

Heat Exchanger Tube Plugging

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1. Purpose

The purpose of this procedure is to establish a guideline for plugging heat exchanger tubes to comply with requirements in ASME PCC-2. The benefit of this document is to assure the safe operation and maintenance of pressurized equipment at the Huntsman Freeport site.

2. Scope

This procedure provides a guideline of what is considered good engineering practice for the installation and safe management of heat exchanger tube plugs at the Huntsman Freeport site to ensure safe integrity.

Tube-to-tubesheet leaks require rerolling tubes or seal welding tubes at tubesheet and usually cannot be repaired by just installing a tube plug. These and other heat exchanger repairs, such as sleeving or pulling tubes, tubesheet repairs, seal welding or strength welding, etc. are not covered by this maintenance procedure.

Inspection methods and testing are not covered by this maintenance procedure.

3. Related Documents

- 3.1. Huntsman Freeport Environmental, Health, and Safety Standard EHS No. 52 Mechanical Integrity
- 3.2. ASME PCC-2 (latest addition) Repair of Pressure Equipment and Piping
- 3.3. Pop-A-Plug® Tube Plugging System Documentation from Curtis-Wright Flow Control Company, EST Group <u>http://www.cw-estgroup.com/Library/Brochures-Pop-A-Plug-Heat-Exchangers-</u> <u>Condensers.aspx</u>

4. Tubeside Repair By Plugging Procedure

- 4.1. The area process engineer shall be consulted when tube plugs are required. The number of previous tube plugs, condition of the tubes, and number of new plugs required, should be reviewed to determine how much the new plugs will affect production and if this will be a temporary fix or a permanent fix.
- 4.2. Pressure loss due to tube pluggage should be considered, as some exchanger types cannot function properly beyond certain tubeside 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 ASME PCC-2 (latest addition).

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- 4.3. Installing tube plugs is an accepted repair procedure and therefore does not require a MOC. However, if installing tube plugs is going to cause a reduction of production rates or bypassing pass partitions, a temporary MOC should be entered by the area process engineer until heat exchanger can be retubed or replaced.
- 4.4. Always consult equipment drawings for correct materials. Tube plugs should normally match the tube material but if process chemical is on shell side, it should be considered to match the tube sheet or shell material. If there is any doubt of what material to use contact the reliability engineer.
- 4.5. Tube plugs (all types) must be sized to fit the ID of the heat exchanger tubes. If the tube OD and gage is not known, the tube ID must be measured. Measure the tube gage in the rolled area of the tube sheet. If the measurement is taken behind this rolled area, a false reading may result in the improper size plug being selected. In the event that the tube has been removed and the tube sheet is being plugged, measure the tubesheet hole ID making certain that the measurement is not being taken in the grooved area of the tube sheet.
- 4.6. Select the proper size plug using a sizing chart (consult Huntsman chief inspector, tube plug supplier, or leak repair company for proper sizing).
- 4.7. Repair of tubes may be accomplished by plugging the tube at the tubesheet with a Friction fit tapered plug, welded plug, or mechanical fit plug.
- 4.8. <u>All</u> tubes that are to be plugged, regardless of type of plug, should be pierced to provide for venting and draining. 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. Large temperature differential between tubeside and shell side may require the tube to be cut in two. Use a tube cutter and manually rotate the cutter clockwise until the blade pierces the tube wall. Reverse rotation and the cutter blades retracts so the tool can be removed. Continual clockwise rotation may result in the tube being severed in two.

Example of a Tube Cutter



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- 4.9. If the tube cannot be pierced, the tube should be pulled or other measures should be taken to ensure personnel protection, and draining all liquids from the tube being plugged. Reliability engineer should be consulted first.
- 4.10. Friction fit tapered plugs that are installed without piercing tubes, can present a serious safety hazard. Friction fit tapered plugs can be expelled during shell side pressure testing or from built up pressure from increased temperature, potentially resulting in serious safety concerns for surrounding personnel and equipment. Tapered plugs that have not been welded can eject when system is pressurized and become a lethal projectile.



Example of a Friction Fit Tapered Plug

4.11. Mechanical fit tube plugs, Pop-A-Plug® (or equivalent brands), are the <u>preferred</u> tube plugs whenever possible.



Mechanical Fit Tube Plug



Multiple points of contact with tube/tubesheet

- 4.12. At times when it is not possible to use Mechanical fit tube plugs, standard friction fit tapered plugs may be used following this procedure and with reliability engineer or maintenance manager's approval. If the tubes have a welded seam, it is not possible to use Mechanical fit tube plugs as it may split the seam when installed. Very thin tubes may break if using Mechanical fit tube plugs also. Delivery of certain materials may be an issue. Friction fit tapered plugs (welded to tubesheet or not) may be considered in these cases.
- 4.13. Tapered plugs must be welded in place if pressure can exceed 200 psig or if temperature exceeds 205 ℃ (400 °F). Mechanical fit tube plugs can be used up to 7,000 psig and 595 ℃ (1,100 °F)

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- 4.14. Before installing the plug, the tube end or tube sheet hole must be as clean as possible. Hydroblast the tubes if possible. Remove any oil, grease, lubricants, or chemicals that could affect the sealing surface of the plugs. Brushing the area with a turbo brush will provide an ideal surface for tube plug installation. Select the smallest of the tube preparation brushes that interferes with the tube ID. Operate the brush with a power drill for at least 30 seconds (5 seconds for 90/10 Cu/Ni and Brass tubes) back and forth from the tube opening to the installation depth evenly to prevent a tapered condition. If as a result of uneven brushing the tube entrance is smaller, the installed plug may be undersized and leak. Do not use an oversized brush, force the brush into the tube, or bend the stem. These actions may break the stem and cause deep grooves in the tube. Do not reverse drill because bristles will fall out. A Brush lubricant/ Spark inhibitor may be used if required. This should be used when brushing stainless steel tubes or brush may wear out quickly. Brush lubricant/ Spark inhibitor should be cleaned from tube before plugging.
- 4.15. Check for scratches or cracks that run from inside of the tube sheet to the outside of the tube sheet. These scratches can result into a leak path after plugging.
- 4.16. If the tube ends are projecting from the tube sheet, prior to installing tube plug, use a tube facer to trim the tubes flush with the tube sheet. Tube projection will not allow the friction fit tapered plug to seal under the tube sheet, resulting in possible plug failure.
- 4.17. Make sure the friction fit tapered tube plugs are clean and free from any lubricants or debris. Insert the tapered plug into the tube end or tube sheet hole to be plugged. Set the tube plug into the tube or sheet hole as far as it will go, just lightly tapping it in. Then drive the plug into the tube not more than 1/16" to create the seal. Driving the plug too deep may damage or crack the tubesheet hole, causing adjacent tubes to start leaking or making tubesheet unusable when it is time to retube the heat exchanger.

4.18. See Appendix A for Mechanical Fit Tube Plug Installation Procedure

5. Tube Plug Removal Instructions

- 5.1. Must be assured that the tube was properly pierced before removal of tube plugs.
- 5.2. Stand to the side, not directly in-line of fire of the tube plugs, during all of the following steps, even if tube was previously pierced.
- 5.3. If it cannot be assured that the tube was pierced prior to installation of the tube plugs, it must be assumed that they were not pierced and may be under pressure.

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5.4. Friction Fit Tapered Tube Plug Removal Instructions

- 5.4.1. Twisting Remove the tapered plug from the tube by twisting the plug to break the mechanical bond. Vise grips or a pipe wrench should be used. If the plugs do not have enough length sticking out to secure a grip, the plug must be drilled out.
- 5.4.2. Heating Heat the tube plug to approximately 1000 °F, and then quickly chilling it with cold water, the ring and pin will loosen up enough to be removed. Care should be taken so that the tube sheet is not directly subjected to this heat.
- 5.4.3. Drilling The entire tapered plug may be drilled out. A drill slightly smaller than the tube ID can be used to bore a hole thru the plug. Once the pressure is reduced, vice grips can be used to twist the remaining plug free. Caution should be used to avoid the drill bit from damaging the tube sheet hole.
- 5.4.4. If the tubes were not previously pierced, the friction fit tapered tube plug must be first tack welded to the tubesheet. Then follow step 5.4.3 to drill a hole through the plug to vent it first and then welds can be ground off and plug removed.
- 5.5. Alternatively, if entire exchanger or tube bundle is going to be demoed and not reused, may choose to cut entire exchanger or bundle in half using heavy demolition equipment, high pressure water cutters, or similar equipment.

5.6. See Appendix B for Mechanical Fit Tube Plug Removal Procedure

6. Documentation

- 6.1. A plug map should be developed by Chief Inspector to record the number and location of tubes that have been plugged. Additionally, the cumulative number of tubes plugged with dates installed should be charted.
- 6.2. It should also be noted on plug map if the tubes were properly pierced, vented and drained, and what type of plugs were installed *(friction fit tapered plugs, welded plugs, or mechanical fit plugs)*.
- 6.3. Documentation shall be placed in each individual equipment file.



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APPENDIX A - Mechanical Fit Tube Plug Installation Procedure

POP-A-PLUG® MANUAL INSTALLATION TOOL INSTRUCTIONS

WARNING!

- IMPORTANT: FOLLOW <u>ALL</u> INSTRUCTIONS FOR TUBE PREPARATION AND PLUG SIZING THAT ACCOMPANY THE CPI/PERMA OR P2 POP-A-PLUG TO BE INSTALLED.
- FAILURE TO PROPERLY PREPARE THE TUBE AND USE THE CORRECT SIZE PLUG WILL RESULT IN PLUG FAILURE.
- BEFORE USING THESE INSTRUCTIONS REFER TO EITHER EST DOCUMENTS DC4010 (NOTES 1-5) OR DC4000 (NOTES 1-10) WHEN INSTALLING P2 POP-A-PLUGS., OR EST DOCUMENT DC1220 (NOTES 1-4) WHEN INSTALLING CPI/PERMA PLUGS.
- IF YOU DO NOT HAVE THE ABOVE INSTRUCTIONS, PLEASE CONTACT EST CUSTOMER SERVICE.

P2 & CPI/PERMA MANUAL TOOL ASSEMBLY & OPERATION

 Carefully remove Breakaway from Pop-A-Plug to be installed: Hold plug with pliers on shoulder of Breakaway and at the end of the pin placing the red cap from plug packaging on the pin to avoid damage by pliers. (See Figure A). Never use pliers on ring serrations or on pin surface.



2. Thread Breakaway fully into both the plug pull rod and nut pull rod (See Figure B). For P2 sizes .400-.440 and CPI/Perma sizes .471 & .491 the side of the breakaway with the smaller diameter thread must be engaged into the plug pull rod. Slip antigall washer over nut pull rod threads and engage hex nut onto pull rod by several turns (See Figure B). Insert this assembly into the back end of the tool body. Place large end of plug positioner into recess on the front of the tool body. Fully engage the Pop-A-Plug onto the exposed stud on the plug pull rod. Hand-tighten hex nut to remove slack in assembly (See Figure C).



