EST Group

# Pop-A-Plug® Tube Plugs

## A Safer Repair Solution for Critical-Use Heat Exchangers

*Fertilizer manufacturing plants employ heat exchangers for a host of critical roles, from process gas heating and cooling to steam generation to boiler water heating. Each of these processes places severe demands on the heat exchanger equipment, with elevated temperatures, high pressures and cyclic operations being the routine rather than the exception.*

*A shell and tube heat exchanger is a widely used design option for most fertilizer applications, due to its simplicity, relatively low design costs and ease of maintenance. As the name implies, a shell and tube exchanger consists of a series of tubes encased in an outer vessel, or shell. One fluid runs through the tubes, while another fluid flows through the shell and over the tubes. This movement of two fluids with different temperatures, and separated by the tubes and the shell, transfers heat between the two liquids. These exchangers are robust and designed for applications where pressures exceed 435 PsiG (30 BarG) and temperatures are greater than 500°F (260°C).*

## Efficiency challenges

Optimizing the operating efficiency of a heat exchanger requires a balance between maximizing the exchanger's throughput and minimizing its operating costs. Each component of the heat exchanger, from the materials used to the number of tubes to the flow rates of fluids in the system, are designed to maximize the efficiency of heat transfer between the two liquids. Design improvements continue in an effort to meet the industry's growing need to reduce operating costs and minimize environmental impacts.

However, no matter how carefully a heat exchanger has been designed, certain processing problems will arise that negatively affect its efficiency—and consequently, the overall operation of the entire facility.

For example, hot fluids moving through the tubes are usually not uniformly distributed, with some tubes experiencing more elevated temperatures in some places. This uneven heating and cooling of the tubes gives rise to variable thermal strain, which leads to excessive stress on the end plates that keep the tube bank in position.

In addition, fouling of the tube walls in the form of scale and other solid deposits lowers the unit's overall heat transfer efficiency. If left unchecked, fouling commonly leads to leaks caused by aggressive corrosion.

## Common plugging solutions fall short

Friction fit tapered plugs are a widely used tube plugging option designed to isolate a section of a tube during a repair or replacement. However, these plugs present several onsite reliability risks and dangers, beginning with their lack of a pressure rating that results in an unknown safety factor. If the plugs are expelled during shell side pressure testing, or from tubes that have not been properly vented prior to plugging, they become projectiles that pose serious safety concerns for personnel and surrounding equipment.

Friction fit plugs are installed with a setting force that is not regulated or controlled, raising the risk that tube sheet joints can be overstressed or damaged. This uncontrolled setting can also result in costly repairs when the plugs are installed in tube sheets with epoxy-coated liners.

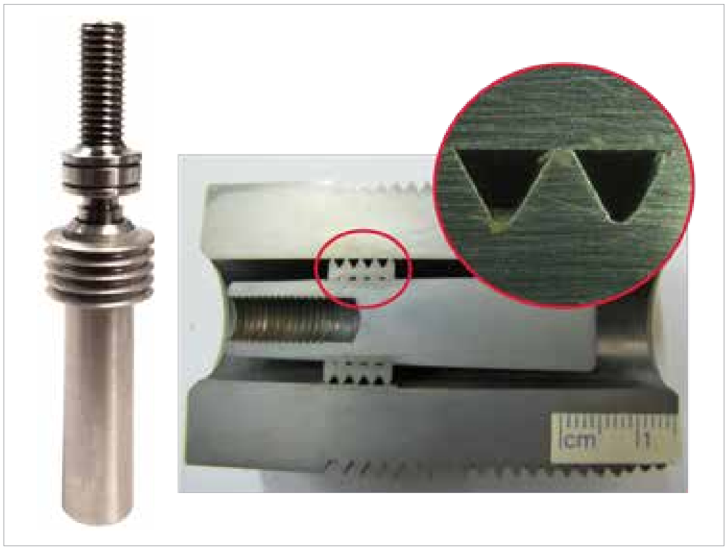
Friction fit plugs do not conform to ASME PCC-2-2015 recommended tube plugging repair methods for operations exceeding 200 PsiG (14

BarG). In high-pressure service, these plugs must be welded in place, which raises the risk of leaking due to stress cracking. Welded plugs also typically require time-consuming pre-heat and post-weld heat treatment, and even then, the quality of the weld is difficult to assure. Installing welded plugs also comes with significant safety concerns when the heat exchanger contains toxic, explosive and/or corrosive residual contaminants.

