# Program of Asset Integrity Management for Oil Process

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The program just be drafted for implementation of Asset Integrity Management at Oil Process.

# 1. Process Facility

## 1.1 Update P&ID or As-built;

- Freewater KOD + Heater Treater + Separator + Emulsion Treater + API

## 1.2 Separator

- **Size and MAWP**

**Table 1—Horizontal Separators Size and Working Pressure Ratings**

| Nominal Diameter in. | Maximum Allowable Working Pressure psig @ 130°F | | | | | | |
|---|---|---|---|---|---|---|---|
| 12 3/4 | — | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 16 | — | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 20 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 24 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 30 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 36 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 42 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 48 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 54 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 60 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |

NOTE 1 Shell length is generally expanded in 2 1/2-ft increments measured from head seam to head seam and is typically 5 ft, 7 1/2 ft, or 10 ft. A minimum length-to-diameter ratio of 2.0 is normally used.

NOTE 2 Vessel diameter is generally expanded in 6-in. increments, measured either as outside diameter (OD) or inside diameter (ID). OD separators are normally furnished up to 24-in. diameter. Separators above this size may be either OD or ID vessels.

**Table 2—Vertical Separators Size and Working Pressure Ratings**

| Nominal Diameter in. | Maximum Allowable Working Pressure psig @ 130°F | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 | — | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 20 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 24 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 30 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 36 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 42 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 48 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 54 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |
| 60 | 125 | 230 | 600 | 1,000 | 1,200 | 1,440 | 2,000 |

NOTE 1 Shell length is generally expanded in 2 1/2-ft increments measured from head seam to head seam and is typically 5 ft, 7 1/2 ft, or 10 ft. A minimum length-to-diameter ratio of 2.0 is normally used.

NOTE 2 Vessel diameter is generally expanded in 6-in. increments, measured either as outside diameter (OD) or inside diameter (ID). OD separators are normally furnished up to 24-in. diameter. Separators above this size may be either OD or ID vessels.

- **Design Calculation**

**Two-Phase**

- Maximum allowable superficial velocity of Gas;(10-mirons liquid droplets to settle with Wire mesh mist extractor)
- Oil Capacity: Retention time, gas-oil interface area;

Basic design criteria for liquid retention time in two-phase separators are generally as follows:

| Oil Gravities | Minutes (Typical) |
|---|---|
| Above 35° API | 1 |
| 20° – 30° API | 1 to 2 |
| 10° – 20° API | 2 to 4 |

**Three-Phase**

- Gas Velocity for liquid drop out;
- Gas be scrubbed by mist extractor;
- Water and oil, Turbulence-free section;
- Water-oil interface;
- Oil setting time;
- Water setting time;

The usual approach in design is to allow equal retention times for oil and water. This is accomplished with a wide range interface level controller or variable water weir. Basic design criteria for liquid retention time in three-phase separators are generally as follows:

| Oil Gravities | Minutes (Typical) |
|---|---|
| Above 35° API | 3 to 5 |
| Below 35° API | |
| 100 + °F | 5 to 10 |
| 80 + °F | 10 to 20 |
| 60 + °F | 20 to 30 |

- Primary Separation Section
  - Removing the bulk of the liquid in the inlet stream. Liquid slugs and large liquid particles are removed first to minimize gas turbulence and re-entrapment of liquid particles in preparation for the second step of separation. To do this, it is usually necessary to absorb the momentum and change the direction of flow by some form of inlet baffling.
- Secondary Separation Section
  - The major separation principle in this section is gravity settling of liquid from the gas stream after its velocity has been reduced. The efficiency of this section depends on the gas and liquid properties, particle size and degree of gas turbulence. Some designs use internal baffling to reduce turbulence and to dissipate foam. The baffles may also act as droplet collectors.
- Liquid Accumulator Section
  - The liquid is collected in this section. The liquid should have a minimum of disturbance from the flowing gas stream. Sufficient capacity is necessary to allow

for surges and to provide the retention time necessary for efficient separation of gas breaking out of solution and separation of free water from oil in three-phase separators. A vortex breaker may be located over the liquid outlet nozzle to prevent gas or oil entrapment with the bottom liquid.

- Mist Extraction Section
  - The mist extractor of the coalescing section can be one of several designs (a series of vanes, woven wire mesh pad or a centrifugal device). The mist extractor removes from the gas stream the small droplets (normally down to 10-micron diameter) of liquid before the gas leaves the vessel. Liquid carryover is normally less than 0.1 gallon per MMSCF.
- Process Controls
  - Operating pressure, minimum separator pressure;
  - Liquid level controls
  - Baffles, gauge glasses;
  - Pressure gauge; thermometer;
- Relief Devices
  - Pressure protective devices: MAWP;
  - Rupture disk is normally selected to relieve above the set pressure of the relief valve;

➢ **Scrubber**

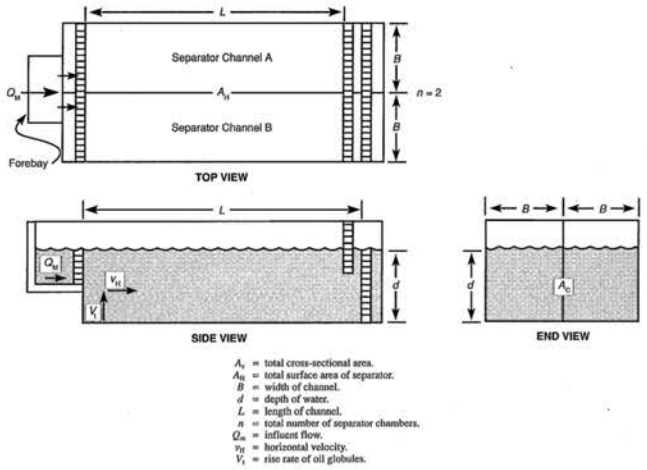
- High gas-to-liquid ratios

➢ **Freewater KOD of Disposal System Components (API RP 521)**

- Sizing a knockout drum is generally a trial-and-error process:
  **The first step** is to determine the drum size required for liquid entrainment separation. Liquid particles will separate (a) when the residence time of the vapor or gas is equal to or greater than the time required to travel the available vertical height at the dropout velocity of the liquid particles, and (b) when the vertical gas velocity is sufficiently low to permit the liquid dropout to fall.
  Since the flare can handle small liquid droplets, the allowable vertical velocity in the drum may be based on that necessary to separate droplets from 300 micrometers to 600 micrometers in diameter.

**The second step** in sizing a knockout drum is to consider the effect any liquid contained in the drum may have on reducing the volume available for vapor/liquid disengagement. This liquid may result from (a) condensate that separates
during a vapor release, or (b) liquid streams that accompany a vapor release.

