Floating head backing ring
Channel Cover	Test ring flange and gland
Stationary tubesheet	
(Add.)	

G-6.7 All exchangers shall be shipped in the "as test" condition so that no further hydrostatic testing need be required after installation. (Add.)

G-6.8 Painting requirements shall be as specified by the purchaser. (Add.)

G-6.9 Test holes in reinforcing pads shall be left open for use as telltale holes. They shall be filled with grease after hydrostatic test and prior to shipment. (Add.)

G-6.10 The item number, shipping weight, and purchaser's order number shall be painted on the exchanger. Information shall be painted clearly in white paint in capitals of at least 50 mm high. All boxes, crates, or packages shall be marked as specified. (Add.)

G-7 General Construction Features of TEMA Standard Heat Exchangers

G-7.4 Where applicable, the type of expansion joint shall be specified in the preliminary stage of quotation. (Add.)

SECTION 4 (E) INSTALLATION, OPERATION AND MAINTENANCE

E-4 Maintenance of Heat Exchangers

E-4.14 Shell-and-tube heat exchangers shall be provided with test rings or test flanges as follows:

Each exchanger with a bonnet-type head, a removable bundle, and a tube sheet of diameter smaller than the outside diameter of the connecting shell flange, shall be provided with test rings or test flanges.

Each exchanger with a type S or type T floating head shall be provided with a test ring.

Unless otherwise specified in the data/requisition sheet, each unit of identical heat exchangers performing a common duty shall be equipped as follows:

- a) One test flange or ring, per two bundles per unit.
- b) Two test flanges or rings, per three or more bundles per unit.
- c) For stacked exchangers, a sufficient number of test rings shall be provided to enable their testing in a stacked condition. (Add.)

E-4.6 The manufacturer shall include with his quotation a list of recommended spare parts. For high pressure and special design exchangers a list of required special tools and parts such as bolt tensioner, diaphragm weld cutter, etc. should be also included. (Sub.)

E-4.61 Spare part list shall, as a minimum, include the followings:

- Two sets of gaskets for each exchanger.
- One piece floating head expansion joint, if any, for each type installed. (Add.)

SECTION 5 (RCB)
MECHANICAL STANDARDS TEMA CLASS RCB

RCB-1 Scope and General Requirements

RCB-1.13 CONSTRUCTION CODES

BASIC STANDARD

TEMA (TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION)

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Section VIII Pressure Vessel Code.

IPS (IRANIAN PETROLEUM STANDARDS)

G-ME-150 "Standard for Pressure Vessels"

MATERIAL STANDARD

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

DIMENSIONAL STANDARD

TEMA, ASME Section VIII, ASTM-A-450.(Mod.)

RCB-1.15 Where materials of construction for heat exchanger components are not indicated by the purchaser on the exchanger drawings and/or the exchanger specification sheets, the vendor shall select them to his engineering experience for the specified design service conditions. The materials selected shall conform to the specifications given in Section II of the ASME boiler and pressure vessel code or other governing code. Materials of construction are subject to approval by the Company. (Add.)

RCB-1.16 All materials must be new. (Add.)

RCB-1.17 Material equivalent to the material specified in the applicable code or standard may be acceptable at the Company's option. Vendor must furnish complete description of mechanical and physical properties of all such material for the Company's approval. (Add.)

RCB-1.18 Carbon-½ molybdenum materials shall not generally be used, any exception shall receive written approval by the company. (Add.)

RCB-1.19 All materials used in the manufacture of pressure parts of heat exchangers constructed to this Standard shall have available test certificates of chemical analysis and physical properties. Materials for which test certificates are not available may be used for supporting lugs, baffles, spacers and other similar non-pressure parts. (Add.)

RCB-1.2 Design pressure

RCB-1.21 The design pressure shall be in accordance with the ASME Pressure Vessel Code requirements and as shown on the individual process data sheet.(Mod).

RCB-1.22 The most unfavorable combination of design pressures on the shell and tube side shall be used in the calculations for floating heads and tubes.(Add.)

RCB-1.23 The maximum differential pressure over the circuit can only be applied for the tube sheet thickness calculation.(Add.)

RCB-1.24 The possibility of exposure to system pressure waves, e.g., water hammer, shall be taken into account.(Add.)

RCB-1.31 The minimum fluid temperature for hydrostatic testing shall be 16°C. If however, the exchanger is designed for a temperature below 16°C, the minimum fluid temperature may be equal to the design temperature. This temperature restriction does not apply to units fabricated from austenitic stainless steel. (Sub.)

