ENGINEERING PRACTICE

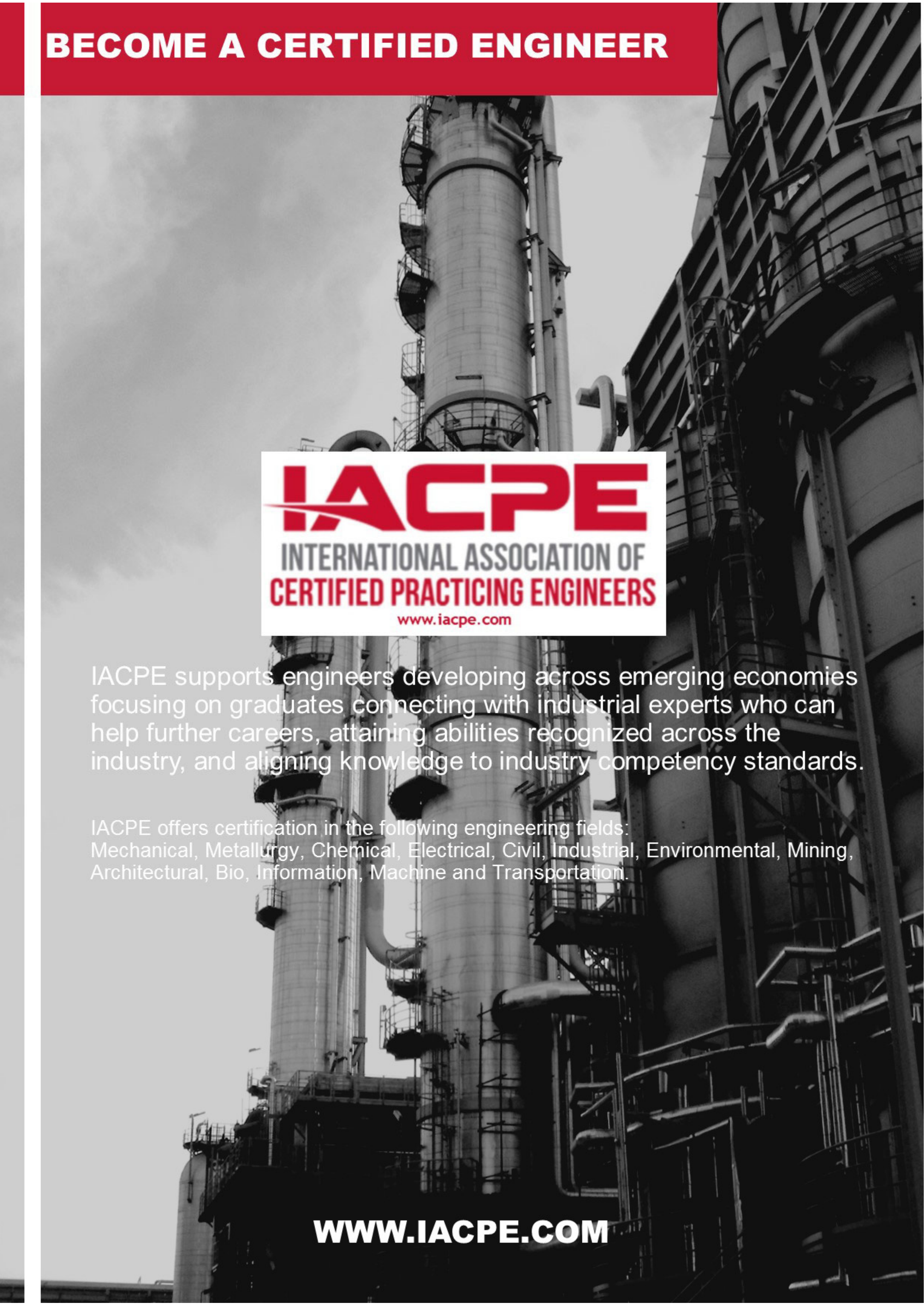
VOLUME 6 NUMBER 21

APRIL 2020

SPECIAL FEATURES

IACPE
INTERNATIONAL ASSOCIATION OF CERTIFIED PRACTICING ENGINEERS

Z Z Z IIDFSHFR P #


BECOME A CERTIFIED ENGINEER
IACPE
INTERNATIONAL ASSOCIATION OF CERTIFIED PRACTICING ENGINEERS
www.iacpe.com
IACPE supports engineers developing across emerging economies focusing on graduates connecting with industrial experts who can help further careers, attaining abilities recognized across the industry, and aligning knowledge to industry competency standards.
IACPE offers certification in the following engineering fields: Mechanical, Metallurgy, Chemical, Electrical, Civil, Industrial, Environmental, Mining, Architectural, Bio, Information, Machine and Transportation.
WWW.IACPE.COM

How to... BUBBLE CAP TRAY

How to design and optimize Bubble Cap Trays | Part 2

Dr.-Ing. Volker Engel

Tower trays and internals are the heart of all distillation columns. Their design is an essential part of a process engineer's task and determines the process reliability and economy.
This article is the 2nd part of a series on different kinds of trays and internals.

Bubble Cap trays have been used for about 80 years in technical applications and are a very well studied tray type. Nowadays, they are mainly used for handling low liquid loads, as for this field of application there are only few alterna- tives!
On a distillation tray vapor enters liquid and forms a two phase regime (bubbling, froth, spray). The tray types differ mainly in the way the vapor enters the liquid. For Bubble Cap Trays the gas flow path is very different compared to other tray types and is depicted in Fig. 1.
Before entering the liquid, the gas ascends in the riser (a), is redirected in the top of the cap (b) (reversal area) and then flows downwards in the cylindrical annular gap (c). Finally, the vapor enters the liquid layer through vertical slots, holes or the skirt of the cap (d).

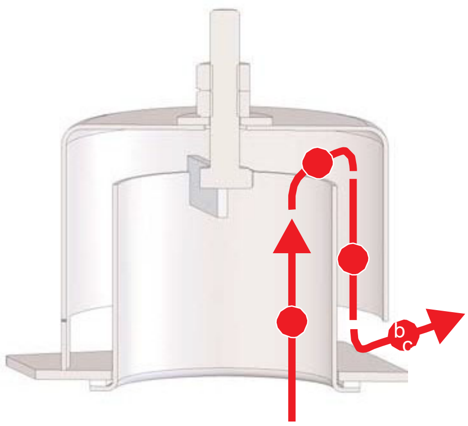


Fig. 1: Gas Flow Path

As long as the riser is higher than the outlet weir and the panels and risers are liquid-tight, the tray is able to handle very small amounts of liquid. This is the main advantage of this tray type and a typical field of application.

The main disadvantages are the relatively high costs for the equipment and a higher pressure drop compared to other tray types.

There are many different types and sizes of bubble caps. Historically, there are cast iron types (still in use!), oval, rectangular and round bubble caps.

Today, new bubble cap trays are usually equipped with bubble caps with an outer cap diameter of 2 inch, 3 inch, 4 inch or 6 inch. As the caps are fabricated by deep drawing, the material thickness is about 1mm. For special materials types or thick materials, the caps are rolled and welded.

There are several types of cap designs (Fig. 2).

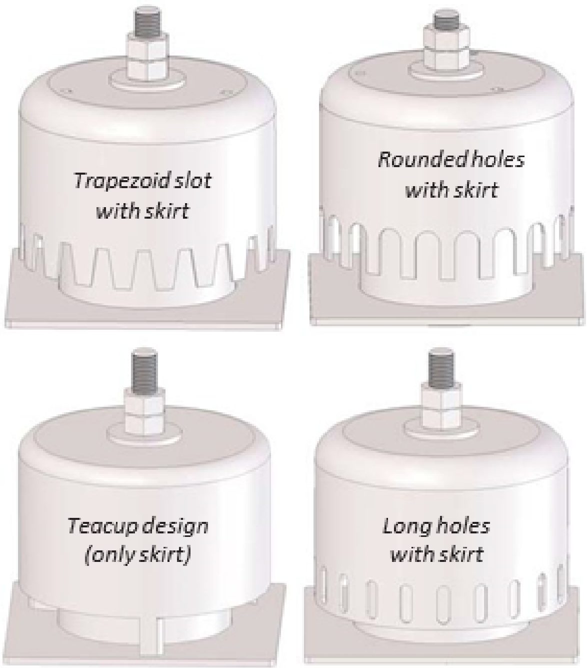


Fig. 2: Bubble Cap Designs

The cap is normally bolted (double nut!) to the riser, sometimes welded, sometimes wedged. (It is not fun to move on the top of bubble caps for maintenance or inspection duty.)

The caps are categorized by the top level of the gas opening and the area of the openings (expressed by a function of the "opened" height of the slots / skirt).

The pitch of the bubble caps is important for the function of the tray: In standard applications it is triangular and expected to be 1.25 .. 1.5 times the cap diameter [HOPPE/MITTELSTRASS 1967].

The risers are welded or pressed in the tray panel or gasketed by pulling the riser flange to the tray panel (Fig. 3).

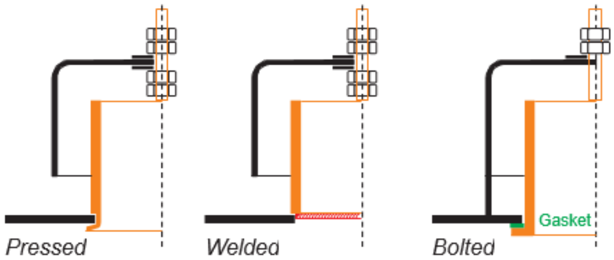


Fig. 3: Fastening of Risers

The values of the riser area, the reversal area, the annular gap as well as the escape area of the bubble cap have to be balanced. As the fabrication possibilities are on the one hand confined by the riser dimension, which is limited by the available pipe dimensions, and on the other hand by the cap, which is restricted to the dimensions of the deep drawing tools, you will have to find a compromise to have almost equal values for all areas.

The relative free area (riser area per active area) is typically about 5 to 10% and the resulting total pressure drop per tray is about 8 to 12mbar. The tray spacing is usually not less than 500mm (for large tower diameters it should be higher due to inspection and maintenance reasons).

The Operating Area of a bubble cap tray is defined by different limits. In Fig. 4, a qualitative operation diagram is shown. Please note, that the position and shape of all curves depend on the physical data, the tray and cap geometry and the gas/liquid load. Each curve can be limiting!

The Operation Point (Op in Fig. 4) of the design case (as well as the minimum and maximum load) has to stay inside all limiting curves. For stable operation and good efficiency there is a useful operation area with narrower limits (e.g. 80%-FFCF and 85%-FFJF curves).