- **API Separator**




**(Free oil: Vertical velocity of oil globules VS Surface-loading rate)**

Free oil: Residence time, Gravity; (Turbulence, Laminar flow; Eddies);
Emulsified oil: Inter-particle force, 20 microns, Chemical addition and coalescing or flotation;
Dissolved oil: Biological treatment;

- Design

1. Wastewater Characterization

   Performance of API: Flow rate, specific gravity, salinity, temperature, viscosity, oil-globule size (0.015 centimeter);

2. Establishing a design flow

3. **Design Calculation:**

   Ratio of Depth to Width: 0.3-0.5; Ratio of Length to Width: 5;

   Rise rates of Oil-globule:

$$V_t = (g/18\mu)(\rho_w \rho_o)D^2$$

$$V_t = 0.0241\frac{S_w - S_o}{\mu}$$

0.015 centimeter; (Reynolds number < 0.5)

Horizontal Velocity:

$$v_H = 15V_t \leq 3$$

Minimum Vertical Cross-section Area:

$$A_c = Q_m / v_H$$

Number of Channels:

$$n = A_c / 160$$

Channel Width and Depth:

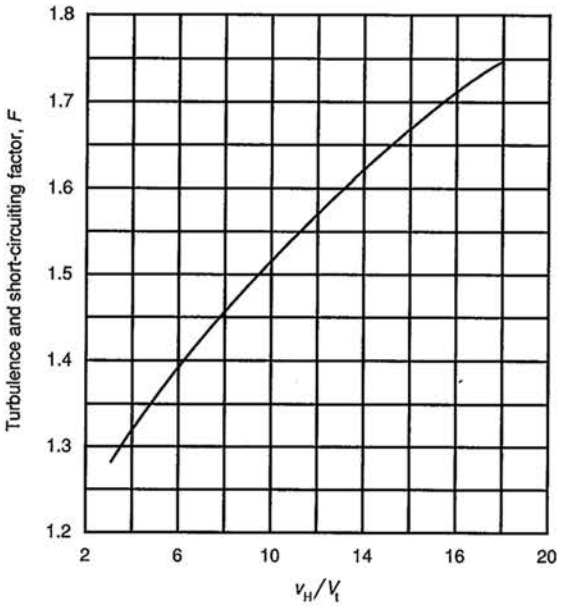
$$d = A_c / Bn$$

Channel width (B): 6-20 feet;

Separator Length:

$$L = F(v_H / V_t)d$$

Turbulence and Short-circuiting factor (F):

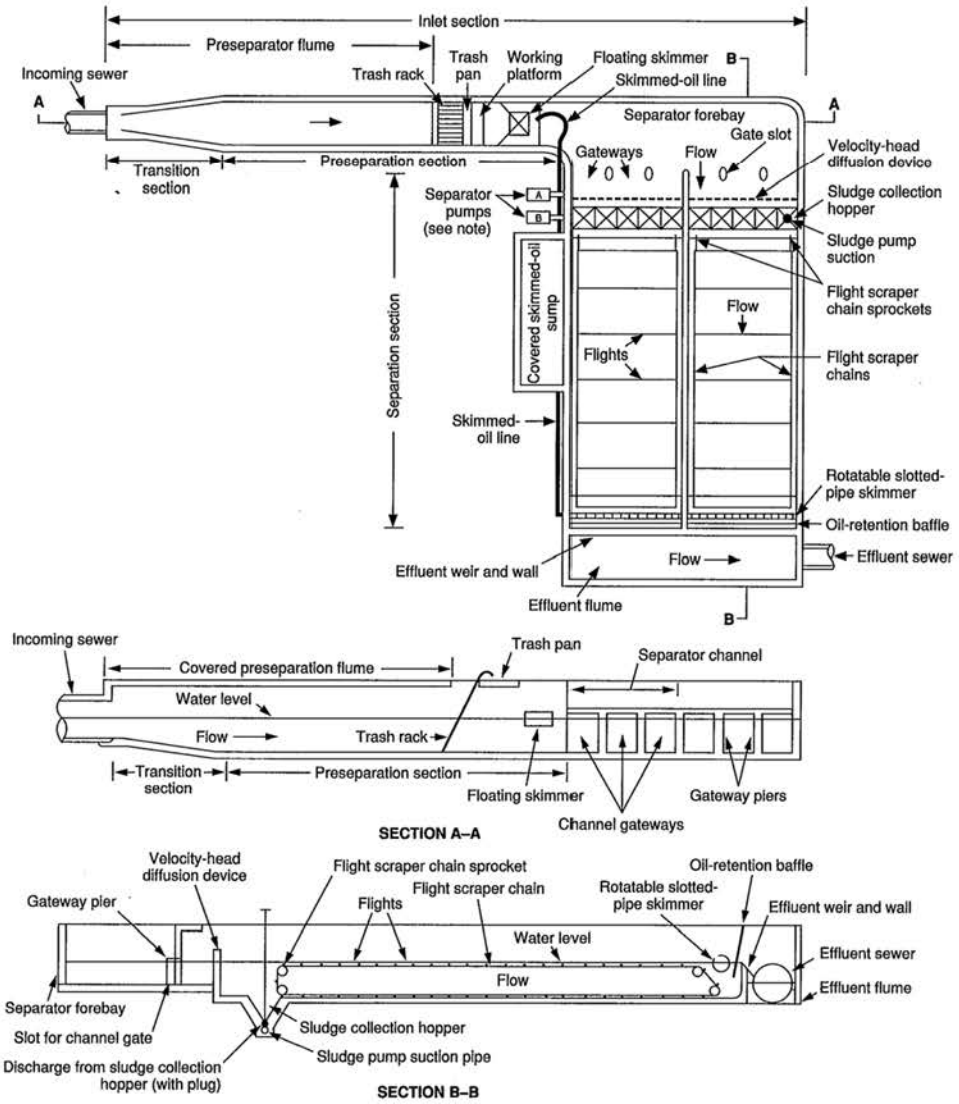



| $v_H/V_t$ | Turbulence Factor ($F_t$) | $F = 1.2(F_t)$ |
|---|---|---|
| 20 | 1.45 | 1.74 |
| 15 | 1.37 | 1.64 |
| 10 | 1.27 | 1.52 |
| 6 | 1.14 | 1.37 |
| 3 | 1.07 | 1.28 |

Minimum Horizontal Area:

$$A_H = F\left(\frac{Q_m}{V_t}\right)$$

## ■ Construction




Velocity Reduction (10-20 feet per minute, 1~2minute detention time);

Inlet sewer; Transition section: Flare and sloped; Trash rack, oil skimmer, oil-retention baffle;

Separator Fore-bay: Water jet, Reaction-jet diffusion device;

Separation channel: gateway, velocity-head diffusion device (Reaction jets, vertical-slot baffles), oil- and sludge-moving device, oil skimmers (Rotatable slotted-pipe skimmer, rotary-drum skimmer, floating skimmer), retention baffles, oil- and sludge-collection equipment; Effluent Weir;

## ■ Performance and Troubleshooting

100 PPM, 50-200 milligrams per liter;

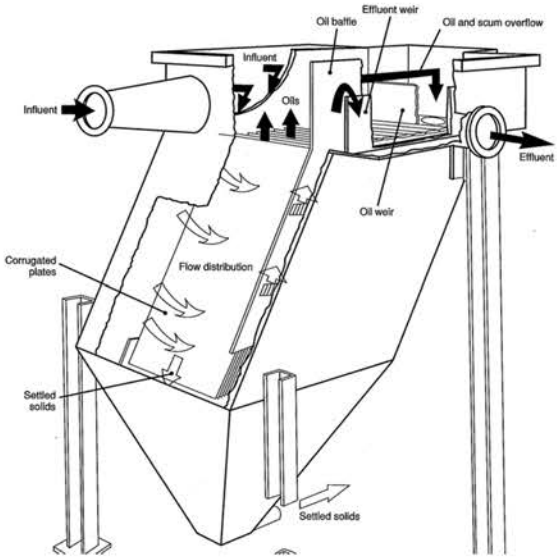
Design Review: Representative Data, Check the Separator Design step-by-step;

Emulsified or dissolved oil;

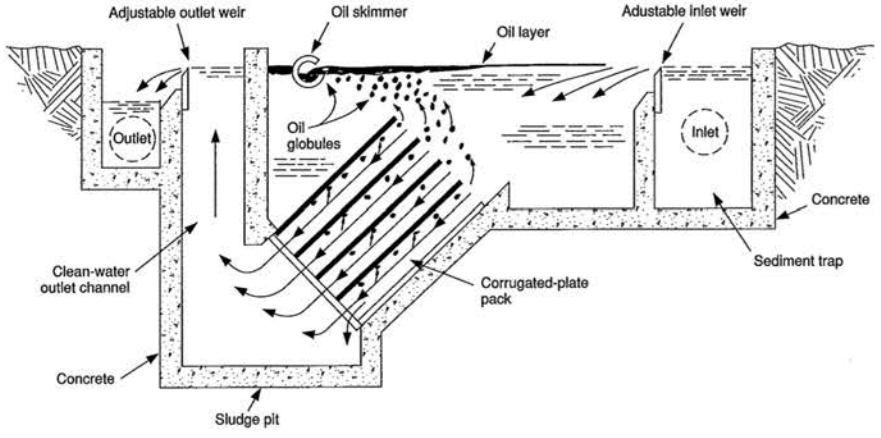
Dealing with Emulsified Oil: PH (6-7), Chemical emulsified oil (Bench-scale treatability test);

