Process Equipment—Heat Exchangers

G7E
Heat Exchanger Repair: Plugging Tubes and Tubesheets

Table of Contents

1. Scope 1
2. References 2
3. Background 2
4. Safety 2
5. Welded vs. non-welded plugs 3
6. Types of plugs 3
6.1 One piece tapered plug 3
6.2 Two piece plug 4
6.3 Torq'n seal plug® 4
6.4 Torq'n seal condenser plug 5
6.5 Pop-a-plug® 5
6.6 Explosive welded plug 5
6.7 Explosive expanded plug 5
7. Plug material 5
8. Tube preparation 6
9. Testing 6

List of Figures

Figure 1. One-piece plug 9
Figure 2. Two-piece tube plugs 10
Figure 3. Torq n' seal plug 11
Figure 4. Pop-A-Plug 12
Figure 5. Explosively welded plug after firing 13
Figure 6. Explosively expanded plug after firing 14

List of Tables

Table 1. Safety check list[a] 7
Table 2. Plug Vendors 8
Table 3. Tube plugging procedure 8

Vendors and merchandise designations are given to describe materials and may not include all acceptable products. Substitutions by suppliers are to be made only on approval of the local authority initiating the use of this standard.

Document issued October 2000

Contact Valerie.S.Lamison@usa.dupont.com by e-mail for more information.

1. Scope

This standard reviews the types of plugs, and plug installation, for heat exchanger repair.

2. References

Maintenance and Construction Procedures

PH83 Heat Exchanger Inspection and Maintenance

Standard Engineering Specifications

SG4.1T Mass Spectrometer-Helium Leak Test

Engineering Standards

G6E Heat Exchanger Repair: Pulling Tubes

Engineering Textbooks

"Tubular Heat Exchanger Inspection, Maintenance, and Repair" by Carl F. Andreone and Stanley Yokell, Published by McGraw-Hill

3. Background

It is common practice to plug a leaking tube rather than to replace it. Most heat exchangers are designed with excess capacity so that the loss of a small percentage of the tubes will not effect performance. It normally is not worth the cost, in time as well as money, to replace the tubes.

The tube must be mechanically punctured or ruptured before plugging so pressure can not build up in the sealed and plugged tube. The heat exchanger is then pressure tested and put back in service.

The discussion in this standard is focused on plugging of tubes but the same information can be used for plugging tubesheets. The only caution is that the tubesheet hole may require more preparation than a tube. The act of expanding and rolling the tube into the tube sheet hole, or driving out the tube, may damage the tube sheet hole.

If the plugs are to be welded, than the repair organization must have a National Board R stamp.

4. Safety

The heat exchanger must be drained and decontaminated. All safety concerns must be addressed in a meeting between the site and contractor representative and the Material Safety and Data Sheets (MSDS) must be available.

See **Table 1** for a safety checklist.

5. Welded vs. non-welded plugs

The choice of a welded or non-welded plug is typically based on the condition of the hole, or type of joint, or configuration of the heat exchanger (double tubesheet). A severally corroded or deformed tube hole may be difficult, if not impossible, to seal using a non-welded plug. In these cases it may be necessary to use a welded plug, or to remove the tube to expose the tube sheet hole which may be in better condition and allow the use of a non-welded plug.

If the tube is undamaged either welded or non-welded plugs may be used.

The most common type of plug is the tapered plug that is driven into the tube hole and seal welded. However, if welding is not feasible, either for process hazard reasons or potential equipment damage, then a non-welded plug should be used. A tapered plug may be driven in to produce a metal to metal seal and **not** welded but that introduces new concerns.

A tapered plug that is not welded can be a safety hazard since it is a potential projectile. If the tube is pressurized from the shell side the plug can be expelled at high velocity when pressure on the tube side is lowered.

There is also the possibility that un-welded tapered plugs can come out during operation. The user needs to consider the effects of the two process streams combining if the plug comes out while in service.

The non-welded plug is inserted in the tube and then mechanically expanded. These will be discussed in detail in **Section 6**. There may be considerations other than not being able to weld when selecting a plug. Each plug is different and the user will have to decide which is best for the application if the taper plug can not be used. Some of the non-welded plugs can be installed faster than the welded plug. If there are many tubes to plug then time may be important.