## A low-risk plugging solution

EST Group engineers its Pop-A-Plug Tube Plugs to deliver a permanent, cost-effective tube plugging solution that eliminates the safety and reliability concerns that friction fit tapered plugs bring. The plugs meet ASME PCC-2 Article 3.12 recommendations for the inspection and repair of shell and tube heat exchangers, and are pressure rated up to 7000 PsiG (483 BarG).

A simple hydraulic installation provides a safe method for sealing heat exchanger tubes with superior stability. Each plug is installed using a hydraulic ram using the onsite air supply. As the ram pulls the tapered pin through the ring, it expands into the tube to create a helium leak-tight seal to 1 x $10^{-10}$ cc/sec. When the proper force is reached, the breakaway pops.




Pop-A-Plug Tube Plug and sectioned serration detail

Pop-A-Plug Tube Plugs' controlled and repeatable weld-free installation protects against damage to tube sheet ligaments and the adjacent tube sheet joints. Plug material must always match to the host tube to prevent any undesirable galvanic interaction, maintaining a leak-tight seal under extreme thermal and pressure cycling.

## Getting waste heat boilers back in service

### *Success in Qatar*

A fertilizer plant manufacturing ammonia in Qatar found a major operational problem in a critical waste heat boiler. Tubes


Significant cracking within the heat affected zones resulting from the use of welded plugs in the waste heat boiler

in several heat exchangers within the boiler developed stress corrosion cracking and needed to be plugged. When waste heat boilers are shut down due to tube leaks, the entire plant has to be shut down—directly impacting the operator's production and revenue.

The operator decided to implement the common leak repair solution of welded tube plugs, given the high operating temperatures and pressures of the waste heat boiler. However, this solution brought with it a number of potential problems. The welding process was complicated, involving rework to seal off leaks missed the first time, and the lengthy periods of preheating and post weld heat treatment were too much for the operator to bear.

In this particular boiler, the welding process was further complicated by the presence of an Inconel weld clad overlay on the Alloy F22 tube sheet. After the first few plugs were welded, cracking was observed in adjacent tubes and welds around the heat-affected zone.

The operator realized that the welded plug solution would do more harm than good and the boiler, or the plant as a whole, would likely not be brought online again. As a result, the waste heat boiler remained out of service and the entire production facility would be down for several months until a new waste boiler could be installed.

EST Group used information provided by the operator to develop an alternative solution. Custom Pop-A-Plug P2 plugs were designed and manufactured from ASTM A-182 F22 CL3 material for inside diameters up to 2.76" (70.1 mm). This solution allowed the operator to machine the tube end partially out of the tube sheet, then install the plugs directly into the tube sheet, without the need for welding. This installation method also reduced downtime associated with tube repairs from days to hours.

More than 130 plugs were installed, including installing a plug 18” (457.2 mm) deep in order to plug a tube that had developed a crack on an internal bore weld. The plugs were installed in a much shorter time than would have been required for welded plugs. Because there were no issues with heat-affected zones, no further tube and weld damage occurred. The waste heat boiler was safely brought back into service and the entire plant resumed operation.

An EST Group supervisor was deployed onsite to train the operator’s technicians on safe and efficient installation of the plugs. Since this first installation, the operator placed three additional orders for the plugs and decided to abandon the time-consuming and damaging process of using welded plugs.