## ■ Parallel-plate Separators

Cross-flow inclined plate:




Down-flow inclined plate:




## ■ Operation and Maintenance

# 1.3 Heater

- Tube:

  Tube Wall Thickness

**Table 1 — Minimum allowable thickness of new tubes**

| Tube outside diameter | | Minimum thickness | | | |
|---|---|---|---|---|---|
| | | Ferritic steel tubes | | Austenitic steel tubes | |
| mm | (in) | mm | (in) | mm | (in) |
| 60,3 | (2,375) | 3,4 | (0,135) | 2,4 | (0,095) |
| 73,0 | (2,875) | 4,5 | (0,178) | 2,7 | (0,105) |
| 88,9 | (3,50) | 4,8 | (0,189) | 2,7 | (0,105) |
| 101,6 | (4,00) | 5,0 | (0,198) | 2,7 | (0,105) |
| 114,3 | (4,50) | 5,3 | (0,207) | 2,7 | (0,105) |
| 141,3 | (5,563) | 5,7 | (0,226) | 3,0 | (0,117) |
| 168,3 | (6,625) | 6,2 | (0,245) | 3,0 | (0,117) |
| 219,1 | (8,625) | 7,2 | (0,282) | 3,3 | (0,130) |
| 273,1 | (10,75) | 8,1 | (0,319) | 3,7 | (0,144) |

**Minimum Thickness VS Average Thickness;**

**Elastic design pressure:**

$$\delta_\sigma = \frac{p_{el} D_o}{2\sigma_{el} + p_{el}} \quad \text{or} \quad \delta_\sigma = \frac{p_{el} D_i^*}{2\sigma_{el} - p_{el}}$$

$$\delta_{min} = \delta_\sigma + \delta_{CA}$$

**Rupture design pressure:**

$$\delta_\sigma = \frac{p_r D_o}{2\sigma_r + p_r} \quad \text{or} \quad \delta_\sigma = \frac{p_r D_i^*}{2\sigma_r - p_r}$$

$$\delta_{min} = \delta_\sigma + f_{corr}\delta_{CA}$$

**Ferritic steel VS Austenitic steel**

| | Figure number | Alloy |
|---|---|---|
| Ferritic steels | E.1 (F.1) | Low-carbon steel (A 161, A 192) |
| | E.2 (F.2) | Medium-carbon steel (A 53B, A 106B, A 210A-1) |
| | E.3 (F.3) | C-½Mo |
| | E.4[a] (F.4) | 1¼Cr-½Mo |
| | E.5[a] (F.5) | 2¼Cr-1Mo |
| | E.6[a] (F.6) | 3Cr-1Mo |
| | E.7[a] (F.7) | 5Cr-½Mo |
| | E.8 (F.8) | 5Cr-½Mo-Si |
| | E.9[a] (F.9) | 7Cr-½Mo |
| | E.10[a] (F.10) | 9Cr-1Mo |
| | E.11 (F.11) | 9Cr-1Mo-V |
| Austenitic steels | E.12 (F.12) | 18Cr-8Ni (304 and 304H) |
| | E.13 (F.13) | 16Cr-12Ni-2Mo (316 and 316H) |
| | E.14 (F.14) | 16Cr-12Ni-2Mo (316L) |
| | E.15 (F.15) | 18Cr-10Ni-Ti (321) |
| | E.16 (F.16) | 18Cr-10Ni-Ti (321H) |
| | E.17 (F.17) | 18Cr-10Ni-Nb (347 and 347H) |
| | E.18 (F.18) | Ni-Fe-Cr (Alloy 800H/800HT) |
| | E.19 (F.19) | 25Cr-20Ni (HK40) |

[a] Broken lines on these figures indicate the elastic allowable stresses for the A 200 grades. These figures do not show the yield strengths of the A 200 grades. The yield strengths of the A 200 grades are 83 % of the yield strengths shown. The tensile strengths, rupture allowable stresses, rupture strengths, and rupture exponents for the A 213 and A 335 grades.

**Equivalent tube metal temperature;**

$$T_{eq} = T_{sor} + f_T\,(T_{eor} - T_{sor})$$

**Estimation of Remaining Tube Life:**

F.R. Larson and J. Miller proposed that creep rate could adequately be described by the Arrhenius type equation:

$$r = A \cdot e^{-\Delta H/(R \cdot T)}$$

Where r is the creep process rate, A is a constant, R is the universal gas constant, T is the absolute temperature, and $\Delta H$ is the activation energy for the creep process. Taking the natural log of both sides:

$$\ln(r) = \ln(A) - \Delta H/(R \cdot T)$$

With some rearrangement:

$$\Delta H/R = T \cdot (\ln(A) - \ln(r))$$

Using the fact that creep rate is inversely proportional to time, the equation can be written as:

$$\Delta l/\Delta t = A' \cdot e^{-\Delta H/(R \cdot T)}$$

Taking the natural log:

$$\ln(\Delta l/\Delta t) = \ln(A') - \Delta H/(R \cdot T)$$

After some rearrangement the relation finally becomes:

$$\Delta H/R = T \cdot (B + \ln(\Delta t)), \text{ where B} = \ln(A'/\Delta l)$$

This equation is of the same form as the Larson–Miller relation.

$$LMP = T \cdot (C + \log(t))$$

1. Larson-Miller parameter:

When $T_d$ is expressed in degrees Celsius:

$$(T_d + 273)\,(C_{LM} + \lg t_{DL}) \times 10^{-3}$$

When $T_d$ is expressed in degrees Fahrenheit:

$$(T_d + 460)\,(C_{LM} + \lg t_{DL}) \times 10^{-3}$$

## Larson–Miller relation

From Wikipedia, the free encyclopedia

The **Larson–Miller relation**, also widely known as the **Larson–Miller parameter** and often abbreviated **LMP**, is a parametric relation used to extrapolate experimental data on creep and rupture life of engineering materials.

### Background and usage [edit]

F.R. Larson and J. Miller proposed that creep rate could adequately be described by the Arrhenius type equation:

$$r = A \cdot e^{-\Delta H/(RT)}$$

Where r is the creep process rate, A is a constant, R is the universal gas constant, T is the absolute temperature, and $\Delta H$ is the activation energy for the creep process. Taking the natural log of both sides:

$$\ln(r) = \ln(A) - \Delta H/(R \cdot T)$$

With some rearrangement:

$$\Delta H/R = T \cdot (\ln(A) - \ln(r))$$

Using the fact that creep rate is inversely proportional to time, the equation can be written as:

$$\Delta l/\Delta t = A' \cdot e^{-\Delta H/(R \cdot T)}$$

Taking the natural log:

$$\ln(\Delta l/\Delta t) = \ln(A') - \Delta H/(R \cdot T)$$

After some rearrangement the relation finally becomes:

$$\Delta H/R = T \cdot (B + \ln(\Delta t)), \text{ where B} = \ln(A'/\Delta l)$$

This equation is of the same form as the Larson–Miller relation.

$$LMP = T \cdot (C + \log(t))$$

where the quantity LMP is known as the Larson–Miller parameter. Using the assumption that activation energy is independent of applied stress, the equation can be used to relate the difference in rupture life to differences in temperature for a given stress. The material constant C is typically found to be in the range of 20 to 22 for metals when time is expressed in hours and temperature in degrees Rankine.

