CORPORATE SEPARATENESS NOTICE

Management of each affiliate or other local entity implementing this Tier 1 Manufacturing Best Practice retains ultimate responsibility for adopting and implementing this best practice in its country or area of operation. Each affiliate or other local entity implementing this Tier 1 Manufacturing Best Practice has chosen to adopt and implement this best practice following its appropriate decision making procedures. Working relationships discussed in this material do not necessarily represent a reporting connection, but may reflect a functional guidance, stewardship, or service relationship. Where shareholder consideration of a local entity matter is contemplated by this material, responsibility for action remains with the local entity. Nothing contained is this material is intended to override the corporate separateness of local entities.

TIER 1 MANUFACTURING BEST PRACTICES - GENERAL SCOPE AND APPLICATION

This Best Practice has been designated a Tier 1 Manufacturing Best Practice, which has the potential to prevent or eliminate safety, health, environmental, or security issues that are higher risks. Implementation is mandatory at each Refining and Chemical site owned or operated by Exxon Mobil Corporation or its wholly-owned or majority-owned affiliates adopting Tier 1 Manufacturing Best Practices and is the responsibility of Line Management. Target implementation timing has been developed by the relevant Leadership Council, with review and endorsement by the Global Manufacturing Leadership Council (GMLC). This Best Practice shall be implemented within twelve months from GMLC endorsement. Any site deviation from recommended implementation timing or a site or capital project decision not to implement a Tier 1 Manufacturing Best Practice requires Regional Director endorsement. All new capital investments must comply with Tier 1 Manufacturing Best Practices. Compliance with local laws and regulations and timing of such compliance are independent of the requirements expressed here. **For clarity, use of the term "shall" in this Tier 1 Manufacturing Best Practice denotes a mandatory requirement for sites adopting this best practice and use of the term "should" denotes an advisory recommendation.**

1.0 SCOPE

The purpose of this Tier 1 Manufacturing Best Practice (BP)is to provide guidelines for reducing risks associated with plugging and hydrotest of corroded or leaking tubes in shell and tube exchangers, air fin exchangers and tubular reactors where immediate tube replacement is not practical. The guidelines are also suitable for plugging tubesheet holes after tubes have been removed. In some circumstances it may be possible to sleeve damaged tubes as an alternative to plugging. For additional information on this option contact Core Engineering or EMRE.

The safety considerations of this BP are applicable to future hydrotests on equipment containing previously plugged tubes, as well as hydrotests following tube plugging repairs. Application of the BP is not retroactive.

2.0 INTRODUCTION

The maintenance plugging of tubular exchangers or reactors have the potential to result in significant personal safety concerns as a result of a tube plug being ejected at high velocity during a post repair hydrostatic test1) or during subsequent hydrotests.

Plug failure during operation2) will also impact the mechanical reliability of the equipment and may result in additional maintenance and lost opportunity costs. In addition failure to vent or cut plugged tubes in an appropriate manner can lead to subsequent equipment damage.

The purpose of this document is to consolidate affiliate feedback and lessons learned on various aspects of tube plugging and to present this as a Best Practice in order to assist affiliates in reducing safety and reliability risks associated with tube plugging. The information in this practice was originally obtained via the Fixed Equipment Network discussion group and has been documented in the lessons learned section of the KBS.

1) High pressure water jetting of tubesheets may result in loosening of plugs and lead to safety concerns. See attachment 3.

2) Unwelded plugs, including engineered plugs may be unsuitable in some services - see table 1 and attachment 3

2.1 TUBE PLUGGING POTENTIAL SAFETY CONSIDERATIONS

1. The principal safety concern with plugging tubes is a plug blowing out at high velocity, particularly during the post plugging hydrotest. Since all plugged tubes should be holed or cut, exchangers with high pressure on either the shell or tube sides pose a more significant risk.

