

# Pig Trap Design And Assessment Considerations

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A pig trap must be designed to match the pipeline section design specifications. The mechanical design characteristics of the pig trap should meet or exceed the design pressure, have the same design factor, have compatible material type, be designed using the same design code and be suitable for the same temperature range as the pipeline section that it serves. Also, a pig trap must be dimensionally suited for the type of pigging that is expected on the pipeline section. The critical lengths of the barrels and line size pipe sections must be long enough to accommodate the longest pig that will be used in the pipeline section.

When deciding where to locate a pig trap, there are various things to consider. The pig trap should not be placed near any open flames or ignition sources. Many building codes and pipeline companies have rules and regulations about what type of powered equipment is allowed within certain distances of an opening to the pipeline such as a closure door. If the pig trap is to be located in an area where horizontal space is not at a premium (such as on an offshore platform or a refinery), then care should be taken to provide sufficient work space adjacent to the closure door for pigging operations. These operations can take the form of loading and unloading long inspections pigs, removal of liquids and debris from the pipeline and into a waste container, installation and operation of a temporary separator, etc.

Another consideration that is important to the safe and efficient operation of a pig trap is how the barrel is oriented at the pigging station. Any valves or instrumentation associated with the operation of the pig trap should be given adequate space to provide routine maintenance or replacement. The closure door should face away from other equipment and places where people typically congregate (i.e. break areas, parking lots, etc.). There have been rare occurrences where pigs have shot out of pig traps and damaged equipment, as well as, injured people. The oversized pipe section of a pig trap is not named barrel by coincidence.

In recent years, the energy industry has become increasingly focused on what effect its operations are having on the environment. The placement of a pig trap is also a concern in this area. When a pig trap is vented or a closure door is opened, forethought should be taken to minimize or eliminate the occurrence of hazardous contaminants within a pipeline from reaching the outside atmosphere or con-

taminating the nearby ground or water.

Pipeline companies that operate large-diameter pipelines should consider the use of material-handling equipment when it comes to conducting pigging operations. Mandrel or spherical pigs used in a pipeline that is 20 inches in diameter or large can be too heavy or awkward for one or two people to handle safely. In addition, even small-diameter inspection tools are typically too heavy and

long for one or two people to easily manipulate into or out of a pig trap. There are various designs of pig trays available on the market. Some pig trays have wheels while others are stationary. There are other pig trays that have automation for pushing a pig into or pulling a pig out of a pig trap. Many pig trays are fitted with drip pans for collecting liquids or fine debris that may fall off of a pig once it is out of the receiver. In some cases, lifting equipment may be necessary to move large pigs into position. Jib cranes, gantry cranes and fork lifts are all examples of pig-handling equipment.

Pig traps and pigging systems should be designed according to the same design codes as the pipeline to which they are connected. The predominant codes used for pipeline design in many countries are written by ASME. The ASME codes commonly encountered in the pipeline industry are ASME B31.4 which governs the design of liquid pipelines; ASME B31.8 which governs the design of gas pipelines; ASME B31.3 which governs the design of process piping and ASME Section VIII, Div. 1 and 2 which governs the design of pressure vessels (sometimes referred to as the Boiler Code). There are other codes in use that govern the design of pig traps such as CSA Z-662 in Canada or ASME B31.11 for slurry pipelines.

It is helpful to the purchaser of pipeline equipment to understand some of the differences among the commonly used ASME codes. ASME B31.4 – Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids (crude oil, liquid petroleum gas, anhydrous ammonia, alcohols and carbon dioxide) allows for design with certain steel materials – ASTM A694 F42 to F70, A707 L3 CL3,



Assessment Team members photographed at the time the article was written include (left to right) Chris Cloyde, Coleman McDonough and Robert Cortez.

A105, A350 LF2, A182 F316, A182 F51 (Duplex) and others; the design maximum allowable stress values are determined by design factors (0.72 or 0.6) multiplied by specified minimum yield strength (SMYS) of material; Pipe Wall Thickness Formula:  $wt = PD/2SF$  (wt=wall thickness; P=design pressure; D=pipe diameter(OD); S=allowable stress; F=design factor); based upon the allowable hoop stress of the material in question; welding standard is per API 1004.

ASME B31.8 – Gas Transmission and Distribution Piping Systems. Gas (not gasoline) as used in this code commonly refers to natural gas, manufactured gas and liquefied petroleum gas distributed as a vapor. This code allows for design with similar materials as in ASME B31.4. Design maximum allowable stress values are determined by design factor (0.8, 0.72, 0.6, 0.5 or 0.4) multiplied by SMYS of material. Design factors are related to population density in proximity of the pipeline. Pipe Wall Thickness Formula:  $wt = PD/2SF$  (wt=wall thickness; P=design pressure; D=pipe diameter(OD); S=allowable stress; F=design factor); based upon the allowable hoop stress of the material in question. Welding standard is per API 1004.