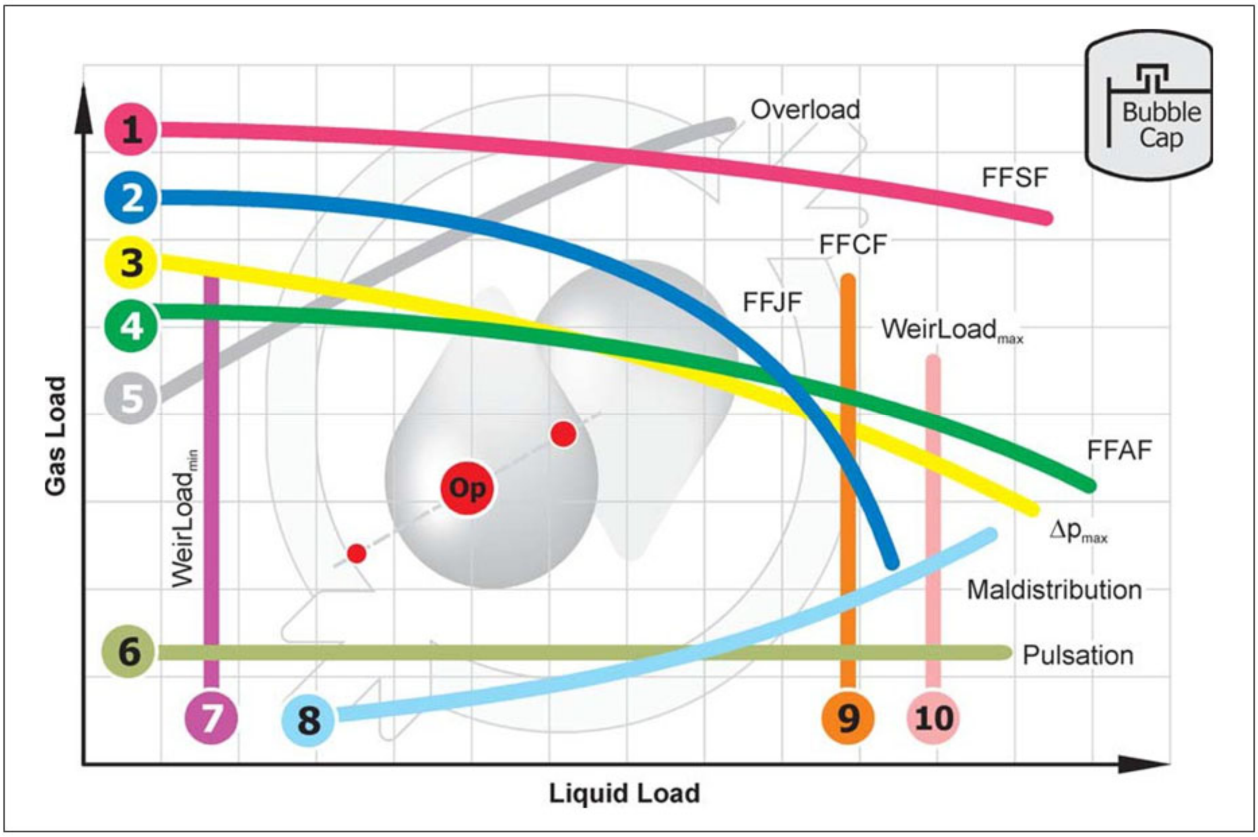


Fig. 4: Qualitative Operation Diagram for Bubble Cap Trays

The first step in analyzing a design is – of course – calculating all relevant parameters. For a bubble cap tray design there are 10 main parameters shown as curves in Fig. 4. These parameters are discussed in this article. There are some additional effects you will have to look at: entrainment, head loss at downcomer exit (clearance), flow regime, downcomer residence time, efficiency, sealing, construction issues, statics, …

Please note, that all free suppliers' software only show a limited number of these parame- ters and therefore are not save to use for design, rating and troubleshooting of trays. For save design you should be able to calculate all parameters! (e.g. software TRAYHEART OF WELCHEM)

In the following sections, all 10 main parameter curves of Fig. 4 are described. Each suggested action for preventing a certain effect may result in fertilizing another. The main task for designing trays is to balance these different and contradicting effects.

1 System Flood FFSF

There is a system limit set by the superficial vapor velocity in the tower. When the vapor velocity exceeds the settling velocity of liquid droplets („Stokes Law Criterion"), vapor lifts and takes much of the liquid with it. A well known model was published by STUPIN AND KISTER 2003.

This flooding effect cannot be reduced by use of other tray types or by increasing tray spacing.

The only way is to enlarge the vapor cross section area (e.g. enlarging tower diameter or reduce downcomer area).

2 Jet Flood FFJF

There are several definitions in literature for the so called Jet Flood. Similar definitions are Entrainment Flood, Massive Entrainment, Two- Phase Flood or Priming. For practical under- standing, Jet Flood describes any liquid carried to the tray above by the gas stream. This leads to a shortcut recycling of the liquid with loss of tray efficiency, additional pressure drop and additional downcomer load. For good tray performance, the Jet Flood value should be less than 75-80%.

You can reduce Jet Flood by

a. lowering the gas velocity (higher open area, i.e. more bubble caps, higher escape area)

b. enlarging the tray spacing

c. lowering the froth height on the tray deck (by reducing weir height or weir crest height)

d. enlarging the active area (i.e. the gas flow area) by sloping the downcomers

Pressure Drop 3

In most cases there is specified a maximum allowable pressure drop of the tower. You have to ensure that the pressure drop per tray does not exceed a certain value. This leads to a limiting curve within the operation diagram.

To reduce the pressure drop of a design, you can

a. lower the gas velocity by enlarging the number of bubble caps or change their geometry

b. lower the froth height on the tray deck (by reducing weir height or weir crest height)

c. enlarge the active area (with place for more bubble caps) by reducing the downcomer area or sloping the downcomers

Aerated Downcomer Backup FFAF 4

This limiting effect is also known as Downcomer Backup Flood. It describes the (aerated) backup of the downcomer due to pressure drop effects. It is important to not mix this up with the

Choke-Flood-effects (ref. to 9).

The level of the liquid in the downcomer is the result of (i) head loss at the clearance, (ii) the liquid height on the outlet deck, (iii) an inlet weir (if present) and (iv) the pressure drop of the tray itself. All these effects can be expressed by "hot liquid height". This resulting level in the downcomer has to compensate these effects! Taking into account the aeration of the liquid in the downcomer, the level has to be less than tray spacing plus weir height.

To reduce a high Aerated Downcomer Backup value you have to

a. reduce the pressure drop of the tray (ref. to 3)

b. reduce the head loss of the clearance (use higher clearance height or radius lips or recessed seal pans in case of insufficient sealing)

c. avoid inlet weirs

Please note, that it is no option to enlarge the downcomer area to reduce this flooding effect!

5 Overload Caps

At high gas loads, the space between the caps is dried - the liquid can't enter this region and is blown to a froth layer above the caps. This is not a recommended and stable regime! The effect is close to the Blowing effect of sieve trays (where the liquid layer is "disconnected" from the tray panel and blown upwards).

Therefore, the bottom skirt of the bubble cap should not be used for the gas outlet. (In a teacup design, the skirt should not be blown totally free.)

To prevent overload of caps, you can

a. adapt the design of the caps (more slots, enlarge width of slots, higher skirt)

b. enlarge the number of caps

6 Pulsation

The slots of bubble caps are opened by the gas flow. To have a stable operation, the gas has to open all slots of all bubble caps. If there is not enough gas (minimum slot velocity not reached), the bubble caps are pulsating.

To reduce Pulsating you have to

a. change cap design (less slots, reduce width of slots)
b. reduce number of bubble caps

7 Minimum Weir Load

The uniform thickness of the two-phase layer is essential for the successful operation of a tray.

To achieve this uniform flow, the tray panels have to be in level and the outlet weir has to be installed accurately.

To compensate small tolerances, the weir crest should be higher than 3mm and the weir load more than 9 $m^3/m/h$. In case of low weir loads you will normally have to consider gasketing the tray to avoid any leakage and loss of liquid.

To ensure these minimum values, you can use

a. notched weirs
b. blocked weirs

Gas Maldistribution 8

In all types of trays the liquid must have a driving force to flow from the inlet to the outlet. As long as there is no gas driven flow (as generated by fixed valves or push valves) the hydraulic gradient is the main reason for liquid flow.

Because the bubble caps are obstacles in the liquid flow pass, the hydraulic gradient is significant higher for bubble cap trays than for other trays.

Why might the hydraulic gradient be a problem? At a high hydraulic gradient, the tray will not work properly (Fig. 5): At the tray inlet the liquid "closes" the caps. The gas will use less liquid affected bubble caps for passage. This leads to a gas maldistribution and a bad efficiency of the tray. If the liquid head of rows with high gradient gets too high, weeping occurs!

To reduce gas maldistribution you have to

a. reduce the number of cap rows (e.g. by switching to a design with more flow passes)
b. cascade the active area

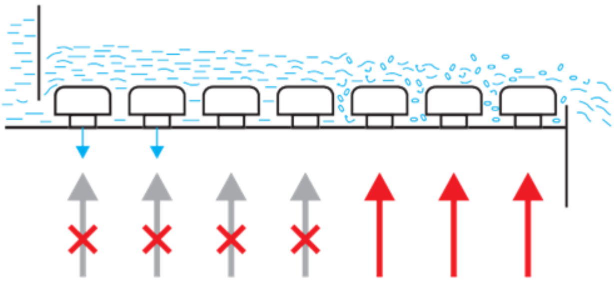


Fig. 5: Maldistribution

9 Choke Flood

The maximum liquid throughput of a down- comer is limited by the liquid velocity and the effect of overload (so called Choke Flood). The maximum allowable liquid velocity in the down- comer depends on the density ratio of gas to liquid, the tray spacing and the system factor. (The system factor describes the difficulty of phase separation. For common applications it is 1.0.) The most popular downcomer choke flooding calculation was published by GLITSCH 1993.

Another effect of Choke Flood at center and off-center downcomers is initiated by the mutual interference of the two liquid flows into the downcomer.

To prevent downcomer Choke Flood you have to

a. enlarge the downcomer area
b. implement more flow passes (with in sum an overall higher downcomer area)
c. enlarge the tray spacing (if limiting)
d. install anti-jump baffles for center / off-center downcomers

Maximum Weir Load 10

The maximum liquid flow handled by a downcomer can also be limited by the weir.
If the weir crest exceeds 37mm or the weir load 120 m³/m/h, the liquid will not enter the downcomer properly.
To prevent overload of the weir, you have to extend the weir length by

a. larger downcomers with longer weirs (or multichordal downcomers)
b. more flow passes
c. swept back weirs at the side downcomers

Conclusion

There are multiple limiting effects that have to be considered at the design and operation of bubble cap trays. Among the "standard" limits there are bubble-cap-individual limits as pulsating, gas maldistribution and cap overload.
Even if bubble caps are sometimes considered as dinosaurs, they are still in use and often the only solution (among all types of internals!) for low liquid loads.

About the Author

Volker Engel studied process engineering at the Technical University of Munich and did his Ph.D. thesis on packed columns with Prof. Johann G. Stichlmair. Since 1998 he has been the managing director of WelChem Process Technology GmbH and head of the TrayHeart software. TrayHeart has developed into a state-of-the-art design tool for trays and internals in process technology.

References

Glitsch Ballast Tray Design Manual. Bulletin 4900, 6th edition, Dallas 1993

Hoppe, K.-H.; Mittelstrass, M.: Grundlagen der Dimensionierung von Kolonneböden, Steinkopff, 1967

Lockett, M. J.: Distillation tray fundamentals, Cambridge University Press, New York, 1986

Colwell, Charles J.: Clear Liquid Height and Froth Density on Sieve Trays. Ind. Eng. Chem. Process Des. Dev. 1981, 20, p. 298-307

Stichlmair, J.; Bravo, J. L.; Fair, J. R.: General Model for Prediction of Pressure Drop and Capacity of Countercurrent Gas/Liquid Packed Columns, Gas Separation & Purification (1989) 3; p. 19-28

Stupin, W.J.; Kister, H.Z.: System Limit: The ultimate capacity of fractionators, Chem.Eng.Res.Des. 81, January (2003), p. 136-146

WelChem Process Technology: TrayHeart Software. Tower Internals Calculation Software. Internet: www.welchem.com; Info: service@welchem.com

PROCESS
ENGINEERING ASSOCIATES, LLC
"Excellence in Applied Chemical Engineering"

Corporate Office

700 South Illinois Ave.
Suite A-202
Oak Ridge, TN 37830

Phone: +1 (865) 220-8722

Process Engineering Associates, LLC
Process Engineering International, LLC

We provide engineering services exclusively via highly qualified chemical engineers and we specialize only in process engineering. Our industrial process design and plant operations experience are extensive. Our companies provide only Chemical Engineering process design and process safety services and currently employ over 50 highly qualified, full-time chemical engineers.