6. Types of plugs

See **Table 2** for a partial list of vendors.

6.1 One piece tapered plug

This is the most commonly used plug. It is approximately 1-3/4 in. to 3 in. long and made of the same material as the tube. Each plug will fit a range of tube sizes. The plug has a 32 RMS finish and the driving end is slightly rounded. The plug is hand fit into the tube and then it is driven in until it is solid. The plug is then seal welded in one pass. See **Figure 1.**

When a one-piece tapered plug is inserted, it contacts the tube along a circumferential ring. This line contact is deformed into a conical surface when the plug is driven in place. Driving the plug creates an interfacial pressure between the plug and tube as well as an additional interfacial pressure between the tube OD and the tubesheet.

Taper plugs are not effective for sealing joint leaks (without welding the plug) when tubes are welded into tubesheets because they depend on deforming the tube to effect a seal. Deforming the weld may expose porous metal or cracks.

6.2 *Two piece plug*

The ring of the two piece plug is tapered on the inside and parallel to the tube on the outside. A tapered pin is driven into the ring, which causes the expansion of the ring. The OD of the ring may be either plain or serrated. The sealing is accomplished on the length of the ring that is on the order of the tube diameter. To maintain a seal requires that interfacial pressure be developed between the pin and ring and the ring and tube. Since the contact area is much greater than that of the one-piece taper plug, not as much interfacial pressure is required.

This is designed to seal without welding but the reader is cautioned that this plug has the same potential to be blown out as the one-piece taper plug. See **Figure 2.**

6.3 *Torq'n seal plug ®[1]*

This is a patented plug that is designed to expand when the internal drive mechanism is rotated. As the drive is turned a cam locks the plug in position and further turning expands the plug. The expansion of the plug is fairly small so an accurate measurement of the tube is required. The correct size plug is 0.005 to 0.010 in. less than the tube ID.

The plug requires a tube sheet that is at least 2 in. thick.
See **Figure 3.**

[1] JNT Technical Services Inc.
85 Industrial Ave.
Little Ferry, NJ 07643

6.4 Torq'n seal condenser plug

This is an expandable Buna-N rubber plug designed for temperatures to 275°F (135°C) and pressure to 150 psi. They are installed with a slotted screwdriver. Other materials may be available from other vendors.

Elastomers have a finite life so these plugs are considered a short-term solution. They are only recommended for water service.

6.5 Pop-a-plug ®[2]

This patented plug utilizes a tapered pin, a serrated and annealed ring, and a breakaway. The plug is positioned anywhere in the rolled area of the tube. With either a manual or hydraulic tool, the pin is pulled through the ring, the ring expands until the serration seals the tube. At that moment, the tensile strength of the breakaway is exceeded, and the breakaway "pops". Two designs are available, a 7,000-psi rated design, and a 700-psi rated design. Both designs are rated helium leak tight, yet removable for exchanger retubing. By adding extensions to the installation tool, the plug can be passed through a leaking tube, and seal both ends of a tube with only one head removed. See **Figure 4.**

6.6 Explosive welded plug

A small explosive charge is used to metallurgically bond the necked down portion of the plug to the tube. The most common material for the plug is nickel because of its excellent weldability in explosive applications. Explosive welded plugs provide the greatest contact area of all plugging techniques. They are also the most expensive and require a skilled person to install. See **Figure 5.**

6.7 Explosive expanded plug

This is similar to the one above except the plug is only expanded by the explosion, not welded. The sealing is done by O-rings on the plug. This has the same cost drawbacks as the one above and is not as permanent since the elastomer has a finite life. See **Figure 6.**

7. Plug material

The tapered plug must be the same material as the tube or tube sheet but, if necessary, may be made from a material that is both

[2] Expansion Seal Technologies, 334 Godshall Drive, Harleysville, PA 19438-2008

compatible with the process fluids, and has good weld compatibility with the tube material. Other type of plugs may be made from a material other than that of the tube provided the material is compatible with the process. Process temperature and temperature cycling, including cleaning, must be considered when choosing the correct plug material.

