FATIGUE TECHNOLOGY

A PCC Company

Seattle, Washington • U.S.A.

Tooling Catalog

Revision 6 - June 2009

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Revision 6
Printed June 2009
Serial #: _____

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We are pleased to provide you with this completely revised and updated Fatigue Technology Cold Expansion Systems Tooling Catalog.

Your new serial-numbered Tooling Catalog describes our complete range of cold expansion tooling with information on our structural life improvement systems. The catalog provides information necessary to determine your specific requirements and also details procedures to facilitate order placement.

The catalog will be updated as we develop or improve tooling and processes; thereby, keeping you abreast of changes and new fatigue life improvement technology. Our customers have come to rely on our engineering and tooling; yet more importantly, our customers trust and depend on our technical expertise and the support we provide for our products. This support includes on-site assistance, complete cold expansion training, a comprehensive testing facility to test your applications, and an on-going commitment to the integrity of the entire cold expansion process.

We welcome your comments on our new Tooling Catalog and trust that it will be a useful document. If you require any further information on our services and products, please do not hesitate

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INDEX OF SECTIONS

As of the printing date for this catalog, the following sections were available. The catalog has been designed so that we may send out new sections or update existing sections as tooling improvements and revisions are made. If you are not sure your catalog is up to date, please contact your nearest FTI office or representative.

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INTRODUCTION

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1.1 ABOUT FATIGUE TECHNOLOGY

Fatigue Technology (FTI) has been providing innovative solutions to aircraft manufacturers since 1969. FTI's complete systems of tooling are used worldwide to significantly reduce manufacturing and maintenance flow-time and costs in both military and commercial aircraft programs.

FTI's professional staff provides a full range of support services which include:

- *Special project application engineering*
- *Detailed project planning, implementation and management*
- *On-site assistance which includes training and tool room setup*
- *Materials testing of metallic and composite materials*

FTI manufactures most of the Cold Expansion process tooling and carries a complete inventory which allows timely, innovative responses to customers' requirements.

Our Technical Sales department is available to assist with your special fatigue life enhancement requirements and tooling selection. We would welcome an opportunity to assist you if you have any questions regarding any of our products or services.

FTI's Cold Expansion™ Systems and processes are the subject matter of one or more of the following patents: U.S. 4,187,708/5,129,253/4,423,619/4,425,780/4,471,643/4,524,600/4,557,033/4,809,420/4,864,732/4,885,829/4,934,170/5,083,363/5,096,349/5,103,548/5,127,254/5,218,854/5,245,743/5,305,627; Belgium 0.086.344, 0.131.648; France 0.086.344, 0.131.648; Germany P33 79 577.0-08, P33 82 069.4-08; Israel 67810; Italy 0.086.344, 0.131.648; Switzerland 0.086.344, 0.131.648; The Netherlands 0.086.344, 0.131.648; United Kingdom 0.086.344, 0.131.648; and other patents pending in the U.S., Europe, and Japan. These systems and processes are tooling critical and must be performed in accordance with FTI's specifications or controlling documents. To ensure proper results from FTI's Cold Expansion™ Systems and to be licensed to use FTI's patented processes, it is essential that FTI's complete integrated system of tooling be purchased and utilized. The use of tooling procured from other than a licensed supplier could jeopardize fatigue life enhancement and may constitute patent infringement.

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1.2 USING THIS CATALOG

This catalog is organized into separate tabbed sections with an introduction, detailed tooling, and one section for each of FTI's Tooling Systems. As a general rule, determine the correct tools for each application by following these steps:

Step 1. Determine the material to be cold expanded.

Step 2. Choose the applicable process and turn to that section in this catalog:

- CB Tooling — Split Sleeve Cold Expansion™ in Aluminum and Mild Steel
- CW Tooling — Low Interference Cold Expansion in Aluminum
- CA Tooling — Split Sleeve Cold Expansion™ in Titanium and High Strength Steel
- CR Tooling — Rework Split Sleeve Cold Expansion in Aluminum and Mild Steel
- KB2 Tooling — Split Sleeve Cold Expansion to Size™ in Aluminum
- CB/KB Tooling — Countersink Cold Expansion™ in Aluminum
- SaCx™ Tooling — Semi-Automatic Cold Expansion™ in Aluminum
- FmCx™ Tooling — ForceMate® Bushing Installation
- BlCx™ Tooling — BushLoc® Hole Resizing and Bushing Installation
- FtCx™ Tooling — ForceTec® Rivetless Nut Plate
- GrCx™ Tooling — GromEx® Composite Hole Reinforcement
- ScCx™ Tooling — StopCrack™ Enhanced Stop Drill Repair Method

Step 3. Select the Standard Tool Diameter Tool Number (STDN), where applicable.

Step 4. Use the STDN to select the system of Standard Tools and their model numbers.

Step 5. Refer to the Detailed Tooling Section where there is a complete description of each tool for any additional information you may require.

Step 6. For assistance, call your Regional Manager or Representative. Please refer to www.fatiguetech.com for a complete listing of FTI offices.

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1.3 SYSTEM OF TOOLING

To assure maximum fatigue life enhancement of a cold expanded hole, it is critical that FTI's integrated system of tooling be utilized. FTI's fatigue life enhancement processes incorporate a *system* of technology and tooling designed to provide optimum performance. If you are unable to find your special tooling needs using this catalog, please contact FTI's Technical Sales Staff or Engineering Staff for assistance in meeting your unique tooling requirements.

A typical FTI system of tooling consists of everything necessary to properly cold expand a hole including cutting tools, PowerPak, puller unit, mandrel, checking fixtures, and split sleeves.

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1.4 PLACING AN ORDER

To place an order, call our Contracts Coordination Staff or send your order by FAX direct to the Seattle office. Your order will be acknowledged in accordance with the terms and conditions listed on the following page.

Tooling from this catalog may be ordered individually or in a kit, if required. A complete system of tooling for a particular hole size, comprising all necessary tools, can be ordered in kit boxes. Capital tooling (PowerPaks, puller units) may be rented (subject to availability).

FTI provides an expedite delivery service (AOG); however, rush orders are subject to an expedite charge.

What we need to know:

When you place an order, please provide the following information:

1. The **model or part number** of the items required.
2. **Quantity** required.
3. **Aircraft** order is for.
4. **Acceptable alternative**–if any (give us the application details–material, stackup, thickness, etc.)
5. Required **shipping date**. If less than standard lead time is needed for non-stock items, an expedite charge may be assessed.
6. Whether **partial shipments will be accepted**.
7. **How you want it shipped** and by what carrier.
8. **Where** you want it shipped.
9. Where you want **invoices sent**.
10. The **purchase order number**.
11. **Contact name** and information.

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1.5 STANDARD TERMS AND CONDITIONS

Quotations:

Standard quotations are valid for 90 days unless otherwise stated.

Payment Terms:

Net 30 days for approved customers, 1.5% interest per month on invoices over 45 days past due. (Prior credit approval required).

Non-approved customers require COD certified check, credit card, or Cash-in-Advance Terms.

Pricing:

All prices are quoted from our current catalog price list.

Individual orders for sleeves are subject to a minimum line order charge.

Minimum order charge applies.

An expedite charge may be applied for urgently required orders or in-stock orders requiring shipment in less than five days.

Lead Times, Packaging, and Shipping:

Quoted schedules are subject to pre-emption by a purchase order expedited from another customer.

A firm schedule commitment will be provided prior to issuance of a purchase order.

Normal lead time applies for standard in-stock items. Allowances should be made for special or non-standard items which could require special manufacturing.

Cost of shipping will be the responsibility of the customer, F.O.B. point shall be ex works FTI dock.

A certificate of conformance is supplied with all shipments.

Order Cancellation Charges:

After management reviews order, cancellation charges will apply for non-standard parts in accordance with the current policy.

When authorized by FTI, returned parts will be allowed full credit less re-stocking charge.

Rentals:

A range of capital tooling may be rented (subject to availability).

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Cold Expansion:

Split Sleeve Cold Expansion system is performed by inserting a mandrel, pre-fitted with a disposable, solid-film lubricated sleeve, into a hole, and then pulling the mandrel back through the sleeve. The internally lubricated split sleeve protects the hole from damage and makes the system a one-sided process. The action of drawing the mandrel through the pre-lubricated split sleeve causes a radial plastic flow of the workpiece material; this produces an annular zone of residual compressive stresses that extends one radius to one diameter beyond the periphery of the hole. A zone of tension stress balances the zone of compressive stresses. The desired final hole diameter is obtained by reaming the cold expanded hole to the size required, or by using the Cold Expansion to Size process where no final ream is required.

The ForceMate process involves drawing an oversize mandrel through a pre-positioned clearance-fit bushing that has been internally pre-lubricated by an FTI proprietary process. The tooling is sized so that a one-sided operation is standard. The resulting interference fit of the bushing, coupled with simultaneous cold working of the metal surrounding the hole, produces a 500 percent or better improvement in fatigue life. The bushing is then reamed to the required hole diameter.

The BushLoc process uses a split sleeve inside the bushing to provide the necessary lubricant for the mandrel, unlike ForceMate, which does not use a sleeve. Use of a split sleeve allows the customer to manufacture bushings as needed using the details outlined in FTI Process Specification 9601. The bushing is installed at a consistent interference fit and without the safety hazards associated with using cryogenic materials, which are needed for shrink-fit applications.

The ForceTec process is a revolutionary rivetless nut plate system that uses split sleeve cold expansion. The rivetless nut plate installation consists of a retainer/cage assembly which is placed into a single hole from the back side. A mandrel pre-fitted with a split sleeve is inserted through the retainer from the front side. When the mandrel is drawn back through the sleeve, the retainer is expanded into the hole at an interference fit. The installed retainer holds a variety of standard floating locking nuts. This process results in increased fatigue life of the installation due to the high interference fit of the retainer, residual stresses imparted into the parent material by the cold expansion process, and elimination of fatigue prone satellite holes.

The TukLoc system combines cold expansion technology with the ease and versatility of blind nuts. FTI's state-of-the-art cold expansion process locks the nut in the aircraft structure providing resistance to fatigue cracking by combining an interference fit nut with an installation in a clean, round hole. In addition to the benefits of cold expansion, preparation of the starting holes for TukLoc is easy as there are no special non-round countersinks or stringent surface preparation requirements. TukLoc nuts meet or exceed all requirements of industry accepted procurement specifications, including NASM-25027. The TukLoc nuts are available in open and domed (sealed) configurations.

The GromEx process has been designed to install titanium or stainless steel grommets in composite materials to reinforce fastener holes. The system works by drawing a mandrel through an internally pre-lubricated grommet. The grommet is expanded into place, creating a fit that is more reliable than adhesively bonded grommets with better electrical grounding capability. Due to the complex nature and variety of composites, it is recommended that customers work closely with FTI's Engineering and Technical Sales departments to determine the feasibility of any GromEx application before ordering any tooling.

