BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 2.36

PRODUCTION PROCESS STANDARD

Cold Expansion of Holes

Issue 9
- This standard supersedes PPS 2.36, Issue 8.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to PPS.Group@aero.bombardier.com or (416) 375-4365.
- This PPS is effective as of the distribution date.

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	Quality		

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1 Scope

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for cold expansion of drilled holes using the split sleeve or split mandrel cold expansion process.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS must be followed to ensure compliance with all applicable specifications. In general, if this PPS conflicts with the engineering drawing, follow the engineering drawing. The requirements specified in this PPS are necessary to fulfil the engineering design and reliability objectives.

1.1.2 Refer to PPS 13.26 for the subcontractor provisions applicable to this PPS.

1.1.3 Procedure or requirements specified in a Bombardier BAPS, MPS, LES or P. Spec. **do not** supersede the procedure or requirements specified in this PPS.

2 Hazardous Materials

2.1 Before receipt at Bombardier Toronto (de Havilland), all materials must be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier Toronto (de Havilland) Environment, Health and Safety Department. Refer to the manufacturer's MSDS for specific safety data on any of the materials specified in this PPS. If the MSDS is not available, contact the Bombardier Toronto (de Havilland) Environment, Health and Safety Department.

3 References

3.1 PPS 1.09 - Drilling and Reaming.

3.2 PPS 13.26 - General Subcontractor Provisions.

4 Materials and Equipment

4.1 Materials

4.1.1 Split sleeves as supplied in STDN tool kits. See Figure 4 for a description of the split sleeve.

4.1.2 Lubricant (e.g., Boelube).

4.2 Equipment

4.2.1 STDN tool kits as listed in Table 2. Refer to section 5.2 for tool descriptions.

4.2.2 Cold hole expansion puller unit (e.g., Split sleeve process: Fatigue Technologies Inc. LB-20 “Little Brute”, MB-30 “Medium Brute” or BB-30 “Big Brute” puller units; refer to Table 1 for capabilities. Split mandrel process: West Coast Industries WCI-300-XX, WCI-350-XX or WCI-400-XX).

4.2.3 Cold hole expansion hydraulic powerpack (e.g., Fatigue Technologies Inc. #FT-20 Powerpack). The FTI #FT-20 powerpack can be used with the “Little Brute”, “Medium Brute” and “Big Brute” puller units.

Table 1 - FTI Puller Unit Capabilities

PULLER UNIT	MAXIMUM STACK-UP	MAXIMUM TOOL KIT	
		ALUMINUM OR MILD STEEL	TITANIUM OR HIGH STRENGTH STEEL
LB-20 “Little Brute”	2.0''	16-0	12-0
MB-30 “Medium Brute”	3.3''	30-0	24-0
BB-30 “Big Brute”	3.0''	All tool kits listed in this PPS	

5 Procedure

5.1 General

5.1.1 The purpose of the cold expansion process is to improve the fatigue life of the structure in which the fasteners are located. Cold expansion of fastener holes involves producing a close tolerance reamed hole, expanding the hole using the split sleeve or split mandrel process and then reaming the hole to the required final diameter. Unless use of the split mandrel process is specified by the engineering drawing, use the split sleeve process for cold expansion of fastener holes.

5.1.2 The split sleeve expansion process consists of mounting a pre-lubricated split sleeve on a mandrel, inserting the mandrel/sleeve combination into a close tolerance reamed hole and then pulling the mandrel back through the sleeve. The action of drawing the mandrel through the split sleeve causes a radial plastic flow of material. The split mandrel process is similar, except that a sleeve is not used. Both processes produce a circular zone of residual compressive stresses that extends approximately one radius beyond the periphery of the hole. These residual compressive stresses provide the improvement in the fatigue life of the structure.

5.1.3 Standard tools required for cold expanding each specific size hole are contained in an STDN tool kit. These tool kits are identified by a standard tool diameter number (STDN) and are listed in Table 2. It is acceptable to use alternative equipment in place of that specified in Table 2 provided that all the hole requirements specified in Table 4 are met. At Bombardier Aerospace Toronto, refer to TS.671.10.10 for a listing of split sleeve process tool kits available.

Table 2 - STDN Tool Kit Selection

NOMINAL FASTENER DIAMETER	TOOL KIT STDN CODE
1/8"	4-0
9/64"	4-1
5/32"	4-2
11/64"	4-3
3/16"	6-0
13/64"	6-1
7/32"	6-2
15/64"	6-3
1/4"	8-0
17/64"	8-1
9/32"	8-2
19/64"	8-3
5/16"	10-0
21/64"	10-1
11/32"	10-2
23/64"	10-3
3/8"	12-0
25/64"	12-1
13/32"	12-2

NOMINAL FASTENER DIAMETER	TOOL KIT STDN CODE
27/64"	12-3
7/16"	14-0
29/64"	14-1
15/32"	14-2
31/64"	14-3
1/2"	16-0
33/64"	16-1
17/32"	16-2
35/64"	16-3
9/16"	18-0
37/64"	18-1
19/32"	18-2
39/64"	18-3
5/8"	20-0
41/64"	20-1
21/32"	20-2
43/64"	20-3
11/16"	22-0
45/64"	22-1

NOMINAL FASTENER DIAMETER	TOOL KIT STDN CODE
23/32"	22-2
47/64"	22-3
3/4"	24-0
49/64"	24-1
25/32"	24-2
51/64"	24-3
13/16"	26-0
53/64"	26-1
27/32"	26-2
55/64"	26-3
7/8"	28-0
57/64"	28-1
29/32"	28-2
59/64"	28-3
15/16"	30-0
61/64"	30-1
31/32"	30-2
63/64"	30-3

Note 1. When using the split sleeve process **only**, for fasteners with a nominal diameter of 3/16" or greater, it is acceptable to use the next smaller tool kit (e.g., for a 1/4" nominal diameter fastener, a 6-3 tool kit could be used to expand the hole). The lower number tool kit requires preparing a smaller starting hole and more reaming after cold working. When selecting a tool kit, ensure that the kit includes a finish reamer of the required size since, although two kits may be acceptable, in some cases finish reamers for the required final size may not be available.

Note 2. Although the tool kit STDN code for a particular nominal fastener diameter maybe the same for both the split sleeve and split mandrel processes, the tooling in each kit is **not** identical or interchangeable.