The Larson–Miller model is used for experimental tests so that results at certain temperatures and stresses can predict rupture lives of time spans that would be impractical to reproduce in the laboratory.

Expanding the equation as a Taylor series makes the relationship easier to understand. Only the first terms are kept.

$$\Delta LMP = \frac{\partial LMP}{\partial T} \cdot \Delta T + \frac{\partial LMP}{\partial \log(t)} \cdot \Delta \log(t) + \cdots$$

$$\frac{\partial LMP}{\partial T} = 20 + \log(t) \qquad \frac{\partial LMP}{\partial \log(t)} = T$$

Changing the time, by a factor of 10, changes the logarithm by 1 and the LMP changes by an amount equal to the temperature.

$$\Delta LMP = \frac{\partial LMP}{\partial \log(t)} \cdot \Delta \log(t) = T \cdot \Delta \log(t) = T \cdot 1 = T$$

To get an equal change in LMP by changing the temperature, the temperature needs to be raised or lowered by about 5% of its absolute value.

$$\Delta LMP = T = \frac{\partial LMP}{\partial T} \cdot \Delta T \qquad \Delta T = \frac{\Delta LMP}{\frac{\partial LMP}{\partial T}} = \frac{T}{(20 + \log(t))} \approx \frac{T}{20} = 5\%T$$

Typically a 5% increase in absolute temperature will increase the rate of creep by a factor of ten.

2. :

**Instrumentation and Control of Heater:**

1. Fuel/air ratio (Fuel composition fluctuation, oxygen content, High/low limiting);
2. Minimum burner pressure (bypass regulator, Pilot),
3. Firebox Pressure Control (Induced-draft fan, Stack Dumper);

**Protective Instrumentation Alarms and Shutdown Devices:**

3. Pre-Ignition, pre-purge, purging cycle
    a. Confirm that the main fuel and pilot gas safety shutoff valves are closed;
    b. Confirm that no flame in present at the burner;
    c. Start the fan of other purge system;
    d. Satisfy the fan or purge interlocks;
    e. Satisfy appropriate fuel interlocks;
    f. Confirm purge by satisfying: Air pressure, flow interlock; purge airflow;
    g. Purge for a period of not less than five minutes or five heater volume changes;
    h. Atomizing medium;
    i. Set control to light-off positions;
    j. Confirm the dampers and fuel control valves are in light-off position.
4. Manual Trip: Final Shutdown (fuel and pilots);
5. Low fuel pressure (Burner failure)

    Alarm, Low-pressure shutdown sensor after Firing-rate control valve, SD (being equipped with pilots or not);
6. High fuel pressure (Overfiring and/or Flameout)

    Alarm, High-pressure shutdown sensor after Firing-rate control valve, SD;
7. Low pilot gas pressure

    Alarm, High-pressure shutdown sensor after Firing-rate control valve, SD pilot and trip the main fuel;
8. Low fuel oil temperature

Alarm;

9. Low/high stack temperature

   Alarm: Leaking heater tube, loss of air preheater drivers, Condensation of acid;

10. Loss of flame (flame failure)

    Alarm, SD; Flame detector/monitor: Built-in adjustable time delay;

11. High heated-fluid temperature

    Alarm: Locating the measurement point near the point of maximum temperature;

12. High tube-skin temperature (Overheating)
13. High/Low draft (Back firing) : Alarm
14. High/Low firebox pressure: Alarm
15. High Combustibles in the stack: fuel/air ratio (afterburn, emission of unburned fuel)
16. Low Charge flow (Overheating of tubes): alarm, SD
17. Loss of Motive power (Instrument air, electric power: energize-to -trip)
18. Low Atomizing-steam pressure (Loss of flame)
19. Low of Air preheater drive (Decreased fired heater efficiency, Mechanical damage of preheater)
20. Low of Forced-draft fan: low fan speed
21. Low of Combustion Air: Air door; Forced-draft fan, Induced-draft fan, Natural draft; Preheater;
22. Safety Shutoff Valves (Pilot gas, fuel gas, or fuel oil);

    Fail-safe; Re-opening after trip;

23. Soot Blowers;

- **Fired Heater**

  Corrosion allowance:

  - Carbon steel through C-1/2 Mo: 0.125 inches;
  - Low alloys through 9Cr-1 Mo: 0.080 inches;
  - Above 9Cr-1 Mo through austenitic steel: 0.040 inches.

- Header:

➢ **Indirect Heater**

- Material: Coils-seamless pipe, Flanges, Fittings (Couplings, return bends, ells, tees; Fitting for Chocks, valves, unions), Bolting and Nuts; Shells, Structure supports, Firetube, and Stacks;
- Design

1. Coil working Pressure:
2. Nominal wall thickness (T),
3. Minimum wall thickness ($t_m$=0.875T),
4. Required wall thickness (tr, Mechanical, corrosion, erosion);

C (Mechanical allowance + corrosion allowance + erosion allowance):

**Table 3—Thread Allowance for Pipe Wall Thickness Calculations**

| Nominal Pipe Size in. | Thread Depth in. [a] |
|---|---|
| 1/2 – 3/4 | 0.0571 |
| 1 – 2 | 0.0696 |
| 2 1/2 – 8 | 0.1000 |
| [a] From ASME B2.1-1968. | |

The required wall thickness ($t_r$) for maximum non-shock internal working pressure ($P$) shall be calculated by Equation (1).

$$t_r = \frac{PD}{2(S+PY)} + C \quad (1)$$

The maximum internal working pressure ($P$) may be calculated by Equation (2).

$$P = \frac{2S(t_m - C)}{D - 2Y(t_m - C)} \quad (2)$$

5. Temperature: Maximum 250F;
6. Maximum internal working pressure of Coils:

Table 2—Maximum Coil Working Pressure ($P$)

$C = 0$

$t_m = 0.875T$

| Nominal Pipe Size in. | $T$ Nominal Wall in. | $P$ Maximum Working Pressure psig Grade B $S$ = 20,000 | $P$ Maximum Working Pressure [a] psig Grade C $S$ = 23,300 |
|---|---|---|---|
| 1 XS | 0.179 | 5,270 | — |
| 2 Std | 0.154 | 2,380 | — |
| 2 XS | 0.218 | 3,440 | — |
| 2 XXS | 0.436 | 7,340 | 8,560 |
| 2 1/2 Std | 0.203 | 2,600 | — |
| 2 1/2 XS | 0.276 | 3,610 | — |
| 2 1/2 XXS | 0.552 | 7,770 | 9,050 |
| 2 1/2 | 0.750 | 10,720 | 12,490 |
| 2 1/2 | 0.875 | 12,530 | 14,600 |
| 3 Std | 0.216 | 2,260 | — |
| 3 XS | 0.300 | 3,200 | — |
| 3 XXS | 0.600 | 6,820 | 7,940 |
| 4 Std | 0.237 | 1,920 | — |
| 4 XS | 0.337 | 2,770 | — |
| 4 XXS | 0.674 | 5,860 | 6,830 |
| 6 Std | 0.280 | 1,530 | — |
| 6 XS | 0.432 | 2,400 | — |
| 6 XXS | 0.864 | 5,030 | 5,860 |
| 8 Std | 0.322 | 1,350 | — |
| 8 XS | 0.500 | 2,120 | — |
| 8 XXS | 0.875 | 3,830 | 4,460 |

[a] Maximum working pressure ($P$) has been rounded up to the next higher unit of 10 psig.

7. Shell: Atmospheric pressure, cylindrical or rectangular;

   American Institute of Steel Construction Manual:

   1) Allowable shear stress is 40% of the specified minimum yield;

   2) Allowable tensile and compression stresses are 60% of the specified minimum yield;

   3) Allowable bending stresses are 66% of the specified minimum yield strength. Specified

8. Shell Support: Saddles or Steel Skid;

   Structure Integrity: Loads by testing, lifting, transportation, wind, earthquake, and normal operation;

   1) Saddles

      Saddles for cylindrical shells should be designed in such a manner that excessive stresses are not induced in the shell. The saddles or legs shall be adequate to support the heater assembly under normal operating conditions. No more than two saddles should be used on a cylindrical shell.