8. Tube preparation

Before plugging a tube it must be punctured or ruptured to prevent pressure from building up inside the tube. Preparation of the hole ID for plugging is based on the type of plug to be installed. Specialized non-welded plugs and non-welded taper plugs require a smoother, undamaged bore to get a leak tight seal.. When using specialized non-welded plugs, follow the manufacturer's recommendations for surface preparation. However, in most cases all corrosive oxide formation, loose scale, and any portion of the seal weld that over laps into the ID needs to be removed. It may be necessary to hone, ream or other wise dress the hole ID to effect the necessary cleaning to make the ID smooth enough to get a leak tight seal.

Seal welded plugs can be used on tubes that are corroded or damaged but the hole needs to be properly prepared. Before welding, the area to be welded needs to be cleaned of all contamination. This is typically done by grinding, sanding or power wire brushing to get the proper surface cleanliness. All seal welding should be performed using a procedure and welder qualified to the requirements of the ASME B&PV Code, Section IX.

If more than four tubes to be plugged are concentrated in one area a stress analysis may be required. The plugged tubes will have greater thermal expansion than non-plugged tubes and may impose excessive loads on the tube sheet. Contact a member of the Process Equipment Group or the Materials Group at Corporate Engineering for assistance.

A written procedure must be developed that engages all parties involved in the job. See **Table 3** for items that must be included in the procedure.

9. Testing

The method of testing depends on the consequences of a leak. Hydrostatic testing is normally acceptable for many services. Helium leak testing according to SG4.1T may be employed for critical services. A liquid penetrant test, using a qualified examiner, is required on all seal welds.

Table 1. Safety check list[a]

A. Isolation of equipment
1. Depressurize
2. Drain
3. Blank
4. Lock/Tag/Try
B. Product in exchanger
1. Cleaning/Decontamination
2. Sniffing
3. MSDS available
C. Identify all personal protective equipment required
D. Existing plugged tubes
1. Review location of existing plugs in relation to new plugs to be installed. Is there any potential interaction?
E. Tube plugging
1. Review equipment set-up for potential hazards
2. Review location of personnel during plugging

[a] This is a minimum list. Site safety practices take precedence.

Table 2. Plug Vendors

This is only a partial list.	
Pop-A-Plug®	Expansion Seal Technologies 334 Godshall Drive Harleysville, PA 19438-2008
Torq N' Seal®	JNT Technical Services Inc. 85 Industrial Avenue Little Ferry, NJ 07643
Tapered plugs	Ohmstede, Inc 1750 Swisco Road Sulpher, LA 70664-1087
Airetool® Two piece plug	Cooper Power Tools Airetool Operation 302 South Center St Springfield, OH 45506

Table 3. Tube plugging procedure

Equipment Number _____ Date _____

	Item	Responsibility
A	**Preparation**	
1	Identify tubes to be plugged on a tube sheet map	
2	Identify group that will perform the work	
3	Select type of plug	
4	Specify hole preparation procedure	
5	Establish estimated time to complete the plugging	
B	**Plug tubes**	
1	Develop installation procedure	
2	For welded plugs	
	a. Specify surface preparation required	
	b. Preheat required?	
	c. Postheat required?	
	c. Weld technique	
C	**Non-destructive testing**	
1	Specify test details and acceptance criteria	
D	**Update equipment file**	
1	Copy of Tubesheet map, weld procedure and job description is to be included in file.	