RCB-1.312 Water used for hydrostatic testing of units in which austenitic stainless steel materials will be exposed to the test fluid shall be potable water with a chloride ion content of less than 150 parts per million. After hydrostatic testing, these units shall be completely drained immediately. (Add.)

RCB-1.32 When liquid cannot be tolerated as a test medium, then by agreement between the company and manufacturer, the exchanger may be given a pneumatic test in accordance with the code requirements. (Mod.)

RCB-1.34 All hydrostatic tests shall be made in the presence of an inspector authorized by the purchaser and with his approval. (Add.)

RCB-1.35 When the heat exchanger is constructed with an expansion joint assembly, the maximum allowable differential pressure of the expansion joint shall be taken into account and a detailed test procedure shall be presented for the company's approval. (Add.)

RCB-1.36 Before hydrostatic testing the exchanger, the welds of each reinforcing pads shall be pneumatically tested at a minimum pressure of 70 kPa (10 Psig). (Add.)

RCB-1.42 Design temperature of heat exchanger parts

The design temperature for the shell side and the tube side shall be as specified separately on the individual process data sheet and as the following: (Mod.)

RCB-1.421 The shell side design temperature shall be used for the design metal temperature of the shell and the shell cover (including flanges). The tube side design temperature shall be used for the design metal temperature of the channel (including flanges) and the channel cover. The design temperature of bolts and gaskets shall be the same as that for the respective flange; however, the design temperature of the bolts and gaskets for shell-to-channel joints shall be the same as the shell-side or tube-side design temperature, whichever is more severe.(Add.)

RCB-1.422 When, due to the possible loss of flow of the cooling medium, the tubes, tube sheets and floating heads may be subject to the full inlet temperature, it shall be indicated on the individual process data sheet and these components shall be designed for the maximum anticipated operating temperature of the hotter medium.(Add.)

RCB-1.423 In selection design temperatures for multiple exchangers in series, consideration shall be given to the maximum or minimum temperature, on each side of each exchanger, that results from clean or fouled operation using the specified fouling.(Add.)

RCB-1.424 For fixed tube sheet exchangers without expansion joints, the differential between the average shell metal temperature and the average metal temperature of any one tube pass shall not exceed 28°C. When temperature differential exceed 28°C, an expansion joint shall be furnished.(Add.)

RCB-1.5 Standard corrosion allowances

RCB-1.54 Where bonded cladding(including weld overlay) is used, the thickness of the cladding to be used as corrosion allowance shall be 3 mm minimum. (Add.)

RCB-1.6 Service Limitations

RCB-1.63 Material in contact with hydrogen sulphide, including trace quantities, shall conform to the requirements of NACE Standard MR-01-75, "Sulfide stress cracking resistance material for oil field equipment". (Add.)

RCB-1.64 The material for the tubes of water-cooled exchangers shall be selected as follows: (Add.)

RCB-1.641 If carbon steel is suitable for the process fluid (shell side) and the water is stated as being suitably treated so that it is not corrosive to carbon steel, carbon steel tubes and tube sheets are acceptable. The use of carbon steel tubes for other conditions shall be proposed for agreement by the company. (Add.)

RCB-1.642 Where the water is not specified to be treated as in para. RCB-1.641 above the following materials shall be used for tubes subject to process (shell) side acceptability.

- a) Admiralty brass for fresh and recirculated waters.
- b) Aluminum brass for salt water and other corrosive water.
- c) Copper-Nickle tubes for sea water.

Other materials may be used subject to prior written approval of the company. (Add.)

RCB-1.643 Where the process (shell) side requires materials other than brass, the use of bi-metallic tubes shall be considered. (Add.)

RCB-1.644 In acetylene service, material containing more than 60 percent of copper shall not be used in the construction of any parts. Materials containing lower percentage of copper may be proposed for agreement with the company. (Add.)

RCB-1.645 Stainless steel and non-ferrous tubes shall be seamless. Carbon steel tubes shall be either seamless or electric resistance welded type. (Add.)

RCB-1.7 Interchangeability

All exchangers of the same size, type and material shall maximize interchangeability of parts where practical. The highest practical number of exchangers shall have interchangeable tube bundles. Whenever possible tube bundles shall be designed to permit rotation through 180°. (Add.)