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1.7 MATERIALS TESTING FACILITY

Special Tool Design Capabilities:

Our 40 years' experience covers a wide range of problems and solutions. The professional staff at FTI is readily available to design and develop special tooling for fatigue life enhancement repairs and rework. With support of our in-house R & D department and our Materials Testing Facility, we can support fatigue life testing in different materials, and the development of new tooling and applications.

Fatigue Technology's Materials Testing Facility performs state-of-the-art testing of metals and composites. We offer the following specific services:

- Fatigue and crack growth cyclic testing under broadband spectrum and constant amplitude loading
- Automated static testing (tensile, compression, shear, flexure)
- Environmental effects testing (thermal shock, thermal gradient, humidity cycling, ultraviolet/moisture exposure)
- Crack growth rate (da/dN)
- Fracture toughness testing (K_{Ic})
- Stress corrosion testing

Associated services include automated/manual eddy current inspection, strain gage installation/monitoring, and preparation of photo-elastic coatings. Our complete CNC machining facility is capable of fabricating complex fixtures and specimens. FTI takes a realistic approach to testing. We believe that we must be responsive to the unique requirements of each customer:

- Testing must be cost-effective for the customer. To enable as much productivity as possible in a 24-hour day, we have automated our test equipment and data collection.
- Flexibility and adaptability are required. We recognize that procedures and test methods must often be modified to accommodate unpredictable test results.
- We focus particularly on test planning and in-process monitoring of test data; the most expensive tests are often those that produce results that may be questioned or doubted.
- Maintaining continual communications with the customer. We provide timely, complete reports tailored to meet customers' needs.

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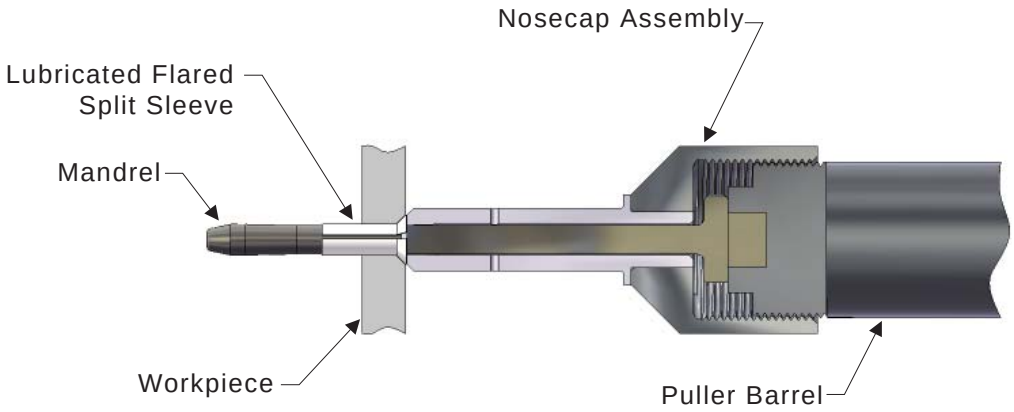


Figure 2.1-1
Cold Expansion System Components

Fatigue Technology's split sleeve cold expansion systems are comprised of compatible pieces of tooling as seen in the above diagram. All tooling is divided into three categories: capital, durable, and expendable tooling.

Capital Tooling

Capital tooling consists of:

hydraulic PowerPaks,

puller units,

and offset adapters.

Durable Tooling

Durable tooling consists of:

cutting tools,

gages,

mandrels,

and nosecap assemblies.

Expendable Tooling

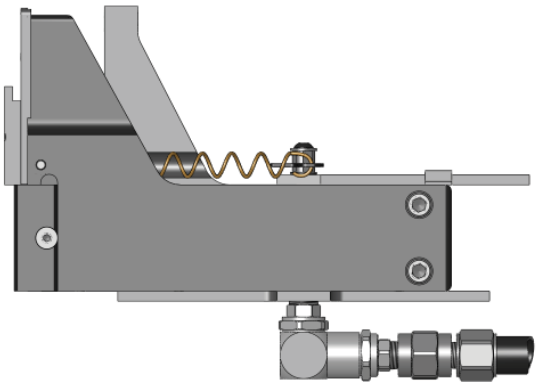
Expendable tooling consists of:

split sleeves

and backup blocks.

Puller Units

Offset Adapters



PowerPaks

Detailed Tooling
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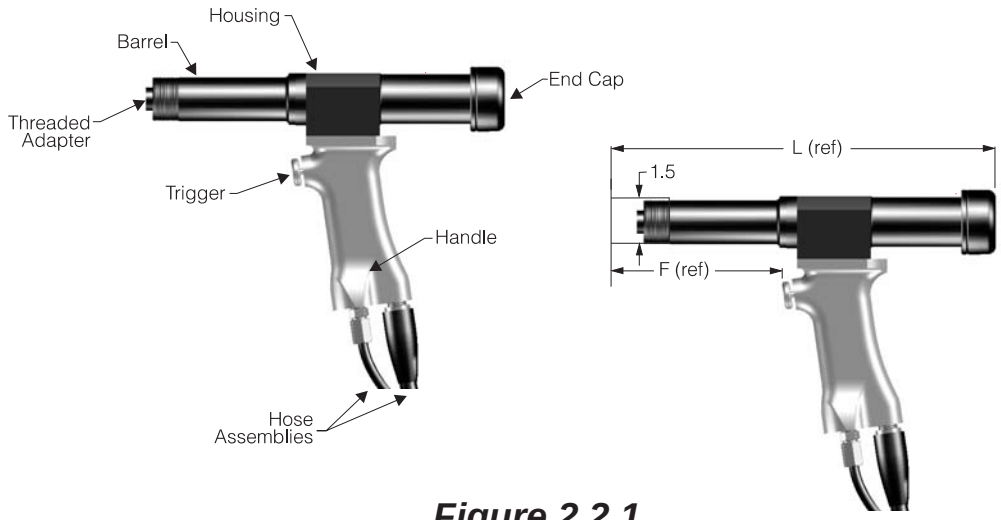

Figure 2.2.1
Little Brute Puller Unit

- Air-actuated, hydraulic puller is capable of cold expanding holes up to 1/2-inch diameter in aluminum and mild steel and up to 3/8-inch diameter in titanium and high-strength steel.
- Up to 3.5-inch material stackup capacity.
- Maximum pull force of 8,000 pounds at 10,000 psi hydraulic pressure.
- Includes a 10-foot hose assembly, spanner wrench, and nosecap pin wrench.
- Hydraulic pressure is provided by an FT-200 or FT-20 PowerPak.
- The LB puller is compatible with FTI extension and flush nosecaps. See nosecap section.
- The LB puller is directly compatible with standard Type 1 (7/16-20) threaded mandrels.

Table 2.2-1
Little Brute Specifications

Model Number	Maximum Material Stackup (inch)	L (Ref. Fig. 2.2-1) (inch)	F (Ref. Fig. 2.2-1) (inch)	Weight (lb.)	Stroke (inch)
LB-10	1.0	9.2	4.0	10.75	2.1
LB-15	1.5	10.2	4.5	11.00	2.6
LB-20	**2.0**	**11.2**	**5.0**	**11.25**	**3.1**
LB-25	2.5	12.2	5.5	11.50	3.6
LB-30	3.0	13.2	6.0	11.75	4.1
LB-35	3.5	14.2	6.5	12.00	4.6

Note: The LB-20 puller is standard since material stackups rarely exceed 2 inches in the applicable diameter range. Little Brute is designed for use with all FTI processes.

2.2.2 Medium Brute Puller Unit

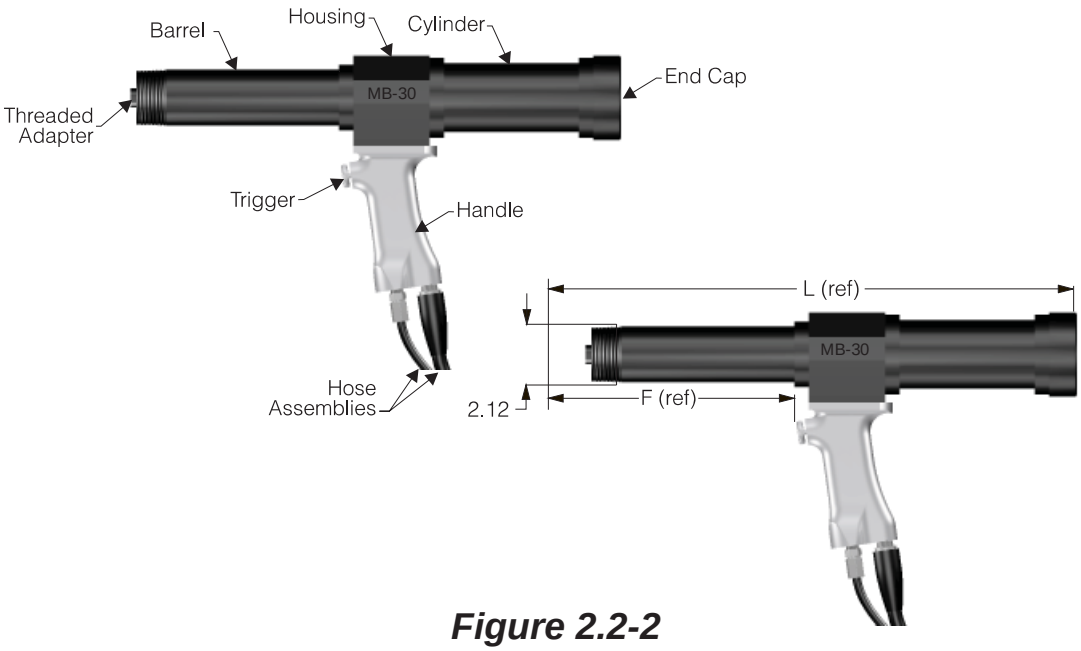

Figure 2.2-2
Medium Brute Puller Unit

- Air-actuated, hydraulic puller is capable of cold expanding holes up to 15/16-inch diameter in aluminum and mild steel and up to 3/4-inch diameter in titanium and high strength steel.
- Maximum pull force of 24,000 pounds at 10,000 psi of hydraulic pressure.
- Includes a 10-foot hose assembly, 5/8-inch (-2) and 7/8-inch (-5) threaded adapters spanner wrench, and nosecap pin wrench.
- Available in 3.0 and 7.0-inch stackup capabilities, depending on model.
- Hydraulic pressure is provided by an FT-200 or FT-20 PowerPak.
- The MB puller is compatible with FTI Medium Brute extension and flush nosecaps. See nosecap section.
- The MB puller is directly compatible with standard Type 2 (5/8-18) threaded mandrels or may be used with Type 5 (7/8-14) threaded mandrels with the proper threaded adapter.

Note: The MB-30 is standard.

