

# Engineering Standard

SAES-E-014

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## Design Criteria of Plate and Frame Heat Exchangers

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## Saudi Aramco DeskTop Standards

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## 1 Scope

- 1.1 This standard covers the minimum mandatory requirements for the thermal and mechanical design of new plate and frame type heat exchangers (herein referred to as exchangers) used for liquid hydrocarbon and utility services. It does not cover exchangers that undergo repairs or alterations.
- 1.2 This standard establishes the rules for thermal and mechanical design requirements and assists the Design Engineers in the specification and selection of exchangers.
- 1.3 This standard shall not be attached to nor made a part of purchase orders.

## 2 Conflicts and Deviations

- 2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, Codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

## 3 References

The selection of material and equipment, and the design and construction of exchangers covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

### 3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a  
Mandatory Saudi Aramco Engineering  
Requirement*

Saudi Aramco Engineering Standards

[SAES-A-005](#)

*Safety Instruction Sheet*

[SAES-A-112](#)

*Meteorological and Seismic Design Data*

[SAES-H-001](#)

*Selection Requirements for Industrial Coatings*

[SAES-H-101](#)

*Approved Protective Coating Systems*

[SAES-W-010](#)

*Welding Requirements for Pressure Vessels*

#### Saudi Aramco Materials System Specification

[32-SAMSS-019](#)

*Manufacture of Plate and Frame Heat Exchangers*

#### Saudi Aramco Forms and Data Sheets

*Form 8172-ENG*

*Plate Type Heat Exchanger Specification Sheet  
(hereinafter referred to as data sheet)*

*Form 8173-ENG*

*Safety Instruction Sheet*

### 3.2 Industry Codes and Standards

#### American Society of Civil Engineers

*ASCE 7*

*Minimum Design Loads for Buildings and Other  
Structures*

#### American Society of Mechanical Engineers

*ASME SEC II*

*Material Specifications Parts A, B and D*

*ASME SEC V*

*Nondestructive Examination*

*ASME SEC VIII D1*

*Rules for Construction of Pressure Vessels*

*ASME SEC VIII D2*

*Rules for Construction of Pressure Vessels,  
Alternative Rules*

*ASME B16.5*

*Pipe Flanges and Flanged Fittings*

#### American Petroleum Institute

*API STD 662*

*Plate Heat Exchangers for General Refinery  
Services*

## 4 Definitions

**Cyclic Services:** Services that require fatigue analysis per AD-160 of ASME SEC VIII D2. This applies to Division 1 and Division 2 of ASME SEC VIII.

**Design Engineer:** The Engineering Company responsible for specifying on the data sheet the thermal and mechanical design requirements for exchangers.

**Plate and Frame Exchanger:** Exchanger equipment that utilizes plates that are pressed to provide channels for heat transfer between one fluid and another. Plate assemblies are supported in a structural frame.

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**Exchanger Manufacturer:** The company responsible for the manufacture of exchangers.

**Hydrocarbon Service:** Process streams of liquid or gaseous hydrocarbon materials.

**Hydrogen Service:** Process streams containing relatively pure hydrogen and component streams containing hydrogen with a partial pressure of 350 kPa abs (50 psia) and higher.

**Lethal Services:** Process streams containing a concentration of hydrogen sulfide in excess of 20% by volume shall be considered as lethal service.

**Saudi Aramco Engineer:** The Supervisor of the Process Equipment Unit, Consulting Services Department, Dhahran.

**Utility Services:** Includes potable water, cooling water, and seawater.

**Wet Sour Service:** Following process streams containing water and hydrogen sulfide:

- 1) Sour water with a hydrogen sulfide concentration above 2 milligrams per liter.
- 2) Crude containing hydrogen sulfide when transported or processed prior to completion of stabilization (60 ppm H<sub>2</sub>S and higher).
- 3) Gas or hydrocarbon condensate containing hydrogen sulfide when transported or processed prior to completion of sweetening or hydrogen sulfide stripping.
- 4) Multiphase services when the partial pressure of hydrogen sulfide is above 0.34 kPa abs (0.05 psia) in the gas phase or a concentration of hydrogen sulfide above 2 milligrams per liter in the water phase.