5.1.4 This process is tooling critical. The use of non-conforming or worn tools can result in a significant reduction in the expected fatigue life improvement or result in extensive rework associated with the removal of tooling embedded in the aircraft structure.

5.1.5 Perform all drilling and reaming of holes according to the procedure and requirements specified in PPS 1.09.

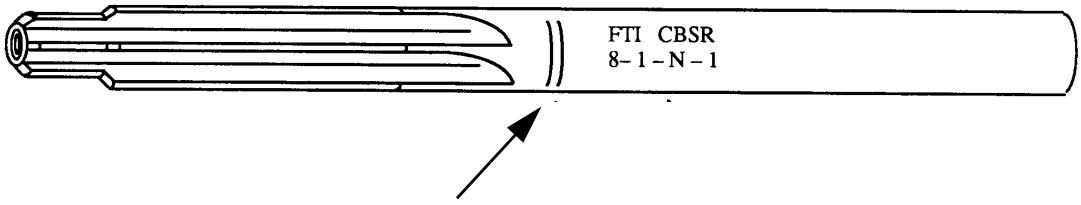
5.1.6 Ensure that material has faying surface contact during drilling, reaming, cold hole expansion and final sizing operations.

5.2 Tool Descriptions

5.2.1 **Starting Drill**: The starting drill is a standard, straight shank twist drill (see Figure 1) that is used to drill a pilot hole for the starting reamer.

Figure 1 - Starting Drill

5.2.2 **Starting Reamer**: Starting reamers are of the straight flute configuration with a straight shank. All starting reamers feature a pilot which is sized to the starting drill hole. Identification of an FTI starting reamer is provided by an electro-etched part number starting with CBSR and **two** circumferential lines ground or electro-etched on the shank (see Figure 2).



FTI identification markings
(two lines indicate a starting reamer;
three lines identify a finish reamer)

Figure 2 - Starting Reamer

5.2.3 **Mandrel (Split Sleeve Process):** The purpose of the mandrel is to expand the reamed starter hole. The major diameter of the mandrel provides the radial interface required by the split sleeve cold expansion process. The minor shank diameter is sized so that when the appropriate sleeve is placed on the mandrel, it will fit into the correct starting hole (see Figure 3).

5.2.4 **Nosecap:** The purpose of the nosecap assembly is to retain the split sleeve in the hole while the mandrel is drawn through the sleeve (see Figure 3).

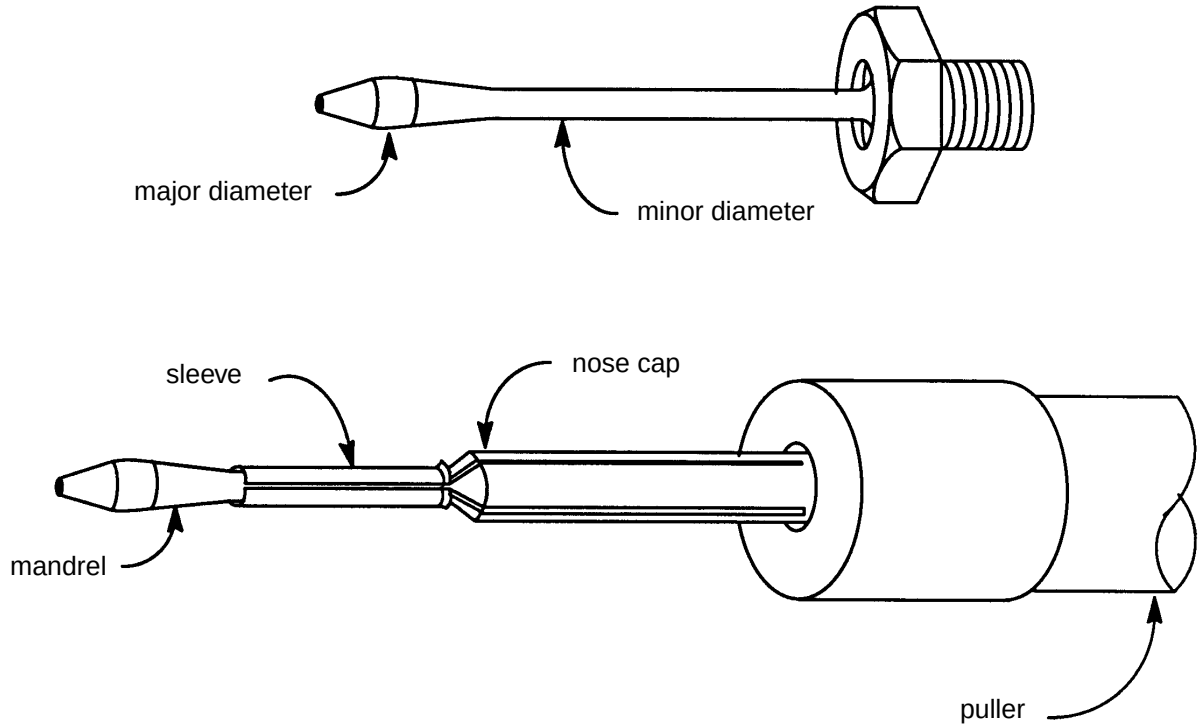


Figure 3 - Mandrel and Nosecap (Split Sleeve Process)

5.2.5 **Split Sleeve:** The split sleeve is fabricated from 301/302 stainless steel (see Figure 4). A dry film lubricant is baked onto the internal surface to ensure optimum lubricity. The split sleeve prevents damage to the hole as the mandrel is drawn through the hole. Sleeves must be 1/32" - 5/32" longer than the material stackup, depending upon the type of nosecap used.

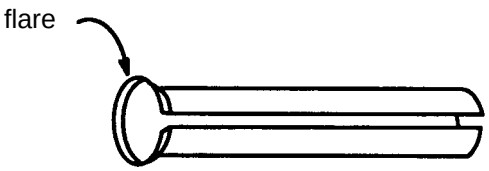


Figure 4 - Split Sleeve

5.2.6 **Mandrel (Split Mandrel Process):** A tool manufactured from high strength steel with dual tapers and longitudinal slots. The slots and front taper allow the mandrel to be inserted in the starting hole (see Figure 5).