Table 2.2-2
Medium Brute Specifications

Model Number	Maximum Material Stackup (inch)	L (Ref. Fig. 2.2-2) (inch)	F (Ref. Fig. 2.2-2) (inch)	Weight (lb.)	Stroke (inch)
MB-30	**3.3**	**18.2**	**8.6**	**20**	**5.2**
MB-70	7.0	25.5	11.6	24	8.9

Note: The MB-30 is standard. Medium Brute is designed for use with all FTI Split Sleeve, ForceMate, and BushLoc processes.

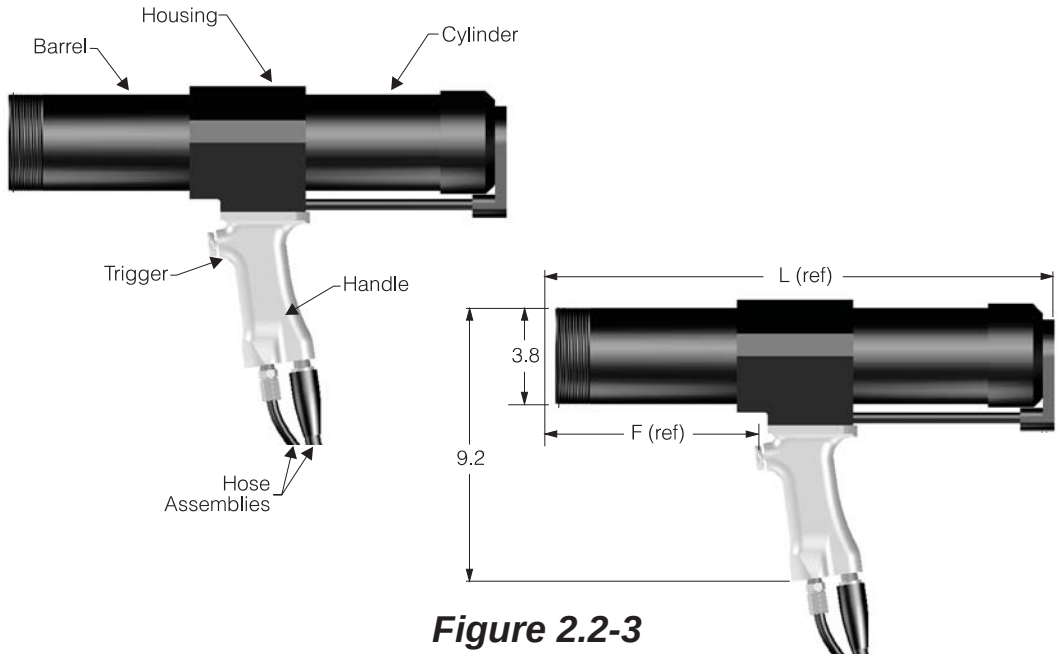

Figure 2.2-3
Big Brute Puller Unit

- For tool sizes larger than STDN 30-3-N or thick stackups of Ti or high strength steel; smaller tool sizes can be adapted. Contact FTI for more information.
- Maximum pull force of 38,000 pounds at 10,000 psi hydraulic pressure.
- Includes a 10-foot hose assembly, spanner wrench, and nosecap pin wrench.
- Capable of cold expanding holes with 3.0 and 7.0 inch stackup.
- Cold expands holes with 2.5 inches diameter in aluminum and mild steel; 1.25 inches diameter in titanium and high strength steel.
- Hydraulic pressure is provided by the FT-200 PowerPak.
- The BB puller is compatible with both Big Brute flush and extension nosecaps. See nosecap section.
- The BB puller is directly compatible with threaded -5 or tang -3 mandrels (see Mandrel Attachment in Table 2.2-3). Also compatible with special adapters to -4 and -9 adapters.

Table 2.2-3
Big Brute Specifications

Model Number	Maximum Material Stackup (inch)	L (Ref. Fig. 2.2-3) (inch)	F (Ref. Fig. 2.2-3) (inch)	Weight (lb.)	Mandrel Attachment	Stroke (inch)
BB-30	**3.0**	**23.3**	**10.5**	**35**	**.960" tang**	**6.26**
BB-30A	7.0	23.3	10.5	35	7/8-14thd	6.26
BB-70	7.0	27.0	13.4	40	.960" tang	9.14
BB-70A	7.0	27.0	13.4	40	7/8-14thd	9.14

Note: The BB-30 is standard.

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2.2.4 SUPER BRUTE PULLER UNIT

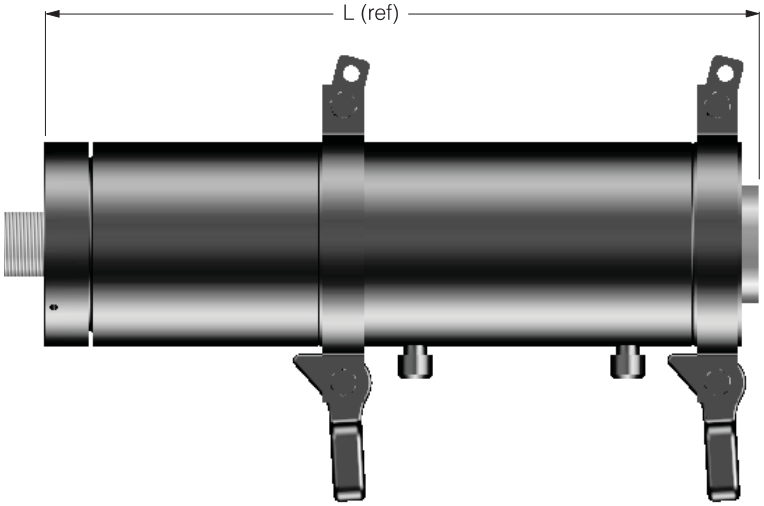

Figure 2.2-4
SB-2A

- The SB-2A is an application-specific puller and uses special mandrels and nosecaps. Please contact FTI for assistance in selecting tooling.
- Uses a hydraulic return system for rapid cycle times.
- Maximum pull force of 120,000 pounds at 10,000 psi pump pressure.
- Stroke of 6.5 inches enables the puller unit to expand large holes with 4.0-inch material stackup in titanium or high strength steel.
- Used with the FTI FT-200 PowerPak and a remote air trigger, FTI part number 2049-007.
- May require additional mechanical support to enable the puller to be held in position during operation.

Table 2.2-4
Super Brute Specifications

Model Number	Maximum Material Stackup (inch)	L (Ref. Fig. 2.2-4) (inch)	Weight (lb.)	Mandrel Attachment	Stroke (inch)
SB-2A	4.0*	23.4*	120 lbs.*	*	6.5

*Application specific. Contact FTI Technical Sales for assistance.

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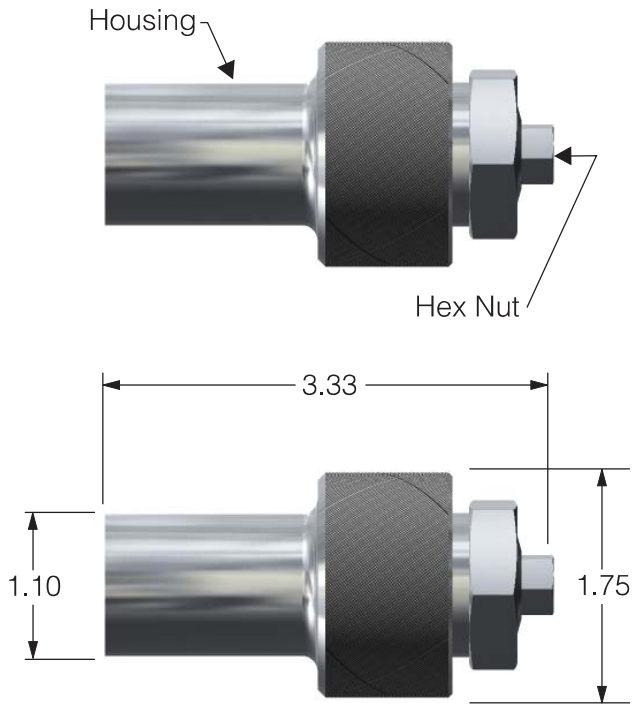

Figure 2.2-5
HP-10 Hand Puller

- Compact mechanical hand puller ideal for restricted access locations.
- Suitable for cold expanding holes in aluminum up to 1/2-inch diameter and up to 3/8-inch diameter in steel and titanium.
- Pull force of approximately 8,000 pounds.
- Each rotation of the hex nut provides .167 inch of travel.
- A ratchet wrench is included to operate the hand puller.
- Uses Little Brute mandrels with either special flush HP-10 nosecaps or modular extension nosecap with "B" threaded extension jaws (see nosecap section, Table 2.3-58 for extension nosecap information, call FTI Technical sales for flush nosecap information).
- Maximum material stackup 1.0 inch; overall length 3.50 inches with flush jaw.

2.2.5 HAND PULLERS

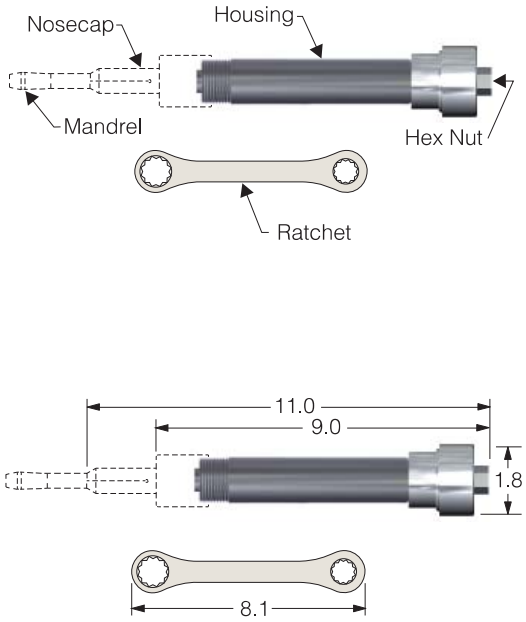

Figure 2.2-6
HP-20 Hand Puller

- Mechanically actuated puller designed for applications where a limited number of holes are cold expanded.
- Suitable for cold expanding holes in aluminum up to 3/8-inch diameter and up to 1/4-inch diameter in steel and titanium.
- Pull force of approximately 4,000 pounds.
- Each rotation of the hex nut provides .050 inch of travel.
- A ratchet wrench is included to operate the hand puller.
- Uses Little Brute nosecaps and mandrels.
- Maximum material stackup 2.0 inches; overall length 11.0 inches when using 2-inch extension nosecap.

Note: Hand Pullers are designed for use with all FTI processes.

