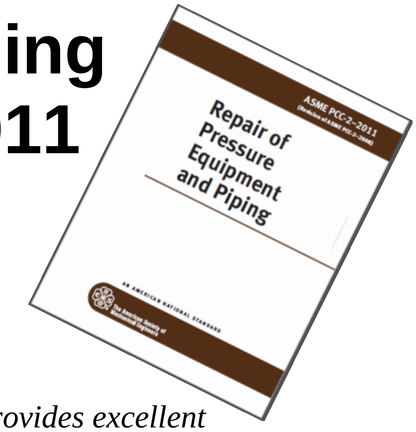
Heat Exchanger tube plugging relative to ASME PCC-2 2011



Abstract

The 2011 issue ASME PCC-2 (Repair of Pressure Equipment and Piping) provides excellent guidance in Article 3.12 in regards to "Inspection and Repair of Shell and Tube Heat Exchangers". Specifically paragraph 4.2 deals with "Tubeside Repair by Plugging". This paper describes the various options of ASME PCC-2, and the associated limitations. The ultimate goal to reducing unnecessary downtime is to determine a strategy which includes the review of all the heat exchangers on a given location to accomplish implementation of a safe, reliable and fast tube plugging maintenance system meeting the ASME PCC-2 code requirements.

H.M. (Rik) Warmerdam, EST Group B.V, The Netherlands

Introduction

Plugging leaking or degraded tubes in heat exchangers is a common practice throughout any industry and ranges from condensers operating under vacuum to ultra-high pressure heat exchangers exceeding 6000 PsiG (414 BarG) design pressures.
The “how to perform plugging” has never been addressed before as detailed as in the ASME PCC-2 (Repair of Pressure Equipment and Piping). Needless to mention there are hundreds of corporate and site standards in existence today but they have been typically developed from actual positive or negative experiences of a particular site and production process. Article 3.12 addresses "Inspection and Repair of Shell and Tube Heat Exchangers", and specifically paragraph 4.2 deals with "Tubeside Repair by Plugging".
This paper provides a better insight of how PCC-2 can be viewed and implemented and how it can provide a cost saving
As the global heat exchanger designs change in relation to 1) Materials being used (Tubes are available is more material groups and grades as ever before, clad overlays on substrate tubesheet materials) and 2) Processes of joining tube to tubesheet (various expansion and weld processes) there is a requirement for a better review.

ASME PCC-2

Article 3.12 Paragraph 4.2 says :

Tubeside Repair by Plugging
Repair of tubes may be accomplished by plugging the tube at the tubesheet with a welded or mechanical attachment.

(a) *All tubes that are plugged should be pierced to provide for venting and draining. When doing so, vertical tubes should be pierced at each end, and horizontal tubes should be pierced on top and bottom of the tube. Piercing of each tube prevents possible plug blowout and permits the validation of the integrity of the tube plug, see para. 4.2(b)(4). Large temperature differential* between tube side and shell side may require the tube to be cut in two.

Fig. 1 Typical Friction Fit Tapered Tube Plug

(b) Friction fit tapered plugs (Fig. 1) **shall only be used in services that meet all of the following conditions**, unless an engineering evaluation is performed indicating the acceptability of these plugs in other services:

(1) shell-side operating pressure 1.5 MPa (200 psi) or less.

(2) shell-side operating temperature 205°C (400°F) or less.

(3) tube-to-tubesheet joints are expanded and not welded.

NOTE: Inspection of the expanded tube for tube thinning should be made to ensure that installation of the plug does not further damage the tube leading to seal failure between the plug and the tubes.

(4) tapered plugs that are installed where tubes are not pierced can present a serious safety hazard. If the tube cannot be pierced, the tube should be pulled or other measures should be taken to ensure personnel protection, such as welding the plug to the tubesheet and draining all liquids from the tube being plugged.

(c) Mechanical plugs (Fig. 2) should be considered in situations where friction fit tapered plugs are not appropriate for the pressure and/or temperature of service or other mechanical/environmental conditions.