ASME B31.3 – Process Piping (has been referred to as refinery piping) Allowable materials are restricted to B31.3 “listed” materials – usually A105, A350 LF2, A182 F316. Some commonly used high-yield materials (i.e. A694 & A707) are not permitted under this Code. Design maximum allowable stress values are determined by the lesser of (1/3 x Su(tensile strength)) or (2/3 x Sy(yield stress)); the allowable stress values are found in B31.3 as “tabulated” values. Overall,

material thicknesses calculated using B31.3 tend to be more conservative or thicker than those calculated using B31.4 or B31.8. Pipe Wall Thickness Formula:  $wt = PD/2(SE+PY)$  (wt=wall thickness; P=design pressure; D=pipe diameter(OD); S=allowable stress; E=quality factor; Y=coefficient); based upon the tensile strength of the material. Welding standard is per ASME Section IX.

ASME Section VIII Division 1 – ASME Boiler & Pressure Vessel Code Rule for Construction of Pressure Vessels. Allowable materials are restricted to ASME Section II “listed” materials – usually SA105, SA350 LF2, SA182 F316. Some commonly used high-yield materials (i.e. A694 & A707) are not permitted under this Code. Design maximum allowable stress values are found in ASME Section II as “tabulated” values. Overall, material thickness calculated using ASME Section VIII Div. 1 tend to be more conservative or thicker than those calculated using B31.3. Pipe Wall Thickness Formula:  $wt = PR/2(SE-0.6P)$  (wt=wall thickness; P=design pressure; R=pipe radius(inside radius); S=allowable stress [lesser of (Su(tensile strength) divided by 3.5) or (2/3 multiplied by Sy(yield stress))]; E=quality factor); based upon the tensile strength of the material. U Stamp – the official Code U Symbol for stamp (marking) on the vessel or closure to denote inspection and testing in compliance with Code requirements.

All of the codes discussed can be used

to design pig traps. Inspection criteria vary among these different codes. Generally, given the same pipeline design parameters, a pig trap designed from ASME B31.3 will tend to be costlier than one designed from ASME B31.4 or B31.8 because of the difference in material grades and thicknesses. In addition, a pig trap designed from ASME Section VIII Div.1 will tend to be more expensive than one designed from ASME B31.3 for the same reasons.

### **Pig Trap/Pigging System Assessments**

Like any other piece of equipment connected to the pipeline, pig traps should be assessed at regular intervals for various reasons. The pipe and fittings that make up a pig trap will age and deteriorate over time. Pipeline companies may acquire existing pipelines with pig traps and it will be important to know the condition of these used assets. Some existing pipelines undergo a change in use whether it has to do with a reversal of flow direction or a change in product being transported. Existing pig traps can change the way they are used. A pig trap sized for cleaning pigs may need to be modified so that it can accommodate inspection pigs. A launcher may need to be changed from a manually operated pigging system to an automated pigging system.

A receiver may need to be modified so that it can receive more than one pig at a time. The initial design of the pig trap may be inappropriate for the current pipeline condi-

tions. At some point in the history of the trap, modifications may have been made that were inappropriate for the proper performance of the pigging system. These are all reasons for performing an assessment on a pig trap or pigging system.

The time it takes to perform a trap assessment depends on the level or levels of assessment required, the experience of the trap assessment team, the working conditions where the trap is located, the remoteness of the trap to be assessed (onshore and offshore) and the operational circumstances of the pipeline section at the time of assessment.

There is a difference between trap assessments and piggability assessments. A trap assessment is an evaluation on the piece of pipeline equipment used for introducing or retrieving a pipeline tool from the pipeline without interruption of pipeline flow. This assessment deals with the evaluation of an existing piece of pigging equipment or pigging system used for launching and receiving pigs or pipeline tools. In contrast, a piggability assessment is an evaluation of an existing pipeline for the purpose of determining the necessary modifications in order to make a pipeline section capable of safely launching, running and receiving pipeline tools.

### **Levels Of Trap Assessment**

A trap assessment can range in complexity and sophistication. There are many levels of

trap assessments that can be conducted. Let us look at a description of each level of trap assessment. It may be noted that each level of assessment increases in complexity.