2. Consideration shall be given to the possible disturbance of plugs and increased risk of plug ejection during a hydrotest following high pressure jetting, or plugs which have been exposed to services defined in table 1 note 7.
3. Plugs shall never be hammered while the exchanger is under pressure.
4. All leaking tubes shall be cut or drilled positively behind the tube sheet to vent off any pressure buildup.
5. Plugs shall be seal welded, except where justified per section 4.4, or an engineered plug should be used to reduce the risk of plug blowouts.
6. Engineered plugs shall be selected and verified in accordance with manufacturer's standards, based on actual tube/plug dimensions, which account for the effects of tube cleaning or corrosion/erosion on tube internal diameter.
7. Personnel shall never stand in front of the tube sheets while the exchanger tube bundle is under pressure. Inspection shall only take place after the test pressure is reduced to a predetermined safe pressure (e.g. design pressure). All inspection shall be done from the side, at a safe distance, during the hydrotest.
8. Consideration should be given to placing a substantial safety shield or barrier in front of exposed exchanger tubesheets during pressure testing to contain a potential high velocity plug, should it be dislodged. Such a shield or barrier shall be mandatory in the case of unwelded hammered plugs.
9. Caution is required if the tube is perforated and filled with flammable material in service, as the bundle may not be gas free, and therefore could be dangerous to work on.
10. Prior to removing a plug, the inspection records shall be consulted to confirm that the tube was perforated. If any doubt exists, assume that it has not been perforated. If it is suspected that a plugged tube was not perforated, or that the tube may have become pressurized, then the precautions suggested below are required during plug removal. ªIf the plug is seal welded, the weld integrity should be confirmed using Dye Penetrant then the plug may be drilled to relieve any pressure present before attempting to remove it. ᵇIf the plug is not welded, no attempt shall be made to remove it, until a thorough method statement has been developed and this has had an appropriate safety and risk review.

2.2 TUBE PLUGGING PROCESS EFFICIENCY CONSIDERATIONS

Tube plugging results in four effects per tube pass which should be considered in terms of process efficiency and potential EDD's.

1) Reduces the effective heat transfer surface in proportion to the change in tube numbers.
2) Increases the tube side velocity in proportion to the change in tube numbers.
3) Increases the tube side pressure drop in proportion to the square of the change in tube numbers.
4) Increases the tube side heat transfer film coefficient. (This does not compensate for the loss of heat transfer area).

The practice recognizes and endorses various types of plugs, which are classified into two general categories.

a) Hammered plugs: which may or may not be seal welded.
b) Engineered plugs: typically these are expanding plugs and are commercially available. These can be installed by a contractor or by maintenance personnel.

3.0 PLUG TYPES

Hammered Plugs: This type of plug can take the form of a Solid Tapered Plug, Counterbored Tapered Plug, or Two Piece Plugs. All are driven into a tube with a hammer.

Solid Tapered Plug: A Standard Tapered Plug is a metallic plug, of compatible metallurgy to the tube to be plugged, with an approximate 2 percent taper. The plug is manually hammered home and the axial movement is typically around 10 mm (0.4 in) for a 2 percent taper on a 19 mm (3/4") diameter plug. The contact is roughly a point load. The plug may be provided with a tapped blind hole in the outer end to facilitate installation and removal. e.g. into an air fin header box.

Counterbored Tapered Plug: A counterbored Tapered Plug is the same as the Standard Tapered Plug, but with the plug counter bored to about half length, or around 10 mm (0.4 in) below the final surface of the tubesheet when hammered home. This provides some flexibility on the wall of the plug and reduces the point contact loads on the tube and stress in the tubesheet ligaments. The plug wall thickness is typically similar to the uncorroded tube thickness.

Two Piece Plug: This plug consists of an outer ring which has no taper on the outside diameter, but a tapered bore and an inner pin with a matching tapered OD. The outside diameter of the ring is custom made and machined to give a snug push fit into the tube, is typically about 50 - 60 mm (2 - 2-1/2") long, and has a shoulder equal to the tube thickness and tube OD. This stops it being driven into the tube, however it is good practice to grind the tube end flush with the tubesheet prior to inserting this type of plug. The minimum wall thickness of the outer ring is typically 2 mm (0.080 in). The inner diameter of the outer ring and the outer diameter of the inner pin have matched 1-% tapers. The wider diameter is at the tube sheet face. The inner pin is hammered into the outer sleeve just like a solid taper plug. The advantage of this type is that there is no relative movement or damage between the plug and the tube, and the seating load between the plug and tube is more uniform over its entire length.