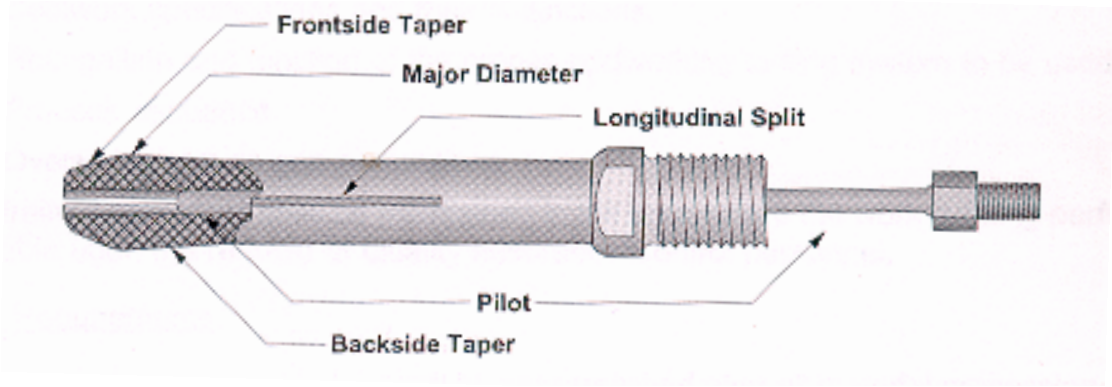


Figure 5 - Mandrel (Split Mandrel Process)

5.2.7 **Hydraulic Powerpack**: The powerpacks are an air powered hydraulic unit having a 3 horsepower multi-vane rotary air design which powers a two-stage hydraulic pump (see Figure 6). It is recommended that, at the beginning of each shift, the operator ensure all hydraulic and air connector mating surfaces are free from dirt, metal filings, etc.

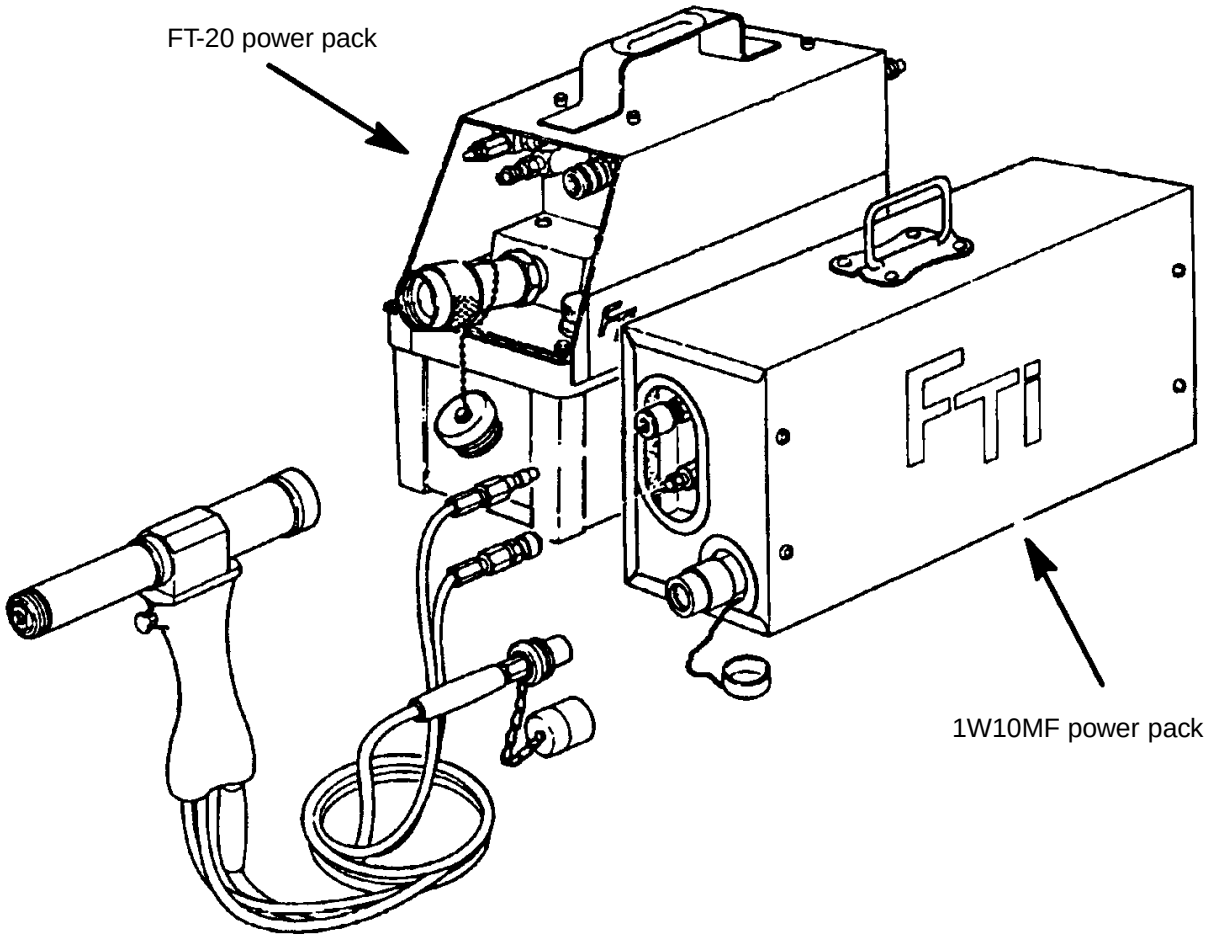
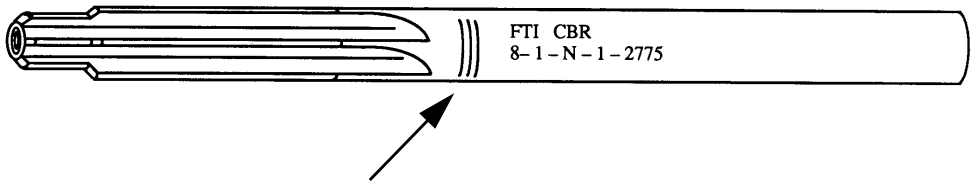


Figure 6 - Puller Unit/Hydraulic Power Pack

5.2.8 **Puller Unit:** The puller unit is specifically designed for use with the split sleeve cold expansion process. The purpose of the tool is to pull the mandrel through the prepared hole lined with a split sleeve. The puller unit features a fail-safe air logic control subsystem. This system causes the mandrel retraction cycle to be interrupted whenever the operator releases finger pressure on the trigger or in the event of air or hydraulic hose failure.