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- The locating pin must be inserted into a tube close to the tube to be plugged. When access to tubes is limited, a plugging sequence should be determined to insure that the locating pin can be inserted into an unplugged tube otherwise another reaction device will need to be used.
- 4. Insert the plug and locating pin into their respective tubes. The ring section of the plug must be positioned within the tubesheet area. (See Figure D). Begin installing plug by tightening hex nut on the back of the tool in a clockwise motion using a wrench, socket or air tool. Continue tightening until the breakaway shears.



5. Pull body of tool straight back from tubesheet separating tool body from the installed plug and plug pull rod (See Figure E). Depending on plug size installed, the positioner may be with plug pull rod. Unthread plug pull rod from the installed Pop-A-Plug. If pin is stuck in positioner after installation, the plug must be removed and a larger plug installed. Remove breakaway sections from pull rods for next installation.

QUESTIONS? Contact EST Group Customer Service at any of the following locations with questions. In USA and Canada: tel: 800-355-7044, fax: 215-721-1101, e-mail: <u>est-info@curtisswright.com</u> In Europe: tel: +31-172-418841, fax: +31-172-418849; e-mail: <u>est-emea@curtisswright.com</u> In Asia: tel: +65-6745-8560, fax: +65-6742-8700, e-mail: <u>est-asia@curtisswright.com</u> On the Internet: <u>http://estgroup.cwfc.com</u>

EST Group is a business unit of Curtiss-Wright Flow Control Company. EST Group provides a complete range of repair products, services and replacement parts covering the life cycle of tubular heat exchangers and condensers; additionally EST Group provides products and services to facilitate pressure testing pipe, piping systems, pressure vessels and their components. Visit EST Group on the Internet at http://estgroup.cwfc.com.

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Procedure for Pop-A-Plug[®] CPI/Perma[™] Near End Installation

WARNING

- Pop-A-Plug CPI/Perma plugs must be installed in the heat exchanger tube section where the tube has been expanded into the tubesheet. In cases where the heat exchanger tube has been removed, the Pop-A-Plug CPI/Perma can be installed directly into the tubesheet.
- Installed Pop-A-Plug CPI/Perma plugs should not project beyond the tubesheet face unless on the perimeter or in a thin tubesheet. In cases where the pin of an installed plug extends beyond the tubesheet, extra caution must be taken to ensure the pin is not struck by another object.
- Remove tube sleeves or shields prior to tube preparation and plugging.
- Never hit the Pop-A-Plug CPI/Perma Pin with a hammer or heavy object.
- Failure to remove weld droop prior to installing the Pop-A-Plug CPI/Perma plug will result in a false reading with the Go/No Go Gage. This false Go/No Go Gage reading will direct the user to install an undersized Pop-A-Plug CPI/Perma plug which will either leak initially or later.

Use the procedure outlined below to properly prep the tube ID and perform a near end installation with Pop-A-Plug CPI/Perma plugs.

Step/Action

Additional Action/Information/Result

 If tube is welded to sheet, remove any weld droop protruding into the tube ID with a Tapered Reamer. Removing weld droop is a fairly quick step and should only take 15 – 30 seconds to remove. Only remove the weld droop (burr) projecting into the tube ID.

Note A straight reamer should never be used.

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Install tapered reamer in a variable speed drill and lightly lubricate. The small end of tapered reamer should fit into tube ID and large end should not. The reamer should be operated in the following manner:

- Keep reamer axis parallel to tube axis and lightly squeeze the trigger on the drill to a low rpm in short intervals.
- Use slight forward pressure. If too much pressure is used the reamer may catch.
- Never force the reamer into the tube ID.
- Service permitting, puncture both ends of the tube to be plugged just beyond the tubesheet to minimize the potential of trapped pressure.
- 3. Take initial tube ID measurement with Go/No-Go Gage.



Small end of gage should fit in tube to installation depth and large end should not.

4. Select the smallest of the Tube Preparation Brushes furnished in the Brush Kit that interferes with the tube ID. Operate the brush with a power drill for at least 30 seconds (5 seconds for 90/10 Cu/Ni and Brass tubes) back and forth from the tube opening to the installation depth evenly to prevent a tapered condition. If as a result of uneven brushing the tube entrance is smaller, the installed plug may be undersized and leak.



Do not use an oversized brush, force the brush into the tube, or bend the stem. These actions may break the stem and cause deep grooves in the tube. Do not reverse drill because bristles will fall out. A Brush lubricant/Spark inhibitor Lube-A-Tube is available from EST Customer Service if required. This should be used when brushing stainless steel tubes or brush may wear out quickly. Brush lubricant / Spark inhibitor should be cleaned from tube before plugging.

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Step/Action

Additional Action/Information/Result

 Carefully inspect tube for scale, pitting or other defects. These conditions must be corrected for plug to seal properly. A properly brushed tube should have a shiny metallic finish. Deeply pitted tubes may require using larger preparation brushes and plugs.

 Take a second measurement with Go/No-Go Gage to installation depth.



Brushing may remove enough tube material to require the next larger size gage and Pop-A-Plug.

- Thread the Pop-A-Plug size that matches the correct Go/No-Go Gage size onto the appropriate Pull Rod Assembly (See stamping on parts or table on reverse side for part numbers).
- Remove Safety Hex Nut and Knurled Nut and insert Pull Rod Assembly into Hydraulic Ram. Thread Knurled Nut onto Pull Rod removing all slack in assembly. Secure Safety Cable on Pull Rod and thread Safety Hex Nut onto Pull Rod.





Failure to correctly seat and tighten hydraulic fittings will cause ram piston to lock in extended position after activation.

 Insert Pop-A-Plug into prepared tube to 1" (25.4 mm) installation depth. If the thickness of the tubesheet or the expanded length of the tube cannot accommodate a 1" (25.4 mm) installation depth, install the plug as deep as possible while keeping the Pop-A-Plug positioned within the tubesheet.



Never stand directly behind Ram. Guide Ram with hands to avoid cocking Pop-A-Plug.

Activate Rolease

If plug does not "POP" and PsiG exceeds 7000 PsiG (483 BarG) on gage, STOP. Depress front of Hydraulic Pump pedal and Hydraulic Ram will retract. If the ring has not contacted the tube ID and plug can be removed from the tube on this first stroke you may have an UNDERSIZED PLUG. Otherwise tighten knurled nut and depress pump pedal. If plug does not "POP", on second stroke an UNDERSIZED PLUG has been installed, stop and contact EST Customer Service, or your local representative for assistance.

 Depress Hydraulic Pump pedal, Hydraulic Ram will stroke.

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Step/Action Additional Action/Information/Result 11. After Pop-A-Plug installation, remove the Breakaway stub from the installed Pop-A-Plug by turning counter-clockwise. Image: Content of the installed Pop-A-Plug by turning counter-clockwise.

Note: Weeping during hydro test indicates small surface imperfections in the tube that are difficult to see. A large leak indicates a surface imperfection in the tube such as scarring from a drill used to remove a sleeve or tapered pin that should have been seen in step 5. In either case, remove Pop-A-Plug using EST Group Plug Removal Tool and repeat procedure using next larger Tube Preparation Brush and Pop-A-Plug size.

Table 1: Operator Troubleshooting Guide

Problem	Cause	Solution				
Imperfections such as pitting, gouges or scratches still exist within the tube ID after brushing.	Deep imperfections can exist from normal heat exchanger operation or maintenance work.	Continue brushing with Tube Preparation Brush until little or no resistance is encountered. If imperfections still exist, move up to the next Pop-A-Plug size and repeat tube preparation steps.				
Plug Positioner flares or becomes stuck on installed plug. Breakaway fractures on side opposite the undercut. (Normally the Breakaway fractures at the undercut) Pop-A-Plug does not "POP" after second stroke of hydraulic ram.	Undersized Pop-A-Plug The Pop-A-Plug was installed beyond the thickness of the tubesheet Heat Exchanger tube is not expanded (rolled or similar) into the tubesheet.	Gage or measure tube ID at location where Pop-A-Plug will be installed. Refer to heat exchanger datasheet to determine tubesheet thickness. Install Pop-A-Plug within the tubesheet length. Roller expand heat exchanger tube at Pop-A-Plug installation depth otherwise contact EST for assistance.				
Go/No-Go Gage indicates proper Pop-A- Plug size, but problems related to an undersized Pop-A-Plug occur.	Weld droop has not been removed. Heat exchanger tube is only "soft rolled" for a short distance and is expanded to a larger tube ID beyond the "soft roll" length.	Remove weld droop using tapered reamer. Using Tube Preparation Brush, enlarge the heat exchanger tube so that the tube entrance and "soft roll" area has same ID as at the Pop-A-Plug installation depth.				
Hydraulic Ram is stuck in extended position and will not retract.	Mating quick connects between Hydraulic Ram and hose or between Hydraulic Pump and hose are not fully engaged and tightened. Piston within Hydraulic Ram has been damaged	Using gripping pliers turn locking collar on female quick connect to further engage connection. Continue tightening until Hydraulic Ram retracts. Return Hydraulic Ram to EST for repair.				
Stem of Tube Preparation Brush fractures	Brush size is too large The brush was forced or advanced too quickly	Gage the heat exchanger tube using Go/No-Go Gage and select corresponding brush size. Slowly feed the Tube Preparation Brush into the heat exchanger tube if significant resistance is encountered.				
Bristles fall out of Tube Preparation Brush	The brush was run counter-clockwise in the drill.	Obtain a new brush and operate brush clockwise.				
Inadequate space to get plug into tube when using the standard Hydraulic Ram with Pull Rod Assembly.		Use EST's Close Quarter Ram for Pop-A-Plug installation.				

