PLANT EQUIPMENT
HEAT EXCHANGERS
Integration and Professionalism

IN ACCORDANCE WITH
TEMA STANDARD
HEAT EXCHANGER HANDBOOK

PLUS INTERNATIONAL CODES WHICH PROVIDING
Practical solution & Academic Studies

DR. ENG. MOHAMED AL-KHAWAGA
Update: November 2016
PLANT EQUIPMENT
HEAT EXCHANGERS

PREFACE

PROGRAM STRUCTURE AND GUIDANCE
BODY OF KNOWLEDGE AND OVERVIEW
PLANT EQUIPMENT
HEAT EXCHANGERS

I. PREFACE

BODY KNOWLEDGE

Module I.
PREFACE AND OVERVIEW
Heat Transfer Philosophy and methodology and other concepts

Module II.
H. EX. TYPES AND CLASSIFICATION
Illustration of H. Ex. Classification in depending on industries types and related to process targets

Module III.
H. EX. DESIGN
Specific overview for all design recommendation

Module IV.
H. EX. Construction
Specific overview for all fabrication, Quality and installation gaudiness

Module V.
H. EX. MAINTENANCE
Specific overview for Inspection, repair and cleaning
Heat always moves from a warmer place to a cooler place. Hot objects in a cooler room will cool to room temperature. Cold objects in a warmer room will heat up to room temperature.

**HEAT TRANSFER METHODS**
- Conduction
- Convection
- Radiation

**Conduction**
The transfer of heat through a fluid caused by molecular motion.

**Convection**
The transfer of heat from one substance to another due to direct contact.

**Radiation**
Energy that is radiated or transmitted in the form of rays or waves or particles.
PLANT EQUIPMENT
HEAT EXCHANGERS

I. PREFACE

H. EX. PARTS

<table>
<thead>
<tr>
<th>MAIN COMPONENTS / PARTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel [Body]</td>
</tr>
<tr>
<td>Floating Head</td>
</tr>
<tr>
<td>Channel</td>
</tr>
<tr>
<td>Channel Cap</td>
</tr>
<tr>
<td>Tube Bundle</td>
</tr>
<tr>
<td>Baffles</td>
</tr>
<tr>
<td>Guides</td>
</tr>
<tr>
<td>Nozzles</td>
</tr>
<tr>
<td>Supports</td>
</tr>
</tbody>
</table>

![Diagram of heat exchanger components](image)
PLANT EQUIPMENT
HEAT EXCHANGERS

I. PREFACE
PLANT EQUIPMENT
HEAT EXCHANGERS

I. PREFACE

H. EX. P&ID
I. PREFACE

H. EX. PROCESSING

COLD FLUID THEN HOT FLUID

METAL

QUENCHING
Module II
HEAT EXCHANGER CLASSIFICATION
RELATED TO INDUSTRIES
Classification According to Transfer Process

In-Direct Contact Type
- Direct Transfer Type
  - Single Phase
  - Multi Phase
- Strong Type
- Fluidized bed

Direct Contact Type
- Immiscible fluid
- Gas - Liquid
- Liquid - Vapor

Classification According to Number Of Fluid

- Two Fluids
- Three Fluids
- N Fluids [N>3]
Classification According to Surface Compactness

- **Gas To Fluid**
  - Compact: \( \beta \geq 700 \frac{m^2}{m^3} \)
  - Non-Compact: \( \beta < 700 \frac{m^2}{m^3} \)

- **Liquid to Liquid**
  - Compact: \( \beta \geq 400 \frac{m^2}{m^3} \)
  - Non-Compact: \( \beta < 400 \frac{m^2}{m^3} \)

Classification According to Heat Transfer Mechanism

- **Single Phase Convection in both side**
- **Single Phase Convection in one side**
  - Two Phase Convection in other side
- **Two Phase Convection in both side**
- **Combined Convection and radiation heat transfer**
PLANT EQUIPMENT
HEAT EXCHANGERS
I. H. EX. CLASSIFICATION

Classification According to Construction

Tabular

Plate Type

Extended Surface

Regenerative

PHA
Spiral
Plate Coil
Printed

Casketed
Welded
Brazed

Double Pipe
Shell & Tube
Spiral Tube
Pipe coil

Parallel Flow to tube
Cross flow to tube

Plate Fin
Tube Fin

Rotary
Fixed Matrix
Rotating Hoods

Ordinary Sep. Wall
Heat Pipe Wall
**Plant Equipment**

**Heat Exchangers**

I. H. Ex. Classification

Classification According to Flow Arrangement

- **Single Pass**
  - Counter Flow
  - Parallel Flow
- **Multi Pass**
  - Cross Flow
  - Split Flow
  - Divided Flow
- **Extended Surface**
  - Cr. Counter Flow
  - Cr. Parallel Flow
- **Shell and Tube**
  - Compound Flow
  - P. Counter Flow
  - Split Flow
  - Divided Flow
  - Fluid 1 m passes
  - Fluid 2 n passes
- **Plate**
  - M shell passes
  - N Tube passes
Concentric-Tube Heat Exchangers