5.2.9 **Finish Reamer**: The finish reamer has a non-cutting, non-detachable pilot (see Figure 7). This pilot is sized such that it acts as a GO/NO-GO gauge and will not fit into a hole that has not been correctly cold expanded. Identification of an FTI finish reamer is provided by an electro-etched part number starting with CBR and three circumferential lines ground or electro-etched on the shank.



FTI identification markings
(two lines indicate a starting reamer;
three lines identify a finish reamer)

Figure 7 - Finish Reamer

5.2.10 **Mandrel Check Fixture** (see Figure 8): The mandrel check fixture is used to check mandrels for excessive wear. The gauge consists of a steel plate with a NO-GO hole in the centre. If the mandrel major diameter passes through the NO-GO hole, the mandrel is worn beyond the specification limit and must be replaced. It is recommended that at least once before use in a particular shift, mandrels should be checked using the mandrel check fixture.

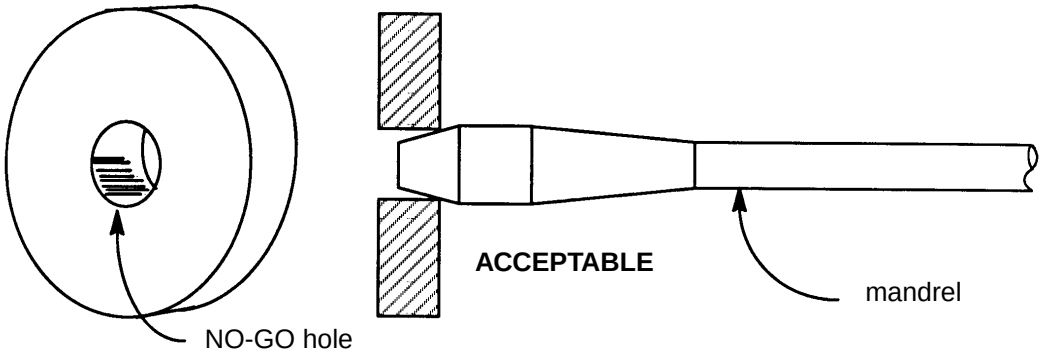


Figure 8 - Mandrel Check Fixture

5.2.11 **Combination Gauge**: The combination gauge (see Figure 9) consists of a reamed starting hole gauge and a post cold expansion gauge. The starting hole gauge is used to ensure that the reamed starting hole is within the specification tolerance of the STDN. If the reamed starting hole NO GO diameter fits into the reamed starting hole, reject the hole (see Figure 9). The post cold expansion gauge is used to ensure that the starting hole has been cold expanded to the correct diameter before a non-piloted finish reamer is used. If the post cold hole expansion gauge does not fit into cold expanded hole, reject the hole.

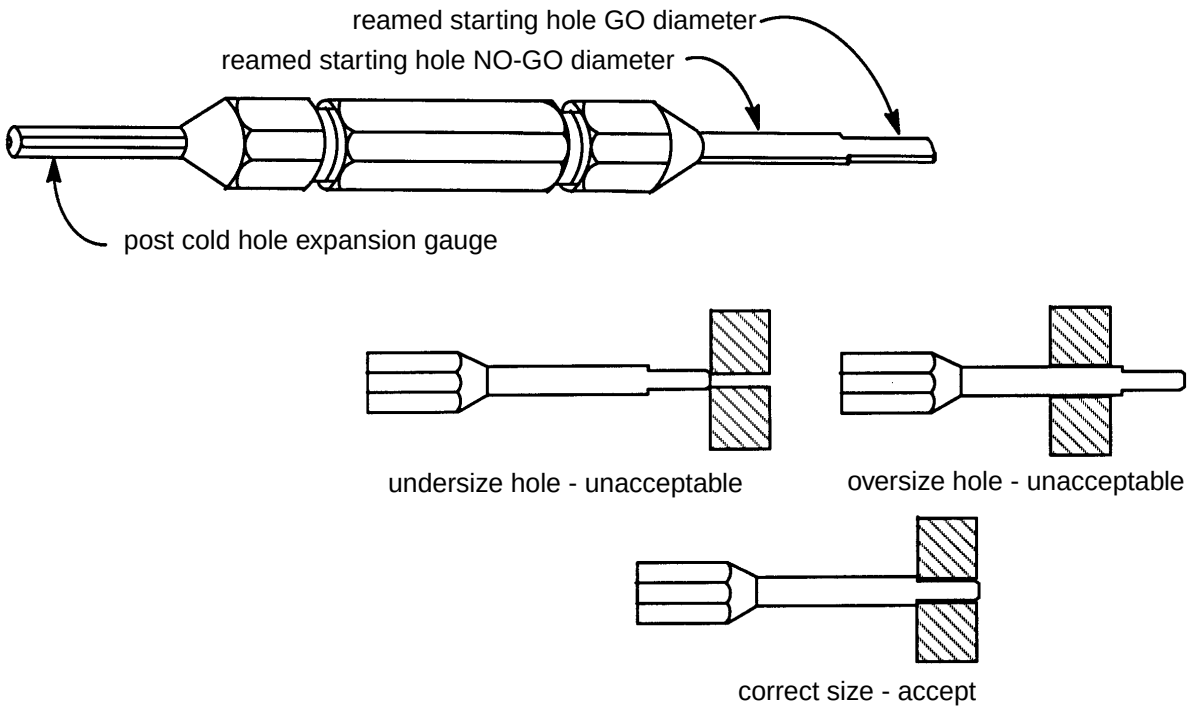


Figure 9 - Combination Gauge

5.3 Preparation of Starting Holes to Pre-Cold Working Size

5.3.1 The prepared starter hole must meet the requirements specified for “Pre-Cold Working” in Table 4. This may be accomplished in several ways:

5.3.1.1 If starting from scratch (i.e., no hole exists), the starter hole may be prepared using the starter drill and starting reamer as supplied in the tool kit. Alternatively, it is also acceptable to prepare the hole using a suitable pilot drill and piloted double margin drill as specified in PPS 1.09.

5.3.1.2 It is acceptable to prepare pilot holes for the starting reamer supplied using N/C equipment. If using the split sleeve process, refer to Table 3 for the required starting reamer pilot hole. After the pilot holes have been prepared, use the starting reamer to open the starting hole to the required "Pre-Cold Working" size specified in Table 4.