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					T	le 2: P	lug Sizing							
		Tube I.D. (see Note 4)					Tube I.D. (see Note 4)							
		Min	Max	Min	Max				Min	Max	Min	Max		
Pop-A-Plug CPI/Perma Kit	Plug Size	(h	n)	((mm)		(mm)		Pop-A-Plug CPI/Perma Kit	Plug Size	(in)		(mm)	
V-471-Q	.471	0.472	0.515	11.99	13.08	5	V-919-Q	.919	.920	1.019	23.37	25.88		
V-491-Q	.491	0.492	0.540	12.50	13.72		V-962-Q	.962	.963	1.027	24.46	26.09		
V-512-Q	.512	0.513	0.562	13.03	14.27		V-979-Q	.979	.980	1.079	24.89	27.41		
V-524-Q	.524	0.525	0.585	13.34	14.86		V-1024-Q	1.024	1.025	1.088	26.04	27.64		
V-555-Q	.555	0.556	0.616	14.12	15.65		V-1054-Q	1.054	1.055	1.154	26.80	29.31		
V-584-Q	.584	0.585	0.649	14.86	16.48		V-1087-Q	1.087	1.088	1.152	27.64	29.26		
V-621-Q	.621	0.622	0.689	15.80	17.50		V-1103-Q	1.103	1.104	1.203	28.04	30.56		
V-649-Q	.649	0.650	0.713	16.51	18.11		V-1149-Q	1.149	1.150	1.213	29.21	30.81		
V-670-Q	.670	0.671	0.740	17.04	18.80		V-1171-Q	1.171	1.172	1.270	29.77	32.26		
V-712-Q	.712	0.713	0.777	18.11	19.74		V-1212-Q	1.212	1.213	1.336	30.81	33.93		
V-735-Q	.735	0.736	0.810	18.69	20.57		V-1334-Q	1.334	1.335	1.458	33.91	37.03		
V-774-Q	.774	0.775	0.838	19.69	21.29		V-1456-Q	1.456	1.457	1.579	37.01	40.11		
V-804-Q	.804	0.805	0.890	20.45	22.61		V-1578-Q	1.578	1.579	1.701	40.11	43.21		
V-837-Q	.837	0.838	0.902	21.29	22.91		V-1700-Q	1.700	1.701	1.823	43.21	46.30		
V-853-Q	.853	0.854	0.949	21.69	24.10		V-1822-Q	1.822	1.823	1.945	46.30	49.40		
V-899-Q	.899	0.900	0.963	22.86	24.46		V-1944-Q	1.944	1.945	2.067	49.40	52.50		

Pop-a-Plug CPI/Perma kits contain (10) plugs and a Go/No-Go Gage, Brush Kits sold separately. EST Group recommends one Tube Preparation Brush Kit for every two Pop-A-Plug CPI/Perma Kits. Brushes are marked with size on swage. Ensure correct size brush is chosen before brushing. The suffix "Q" in the Pop-A-Plug CPI/Perma kit part number is the Pop-A-Plug CPI/Perma material designator. Please replace "Q" with one of the following:

B = Brass	M = Monel	D=Duplex 2205 Stainless	NI=Nickel 200	A = 4142 Alloy	
C = Carbon Steel	S = 316 Stainless	F22=F22 Alloy	NI2=Nickel 201	I=Inconel 600	
H=70/30 Copper Nickel	E = 304 Stainless	F11=F11 Alloy Steel	P=430 Stainless	X=AL6Xn	Additional materials are readily available to
N = 90/10 Copper Nickel	T = Titanium	Y=Incoloy 825	K=410 Stainless	ZC=Zirconium	meet your tube plugging needs.

To minimize effects of corrosion and thermal expansion, the Pop-A-Plug material should closely match the heat exchanger tube material. Contact EST Group if materials other than those listed above are needed.

Standard Materials

- The suffix Q in the Part Number column is a plug material designator.
- Replace Q with one of the following: (B) for Brass, (C) for Carbon Steel, (S) for 316 Stainless Steel, (E) for 304 Stainless Steel, (A) for 4142 Alloy, (H) for 70/30 CU/NI, (N) for 90/10 CU/NI, (M) for Monel, (D) for Duplex 2205, (F11) for Chromoly Grade 11, (F22) for Chromoly Grade 22.
- (T) Titanium plugs do not have the same tube I.D. range. Please consult factory for ranges.
- The suffix (YY) in the Pull Rod Assembly column signifies the length, in feet, of the channel head extension. These parts are available in 1, 2, 3, 4, and 6 foot lengths (304.8, 609.6, 914.4, 1219.2 & 1828.8 mm). Add -01, -02, -03, etc. for the respective channel head extension length required.



North, Central & South America EST Group 2701 Township Line Road Hatfield, PA 19440-1770 USA I +1.215.721.1100 +1.800.355.7044 I est-info@curtisswright.com

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Table 3: Installation Equipment

Installation Equipment Small Ram					
Pop-A-Plug CPI/Perma Size	Plug Positioner	Pull Rod Assembly	Channel Head Pull Rod Assembly (see Note 1)	Tube Preparation Brush Kit	
.471	P-471	PA-471	CPA-471-YY	BSH-471-(HT)	
.491	P-491	PA-491	CPA-491-YY	BSH-491-(HT)	
.512	P-512	PA-512	CPA-512-YY	BSH-512-(HT)	
.524	P-524	PA-524	CPA-524-YY	BSH-524-(HT)	
.555	P-555	PA-555	CPA-555-YY	BSH-555-(HT)	
.584	P-584	PA-584	CPA-584-YY	BSH-584-(HT)	
.621	P-621	PA-621	CPA-621-YY	BSH-621-(HT)	
.649	P-649	PA-649	CPA-649-YY	BSH-649-(HT)	
.670	P-670	PA-670	CPA-670-YY	BSH-670-(HT)	
.712	P-712	PA-712	CPA-712-YY	BSH-712-(HT)	
.735	P-735	PA-735	CPA-735-YY	BSH-735-(HT)	
.774	P-774	PA-774	CPA-774-YY	BSH-774-(HT)	
.804	P-804	PA-804	CPA-804-YY	BSH-804-(HT)	
.837	P-837	PA-837	CPA-837-YY	BSH-837-(HT)	
.853	P-853	PA-853	CPA-853-YY	BSH-853-(HT)	
.899	P-899	PA-899	CPA-899-YY	BSH-899-(HT)	
.919	P-919	PA-919	CPA-919-YY	BSH-919-(HT)	
.962	P-962	PA-962	CPA-962-YY	BSH-962-(HT)	
.979	P-979	PA-979	CPA-979-YY	BSH-979-(HT)	
1.024	P-1024	PA-1024	CPA-1024-YY	BSH-1024-(NY)	
1.054	P-1054	PA-1054	CPA-1054-YY	BSH-1054-(NY)	
1.087	P-1087	PA-1087	CPA-1087-YY	BSH-1087-(NY)	
1.103	P-1103	PA-1103	CPA-1103-YY	BSH-1103-(NY)	
1.149	P-1149	PA-1149	CPA-1149-YY	BSH-1149-(NY)	
1.171	P-1171	PA-1171	CPA-1171-YY	BSH-1171-(NY)	
1.212	P-1212	PA-1212	CPA-1212-YY	BSH-1212-(NY)	

Installation Equipment Large Ram				
Pop-A-Plug CPI/Perma Size	Plug Positioner	Puli Rod Assembly	Channel Head Pull Rod Assembly (see Note 1)	Tube Preparation Brush Kit
1.334	P-1334	PA-1334-L	CPA-1334-L-YY	BSH-1334-(NY)
1.456	P-1456	PA-1456-L	CPA-1456-L-YY	BSH-1456-(NY)
1.578	P-1578	PA-1578-L	CPA-1578-L-YY	BSH-1578-(NY)
1.700	P-1700	PA-1700-L	CPA-1700-L-YY	BSHV-1700-(NY)
1.822	P-1822	PA-1822-L	CPA-1822-L-YY	BSH-1822-(NY)
1.944	P-1944	PA-1944-L	CPA-1944-L-YY	BSH-1944-(NY)

NOTES:

- The extended length of the Channel Head Assembly allows the installer to properly
 position the plug without having to reach or lean into heat exchangers with channel
 barrels or divider plates. The suffix YY signifies the length, in feet, of the Channel
 Head Extension. These parts are available in 1, 2, 3, 4 and 6 foot lengths. Replace
 YY with 01, 02, etc. for respective Channel Head Extension size required.
- 2. Tube Preparation Brush Kits are required for tube preparation with all POP-A-PLUG*CPI/Perma plugs. EST Group recommends one Tube Preparation Brush Kit for every two Pop-A-Plug CPI/Perma Kits. Brushes are marked with size on swage. Ensure correct size brush is chosen before brushing. The part number suffix "The is used to denote the most aggressive brushes for carbon steel and stainless steel (hard alloys) applications, no suffix is used for brass, CuNi 90/10 (soft alloys). See DC 1225 for other material recommendations. The part number suffix "NY" is used to denote the nylon coated brushes for all materials. For Utility applications, (1) brush kit per order plus (1) additional brush kit per each (5) plug kits ordered is recommended. For Petrol/Chem applications, (2) brush kits per order plus (2) additional brush kits per each (5) plug kits ordered are recommended.
- EST can provide a brush lubricant / spark inhibitor, which will reduce the potential of sparking during all brushing and reaming, P/N: BSH-LUBE.
- If tube is not expanded into the tubesheet the maximum tube ID limit is reduced by 0.020"(0.51mm). See DC1222 for tube ID ranges of Titanium plugs. Tube ID ranges for Titanium Pop-A-Plug CPI/Perma plugs differ from standard materials.

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Heat Exchanger Tube Plugging