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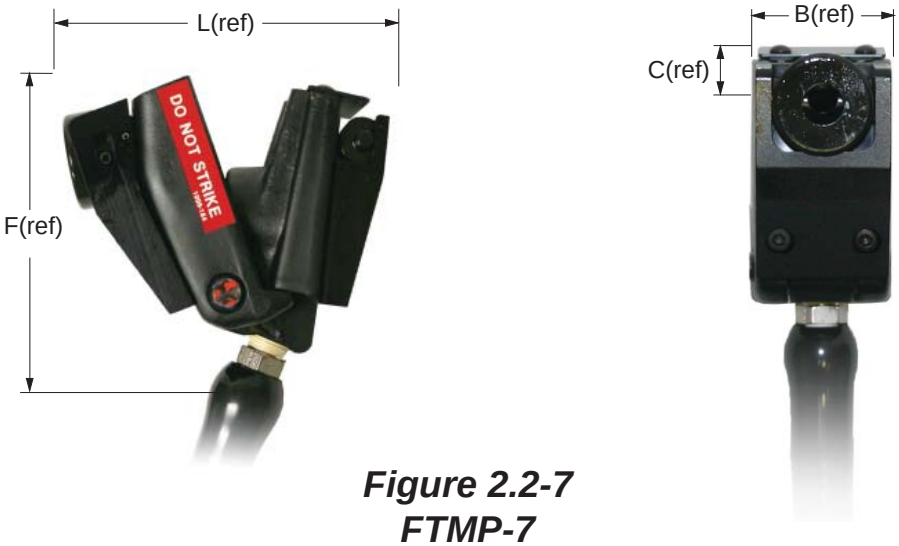

Figure 2.2-7
FTMP-7

Figure 2.2-8
FTMP-12 / FTMP-8

- Hydraulic actuated pullers designed for use in severely restricted access areas.
- Weigh approximately 10 pounds with hoses. A 10-foot hydraulic hose assembly is included.
- Use Little Brute flush or extension jaws. Modular extension jaws may be used with the proper adapter. Contact FTI.
- FTMP-12 and FTMP-8 are powered either by the FT-20 PowerPak or a hand pump. **The FTMP-7 should only be powered by the hand pump.**
- If using a FT-20 with FTMP-12 or FTMP-8 then a remote trigger assembly is required (2049-007).

Table 2.2-5
FTMP Specifications

Midget Puller Type	Max. Pull Force (lb.)	Max. Hole Dia. in Aluminum (inch)	Max. Hole Dia. in Ti and Steel (inch)	Max. Mandrel Stackup (inch)	Stroke (inch)
FTMP-7	4,000	5/16	1/4	0.75	1.25
FTMP-8	8,000	1/2	3/8	0.8	1.6
FTMP-12	8,000	1/2	3/8	1.2	2.0

Midget Puller Type	Working Front Side Clearance L (Ref. Fig. 2.2-7, -8) (inch)	Lateral Clearance C (Ref. Fig. 2.2-7, -8) (inch)	Width B (Ref. Fig. 2.2.7, -8) (inch)	Working Height Clearance F (Ref. Fig. 2.2.7, -8) (inch)	Compatible Hydraulic PowerPak*
FTMP-7	5.0	.75	2.2	7.0	FTP-70 only
FTMP-8	4.6	.80	2.5	11.5	FTP-70/FT-20
FTMP-12	5.0	.80	2.5	11.5	FTP-70/FT-20

* Hand pumps and FT-20 hydraulic PowerPaks are purchased separately. Purchase of an air trigger is required to actuate the FTMP-12 or FTMP-8 using the FT-20 PowerPak. **Remote Trigger, part number 2049-007.**

Table 2.2-6
FTMP Jaw Callout

Flush Jaw Callout	STDN Range
CBC-10-04F	4-0-N thru 4-3-N
CBC-10-06F	4-4-N thru 6-3-N
CBC-10-08F	6-3-N thru 8-3-N
CBC-10-10F	8-3-N thru 10-2-N

Extension Jaw Callout	STDN Range
CBCE-14A-0401F-JO	4-0-N thru 4-1-N
CBCE-14A-0423F-JO	4-2-N thru 4-3-N
CBCE-14A-0601F-JO	4-4-N thru 6-1-N
CBCE-14A-0623F-JO	8-0-N thru 8-1-N
CBCE-14A-0801F-JO	6-2-N thru 6-3-N
CBCE-14A-0823F-JO	8-2-N thru 8-3-N

Mandrel Selection: The FTMPs require special FTMP mandrels.

FTMP-12 and FTMP-8 can use LB mandrels but one inch of length is lost to the puller.

Sleeve Selection: The FTMP-7 and FTMP-8 use 3/4-inch long sleeves, CBS-STDN-12F.

The FTMP-12 uses 16F sleeve lengths.

Ordering Example: (FTMP-12)

CBM-10-0-N-1-20-V1	Mandrel
CBS-10-0-N-16F	Sleeve
CBC-10-10F	Jaw

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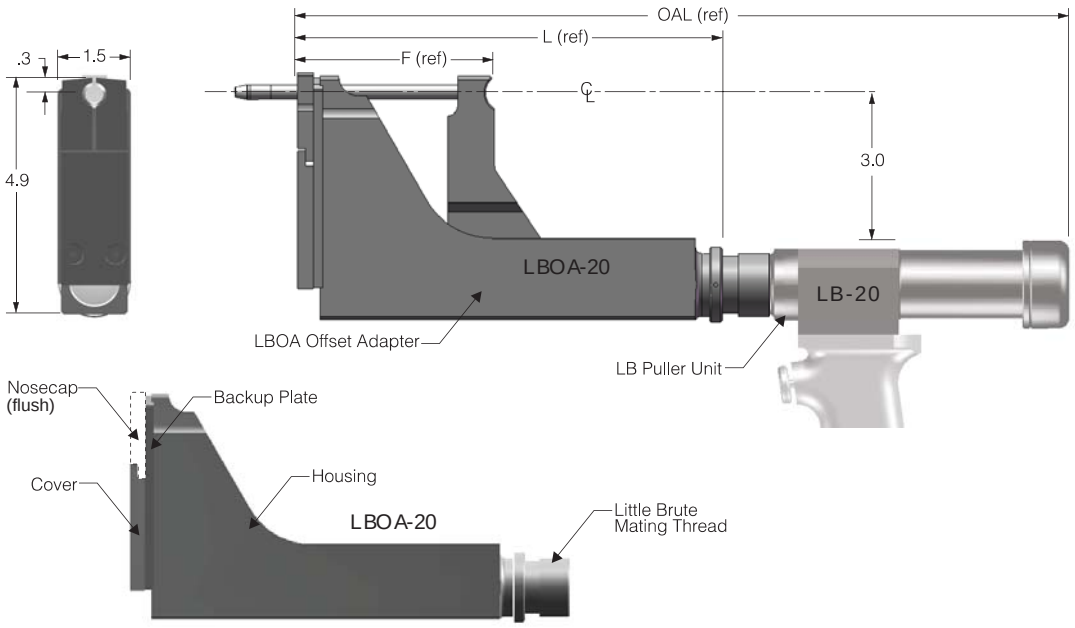

Figure 2.2-9
Little Brute Offset Adapter

- Capable of cold expanding holes in restricted access areas up to 1/2-inch diameter in aluminum and mild steel and 7/16 inch diameter in titanium and high strength steel.
- Attaches to the Little Brute (LB) series of puller units.
- Adapter weighs 6.5 pounds. With LB puller unit attached, unit weighs approximately 17.0 pounds.
- Requires only 1/4-inch lateral clearance.
- Maximum pull force of 7,000 pounds (generated by the Little Brute Puller Unit).
- Identification is provided by a machined model number and serial number.

Table 2.2-7
Little Brute Offset Adapter Specifications

Model Number	Maximum Material Stackup (inch)	Combination Puller and Length OAL (Ref. Fig. 2.2-9) (inch)	Adapter Length L (Ref. Fig. 2.2-9) (inch)	Frontside Clearance F (Ref. Fig. 2.2-9) (inch)
LBOA-10	1.0	11.8	6.7	3.40
LBOA-15	1.5	13.3	7.7	3.90
LBOA-20	**2.0**	**14.8**	**8.7**	**4.40**
LBOA-25	2.5	16.3	9.7	4.90
LBOA-30	3.0	17.8	10.7	5.40
LBOA-35	3.5	19.3	11.7	5.90

Note: The LBOA-20 is standard.
Nosecap Selection: Refer to nosecap section for applicable LBOA nosecaps.
Mandrel Selection: Refer to mandrel section for applicable mandrels.

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2.2.8 HYDRAULIC OFFSET ADAPTERS (HOA)

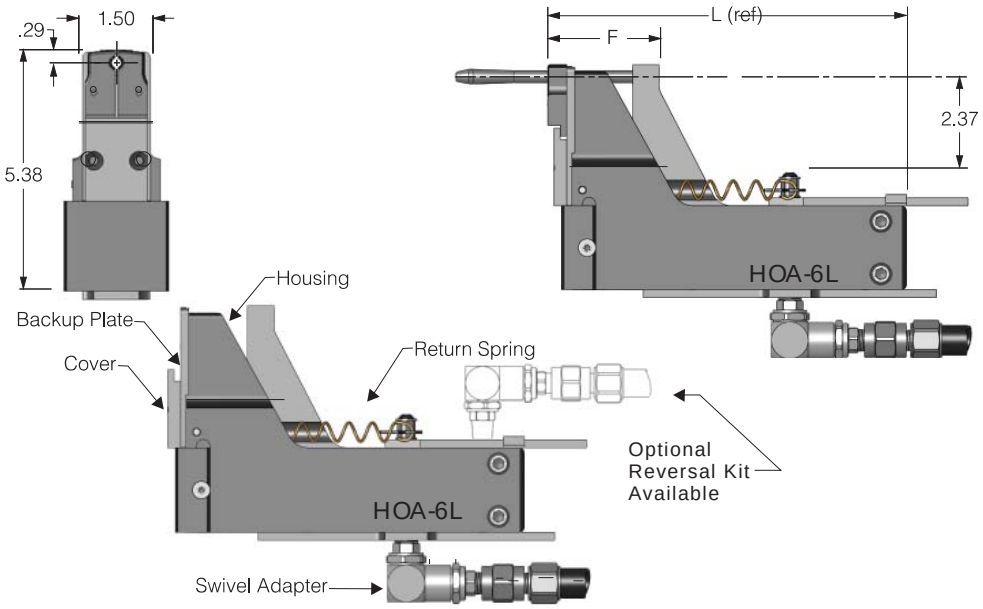

Figure 2.2-10
Hydraulic Offset Adapter

- For use in severely restricted access areas.
- Use with the FTP-19 hand hydraulic pump (included with purchase of puller unit).
- Cold expands holes in aluminum or mild steel up to 3/8-inch diameter and up to 5/16-inch diameter in high strength steel or titanium.
- Up to 2.5 inch material stackup capacity, maximum pull force of 5,000 pounds.
- Weighs 15 pounds with 10-foot hose (dry), which is included.
- Hose may be ported top or bottom. Hose Reversal Kit available. For HOA-6L, FTI part number 2816-001, HOA-7L part number 2816-002, HOA-8L, part number 2816-003.
- Can be used to cold expand holes with lateral restrictions as low as .29 inch.
- Mandrel center line offset is 3 inches.