Figure 1. One-piece plug

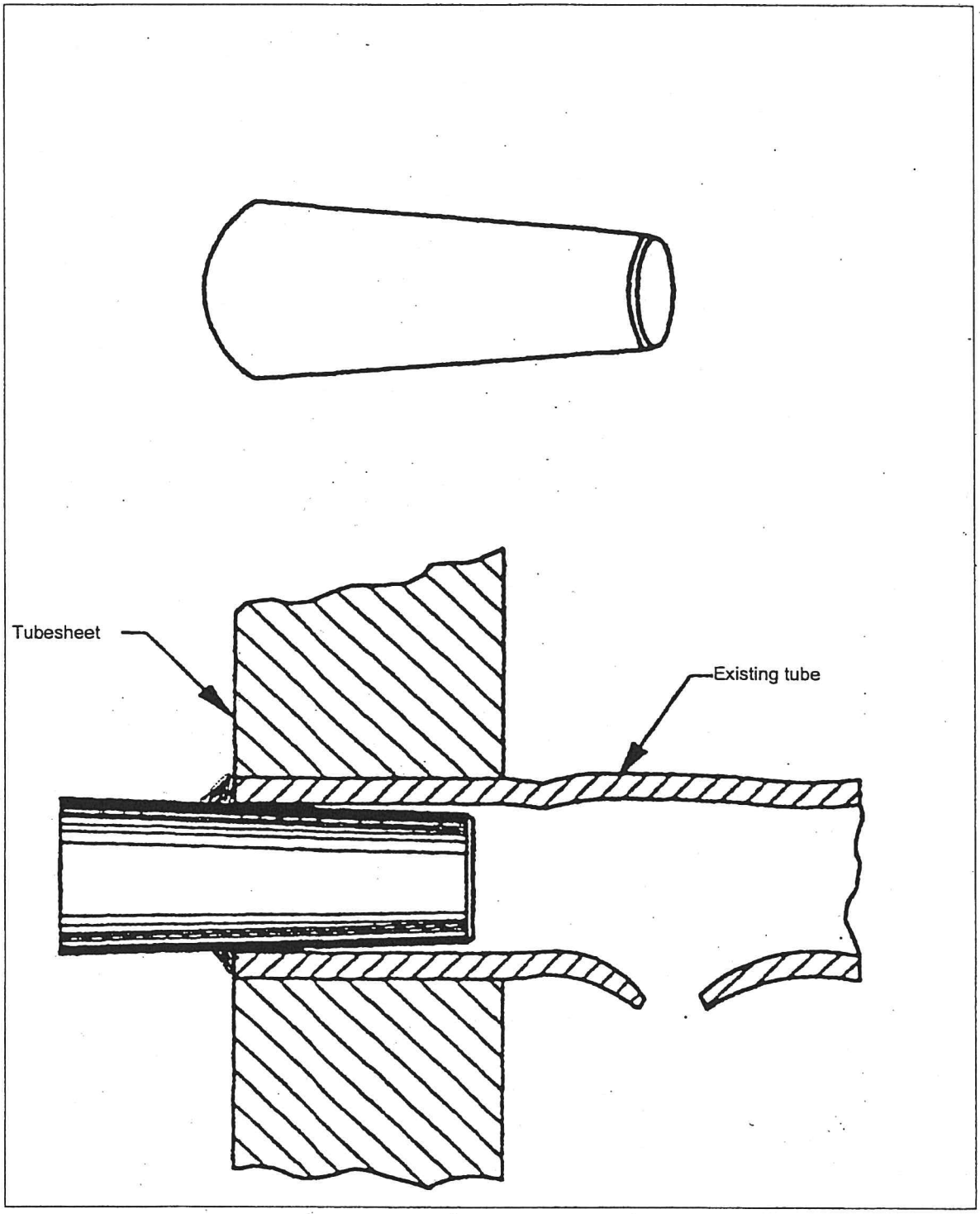

Figure 2. Two-piece tube plugs