5.3.1.3 If performing rework or repair on an existing hole, it is recommended that a piloted double margin drill as specified in PPS 1.09 be used to open the hole to the required "Pre-Cold Working" size specified in Table 4.

5.3.2 Ensure that each prepared starting hole meets the requirements of Table 4. If using the split sleeve process, use the GO/NO-GO end of the combination gauge supplied in the STDN tool kit, if available. If undersize holes are discovered, verify the diameter of the reamer or double margin drill before re-reaming the holes. Refer oversize holes to Inspection and Liaison Engineering for disposition.

Table 3 - N/C Preparation of Starting Reamer Pilot Hole (Split Sleeve Process)

TOOL KIT	STARTING REAMER PILOT HOLE (-0.001"/+0.003")
4-0	#38 (0.1015")
4-1	#32 (0.1160")
4-2	#30 (0.1285")
4-3	#25 (0.1495")
4-4	#20 (0.1610")
6-0	#19 (0.1660")
6-1	#15 (0.1800")
6-2	#9 (0.1960")
6-3	#4 (0.2090")
8-0	7/32" (0.2188")
8-1	15/64" (0.2344")
8-2	1/4" (0.2500")
8-3	17/64" (0.2656")
10-0	9/32" (0.2812")
10-1	19/64" (0.2969")
10-2	5/16" (0.3125")
10-3	21/64" (0.3281")
12-0	11/32" (0.3438")
12-1	23/64" (0.3594")
12-2	3/8" (0.3750")
12-3	25/64" (0.3906")
14-0	13/32" (0.4062")
14-1	27/64" (0.4219")
14-2	27/64" (0.4219")
14-3	7/16" (0.4375")
16-0	29/64" (0.4531")
16-1	15/32" (0.4688")
16-2	31/64" (0.4844")
16-3	1/2" (0.500")
18-0	33/64" (0.5156")
18-1	17/32" (0.5312")
18-2	35/64" (0.5469")
18-3	9/16" (0.5625")
20-0	9/16" (0.5625")
20-1	37/64" (0.5781")
20-2	19/32" (0.5938")
20-3	39/64" (0.6094")
22-0	5/8" (0.6250")
22-1	41/64" (0.6406")
22-2	21/32" (0.6562")
22-3	43/64" (0.6719")
24-0	11/16" (0.6875")
24-1	45/64" (0.7031")
24-2	23/32" (0.7188")
24-3	47/64" (0.7344")
26-0	3/4" (0.7500")
26-1	49/64" (0.7656")
26-2	25/32" (0.7812")
26-3	51/64" (0.7969")
28-0	13/16" (0.8125")
28-1	53/64" (0.8281")
28-2	27/32" (0.8438")
28-3	55/64" (0.8594")
30-0	7/8" (0.8750")
30-1	57/64" (0.8906")
30-2	29.32" (0.9062")
30-3	59/64" (0.9219")

5.4 Preparation of Tooling

5.4.1 Prepare split sleeve cold hole expansion tooling as follows (see Figure 10):

Step 1. Thread the mandrel supplied in the STDN tool kit into the puller unit.

Step 2. Slide the nosecap supplied in the STDN tool kit over the mandrel and tighten the threaded knurl nut onto the outside threads of the puller unit.

Step 3. Connect the hydraulic and air control lines from the puller unit into the hydraulic powerpack. Ensure that the mating surfaces on the air and hydraulic connectors are free from dirt, metal filings, etc.

Step 4. Connect the shop air supply to the powerpack.

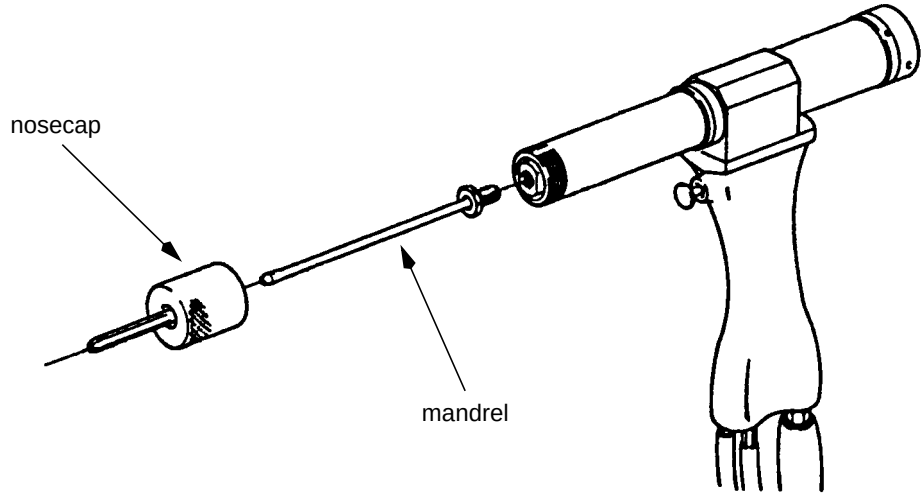


Figure 10 - Assembly of Mandrel/Nose Cap to Puller Unit

5.4.2 Prepare split mandrel cold hole expansion tooling as follows (see Figure 11):

Step 1. Install the pilot into the puller unit

Step 2. Install the mandrel by placing it over the pilot and inserting the threaded end into the threaded adapter and tightening the set screw.

Step 3. Place the barrel over the mandrel and securely thread it into the puller unit.

Step 4. Install the nosecap assembly over the mandrel and onto the barrel. Tighten the set screws to secure the nosecap.

Step 5. If the puller is equipped with an automatic lubrication system, connect the lube line to the nosecap.

Step 6. Connect the hydraulic and air control lines from the puller unit into the hydraulic powerpack. Ensure that the mating surfaces on the air and hydraulic connectors are free from dirt, metal filings, etc.

Step 7. Connect the shop air supply to the powerpack.