Engineered Plug: An Engineered plug is a serrated or grooved expanding two piece plug, which is designed with an "engineered" pull that correctly expands the plug by applying a specific load or movement relative to the tube ID. Satisfactory experience has been obtained with several types of expanding plug, which are illustrated in attachment 1:

Several engineered plugs have been reported to have exhibited movement following hydrotest. This is believed to be due to incorrect plug selection relative to the "actual" tube ID. It is essential that the actual tube ID is measured and that the selected plug is within the manufacturer's application limits. See also table 1 for limitations in the use of engineered plugs.

a) Expansion Seal Technologies' "Pop A Plug" b) Furmanite's expanding plug. C) USA Industries "Snap-it Jr Plugs"

Note:
These illustrate typical engineering plugs. Similar products are available from other vendors.

The Pop A Plug and Snap -it, snaps off a shaft at a set load and the Furmanite plug is set by torquing a nut. Both these plugs are expanded from the back side of the tube sheet, therefore additional shell side pressure tends to increase the plug seating load, rather than reduce it, as occurs in a hammered plug. The attached Pop A Plug data sheet illustrates the considerations and information required prior to using these types of plugs. (Note the Go-NoGo gauge to check tube/plug compatibility).

The Pop A Plug can also be used in conjunction with a hammered plug to seal a thick tubesheet. In this case the Pop A Plug is applied to the back of the tubesheet and a hammered plug to the front. The Pop A Plug can also be installed at the rear end of a bundle allowing plugging of remote locations

4.0 PLUG SELECTION

The selection of plug type may be risk based and or driven by factors such as time available for repair, tube/tubesheet metallurgy or condition of tube/tubesheet. Table 1 and the notes below provide some guidance in selecting a suitable plug type.

1) Hammered plugs can be of three generic types. 1) Solid taper, 2) Counterbored taper or 3) Two piece taper. Plug types 1) and 2) typically have a 2% taper and type 3) typically would have a 1% matching taper between the mating parts - taper expressed as change in radius over length. Typically plugs have a length of 50 - 60 mm (2 - 2-1/2").

2) Plugs should be of a similar metallurgy to the tube being plugged in order to have compatibility of mechanical properties, thermal expansion and corrosion resistance. For seal welding compatibility between tubes, tubesheets and plugs needs to be considered. Note: Some plug suppliers may offer AISI 4142 (1% Cr) plugs as standard for all applications. Material suitability should be assessed and PMI applied if critical. See attachment 3 for example of an engineered plug of similar metallurgy leading to microbiological induced corrosion.

3) The plug type shall take account of the corroded surface condition of the tube to be plugged, its ability to be seal welded and the condition and strength of adjacent

tubes and surrounding tubesheet ligaments. e.g. a hammered plug resulting in high point contact may damage tubesheet ligaments or disturb adjacent tubes in damaged or brittle situations. Any tapered plug will also result in a crevice between the tube ID and the plug. The crevice will normally be exposed to the shell side process conditions.

4) Seal welding is recommended for all hammered plugs made from carbon steel, stainless steel, monel and other easily weldable materials used in equipment with a shell side flange rating greater than ASME B16.5, Class 150#. Seal welding may be waived where there is concern that welding may create additional problems for adjacent tubes, where the welding is impractical or where the risks arising from a plug blow out have been fully considered and appropriate actions taken.

   If hammered plugs are used in services with shell side flange ratings of 600# or greater per ASME B 16.5, then strength welding to the tube and tubesheet wall is required. One option to achieve this is to cut the tube back 6 - 12 mm behind the tubesheet face and weld the plug to the tube end and the tubesheet hole by a two pass process.

   If a hammered plug is not seal welded for any reason the risk of plug blow out during hydrotest must be understood and mitigated by suitable safety procedures

   Although consideration may be given to brazing brass and copper-nickel plugs this is often not practical. Admiralty and Cu-Ni can be welded with Ni base fillers like Inco Weld A or Inco 182.