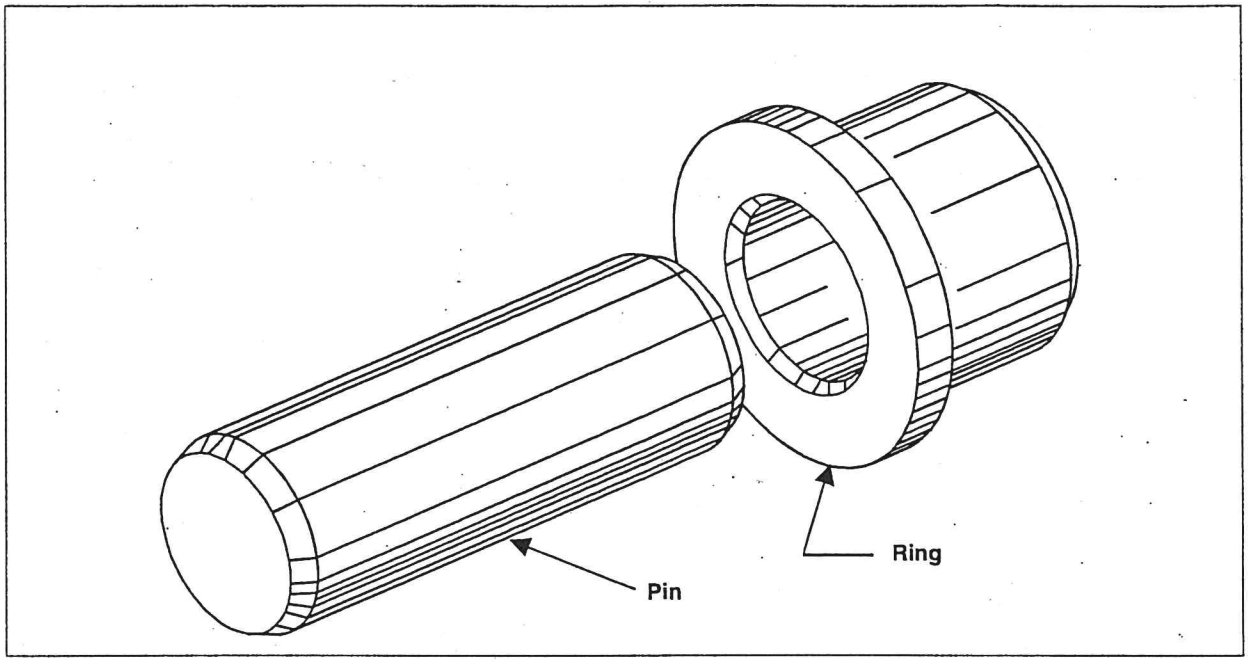

Figure 3. Torq n' seal plug

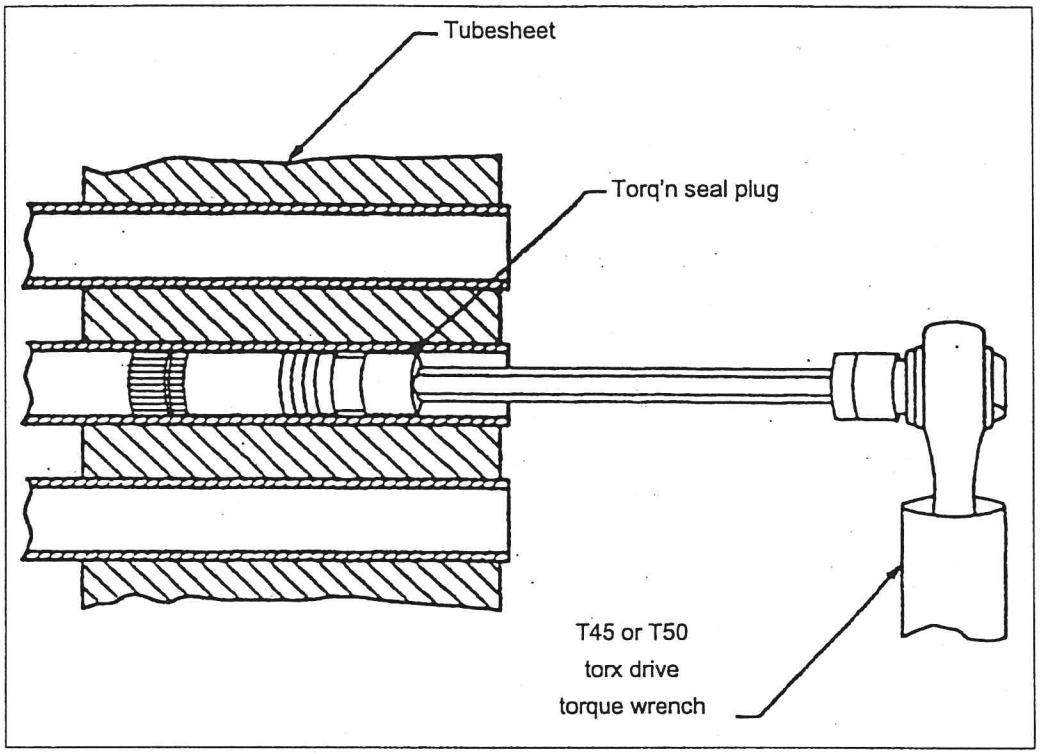