**Wet Sour HIC Services:** All of the above Wet Sour Services where the H<sub>2</sub>S concentration in the water phase is above 50 milligrams per liter. Exception: lean and rich DGA services, other lean amine services, and caustic services are not included.

## 5 Responsibilities

- 5.1 The Design Engineer is responsible for specifying the basic thermal and mechanical design requirements and completing the data sheet, Form 8172-ENG, in accordance with this standard. The Design Engineer may also carry out the thermal design.
  - 5.2 The Exchanger Manufacturer is responsible for the thermal design (rating) and verification of the Design Engineer's thermal design, if applicable. The Exchanger Manufacturer is also responsible for the manufacture of exchangers, which includes the complete mechanical design, Code and structural calculations,
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supply of all materials, fabrication, nondestructive examination, inspection, testing, surface preparation, and preparation for shipment, in accordance with the completed data sheet and the requirements of [32-SAMSS-019](#).

## 6 Basis for Thermal Design

### 6.1 General

- 6.1.1 Exchangers shall only be used for liquid hydrocarbon and utility services within the limitations as specified in this standard. Prior approval from the Saudi Aramco Engineer is required for uses outside these limits.
- 6.1.2 Exchangers shall not be used for hydrogen, lethal, wet sour, cyclic or condensing/boiling services.
- 6.1.3 Gasketed exchangers shall be limited for use for services in which the maximum operating pressure is less than 2 MPa (300 psi), and/or the maximum operating temperature is less than 149°C (300°F).
- 6.1.4 Use of all-welded exchangers or welded-gasketed exchangers requires prior approval from Saudi Aramco Engineer.

### 6.2 Thermal Design

- 6.2.1 Exchangers shall be designed for the excess thermal capacities as specified as follows:
  - 1) A minimum of 15% excess thermal capacity shall be provided for clean services such as cooling of process water, light oils and light process streams, utilizing tempered water as the cooling medium.
  - 2) A minimum of 20% excess thermal capacity shall be provided for fouling services such as cooling of crude oil, emulsion and heavy process streams, utilizing seawater or other process fluids as cooling medium.

*Commentary Note:*

*Fouling factors used in the design of shell & tube type heat exchangers are too high and are not appropriate for plate & frame type heat exchangers. Due to large turbulence induced in the plate & frame exchangers, much lower fouling is experienced. Hence, typically, 10 to 25% excess thermal capacity is used in lieu of normal fouling factors.*

- 6.2.2 For exchangers in heavy fouling services, (excessive heat transfer resistance caused by dirt, sludge and polymer) provision of onstream cleaning and/or spare units shall be considered.
- 6.2.3 If an exchanger is used in heavy fouling service with seawater as the cooling medium and if, due to process streams considerations a low heat transfer rate is expected, consideration shall be given to the addition of backwash facilities on the seawater stream in combination with chlorination and filters.
- 6.2.4 In heavy fouling services, where there is a potential of blocking flow passages between plates, consideration shall be given to providing filters upstream of exchangers.
- 6.2.5 The value for the maximum allowable pressure drop in the clean condition shall be specified on the data sheet.
- 6.2.6 Single pass designs (i.e., all connections on front pressure plate) are preferred and shall be used wherever possible.

## 7 Mechanical Design

### 7.1 General

- 7.1.1 All exchangers shall be mechanically designed in accordance with the rules of the ASME SEC VIII D1 (herein referred to as the Code), API STD 662 and the requirements of [32-SAMSS-019](#).
- 7.1.2 The applicable edition of the Code to be used for the design of exchangers shall be specified on the data sheet.
- 7.1.3 The application of ASME Code Cases to the design of exchangers requires the approval of the Saudi Aramco Engineer.

### 7.2 Design Pressure

- 7.2.1 Exchangers shall be designed to withstand the maximum internal pressure and/or vacuum which can occur during operation, shutdown or during any upset conditions.
  - 7.2.2 Exchangers shall be designed to withstand the full design pressure on either side of the plate with no pressure on the other side.
  - 7.2.3 The values of normal operating pressure, maximum operating pressure, if applicable, and design pressure shall be specified on the data sheet.
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7.2.4 Internal design pressures shall not be less than the larger of the maximum operating pressure plus 100 kPa (15 psi) or 110% of the maximum operating pressure.

### 7.3 Design Temperature

The design temperature shall not be less than the maximum operating temperature plus 10°C (50°F) and must include consideration for any upset conditions.