Our services are provided to most industrial process markets including chemical / petro-chemicals, petroleum refining, alternative fuels, power generation, metals/mineral processing industries, foods, pharmaceuticals, and more.

PROCESS' personnel are experienced, highly-motivated Chemical Engineers with track records of significant achievement in the process engineering field.

PROCESS has experience in providing exceptional process design services for the development of conceptual and detail process design, process modeling and simulation, and operations support. Typical services include process option screening studies/evaluations, preliminary process designs (FEL & FEED), comprehensive Schedule A process design packages, detail engineering process support, process construction oversight, startup assistance, and more.

Overview of Services

We specialize in process chemical engineering, process design, and process safety.

- Process Design
- Process Modeling/Simulation (CHEMCAD / AspenPlus / HYSYS / etc.)
- Operations Support
- Process Safety Management
- Safety Instrumented Systems / ISA Compliance
- Additional Capabilities

Please visit our websites at http://www.ProcessEngr.com and http://www.ProcessEngr-Intl.com.

Considerations for Reactor Scaleup

Joe Bonem

Chemical Engineers as part of a conceptual or final design are often required to scaleup a laboratory batch reactor to a full size continuous commercial reactor. This will always involve consideration of the following areas:

- Heat removal/addition
- Reactor Style
- Mixing
- Reactant injection into the reactor
- Safety considerations

The following paragraphs describe considerations for scaling up a laboratory batch reactor to a continuous flow commercial reactor.

When considering laboratory reactor scaleup the first step is to decide the directional mode of the scaleup. There are 4 likely possibilities. While one can visualize other possibilities, these are the main ones of interest:

1. Scaling up from a laboratory batch reactor to a pilot plant or commercial batch reactor.
2. Scaling up from a laboratory batch reactor to a pilot plant or commercial Continuous Stirred Tank Reactor (CSTR).
3. Scaling up from a laboratory batch reactor to a continuous pilot plant or a continuous commercial reactor where both are operating in the plug flow mode and can be simulated using the Plug Flow Assumption (PFA).
4. Scaling up from a continuous laboratory plug flow reactor to a continuous pilot plant or a continuous commercial reactor where both are operating in the plug flow mode (PFA).

While there may be other possibilities, these are the most likely and most frequently encountered. Of course, there are scaleups from a continuous pilot plant operating in the CSTR or plug flow mode to a commercial reactor operating in a similar mode. These scaleups are essentially scaling up heat transfer and agitator design. The concepts discussed in the 4 scaleup scenarios mentioned above are applicable to scaling up from a pilot plant to a commercial plant or from a small commercial plant to a larger one.

In considering reactor scaleup, there are 4 main areas that must be considered. They are reactor residence time distribution, mixing, heat transfer and reactants injection nozzles. The need to consider these areas is not always required for each of the cases shown above. The table shown below illustrates what should be considered for each case.

	Scaleup Design Considerations			
Scaleup Mode [1]	RTD	Mixing	Heat Transfer	Nozzle
Batch to Batch		X	X	X
Batch to CSTR	X	X	X	X
Batch to Tubular				
Laminar Flow	X	X	X	X
Laminar Flow in Packed Bed		X	X	X
Turbulent Flow		X	X	X
Tubular to Tubular				
Laminar Flow	X	X	X	X
Laminar Flow in Packed Bed		X	X	X
Turbulent Flow		X	X	X

(1) Scaleup mode is the description of moving from the smaller facility to a larger one. A "X" indicates that this variable needs to be considered in the design of the larger reactor whether it is a commercial or pilot plant reactor. For example, "Batch to Batch" involves moving from a bench scale batch reactor to a commercial batch reactor and will involve considering mixing, heat transfer and nozzle design and nozzle location.

The four most important considerations are as follows:

- RTD is an acronym for Residence Time Distribution. RTD provides a calculation technique to evaluate the by-passing effect in a CSTR that reduces the effective residence time. As shown in the table, it is not significant in the scaleup modes of batch to batch or batch to tubular flow if the larger reactor contains packing or is in the turbulent flow regime. However, it must be considered in the other modes.
- Mixing is the desire to have a similar mixing pattern in the larger reactor.
- Heat Transfer deals with the design considerations that ensure that the likely reduced A/V ratio of the larger reactor is taken into account. It includes the phases of reactor startup, steady state operation and potential loss of temperature control (temperature runaway).
- Nozzle is the design consideration that deals with the desire to obtain good dispersion of the catalyst and/or reactants at the inlet to the reactor.

An example of the use of this table would be the scaleup of a laboratory batch reactor to a commercial size CSTR. Each of the areas shown in the table must be considered in the design. Since in a CSTR some of the reactants leave the reactor immediately and some significant amount remain in the reactor as long as 4 to 5 times the average residence time, the residence time distribution (RTD) must be considered. Because of some of the reactants leaving the reactor immediately, a CSTR of the same average residence time as the batch reactor will always have a lower conversion and/or lower catalyst efficiency. In the design of the CSTR, this by-passing is usually mitigated by a larger reactor or using multiple reactors in series.

It is often desirable to have similar mixing patterns in the small reactor and the larger reactor. Evaluation of mixing patterns often requires the assistance of a mixer supplier and possibly the utilization of enhanced simulation techniques such as Computational Fluid Dynamics (CFD). Computational Fluid Dynamics is a mathematical technique that allows predicting the flow pattern at every point in a reactor based on the reactor and mixer design. It is of great value in predicting the flow pattern at the reactant and/or catalyst feed injection points.

The size, configuration and location of the feed and/or catalyst nozzles must be carefully considered. It is likely that the reactants in the bench scale reactor were pressured into the reactor at a high rate of speed and thus became mixed almost instantaneously in the small reactor. This is rarely possible in a larger reactor.

The consideration of thermal characteristics in reactor scaleup involves the concept of utilizing data from a bench scale or pilot plant reactor to design a full-size commercial reactor that has capability to remove/add heat to maintain temperature control. Maintaining control covers both static and dynamic conditions. When discussing the thermal characteristics of a specific reaction, it should be recognized that essentially all reactions have a heat of reaction. In addition, 85 to 90% of the reactions are exothermic. That is heat must be removed to maintain a constant temperature.

When scaling up from a laboratory bench reactor or pilot plant reactor to a continuous commercial reactor, consideration of thermal characteristics must include items such as:

- Determining the heat of reaction associated with the reaction.
- Determining the impact of the decreased area to volume (A/V) ratio associated with the larger reactor.
- Determining the potential for the loss of temperature control in the larger reactor.
- Analyzing reactor startup to ensure that there are no negative impacts associated with the temperature vs time profile during startups.
- Analyzing temperature distribution in the reactor with respect to time and location.

In addition to these considerations, the larger reactor will often have additional safety considerations. Safety must be carefully reviewed rather than taking a cavalier attitude –" It was safe in the laboratory."

Author

Joe Bonem's highly productive six-decade career has included over three decades in Polymers manufacturing and process development with Exxon Chemical as well as 20 years in consulting. His areas of expertise include all phases of chemical engineering including Technology Transfer and Assimilation, Process Development and Scaleup, Project Basis Development/ Process Design, Plant Performance Improvements and Safety Assessment of New and Existing Technology. In his consulting role, he has also participated in technology development associated with the Canadian Oil Sands and disposing of brackish water produced from non-conventional oil wells.

Mr. Bonem is experienced in the development and mentoring of young engineers, and has extensive experience in working in foreign countries and cultures. He also has experience serving as an expert witness.


TrayHeart
Tower Internals Design
TrayHeart is a professional software that performs hydraulic calculations for all types of tower trays, random and structured packings and liquid distributors. The development of TrayHeart started in 1998 and was continued jointly by universities, companies of the chemical industry and tower internals suppliers. TrayHeart ...
is based on multiple calculation models and large databases of packings, float valves, fixed valves, bubble caps, and liquid distributor templates
is a supplier-independent tool. There are no preferred product placements or promoted designs
considers static dimensions, manways and fastenings
offers an interactive 3D-view for all designs
can be used for single stage, profile and data validation calculations
has a unique, logical and multi-lingual user interface, with multiple input and output options
applies hundreds of online queries to check the feasibility and limits of the calculated designs
is a well introduced software many companies have relied on for more than 20 years
has extensive documentation and is licensed on annual basis
For more information:
www.welchem.com
service@welchem.com
WELCHEM
PROCESS TECHNOLOGY

Key Process Considerations For Caustic Treatment In CDU

Shahzeb H. M. Ismail MEng, CEng, MIChemE, Chartered Process Engineer.

Opportunity

The recommendations are specific to the injections of caustic into Crude unit for the purpose of optimizing the consumption, its impact in downstream units and minimizing the corrosion due to hydrogen chloride in the overhead system.

Caustic Theory Overview

The addition of Caustic injection into the desalted crude is used to minimize corrosion due to HCl. The evolution of HCl is due to hydrolytic decomposition of chloride salts, principally magnesium and calcium chlorides to form their hydroxides.

$$CaCl_2 + 2H_2O + heat \rightarrow Ca(OH)_2 + 2\ HCl$$

$$MgCl_2 + 2H_2O + heat \rightarrow Mg(OH)_2 + 2\ HCl$$

$$NaCl + H_2O + heat \rightarrow \text{No Reaction}$$

When wet crude oil containing salts is heated, most of the $MgCl_2$ and a small amount of $CaCl_2$ begin to hydrolyze at about 121 °C and form HCl. NaCl does not hydrolyze because of its stability at crude unit operating temperatures.

Injection of dilute caustic into crude exiting the desalter, results in a series of reactions that ultimately results in the formation of Sodium chloride.

$$NaOH + 2\ HCl \rightarrow NaCl + H_2O$$

This reaction limits the net amount of HCl, which will distill into the crude column overhead system, the converted sodium chloride will exit the column with the heavier stream, Residue.

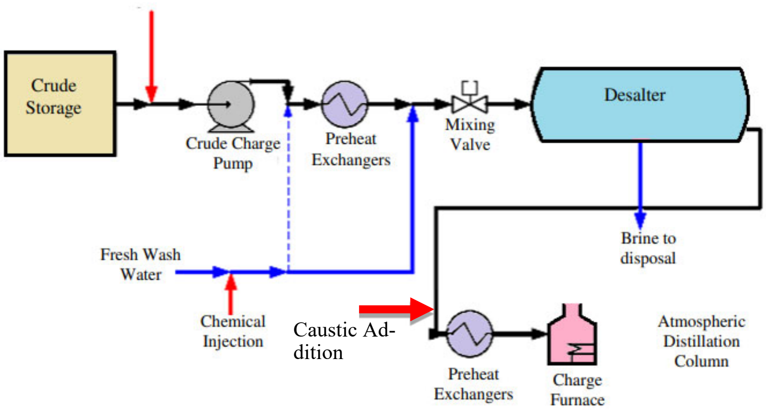
There are number of potential problems that can results from the use of caustic for crude unit corrosion control. They are caustic embrittlement as well as the fouling of lines, furnace tubes, downstream exchangers high Δ P, downstream units catalyst deactivations etc.

Caustic Injection Location & Impact

The caustic should be added in the form of 3-5 wt% aqueous solution in condensate immediately after the desalter in order to allow the maximum time for adequate mixing with the crude oil before hot zones are reached.

The use of higher strength caustic or high rate of caustic injection typically results in lower chloride reduction efficiency; low chlorides are observed in overhead drum boot water & high sodium loading levels in heavier product. That sometimes exceeds the market specification & whole product tank could be off-spec due to high sodium. This problem will vary from unit to unit. Theoretically, no sodium salts should distill in a crude unit. Practically, some sodium can contaminate the distillate cuts by entrainment. The impact of the routine sodium carry-over will have to be considered depending on the downstream unit's sensitivity. One estimate from a 1994 NPRA publication projected increased FCCU catalyst costs of \$200-\$700/day per 0.1 ppm sodium in the FCC feed.