   Some care may be required with the application of a welded plug in a rolled only tubesheet due to possible deformations at adjacent tubes arising from the process of inserting the plug and/or the heat of welding. This situation may justify waiving seal welding in lower risk situations and the use of a two piece plug or engineered plug.

5) Expanding (engineered) plugs are subject to limitations defined in table 1. These plugs are convenient but require more detailed pre planning and QA checks to ensure the correct size plug is selected relative to the actual tube ID, surface condition, joint detail and tubesheet thickness. Two acceptable types of engineered plugs are illustrated in attachment 1.

6) In some cases, it may be desired to extract the leaking tube. e.g if the tube surface is badly corroded or vibration is a concern. In this case plugs can be installed directly in the holes on both tubesheets or within a short sleeve of compatible tube inserted into the tubesheet hole. The tube piece used as the sleeve should be longer than the tubesheet thickness, extending both sides of the tube sheet and is first rolled and expanded, followed by plugging. This process protects the tubesheet hole from damage and is useful if the tube will eventually be replaced. If a tube insert is not used an alternative would be to use a countered bored or two piece plug or an engineered plug.

5.0 TUBE HOLING / CUTTING:

1) When plugging tubes, the tube shall be either holed or cut. This is necessary to prevent pressure build up within the plugged tube as a result of gas diffusion or blocked-in fluid expansion, or to minimize differential expansion stresses between the plugged tubes and adjacent unplugged tubes. The latter problem can arise where the plugged tube will assume the shell side temperature while the unplugged tubes will be at operating temperature somewhere between the shell and tube side temperatures. If a tube is already holed by virtue of a leak, and cutting is not necessary, then additional; holing may not be necessary. Long air fins are a particular example where cutting is typically required. As a guide, consideration should be given to cutting tubes if the mean metal temperature difference between the plugged and unplugged tubes exceeds 28c (50F). Special tools are available to properly perform internal tubing cutting.

2) To provide maximum venting and drainage, U-tubes and straight horizontal tubes should be holed on the bottom of the tube at both ends. Vertical tubes should be holed at both top and bottom.

3) Additional considerations may be required if a cluster of adjacent tubes are to be plugged and cut, as this may reduce the support of the tubesheet provided by the staying action of the tubes. Such cases are not uncommon. As a guide, an engineering review is recommended if nine or more adjacent tubes are involved on a fixed tubesheet design, or if the shell or tube side of the exchanger has a pressure/temperature rating of ASME B 16.5 600# or greater.

4) When tubes are cut, consideration needs to be given to the possibility of the cut tube vibrating in service and damaging adjacent tubes. Where this is a concern, complete removal of the tube is the best approach. If this is not possible internal support by bridging the cut can be achieved using an extended solid taper plug. The extended inner end of the plug should be untapered and should have a diameter that achieves a snug push fit inside the tube. The installed plug shall be seal welded. This type of action may be required for high velocity shell side vapor phase conditions.

6.0 PROCEDURES FOR TUBE PLUGGING

1. Identify the exact locations of tubes in the exchanger which require plugging. Leaking tubes shall be clearly marked at both ends.
2. Determine the tube size, the type of tube/tubesheet joint and tube material.
3. Select the plug type and material to be used with the help of table 1 and the notes of sections 3 & 4.
4. Clean and descale the tube end ID.

5. Measure the tube ID and reconfirm the plug has been correctly selected.
6. Determine whether the tube needs to be cut or holed using the guidance of section 5 and internally perforate all tubes before installing the plugs. If for any reason, the tubes are not perforated or cut, this shall be documented for future reference, and to provide essential safety information to maintenance crews who may have to remove the plug in the future.
7. Determine whether there is a concern for vibration damage from a cut tube using the guidance of section 5.
8. Determine whether the plug needs to be welded or brazed using the guidance of section 4 and review and approve the welding procedures to be used. If welding or brazing is not to be applied, conduct a task risk assessment to review the hydrotest and inspection plan.
9. Fit the plug. In the case of hammered plugs, judge the amount of axial plug movement required by hammering against the suggestions in section 3.
10. Conduct a leak test. (Caution: See Section 2.1, "Tube Plugging Safety Considerations" prior to proceeding with this step). For shell and tube exchangers and tubular reactors where the shell pressure is the higher, then a single test is adequate. If the tube side pressure is highest, a second tubeside test may be required. Since a plug could at some time be subject to a full hydrostatic test, the test pressure should generally be 150% of design pressure, however there may be cases where an alternative test pressure is appropriate. Appendix 2 contains a summary of considerations and practices taken from the FEEN mechanical archive and may be used in selecting an appropriate test pressure and/or closure leak test pressure.
11. The location of all plugged tubes and the status of holing or cutting shall be documented on a suitable sketch or tubesheet drawing.