Fig. 2 Typical Mechanical Fit Tube Plugs

These types of plugs have been used in services of up to 50 MPa (7,000 psi) and 595°C (1,100°F). Mechanical plugs are typically installed by a pneumatic or hydraulic system. See Fig. 3.

Fig. 3 Typical Installation of Mechanical Fit Tube Plugs
(©2006 Photo courtesy of EST Group Inc., used with permission.)

Other styles of plugs may be considered for higher pressures. Consideration shall also be given to the following:

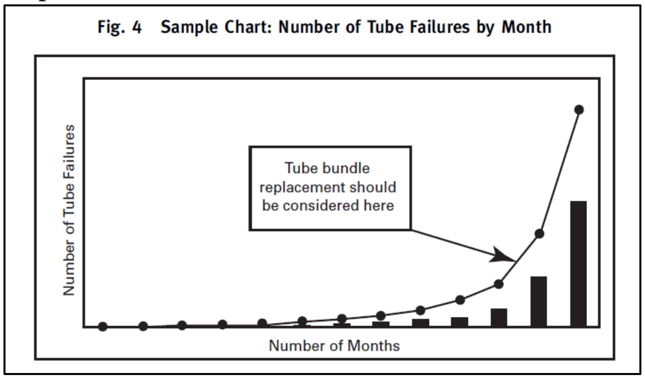
(1) tubes with internal surface severely corroded or cracked

(2) when the tube and the plug have dissimilar metallurgy

(3) installation in severely corrosive service

(4) condition of the mechanical joint of the tube-to-tubesheet in rolled tube situations

(d) *A plug map should be developed to record the number and location of tubes that have been plugged. Additionally, the number of tubes, cumulative number of tubes versus the duration, should be charted. When the sharp turn in tube failure numbers occurs, replacement of the tube bundle should be considered. See Fig. 4 for example chart.*



(e) *Tracking of pressure loss due to tube pluggage should be considered as some exchanger types cannot function properly beyond certain tube side pressure losses. Provisions for internal bypass should be considered*
if repair is not performed in order to prevent failure of pass partitions. Proper design of this bypass can be determined from industry references in section 7 of this Article.

Primary Points Summary

A) Always pierce the tube prior to plugging.
Note : Should piercing or or pulling the tube not be possible then extra safety precautions must be taken. Plugs of all types can act as projectiles when exposed to pressure.

B) Friction fit plugs only allowed in tubes which meet all conditions : expanded, non-welded, below 15 BarG and below 205 Deg.C.
Note : Unless an engineering evaluation is done.

C) Consider Mechanical Tube Plugs where Friction fit plugs are not appropriate for pressure and temperature.

Note : These types of plugs have been used in services of upto 50 MPa (7,000 psi) and 595°C (1,100°F).

D) Special consideration needs to be given to :

- Dissimilar tube and plugs materials
  Note : Avoid where possible!!
- Severely corrosive service.
- Tubesheet joint condition
- Tube internal condition corrosion, cracking.
- Map tube plugging activities and pressures losses relative to performance.

Reality and Practical Side

The Pop-A-Plug® Fig 4 system is a mechanical tube plug to seal leaking or degraded high-pressure heat exchanger tubes. The design objective was to produce a fast and simple to install mechanical tube plug with the same or better installed stability than a friction fit or welded plug.

Figure 4. EST Group Pop-A-Plug®

The Pop-A-Plug® system eliminates the need for hammering or welding tube plugs. The system is long proven in fossil fuel and nuclear power generation stations. The Pop-A-Plug® heat exchanger tube plugging system is the only plug that features external and internal serrated rings designed to maintain a leak-tight seal under extreme thermal and pressure cycling.

The Pop-A-Plug® is installed using a controlled force, which protects against damage to tube sheet ligaments and the adjacent tube sheet joints.