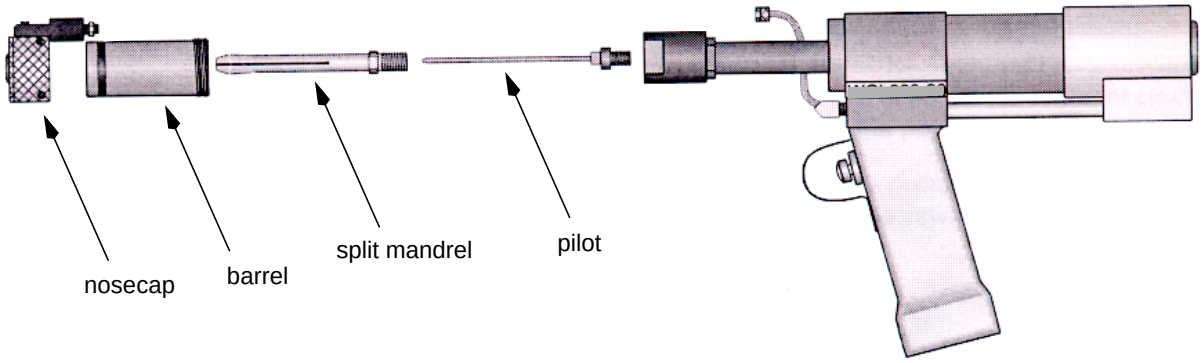


Figure 11 - Assembly of Split Mandrel to Puller Unit

5.5 Cold Expansion of Holes

5.5.1 Cold expand prepared starting holes using the split sleeve process as follows (see Figure 12):

Step 1. Remove excess lubricant from the reamed starter holes.

Step 2. Select the correct length split sleeve from the STDN tool kit.

Step 3. Slide the split sleeve over the mandrel, with the flared end against the nosecap. If use of tool blocks is required (i.e., fastener holes in the lower sill area), slide the sleeve/mandrel assembly through the tool block (see Figure 13).

Step 4. Insert the mandrel/split sleeve assembly (and tool block, if used) into the reamed starter hole. If the edge margin is less than 1.7 e/d, orient the split in the split sleeve away from the narrow edge.

Step 5. Pull the mandrel through the split sleeve and the hole by depressing the trigger on the puller unit.

Step 6. Remove the distorted sleeve from fastener hole and discard. Take care to avoid damage to the hole when removing the sleeve. Cold expansion sleeves can only be used once.

Step 7. Check the hole using the post cold hole expansion end of the combination gauge. If the post hole expansion gauge does not fit into the cold expanded hole, refer the hole to Liaison Engineering for disposition.