Table 1

Plug Type Selection Guidance

Criteria	Solid Taper Plug	Counterbored Tapered Plug	Two Piece Plug	Engineered Plug (Note 6)
Shell side flange rating <= 150# and plug not welded.	✓ Note 6	✓ Note 6	✓ Note 6	✓ Note 8
Concern for mechanical damage to adjacent tubes, stress corrosion cracking of tubesheet or crevice corrosion due to driving in tapered plugs.			✓ Note 2	✓ Note 8
Concern for welding induced damage to adjacent tubes or rolled only tubes.		✓ Note 3	✓ Note 2	✓ Note 8
Shell side flange rating > 150# and plug seal welded.	✓ Note 4	✓ Note 4		
Shell side flange rating > 150# and plug not welded.	✓ Note 7			✓ Note 8

Notes 1 and 5 apply in all cases

Notes

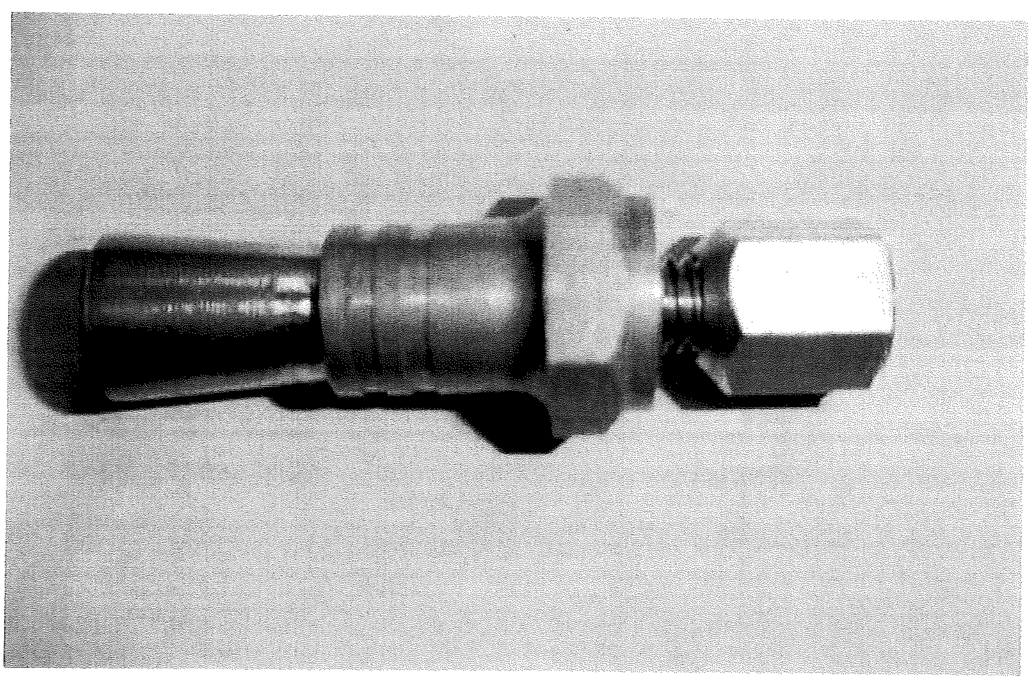
1) A task based risk assessment shall be conducted to ensure adequate safety precautions are in place to avoid injury or damage due to a potential plug blow out during hydrotest, or subsequent plug removal.
2) If shell side pressure rating greater than ASME B 16.5 150#, weld pin to ring.
3) Do not use if shell side pressure rating greater than ASME B 16.5 150#
4) Strength welding required for shell side pressure rating of ASME B 16.5 600# and above.
5) The plug should be of a similar metallurgy to the tube.
6) Hydroblast cleaning procedures shall be reviewed to minimize the risk of inadvertently unseating plugs. e.g. BPEP cleaning procedures limit hydroblasting pressure to 12 ksi (827 bar) when Pop-A-Plugs have been used - see attachment 3.
7) Although an unwelded solid tapered plug is not desired in services > 150#, it may have a lower failure probability compared to engineered plugs depending on the service.
8) Engineered plugs are not recommended in the following services due to observed failures:
   1. Services where flow induced vibration is a known issue
   2. Where the tube side pressure exceeds the shell side pressure by 50 bar (725 psi)
   3. Services containing solids with significant kinetic energy such as coke in tube side flow
   4. In tubes with severe corrosion or scale in the tube ID
   5. Where cross contamination from a tube plug failure can have a significant impact