   2) Rectangular Heaters

      Rectangular heaters should be supported by a structural steel skid. The skid should be designed to support 150% of the dry weight of the entire heater assembly with the skid supported at

its ends. It should also support the heater assembly under normal operating conditions. Deflection should be limited to L/400, where L is the length of the skid. The same considerations apply to skid mounted cylindrical heaters.

3) Rectangular Shells

Rectangular shells should be supported by a rigid frame that will limit deflection in the top, bottom and sides to L/500 with 1 1/2 psi internal pressure or full of water, whichever is greater. The dimension L is the length of the longest side or the distance between rigid structural frame members, whichever is less. Cylindrical shells should be designed for 1 1/2 psi of internal pressure or full of water, whichever is greater.

4) Flat End Deflection

The deflection of flat end closures should be limited to the diameter divided by 500 with 11/2 psi internal pressure or full of water, whichever is greater.

5) Lifting Lugs

Heaters that are furnished with insulation shall also be furnished with two lift lugs unless lifting lugs are furnished on skid-mounted units. Each lug should be designed for 75% of the empty weight of the entire assembly. A maximum lift angle of 30° with the vertical shall be assumed. The effect of the lugs on the shell should be investigated and reinforcement should be provided if required. The lugs should be designed for double shear tear-out and tension on the net section at the pin hole. The lifting lugs on skid-mounted heaters, if furnished, should be designed as above, except that each lug should be designed for 50% of the empty weight of the entire assembly. Many manufacturers attach lift lugs to various components on the heater assembly that are intended for lifting that component only; however, they may not be suitable for lifting the total assembly.

6) Wind Forces

Wind forces on the stack can cause a moment on the cover plate which should be investigated.

7) Evaluations

Piping and coil loads may need to be evaluated. The firetube becomes buoyant when immersed in the heater bath and must be restrained from floating.

9. Firebox Rating for Heaters;

**Table 4—Standard Firebox Rating Based on Heat Input to the Water Bath**

| BTU/hr | BTU/hr |
|---|---|
| 100,000 | 2,000,000 |
| 250,000 | 2,500,000 |
| 500,000 | 3,000,000 |
| 750,000 | 3,500,000 |
| 1,000,000 | 4,000,000 |
| 1,500,000 | 5,000,000 |

10. Heat Flux:

8 5/8-in. OD firetube having 44.3 $ft^2$ of firetube surface and rated @ 500,000 BTU/hr.

$$\text{Average Heat Flux} = \frac{\text{Firetube Rating (BTU/hr)}}{\text{ft}^2 \text{ of Firetube Surface}} = \frac{500{,}000}{44.3} = 11{,}287 \text{ BTU/hr/ft}^2$$

11. Heat Density:

8 5/8-in. OD, 0.188-in. wall, firetube rated for 500,000 BTU/hr

Cross Sectional Area = 53.42 $in.^2$

Assume 70% Efficiency

$$\text{Heat Density} = \frac{\text{Firetube Rating (BTU/hr)}}{(\text{Cross Sectional Area, in.}^2)\ (\text{Efficiency})} = \frac{500{,}000}{53.42 \times 0.70} = 13{,}371 \text{ BTU/hr/in.}^2$$

12. Stack Height: Draft sufficient to overcome the pressure drop in firetube, stack, any stack or flame arrest;

13. Gas Flow Rates:

Table B.1—Gas Flow Rate

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Operating Pressure of Coil psig | | | | | | | | | |
| | 6,000 | 5,000 | 4,000 | 3500 | 3,000 | 2,000 | 1500 | 1,000 | 750 | 500 |
| Nominal Pipe Size in. | Gas Throughput to Provide 80 ft/s Coil Velocity @ 120°F MMSCFD | | | | | | | | | |
| 1 XS | — | 12 | 11 | 9 | 8 | 6 | 4 | 2 | 1.5 | 1 |
| 2 Std | — | — | — | — | — | 25 | 18 | 11 | 8 | 5.7 |
| 2 XS | — | — | — | — | 33 | 22 | 16 | 10 | 7 | 5 |
| 2 XXS | 30 | 28 | 25 | 23 | 20 | 13 | 10 | 6.5 | 4 | 2 |
| 2 1/2 Std | — | — | — | — | — | 36 | 26 | 17 | 12 | 8 |
| 2 1/2 XS | — | — | — | 53 | 47 | 32 | 23 | 15 | 11 | 7 |
| 2 1/2 XXS | 41 | 38 | 34 | 31 | 28 | 19 | 13 | 9 | 6 | 4 |
| 3 Std | — | — | — | — | — | 53 | 40 | 25 | 18 | 11 |
| 3 XS | — | — | — | — | 74 | 47 | 36 | 22 | 16 | 10 |
| 3 XXS | 70 | 65 | 58 | 54 | 46 | 31 | 23 | 14 | 10 | 7 |
| 4 Std | — | — | — | — | — | 95 | 70 | 43 | 30 | 20 |
| 4 XS | — | — | — | — | 130 | 85 | 60 | 38 | 27 | 18 |
| 4 XXS | — | 123 | 110 | 101 | 90 | 61 | 44 | 28 | 20 | 13 |
| 6 Std | — | — | — | — | — | — | 158 | 100 | 73 | 47 |
| 6 XS | — | — | — | — | — | 197 | 143 | 90 | 66 | 42 |
| 6 XXS | — | 291 | 257 | 236 | 210 | 142 | 103 | 65 | 47 | 31 |
| 8 Std | — | — | — | — | — | — | 274 | 173 | 126 | 82 |
| 8 XS | — | — | — | — | — | 345 | 250 | 158 | 115 | 74 |
| 8 XXS | — | — | — | 466 | 415 | 281 | 203 | 128 | 93 | 60 |

The velocity of a single phase gas stream may be determined by the following equation:

$$V_g = \frac{60\, Q_g TZ}{d_i^2 P}$$

where

$V_g$ is the gas velocity, ft/s;

$Q_g$ is the gas flow rate, MMSCFD (14.7 psia and 60°F);

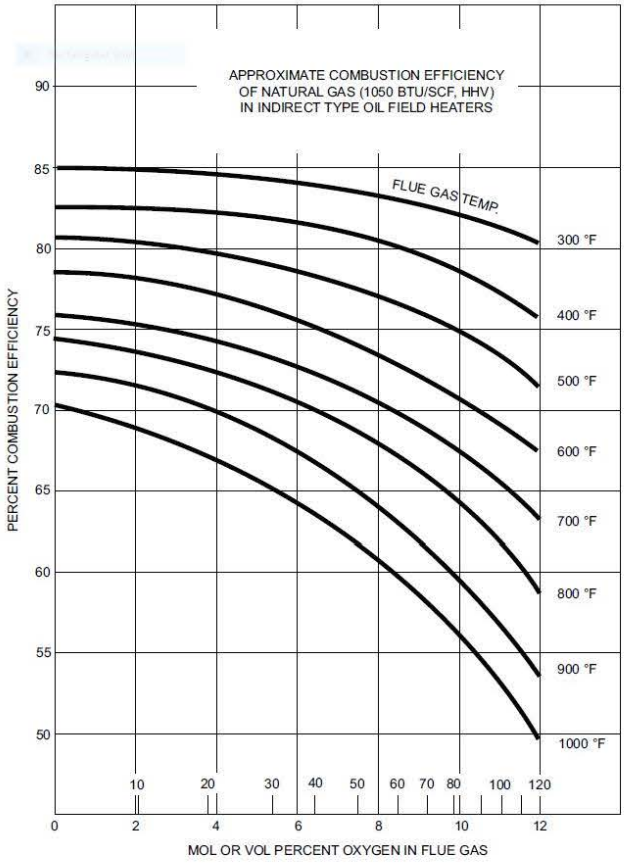
$T$ is the operating temperature, °R;

$Z$ is the gas compressibility;

$d_i$ is the pipe inside diameter, in.;

$P$ is the operating pressure, psia.