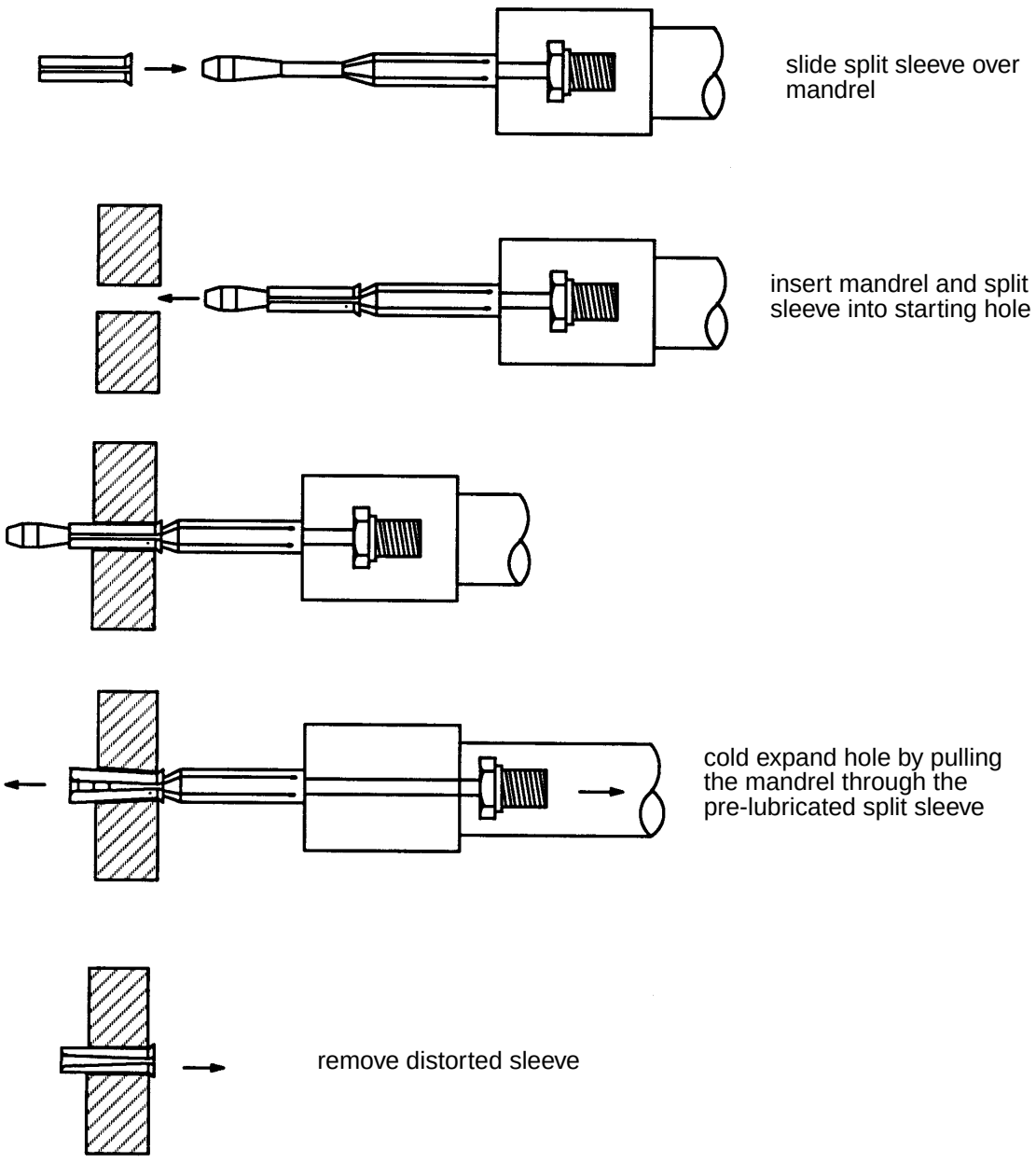


Figure 12 - Cold Expanding Holes

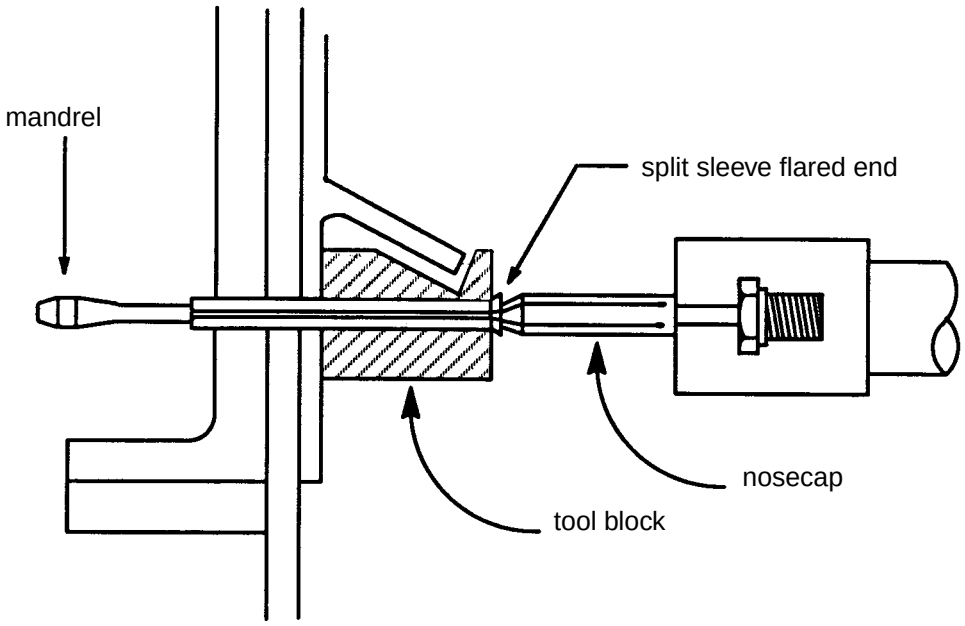


Figure 13 - Use of Tool Blocks

5.5.2 Only if use of the split mandrel process is specified by the engineering drawing, cold expand the prepared starting holes using the split mandrel process as follows:

Step 1. If the puller unit is not equipped with an automatic lubrication system, lubricate the split mandrel to prevent scoring or galling of the hole.

Step 2. For stackups greater than 1.0", lubricate the entire surface of the starting hole.

Step 3. Insert the split mandrel into the starter hole.

Step 4. Pull the mandrel through the hole by depressing the trigger on the puller unit.

Step 5. Check the hole using the post cold hole expansion end of the combination gauge. If the post hole expansion gauge does not fit into the cold expanded hole, refer the hole to Liaison Engineering for disposition.

Step 6. Visually check the hole and mandrel for evidence of galling or other damage caused by improper cold working.

5.6 Post Cold Expansion Procedure

5.6.1 After cold hole expansion countersink, ream and finish the hole as follows:

Step 1. Before starting the drillmotor, align the axial ridge (or ridges) caused by cold expanding the hole between the flutes of the pilot of the finish reamer supplied in the tool kit.

Step 2. Ream the cold expanded hole to the required final hole size. Ensure that the final ream removes the ridge (or ridges) caused when cold expanding the hole.

Step 3. For flush head type fasteners, countersink to the dimensions specified in the fastener PPS.

Step 4. If possible, disassemble mating parts and remove all chips and metal cuttings from faying surfaces.

Step 5. Deburr/edge break hole edges according to the requirements of the fastener PPS.

6 Requirements

6.1 Before cold hole expansion, check the size of each starting hole. Check the starting hole size either using the GO/NO-GO end of the combination inspection gauge or measure to ensure the minimum hole size requirements of Table 4 are met.

6.2 After cold hole expansion and **before** final reaming, check the hole size. Hole size can be checked using either the post cold hole expansion end of the combination gauge supplied in the STDN tool kit or measure to ensure the minimum hole size requirements of Table 4 are met. Ensure that any equipment used for measuring holes is calibrated. If the post cold hole expansion gauge does not fit into the cold expanded hole, refer the hole to Liaison Engineering for disposition.

6.3 Finished holes must be free of the ridge (or ridges) created by cold expansion and must meet the requirements of the applicable fastener PPS.

Table 4 - Hole Requirements

TOOL KIT STDN CODE	REQUIRED HOLE DIAMETER					
	PRE-COLD WORKING STARTING HOLE		MINIMUM AFTER COLD WORKING		MAXIMUM AFTER REAMING (Note 1)	
	SPLIT SLEEVE	SPLIT MANDREL	SPLIT SLEEVE	SPLIT MANDREL	SPLIT SLEEVE	SPLIT MANDREL
4-0	0.113" - 0.115"	n/a	0.1160"	n/a	0.1370"	n/a
4-1	0.128" - 0.130"	n/a	0.1310"	n/a	0.1560"	n/a
4-2	0.144" - 0.146"	0.140" - 0.142"	0.1470"	0.143"	0.1760"	0.1750"
4-3	0.160" - 0.162"	0.155" - 0.157"	0.1630"	0.158"	0.1920"	0.1906"
4-4	0.169" - 0.171"	n/a	0.1720"	n/a	0.2026"	n/a
6-0	0.177" - 0.180"	0.170" - 0.172"	0.1810"	0.173"	0.2130"	0.2061"
6-1	0.192" - 0.195"	0.183" - 0.185"	0.1970"	0.186"	0.2300"	0.2195"
6-2	0.209" - 0.212"	0.198" - 0.200"	0.2130"	0.201"	0.2490"	0.2350"
6-3	0.225" - 0.228"	0.213" - 0.215"	0.2290"	0.216"	0.2650"	0.2520"
8-0	0.235" - 0.238"	0.228" - 0.230"	0.2390"	0.231"	0.2790"	0.2680"
8-1	0.251" - 0.254"	0.243" - 0.245"	0.2550"	0.246"	0.2950"	0.2835"
8-2	0.266" - 0.269"	0.258" - 0.260"	0.2700"	0.261"	0.3128"	0.2989"
8-3	0.283" - 0.286"	0.273" - 0.275"	0.2870"	0.276"	0.3306"	0.3144"
10-0	0.297" - 0.300"	0.289" - 0.291"	0.3010"	0.292"	0.3490"	0.3309"
10-1	0.313 - 0.316	0.304" - 0.306"	0.3170"	0.307"	0.3650"	0.3464"
10-2	0.328" - 0.331"	0.319" - 0.321"	0.3330"	0.322"	0.3852"	0.3619"
10-3	0.344" - 0.347"	0.334" - 0.336"	0.3490"	0.337"	0.3996"	0.3773"
12-0	0.359" - 0.362"	0.350" - 0.352"	0.3645"	0.353"	0.4190"	0.3932"
12-1	0.375" - 0.378"	0.365" - 0.367"	0.3800"	0.368"	0.4350"	0.4087"
12-2	0.391" - 0.394"	0.380" - 0.382"	0.3985"	0.383"	0.4538"	0.4241"
12-3	0.406" - 0.409"	0.396" - 0.398"	0.4120"	0.399"	0.4710"	0.4407"
14-0	0.421" - 0.424"	0.411" - 0.413"	0.4280"	0.414"	0.4860"	0.4562"

Note 1. The “Maximum After Reaming” value is the maximum to which the hole may be expanded without requiring re-cold working and is **not** the size to which the hole should be expanded to install a particular fastener. The final hole size for a particular fastener shall be as specified by the appropriate fastener PPS or Liaison Engineering.