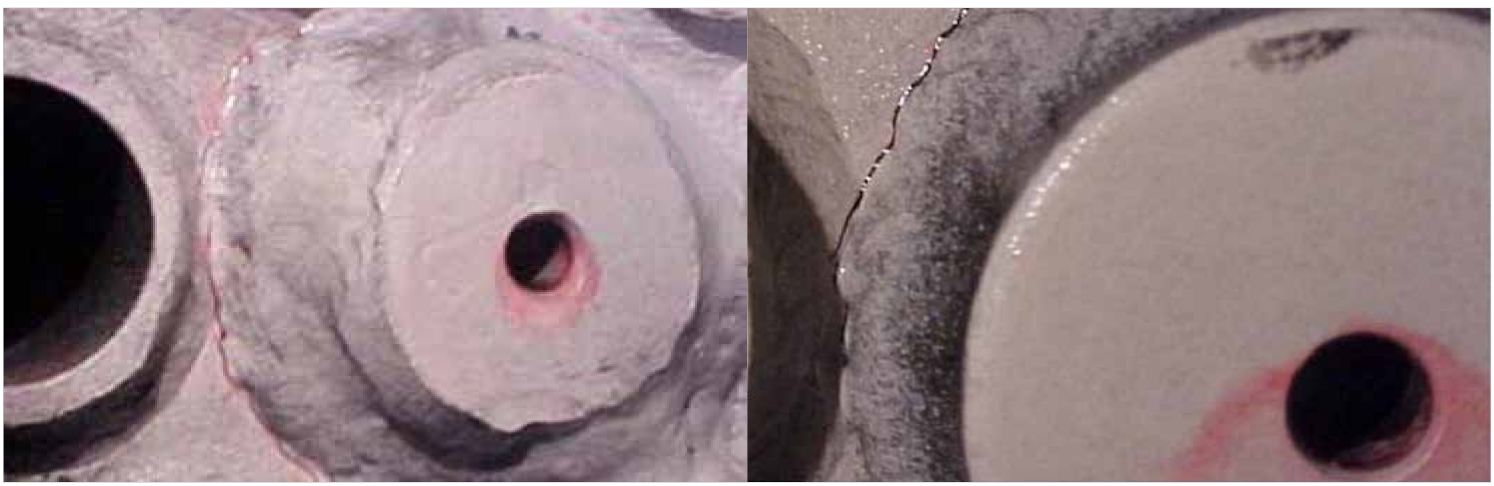
## *Success in Germany*

A large producer of ammonia and urea in Germany experienced similar problems in the high-pressure heat exchangers in several of its plants. In particular, pitting corrosion arising from caustic reaction led to leaking and cracking of several tubes.

Previously, the producer had only used the time-consuming repair process of installing tube plugs with a thread. These plugs were welded into the tubes with pre- and post-heat treatment. Not only did this process add days to a repair job, it also greatly increased the likelihood of circumferential cracks in the vicinity of the repair after the exchanger was brought back online and exposed to the extreme temperature cycles of the waste heat boiler.

The producer approached EST Group for a reliable, weld-free plugging option for one of its units—a fixed-tube vertical heat exchanger with over 1100 tubes. EST Group offered their Pop-A-Plug Tube Plugs for the application.

The plugs were matched to the metallurgy of the tubes and installed using a controlled force, which protected the tube sheet ligaments and adjacent tube sheet joints from damage. Each plug was installed in just minutes, and successfully maintained a leak-tight seal under extreme thermal and pressure cycling. This solution ultimately extended the operating life of this critical use heat exchanger, while reducing operating costs at the same time.



Circumferential cracks after the units have gone back into service and were exposed to extreme temperature cycles

***Processing challenges such as the ones highlighted above are not isolated incidents. As fertilizer plants around the world continue to age (in some cases 30+ years of operation), the need for processing solutions that can improve efficiency and reduce downtime are more critical than ever. Pop-A-Tube Plugs offer just such a solution, by helping bring degraded heat exchangers back online safely and quickly, thus helping to extend the operating life of the entire plant.***

***For more information, visit cw-estgroup.com/pap. Contact us at est-info@curtisswright.com or +1 215.721.1100 / 800.355.7044 to speak with one of EST Group’s Product Experts today!***

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