## 14. Combustion Efficiency:




15. Minimum Stack-gas Temperature: 250F

16. **Heat Transfer:**

$$T_m = \frac{\text{GTD} - \text{LTD}}{\ln(\text{GTD}/\text{LTD})}$$

where

$T_m$ is the log mean temperature difference, °F;

GTD is the greater temperature difference = (water bath temperature) – (inlet fluid temperature);

LTD is the least temperature difference = (water bath temperature) – (outlet fluid temperature);

ln is the natural logarithm.

For high pressure gas streams, the heat required may be determined from the following equation:

$Q = 109.8(G)\,(h_2 - h_1)$ or $Q = M(c)\,(T_2 - T_1)$

where

$Q$ is the heat required (total heat transfer), BTU/hr;

$G$ is the gas flow rate, MMSCFD;

$h_2 - h_1$ is the enthalpy difference at initial temperature and final temperature, BTU/lb-mol;

$M$ is the gas mass flow rate, lb/hr;

$c$ is the specific heat at average or mean temperature, BTU/lb-°F;

$T_2 - T_1$ is the temperature difference of inlet and outlet flowing temperature °F.

The basic heat transfer equation that may be used in indirect heater sizing is as follows:

$$Q = U_o(A)(T_m) \text{ or } A = \frac{Q}{U_o(T_m)}$$

where

$Q$ is the total heat transfer (heat required), BTU/hr;

$U_o$ is the overall heat transfer coefficient, BTU/hr-ft$^2$-°F;

$A$ is the total heat transfer area (coil area), ft$^2$;

$T_m$ is the log mean temperature difference, °F.

# 1.4 Emulsion Treater

- **Structural Integrity:**

  Saddles, Wind Force, Buoyancy;

- **Combustion Efficiency:**

  Burner performance: fuel gas pressure, primary and secondary air, gas orifice size.

- **Retention time:** Residence time in the **oil settling zone** is typically in the range of 30 to 100 minutes. The corresponding residence time in the **water settling zone** is typically in the range of 15 to 30 minutes.

**Table E.1—Retention Volumes of Oil and Water for Conventional Treaters**

| Treater Size | Vertical Treaters | | Horizontal Treaters | |
|---|---|---|---|---|
| | Oil bbl | Water bbl | Oil bbl | Water bbl |
| 3' × 10'-0" | 5.9 | 4.0 | 6.6 | 4.4 |
| 12'-0" | 7.0 | 4.7 | 7.8 | 5.2 |
| 15'-0" | 8.6 | 5.8 | 9.6 | 6.4 |
| 4' × 10'-0" | 10.7 | 7.2 | 11.9 | 7.9 |
| 12'-0" | 12.6 | 8.6 | 14.1 | 9.5 |
| 15'-0" | | | 17.3 | 11.5 |
| 20'-0" | 19.4 | 10.4 | | |
| 2'-6" | 30.3 | 17.1 | | |
| 6' ×12'-0" | 30.4 | 20.5 | 33.2 | 22.6 |
| 15'-0" | | | 39.3 | 26.4 |
| 20'-0" | 44.2 | 27.5 | 51.0 | 34.8 |
| 27'-6" | 68.6 | 42.6 | | |
| 8' × 15'-0" | | | 69.4 | 46.5 |
| 20'-0" | 78.3 | 48.0 | 88.4 | 59.2 |
| 25'-0" | | | 108.7 | 73.0 |
| 27'-0" | 121.4 | 74.9 | | |
| 30'-0" | | | 128.9 | 85.9 |
| 10' × 20'-0" | 122.4 | 82.5 | 144.7 | 96.9 |
| 27'-6" | 189.6 | 124.5 | | |
| 30'-0" | | | 217.8 | 142.6 |
| 40'-0" | | | 284.7 | 183.9 |
| 50'-0" | | | 351.8 | 227.2 |
| 60'-0" | | | 419.0 | 270.6 |
| 12' × 30'-0" | | | 324.7 | 217.6 |
| 40'-0" | | | 422.6 | 284.6 |
| 50'-0" | | | 521.3 | 351.1 |
| 60'-0" | | | 619.9 | 417.5 |

- **Heat Duty:**

$$Q = (W_O)\,(C_O)\,(T_2 - T_1) + (W_W)\,(C_W)\,(T_2 - T_1)$$

where

$Q$ is the heat required, BTU/hr;

$W_O$ is the flow rate of the oil, lb/hr;

$W_W$ is the flow rate of the water, lb/hr;

$C_O$ is the specific heat of the oil, BTU/(lb-F);

$C_W$ is the specific heat of the water, BTU/(lb-F);

$T_1$ is the initial temperature, °F;

$T_2$ is the final temperature, °F.

- **Heat Loss:**

$$Q_1 = K\,(D)\,(L)\,(T_2 - T_\alpha)$$

where

$Q_1$ is the heat loss, BTU/hr;

$K$ is constant;

is 15.7 for 20 mph wind;

is 13.2 for 10 mph wind;

is 9.8 for 5 mph wind;

is 9.3 for still air;

$D$ is the diameter of treater, ft;

$L$ is the height or length of shell, ft;

$T_2$ is the treating temperature, °F;

$T_\alpha$ is the design minimum outside ambient temperature, °F.

- For efficient emulsion breaking it is generally recommended that the oil viscosity within the coalescing section of the treater not exceed **150 Saybolt universal seconds** (SSU);
- Emulsion heating may also be required to eliminate wax or bitumen as particulate matter that would tend to accumulate at the interface. The required treating temperatures are typically in the range of **100°F to 250°F** depending on the above described factors;
- Maximum firetube heat flux of 10,000 BTU/HR/ft2 is allowed for design;
- Coalescing zone;

- Where excelsior (or hay) beds are used for coalescing, maximum design oil emulsion velocities are generally in the range of 7 BPD/ft2 to 40 BPD/ft2 for vertical treaters and 17 BPD/ft2 to 120 BPD/ft2 for horizontal treaters.
- Type, Size, Pressure and Temperature Ratings

**Table 1—Typical Vertical Treater Dimensions and Pressures**

| Outside Diameter ft | Shell Length Head Seam to Head Seam ft, ± 6 in. | Minimum Design Pressure psig |
|---|---|---|
| 3 | 10, 12 or 15 | 50 |
| 4 | 10, 12, 20 or 27 1/2 | 50 |
| 6 | 12, 20 or 27 1/2 | 50 |
| 8 | 20 or 27 1/2 | 40 |
| 10 | 20 or 27 1/2 | 40 |

**Table 2—Typical Horizontal Treater Dimensions and Pressures**

| Outside Diameter ft | Shell Length Head Seam to Head Seam ft, ± 6 in. | Minimum Design Pressure psig |
|---|---|---|
| 3 | 10, 12 or 15 | 50 |
| 4 | 10, 12 or 15 | 50 |
| 6 | 10, 15 or 20 | 50 |
| 8 | 15, 20, 25 or 30 | 50 |
| 10 | 20, 30, 40, 50 or 60 | 50 |
| 12 | 30, 40, 50 or 60 | 50 |

**Table 3—Typical Firebox Ratings**

| Outside Diameter ft | Vertical | | Horizontal | |
|---|---|---|---|---|
| | Minimum Area $ft^2$ | Heat Duty BTU/hr | Minimum Area $ft^2$ | Heat Duty BTU/hr |
| 3 | 10 | 100,000 | 15 | 150,000 |
| 4 | 25 | 250,000 | 25 | 250,000 |
| 6 | 50 | 500,000 | 50 | 500,000 |
| 8 | 100 | 1,000,000 | 75 | 750,000 |
| 10 | 125 | 1,250,000 | 200 | 2,000,000 |
| 12 | — | — | 320 | 3,200,000 |

- **Firetube Heat Flux**: The average heat flux shall be no higher than 10,000 BTU HR/ft2 of exposed area.
- Heat released through the cross-sectional area of the firetube is regulated by the burner mixer and burner nozzle.
- **Firetube Heat Density**: Treaters will have a maximum heat density of 15,000 BTU/HR/in.2 for natural draft burners.
- **Estimated fuel gas consumption:**

  Q = (Heat Duty+ Heat Loss) / (Combustion Efficiency * HV)

- **Corrosion of a treater and accessories:**

Fluid: oxygen—O2; carbon dioxide—CO2; hydrogen sulfide—H2S.