						C	PI/Perma Plug
Part Number	Tube I.D. Range (inches(mm))	Pin Length (inches(mm))	Brush Kit (hard alloys)	Brush Kit (soft alloys)	Positioner	Pull Rod Assembly	Channel Head Pull Rod Assembly
V-471-Q	0.472 - 0.515 (11.99 - 13.08)	1.630 (41.40)	BSH-471-HT	BSH-471	P-471	PA-471	CPA-471-YY
V-491-Q	0.482 - 0.540 (12.50 - 13.72)	1.670 (42.42)	BSH-491-HT	BSH-491	P-491	PA-491	CPA-491-YY
V-512-Q	0.513 - 0.562 (13.03 - 14.27)	1.590 (40.39)	BSH-612-HT	BSH-512	P-512	PA-512	CPA-512-YY
V-524-Q	0.525 - 0.585 (13.34 - 14.86)	1.280 (32.51)	BSH-524-HT	BSH-524	P-524	PA-524	CPA-524-YY
V-555-Q	0.556 - 0.616 (14.12 - 15.65)	1.400 (35.56)	BSH-655-HT	BSH-555	P-555	PA-555	CPA-sss-YY
V-584-Q	0.585 - 0.649 (14.85 - 16.48)	1.320 (33.53)	BSH-584-HT	BSH-584	P-584	PA-584	CPA-584-YY
V-621-Q	0.622 - 0.689 (15.80 - 17.50)	1.570 (39.88)	BSH-621-HT	BSH-621	P-621	PA-621	CPA-621-YY
V-649-Q	0.650 - 0.713 (16.51 - 18.11)	1.320 (33.53)	BSH-649-HT	BSH-649	P-649	PA-649	CIPA-649-YY
V-670-Q	0.671 - 0.740 (17.04 - 18.80)	1.660 (42.16)	BSH-670-HT	BSH-670	P-670	PA-670	CPA-670-YY
V-712-Q	0.713 - 0.777 (18.11 - 19.74)	1.320 (33.53)	BSH-712-HT	BSH-712	P-712	PA-712	CPA-712-YY
V-735-Q	0.736 - 0.810 (18.69 - 20.57)	1.680 (42.67)	BSH-735-HT	BSH-735	P-735	PA-735	CPA-735-YY
V-774-Q	0.775 - 0.838 (19.69 - 21.29)	1.320 (33.53)	BSH-774-HT	BSH-774	P-774	PA-774	CIPA-774-YY
V-804-Q	0.805 - 0.890 (20.45 - 22.61)	1.700 (43.18)	BSH-604-HT	BSH-804	P-604	PA-804	CIPA-604-YY
V-837-Q	0.838 - 0.902 (21,29 - 22.91)	1.320 (33.53)	BSH-637-HT	BSH-837	P-637	PA-837	CPA-637-YY
V-853-Q	0.864 - 0.949 (21.69 - 24.10)	1.720 (43.69)	BSH-853-HT	BSH-853	P-653	PA-853	CPA-853-YY
V-eee-V	0.900 - 0.963 (22.86 - 24.46)	1.320 (33.53)	BSH-899-HT	BSH-899	P-889	PA-899	CPA-889-YY
V-919-Q	0.920 - 1.019 (23.37 - 25.88)	1.760 (44.70)	BSH-919-HT	BSH-919	P-819	PA-919	CPA-919-YY
V-962-Q	0.963 - 1.027 (24.46 - 26.09)	1.320 (33.53)	BSH-962-HT	BSH-962	P-962	PA-962	CPA-962-YY
V-979-Q	0.960 - 1.079 (24.89 - 27.41)	1.820 (46.23)	BSH-979-HT	BSH-979	P-879	PA-979	CPA-979-YY
V-1024-Q	1.025 - 1.088 (26.04 - 27.64)	1.320 (33.53)	BSH-1024-NY	BSH-1024-NY	P-1024	PA-1024	CPA-1024-YY
V-1054-Q	1.055 - 1.154 (26.80 - 29.31)	1.900 (48.26)	BSH-1054-NY	BSH-1054-NY	P-1054	PA-1054	CPA-1054-YY
V-1087-Q	1.068 - 1.152 (27.54 - 29.26)	1.320 (33.53)	BSH-1067-NY	BSH-1067-NY	P-1087	PA-1087	CPA-1067-YY
V-1103-Q	1.104 - 1.203 (28.04 - 30.56)	1.900 (48.26)	BSH-1103-NY	BSH-1103-NY	P-1103	PA-1103	CPA-1103-YY
V-1149-Q	1.150 - 1.213 (29.21 - 30.81)	1.320 (33.53)	BSH-1149-NY	BSH-1149-NY	P-1149	PA-1149	CPA-1149-YY
V-1171-Q	1.172 - 1.270 (29.77 - 32.26)	2.000 (50.80)	ESH-1171-NY	BSH-1171-NY	P-1171	PA-1171	CPA-1171-YY
V-1212-Q	1.213 - 1.336 (30.81 - 33.93)	2.000 (50.80)	BSH-1212-NY	BSH-1212-NY	P-1212	PA-1212	CPA-1212-YY
V-1334-Q	1.335 - 1.458 (33.91-37.03)	2.000 (50.80)	BSH-1334-NY	BSH-1334-NY	P-1334	PA-1334L	CPA-1334L-YY
V-1456-Q	1.457 - 1.579 (37.01-40.11)	2.000 (50.80)	BSH-1456-NY	BSH-1456-NY	P-1456	PA-1456L	CPA-1456L-YY
V-1578-Q	1.579 - 1.701 (40.11-43.21)	2.000 (50.80)	BSH-1578-NY	BSH-1578-NY	P-1578	PA-1578L	CPA-1578L-YY
V-1700-Q	1.701 - 1.823 (43.21-46.30)	2.000 (50.80)	BSHV-1700-NY	BSHV-1700-NY	P-1700	PA-1700L	CPA-1700L-YY
V-1822-Q	1.823 - 1.945 (46.30-49.40)	2.000 (50.80)	BSH-1622-NY	BSH-1822-NY	P-1822	FA-1822L	CPA-1822L-YY
V-1944-Q	1.945 - 2.067 (49.40-52.50)	2.000 (50.80)	BSH-1944-NY	BSH-1944-NY	P-1944	PA-1944L	CPA-1944L-YY

Specifications subject to change without notice. See DC1224 for more information.

Ordering Information

Please supply the following information when ordering:

- Tube 0.D. and wall thickness; or measured tube I.D.
- · Tube material and/or tubesheet material
- · Maximum pressure and temperature
- . The type of tube-to-tubesheet joint (rolled, welded, etc.)

• Each kit includes a Go/ No-Go Gage for ensuring proper plug size (Brush kits and installation equipment sold separately.)

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TITANIUM CPI / PERMA PLUGS NEAR END INSTALLATION INSTRUCTIONS (SUPPLEMENTS DC1220)

Heat Exchanger Tube Plugging

Tube ID's applicable to Titanium CPI / Perma plugs may differ from plugs manufactured in other materials. See chart below for Titanium plugs ranges only. For ID ranges for all other plug materials, see DC1220 Page 2.

> FIGURE A: SIGNS OF UNDERSIZED PLUG, A PLUG INSTALLED BEYOND THE TUBESHEET, OR A PLUG INSTALLED IN UNROLLED TUBE INSIDE TUBESHEET



PLUG	TUBE I.D. RANGE	TUBE I.D. RANGE	CPI/PERMA	PLUG	PULL ROD	CHANNEL HEAD	TUBE PREPARATION
SIZE	(INCHES)	(mm)	PLUG KIT	POSITIONER	ASSEMBLY	PULL ROD ASSEMBLY	BRUSH KIT
	(SEE NOTE 5)	(SEE NOTE 5)	(SEE NOTE 1)			(SEE NOTE 2)	(SEE NOTE 3&4)
.471	.472 TO .507	11.99 TO 12.88	V-471-T	P-471	PA-471	CPA-471-YY	BSH-471-HT
.491	.492 TO .530	12.50 TO 13.46	V-491-T	P-491	PA-491	CPA-491-YY	BSH-491-HT
.512	.513 TO .552	13.03 TO 14.02	V-512-T	P-512	PA-512	CPA-512-YY	BSH-512-HT
.524	.525 TO .563	13.34 TO 14.30	V-524-T	P-524	PA-524	CPA-524-YY	BSH-524-HT
.555	.556 TO .600	14.12 TO 15.24	V-555-T	P-555	PA-555	CPA-555-YY	BSH-555-HT
.584	.585 TO .632	14.86 TO 16.05	V-584-T	P-584	PA-584	CPA-584-YY	BSH-584-HT
.621	.622 TO .672	15.80 TO 17.07	V-621-T	P-621	PA-621	CPA-621-YY	BSH-621-HT
.649	.650 TO .704	16.51 TO 17.88	V-649-T	P-649	PA-649	CPA-649-YY	BSH-649-HT
.670	.671 TO .727	17.04 TO 18.47	V-670-T	P-670	PA-670	CPA-670-YY	BSH-670-HT
.712	.713 TO .775	18.11 TO 19.69	V-712-T	P-712	PA-712	CPA-712-YY	BSH-712-HT
.735	.736 TO .800	18.69 TO 20.32	V-735-T	P-735	PA-735	CPA-735-YY	BSH-735-HT
.774	.775 TO .838	19.69 TO 21.29	V-774-T	P-774	PA-774	CPA-774-YY	BSH-774-HT
.804	.805 TO .879	20.45 TO 22.33	V-804-T	P-804	PA-804	CPA-804-YY	BSH-804-HT
.837	.838 TO .902	21.29 TO 22.91	V-837-T	P-837	PA-837	CPA-837-YY	BSH-837-HT
.853	.854 TO .933	21.69 TO 23.70	V-853-T	P-853	PA-853	CPA-853-YY	BSH-853-HT
.899	.900 TO .963	22.86 TO 24.46	V-899-T	P-899	PA-899	CPA-899-YY	BSH-899-HT
.919	.920 TO 1.011	23.37 TO 25.68	V-919-T	P-919	PA-919	CPA-919-YY	BSH-919-HT
.962	.963 TO 1.027	24.46 TO 26.09	V-962-T	P-962	PA-962	CPA-962-YY	BSH-962-HT
.979	.980 TO 1.079	24.89 TO 27.41	V-979-T	P-979	PA-979	CPA-979-YY	BSH-979-HT
1.024	1.025 TO 1.088	26.04 TO 27.64	V-1024-T	P-1024	PA-1024	CPA-1024-YY	BSH-1024-NY
1.054	1.055 TO 1.154	26.80 TO 29.31	V-1054-T	P-1054	PA-1054	CPA-1054-YY	BSH-1054-NY
1.087	1.088 TO 1.152	27.64 TO 29.26	V-1087-T	P-1087	PA-1087	CPA-1087-YY	BSH-1087-NY
1.103	1.104 TO 1.203	28.04 TO 30.56	V-1103-T	P-1103	PA-1103	CPA-1103-YY	BSH-1103-NY
1.149	1.150 TO 1.213	29.21 TO 30.81	V-1149-T	P-1149	PA-1149	CPA-1149-YY	BSH-1149-NY
1.171	1.172 TO 1.270	29.77 TO 32.26	V-1171-T	P-1171	PA-1171	CPA-1171-YY	BSH-1171-NY
1.212	1.213 TO 1.336	30.81 TO 33.93	V-1212-T	P-1212	PA-1212	CPA-1212-YY	BSH-1212-NY
1.334	*1.335 TO 1.458	33.91 TO 37.03	V-1334-T	P-1334	PA-1334-L	CPA-1334-L-YY	BSH-1334-NY
1.456	*1.457 TO 1.579	37.01 TO 40.11	V-1456-T	P-1456	PA-1456-L	CPA-1456-L-YY	BSH-1456-NY
1.578	*1.579 TO 1.701	40.11 TO 43.21	V-1578-T	P-1578	PA-1578-L	CPA-1578-L-YY	BSH-1578-NY
1.700	*1.701 TO 1.823	43.21 TO 46.30	V-1700-T	P-1700	PA-1700-L	CPA-1700-L-YY	BSHV-1700-NY
1.822	*1.823 TO 1.945	46.30 TO 49.40	V-1822-T	P-1822	PA-1822-L	CPA-1822-L-YY	BSH-1822-NY
1.944	*1.945 TO 2.067	49.40 TO 52.50	V-1944-T	P-1944	PA-1944-L	CPA-1944-L-YY	BSH-1944-NY

*Must use Large Hydraulic Ram, P/N: PAP-1750, to install these plugs

471 - 512 ONLY

NOTES:

CPI/PERMA Plug kits contain 10 plugs. The suffix "T" in the CPI/PERMA PLUG kit part designates Titanium. Plug material must match tube material. 1. 2.