RCB-2 Tubes

RCB-2.21 The tube diameter and wall thickness shall be the preferred values listed in Table RCB-2.21 below. Other diameters and gages are acceptable upon approval. (Mod.)

TABLE RCB-2.21 - BARE TUBE DIAMETERS AND GAGES

O.D. Inches	COPPER AND COPPER ALLOYS	CARBON STEEL, ALUMINUM AND ALUMINUM ALLOYS	OTHER ALLOYS
	B.W.G.	B.W.G.	B.W.G.
1/2	20	18	20
	18	16	18
5/8	20	18	20
	18	16	18
	16	14	16
3/4	20	16	18
	18	14	16
	16	12	14
7/8	18	14	16
	16	12	14
	14	10	12
	12	—	—
1	18	14	16
	16	12	14
	14	11	12
		10	
1-1/4	16	14	14
	14	12	12
1-1/2	16	14	14
	14	12	12

Note:

Tube thicknesses are given in Birmingham Wire Gage (BWG).

RCB-2.21 (Note 1 of table RCB-2.21 modified)

No minuse tolerance for tube wall thickness is allowed. (Mod.)

RCB-2.21 (Note 3) Tube outside diameter and wall thickness tolerances for carbon, ferritic alloy, and austenitic alloy steel tubes shall be per ASTM A-450. For non-ferrous tubes, the said tolerances shall be in accordance with the appropriate heat exchanger tube specification. (Add.)

RCB-2.23 Longitudinal-Finned (high finned) tubes are only allowed for double-pipe heat exchangers. This will normally be high-finned tubing. (Add.)

RCB-2.3 U-Tubes

RCB-2.311 For U-Tubes Heat exchangers, welded tube bends are not permitted. (Add.)

RCB-2.321 The mean radius of U-Bends shall not be less than 1½ times the nominal outside diameter of the tube. (Mod.)

RCB-2.323 The tolerance of the center to center dimension between the parallel legs of U tubes, shall be within the following:

- a) When the dimension is less than
5 times the tube O.D.: ±1.0 mm

- b) When the dimension is more than
5 times the tube O.D.: ± 1.5 mm

(Add.)

RCB-2.33 Heat treatment

RCB-2.331 The Bent portion of the following U-tubes shall be stress relieved after bending.

- a) Carbon steel tubes for Amine or caustic service.
- b) Carbon molybdenum, Chromium-molybdenum and ferritic stainless steel U-tubes having bend radius smaller than five times their outside diameter or which have been annealed in the straight condition.
- c) All nonferrous U-tubes.
- d) Austenitic stainless steel tubes which have been annealed in straight condition or are at the danger of stress corrosion cracking. (Mod.)

RCB-2.332 The heat treated portion of the U-bend shall extend at least 150 mm beyond the point of tangency. (Add.)

RCB-2.333 U-tubes shall be totally heat-treated when the application of local heat treatment to the bent portion only would possibly induce embrittlement or susceptibility to stress corrosion in the transition zones between the straight legs of the U-tube and the bend. (Add.)

RCB-2.6 Stainless steel and non-ferrous tubes shall be seamless. Carbon steel tubes shall be either seamless or electric resistance welded type. (Add.)

RCB-2.7 Welded tubes shall be tested by means of ultrasonic or eddy current examinations. (Add.)

RCB-2.8 Carbon steel, ferritic alloy, and austenitic alloy steel tubes shall meet the requirements of ASTM A-450 "General requirements for carbon, ferritic, and austenitic alloy steel tubes". (Add.)

RCB-2.9 When U-Tubes are specified, cold work forming shall be employed for the bending of tubes with heat treatment as per RCB-2.33 (Add.)

RCB-2.10 All tubes shall be formed from a single length having no circumferential weld. (Add.)

RCB-3 Shells and Shell Covers

RCB-3.11 Up to nominal diameter of 600 DN (24 inch) the use of pipe is preferred. (Sub.)

RCB-3.122 The diametral tolerance on shells with removable bundles shall be such that at any section the minimum internal diameter is not less than the nominal internal diameter. (Mod.)

RCB-3.13 The minimum thickness of the shell shall be selected as per Table RCB-3.13 below:

TABLE RCB-3.13 - MINIMUM SHELL THICKNESS

NOMINAL SHELL DIAMETER**	MINIMUM THICKNESS				
	CARBON STEEL			ALLOY*	
	PIPE		PLATE	PIPE	PLATE
mm (inch)	mm (inch)	mm	mm (inch)	mm	
150 (6)	SCHED. 40		3.175 (1/8)		
200 - 300 (8-12)	SCHED. 30		3.175 (1/8)		
350 - 600 (14-24)	9.525 (3/8)		4.763 (3/16)		
350 - 725 (14-29)		10		5	
750 - 950 (30-38)		12		6	
1000 -1500 (40-60)		13		8	

* Schedule 55 is permissible for 200 DN (8 inch) nom. diameter.