Table 2.2-8
Hydraulic Offset Adapter Specifications

Model Number	Nominal Maximum Stackup (inch)	Overall Length L (Ref. Fig. 2.2-10) (inch)	Frontside Clearance F (Ref. Fig. 2.2-10) (inch)	Stroke (inch)
HOA-6L	**1.0**	**6.4**	**2.7**	**1.62**
HOA-7L	1.5	7.4	3.1	2.06
HOA-8L	2.0	8.4	3.6	2.49
HOA-9L	2.5	9.5	4.3	2.92

Note: The HOA-6L is standard and comes with an FTP-19 Hand Pump.
Nosecap Selection: The HOA puller is compatible with LBOA flush and extension nosecaps. See nosecap section.
Mandrel Selection: Refer to mandrel section for applicable mandrels.

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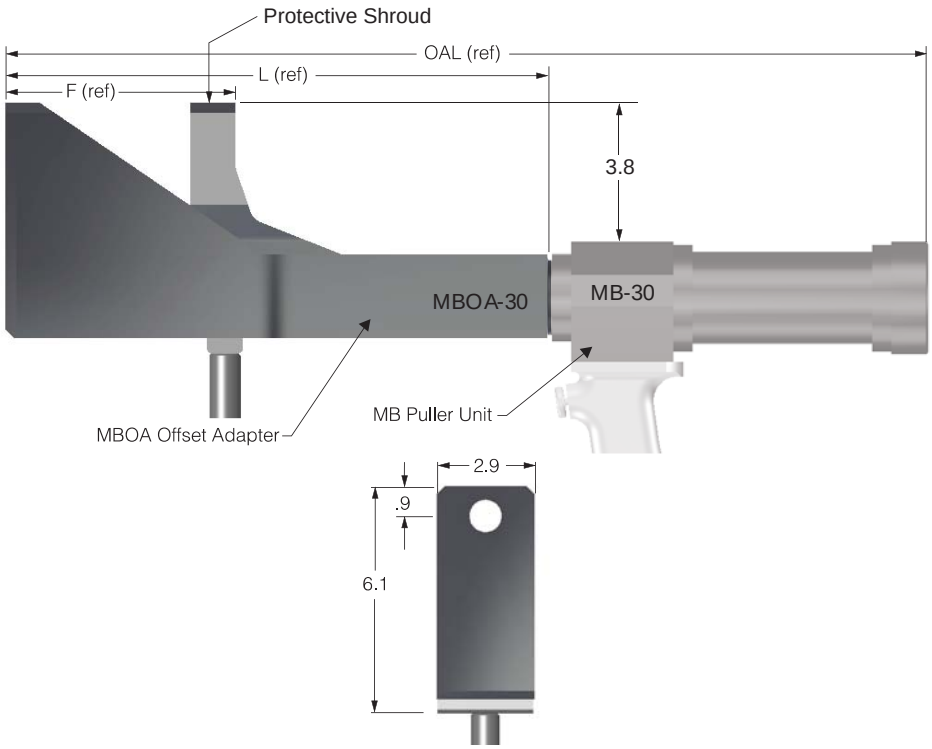

Figure 2.2-11
Medium Brute Offset Adapter

- Designed for use with the Medium Brute (MB-30) Puller Unit.
- Capable of cold expanding holes in aluminum and mild steel up to 15/16-inch diameter and up to 1/2-inch diameter in steel and titanium in restricted access areas.
- Used to cold expand holes with lateral clearances of 0.90 inch.
- A backup plate is included with each offset adapter.
- Weighs 30 pounds. With MB-30 puller attached, unit weighs 47 pounds.
- Identification is provided by an engraved model number and serial number.
- Maximum pull force of 22,000 lbs (from the Medium Brute Puller Unit).

Table 2.2-9
Medium Brute Offset Adapter Specifications

Model Number	Maximum Material Stackup (inch)	Combined Puller and Adapter Length OAL (Ref. Fig. 2.2-11) (inch)	Adapter Length L (Ref. Fig. 2.2-11) (inch)	Frontside Clearance F (Ref. Fig. 2.2-11) (inch)
MBOA-30A	3.0	24.8	14.8	6.8

Nosecap Selection: The MBOA uses special MBOA extension and flush nosecaps.
Mandrel Selection: Refer to mandrel section for applicable mandrels.

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2.2.10 Medium Brute Hydraulic Offsets (MBHO)

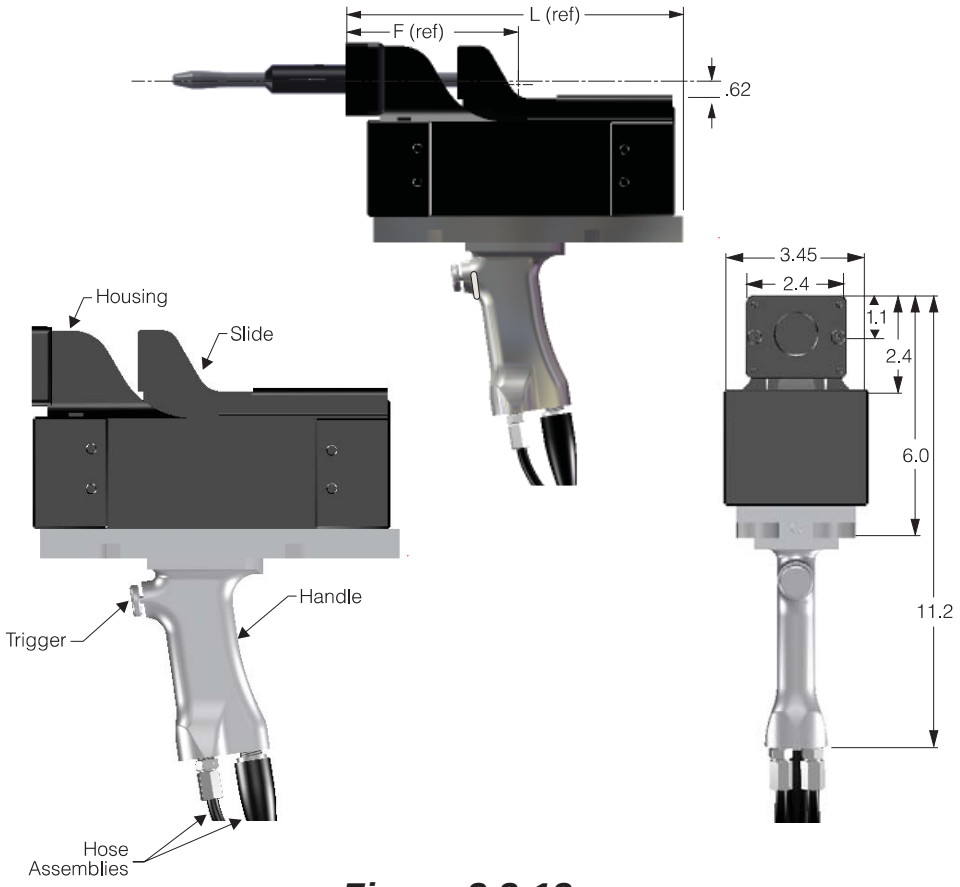

Figure 2.2-12
Medium Brute Hydraulic Offset Puller

- Designed to cold expand holes from 3/8 to 15/16-inch diameter in aluminum and mild steel and 3/8 to 3/4-inch diameter in high strength steel and titanium.
- Pull force capacity of 17,000 pounds at 10,000 psi of hydraulic pressure provided by the FT-20 or FT-200 PowerPak.
- Up to 3.5 inches material stackup capacity with an overall length of 12.1 inches excluding nosecap.
- Weighs 25 pounds with 10-foot hose assembly.
- Uses MBHO nosecaps with standard MB replacement jaws. See nosecap section.

Table 2.2-10
Medium Brute Hydraulic Offset Adapter Specifications

Model Number	Maximum Material Stackup (inch)	Overall Length L (Ref. Fig. 2.2-12) (inch)	Frontside Clearance F (Ref. Fig. 2.2-12) (inch)	Stroke (inch)
MBHO-20	2.0	9.1	5.6	3.10
MBHO-35	3.5	12.1	7.1	4.60

Nosecap Selection: The MBHO puller is compatible with MBHO series of nosecaps.
Mandrel Selection: The MBHO puller is directly compatible with the 5/8-inch (Type 20A) threaded Medium Brute Offset Adapter mandrels.

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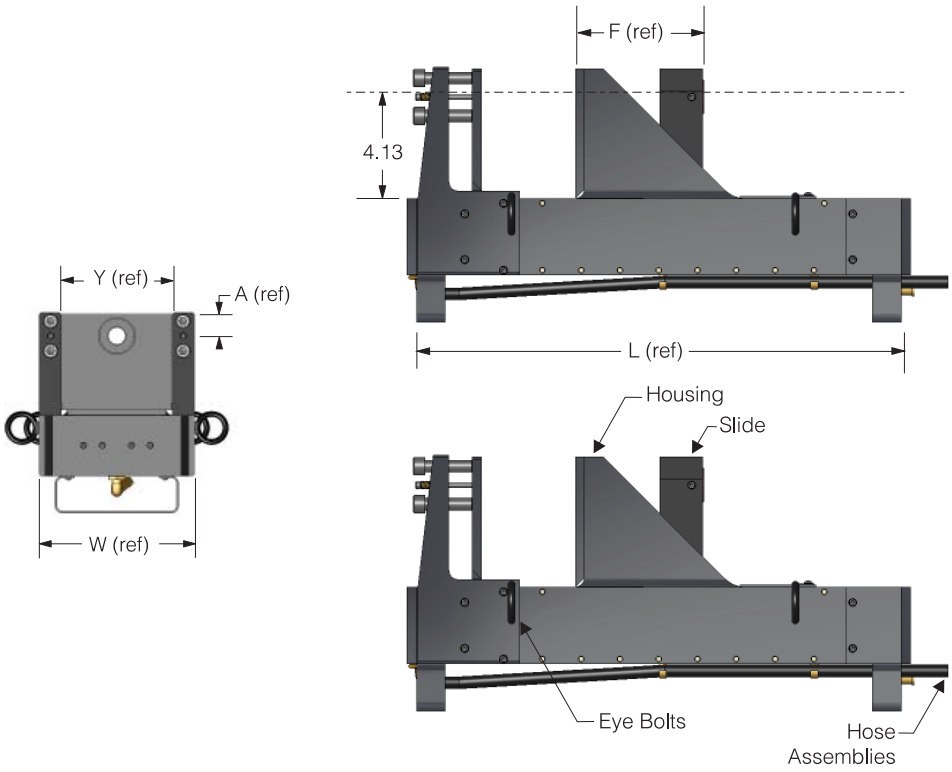

Figure 2.2-13
Big Brute Hydraulic Offset Puller

- Designed to cold expand holes up to 2.5 inches diameter in aluminum and mild steel and up to 1 inch diameter in titanium and high strength steel. For other processes such as ForceMate, diameters are greater. Contact FTI for assistance.
- Pull force capacity of 35,000 pounds at 10,000 psi of hydraulic pressure provided by the FT-200 PowerPak.
- Up to 5.0 inches material stackup capacity.
- Weighs 160 pounds with 10-foot hose assembly.
- **The BBHO is a specially designed tool for specific applications involving large holes in restricted access areas. For nosecap and/or mandrel selection, contact FTI's Technical Sales Department for assistance.**

Table 2.2-11
Big Brute Hydraulic Offset Specifications

Model Number	Maximum Material Stackup (inch)	Overall Length L (Ref. Fig. 2.2-13) (inch)	Frontside Clearance F (Ref. Fig. 2.2-13) (inch)	Overall Width W (Ref. Fig. 2.2-13) (inch)	Lateral Clearance A (Ref. Fig. 2.2-13) (inch)	Housing Width Y (Ref. Fig. 2.2-13) (inch)
BBHO-30	5.0	21.09	5.38	5.93	1.49	3.89
BBHO-30A	5.1	22.21	4.18	9.11	1.49	6.28

Note: The BBHO-30 is equipped with a tang mandrel attachment and the BBHO-30A is equipped with a threaded mandrel attachment.