Figure 4. Pop-A-Plug

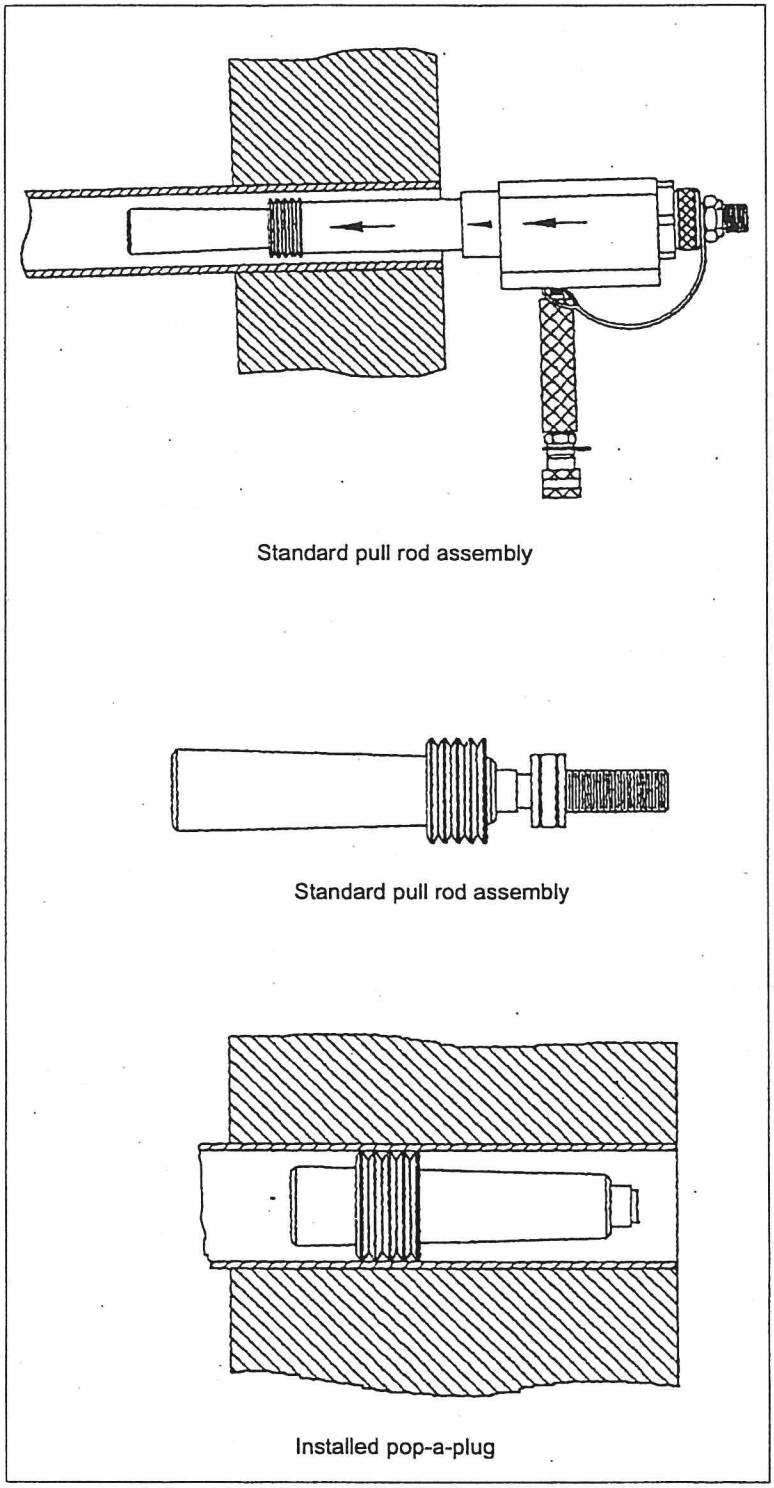

Figure 5. Explosively welded plug after firing