** For shells rolled from plate, the nominal shell diameter is the shell inside diameter.

(Mod.)

RCB-3.14 Lining for exchanger shells and other parts shall be of integrally clad plate or build up and machined weld deposit.

Applied alloy protective lining shall be considered as corrosion allowance only, not as part of the base metal, when calculating the thickness of pressure parts. (Add.)

RCB-3.15 Kettle type exchanger shells shall be in accordance with TEMA K and (except for steam generators) shall have a weir plate. The weir plate shall be full welded to the shell, be watertight and sufficiently high to flood the top tubes by a minimum of 50 mm (2") during normal operation. (Add.)

RCB-3.16 Riding rails shall be provided inside shell of kettle type exchangers to support and guide tube bundle. These shall be fully seal welded to shell sides. (Add.)

RCB-3.17 For kettle type exchangers Tube bundle retention shall be provided by the fitting of a retaining angle. (Add.)

RCB-3.3 Fabrication of heat exchangers shell shall be done as per ASME Code section VIII division 1 and all machining and assembly work shall be carried out to ensure easy assembly of all exchanger parts, in compliance with the clearance and interchangeability of the bundles. (Add.)

RCB-3.4 All longitudinal and circumferential welds of shells for other than kettle-type units shall be finished flush with the inner contour for ease of tube-bundle insertion and withdrawal. For kettle-type units, this requirement is waived for welds in the enlarged section that are not in the bottom quadrant of the shell. (Add.)

RCB-4 Baffles and Support Plates

RCB-4.611 Plate impingement baffle, if used, shall extend at least 25 mm beyond the projection of the nozzle bore. (Add.)

RCB-4.7 Tie rods and spacers shall be equally divided around the circumference of the baffles. (Mod.)

RCB-5 Floating and Construction

RCB-5.131 Floating head flange bolting of ferritic material shall be ASTM A 193 Gr. B7 M if the shell side service has been specified to contain: Wet H₂S, wet H₂S plus cyanides. Caustic solutions in concentrations which would require postweld heat treatment or amines.

If the shell side corrosion allowance is greater than 3 mm, floating head flange bolting shall be either 12 Cr conforming to ASTM A 193 Grade B6 or 18 Cr 8 Ni conforming to ASTM A 320 Grade B8, strain hardened. Material selection for this case shall be approved by the Company. (Mod.)

RCB-5.132 Floating head cover bolting shall be readily accessible when the shell cover is removed. (Add.)

RCB-5.2 Packed floating-head design (TEMA type P) is not acceptable. (Therefore paragraphs RCB-5.21 through RCB-5.25 are not applicable). (Del.)

RCB-5.3 Externally sealed floating tube-sheet (TEMA type W) design is not acceptable. (Therefore paragraphs RCB-5.31 through 5.34 are not applicable). (Del.)

RCB-6 Gaskets

RCB-6.1 Gaskets should, wherever possible, be of one piece construction, i.e. with no welding. If however due to size limitations, welding is unavoidable, welding details, including any necessary heat treatment shall be included in quotation. (Mod.)

RCB-6.21 Gaskets in hydrocarbon service shall be double-jacketed asbestos filled metal, solid metal, or spiral-wound filled metal. (Add.)*

RCB-6.22 AISI type 304 L or type 304 may be used for metal jacketed asbestos gaskets as an alternative to 5 Cr ½Mo, provided that they are manufactured from fully softened sheet for which the initial hardness shall be no greater than 160 BHN and that preferably they are not used in a location where chlorides can concentrate. (Add.)

RCB-6.23 Material for metal jacketed or solid metal gaskets shall have a corrosion resistance at least equal to that of the gasket contact surface material. (Add.)

RCB-6.6 Compressed asbestos gaskets shall be graphited on both sides or contain an antistick release agent, except that for the gaskets to be used with austenitic stainless steel flanges, graphiting shall not be applied. (Add.)*

RCB-6.7 In preparing gasket drawings (and ordering spare gaskets) the dimensions specified shall take into account the tolerances permitted by TEMA for tubesheet grooving. (Add.)