2.2.12 RIGHT ANGLE ADAPTER

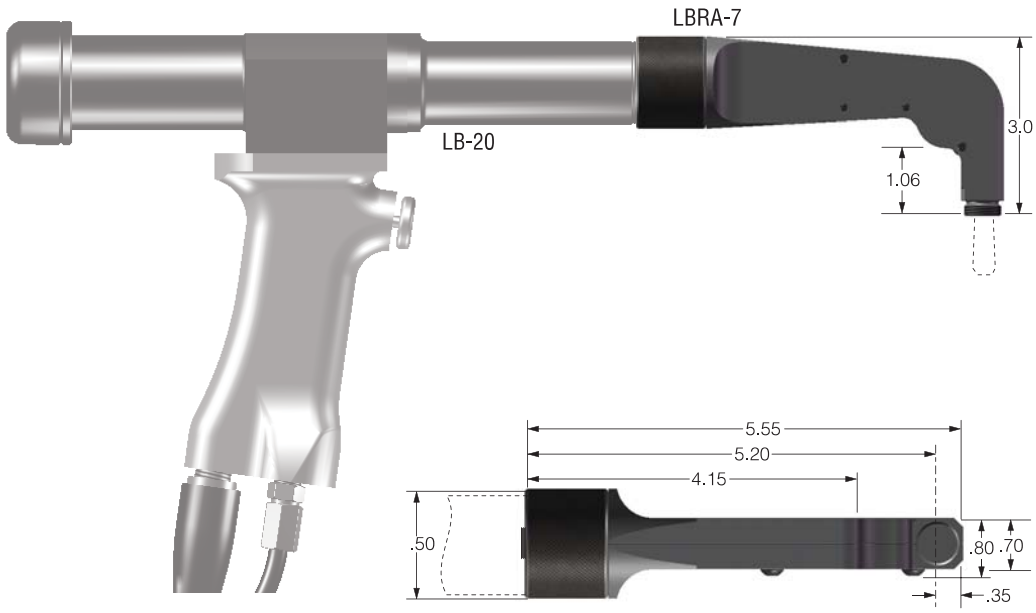

Figure 2.2-14
Right Angle Adapter

- Operated by attaching to the end of any Little Brute Puller Unit.
- Capable of cold expanding holes up to 0.40 inch diameter in aluminum.
- Pull force of approximately 3,400 pounds.
- Adapter weighs 1.4 pounds.
- Head can rotate 360 degrees on puller unit.
- Adapter may be disassembled to perform routine maintenance.

Table 2.2-12
LBRA-7 STDN and Maximum Material Stackup

Model Number	STDN Size	Maximum Sleeve Length	Maximum Material Stackup (inch)
LBRA-7	4-0-N thru 8-1-N	-14F (7/8")	0.840
	8-2-N thru 12-3-N	-12F (3/4")	0.715

Note: See mandrel and nosecap sections for correct LBRA-7 tooling.

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Overall Dimensions
19"L X 28"H X 12"W

Figure 2.2-15
FT-200 PowerPak

- FT-200 PowerPak best supports the FTI system of tooling. It is used to operate the FTI family of puller units including the Little Brute, Medium Brute, Big Brute, and Medium Brute Hydraulic Offset.
- Air-powered hydraulic unit that utilizes a hydraulic pump driven by an air motor to generate up to 10,000 psi of hydraulic pressure.
- The air motor is driven by compressed air at 90 to 120 psi and 50 cubic feet per minute (cfm) flow through a 3/8-inch or 1/2-inch inside diameter air hose supply. FTI recommends using 1/2-inch diameter hose (the FT-200B is equipped for 1/2-inch hose).
- Weighs 65 pounds when filled with 2 gallons (7.57 liters) of oil (85 pounds shipping weight).
- Wheels are included for portability.
- Typical cycle time is approximately 7 holes per minute in 1/4-inch thick aluminum and 5/16-inch diameter holes.
- Replaces the IW100MF PowerPak.

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2.2.14
FT-220
POWER PAK

Figure 2.2.16
FT-220 PowerPak

- Dual acting for hydraulic return puller unit.
- For use with Super Brute Puller Unit.
- Air-powered hydraulic unit that utilizes a hydraulic pump to generate up to 10,000 psi of hydraulic pressure.
- The air motor is driven by compressed air at 90 to 120 psi and 50 cubic feet per minute (cfm) flow through a 1/2-inch inside diameter air hose supply.
- Weighs 65 pounds when filled with 2 gallons (7.57 liters) of oil (85 pounds shipping weight).
- Wheels are included for portability.

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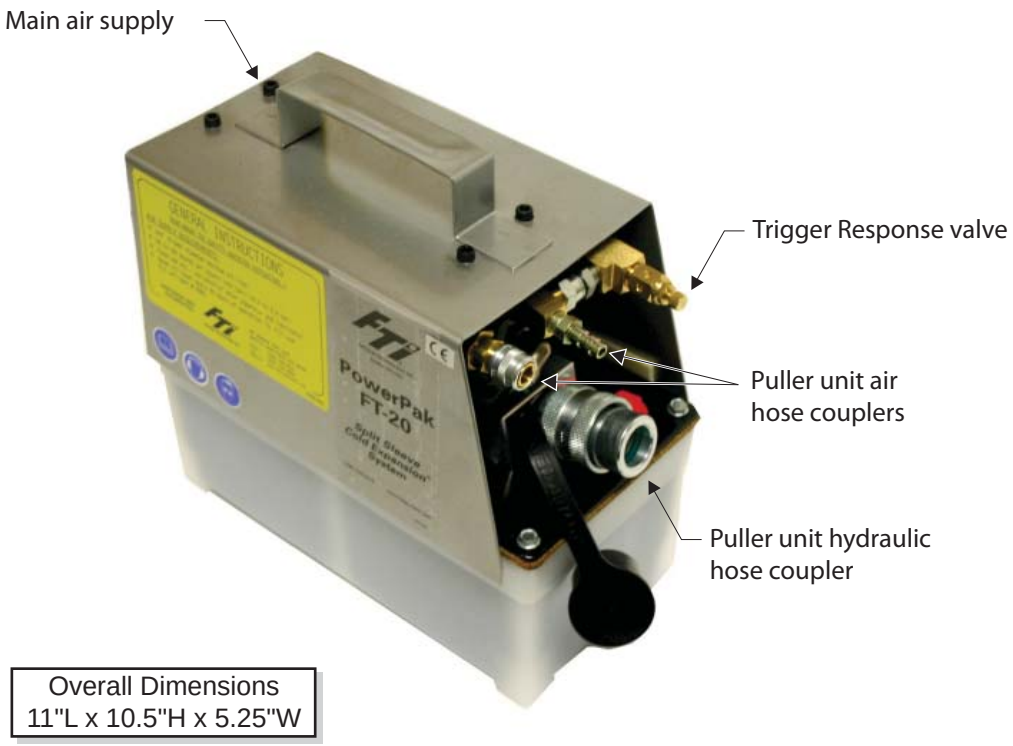

Figure 2.2-17
FT-20 PowerPak

- Used to operate the FTI standard series of puller units, including the Little Brute, Medium Brute, and Big Brute.
- Air-powered hydraulic unit.
- Lightweight and portable design to be used for applications where mobility is a key consideration.
- Weighs 18 pounds when filled with .45 gallons (1.72 liters) of oil (20 pounds shipping weight).
- Supplies up to 10,000 psi hydraulic pressure to the puller unit.
- The air motor is driven by compressed air at 90 to 120 psi and 20 cubic feet per minute (cfm) flow through a 3/8-inch inside diameter supply air hose.
- Equipped with a 3/8-inch diameter male quick disconnect air inlet fitting.
- Replaces the IW10MF PowerPak.

2.2.16 FTP-70 HAND PUMP

Figure 2.2-18
FTP-70 Hand Pump

- Manually operated pump allows improved control of pullers during cold expansion.
- Weighs 9 pounds when filled with hydraulic fluid.
- Provides power for the FTMP-7 Midget Puller and the HOA offset puller.
- Provides up to 10,000 psi of hydraulic pressure.
- Identification is provided by decals on reservoir.

Table 2.2-13
FTP-70 Specifications

Model Number	Pressure Rating (psi)	Reservoir Capacity (cubic inches)
FTP-70	10,000	55

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2.3.1 STARTING DRILLS

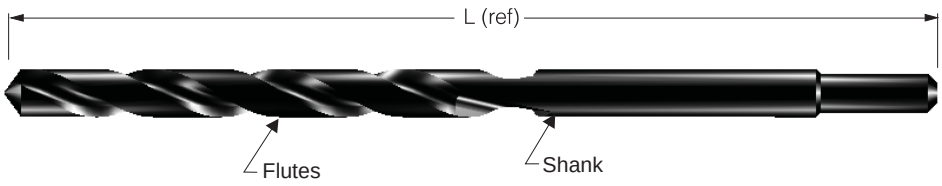

Figure 2.3-1
Starting Drill

- Used to create new holes in production or remove large amounts of material in rework.
- Designed to reduce the amount of force necessary to drill a hole; provides improved hole surface quality; split point feature improves accuracy of hole location.
- Identification is provided by an electroetched model number and a single-line ground or electroetched mark on the shank, indicating the first cutting tool operation.
- Available in high-strength steel, cobalt, or carbide. High-speed steel drills are most common, but cobalt and carbide drills are available for special applications.
- Special lengths and attachments are available upon request. For tooling outside standard tooling range, please contact our Technical Sales Staff.