**a) Oxygen:**

1. less than 0.005 ppm in natural brine—non-corrosive;
2. from 0.005 ppm to 0.025 ppm requires consideration;
3. greater than 0.025 ppm in natural brine—corrosive.

**b) Carbon dioxide:**

4. less than 600 ppm in natural brine—non-corrosive;
5. from 600 ppm to 1200 ppm requires consideration;
6. greater than 1200 ppm in natural brine—corrosive.

**c) Hydrogen sulfide.**

7. Hydrogen sulfide content for selection of materials resistant to sulfide stress cracking (SSC).

**d) Measures:**

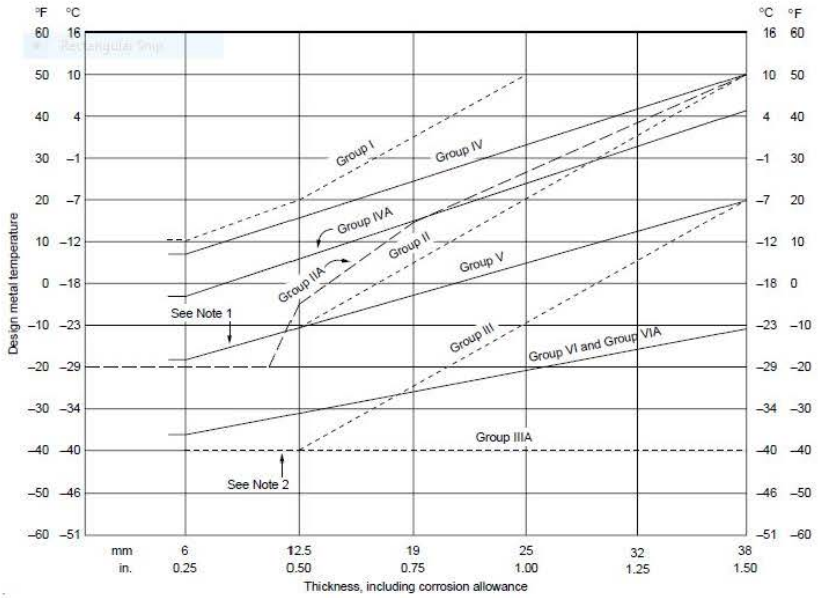
8. An allowance for corrosion to the parts may be made according to ASME Section VIII, Division 1.
9. Corrosion effects may be disregarded. However, the system should be monitored periodically for possible new corrosion.
10. Corrosion effects may be reasonably controlled with holiday-free internal coatings on all exposed metal surfaces.
11. Some materials, such as copper bearing alloys, should be avoided where hydrogen sulfide is present in the process streams.
12. Cathodic protection should be considered in the water area of the treating vessels. This protection may be in the form of sacrificial anodes placed in the vessel or through the vessel wall, and may be either of the galvanic or impressed current type.

    - If a sulfur-free gas issued with uninsulated stacks, a minimum exit flue gas temperature of 250°F should be maintained to avoid internal stack corrosion.
    - If sulfur is present in the fuel gas, the minimum exit flue gas temperature should be maintained in the range of 300°F to 400°F for sulfur contents ranging from approximately 0.05% to 1.0% by volume in the fuel gas.
    - This 300°F to 400°F temperature range can be reduced by roughly 50°F for insulated stacks.

# 1.5 Pump

# 1.6 Storage Tank

1.6.1 Material:




- Material Selection
  - **Group-Ⅰ through Group-ⅢA**
  - Group-IVthrough Group-VI
    - Lower Stress of Group-Ⅰthrough Group-ⅢA: Material properties and process method; Allowable stress level; Notch toughness; Welding procedure and consumable; Thermal stress relief; Temporary and permanent attachment details and procedure; Nondestructive examination;
- Plates: Strength, Toughness;
  - Open-hearth, electric-furnace, basic oxygen process, Thermo-mechanical control process;
  - A36;

- Heat treatment
  - Killed plates, Grain refinement, Mill test; Control-roll plate; Tensile test;
- Impact testing
  - Charpy V-notch impact energy testing, ASTM A 370;
- Toughness

➢ Sheets: A570, grade C or D; Open-hearth, basic oxygen process;

➢ Structural Shapes: ASTM A 36M/A 36

Open-hearth; electric-furnace; basic oxygen process;

➢ Piping and pipe couplings, Forgings: ASTM A 53, 4-106, API Spec 5L;

➢ Shell nozzle and shell manhole neck: seamless;

➢ Flanges: ASME B16.5, Forged carbon steel flanges; Nozzle; More than NPS24;

➢ Bolting: ASTM A 307, A 193M/A

➢ Arc-Welding Electrodes: E60, E70; Current

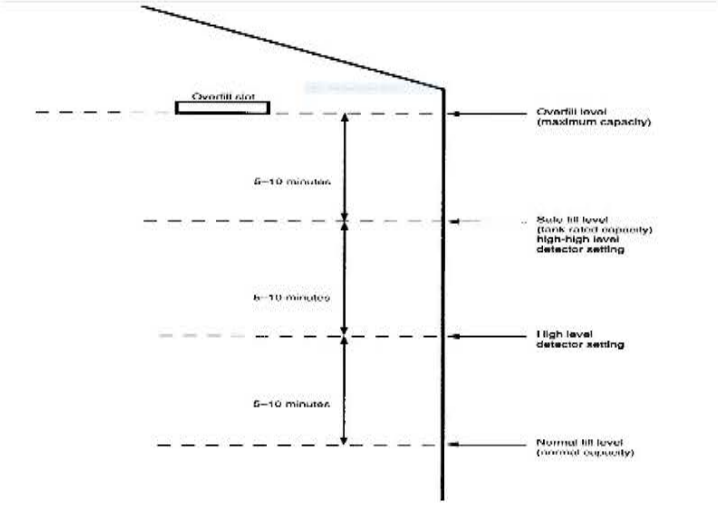
1.6.2 Design

➢ Joints

- Vertical shell joints, Horizontal shell joints, Lap-welded bottom joints, Butt-welded bottom joints, Bottom Annual-plate joints, Shell to bottom fillet welds, Wind girder joints, Roof and top-angle joints;

➢ Tank Capacity:

- **Overfill protection level:**




➢ Foundation

Safety factor of Foundation of Allowable soil bearing pressure:

- **2-3 for normal operating condition;**
- **1.5-2.25 for hydrostatic testing;**
- **1.5-2.25 for operating plus Max effect of wind or seismic load;**

- Tank Grade

  0.3m above surrounding; Fine and uniform material for Grade; Clean washed sand 75-100mm; Grade slope: one inch in ten feet;

- Typical Foundation Type:

  Small Tank Foundation: compacted crushed stone, screenings, fine gravel, clean sand, or similar material placed directly on virgin soil;

  - Concrete Ringwall; 300mm* 0.6m*20MPa;
  - Crushed Stone Ringwall;

- Tank supported by Grillage:

  - Spacing between grillage members: b
  - Thickness of the bottom plate supported on grillage: tg

- Leak detection and subgrade protection Under Tank

  **Release Prevention Barrier**: steel bottom, synthetic material, clay liner;

  **Flexible-membrane:** thickness 800μm-1000μm;

  **Drain pipe**: diameter – NPS 1, Wall thickness - Schedule 40;

- Weld hardness:

  - **Hardness test, Heat-affected zone;**
  - **Hardness test for each vertical weld, one test for each 30m of circumferential weld;**

- Bottom: 6mm+CA
- Annular bottom plate

Table 3-1—Annular Bottom-Plate Thicknesses

| SI Units | | | | |
|---|---|---|---|---|
| Nominal Plate Thickness[a] of First Shell Course (mm) | Hydrostatic Test Stress[b] in First Shell Course (MPa) | | | |
| | ≤ 190 | ≤ 210 | ≤ 230 | ≤ 250 |
| $t \le 19$ | 6 | 6 | 7 | 9 |
| $19 < t \le 25$ | 6 | 7 | 10 | 11 |
| $25 < t \le 32$ | 6 | 9 | 12 | 14 |
| $32 < t \le 38$ | 8 | 11 | 14 | 17 |
| $38 < t \le 45$ | 9 | 13 | 16 | 19 |

- **Shell design**
  - Thickness:

| Nominal Tank Diameter (See Note 1) | | Nominal Plate Thickness (See Note 2) | |
|---|---|---|---|
| (m) | (ft) | (mm) | (in.) |
| < 15 | < 50 | 5 | $^3/_{16}$ |
| 15 to < 36 | 50 to < 120 | 6 | $^1/_4$ |
| 36 to 60 | 120 to 200 | 8 | $^5/_{16}$ |
| > 60 | > 200 | 10 | $^3/_8$ |

  - Allowable Stress: $S_d$, $S_t$
  - Calculation of Thickness
    1- **Foot method;**
    2- **Variable-design-point method; First course, second course;**
    3- **Elastic Analysis;**

- Shell Openings
  - Opening near bottom of tank

    **Allowable external loads on tanks shell openings: <u>Limit Loads & Allowable Stresses:</u>**

    1. FR = radial thrust applied at the mid-surface of the tank shell at the opening connection;
    2. MC = circumferential moment applied to the mid-surface of the tank shell;
    3. ML = longitudinal moment applied to the mid-surface of the tank shell.

**Dimension, Thickness & Weld of Nozzles, Manholes, Flush-type Cleanout opening Fittings;**

- Manhole Size: 500,600,750,900 mm;
- Thickness of Cover Plate, Bolting Flange, Neck;
- Reinforcement and welding

  Spacing of welds around Connection, Thermal stress relief;

- Shell attachments and tank appurtenances

  Roof Manhole, Roof Nozzles, Rectangular roof openings, water draw-off sumps, scaffold-cable support, Platforms, walkways, and stairways;

- Wind girders – Stiffening Rings

  Top Wind girder - Section Modulus= (D*D*H)/17;

  Intermediate Wind girder – Max Height of Unstiffened shell;

- Roofs

  Allowable Stresses: Thickness, Slenderness ratios;

  Supported Cone roofs;

  Self-Supported Cone Roofs;

  Self-Supporting Dome and Umbrella roofs: Radius, Thickness;

- Overturning stability:
  - Wind load=(V/160)2;
  - Overturning moment from wind pressure or Seismic;
- Corrosion Control
  - Coating; Lining; Cathodic Protection; Chemical Control;
  - Corrosion Allowance

    **Minimum corrosion allowance: 1/16 inch**;
- Vent
  - Normal Venting;
  - Emergency Venting;
- Lightning protection

1.6.3 Construction

- Detail of welding: Bottoms, shells, Shell-to-bottom weld; Roofs;
- Inspection of welds: Butt-weld, Fillet weld;
- Radiographic, Ultrasonic, MPI, Visual Examination, and Vacuum testing;
- **Examination and testing of Tank bottom;**
- **Inspection of Reinforcement-plate welds;**
- **Testing of Shell;**
- **Testing of Roof;**

1.6.4 Operation

- Safe Operation Procedure of Filling;

1.6.5 Maintenance and Examination, Inspection

- Overfill protection system: Level, detector alarm/signal, float, displacers, automatic SD, electronic supervision etc.
    - Level detector:
        - Float or displacer, Weight; Ultra-sonic; OPTO-electronic;
        - Selection of detector;
    - Control panel;
    - Audible and Alarm signal;
    - Power-Operated Valves
- Thickness Measure: location, number

1.6.6 Repair and Alteration

## 1.7 Pipeline

- Specification of Flow line, Trunk line and Shipping line;
- Flow rate, Pressure and Temp.
- Corrosion rate and Tolerable;
- Pigging schedule, based on Pressure; Internal and external Corrosion Protection;

# 1.8 Measurement, Instrumentation and Control

1.8.1 Process Control

**Differential equation base:** Material balance, Energy balance, Transfer rates, Stage efficiencies, Phase equilibrium relation, and Parameter of sensing device;

1.8.2 Control Logic

- Feedback control:

  Proportional, Integral, Derivative;

  Temp. Pressure, Level, Flow rate, Flow ratio, Composition;

- **Heater Exchange**

- **Liquid pumps:**

  Centrifugal: Flow Characteristics, Throttling of discharge, Variable speed, Suction throttling;

  Rotary positive displacement: Bypass control, Speed control;

  Reciprocating: Adjustment of length or frequency of the stroke (Solenoid or Pneumatic);

- **Compressors:**

  Centrifugal and Axial: Throttling of suction, Speed control, Characteristics (Surging and bypass);

  Rotary continues positive displacement: Bypass, Speed control (Not Variable speed gear, or belt drivers, but Magnetic clutches and hydraulic couplings);

  Reciprocating positive displacement;

- Feedforward control;

1.8.3 Measure Devices

- Flow

  1. Differential-head meters;

     **Orifice Plate**

  2. Variable-area meters;

  3. Magnetic meters;

  4. Turbine meters;

  5. Positive-displacement meter;

6. Vortex meters

7. Mass flowmeters;

# 2. Produced Fluid;

2.1 Physical Properties

- Combination of Produced Fluid: Oil, Gas and Produced water;
- Specific Pressure and Specific Temperature
- Viscosity, Specific Heat, Z of Gas, GOR, Water Cut, Paraffin, etc.

2.2 Current Field Production VS Capacity of CPF facilities;

- Oil and Water inlet: BBL and WC;
- Gas: MMSCF

# 3. Operation Range and Monitoring

- De-emulsion VS Heat and Chemical;
- Separation effective: Gas inlet and Liquid retention time;
- De-hydra. VS Heat and Chemical or Heat and Elec. (Optional);
- OIW of Disposal Water after Skim and API for Environment Protection;
- Analysis of Pump effect with VSD;

# 4. Process Safety Management

4.1 Design Integrity

- Facilities Parameter, and Requirement for Operation by Operator;
- Safety devices for Flow, Pressure and Temperature control at each Equipment;
- Verification the Discharge Area of PRV or Vent, VS Fluid (gas, vapor, steam, liquid) and Undesirable Events for facility and Tanks;
- 
- Fire prevention and protection: Material, Detect and Verification of Firefighting Capacities;

4.2 Technical Integrity

- PM and CM of SCE;
- Fitness for Service of Tanks, and other Equipment, according to the R.P. 579, provided by API;
- SD schedule for Facilities Inspection and Maintenance;

4.3 Operation Integrity

- Operation procedure, include Normal operation, Startup, SD, and Re-startup after BD or Emergency;
- Verification of Bypass, and Approval of MOC;
- Alarm Management VS Cause-effect;
- Competence Matrix and Schedule for Operator training;
- Emergency Exercise and Drill;