RCB-7 Tubesheets

RCB-7.44 All tube holes for expanded joints shall be machined with at least two grooves, each approximately 3.2 mm wide by 0.4 mm deep. The distance from one groove center line to the cover side of the tube sheet shall be 9.5 mm. The distance between groove center lines shall be 9.0 mm. For tube sheets constructed of integrally clad plate or with applied corrosion-resistant facings, if possible, one additional groove shall be in the center of the cladding/facing material thickness. (Mod.)

* Due to the health hazardous, use of asbestos is not permitted and materials equivalent to asbestos shall be used.

RCB-7.513 Tube projection

Tubes shall extend between 3 mm and 5 mm beyond the face of the tubesheet, except in the case of the top tubesheet of vertical exchangers when tubes shall be flush with the face of the tubesheet to facilitate drainage. (Mod.)

RCB-7.6 Tubesheet pass partition grooves

RCB-7.61 The distance between the edge of the tube holes and the edge of all gasket grooves shall not be less than 1.5 mm for tubesheets with expanded tube to tubesheet joints and not less than 3.2 mm for tubesheets with seal-or strength-welded tube-to-tubesheet joints. (Add.)

RCB-9 Channels, covers and bonnets

RCB-9.133 Pass partition plates for forged or welded channels and floating heads shall be welded full length, either from both sides or with full-penetration welds, except for special designs approved by the company. (Mod.)

RCB-10 Nozzles

RCB-10.1 Couplings installed in the shell cylinder shall not protrude beyond the inside surface of the cylinder. (Mod.)

RCB-10.34 Kettle type exchangers shall also have:

- Two connections 25 DN (1") for liquid level gage glass.
- Two connections 50 DN (2") for level controller.
- Connections 38 DN (1½") for drain and vent.
- One connection 19 DN (¾") for chemical cleaning.

(Add.)

RCB-10.41 On multi-shell units where shells are stacked, the superimposed loads must be considered in design so that distortion of shells and binding of removable tube bundles is avoided. (Add.)

RCB-10.42 Where exchangers are stacked, the center line of the uppermost exchanger shall be not more than 3700 DN (12 ft.) above grade unless this is specified as permissible. (Add.)

RCB-10.43 When arranging stacked shells, differential expansion between shells shall be considered. On high temperature duties, nozzles connecting two shells shall be at the channel ends to minimize expansion stresses. (Add.)

RCB-10.7 Suitable arrangements for expansion shall also be provided for exchangers in a horizontal train which are coupled directly to one another by flanges or welding without the use of intermediate piping. (Add.)

RCB-10.8 Large size solid stainless steel nozzles DN 50 (2 inch) and larger shall not be used for stainless steel clad or lined exchanger. Such nozzles shall be either:

- fabricated from clad plate, or;
- provided with a weld deposit overlay, or;
- provided with a liner bonded by explosion welding.

(Add.)

RCB-12 Inspection and Test (Add.)

RCB-12.1 All welding shall conform to ASME code requirement, regardless whether or not the equipment carries a code stamp. (Add.)

RCB-12.2 Welding procedure and welders performance qualifications shall be in accordance with the requirements of ASME code Section IX. (Add.)

RCB-12.3 The time that the manufacturer shall, before start of fabrication, notify the Purchaser, shall be agreed upon between the purchaser and the manufacturer. The manufacturer shall also notify the purchaser of the date for bundle insertion and final inspection and test. (Add.)

RCB-12.4 Final weld inspection shall be performed after post-weld heat treatment. (Add.)

RCB-12.5 On components subject to full radiography, nozzle attachment welds that cannot be radiographed shall be examined for the presence of cracks by magnetic-particle, liquid-penetrant or ultrasonic methods. Examination shall apply to the root pass after back chipping, or after flame gouging where applicable, and to the complete weld. Any defects revealed shall be removed before the weld is finished. (Add.)

RCB-12.6 If full radiography is not specified, at least one spot radiograph shall be made of each Category A and B joint (as defined by Section VIII, Division 1, of the ASME Code). Nozzle welds are excluded from this requirement. (Add.)

RCB-12.7 The magnetic-particle examination and the criteria for acceptance shall comply with Appendix 6, Section VIII, Division 1, of the ASME Code. (Add.)

RCB-12.8 For nonmagnetic materials, a liquid-penetrant examination shall be used in place of any required magnetic-particle examination. (Add.)