Processes like Resid Cracking (RFCC) or Resid Hydrodesulfurization (ARDS) can be impacted by upstream sodium usage. For planning purposes, assume that the sodium in the desalted crude and any added to it will remain in the residuum.



It is commonly believed that Visbreakers are also adversely affected by high sodium content in the vacuum residue used as feedstock. Excessive sodium content in the feed leads to higher off-gas production and lowers the yields for more desirable distillates. A limit of 25 ppm is often quoted as a working maximum for sodium in the VBU feed.

Some refineries are concerned about the sodium content in the coker feed or have specifications for sodium in the produced coke. Sodium limits in the coker feed range from 50 ppm to no limit. Again, each processing unit has to determine the sodium specification for the coker feed.

Injection of caustic upstream of desalter is not recommended because high desalter water pH can results in the formation of Emulsions and can drive amine compounds into the crude. Also, the caustic will be unavailable to react where the salt hydrolysis takes place since it will typical be removed in the desalter brine. This indirectly also means that the demulsifier dosage requirement would become higher than normal.

Caustic Injection Rates Calculation

The theoretical Caustic Injection rate can be calculated as;

CAUSTIC PTB = (OH Chloride Reduction) x (40/35.5) x 1000/ (OH water)

OH Chloride reduction: Measured OH water chloride (ppm) – 10 ppm

OH Chloride reduction: 15 ppm.

OH water: Atm Tower Steam + Desalted Crude Water (lbs/Bbl Crude)

OH water: 9.0 lbs/bbl of Crude.

CAUSTIC = 1.86 PTB (5.5 ppm)

The calculated number is anticipated 100% Neutralization efficiency for the caustic added. The lower the caustic strength used, the higher will be the caustic efficiency. In no case should this quantity exceeds 5 PTB (15 ppm) of caustic or it could be troublesome for the pre-heaters & furnaces if caustic dosing results in less than 10 ppm chloride measured in the overhead boot water.

Preliminary Caustic Rate

Start caustic addition to the crude charge at 50% of the rate calculated to obtain the desired salt neutralization as established above – but not more than 1.5 PTB.

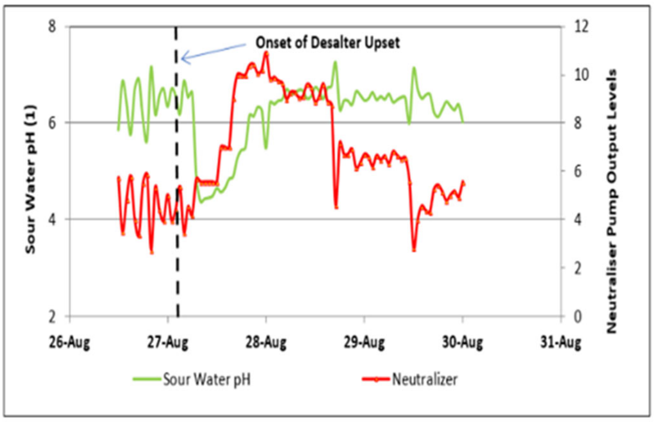
Determine the chloride content of the atmospheric tower overhead receiver water one to two hours after the start of caustic addition. If the chloride content is less than 10 ppm, reduce the caustic addition rate. If the chloride content is greater than the target overhead chloride level, the caustic addition rate may be increased gradually to the level needed to get within the targeted chloride control range. For systems without a desalter, the rate may be up to a maximum of 5 PTB NaOH. If these limits are ever exceeded, the Inspection Department must be notified.

Monitoring And Adjustment In Caustic Rate

Normally, once the caustic injections reach a level at which the unit is consistently within its targeted OH chloride range, the caustic injection rate is then fixed and only adjusted if there is a step change in performance.

Overhead PH Control should be maintained by adjusting Neutralizer Injection, not varying the caustic injection rates. Caustic injection rates must be adjusted whenever the actual caustic solution strength changes in order to maintain target ppm of caustic in crude. For example;

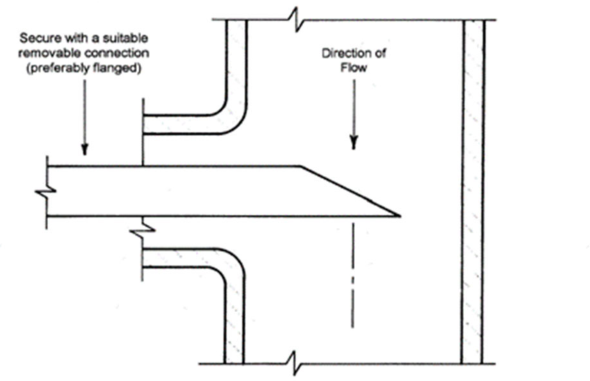
In one incident, the crude tank that was about to be brought online had been reported as containing a higher level of BS & W than the one currently feeding the crude unit. As this tank was brought online, desalter amps and interface levels rose sharply indicating a water slug had hit the desalter. To mitigate this event, operators increased demulsifier dosing and reduced desalter wash water rates. Shortly after, the overhead sour water pH dropped quickly from pH 6.5 to 4.5 as it can be seen below. In response to this reduction in pH, the 3DTCOS online Analyzer significantly increased the neutralizer dose rate to increase the PH back to normal. Here it can be observed that nobody talks about manipulating the caustic dosage. There is a very important lesson here that the overhead chlorides are controlled through caustic and PH is controlled through Neutralizer.



Inspection Requirement

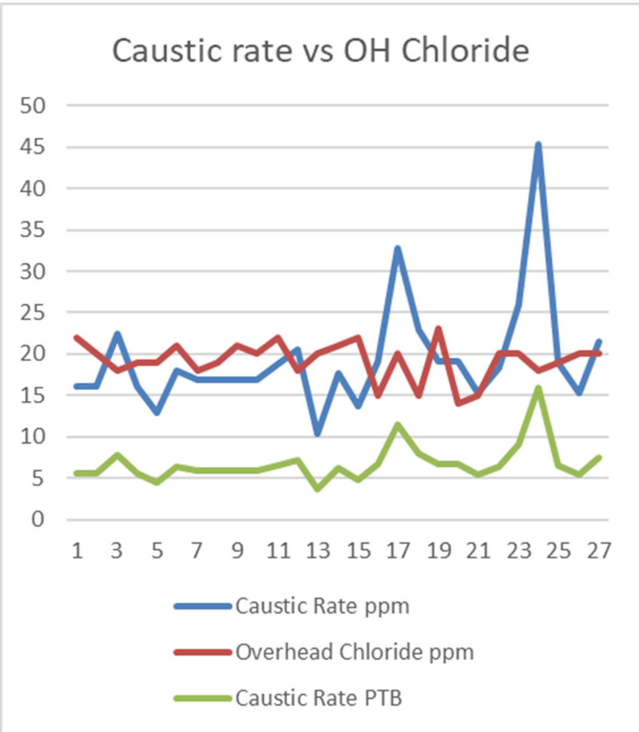
The caustic injection point should be included in the injection point inspection program. This includes setting up inspection locations in the piping around the injection point and radiography of the quill to ensure that it remains intact. The quill should be pulled during each unit turnaround and visually inspected.

INJECTION QUILL



Case Study: Caustic Injection Rates

This study was carried out in one of the oil refineries located in Asia in which the recently discussed rule was not instigating. What could be the main reason?



From the above Half monthly trends, it seems that the proven rule which is, increasing the caustic rate lessens the chloride ppm in overhead boot water fails here but it is not. Upon investigation it was identified that the desalter outlet salts have increased too much due to bad performance of Single stage desalter so against that the operation team raised the caustic dosage in order to control the ppm of overhead chloride to normal 20-25 ppm. Therefore, on grounds things could be different but most of time verifies theories.

Recommendations

- It is highly recommended to maintain caustic injection rates in the range of 5-15 ppm or doesn't exceed below 12 ppm in the overhead chloride.
- Caustic to be dosed at the downstream of desalter, not at upstream.
- Caustic solution should be made in condensate.
- Caustic strength to CDU to be maintained at 3.0- 5.0 wt%. At a minimum, the caustic strength should be verified using a hydrometer at the storage tank each time a batch of caustic is made and mixing is complete. A chart relating NaOH wt% back to density (read from the hydrometer) should be used for this initial verification. On systems with the continuous on-line mixing system, the use of a meter to measure caustic strength should be seriously considered.
- These caustic strength numbers should be recorded and available to operations and the chemical vendor on the unit. They should be used by operations to adjust the caustic solution injection rate to ensure sufficient flow to maintain the same PTB injection, as it would have been at the caustic strength of the previous batch of dilute caustic. This avoids over injection of caustic and assists in maintaining stable chloride levels in the overhead system.

References

SUEZ Recommended best practices – Process parameters Impacting Reliability & Corrosion on Crude units.

Refinery Injection and process mixing points, NACE international Publication 34101, NACE International, Houston Texas, March 2001.

Corrosion and Fouling Management Course, UOP Process Division, Des Plaines, IL, November 1982.

Bagdasarian, A., Feather, J., Hull, B., Stephenson, R. and Strong, R., "Crude Unit Corrosion and Corrosion Control", presented at NACE Corrosion/96, Paper No. 615.

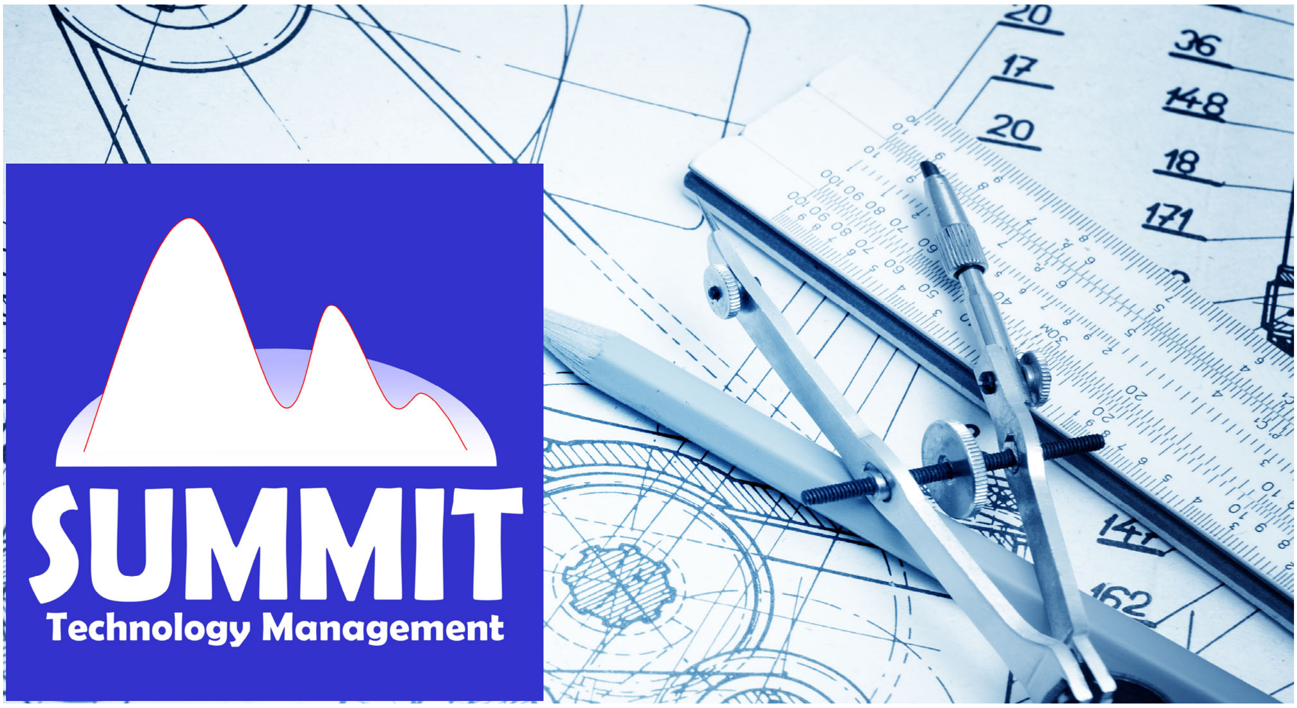
Refinery Corrosion Control Handbook, Gulf

Science and Technology Company, Pittsburgh, PA, Report No.561RF058, September 1977.