Design inlet cooling water temperature to be used in the design of heat exchangers utilizing seawater shall as follows:

Conditions	Design Inlet Cooling Water Temperature	
	East Coast	West Coast
Summer	35°C (95°F)	33°C (91.4°F)
Winter	9°C (48.2°F)	9°C (48.2°F)

The maximum cooling water outlet temperature shall be 49°C.

### 7.4 Loads

#### 7.4.1 Wind and Earthquake Loads

- 1) Wind and Earthquake loads shall be determined by the Exchanger Manufacturer in accordance with the procedures detailed in ASCE 7.
- 2) The Design Engineer shall determine the basic wind speed corresponding to the Saudi Aramco site in accordance with [SAES-A-112](#). The basic wind speed shall be specified on the data sheet.
- 3) The Design Engineer shall determine the earthquake zone, soil coefficient and effective peak acceleration ratio ( $A_v$ ) corresponding to the Saudi Aramco site in accordance with [SAES-A-112](#). The earthquake zone and site soil coefficient shall be specified on the exchanger data sheet.

#### 7.4.2 Piping and Equipment Loads

- 1) Nozzles shall be designed for external piping loads, such as may be produced from thermal expansion or contraction and weight.
- 2) Where such conditions exist, the Design Engineer shall specify these loads on the data sheet.

## 8 Nozzles and Gaskets

### 8.1 General

- 8.1.1 The sizes and pressure classes of inlet and outlet piping shall be specified on the data sheet by the Design Engineer.
- 8.1.2 The Design Engineer is responsible for ensuring that the facings, bolt centers, number of bolts and size of bolts of exchanger nozzles match the mating piping flanges.
- 8.1.3 Nozzles with NPS of 2½, 3½, and 5 shall not be used.
- 8.1.4 All inlet and outlet nozzles NPS 2 and greater shall be flanged.
- 8.1.5 Two-0.75 inch threaded connections shall be specified on each inlet and outlet nozzle for local temperature and pressure measurement.

### 8.2 Ratings (ASME Pressure Classes) and Facings

- 8.2.1 The ASME pressure classes shall be specified on the data sheet.
- 8.2.2 ASME Class 400 is not permitted..
- 8.2.3 Pressure ratings shall be in accordance with ASME B16.5.
- 8.2.4 Flat face flanges may be used only for exchangers in utility services.

### 8.3 Gaskets

The gaskets shall be suitable for the specified service conditions and shall be of proven design and materials.

## 9 Material Selection

- 9.1 The materials of construction for pressure and non-pressure components shall be based on the design temperature, design conditions, and service in accordance with [32-SAMSS-019](#).
- 9.2 Use of materials other than those specified in [32-SAMSS-019](#) shall require a prior approval from the Saudi Aramco Engineer.

## 10 Painting

- 10.1 The selection of the type of coating shall be in accordance with [SAES-H-001](#).
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- 10.2 The Approved Protective Coating Systems (APCS) shall be selected from [SAES-H-101](#) and specified on the data sheets together with the applicable Class 09 Saudi Aramco Material System Specification for the surface preparation and painting systems.

## 11 Drawings and Calculations

- 11.1 The data sheet and any relevant forms are to be completed by the Design Engineer to the extent as detailed in this standard.
- 11.2 The Design Engineer is responsible for the completion of the exchanger-Safety Instruction Sheet (Form 8173-ENG) in accordance with [SAES-A-005](#) and the data on the Exchanger Manufacturer's drawings.
- 11.3 When completing the data sheets using the SI system of measurement, the following units shall be used:
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|------------------------|--|
| Flow rate: kg/h        | Length: m or mm                        |
| Temperature: °C        | Density: kg/m <sup>3</sup>             |
| Heat Capacity: kJ/kg K | Thermal Conductivity: W/m K            |
| Pressure: kPa          | Heat Transfer Rate: W/m <sup>2</sup> K |
| Latent Heat: kJ/kg     | Heat Duty: W                           |
- 11.4 The as built thicknesses of pressure components shall be specified by the Design Engineer on the Safety Instruction Sheet (SIS) after the completion of fabrication.
- 11.5 All data sheets, drawings and forms are to be suitable for microfilming.

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**Revision Summary**  
Major revision.