RCB-12.9 The liquid-penetrant examination and the criteria for acceptance shall comply with Appendix 8, Section VIII, Division 1 of the ASME Code. (Add.)

RCB-12.10 Hardness shall not exceed 225 Brinell for materials with P numbers of 1, 3, or 4, or 240 Brinell for materials with P numbers of 5, 6 or 7. (Add.)

RCB-12.11 Manufacturer shall prepare records of nondestructive examinations performed. Examples of such records are given in Appendix D. (Add.)

RCB-12.12 Shells shall be checked for tolerances on diameters. Removable tube bundles shall be checked for ease of insertion by locating in the shell at two positions 180° apart unless otherwise agreed with the company. (Add.)

RCB-12.13 Tube holes shall be checked for finish and grooving prior to the fitting of tubes in the tube sheet. (Add.)

RCB-12.14 After expansion, the length of expansion and the amount of tube wall thinning due to expansion shall be checked. If seal or strength welding is specified, the qualification of such welds shall be approved by the authorized inspector. (Add.)

RCB-12.15 Scope and extent of inspection for shell and tube heat exchangers are given in Appendix C as a guide. (Add.)

SECTION 7 (T)

THERMAL RELATIONS

T-1 Scope and Basic Relations

T-1.0 Thermal design of shell and tube heat exchangers shall be in accordance with Iranian Petroleum Standard IPS-E-PR-770 "Process Design of TEMA Type Shell and Tube Heat Exchangers". (Add.)

APPENDICES

APPENDIX A ENQUIRIES AND QUOTATIONS

A.1 Enquiries

A.1.1 An enquiry to a supplier by or on behalf of the company will include the heat exchanger specification sheet partially completed as appropriate.

A.1.2 All necessary data including any special requirements or exceptions to this Standard will be provided.

A.2 Quotations

A.2.1 The vendor's proposal shall include, for each unit, a completed specification sheet or, when a specification sheet is included in the enquiry, a statement indicating complete compliance with that specification sheet.

A.2.2 The proposal shall include a detailed description of all exceptions to the specified requirements, together with the reasons for deviations.

A.2.3 Where expansion joints or shell bellows are proposed the vendor shall define the type of construction.

A.2.4 The quotation shall be in accordance with technical specification of this Standard, and the specific requirements for each unit as specified in the data sheet or purchase order.

A.2.5 The following information shall be submitted in the quotation:

A.2.5.1 Price

Separate prices shall be quoted for test rings, if required.

A.2.5.2 Delivery time

A.2.5.3 Estimated total shipping weight for each heat exchanger.

A.2.5.4 The name(s) of subcontractor(s) if any for the fabrication of any part thereof. Such subcontractors shall be subject to approval by the company. It shall be noted that the quality of subcontractor's work shall, in all respects, at least be equal to the supplier's own.

A.2.6 Any purchase order will be subject to all terms, conditions, etc. forming part of the enquiry and any agreed documents to it.

A.2.7 The engineering documents shall be in English. Descriptions on drawings and similar documents may be in other languages, provided English Translations are also given.

APPENDIX B HEAT EXCHANGER SPECIFICATION SHEET

1	Job No.	
2	Customer	Reference No.
3	Address	Proposal No.
4	Plant Location	Date
5	Service of Unit	Item No.
6	Size	Connected in Parallel
7	Surf/Unit (Gross/Eff.) m ²	Surf/Shell (Gross/Eff.) m ²
8	PERFORMANCE OF ONE UNIT	
9	Fluid Allocation	Shell Side
10	Fluid Name	Tube Side
11	Fluid Quantity, Total	
12	Vapor (In/Out)	
13	Liquid	
14	Steam	
15	Water	
16	Noncondensable	
17	Temperature (In/Out) °C	
18	Specific Gravity	
19	Viscosity, Liquid mPa.s	
20	Molecular Weight, Vapor	
21	Molecular Weight, Noncondensable	
22	Specific Heat kJ/kg °C	
23	Thermal Conductivity W/(m °C)	
24	Latent Heat kJ/kg	
25	Inlet Pressure kPa	
26	Velocity m/s	
27	Pressure Drop, Allow/Calc'd, kPa	
28	Fouling Resistance (thin.)	
29	Heat Exchanged kJ/s	kW (Corrected)
30	Transfer Rate, Service	kW/m ² °C
31	CONSTRUCTION OF ONE SHELL	
32	Sketch (Bundle)	Sketch (Bundle)
33	Design Test Pressure kPa	Shell Side
34	Design Temperature °C	Tube Side
35	No. Passes Per Shell	
36	Corrosion Allowance mm	
37	Connections, In	
38	Size	Out
39	Rating	Intermediate
40	Tube No.	mm (Inch/4x4) mm Length mm Pitch mm
41	Tube Type	Material
42	Shell ID	mm Shell Cover (Inlet/Removal)
43	Channel or Bonnet	Channel Cover
44	Tube Sheet-Stationary	Tube Sheet-Floating
45	Flange Head Cover	Impingement Protection
46	Baffle-Cross Type	mm Cut (Dia/Area) Spacing c/c Inlet mm
47	Baffle-Long	Seal Type
48	Support-Tube	U-Bend Type
49	Excess Seal Arrangement	Tube-tube sheet joint
50	Expansion Joint	Type
51	1" Inlet Nozzle	Bundle Entrance
52	Outlet Shell Side	Tube Side
53	Flange Head	
54	Code Requirements	Item Class
55	Weight/Shell	Filled with water
56	Remarks	Bundle
57		
58		
59		
60		