Hausler, R.H. and Coble, N.D., "Corrosion Control in Crude Unit Overhead Systems", presented at API Refining Division 37th Mid-Year Meeting, New York, NY, May 8-12, 1972.

Author

Shahzeb H. M. Ismail holds a master degree in chemical engineering from NED Institute of Technology, Karachi, Pakistan. He is Chartered Chemical Engineer from IChemE & a Chartered Engineer from Engineering Council UK. His expertise over 6 years of experience Covers Pakistan refinery Technical services, Operations & Process Safety. His Major role is to provide Process simulation support, optimization, Crude Evaluations, Crude recipe development, Supervise Catalyst regenerations & Troubleshooting's. Currently working as Lead Process Engineer, Crude Distillation Unit.


SUMMIT
Technology Management

Punch List– The Conclusive Specific Comments Writing

Lalit Mohan Nainwal, C Eng. (India), MBA

Punch list writing is "No Monkey Business".

Most of us know that construction / pre-commissioning punch list walk-downs on sim-ops ongoing pipe racks and ISBL /OSBL areas are tiring and frustrating works. It may be due to physical activities of going through many scaffolding ladders, platforms, twisting body to get into places to see if a certain item is welded/installed or not. The work sometimes requires passing safely through areas where welding, shot blasting, painting, fireproofing or other works are in progress. During the pre-commissioning phase, a construction / pre-commissioning punch list originator has to pass safely near the area where he can find another line is under the signage of pressure test or blowing.

Significance of Punch, the cost of actual work and punch work, if compared, punch work are too expensive as the contractor has to mobilize a whole lot of skilled manpower, equipments and accessories for correcting the left out bit and pieces. The same work could have been done in a matter of hours which sometimes takes days to obtain permits during punch closing or punch killing phase.

That is the reason, many companies promote "Zero-Punch" workmanship.

I. What is Punch-List

A punch list, like almost every other list, sounds very simple to make, list down the things that need to be corrected/installed. Though it looks very simple, the task list is not always that easy. A punch list most commonly has an explanation that gives the purpose of the punch list followed by the actual list of tasks or missing items that need immediate attention.

Punch lists or punch points are observations made by an experienced professional or subject matter expert (EP/SME) referring to a set of drawings, procedures or specifications. This work carried out when the Installation contractor deems a test pack, subsystem or subsystem is complete and invites or solicits his walk-down on a piping system, subsystem or a test pack.

II. What sense "deems a test pack, subsystem or subsystem is complete" make

For the construction team at the site many times the word complete is very common but what is "complete"?

Let me explain, the client's EP/SME is always free to comment but there are several phases of construction and the EP/SME must keep in mind at what phase of construction the contractor has invited him for walk-down.

Particularly in piping construction, hydro/ pneumatic test pack level walk-downs starts when another piping spool has not yet been installed. Does it mean "we shall cancel the walk?'"

Answer is "No", if the test-pack limit is completely constructed for the pressure envelope, we can go ahead with the test, keeping a punch list of items for the final installation of that test pack in the subsystem/system.

III. Punch Listing Management

The management of the punch list is dependent on Built-Method accepted between company management and contractor. The built method is a written method statement about how the structure, piping & E&I will be erected. The EP/SME should always note that a particular spool or structure he is finding missing right when he was invited to walk-down will be erected after sometime when another item is erected otherwise there will be no access or interference for that.

IV. International Standards & Reading of Engineering Drawings

Unless it is a trade secrecy, the symbols, nomenclature and other drawing codes shall be kept to international standards to the maximum extent. This will reduce misinterpretation issues in punch listing and create uniformity of understanding.

V. The Punch Categories

As mentioned earlier, in the beginning construction is a very dynamic process and so shall be the punch list. EP/SME writes punch points in three (3) or four (4) categories-

A Punch

B Punch

in some cases, if commissioning philosophy allows

C Punch

D Punch

For example, In some companies it's a practice to write A punch in Pink pages having standard formed printed, B in light blue papers, C in white paper printed forms and D in Yellow. Since the technology has advanced and database systems are being used that color segregation is not that prevalent now.

So what are those categories in specific, let me explain,

A Punches are normally written on observations of critical items that are left to install/weld without those the pressure envelope can not be complete. For example a welding joint not complete or a test pack has a line item included in the test limit. A Punch or Pink Pages are immediate action items.

What if the test pack was not a pressure test pack - it was just an open to atmosphere vent or open to funnel drain line after trap or valve?

Many PE/SMEs choose to write visual test pack missing items in A category as the contractor may not invite reinstatement to walk-down in these kinds of items.

B Punches marked are in most cases those items which can be installed after pressure test, through reinstatement activities and has no direct contact with pressure envelope such as guide beside shoe, trunnion bases and guides or Anchors under shoe support. B Punch or Light Blue papers are second priority.

Marking any observation as category A or B in the punch list is an experience-based work.

There will always be technical arguments, the PE/SME has to be very clear, will this item need dismantling of line from its location? Will the contractor disturb the alignments to critical equipment to get B punch listed items closed?

Unfortunately in many instances PE/SME finds at later phase the items which were marked as B items to let the pressure test go has created more work than it was thought of at the initial state.

C Punch/White Paper, in concurrence with commissioning manager, marked for few items or remaining works that can be installed/completed after pre-commissioning during the commissioning phase.

D Punches/Yellow Paper are not common and user-specific, normally for Lettering or QR tags, paint/color band or flow arrows or few valves/specialties that were kept closed for preservation reason need opening, etc.

VI. Punch List Forms, what it must ask for

When a company develop it's construction/pre-commission or any else punch list format, the following clear details to be asked-

a. system no., b. subsystem no, c. drawing, d. item no in MTO which was observed incomplete, e. punch description, f. originator details, g. date of observation, h. action by (Dept details, such as Piping, Structure, Paint, Insulation), i. date closed sign column for contractor, j. punch close sign off by company EP/SME.

VII. Punch writing

The punch writing is an experience-based skill acquired through the number of jobs someone has handled in construction.

In punch writing, someone should use the specific terms and items marked in the drawing or else being referred and based on the current execution status when the walk-down is invited. The PE/SME shall not use ambiguous language that can lead to confusion later.

Punched items if not PE/SME's department-specific, shall be discussed with other departments on how to note those. For example, a Piping PE/SME suspect that at a modular construction of piping steel below the shoe is not finally painted and yet the line is installed with guides in place..! One day either piping team or painting team will find that one side guide is removed and the pipe is lifted to paint the steel below the shoe support and yet there was no punch during the initial walk that guide to be installed. The installation contractor may leave the damaged work as it never made its way to the punch list. Tricky situation, isn't it….!

Now, mixing many items as punch in a single punch item. For example, the PE/SME marked, Piping support clamp to be tightened, contact point paint to be completed and guides to be welded at so & so location in a particular drawing. Hang On..! This is complicated.

You know the above example has so many activities, fasteners-related, welding-related & Painting-related.

No Punch shall be written based on assumptions and speculations, all punch-list comments shall have a strong document-based or experience-based justification.

VIII. A Valid Punch

A valid punch is that can stand argument in case the contractor who deems work was complete yet pointed by PE/SME that his work needs further work. In short, the left out work which against drawings or else, PE/SME can justify his stand.

A disorganized punch list will often be hard to understand what purpose had originator thought when commented, making potential dangers of future argument.

When writing a punch list, the writer needs to make it so that the matters he or she is trying to draw attention to will get the notice it needs.

IX. What are the back-up documents for punch list

Normally PE/SME notes punch against drawings, standards, specifications, and good engineering practices. Having a set of standard drawings or else will be the back-up. In many cases, the experience is also a key to quality punch listing.

X. Understanding the Phase of Project Execution/Construction

A good understanding of which walk down someone is invited for is a major game-changer. One item observed as left to install at an earlier test pack phase can be marked as a B item on that instance, the same item can be a potential A item if it appears incomplete at the pre-commissioning phase or during subsystem/system walk-down.

XI. The Disputable Punch

As stated earlier in this article, the punch list originator has the responsibility to write conclusive specific comments. There are instances when PE/SME's comment left to dispute at contractor's end and engineering advice is sought.

for example a punch on guide gaps, forgotten weep-holes or sliding plate or PTFE sheets.

At the pump or compressor nozzle, where the piping will be welding the flange but the tolerance is to be within the rotating equipment team's acceptance. Similarly, the spring support locations, PSV alignments, etc. many points come to the observation which was not there earlier such as guide gaps, supports not resting, etc. In these cases a PE/SME to make a note on a particular situation and give an input.

XII. Punch Killing

The process of closure of comments raised through punch-list is called punch killing and it is an activity where the cost of work repetition starts hitting the contractor and confrontation is expected. It is always advisable to keep the punch list as small as possible, if something can be done before

XIII. Cost Analysis

ROUGH Approximation, Example "A Piping Supports Guide observed not-welded during pretest walk"

B Punch noted -

Original cost when all construction work was on going (For Approximation only)

Lets only calculate Man-power related cost (leaving Scaffolding, Power, consumables)

SKILL	*Nos./EA*	*TIME Hr.*	*$ COST/Hr(For Example)*	*Total cost*
Fitter	1	0.5	20	10
Grinding Man	1	0.5	15	7.5
Welder	1	1	30	30
			Total cost when construction was on	**47.5**

Punch Killing Cost when actual construction is over but need to close open comment(For Approximation only)

Lets only calculate Man-power related cost (Lets assume Power, consumables still available)
Permit coordinator involved, Idle manpower due to Hot work Permit (Assume 2 hours for permit and 3 hours for scaffs OK), Scaffolding Installation /erection by 4 scaffolders took 3 Hours after permit arrived. Supervisor explained what work required (0.25 Hour). Paint Damage / Fireproofing damage and Repair to this work (Lets take lumpsum $100), Punch close walk by Company & Contractor supervision, dismentaling of scaffolding cost - Lets take lumpsome - $100)

SKILL	*Nos/EA*	*TIME Hr.*	*$ COST/Hr(For Example)*	*Total cost*
Fitter	1	5.5	20	110
Grinding Man	1	5.5	15	82.5
Scaffolders	4	5	20	100
Supervisor	1	0.25	40	10
Permit coordinator	1	2	30	60
Welder	1	6	30	180
Paint/FP damage repair	1		LS	100
Punchclose walk & dismantle of scaff			LS	100
Total cost when construction was over but need comment closing				**742.5**

Note - This is a rough calculation only for developing reader's understanding purpose only.

XIV The Conclusion

At the end of construction projects, the completion managers normally find so many punch items left unattended and unclosed in the database. The situation forces them to organize a meeting with PE/SME and contractor's representatives. The resolution is not always so easy to reach. Few items/corrections what PE/SME think is a must to close a punch, contractor find unable due to no access, not specifically suggested in specifications.

A good contractor avoids punch by performing as required by specifications and a good PE/SME avoids confusion by giving clarity on what needs to be done and mark the requirements separately if many items belong to many departments. The understanding of the sequence of work, stage/phase of work is the key. Punch listing and punch killing both consume a considerable time & resources, I repeat punch list writing is "No Monkey Business".

Author

Lalit Mohan Nainwal has always strived for knowledge, Lalit continued his education with his career as a shipwright apprentice and achieved his AMIE(Mech), C Eng (India) & MBA. Apart from Indian Navy's Docks, Lalit worked with several renowned EPC companies in India & abroad such as Tata Projects, SKE&C, and KBR Inc. in major projects such as HRRL, KPPC Aromatics, Pearl GTL, and Ichthys LNG Project.