Table 4 - Hole Requirements

TOOL KIT STDN CODE	REQUIRED HOLE DIAMETER					
	PRE-COLD WORKING STARTING HOLE		MINIMUM AFTER COLD WORKING		MAXIMUM AFTER REAMING (Note 1)	
	SPLIT SLEEVE	SPLIT MANDREL	SPLIT SLEEVE	SPLIT MANDREL	SPLIT SLEEVE	SPLIT MANDREL
14-1	0.437" - 0.440"	0.426" - 0.428"	0.4440"	0.429"	0.5020"	0.4746"
14-2	0.450" - 0.453"	0.441" - 0.443"	0.4580"	0.444"	0.5150"	0.4871"
14-3	0.465" - 0.468"	0.456" - 0.458"	0.4735"	0.459"	0.5300"	0.5026"
16-0	0.474" - 0.477"	0.470" - 0.472"	0.4825"	0.473"	0.5390"	0.5165"
16-1	0.490" - 0.493"	0.486" - 0.488"	0.4980"	0.489"	0.5550"	0.5329"
16-2	0.505" - 0.508"	0.501" - 0.503"	0.5135"	0.504"	0.5700"	0.5484"
16-3	0.521" - 0.524"	0.516" - 0.518"	0.5285"	0.519"	0.5860"	0.5638"
18-0	0.537" - 0.540"	0.532" - 0.534"	0.5460"	0.535"	0.6020"	0.5790"
18-1	0.553" - 0.556"	0.548" - 0.550"	0.5615"	0.551"	0.6180"	0.5954"
18-2	0.568" - 0.571"	0.563" - 0.565"	0.5780"	0.566"	0.6330"	0.6108"
18-3	0.583" - 0.586"	0.578" - 0.580"	0.5940"	0.581"	0.6480"	0.6263"
20-0	0.597" - 0.600"	0.593" - 0.595"	0.6080"	0.596"	0.6620"	0.6417"
20-1	0.613" - 0.616"	0.608" - 0.610"	0.6235"	0.611"	0.6780"	0.6573"
20-2	0.631" - 0.634"	0.623" - 0.625"	0.6410"	0.626"	0.6960"	0.6728"
20-3	0.646" - 0.649"	0.638" - 0.640"	0.6565"	0.641"	0.7110"	0.6882"
22-0	0.659" - 0.662"	n/a	0.6710"	n/a	0.7240"	n/a
22-1	0.675" - 0.678"	n/a	0.6865"	n/a	0.7400"	n/a
22-2	0.690" - 0.693"	n/a	0.7025"	n/a	0.7550"	n/a
22-3	0.706" - 0.709"	n/a	0.7185"	n/a	0.7710"	n/a
24-0	0.718" - 0.721"	n/a	0.7305"	n/a	0.7830"	n/a
24-1	0.734" - 0.737"	n/a	0.7460"	n/a	0.7990"	n/a
24-2	0.749" - 0.752"	n/a	0.7625"	n/a	0.8140"	n/a

Note 1. The “Maximum After Reaming” value is the maximum to which the hole may be expanded without requiring re-cold working and is **not** the size to which the hole should be expanded to install a particular fastener. The final hole size for a particular fastener shall be as specified by the appropriate fastener PPS or Liaison Engineering.

Table 4 - Hole Requirements

TOOL KIT STDN CODE	REQUIRED HOLE DIAMETER					
	PRE-COLD WORKING STARTING HOLE		MINIMUM AFTER COLD WORKING		MAXIMUM AFTER REAMING (Note 1)	
	SPLIT SLEEVE	SPLIT MANDREL	SPLIT SLEEVE	SPLIT MANDREL	SPLIT SLEEVE	SPLIT MANDREL
24-3	0.765" - 0.768"	n/a	0.7785"	n/a	0.8300"	n/a
26-0	0.782" - 0.785"	n/a	0.7965"	n/a	0.84700"	n/a
26-1	0.798" - 0.801"	n/a	0.8120"	n/a	0.8630"	n/a
26-2	0.811" - 0.814"	n/a	0.8255"	n/a	0.8760"	n/a
26-3	0.826" - 0.829"	n/a	0.8415"	n/a	0.8910"	n/a
28-0	0.841" - 0.844"	n/a	0.8570"	n/a	0.9060"	n/a
28-1	0.857" - 0.860"	n/a	0.8725"	n/a	0.9220"	n/a
28-2	0.879" - 0.882"	n/a	0.8950"	n/a	0.9440"	n/a
28-3	0.894" - 0.897"	n/a	0.9110"	n/a	0.9590"	n/a
30-0	0.901" - 0.904"	n/a	0.9119"	n/a	0.9660"	n/a
30-1	0.917" - 0.920"	n/a	0.9340"	n/a	0.9820"	n/a
30-2	0.933" - 0.936"	n/a	0.9510"	n/a	0.9980"	n/a
30-3	0.949" - 0.952"	n/a	0.9670"	n/a	1.0140"	n/a

Note 1. The “Maximum After Reaming” value is the maximum to which the hole may be expanded without requiring re-cold working and is **not** the size to which the hole should be expanded to install a particular fastener. The final hole size for a particular fastener shall be as specified by the appropriate fastener PPS or Liaison Engineering.

7 Safety Precautions

7.1 Observe general shop safety precautions when performing the procedure specified herein.

7.2 Disconnect the air supply when changing mandrels on pulling tools.

8 Personnel Requirements

8.1 Personnel must have a good working knowledge of the applicable procedure and requirements as specified herein and must have exhibited their competency to their supervisor.

Flow Chart 1 - Preparing and Cold Expanding Holes