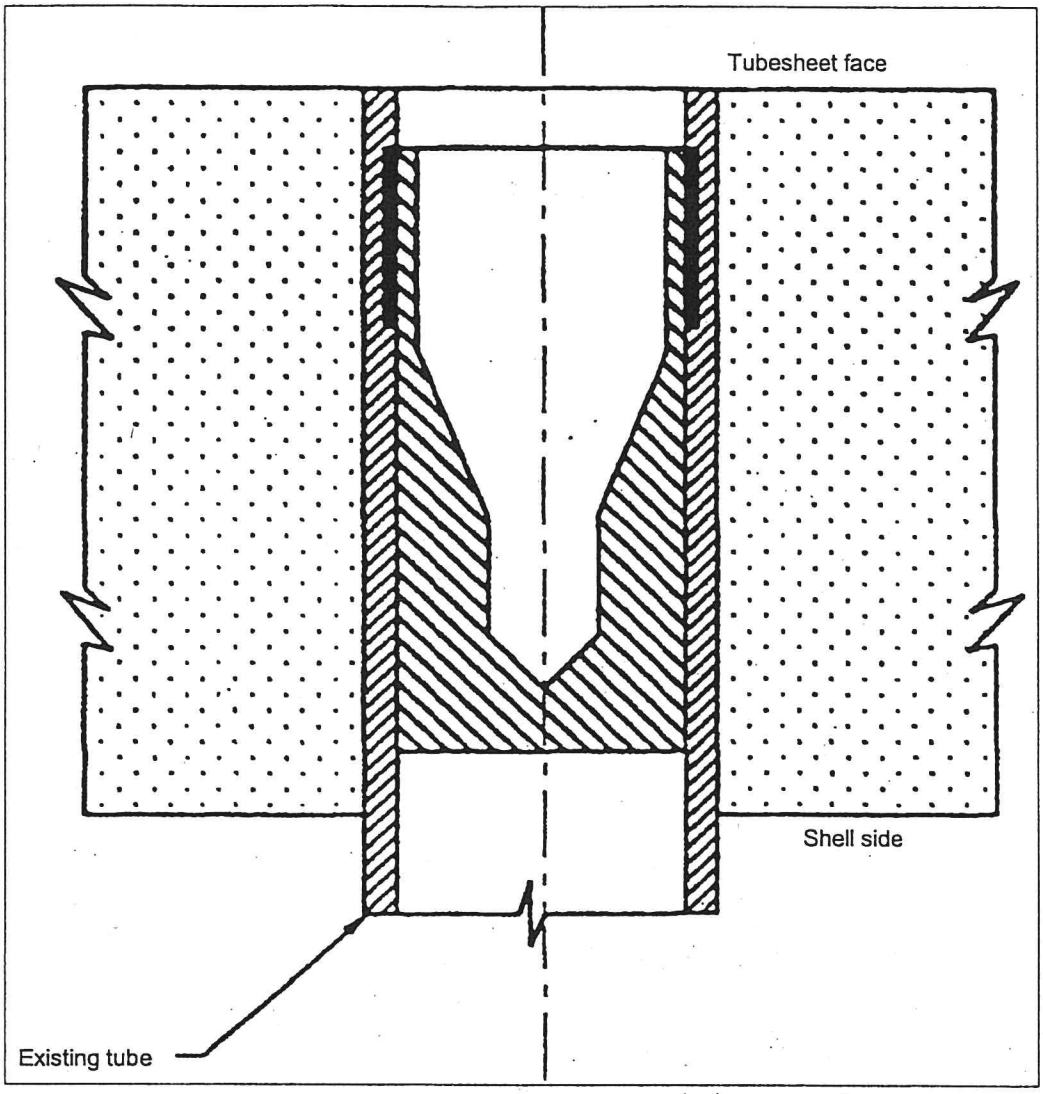

Figure 6. Explosively expanded plug after firing