The first level — or Level 1 — trap assessment is called a Research Assessment. This level of assessment explores the history and design parameters of the pig trap. It notes any modifications that have been made to the pig trap from the time of installation to the present, mechanical design limitations of the pig trap, the physical location or designation of the trap or pipeline section, trap dimensions, the location and use of each nozzle on the pig trap.

The Level 2 trap assessment is called an Operational Assessment. This level of assessment is concerned with the current-day operational condition of the pig trap and aspects of the overall pigging system. This assessment observes whether the closure opens, closes or seals properly, whether the pressure warning device on the closure operates correctly, whether the various valves on the pigging system seal adequately, whether the pig signal and pressure gauge work as they should and whether the kicker or bypass nozzles are sized properly.

The Level 3 trap assessment is called the Functionality Assessment. This level of trap assessment determines if the pigging system is performing to its peak effectiveness. If it is desirable to launch or receive inspection tools, is the trap or the surrounding area dimensionally capable of handling this operation? Are there physical obstructions (handrails, stairs, piping, etc.) that make it difficult to safely load or unload pigs? Are piping modifications needed to allow for inspection pigging? Should an equalization line be added across the trap reducer for safety or to improve pigging operations? Should additional vent and pressure gauge nozzles be added to the line size pipe for safety? Should additional drain nozzles be added to the pig trap? These are all questions that this level of trap assessment seeks to answer.

The Level 4 trap assessment is called the Corrosion Assessment. This level of assessment is the most complex and typically will require an NDE technician or engineer to be on the trap assessment team. This evaluation seeks to determine the existence of corrosion agents acting on the components of the pig trap and whether or not these corrosion agents have affected the structural integrity of the carbon steel enough to cause the trap to be unsafe to operate. Are liquid or debris samples being taken? If so, are the samples analyzed for corrosion agents? Are there sampling ports for obtaining liquid or debris samples on the pigging system? Have any inhibitors or biocides been applied to this pipeline section? If so, what was the name of the inhibitor or biocide used and what was the interval of application? Did the inhibitor or biocide have a positive effect or not? Have in-line inspections been conducted on this pipeline section? Has any form of NDE been conducted on the trap since it was installed? If so, has the data been analyzed to assess minimum pipe wall thicknesses? Is NDE performed regularly on the traps to monitor corrosion growth rates? If previous NDE data is provided, corrosion growth rates can be used to estimate the time when repair or replacement of the trap would be necessary.

## Trap Assessment Team

A Trap Assessment Team should be composed of the following members at a minimum:

(1) Team Leader/Project Manager — this member is responsible for the assessment team in the field and ensures that the necessary data is collected for the technical writer to create the assessment report.

(2) Project Engineer — this member is the technical expert on the design and operations of pig traps and pigging systems. This member can assume the role of Team Leader/Project Manager for economy of workforce.

(3) Technical Writer — this member assembles the data collected into a technical report which explains to the client the findings of the assessment.

(4) NDE Technician (optional member, for Level 4 Assessments only) — this member performs the non-destructive examination on the trap and provides the data to the Project Engineer for mechanical integrity evaluation.

## Conclusion

Pig trap development has occurred over many years and will continue as long as there remains the need to pig a pipeline. An understanding of the components, the function of each component and certain performance enhancing and safety features for a launcher and receiver helps one to grasp the function of the overall pigging system and procedures for launching and receiving a pig.

Design considerations should extend beyond the limits of the pig trap to the boundaries of the pigging station. Trap assessments are extremely valuable to the responsible pipeline operator that is concerned with the condition of the pipeline equipment and the safety of the pigging crews in the field. **P&GJ**

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## Assessment Procedure

1. Assemble as much information about the trap and pipeline section as possible before conducting the on-site assessment. Note the history of the trap, pipeline/trap design parameters, location, etc.

2. Onsite Assessment. a) Compare the existing trap with the as-built drawings. If there are any differences, note and sketch them. b) If an as-built drawing is not available, make a sketch of the trap with dimensions. Note nozzle sizes and use. Also note valve types, makes and condition in the pigging system. c) Question the operators and pigging crews about the pigging type, frequency and the operational condition of the different parts of the pigging system. d) Take pictures of the trap. Care should be taken to capture any areas of concern on the trap or pigging system. It has been said that a picture is worth a thousand words. These pictures will be useful as illustrations within the Assessment Report. e) If possible, look inside the trap and note the condition of the inside pipe wall and closure door. f) If a Level 4 Assessment is conducted, the NDE technician should take ultrasonic test readings and record them for further evaluation. g) Assemble the data in an organized fashion and transmit the data to the technical writer.

3. Write the Assessment Report and submit it to the client.



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