Simplest configuration.
Superior performance associated with counter flow.
Cross-flow Heat Exchangers

For cross-flow over the tubes, fluid motion, and hence mixing, in the transverse direction (y) is prevented for the finned tubes, but occurs for the unfanned condition. Heat exchanger performance is influenced by mixing.
Shell-and-Tube Heat Exchangers

Baffles are used to establish a cross-flow and to induce turbulent mixing of the shell-side fluid, both of which enhance convection. The number of tube and shell passes may be varied, e.g.:

- One Shell Pass, Two Tube Passes
- Two Shell Passes, Four Tube Passes
Compact Heat Exchangers

Widely used to achieve large heat rates per unit volume, particularly when one or both fluids is a gas. Characterized by large heat transfer surface areas per unit volume, small flow passages, and laminar flow.

(a) Fin-tube (flat tubes, continuous plate fins)
(b) Fin-tube (circular tubes, continuous plate fins)
(c) Fin-tube (circular tubes, circular fins)
(d) Plate-fin (single pass)
(e) Plate-fin (multipass)
PLANT EQUIPMENT
HEAT EXCHANGERS

Module IV
HEAT EXCHANGER MAINTENANCE
RECOMMENDATION PRACTICE
SHELL & TUBE HEAT EXCHANGERS

Distributor

Gasket

Tube Bundle

Split ring

Tube sheet

Spacer

Gasket

Gasket

Tube sheet

Gasket

Back Cover

Gasket

Floating Head

Shell

Floating Head Detail
Do Not Start The Job Without A Safety Plan
MAINTENANCE ACTIVITY DESCRIPTION

- Blind Inlets-Outlets at plant area
- Disconnect and remove Distributor with gasket
- Disconnect and remove Back cover with gasket
- Disconnect and remove Floating Head with gasket
- Install the bundle puller
- Pull the bundle out
**MAINTENANCE ACTIVITY DESCRIPTION CONTINUATION**

- Clean Shell and covers
- Lift the bundle puller with clean bundle and new gasket, ready for reinstallation

- Lower the bundle and take to hydro-jetting area
Reinsert the bundle by bundle puller

Lower the bundle puller to the ground and take it away
MAINTENANCE ACTIVITY DESCRIPTION

- Install front Test Ring with gasket
- Install back Test Ring with gasket
- Install Blinds in shell
- Install Pressure Gauge
- Connect water pump
- Fill the shell by water
- Raise the pressure up to value given by Inspection
- Check leakages from tubes
SHELL & TUBE HEAT EXCHANGERS

MAINTENANCE ACTIVITY DESCRIPTION.....CONTINUATION

SHELL SIDE HYDRO-TEST
CHECK LEAKAGES FROM TUBES CONTINUATION
**TUBE LEAK ELIMINATION DETAILS**

**Detail “A” [By Expansion both sides]**

**Detail “B” [By Plug both sides]**

**Tube Expander Tool**

**Leak**

**Shell under pressure**

**SHELL & TUBE HEAT EXCHANGERS**

**MAINTENANCE ACTIVITY DESCRIPTION… CONTINUATION**

**SHELL SIDE HYDRO-TEST**
Discharge water from shell drain
Remove Test Ring & gasket [distributor side]

Reinstall distributor with new gasket & tight bolts
Blind Distributor in & out

Remove Test Ring & gasket [floating head side]

Reinstall Floating Head with split flange, new gasket & tight bolts
PLANT EQUIPMENT
HEAT EXCHANGERS
V. H. EX. MAINTENANCE

**SHELL & TUBE HEAT EXCHANGERS**

**MAINTENANCE ACTIVITY DESCRIPTION**

- Install PG in distributor top nozzle
- Connect water pump
- Fill tube side by water
- Raise the pressure up to value given by inspection
- Check floating head gasket sealing
- Check distributor gasket sealing
- Discharge the water, remove PG and water pump
- Remove blinds form distributor nozzle and tight bolts

**TUBE SIDE HYDRO-TEST**

![Diagram of heat exchanger with labeled components]
Install Back cover with Gasket

Connect water pump

Fill Shell side by water

Raise the pressure up to value given by Inspection

Check Back cover gasket sealing

Check bundle to shell gasket sealing

Discharge the water, remove PG and water pump

Remove blinds form shell nozzles and tight bolts
- Remove tools and equipment
- Clean and wash the area

☐ Close Work permit
☐ Remove scaffold after unit start-up