Attachment 1

a) POP A PLUG - Typical data sheet.

"Pop A Plug Spec Sheet.pdf"

b) FURMANUTE PLUG - Photograph



Attachment 2

Summary of leak testing practices and considerations

- The "89 EEEL 925 - MASCOM Heat Exchanger Maintenance Manual" provides a summary of common maintenance practices The following guidance is provided:

  If there have been no weld repairs to the pressure parts of the exchanger, or no loss of metal thickness which requires proving by a strength test, then maintenance pressure testing can be confined to a leak test of the tube / tubesheet joints of the bundle. Shell side testing for leak testing of flanged joints is not considered necessary unless there have been in-service leakage problems."

  Tube bundles in good, uncorroded condition - test tubeside to 1.5 x operating pressure [1)] Tube bundles with corrosion or have been repaired or tubes plugged - tubeside full hydro as per original test. Tube bundles which failed either of the above two tests -- test at full hydro after repairs made.

  1) A common alternative hydrostatic leak test is 1.1 x design pressure.

- Hydrotest pressure may not always correspond to 150% of design pressure. Test pressure for vessels built to codes other than ASME 8 Div 1 or Div 1 post 1998 may have a different test basis. The original test basis should normally be adopted.

- The membrane stress arising from hydrotest should be limited to 90% of the specified minimum yield strength, except in cases where a specific Fitness for Service assessment has been conducted.

- In cases where equipment thickness has been reduced due to corrosion, or where continued operation is contingent upon a Fitness for Service assessment, the test pressure may have to be based on the MAWP or other documented failure basis. This basis should consider the corroded condition at the end of the anticipated run length.

Attachment 3

Experience with the failure of engineered plugs.

Incident following HP jetting

A near miss occurred at BPEP with engineered Pop-a-Plugs. Several previously applied plugs appear to have been loosened by the action of high pressure jet cleaning on a tubesheet. The fact that engineered plugs are tightened by exerting load from behind the plug, may be significant, since the force applied to the plug from jetting will be in the opposite direction and in extreme cases may unseat the plug.

An investigation revealed the following:

- This was the first occurrence of hydro-blasting unseating a Pop-a-Plug to the knowledge of Expansion Seal Technologies.
- The exchanger in question was in fouling (polymer) service and a new cleaning contractor was being utilized. No issues had arisen with the previous cleaning contractor.
- The new contractor was using higher pressures and a different type of lance than had been previously used. The new contractor used an 18ksi (1241 Bar) straight lance to clean the face of the tubesheet and was unaware that the exchanger contained plugs. Plugs were partially obscured by polymer fouling.
- Approximately 20 plugs moved during shell side hydrotest and one plug was ejected.
- Expansion Seal Technologies stated that the blowout pressure for these plugs "as-new" was between 2800-3800 psi (193 - 262 Bar). They also examined the plugs after the fact and stated that they looked "peppered with scars" as though they had taken direct blasting.
- BPEP have revised the cleaning procedure to require a 45degree rotating head and pressures of 10-12ksi (689 - 827 Bar), when cleaning the face of the tubesheet. This procedure has been tested on a plugged bundle and no visible damage or noticeable change in the force required to remove the plugs after cleaning was noted.
- The importance of having a marked-up drawing illustrating the plugged tube locations was emphasized, particularly when a new cleaning contractor is used.