The extended length of the Channel Head Assembly allows the installer to properly position the plug without having to reach or lean into heat exchangers with channel barrels or divider plates. The suffix YY signifies the length, in feet, of the Channel Head Extension. These parts are available in 1, 2, 3, 4 and 6 foot lengths. Replace YY with 01, 02, etc. for respective Channel Head Extension size required.

Brushes are required for tube preparation with all CPI/PERMA Plugs. The part number suffix "HT" is used to denote the most aggressive brushes for Titanium 3. applications. The part number suffix "NY" is used to denote the nylon coated brushes for all materials. For Utility applications, (1) brush kit per order plus (1) additional brush kit per each (5) plug kits ordered is recommended. For Petro/Chem applications, (2) brush kits per order plus (2) additional brush kits per each (5) plug kits ordered are recommended.

4.

EST can provide a brush lubricant / spark inhibitor, which will reduce the potential of sparking during all brushing and reaming, P/N: BSH-LUBE. If tube is not expanded into the tubesheet the maximum tube ID limit is reduced by 0.020"(0.51mm). Titanium Plug tube ID ranges differ from plugs manufactured from 5. other materials. See DC1220 installation instructions for all other material plugs.

Maintenance Procedure

Enriching lives through innovation *Heat Exchanger Tube Plugging*

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Pop-a-Plug[®] Manual Installation Tool

Fast, Reliable Installations

Appropriate for use with manual wrenches or sockets and electric or pneumatic impact wrenches.

The EST Group's Pop-A-Plug[®] manual Installation Tool (MIT) is the perfect companion to our Pop-A-Plug 6600 Hydraulic Ram or our Close Quarter Ram (CQR), providing fast, reliable installation where no air or electricity are available.

Each MIT comes with a Pull Rod and Positioner to install the size and style Pop-A-Plug identified in the tool's model number. The same MIT body accepts all pull rods and positioners for P2s up to 1.160" and CPI/Perma Plugs up to 1.149".

Simplified Installation

- · Connect the reusable hex pull rod to the installation tool.
- Apply the force necessary to expand and install the Pop-A-Plug by tightening the hex nut.

The locating pin acts as a reaction arms to prevent the body from spinning as you tighten the hex nut.





EST Group serves the power generation, refi ning, chemical, pharmaceutical and offshore industries worldwide. QA Program certifi ed to ISO-9001.

Can be supplied under ANSI N45.2, NQA-1, and 10CFR50 Appendix B

HUNTSMAN Maintenance Procedure

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Manual Installation Tools for CPI/Perma Plugs

PART NUMBER	CPI SIZE	Total Length with Plug	PULL ROD	PLUG POSITIONER	BODY & LOCATING PIN	LOCATING PIN
MIT-V-471	.471	7-7/8"(200.0 mm)	MPR-1228	MPP-V-471	MBDY-1	MITLP-01
MIT-V-491	.491	7-7/8" (200.0 mm)	MPR-1228	MPP-V-491	MBDY-1	MITLP-01
MIT-V-512	.512	7-13/16" (198.4 mm)	MPR-1228	MPP-V-512	MBDY-1	MITLP-01
MIT-V-524	.524	7-13/16" (198.4 mm)	MPR-1228	MPP-V-524	MBDY-2	MITLP-02
MIT-V-555	.555	7-15/16"(201.6 mm)	MPR-1228	MPP-V-555	MBDY-2	MITLP-02
MIT-V-584	.584	7-7/8" (200.0 mm)	MPR-0428	MPP-V-584	MBDY-2	MITLP-02
MIT-V-621	.621	8-1/8" (206.4 mm)	MPR-0428	MPP-V-621	MBDY-2	MITLP-02
MIT-V-649	.649	7-7/8" (200.0 mm)	MPR-0428	MPP-V-649	MBDY-2	MITLP-02
MIT-V-670	.670	8-3/16" (208.0 mm)	MPR-0428	MPP-V-670	MBDY-2	MITLP-02
MIT-V-712	.712	7-7/8" (200.0 mm)	MPR-0428	MPP-V-712	MBDY-2	MITLP-02
MIT-V-735	.735	8-3/16" (208.0 mm)	MPR-0428	MPP-V-735	MBDY-2	MITLP-02
MIT-V-774	.774	7-7/8" (200.0 mm)	MPR-0524	MPP-V-774	MBDY-2	MITLP-02
MIT-V-804	.804	8-1/4" (209.6 mm)	MPR-0524	MPP-V-804	MBDY-2	MITLP-02
MIT-V-837	.837	7-7/8" (200.0 mm)	MPR-0524	MPP-V-837	MBDY-2	MITLP-02
MIT-V-853	.853	8-1/4" (209.6 mm)	MPR-0524	MPP-V-853	MBDY-2	MITLP-02
MIT-V-899	.899	7-7/8" (200.0 mm)	MPR-0524	MPP-V-899	MBDY-2	MITLP-02
MIT-V-919	.919	8-1/4" (209.6 mm)	MPR-0524	MPP-V-919	MBDY-2	MITLP-02
MIT-V-962	.962	7-7/8" (200.0 mm)	MPR-0524	MPP-V-962	MBDY-2	MITLP-02
MIT-V-979	.979	8-3/8" (212.7 mm)	MPR-0524	MPP-V-979	MBDY-2	MITLP-02
MIT-V-1024	1.024	7-7/8" (200.0 mm)	MPR-0524	MPP-V-1024	MBDY-2	MITLP-02
MIT-V-1054	1.054	8-7/16" (214.3 mm)	MPR-0524	MPP-V-1054	MBDY-2	MITLP-02
MIT-V-1087	1.087	7-7/8" (200.0 mm)	MPR-0524	MPP-V-1087	MBDY-2	MITLP-02
MIT-V-1103	1.103	8-7/16" (214.3 mm)	MPR-0524	MPP-V-1103	MBDY-2	MITLP-02
MIT-V-1149	1.149	7-7/8" (200.0 mm)	MPR-0524	MPP-V-1149	MBDY-2	MITLP-02

Manual Installation Tools for P2 Plugs

PART NUMBER	P2 PLUG SIZES	TOTAL LENGTH WITH PLUG	PULL ROD	PLUG POSITIONER	BODY & LOCATING PIN	LOCATING PIN
MIT-P2-400-440	.400440"	8-3/8 * (212.7 mm)	MPR-1032	MPP-P2-400-440	MBDY1	MITLP-01
MIT-P2-460-500	.460500"	8-3/8 * (212.7 mm)	MPR-1228	MPP-P2-460-500	MBDY1	MITLP-01
MIT-P2-520-580	.520580"	8-3/8 * (212.7 mm)	MPR-1228	MPP-P2-520-580	MBDY2	MITLP-02
MIT-P2-600-680	.600680"	8-3/8 * (212.7 mm)	MPR-0428	MPP-P2-600-680	MBDY2	MITLP-02
MIT-P2-700-780	.700780"	8-3/8 * (212.7 mm)	MPR-0428	MPP-P2-700-780	MBDY2	MITLP-02
MIT-P2-800-860	.800860"	8-3/8 " (212.7 mm)	MPR-0428	MPP-P2-800-860	MBDY2	MITLP-02
MIT-P2-880-960	.880 <mark>9</mark> 60"	8-3/8 ° (212.7 mm)	MPR-0524	MPP-P2-880-960	MBDY2	MITLP-02
MIT-P2-980-1060	.980-1.060"	8-3/8 * (212.7 mm)	MPR-0524	MPP-P2-980-1060	MBDY2	MITLP-02
MIT-P2-1080-1160	1.080-1.160"	8-3/8 * (212.7 mm)	MPR-0524	MPP-P2-1080-1160	MBDY2	MITLP-02

Heat Exchanger Tube Plugging

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APPENDIX B - Mechanical Fit Tube Plug Removal Procedure

POP-A-PLUG REMOVAL TOOL PROCEDURES

Note: The Pop-A-Plug Removal Tool is designed for use in CPI/Perma Plugs. It may be used to remove P2 Plugs as long as they have not become permanently bonded to the tube by decades of service at high temperatures. See reverse for part numbers and size ranges.

WARNING! TUBE MAY CONTAIN PRESSURE. WHEN HAMMERING PIN, KEEP FACE AND BODY AWAY FROM TUBE OPENING.

- Remove broken end of breakaway with needle nose pliers or by using a pencil eraser. (Figure 1). (See alternate procedure 1 below, if breakaway cannot be removed).
- 2. Fully engage the male thread on the spear tip into Pop-A-Plug pin.(Figure 2)
- 3. Hit the end of Removal Tool or use the slide hammer to drive pin back into tube (Figure 3).

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- Thread spear into ring using 3/4" hex cap on rod end (about 4-6 turns). Use slide hammer to remove ring (Figure 4) or use hydraulic ram as shown below. (Figure 5)
- If spear pulls out of the ring, repeat step 4 using additional turns when threading spear into ring.



FIGURE 1

ALTERNATE PROCEDURE 1: IF BREAKAWAY CANNOT BE REMOVED

1. Lightly strike the front of the plug using a hammer and rod to disengage the pin from the ring (Figure 6). Follow step 4 above and retrieve pin with magnet (available from EST, part number PRT-MAGNET) or other means.



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ALTERNATE PROCEDURE 2: IF RING DOES NOT DISENGAGE FROM TUBE ID

- 1. Leave broken end of breakaway in the installed plug. If it has been removed, re-install the breakaway piece (or pulling stud) back into the plug.
- 2. Lightly strike the front of plug using a hammer and rod to disengage pin from the ring. (Figure 6)
- 3. Break the bond between the ring and tube ID by placing a rod or the plug positioner with the same OD as the ring OD against the ring and hitting with a hammer to move the ring approximately 1/2" deeper. (Figure 7)
- It may be necessary to brush the tube area in front of the ring to remove any fouling/scale that may have accumulated during service using a tube prep brush (available from EST). This will allow the ring to be removed from the tube with less obstruction. (Figure 8)
- Choose the appropriately sized spear (See Table) and thread spear into ring using 3/4" hex cap on rod end (about 4-6 turns). Use slide hammer to remove ring (Figure 4) or use ram as shown below. (Figure 5)

WARNING! USING THE WRONG SIZED SPEAR MAY CAUSE THE SPEAR TIP TO FRACTURE DURING USE

- 6. If spear pulls out of the ring, repeat step 5 using additional turns when threading spear into ring.
- 7. Retrieve pin with a magnet (available from EST, part number PRT-MAGNET) or other means.