Thus the life of your heat exchanger is extended and costs are reduced when you need to re-tube.

Another advantage is the Pop-A-Plug® system takes only minutes to install.

The system is available in a wide array of materials and can be matched to the tube or tube sheet it is installed in. Matching the material eliminates differences in thermal expansion rates and ensures a perfect seal is maintained during temperature cycles experienced by the heat exchanger.

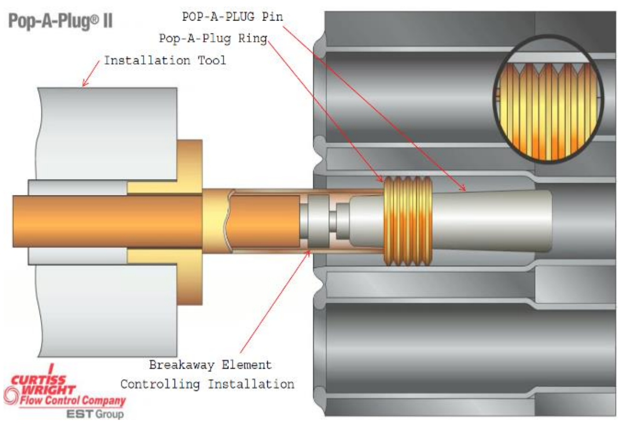
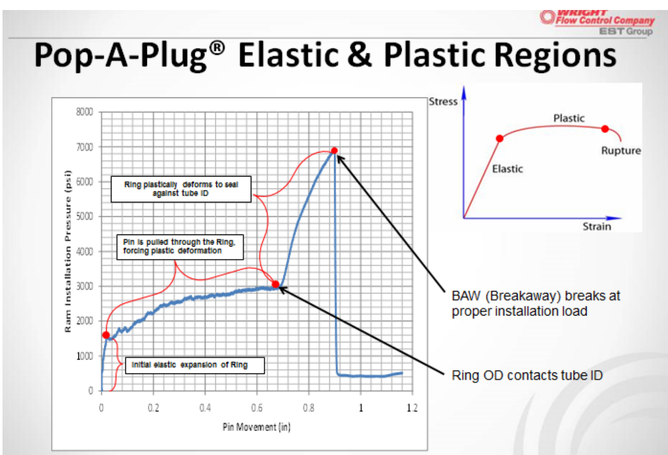
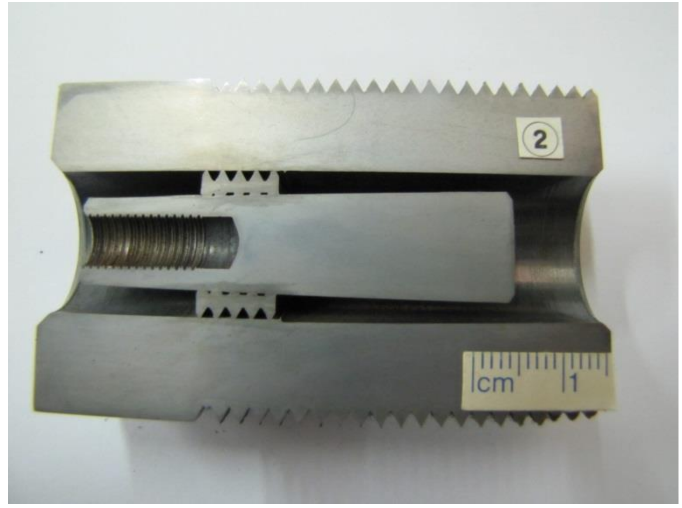
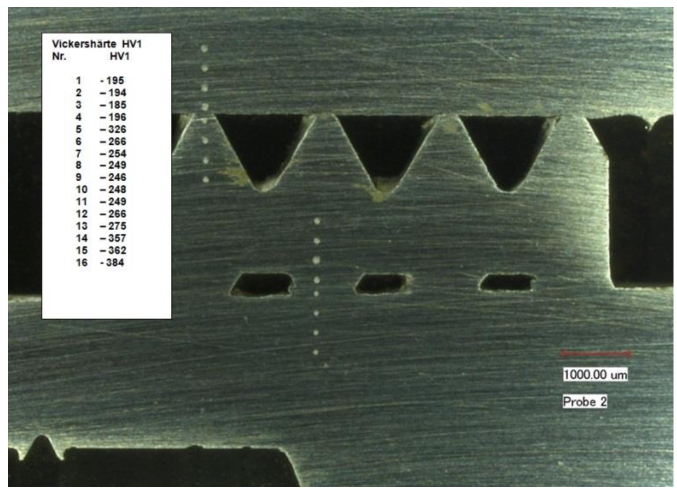