APPENDIX C

SCOPE OF INSPECTION AND TESTING

Unless otherwise specified scope of inspection for shell and tube heat exchanger shall be as follows:

C.1 Material Inspection

- a) review of material certificates;
- b) Identification of material.

C.2 Welding procedure and welders'/welding operators' performance qualification tests.

- a) review of welding procedure specification (WPS);
- b) review of welding procedure qualification Records (PQR);
- c) Review of welders'/welding operators' performance qualification records.

C.3 Random witness in fabrication process, such as edge preparation, fit-up, back-chipping and finish-weld tube-hole preparation and finish, tube expansion, seal welding etc.

C.4 Review of records of post weld heat treatment (if any).

C.5 Non-destructive Examination (where applicable).

- a) Monitoring of radiographic examination and review of radiographs
- b) Witness of ultrasonic examination
- c) Witness of magnetic particle examination.

C.6 Check of hardness test on welds if specified.

C.7 Pressure Tests

- a) Witness of hydrostatic test
- b) Witness of pneumatic test.

C.8 Final Inspection

- a) Visual inspection;
- b) Check of dimensions.

C.9 Painting inspection if applicable.

C.10 Review and endorsement of inspection reports issued by manufacturers.

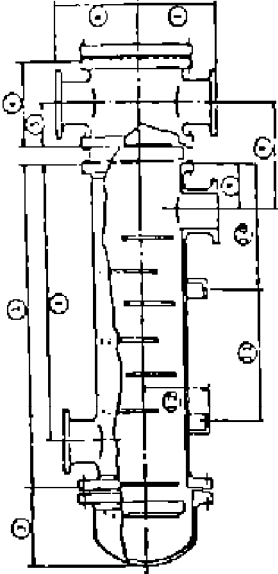
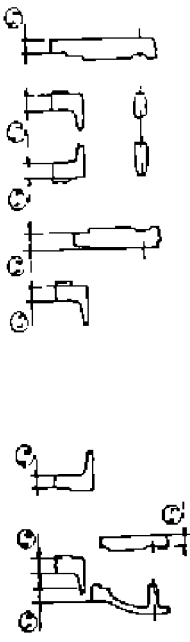
C.11 Unless agreed otherwise, the applicable references for inspection and tests shall be as follows:

C.11.1 This Standard Specification and other standards specified in the purchase order.

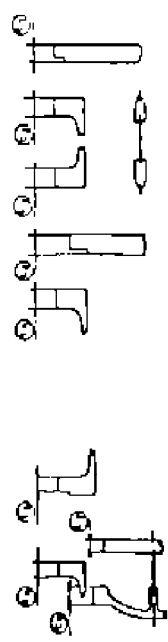
C.11.2 ASME Code / TEMA Std. / ASTM Std. / ANSI Std.

C.11.3 Approved manufacturer's specifications and drawings.