FIGURE 8

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.460 - .580

.600 - .860

.880 - 1.160

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POP-A-PLUG REMOVAL TOOL PARTS LIST

Use CPI or P2 Pop-A-Plug sizes to order removal equipment. An extra spear and stud are recommended for all orders. Consult factory if removing large quantities of plugs.



PLUG REMOVAL TOOL (INCLUDES PULL ROD ASSEMBLY, SUDE HAMMER, SPEAR AND SELE TARDING STUD & ADAPTER)						
PART NUMBER	CPI/PERMA PLUG SIZE	P2 SIZE RANGE				
PRT-001	N/A	.400 – .440				
PRT-002	.471	.460 – .500				
PRT-003	.491 TO .555	.520580				
PRT-004	.584	.600 – .680				
PRT-005	.621 TO .670	.700 – .780				
PRT-006	.712 TO .735	.800 – .860				
PRT-007	.774 TO .853	N/A				
PRT-008	.899 TO .962	.880960				
PRT-009	.979 TO 1.087	.980 - 1.060				
PRT-010	1.103 TO 1.149	1.080 - 1.160				
	SPEAR					
PART NUMBER	CPI/PERMA PLUG SIZE	P2 PLUG RANGE				
PRTS-001	N/A	.400 – .440				
PRTS-002	.471	.460 – .500				
PRTS-003	.491 TO .555	.520 – .580				
PRTS-004	.584	.600 – .680				
PRTS-005	.621 TO .670	.700 – .780				
PRTS-006	.712 TO .735	.800 – .860				
PRTS-007	.774 TO .853	N/A				
PRTS-008	.899 TO .962	.880960				
PRTS-009	.979 TO 1.087	.980 - 1.060				
PRTS-010	1.103 TO 1.149	1.080 - 1.160				
	SLIDE HAMMER					
PART NUMBER	CPI/PERMA PLUG SIZE	P2 PLUG RANGE				
PRH-001	.471 TO 1.149	.400 – 1.160				
(1)	(INCLUDES PULL ROD, NUTS AND THREAD CAP)					
PART NUMBER	CPI/PERMA PLUG SIZE	P2 PLUG RANGE				
PRPR-001	.471 TO 1.149	.400 – 1.160				
S	ELF TAPPING SPEAR STUDS & THREAD	ADAPTER				
PART NUMBER	CPI/PERMA PLUG SIZE	P2 PLUG RANGE				
PRS-1032	N/A	.400 – .440				
TA-1032-1228	.471	N/A				

.491 TO .555

.584 TO .735

.774 TO 1.149

QUESTIONS? Contact EST Group Customer Service at any of the following locations with questions.

In USA and Canada: tel: 800-355-7044, 215-721-1100; e-mail: est-info@curtisswright.com

In Europe: tel: +31-172-418841; e-mail: <u>est-emea@curtisswright.com</u>

In Asia: tel: +65-6745-8560; e-mail: <u>est-asia@curtisswright.com</u>

On the Internet: <u>http://estgroup.cwfc.com</u>

PRS-1228

PRS-0428

PRS-0524

Heat Exchanger Tube Plugging

Pop-A-Plug[®] Removal Plug Removal Made Easy

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The ideal companion to our Pop-A-Plug® installation tools

EST's Pop-A-Plug Removal Tool (PRT) is the ideal companion to our Pop-A-Plug Installation Tools - perfect for removing installed Pop-A-Plugs when retubing or retiring a bundle.

A dual function tool, the PRT features a nose piece that threads into the pin of an installed plug, enabling you to drive the pin from the ring. The PRT retains the pin while a serrated spear grabs the ring's ID. An integral slide hammer then lets you pull out the ring and pin together.

The PRT consist of three components: a main body shaft, a spear and a slide hammer.

Each PRT comes complete with all the parts needed to remove the appropriate size plug. You only need to purchase additional spears if you are removing a different size plug.

Plug Removal Tool

(includes Pull Rod Assembly, Slide Hammer, Spear, Self Tapping Stud & Adapter)

PART NUMBER	CPI PLUG SIZE	P2 PLUG SIZE
PRT-001	N/A	0.400 - 0.440
PRT-002	0.471	0.460 - 0.500
PRT-003	0.491 - 0.555	0.520 - 0.580
PRT-004	0.584	0.600 - 0.680
PRT-005	0.621 - 0.670	0.700 - <mark>0.7</mark> 80
PRT-006	0.712 - 0.735	0.800 - 0.860
PRT-007	0.774 - 0.853	N/A
PRT-008	0.899 - 0.962	0.880 - 0.960
PRT-009	0.979 - 1 .087	0.980 - 1.060
PRT-010	1.103 - 1.149	1.080 - 1.160



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Spear

(includes Self Tapping Stud; 0.460 - 0.500 CPI/Perma Plug includes thread adapter)

PART NUMBER	CPI PLUG SIZE	P2 PLUG SIZE
PRTS-001	N/A	0.400 - 0.440
PRTS-002	0.471	0.460 - 0.500
PRTS-003	0.491 - 0.555	0.520 - 0.580
PRTS-004	0.584	0.600 - 0.680
PRTS-005	0.621 - 0.670	0.700 - 0.780
PRTS-006	0.712 - 0.735	0.800 - 0.860
PRTS-007	0.774 - 0.853	N/A
PRTS-008	0.899 - 0.962	0.880 - 0.960
PRTS-009	0.979 - 1.087	0.980 - 1.060
PRTS-010	1.103 - 1.149	1.080 - 1.160

* Requires use of Thread Adapter (Part Number TA-1032-1228)

Slide Hammer

PART NUMBER	CPI PLUG SIZE	P2 PLUG SIZE
PRH-001	0.471 - 1.149	0.400 - 1.160

Pull Rod Assembly

(includes pull rod, nuts and thread cap)

PART NUMBER	CPI PLUG SIZE	P2 PLUG SIZE
PRPR-001	0.471 - 1.149	0.400 - 1.160

PRT Pull Rod Extension

("LL" is length of the extensions in feet. Available sizes include: 1', 2', 3' and 4'.)

PART NUMBER	CPI PLUG SIZE	P2 PLUG SIZE	
PRPR-001-LL	0.471 - 1.149	0.400 - 1.160]

Self Tapping Spear Studs

PART NUMBER	CPI PLUG SIZE	P2 PLUG SIZE
PRS-1032	N/A	0.400 - 0.440
PRS-1228	0.491 - 0.555	0.460 - 0.580
PRS-0428	0.584 - 0.735	0.600 - 0.860
PRS-0524	0.774 - 1.149	0.880 - 1.160

Extendable Magnet



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APPENDIX C - Mechanical Fit Tube Plug Through The Tube Installation Procedure

THROUGH-THE-TUBE PLUGGING™ WITH CPI / PERMA PLUGS

CPI / Perma Plugs are part of the Pop-A-Plug® Tube Plugging System. Unlike other tube plug designs, and under the proper conditions, CPI / Perma Plugs can be passed through the length of a straight heat exchanger tube and successfully installed at the far end of the tube without having direct access to both tube ends. This procedure outlines the information required to evaluating a heat exchanger for the Through-the-Tube plugging procedure, the limitations of the technique, and the installation process.



WARNING! SUCCESSFULLY INSTALLING CPI / PERMA PLUGS BY PASSING THEM THROUGH-THE-TUBE REQUIRES THAT THE OPERATOR CAREFULLY FOLLOW THIS PROCEDURE. THE OPERATOR SHOULD BECOME FAMILIAR WITH THIS PLUGGING PROCEDURE AND POSSESS A CLEAR UNDERSTANDING OF HOW TO INSTALL CPI / PERMA PLUGS AT THE NEAR END BEFORE ATTEMPTING THROUGH-THE-TUBE PLUGGING.

EVALUATING THE APPLICATION - INFORMATION REQUIRED:

1. Tube Size.

What is the actual tube ID?

2. The tube-to-tubesheet connection.

Is the tube-to-sheet connection expanded, welded, or both? If the tube is expanded the length of the expanded area is required to determine the position where the plug will be installed within the tube. CPI / PERMA PLUGS MUST NEVER BE INSTALLED IN THE TRANSITION ZONE BETWEEN EXPANDED AND UNEXPANDED AREA OF THE TUBE. If the tube is seal welded to the tubesheet then the weld material at the near tube end will need to be removed by lightly reaming with a tapered reamer.



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FIGURE 2. Simplified View of a Straight Tube Heat Exchanger



3. Tubesheet-to-tubesheet length.

What is the distance from the outer face of the near tubesheet to the outer face of the far tubesheet?

4. Tubesheet Thickness.

What is the thickness of the far end tubesheet?

5. Heat Exchanger Channel.

Is there a channel head present at the near end? If so, what is the length of the channel head?

6. Existing Obstructions

Are there any obstructions (division plates, stud bolts, limited clearance overhead, etc.) that may interfere with any of the Pop-A-Plug System equipment? Do any of the obstructions require that the Pull Rod and Tube sections be a specific length?

LIMITATIONS OF THIS TECHNIQUE

While the Through-the-Tube plugging technique has proven to be both effective and reliable means for plugging tubes, several external factors can limit its success. These factors should be recognized and understood prior to starting.

 Condition of the Tubes. The tubes to be plugged must be clean and free of any deposits. Deposits within the tubes can prevent the proper plug size from fitting through the tube to the far end of the heat exchanger. EST recommends hydroblasting and / or the use of aggressive tube cleaning brushes to clean the tubes. Some deposits may require chemical cleaning. Hard deposits that cannot be removed by hydroblasting, brushing, or chemical cleaning may require either drilling or rodding.

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Damaged Tubes. Tubes that are extremely bowed, bent, or have failed as a result of tube denting, implosion or other tube ID altering factor may not allow the plug to be passed through the tube to the far end.

PRIOR TO PLUGGING

- 1. Clean the tube(s) thoroughly.
- If the service of the heat exchanger permits, pierce the wall of the tube(s) in a location just beyond the tubesheet. The puncture should be cleanly through the tube wall.

DETERMINING THE PROPER CPI / PERMA PLUG SIZE

CPI / Perma Plugs and plug installation equipment will be selected based upon the tube ID. Actual tube measurements are best. Ideally the measurements should be taken at two locations, 90 degrees apart, at a point about 1" (25.4 mm) deep within the tube end. Further a number of tubes in both the inlet and outlet pass should be measured. If actual tube measurements are not available then the tube data (tube OD and wall thickness, or gage) may be obtained from the heat exchanger data sheet provided by the manufacturer. The tube data and the sizing guide shown in Appendix 1 may be used to determine the suggested CPI / Perma Plug size. Note: A careful evaluation of the repair history for the heat exchanger is also advised. If the tube bundle and/or tubes have been replaced, the actual tube size may vary considerably from the tube size indicated on the heat exchanger datasheet.