Figure 5. Pop-A-Plug® installation inside the tube inside the tube sheet

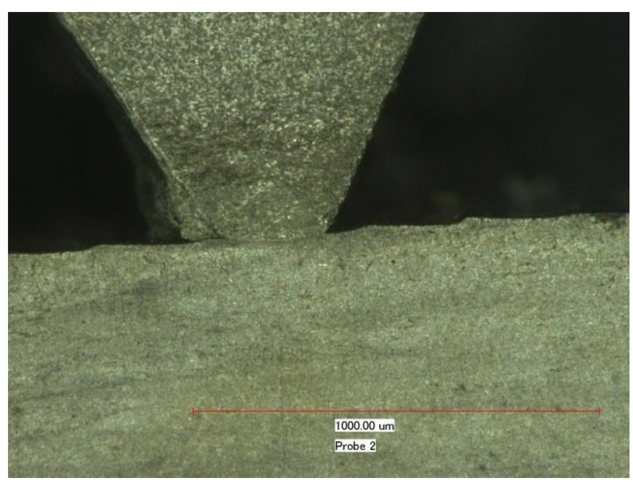




Pop-A-Plug in test coupon sectioned.



Pop-A-Plug detail of compressed internal and external sealing ring serrations.



Pop-A-Plug Detail compressed tip serration.

H.E.A.T. Analysis

Plugging heat exchangers needs to be approached similar to re-tubing or supplying new tube bundles for heat exchangers where advance planning and data collection is a pre-requisite.

All relevant data such as drawings of all heat exchangers in question containing information such as tubes size, wall thickness, materials , design and operating pressures, dimensional restraints need to be recorded. Also all past plugging jobs performed need to be reviewed in regards to which tubes are already plugged, the relevant down times for plugging and issues during the conventional testing and plugging method.
Clients data of the anticipated wall thickness losses for all units in question obtained during the non-destructive examinations in the past.

EST Group combined this information into a H.E.A.T (Heat Exchanger Asset Tool) analysis to determine tube plugs quantities needed, similarity between the all units and properly selection of the required sizes, materials and quantities for the Pop-A-Plug's both Medium pressure CPI/PERMA and High Pressure P2 to cover any anticipated scenario and eliminate redundancy.

EST's proposal encompasses identification per tag number of all materials needed to handle a Tube Plugging operation during a Turn Around. A suitable quantity of installation materials, spare parts, tube testing and tube plugging (Pop-A-Plug Kits) will be proposed for the customers review.

A dedicated tools room person handling the issue of all required items for the specific Tag number in question in combination with (EST) trained internal or external technicians completes a true, operational system.

Conclusion

Waiting until the last moment during a shutdown to perform heat exchanger tube testing or plugging is no longer a reality without consequences. With a heavy emphasis on reduced downtime in combination with critical field requirements such as materials and designs upfront reviewing of heat exchanger data is the key.
As a direct result significant reductions in repair time will be accomplished which will offset any expense for extended downtime or late start up.

EST Group will always review every application for Pop-A-Plugs® in detail prior to order and installation.

EST Group can train your internal or external technicians as certified POP-A-PLUG® installers.

EST Group B.V.
H.M. Warmerdam
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