Model Number Key:

C B S D - 1 0 - 0 - N - 1 - *

- Process Callout: C B
- Starting Drill: S D
- Standard Tool Diameter Number (STDN): 1 0 - 0
- 1 = Straight Shank; 2 = Tapered Shank: 1
- Blank = High-Speed Steel; C = Cobalt; CBD = Carbide: *

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Table 2.3-1
CB Tooling

STDN	Model Number	L (Ref. Fig. 2.3-1) (inch)
4-0-N	CBSD-4-0-N-1	4.62
4-1-N	CBSD-4-1-N-1	5.12
4-2-N	CBSD-4-2-N-1	5.37
4-3-N	CBSD-4-3-N-1	5.37
4-4-N	CBSD-4-4-N-1	5.75
6-0-N	CBSD-6-0-N-1	5.75
6-1-N	CBSD-6-1-N-1	5.75
6-2-N	CBSD-6-2-N-1	6.00
6-3-N	CBSD-6-3-N-1	6.00
8-0-N	CBSD-8-0-N-1	6.00
8-1-N	CBSD-8-1-N-1	6.12
8-2-N	CBSD-8-2-N-1	6.12
8-3-N	CBSD-8-3-N-1	6.25
10-0-N	CBSD-10-0-N	6.25
10-1-N	CBSD-10-1-N	6.37
10-2-N	CBSD-10-2-N	6.37
10-3-N	CBSD-10-3-N	6.50
12-0-N	CBSD-12-0-N	6.50
12-1-N	CBSD-12-1-N	6.75
12-2-N	CBSD-12-2-N	6.75
12-3-N	CBSD-12-3-N	7.00
14-0-N	CBSD-14-0-N	7.00
14-1-N	CBSD-14-1-N	7.25
14-2-N	CBSD-14-2-N	7.25
14-3-N	CBSD-14-3-N	7.25
16-0-N	CBSD-16-0-N	7.50
16-1-N	CBSD-16-1-N	7.50
16-2-N	CBSD-16-2-N	7.75
16-3-N	CBSD-16-3-N	7.75

STDN	Model Number	L (Ref. Fig. 2.3.-1) (inch)
18-0-N	CBSD-18-0-N	8.00
18-1-N	CBSD-18-1-N	8.00
18-2-N	CBSD-18-2-N	8.25
18-3-N	CBSD-18-3-N	8.25
20-0-N	CBSD-20-0-N	8.25
20-1-N	CBSD-20-1-N	8.75
20-2-N	CBSD-20-2-N	8.75
20-3-N	CBSD-20-3-N	8.75
22-0-N	CBSD-22-0-N	8.75
22-1-N	CBSD-22-1-N	9.00
22-2-N	CBSD-22-2-N	9.00
22-3-N	CBSD-22-3-N	9.25
24-0-N	CBSD-24-0-N	9.25
24-1-N	CBSD-24-1-N	9.50
24-2-N	CBSD-24-2-N	9.50
24-3-N	CBSD-24-3-N	9.75
26-0-N	CBSD-26-0-N	9.75
26-1-N	CBSD-26-1-N	9.87
26-2-N	CBSD-26-2-N	9.87
26-3-N	CBSD-26-3-N	10.00
28-0-N	CBSD-28-0-N	10.00
28-1-N	CBSD-28-1-N	10.00
28-2-N	CBSD-28-2-N	10.00
28-3-N	CBSD-28-3-N	10.00
30-0-N	CBSD-30-0-N	10.00
30-1-N	CBSD-30-1-N	10.00
30-2-N	CBSD-30-2-N	10.00
30-3-N	CBSD-30-3-N	10.75

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Table 2.3-2 CA Tooling

STDN	Model Number	L (Ref. Fig. 2.3-1) (inch)
20	CASD-20-1	4.62
21	CASD-21-1	5.12
22	CASD-22-1	5.37
23	CASD-23-1	5.37
30	CASD-30-1	5.37
31	CASD-31-1	5.75
32	CASD-32-1	5.75
33	CASD-33-1	6.00
40	CASD-40-1	6.00
41	CASD-41-1	6.12
42	CASD-42-1	6.12
43	CASD-43-1	6.25
50	CASD-50-1	6.25
51	CASD-51-1	6.25
52	CASD-52-1	6.37
53	CASD-53-1	6.50
60	CASD-60-1	6.50
61	CASD-61-1	6.75
62	CASD-62-1	6.75
63	CASD-63-1	7.00
70	CASD-70-1	7.00
71	CASD-71-1	7.00
72	CASD-72-1	7.25
73	CASD-73-1	7.25
80	CASD-80-1	7.50
81	CASD-81-1	7.50
82	CASD-82-1	7.75
83	CASD-83-1	7.75
90	CASD-90-1	7.75
91	CASD-91-1	8.00
92	CASD-92-1	8.00
93	CASD-93-1	8.25
100	CASD-100-1	8.25
101	CASD-101-1	8.75
102	CASD-102-1	8.75
103	CASD-103-1	8.75
110	CASD-110-1	8.75
111	CASD-111-1	9.00

Table 2.3-3 KB2 Tooling

STDN	Model Number	L (Ref. Fig. 2.3-1) (inch)
40-****-0	KB2SD-40-****-0-1	5.12
41-****-0	KB2SD-41-****-0-1	5.37
42-****-0	KB2SD-42-****-0-1	5.37
43-****-0	KB2SD-43-****-0-1	5.75
60-****- 0	KB2SD-60-****-0-1	5.75
61-****-0	KB2SD-61-****-0-1	5.75
62-****-0	KB2SD-62-****-0-1	6.00
63-****-0	KB2SD-63-****-0-1	6.00
80-****-0	KB2SD-80-****-0-1	6.12
81-****-0	KB2SD-81-****-0-1	6.12
82-****-0	KB2SD-82-****-0-1	6.25
83-****-0	KB2SD-83-****-0-1	6.25
100-****-0	KB2SD-100-****-0-1	6.37
101-****-0	KB2SD-101-****-0-1	6.37
102-****-0	KB2SD-102-****-0-1	6.50
103-****-0	KB2SD-103-****-0-1	6.50
120-****-0	KB2SD-120-****-0-1	6.75
121-****-0	KB2SD-121-****-0-1	6.75
122-****-0	KB2SD-122-****-0-1	7.00
123-****-0	KB2SD-123-****-0-1	7.00

* Lengths may vary depending on tooling type.
**** Refer to Cx2s Tooling for STDN information.

Table 2.3-4 CR Tooling

STDN	Model Number	L (Ref. Fig. 2.3-1) (inch)
R30	CRSD-R30-1	5.37
R32	CRSD-R32-1	5.75
R40	CRSD-R40-1	6.00
R42	CRSD-R42-1	6.12
R50	CRSD-R50-1	6.25
R52	CRSD-R52-1	6.37
R60	CRSD-R60-1	6.50
R62	CRSD-R62-1	6.75

Detailed Tooling
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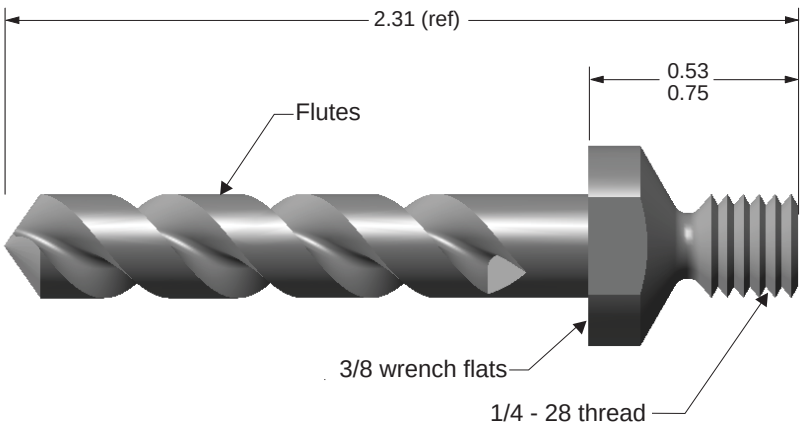

Figure 2.3-2
Right Angle Starting Drill

- Used as starting drills to create holes in applications that have restricted front side clearance.
- The split point configuration reduces the amount of force necessary to drill a hole, and provides improved hole surface quality.
- Identification is provided by an electroetched STDN and a single-line ground or electroetched mark on wrench flat.
- Shorter lengths are available upon request.
- Standard CB, KB, and CR drills are high-speed steel; standard CA drills are cobalt.

Model Number Key:

C B S D - 1 0 - 0 - N - R A

Process Callout — CB
Starting Drill — SD
Standard Tool Diameter Number (STDN) — 10-0
Right Angle — RA

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2.3.2 RIGHT ANGLE STARTING DRILLS

Table 2.3-5 CB Tooling

STDN	Model Number
4-0-N	CBSD-4-0-N-RA
4-1-N	CBSD-4-1-N-RA
4-2-N	CBSD-4-2-N-RA
4-3-N	CBSD-4-3-N-RA
4-4-N	CBSD-4-4-N-RA
6-0-N	CBSD-6-0-N-RA
6-1-N	CBSD-6-1-N-RA
6-2-N	CBSD-6-2-N-RA
6-3-N	CBSD-6-3-N-RA
8-0-N	CBSD-8-0-N-RA
8-1-N	CBSD-8-1-N-RA
8-2-N	CBSD-8-2-N-RA
8-3-N	CBSD-8-3-N-RA
10-0-N	CBSD-10-0-N-RA
10-1-N	CBSD-10-1-N-RA
10-2-N	CBSD-10-2-N-RA
10-3-N	CBSD-10-3-N-RA
12-0-N	CBSD-12-0-N-RA
12-1-N	CBSD-12-1-N-RA
12-2-N	CBSD-12-2-N-RA
12-3-N	CBSD-12-3-N-RA

Table 2.3-6 CA Tooling

STDN	Model Number
20	CASD-20-RA
21	CASD-21-RA
22	CASD-22-RA
23	CASD-23-RA
30	CASD-30-RA
31	CASD-31-RA
32	CASD-32-RA
33	CASD-33-RA
40	CASD-40-RA
41	CASD-41-RA
42	CASD-42-RA
43	CASD-43-RA
50	CASD-50-RA
51	CASD-51-RA
52	CASD-52-RA
53	CASD-53-RA
60	CASD-60-RA
61	CASD-61-RA
62	CASD-62-RA
63	CASD-63-RA
70	CASD-70-RA

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2.3.2 RIGHT ANGLE STARTING DRILLS