CALCULATE INSTALLATION DEPTH FOR FAR END PLUG

The CPI/Perma Plug must be installed into the tubesheet area of the tube only. EST recommends that the plug be positioned in the middle of the rolled area of the far end tube or the middle of the tubesheet if the tube is not rolled. To determine the proper **Installation Depth** subtract one half of the far end tube roll length from the tubesheet to tubesheet length. Refer to Figure 2.

Example:Tubesheet face to tubesheet face = 10 ft. = 120 in.Far end tube roll length or Tubesheet thickness if unrolled = 4"Installation depth= 120" - $[1/2 \times 4"] = 118"$ In this case the Installation Depth would be equal to 118"

REQUIRED INSTALLATION EQUIPMENT

CPI / Perma Plug installation hardware is dedicated to specific CPI / Perma Plug size(s) only. The following equipment is required:

- 1. A sufficient supply of CPI / Perma Plugs in the proper size and plug material.
- Through-The-Tube Thread Adapter Kit(s) for the indicated plug size(s). Refer to the section titled Through-The-Tube Adapter Kit for more information on the Adapter Kits.
- A Pop-A-Plug System Ram Package. Based on the plug size and material select either the Small Ram, Part Number PAP-6600, or Large Ram Package, Part Number PAP-1750. Note: V-1334 plug sizes and larger must be installed using the Large Ram.
- 4. Air Regulator Assembly, Part Number REG-TTT.

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- A sufficient supply of Pull Rod and Tube Extensions to allow the CPI / Perma Plug to be positioned at the far end of the heat exchanger.
- 6. Additional Pop-A-Plug installation hardware is suggested as spares.
 - 6.1. 1 additional Plug Positioner for each CPI / Perma Plug size.
 - 6.2. 1 additional Channel Head Pull Rod Assembly (4 ft. or 6 ft.)
- 7. (2) small pipe wrenches (6" or smaller) or (2) pair of Vise Grips.
- 8. 30' tape measure.

ASSEMBLY OF HYDRAULIC EQUIPMENT:

Installation of CPI / Perma Plugs at the far end of the heat exchanger requires that the Hydraulic Pump be operated to the installation pressure specified for the individual plug size and material. The pulling pressures will also vary by the hydraulic ram used during installation. Installation pressures are shown in either Table 1, for installations with the Small Ram, and Table 2, for installations with the Large Ram. Use of the Air Regular Assembly, Part Number REG-TTT, is mandatory.

- 1. Connect the Air Regulator assembly to the air input connection on the Hydraulic Pump, refer to Figure 3 below.
- Connect the air supply to the Air Regulator input and set regulator to produce the proper hydraulic pressure by performing the following steps.
 - a. Disconnect any items connected to the Hydraulic Pump output.
 - b. Turn the Air Regulator adjustment knob fully counterclockwise.
 - c. Depress the Hydraulic Pump pedal while viewing the pressure gauge. While keeping pump pedal depressed, slowly adjust the Air Regulator knob clockwise to activate the pump. Continue operating the pump until the proper hydraulic pressure required for the CPI / Perma plug size and material is achieved. Refer to Table 1 for plug installations using the Small Ram, or Table 2 for installations using the Large Ram.



FIGURE 3. Air Regulator Assembly And Hydraulic Pump

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- d. Depress the release end of the Hydraulic Pump pedal to release the built-up pressure. Repressurize the Pump to verify that the proper hydraulic pressure has been set. Adjust Air Regulator as necessary. Release pressure.
- e. Connect one end of the hydraulic hose to the Pump output. The other end of the hose is to be connected to the Hydraulic Ram. Verify that all quick connects are fully tightened. The ram is now ready for use.

THROUGH-THE-TUBE ADAPTER KIT

The Through-The-Tube Adapter Kit includes a Through-The-Tube Adapter and a supply of Through-The-Tube Studs as shown in Figure 4. The Through-The-Tube (TTT) Adapter has a right hand male thread on one end and left-hand female thread on the other. The TTT Studs are threaded with both left and right hand threads. TTT Adapter Kits are plug size specific and are to be used in through-the-tube plugging applications in place of the breakaway supplied with the CPI / Perma Plugs. The applicable Adapter Kits for given plug sizes are shown in Tables 1 and 2. Adapter Kits should be installed as outlined in the following section.



FIGURE 4. Through-The-Tube Adapter Kit and CPI / Perma Plug

PULL ROD ASSEMBLY FOR THROUGH THE TUBE PLUGGING, See Figure 5.

The Pull Rod sections need to be assembled to achieve the desired length. The overall suggested length is approximately equal to the heat exchanger tubesheet to tubesheet length plus the length of the channel head (if applicable).

NOTE: Pull Rod Extensions are shipped from the factory with the Pull Rods inside the Compression Tube. To speed the assembly process of the Pull Rod Extensions remove all Pull Rods from the mating Compression Tubes prior to continuing. The Pull Rods should be assembled on the ground to minimize bending. If space is limited, the Pull Rod Extensions can be assembled piece by piece in the heat exchanger tube to be plugged.

- 1. Remove breakaway from the CPI/Perma Plug to be installed through the tube. Note: Do not grip or in any way mar the surface of the tapered pin when unscrewing the breakaway. Discard the breakaway once removed.
- 2. Thread the right hand threaded end of the TTT Stud clockwise into the plug.

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- Holding the plug thread it into the female left hand thread of the TTT Adapter until fully engaged. NOTE: Do not retighten after contact or plug / adapter kit assembly may unthread. The pulling stud will remain with the plug after installation. DO NOT USE A THREAD LOCKING AGENT.
- 4. Thread a TTT Adapter into the end of the first Extension Rod and tighten by hand.



FIGURE 5. Pull Rod Assembly Set-up

WARNING! DURING THESE INSTALLATION PROCEDURES CARE MUST BE EXERCISED SO THAT THE EXTENSION RODS DO NOT ROTATE DURING TIGHTENING OR LOOSENING OF OTHER CONNECTIONS. FAILURE TO HEED THIS WARNING MAY RESULT IN THE THRU-THE-TUBE ADAPTOR PREMATURELY DISENGAGING FROM THE PLUG.

- Install the Plug Positioner, with arrow pointing toward plug, onto the first Extension Rod. The Plug Positioner should be installed so it rests against the plug.
- Install the 6-inch long Tube, supplied as part of the Channel Head Assembly, onto the first Extension Rod so it is against the back of the Plug Positioner.
- Thread the next Extension Rod onto the previous Extension Rod and firmly hand tighten. Keep both Rods straight to make certain that the joint is not subjected to bending while tightening.
- 8. Install the next Extension Tube over the Extension Rods.
- 9. Repeat steps 7 and 8 until the desired Extension length has been achieved. The desired length is approximately equal to the heat exchanger tubesheet to tubesheet length plus the length of the channel (if applicable).
- 10. The Channel Head Rod should be threaded onto the Extension Rods and firmly hand tighten. Keep both Rods straight to make certain that the joint is not subjected to bending while tightening. After tightening, verify that the joint cannot be loosened by hand. If it can, retighten. This is the last Rod section.
- Install the remaining Tubes onto the Rod assembly. Remove slack from the Rod and Tube assembly by holding the last Tube and pulling on the Channel Head Rod.

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12. Set the Stand-Off Ring. A Stand-Off Ring is used to set the proper Installation Depth prior to installing the plug. The Stand-Off Ring locks onto an Extension Tube by tightening a thumb screw, refer to Figure 6. Make a measurement from the middle of the ring back along the Extensions for a distance equal to the Installation Depth. Using a file, mark the Extension at that point. The mark is permanent and will allow you to check that the Stand-Off Ring is in the proper position prior to each plug installation. Slide the Stand-Off Ring to the mark and firmly tighten the thumbscrew.



FIGURE 6. Setting Stand-Off Ring

- 13. Install the Rod & Tube Positioner onto the Rod assembly with arrow pointing toward the plug.
- 14. Thread the Knurled Nut onto the exposed threads of the Channel Head Rod to hold the assembly together during the next step. NOTE: Do not allow the rod to turn while threading on Knurled Nut as it could result in disengaging the TTT Adapter.
- 15. Plug should now be positioned for installation. When maneuvering the Pull Rod set-up make certain that it is adequately supported to avoid bending. Slide the set-up, plug end first, into the heat exchanger tube to be plugged until the standoff ring is against the tube end. Remove slack from the Rod and Tube assembly by holding the last Tube and pulling on the Channel Head Rod.
- 16. Remove the Knurled Nut from the Channel Head Rod without turning rod.
- 17. Slide the hydraulic Ram onto exposed Channel Head Rod. The Ram should be installed so the Ram piston strokes toward the operator.
- Thread Knurled Nut onto the Channel Head Rod and firmly tighten against the Ram. Do not allow the rod to turn while threading on Knurled Nut as it could result in disengaging the TTT Adapter.
- Install the Ram Safety Cable then the locknut onto the Pull Rod and hand tighten. Verify that the Stand-Off Ring is against the tube end.
- 20. While viewing the pressure gauge, press the Pump pedal to slowly pressurize the Ram. The Air Regulator, previously adjusted, will allow only the set pressure to build. If it appears that the proper installation pressure is going to be exceeded, STOP and readjust Regulator as specified above. Continue to operate the Pump until the Ram bottoms out or the previously set installation pressure is reached.