APPENDIX D
MANUFACTURER'S NONDESTRUCTIVE EXAMINATION RECORDS

Standard Confined Joint Construction



Standard Unconfined Plain Face Joint Construction

No.	Description	Location to be measured	Dimension measured	Judgment
1	Dimension of assembly	3 points each		
2				
3				
4	Distance between bolt heads center to center	3 points each		
5	Distance between center line of anchorage and saddle	7 points for each saddle		
6	Thickness	7 points to equal distance		
7				
8				

Date: _____

Sign: _____ Inspector

3 POINTS EACH FOR FACTOR RECORD FROM FOR SMALL AND THIS MAY BE OBTAINED

(to be continued)

APPENDIX D (continued)

MANUFACTURER'S INSPECTION RECORD FOR
RADIOGRAPHIC EXAMINATION

PURCHASER (JOB CODE No.) ()		ITEM No.
CLIENT		EQUIPMENT
PROJECT		APPLICABLE CODE OR SPEC.
P.O.No.		MANUFACTURER
Radiation Source	X- Ray : b X- Ray (up to 400 KVP) b Linear accelerator b Other V- Ray : b Iridium b Cobalt b Other	
Source Size		
Voltage and Amperage		
Distance (source to Film)		
Film Type		
Screen Type		
IQI (Penetrameter designation)		
Radiographic Technique	b Single wall b Double wall	
Location Examined, Weld No. Thickness, Film No. or Film Mark	b See attached detailed records	
Judgement	b See attached detailed records	
<div style="text-align: right;"> Date : Sign : Inspector </div>		

(to be continued)

MANUFACTURER'S INSPECTION RECORD FOR ULTRASONIC EXAMINATION

(to be continued)

APPENDIX D (continued)

**MANUFACTURER'S INSPECTION RECORD FOR
MAGNETIC PARTICLE EXAMINATION**

PURCHASER		ITEM No.	
(JOB CODE No.) ()			
CLIENT		EQUIPMENT	
PROJECT		APPLICABLE	
		CODE OR SPEC.	
P.O.No.		MANUFACTURER	
Stage of Examination	<input type="checkbox"/> Prepared Edge <input type="checkbox"/> After P.W.H.T <input type="checkbox"/> Other <input type="checkbox"/> As Welded <input type="checkbox"/> After Hydro Test		
Surface Preparation	<input type="checkbox"/> Grinding <input type="checkbox"/> Machining <input type="checkbox"/> As Welded <input type="checkbox"/> Other		
Instrument	Type		
Mag. Method	<input type="checkbox"/> Yoke <input type="checkbox"/> Prod <input type="checkbox"/> Other		
Calibration			
Pred. Space			
Current	<input type="checkbox"/> AC <input type="checkbox"/> DC A AT		
Test Temperature			
Particle	<input type="checkbox"/> Dry <input type="checkbox"/> Wet <input type="checkbox"/> Black <input type="checkbox"/> Brown <input type="checkbox"/> Fluorescent		
Locatior, examined	<input type="checkbox"/> See attached detailed records		
Result	<input type="checkbox"/> See attached detailed records		
<div style="text-align: right; margin-top: 20px;"> Date : Sign : <div style="display: inline-block; width: 150px; border-bottom: 1px solid black; margin-top: 5px;"></div> Inspector </div>			

(to be continued)

APPENDIX D (continued)

**MANUFACTURER'S INSPECTION RECORD FOR
LIQUID PENETRANT EXAMINATION**

PURCHASER		ITEM No.	
(JOB CODE No.) (.....)			
CLIENT		EQUIPMENT	
PROJECT		APPLICABLE	
		CODE OR SPEC.	
P.O.No.		MANUFACTURER	
Stage Of Examination	<input type="checkbox"/> Prepared Edge <input type="checkbox"/> After P.W.H.T <input type="checkbox"/> Other <input type="checkbox"/> As Welded <input type="checkbox"/> After Hydro Test		
Surface Preparation	<input type="checkbox"/> Grinding <input type="checkbox"/> Machining <input type="checkbox"/> As Welded <input type="checkbox"/> Other		
Penetrant	Type	<input type="checkbox"/> Color Contrast <input type="checkbox"/> Fluorescent	
	Application	<input type="checkbox"/> Brushing <input type="checkbox"/> Spraying	
	Temperature	°C	Penetrant Time min
Removal	<input type="checkbox"/> Water Washable Penetrants <input type="checkbox"/> Post Emulsifying Penetrants <input type="checkbox"/> Solvent Removal Penetrants	Developing	<input type="checkbox"/> Dry Developer <input type="checkbox"/> Wet Developer
Location Examined	<input type="checkbox"/> See attached detailed records		
Result	<input type="checkbox"/> See attached detailed records		
<div style="display: flex; justify-content: space-between; align-items: flex-end; padding: 10px;"> <div>Date:-----</div> <div>Sign:-----</div> <div>Inspector</div> </div>			