HEAT TRANSFER TECHNOLOGY

PT. WARU TEKNIKATAMA

Waru Teknikatama designs and fabricates heat exchangers, pressure vessels and other equipment to accomplish highest degree of client satisfaction.

Products | Air Cooled Heat Exchangers | Shell & Tube Heat Exchangers | Pressure Vessels | Plate Heat Exchangers | Other Equipment

Services | Heat transfer related calculation, design and development & troubleshooting | Detail Design Packages : Mechanical, Civil, Electrical Engineering design of plant | After Sales Services by providing spare parts and special tools for heat exchangers

Codes & Standards

Pressure Vessel	: ASME Sec VIII Div 1&2, PD 550
ACHE	: API 661, ASME Sec VIII Div 1
STHE	: TEMA, API 660, ASME Sec VIII Div 1&2
Storage Tank	: API 650, API 620, AWWA D100
Piping System	: ASME Sec I, ASME B31.3, B31.4, B31.8
Condenser	: HEI (Heat Exchanger Institute)
LP Heater	
HP Heater	
Deaerator	

Certifications

ASME U, U2, S

The National Board of Boiler and Pressure Vessel Inspectors (NB & R)

ISO 9001 : 2008

HTRI Member

Head Office
Unimas Garden Regency
Jl. Imermotors F-18
Waru, Sidoarjo 61256 – Indonesia
Phone : +62 (0) 31 853 3643, 853 3591, 854 9184
Fax : +62 (0) 31 853 3591
www.waruteknikatama.com
waru@waruteknikatama

Workshop
Desa Domas. Km 11, Trowulan, Mojokerto, East Java, Indonesia

Cert. No. JKT 6006851

ASME - S AND U Stamp

Processing of Heavy Crudes – Challenges and Opportunities to the Downstream Industry

Marcio Wagner

Introduction

The continuous supply of adequate crude oil to the refining hardware is one of the assumptions adopted by the refiners to the installation of refining assets or economic analysis of already installed units. However, according to the installed geopolitical scenario, the supply of adequate crude oil to the refining hardware can be seriously threatened, mainly to refiners that operate with lighter and high cost crudes.

In this sense, more flexible refining hardware in relation of the processed crude slate is an important competitive advantage in the downstream sector, mainly the processing of heavy and extra-heavy crudes due to his lower acquisition cost when compared with the lighter crude oils. The difference in the acquisition cost between these oils is based on in the yield of high added value streams which these oils present in the distillation process, once the lighter crudes normally show higher yields of distillates than the heavier crudes, his market value tends to be higher.

The processing of heavy crudes shows some technologic challenges to refiners once, due to his lower yield in distillates, it's necessary the installation of deep conversion technologies aiming to produce added value streams that meet the current quality and environmental requirements, furthermore the concentration of contaminants like metals, nitrogen, sulfur, and residual carbon tends to be high in the heavier crudes, making the processing of his intermediate streams even more challenger.

Technologic Challenges

The challenge in the processing of heavy crude oil starts in the desalting step before the sent to the distillation unit. The desalting process consists basically in the water addition to the crude aiming to promote the salt removal from the oil phase that tends to concentrate in the water phase, Figure 1 presents a simplified process flow diagram for a crude oil desalting process with two separation stages.

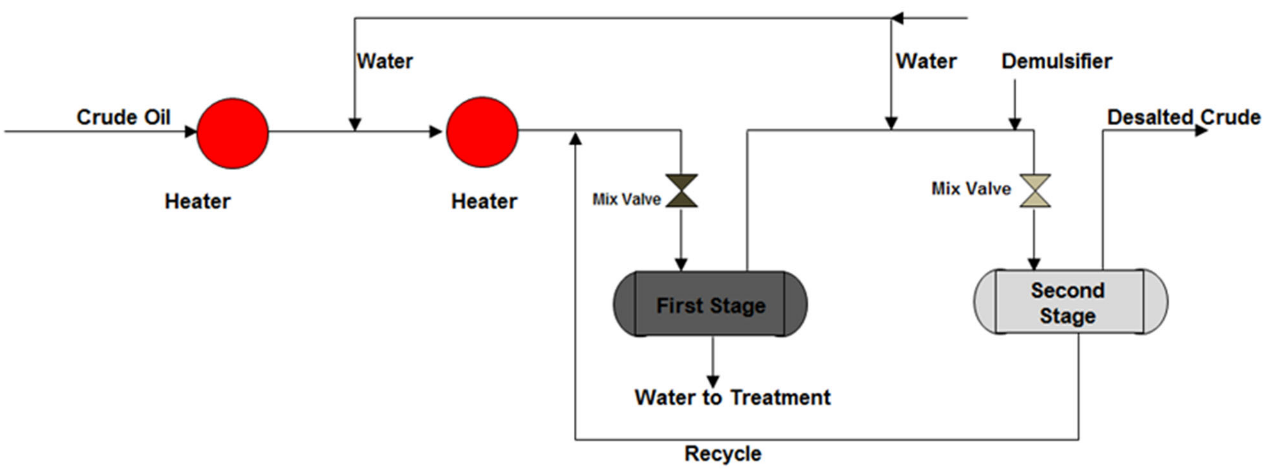


Figure 1 – Crude Oil Desalting Process with two Separation Stages

The separation of oil and water phases in the separation drums occurs through the sedimentation process, due to the density gap between the water and the crude oil. Considering that the sedimentation process can be theoretically described by the Stokes Law, according to equation 1.

$$(1) \qquad v_R = \frac{1}{18}\frac{d_p^2\, g(\rho_p - \rho_f)}{\mu_f}$$

According to equation 1, the sedimentation velocity is proportional the density gap, in the case of heavier crudes, this gap is lower leading to a lower sedimentation velocity and the need of higher residence times to an adequate separation. Another complicating factor in the case of heavy crudes is the higher viscosity of the oil phase that hinders the mass transfer in this phase. Due to these factors, refining hardware designed to process heavy crude oils needs more robust desalting sections taking account the trend of higher salt concentration in the crude and a harder separation process. Table 1 presents an example of crude oil classification based on the API Grade.

Table 1 – Crude Oil Classification Based on API Grade

Classification	**API Grade**
Light Crude	API >31,1
Medium Crude	22, 3 > API < 31,1
Heavy Crude	10,0 > API < 22,3
Extra-Heavy Crude	API < 10,0

After the desalting process, the crude oil is sent to the atmospheric distillation tower, according to presented in Figure 2.

To heavier crudes, the yield of distillates by simple distillation is relatively reduced and the bottom section in the atmospheric distillation units tends to be overload. Table 2 presents a comparative analysis of the yields of different crude oils.

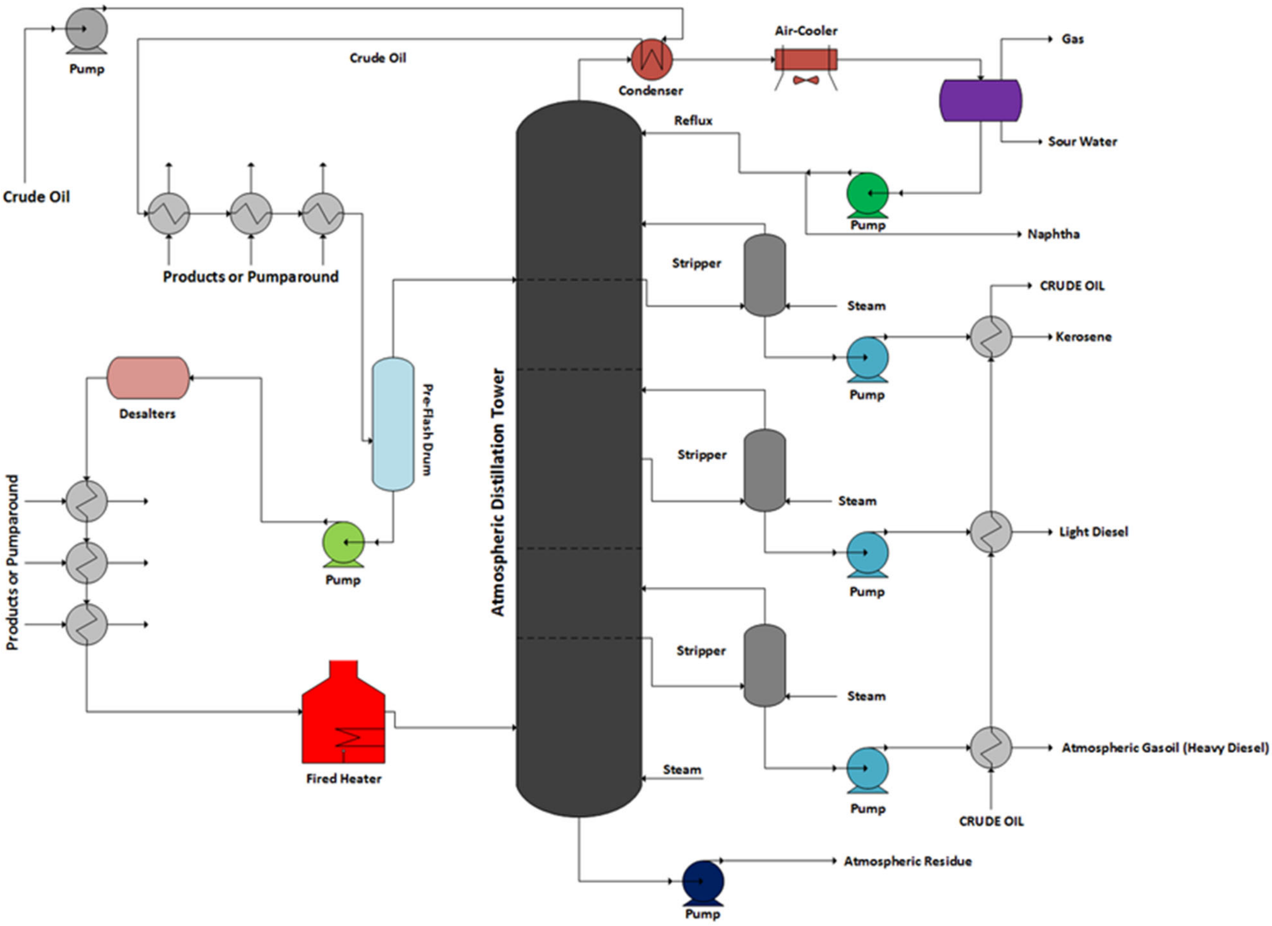


Figure 2 – Atmospheric Distillation Process of Crude Oil

Table 2 – Estimated Yields in the Atmospheric Distillation Process for Different Crude Oils
Where, VGO = Vacuum Gas Oil

Crude Oil Type	Naphtha Yield (wt %)	Middle Distillate Yield (wt%)	VGO Yield (wt%)	Vacuum Residue (wt%)	Sulfur Content (wt%)	Specific Gravity
Brent (°API 38,3)	30,1	25,0	30,3	12,3	0,37	0,8333
Bonny Light (°API 35,4)	27,7	34,1	31,2	5,5	0,14	0,8478
Green Canyon (°API 30,1)	16,9	22,6	32,9	26,1	2,00	0,8752
Ratawi (°API 24,6)	15,8	18,0	32,2	32,9	3,90	0,9065

Normally, heavy crude oils have higher concentration of metals, sulfur, and nitrogen. These contaminants tends to be distributed in the intermediates streams concentrating in the heavier streams, making necessary more robust conversion processes and tolerant to these contaminants.