Incident on HP HEX subject to flow induced vibration, corrosion and incorrect installation

Two consecutive leakages occurred on a HP BFW HEX due to dislodged plugs.

- Between March to July 2007, 74 P2 plugs were installed (U-Tube top 37, bottom 37) due to tube leakage during operation.
- After the Hex was commissioned for several months it leaked again in December 2007,
- PNR, P2 plug installer / vendor was called in to investigate the cause of failure. PNR claimed that there were 24 pcs of P2 plugs pin protruding out of the tube sheet that probably caused the plug to fail.

- The incorrectly installed P2 plugs were removed and replaced with tapered welded plugs. The remainder of the 50 pcs P2 plugs were re-inspected and confirmed by PNR to be in satisfactory condition.
- Tubeside hydrotest was carried-out at 28980Kpag, no leakage was observed.
- After the Hex was commisioned in December 2007, it leaked again. A P2 plug was found to be missing from one of the plugged tubes.
- Decision was made to remove all the remianing 50 pcs P2 plugs and replace it with tapered welded plugs.
- The exchanger is U tube with helix baffle. The bundle has experienced two earlier tube failure due to vibration in March and June 2007. EMRE Dimbled tube support (DTS) were installed in June 2007. DTS was confirmed intact during Dec 2007 repair/inspection.
- Tubeside is BFW service at 180 bar design pressure and shell side is BPA service at 36 bar design pressure. Though poor installation of plug can not be discounted as the root cause, high pressure difference together with vibrating environment are thought to be the primary contributory factors.
- The following is considered to introduce a high risk of failure of engineering plugs
    1. flow induced vibration
    2. tube side pressure greater than shell side pressure by 50 bar as plug may get lossened-(pressure difference is 100 bar (tube side minus shell side) 50 bar is suggested as half of that value.
    3. tube heavily expanded
    4. solid particle in tube side flow as it may hit the plug and loosen it
    5. severe corrosion or scale in the tube ID
    6. caution also required if the plugs have metal bars protruding outside the tubesheet surfaces as they may get knocked and loosened during handling.

Incident resulting from Microbiological Induced Corrosion (MIC)

- During the ROP TA (oct. '07) several corroded tubes (MIC) were discovered in a brackish water condensor.
- The tubes were preventively plugged using IPCO engineered plugs.
- The tube materials is 254SMO and monel plugs were used.
- Based on the findings it was decided to upgrade the bundle to titanium in the US early '09. However last August another leak was discovered in the same condensor. We expected some more leaking tubes. However to our surprise we discovered severly corroded plugs at the floating tubesheet.
- Consultation with Core Engineering revealed that the monel changed from passive to active due to MIC. In the small dead ends created by the plugs MIC caused a sulfuric acid-like environment which altered the monel behaviour from passive to active corrosion.
- At the channel side the zinc anodes protected the active monel plugs from severe corrosion. At the floating tubesheet no anode was present other than the small plugs. Hence a high corrosion rate.
- In contrast we removed some hammered 316-plugs which were only slightly corroded after 3 years of service. The 316 hamered plugs didn't create a dead space and 316 does activate in an oxidising environment. Therefore the corrosion rate was only moderate.

Revision History

Rev 1 (1/3/08)
- Updated sections 1.0 and 2.0 with comments on hydrotests
- Corrected paragraph reference in paragraph 6.0(10)

Rev 3 (22/12/08)
- Updated to reflect experience and lessons with failures of engineered plugs.
- Minor narrative changes and updates to sections: 2, 2.1, 3, 4.2, 4.4 , 4.5
- Change to table 1 selection criteria for engineered plugs including comments from EMRE
- Update to attachment 3 summarizing incidents with engineered plugs.

Rev 4 (9/09)
- Corrected "should shall" to "shall" in introductory paragraph