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- NOTE: When the Ram piston bottoms out the hydraulic pressure will reach the set pressure only because the piston is at the end of its travel. At this point it is still necessary to continue to step 19.
- 21. Release hydraulic pressure to allow the Ram to fully retract. Hold Ram handle while pulling on the Knurled Nut to remove any slack from the set-up. Thread Knurled Nut so it is against the Ram and firmly tighten. Do not allow rod to turn when tightening the Knurled Nut.
- 22. While viewing the pressure gauge, press the Pump pedal to slowly pressurize the Ram. Continue to operate the Pump until the Ram bottoms out or the proper installation pressure is reached. If the Ram bottoms out, repeat step 19. If the proper installation pressure has been reached and the Knurled Nut cannot be hand tightened by more than 1/4 of a turn after the hydraulic pressure is released, the plug has been properly installed. If the proper installation pressure has been reached and tightened more than 1/4 of a turn after the hydraulic pressure is released, the plug has been properly installed. If the proper installation pressure is released, the plug has been properly installed. If the hydraulic pressure is released, repeat steps 19 and 20 until the Knurled Nut cannot be hand tightened by more than 1/4 of a turn after the hydraulic pressure is released.
- NOTE: Additional Adjustment of the Regulator may be necessary during this step.
- NOTE: Having to repeat steps 19 and 20, 4 to 5 times is not uncommon.
- 23. Released hydraulic pressure to allow the Ram to fully retract.
- 24. Remove the Knurled Nut and hydraulic Ram from the Rod. Do not allow the rod to turn while threading off the Knurled Nut.
- 25. Reinstall the Knurled Nut to ensure that no parts slip off of the Rod. Apply a light pulling force while turning the Rod clockwise to unthread the Pull Rod set-up from the installed plug. The Dual Thread Pulling Stud will remain with the installed plug. When disengaged withdraw the Pull Rod set-up from the tube. When maneuvering the Pull Rod set-up, make certain that it is adequately supported to avoid bending.
- QUESTIONS? Contact EST Group Customer Service at any of the following locations with questions. In USA and Canada: tel: 800-355-7044, fax: 215-721-1101, e-mail: <u>est-info@curtisswright.com</u> In Europe: tel: +31-172-418841, fax: +31-172-418849; e-mail: <u>est-emea@curtisswright.com</u> In Asia: tel: +65-6745-8560, fax: +65-6742-8700, e-mail: <u>est-asia@curtisswright.com</u> On the Internet: <u>http://estgroup.cwfc.com</u>

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THROUGH-THE-TUBE PLUGGING TECH TIP

When performing Through-the-tube (TTT) Plugging, the installation load from the hydraulic ram causes the pull rod to stretch and the compression tube to compress. The combined stretch and compression of the extensions takes away from effective travel of the pin relative to the ring. To explain differently, the small ram (PAP-6600) has a total stroke of 1" (25.4mm). If using the PAP-0200 as indicated below, the combined stretch and compression of a 20 foot (6.1m) extension assembly will be approximately 0.85" (21.6mm), refer to Table 1. This translates to approximately 0.15" (3.8mm) of pin travel relative to the ring (1" of ram stroke minus 0.85" of stretch/compression = 0.15" pin movement (25.4mm or ram stroke minus 21.6mm of stretch/compression equals 3.8mm of pin travel relative to the ring)). So when a full stroke of the ram is seen during installation the plug at the far end of the exchanger has only stroked by approximately 0.15" (3.8mm). This is why the TTT Plugging instructions indicate that the ram must be repeatedly stroked to the installation pressure and when released, the knurled nut cannot be tightened by more than ¼ of a turn. This repeated stroking insures that the plug will be properly installed.

Question: What is the longest length of TTT extension we can use?

Answer: The rule of thumb is roughly 20feet (6.1m) for the small ram (PAP-6600) and 40feet (12.2m) for the large ram (PAP-1750). Tubes longer than 40 feet (12.2m) can be plugged using the TTT technique provided a hydraulic ram with enough stroke to overcome the stretch/compression is utilized. Please contact Sales for information regarding your specific application.

Table 1 below shows the combined stretch/compression of our 20foot (6.1m) Rod and Tube Extension Assemblies. Note that the stretch/compression will be less for shorter extension assemblies and more for longer extension assemblies.

	or 110 · 1			· · · ·	- ·
Dort Number	Stretch/Compression of	Breakaway Pressure	Pull Rod OD	Compression Tube	Breakaway
Part Number	20ft. Assembly (in)	(psi)	(in)	OD (in)	Thread
PAP-0200	0.85	2700	5/16	7/16	12-28
PAP-0201	0.71	3000	5/16	1/2	12-28
PAP-0202	0.72	4000	3/8	9/16	1/4-28
PAP-0213	0.80	6600	1/2	11/16	5/16-24
PAP-0203	0.68	6600	1/2	3/4	5/16-24
PAP-0204	0.40	3200 (Lg. Ram)	3/4	1 1/8	1/2-20
PAP-0205	0.32	3200 (Lg. Ram)	7/8	1 1/4	1/2-20

Table 1. Rod and Tube Extension Assembly Stretch / Compression During TTT Plugging.



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TABLE 1. Hydraulic Installation Pressures For Use With Small Ram Package (PAP-6600) Only. (See Table 2 for Large Ram)

CPI / PERMA	THROUGH-THE-TUBE		SMALL RAM	
PLUG SIZE	ADA	PTER KIT	INST	ALLATION
			PRES	SURE (PSI)
	BRASS	STAINLESS	BRASS	STAINLESS
	PLUGS	STEEL &	PLUGS	STEEL &
		CARBON		CARBON
		STEEL		STEEL
		PLUGS		PLUGS
.471	TTT-1032	TTT-1228	1900	2100
.491	Т	TT-1228	2100	2100
.512	Т	TT-1228	2100	2100
.524	Т	TT-1228	2100	3000
.555	Т	TT-1228	2100	3000
.584	Т	TT-1428	2100	3100
.621	Т	TT-1428	2100	3100
.649	Т	TT-1428	2100	4000
.670	Т	TT-1428	2100	4000
.712	TTT-1428		3100	4000
.735	TTT-1428		3100	4000
.774	TTT-51624		3100	5300
.804	TTT-51624		3100	5300
.837	TT	T-51624	3100	5300
.853	TT	T-51624	3100	5300
.899	TT	T-51624	3100	5300
.919	TT	T-51624	4000	5300
.962	TT	T-51624	4000	5300
.979	TT	T-51624	4000	5300
1.024	TT	T-51624	4000	6600
1.054	TT	T-51624	4000	6600
1.087	TTT-51624		4000	6600
1.103	TT	T-51624	4000	6600
1.149	TT	T-51624	4000	6600
1.171	TT	T-51624	4000	6600
1.212	TT	T-51624	5300	6600



FIGURE 7. Small (White) Ram, Model PAP-6600



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TABLE 2. Hydraulic Installation Pressures For Use With Large Ram Package (PAP-1750) Only. (See Table 1 for Small Ram)

CPI / PERMA	THROUGH-THE-TUBE		LARGE RAM	
PLUG SIZE	ADAPTER KIT		INSTALLATION	
			PRES	SURE (PSI)
	BRASS	STAINLESS	BRASS	STAINLESS
	PLUGS	STEEL &	PLUGS	STEEL &
		CARBON		CARBON
		STEEL		STEEL
		PLUGS		PLUGS
.471	TTT-1032	TTT-1228	714	789
.491	T	FT-1228	789	789
.512	T	FT-1228	789	789
.524	T	FT-1228	789	1127
.555	T	FT-1228	789	1127
.584	T	FT-1428	789	1165
.621	T	FT-1428	789	1165
.649	T	FT-1428	789	1503
.670	T	FT-1428	789	1503
.712	T	FT-1428	1165	1503
.735	T	FT-1428	1165	1503
.774	TTT-51624		1165	1991
.804	TTT-51624		1165	1991
.837	TTT-51624		1165	1991
.853	TT	T-51624	1165	1991
.899	TT	T-51624	1165	1991
.919	TT	T-51624	1503	1991
.962	TT	T-51624	1503	1991
.979	TT	T-51624	1503	1991
1.024	TT	T-51624	1503	2479
1.054	TT	T-51624	1503	2479
1.087	TT	T-51624	1503	2479
1.103	TT	T-51624	1503	2479
1.149	TT	T-51624	1503	2479
1.171	TT	T-51624	1503	2479
1.212	TT	T-51624	1991	2479
1.334	Т	FT-1220	2000	3200
1.456	T	FT-1220	N/A	4300
1.578	Т	FT-1220	N/A	4300
1.700	T	FT-1220	N/A	4300
1.822	Т	FT-1220	N/A	4300
1.944	Т	FT-1220	N/A	4300



FIGURE 8. Large (Orange) Ram, Model PAP-1750

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Heat Exchanger Tube Plugging

APPENDIX 1. Recommended CPI / Perma Plug Sizes For Use In
Through-The-Tube Plugging Applications Only

1	WALL THICK	NESS			TUBE OD		
BWG	DECIMAL		5/8"	3/4"	7/8'	1"	1-1/4"
10	.134	UNROLLED ID		.482	.607	.732	.982
		ROLLED ID		.509	.634	.759	1.009
	100	PLUG PART #	N/A	V-4/1	V-584	V-/12	V-962
11	.120	UNROLLED ID		.510	.635	.760	1.010
		RULLED ID	NUA	.034	.009 V 621	./84	1.034
10	100		IN/A	522	657	702	1 022
12	.109	ROLLEDID		.554	679	.762	1.052
		PLUG PART #	N/A	V-512	V-621	V-735	V-979
13	095			560	685	810	1 060
15	.000	ROLLED ID		579	704	829	1.000
		PLUG PART #	N/A	V-524	V-649	V-774	V-1024
14	.083	UNROLLED ID		.584	.709	.834	1.084
	L .	ROLLED ID		.601	.726	.851	1.101
		PLUG PART #	N/A	V-555	V-670	V-804	V-1054
15	.072	UNROLLED ID	.481	.606	.731	.856	1.106
		ROLLED ID	.495	.620	.745	.870	1.120
		PLUG PART #	V-471	V-584	V-712	V-837	V-1054
16	.065	UNROLLED ID	.495	.620	.745	.870	1.120
		ROLLED ID	.508	.633	.758	.883	1.133
17		PLUG PART #	V-471	V-584	V-712	V-837	V-1054
17	.058	UNROLLED ID	.509	.634	.759	.884	1.134
		ROLLED ID	.521	.646	.//1	.896	1.140 V 1102
40	040	FLUG FART#	V-491 507	V-021	V-730 777	v-000	V-1103
18	.049		.027	.052	.///	.902	1.152
		PLUG PART #	V-512	V-621	V-735	V-853	V-1103
19	042		541	666	791	916	1 166
10	.012	ROLLED ID	.549	.674	.799	.924	1.174
		PLUG PART #	V-524	V-649	V-774	V-853	V-1149
20	.035	UNROLLED ID	.555	.680	.805	.930	1.180
	1	ROLLED ID	.562	.687	.812	.937	1.187
		PLUG PART #	V-524	V-649	V-774	V-853	V-1149
21	.032	UNROLLED ID	.561	.686	.811	.936	1.186
		ROLLED ID	.567	.692	.817	.942	1.192
	1	PLUG PART #	V-524	V-670	V-774	V-919	V-1149
22	.028	UNROLLED ID	.569	.694	.819	.944	1.194
		ROLLED ID	.5/5	./00	.825	.950	1.200 V 1174
22	025	FLUG PART#	V-0Z4	V-0/U	V-//4	V-919	V-11/1
23	.025		.5/5	.700	.825	.950	1.200
		PLUG PART #	V-555	V-670	V-804	V-919	V-1171
24	022		581	706	831	956	1 206
-7	1	ROLLED ID	.585	.710	.835	.960	1.210
		PLUG PART #	V-555	V-670	V-804	V-919	V-1171

NOTE: Plug Part Numbers above do not include material designation. For recommended sizes in near end applications refer to CPI / Perma Plug rolled tube sizing chart shown in (DC1221).



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Revision history

The following information documents at least the last 3 changes to this document, with all the changes listed for the last 6 months.

Date	Revised By	Changes
05/15/17	L. Hall	New Procedure