Aiming to avoid damage to the catalysts of deep conversion processes as FCC and hydrocracking, normally refineries that process heavier crudes promotes a better fractionating of bottom streams of vacuum distillation tower. When the crude oil presents high metals content, it's possible to include a withdraw of fraction heavier than the heavy gasoil called residual gasoil or slop cut, this additional cut concentrates the metals in this stream and reduce the residual carbon in the heavy gasoil, minimizing the deactivation process of the conversion processes catalysts as aforementioned. Normally, the residual gasoil is applied as the diluent to produce asphalt or fuel oil.

Due to the high asphaltenes content in the heavier crudes, the residual carbon in the bottom barrel streams is also higher than observed in the lighter crudes, this characteristic reinforces, even more, the necessity of installation process units with high conversion capacity.

Available technologies to processing bottom barrel streams involve processes that aim to raise the H/C relation in the molecule, either through reducing the carbon quantity (processes based on carbon rejection) or through hydrogen addition. Technologies that involves hydrogen addition encompass hydrotreating and hydrocracking processes while technologies based on carbon rejection refers to thermal cracking processes like Visbreaking, Delayed Coking and Fluid Coking, catalytic cracking processes like Fluid Catalytic Cracking (FCC) and physical separation processes like Solvent Deasphalting units.

Due to the high content of contaminants in the crude oil and consequently in the intermediary chains, refining equipment destined to the processing of heavy crudes requires high hydrotreatment capacity. Usually, the feed streams of deep conversion units like FCC and hydrocracking go through hydrotreatment processes aiming to reduce the sulfur and nitrogen contents as well as the content of metals. Higher metals and asphaltenes content lead to a quick deactivation of the catalysts through high coke deposition rate, catalytic matrix degradation by metals like nickel and vanadium or even by the plugging of catalyst pores produced by the adsorption of metals and high molecular weight molecules in the catalyst surface. By this reason, according to the content of asphaltenes and metals in the feed stream are adopted more versatile technologies aiming to ensure an adequate operational campaign and an effective treatment.

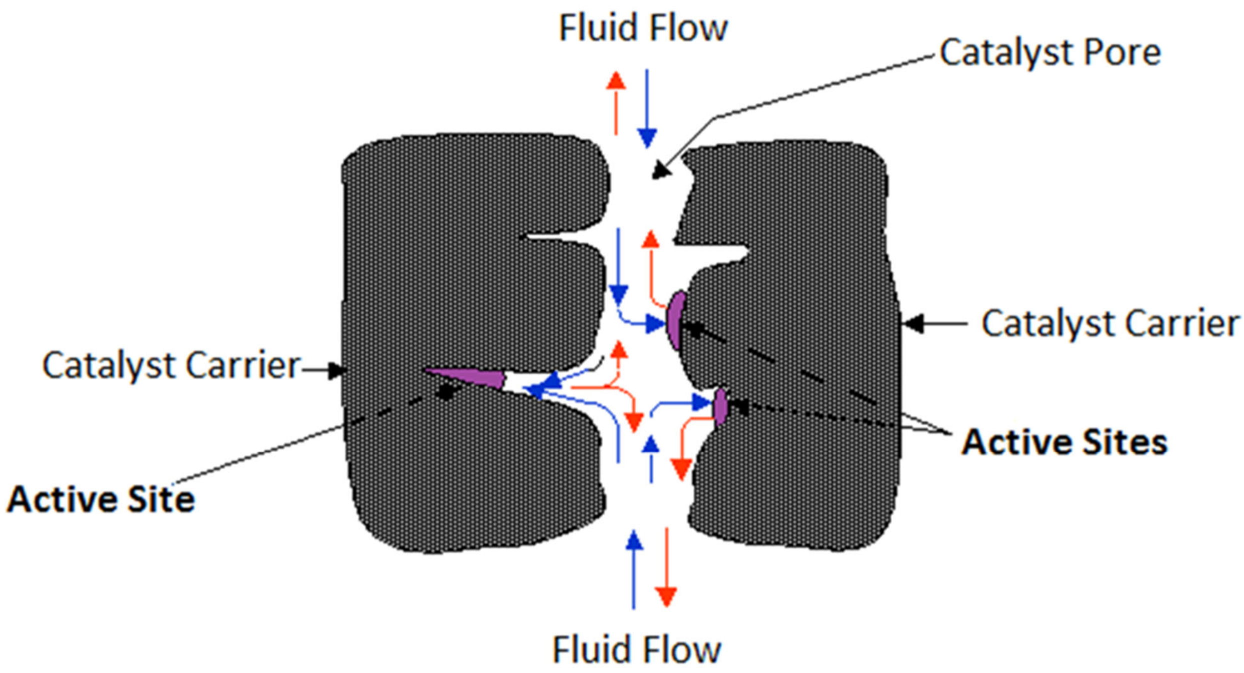


Figure 3 – Reactants and Products Flows in a Generic Porous Catalyst (GONZALEZ, 2003)

Figure 3 presents a scheme of reactants and products flows involved in a heterogeneous catalytic reaction as carried out in the hydroprocessing treatments.

In order to carry out the hydroprocessing reactions, it's necessary the mass transfer of reactants to the catalyst pores, adsorption on the active sites to posterior chemical reactions and desorption. In the case of bottom barrel streams processing, the high molecular weight and high contaminants content require a higher catalyst porosity aiming to allow the access of these reactants to the active sites allowing the reactions of hydrodemetallization, hydrodesulfurization, hydrodenitrogenation, etc. Furthermore, part of the feed stream can be in the liquid phase, creating additional difficulties to the mass transfer due to the lower diffusivity. To minimize the plugging effect, in fixed bed reactors, the first beds are filled with higher porosity solids without catalytic activity and act as filters to the solids present in the feed stream protecting the most active catalyst from the deactivation (guard beds).

Available Processing Schemes and Refining Technologies

Due to the higher severity and robustness of the processes, the installation cost of the refining hardware capable to process heavier crudes tends to be higher when compared with the light and medium oils as well as the operating costs. Figure 4 shows a possible refining configuration to be adopted by refiners to add value to heavy crudes.

The refining scheme presented in Figure 4, normally called Coking/Hydrocracking configuration, is capable of ensuring high conversion capacity, even with extra-heavy crudes. The presence of hydrocracking units gives great flexibility to the refiner, raising the yield of middle distillates. Figure 5 presents a basic process flow diagram for a typical hydrocracking unit designed to process bottom barrel streams.

This configuration is adopted when the contaminants content (especially nitrogen) is high, in this case, the catalyst deactivation is minimized through the reduction of NH3 and H2S concentration in the reactors. Among the main hydrocracking process technologies available comercially we can quote the process H-Oil™ developed by Axens Company, the EST™ process by ENI Company, the Uniflex™ Processes by UOP, and the LC-Fining™ technology by Chevron Company.

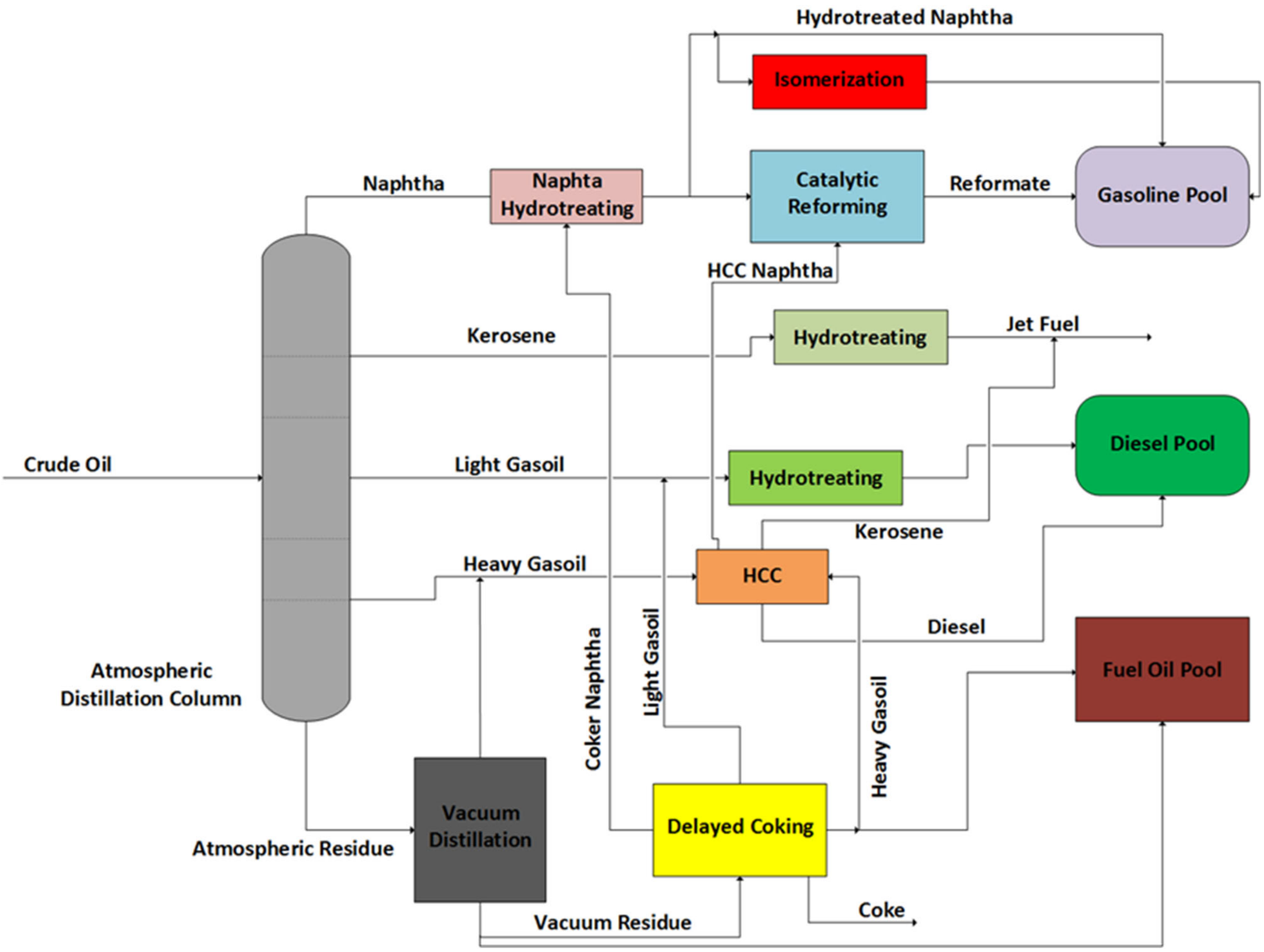


Figure 4 – Process Arrangement to a Refinery Operating Under Coking/Hydrocracking Configuration

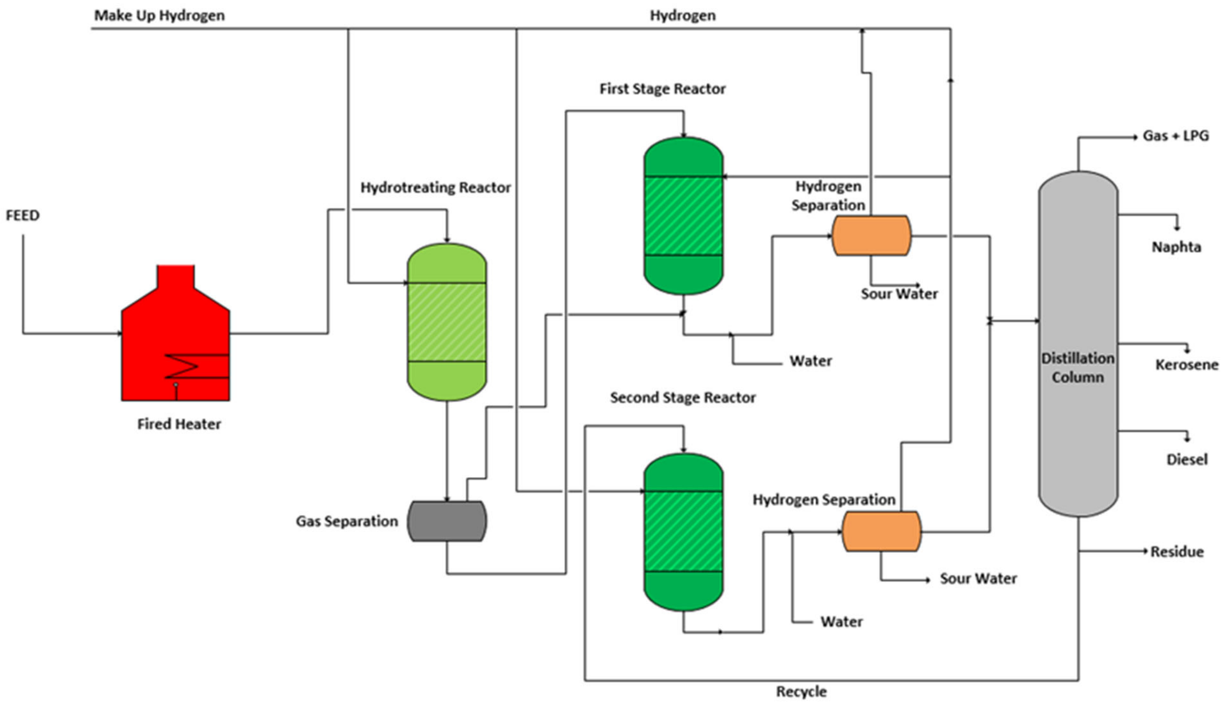


Figure 5 – Typical Hydrocracking Unit Dedicated to Treat Bottom Barrel Streams

Although the higher processing cost, to process heavy crudes can present high refining margin. As described earlier, the reduced acquisition cost in relation of lighter crudes, as well as the ease of access and reliability of supply, can make the heavy crudes economically attractive, mainly in countries like Canada, Venezuela, and Mexico that have great reserves of heavy and extra-heavy crude oils.

The flexibility of the refining hardware is a fundamental factor to ensure the competitiveness of the refiner in the refining market. Normally, the refineries are designed to process a range of crudes, and wider the range, according to the technical limitations, more flexible is the refinery related the processed crude slate, this characteristic is relevant and strategic taking into account the possibility to enjoy the processing of low-cost crude oils by opportunity besides giving more resilience to refiner in scenarios of restricting access to the petroleum market, mainly face geopolitical crisis.

The current scenario of the downstream industry indicates the tendency of reduction in the transportation fuels demand and the raising in the demand by petrochemical intermediates creating the necessity of growing the conversion capacity by the refiners in the sense of raising the yield of light olefins in the refining hardware. Furthermore, the new regulation over the marine fuel oil (Bunker), IMO 2020, should create even more pressure over the refiners with reduced conversion capacity.

In a first moment, aiming to comply with the new bunker specification, noblest streams, normally directed to middle distillates should be applied to produce fuel oil with low sulfur content what should lead to a shortage of intermediate streams to produce these derivatives, raising the prices of these commodities. The market of high sulfur content fuel oil should strongly be reduced, due to the higher prices gap when compared with diesel, his production will be economically unattractive, leading refiners with low conversion capacity to opt to carry out larger capital investment in order to give their refining hardware more robustness for the processing of heavier crudes.

The market value of the crude oil with higher sulfur content, normally the heavier crudes, tends to reduce after 2020. In this case, refiners with refining hardware capable to add value to these crudes can have a great competitive advantage in relation of the other refiners taking into account the lower acquisition cost of the crude oil and higher market value of the derivatives, raising then the refining margins.

Conclusion

As briefly described, heavy crude processing offers technological challenges to refiners, however, according to the geopolitical and the downstream industry scenarios, processing heavier oils can be a competitive advantage. The current scenario of the refining industry indicates a strong tendency to add value through the production of lighter products, mainly petrochemical intermediates. This fact, coupled with the need to produce bottom streams with lower contaminants after 2020 (IMO 2020), increases even more the pressure on refineries with low bottom barrel conversion capacity under risk of loss of competitiveness in the market, in this scenario it is possible to have a strong tendency of resumption in the capital investments in the preparation of these refiners to the processing of petroleum residues and heavier crudes.

References

SPEIGHT, J.G. Heavy and Extra-Heavy Oil Upgrading Technologies. 1st ed. Elsevier Press, 2013.

ROBINSON, P.R.; HSU, C.S. Handbook of Petroleum Technology. 1st ed. Springer, 2017.

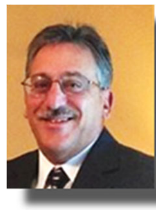
GONZALEZ, G. S. Junior Engineer's Training Course – Kinetics and Reactors. Oxiteno Company, 2003.

GARY, J. H.; HANDWERK, G. E. Petroleum Refining – Technology and Economics.4th ed. Marcel Dekker., 2001.

Author

Dr. Marcio Wagner da Silva is Process Engineer and Project Manager focusing on Crude Oil Refining Industry based in São José dos Campos, Brazil. Bachelor in Chemical Engineering from University of Maringa (UEM), Brazil and PhD. in Chemical Engineering from University of Campinas (UNICAMP), Brazil. Has extensive experience in research, design and construction to oil and gas industry including developing and coordinating projects to operational improvements and debottlenecking to bottom barrel units, moreover Dr. Marcio Wagner have MBA in Project Management from Federal University of Rio de Janeiro (UFRJ) and is certified in Business from Getulio Vargas Foundation (FGV).

Quarterly Safety Connector



For Engineers; Because Safety Is Part Of The Process! By: Chris Palmisano, MESH, IFSAC **Spring 2020**

The Benefits of a Safety Committee

I'm often asked by clients anguishing over numerous workers compensation claims, "What do we do to turn this ship around"? What's the best way to improve our performance NOW?

When asked this question, I typically follow with a question of my own, "Do you have a formalized Safety Committee"? I've learn over the years that companies benefit greatly from having a formalized Safety Committee, over those that do not. The success of a company depends greatly on the support and relevance given to their Safety Committee. Let's look inside the Safety Committee.

Companies that have a successful Safety Committee enjoy many benefits, such as increased awareness of safety issues, a decrease in injuries, quick response to hazard exposures and improved cooperation between all level of employees and management.

When it comes to your company's Insurance Premiums, many elements are measured to obtain that cost of premium, such as your number of employees, payroll, type of business you operate and your X-MOD, or (Experience Modifier Rate). The X-MOD rate is determined by your history and frequency of workers comp claims. Being able to inform your Insurance Carrier that you have a formalized Safety Committee is one of the few methods we have to gain leverage against high Insurance premiums. Another important tool for leverage is being able to tell the Carrier you have a RTW (Return-to-Work) program or Light-Duty Policy that accommodates injured employees placed on sedentary duty after a workplace injury.

The basic function of every Safety Committee should be to encourage and maintain a safe work environment by minimizing risk exposure. A Safety Committee should foster your Safety Polices, employees an opportunity to directly improve safety and reduce injuries within a company, while enhancing communication between management and staff.

To achieve success, a commitment to safety must become a shared responsibility between management and employees. Safety Committee members are responsible for developing and reviewing safety procedures and policies, investigating and reviewing accidents and communicating safety issues, training and/or policies to company employees.

Guidelines for Success

The makeup of the Safety Committee can vary depending on the needs, size and type of company. Consider the following elements when creating a Safety Committee:

Appoint a Chairperson or Leader: This person must display leadership skills such as, organization, dedication, excellent working knowledge of the company and be a person that has respect from the other Committee Members.

Diverse Membership: The committee should be comprised of management and non-management employees that represent all areas within the company such as manufacturing, sale, production, safety, maintenance, shipping and receiving and office/HR personnel. Limiting the size of the committee to 4 – 12 members will help keep meetings moving and allow for everyone to be involved. Members should have knowledge of company operations, safety hazards, possess a strong teamwork attitude and be able to effect change within the company's safety program.

When it comes to voting on important topics/decision the Committee Chair person should not vote, unless there is a tie in a vote decision. So to facilitate voting, always try to have an even number of committee members, without counting the Committee Chair.

Effective Committees Meet Monthly: Meetings should be scheduled at least monthly with a formal written agenda and last no more than one hour. Limiting meetings to under an hour keeps things moving and the agenda on track. In addition, it limits the time employees must spend away from their daily job duties. Even a committee that meets for only 15 minutes a month can make measureable positive change in a company's safety performance.

You may ask why not meet quarterly or bi-annually? The reason is simple, if one person misses a quarterly safety meeting for example, that person may be a key stakeholder on the team and as a result, the committee will go six months before that person will be seen again in a safety meeting. A lot can happen in six month, therefore meeting monthly provides the most effective performance in keep the Committee on task and moving forward.

Set an Agenda: Have a formal written agenda for each meeting that promotes at-the-least, the following:

- Record Of Attendance,
- Review Of Recent Accidents/Injuries,
- Old Business
- Unfinished or New Business,
- Safety Inspection Reports,
- Special Projects and/or Presentations.
- A Review of SDSs, Involving New Chemicals that Are Being Considered
- Monthly Safety Talks
-

Monthly Safety Talks should be leaders to know hazards. Some great example are disturbing heat related illness awareness safety talks in the early summer or driving on icing road safety talks, distributed in the late fall. Preplanned safety talk help us stay ahead of known risk exposures.

Minutes Recorder/Document the Committee's efforts: A written record of the meeting's proceedings should be prepared by the committee's Secretary. The recorder is probably one of the most important members of the team. Previous month's meeting minutes should be discussed at each meeting, as well as any follow-up decisions on action items. Meeting minutes are important! Their value in an OSHA investigation can be paramount in protecting the company, especially when allegations of negligence are made by OSHA. In addition, maximum benefit will be obtained by publicizing the Committee's minutes. The benefits include increased safety awareness and keeping employees and management updated on the progress

of the committee.

Duties and Functions of the Safety Committee

The duties and functions of a Safety Committee will depend on the needs of the company and hierarchical structure of the organization. However, typical responsibilities of the Safety Committee and its members may include:

Conducting periodic safety inspections: Inspections should not only include production areas, but should cover offices, warehouse areas and the outside of the facility. Document unsafe conditions by taking digital pictures of the situation. The photo should then be shared at the monthly meeting, as well as stored in an electronically shared folder for future reference.

Assessing injuries: Review the causes and circumstances of accidents/injuries and suggest corrective action.

Training employees: Keep employees informed by posting information on the company's intranet site, disseminating information at employee meetings and conducting training sessions.

Periodic reviews: Review existing company safety policies and develop new ones.

Gathering employee input: Listen to suggestions by employees, report them to the committee and make appropriate recommendations to management.

Getting management involved: Offering suggestions to management for the improvement of the safety program.

Creating employee awareness: Observe unsafe conditions or work practices, and report them to the committee, supervisors or management.

Every company can benefit from having a formal and functional Safety Committee. A Safety Committee will not only create a safer work environment, but also help involve other employees in the monitoring, education, investigation and evaluation of the company's safety effort. Additionally, the commitment to safety can impact the company's bottom line by reducing the number of costly accidents and injuries.

Chris is a Professional Risk Management Consultant, a former Philadelphia Fire Department Lieutenant and former OSHA Compliance Officer. He is the creator of the InSite GHS Hazcom Workplace Labeling System for Secondary Chemical Containers. https://stop-painting.com/ghs-secondary-labels-roll-of-100/
For questions about this article or his workplace chemical labeling system to meet the OSHA's GHS June 2016 requirement, you can reach Chris at: ChrisAPal@aol.com or at LinkedIn https://www.linkedin.com/in/chris-palmisano-696b3b6/


IACPE
INTERNATIONAL ASSOCIATION OF
CERTIFIED PRACTICING ENGINEERS
www.iacpe.com