Table 2.3-7
KB2 Tooling

STDN	Model Number
40-****-0	KB2SD-40-****-0-RA
41-****-0	KB2SD-41-****-0-RA
42-****-0	KB2SD-42-****-0-RA
43-****-0	KB2SD-43-****-0-RA
60-****-0	KB2SD-60-****-0-RA
61-****-0	KB2SD-61-****-0-RA
62-****-0	KB2SD-62-****-0-RA
63-****-0	KB2SD-63-****-0-RA
80-****-0	KB2SD-80-****-0-RA
81-****-0	KB2SD-81-****-0-RA
82-****-0	KB2SD-82-****-0-RA
83-****-0	KB2SD-83-****-0-RA
100-****-0	KB2SD-100-****-0-RA
101-****-0	KB2SD-101-****-0-RA
102-****-0	KB2SD-102-****-0-RA
103-****-0	KB2SD-103-****-0-RA
120-****-0	KB2SD-120-****-0-RA
121-****-0	KB2SD-121-****-0-RA
122-****-0	KB2SD-122-****-0-RA
123-****-0	KB2SD-123-****-0-RA

**** Refer to Cx2s Tooling for STDN information.

Table 2.3-8
CR Tooling

STDN	Model Number
R30	CRSD-30-RA
R32	CRSD-32-RA
R40	CRSD-40-RA
R42	CRSD-42-RA
R50	CRSD-50-RA
R52	CRSD-52-RA
R60	CRSD-60-RA
R62	CRSD-62-RA

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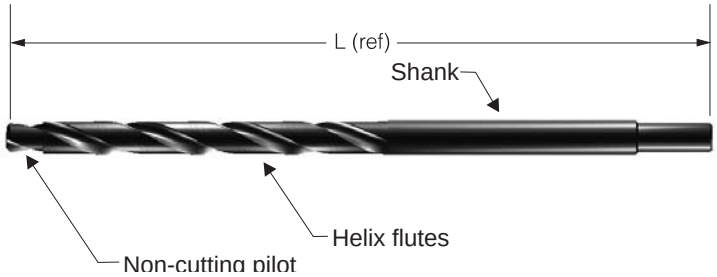

Figure 2.3-3
Core Drill

- Used in rework applications to prepare existing holes for a starting reamer.
- Helical flutes give material removal capability comparable to a twist drill.
- A non-cutting pilot, sized to .001 to .002 inch under the existing hole, followed by cutting flutes gives the locational and dimensional accuracy characteristics of a reamer.
- Identification is provided by an electroetched model number and a single line ground or electroetched on the shank, indicating the first cutting tool operation.
- High-speed steel material is standard. Carbide material can be provided for special applications.
- Pilot diameter (customer supplied) is equal to the minimum existing hole diameter minus approximately .001 inch (in .001 inch increments).
- For other sizes please contact our Technical Sales Staff.

Model Number Key:

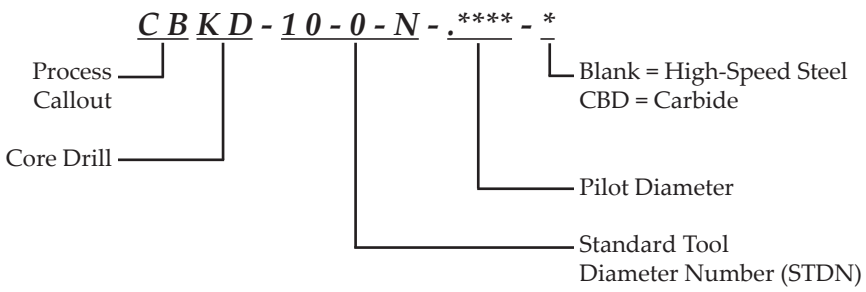

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Table 2.3-9
CB Tooling

STDN	Model Number	L (Ref. Fig. 2.3-3) (inch)
4-0-N	CBKD-4-0-N-.****	4.62
4-1-N	CBKD-4-1-N-.****	5.12
4-2-N	CBKD-4-2-N-.****	5.37
4-3-N	CBKD-4-3-N-.****	5.37
4-4-N	CBKD-4-4-N-.****	5.75
6-0-N	CBKD-6-0-N-.****	5.75
6-1-N	CBKD-6-1-N-.****	5.75
6-2-N	CBKD-6-2-N-.****	6.00
6-3-N	CBKD-6-3-N-.****	6.00
8-0-N	CBKD-8-0-N-.****	6.00
8-1-N	CBKD-8-1-N-.****	6.12
8-2-N	CBKD-8-2-N-.****	6.12
8-3-N	CBKD-8-3-N-.****	6.25
10-0-N	CBKD-10-0-N-.****	6.25
10-1-N	CBKD-10-1-N-.****	6.37
10-2-N	CBKD-10-2-N-.****	6.37
10-3-N	CBKD-10-3-N-.****	6.50
12-0-N	CBKD-12-0-N-.****	6.50
12-1-N	CBKD-12-1-N-.****	6.75
12-2-N	CBKD-12-2-N-.****	6.75
12-3-N	CBKD-12-3-N-.****	7.00
14-0-N	CBKD-14-0-N-.****	7.00
14-1-N	CBKD-14-1-N-.****	7.25
14-2-N	CBKD-14-2-N-.****	7.25
14-3-N	CBKD-14-3-N-.****	7.25
16-0-N	CBKD-16-0-N-.****	7.50
16-1-N	CBKD-16-1-N-.****	7.50
16-2-N	CBKD-16-2-N-.****	7.75
16-3-N	CBKD-16-3-N-.****	7.75

STDN	Model Number	L (Ref. Fig. 2.3-3) (inch)
18-0-N	CBKD-18-0-N-.****	8.00
18-1-N	CBKD-18-1-N-.****	8.00
18-2-N	CBKD-18-2-N-.****	8.25
18-3-N	CBKD-18-3-N-.****	8.25
20-0-N	CBKD-20-0-N-.****	8.25
20-1-N	CBKD-20-1-N-.****	8.75
20-2-N	CBKD-20-2-N-.****	8.75
20-3-N	CBKD-20-3-N-.****	8.75
22-0-N	CBKD-22-0-N-.****	8.75
22-1-N	CBKD-22-1-N-.****	9.00
22-2-N	CBKD-22-2-N-.****	9.00
22-3-N	CBKD-22-3-N-.****	9.25
24-0-N	CBKD-24-0-N-.****	9.25
24-1-N	CBKD-24-1-N-.****	9.50
24-2-N	CBKD-24-2-N-.****	9.50
24-3-N	CBKD-24-3-N-.****	9.75
26-0-N	CBKD-26-0-N-.****	9.75
26-1-N	CBKD-26-1-N-.****	9.87
26-2-N	CBKD-26-2-N-.****	9.87
26-3-N	CBKD-26-3-N-.****	10.00
28-0-N	CBKD-28-0-N-.****	10.00
28-1-N	CBKD-28-1-N-.****	10.00
28-2-N	CBKD-28-2-N-.****	10.00
28-3-N	CBKD-28-3-N-.****	10.00
30-0-N	CBKD-30-0-N-.****	10.00
30-1-N	CBKD-30-1-N-.****	10.00
30-2-N	CBKD-30-2-N-.****	10.00
30-3-N	CBKD-30-3-N-.****	10.75

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Table 2.3-10
CA Tooling

STDN	Model Number	L (Ref. Fig. 2.3-3) (inch)
20	CAKD-20-.****	2.37
21	CAKD-21-.****	2.62
22	CAKD-22-.****	2.75
23	CAKD-23-.****	3.00
30	CAKD-30-.****	5.37
31	CAKD-31-.****	5.75
32	CAKD-32-.****	5.75
33	CAKD-33-.****	6.00
40	CAKD-40-.****	6.00
41	CAKD-41-.****	6.12
42	CAKD-42-.****	6.12
43	CAKD-43-.****	6.12
50	CAKD-50-.****	6.25
51	CAKD-51-.****	6.25
52	CAKD-52-.****	6.37
53	CAKD-53-.****	6.37
60	CAKD-60-.****	6.50
61	CAKD-61-.****	6.50
62	CAKD-62-.****	6.75
63	CAKD-63-.****	6.75
70	CAKD-70-.****	7.00
71	CAKD-71-.****	7.00
72	CAKD-72-.****	7.25
73	CAKD-73-.****	7.25
80	CAKD-80-.****	7.50
81	CAKD-81-.****	7.75
82	CAKD-82-.****	7.75
83	CAKD-83-.****	7.75
90	CAKD-90-.****	7.75
91	CAKD-91-.****	8.00
92	CAKD-92-.****	8.00
93	CAKD-93-.****	8.25
100	CAKD-100-.****	8.25
101	CAKD-101-.****	8.75
102	CAKD-102-.****	8.75
103	CAKD-103-.****	8.75
110	CAKD-110-.****	8.75
111	CAKD-111-.****	9.00

Table 2.3-11
KB2 Tooling

STDN	Model Number	L (Ref. Fig. 2.3-3) (inch)
40-****-0	KB2KD-40-****-0-.****	5.12
41-****-0	KB2KD-41-****-0-.****	5.37
42-****-0	KB2KD-42-****-0-.****	5.37
43-****-0	KB2KD-43-****-0-.****	5.75
60-****- 0	KB2KD-60-****-0-.****	5.75
61-****-0	KB2KD-61-****-0-.****	5.75
62-****-0	KB2KD-62-****-0-.****	6.00
63-****-0	KB2KD-63-****-0-.****	6.00
80-****-0	KB2KD-80-****-0-.****	6.12
81-****-0	KB2KD-81-****-0-.****	6.12
82-****-0	KB2KD-82-****-0-.****	6.25
83-****-0	KB2KD-83-****-0-****	6.25
100-****-0	KB2KD-100-****-0-.****	6.37
101-****-0	KB2KD-101-****-0-.****	6.37
102-****-0	KB2KD-102-****-0-.****	6.50
103-****-0	KB2KD-103-****-0-.****	6.50
120-****-0	KB2KD-120-****-0-.****	6.75
121-****-0	KB2KD-121-****-0-.****	6.75
122-****-0	KB2KD-122-****-0-.****	7.00
123-****-0	KB2KD-123-****-0-.****	7.00

**** Refer to Cx2s Tooling for complete STDN information.

Detailed Tooling Page 40

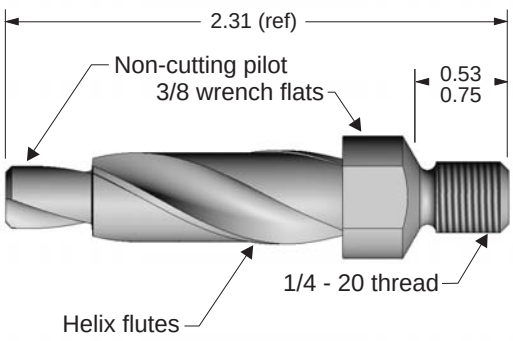

Figure 2.3-4
Right Angle Core Drill

- Used in rework applications to prepare existing holes for the starting reamer.
- Helical flutes give material removal capability comparable to a twist drill.
- A non-cutting pilot sized to .001 to .002 inch under the existing hole, followed by cutting flutes, gives the locational and dimensional accuracy characteristics of a reamer.
- Identification is provided by an electroetched model number.
- High-speed steel drills are standard. Carbide drills can be provided for special applications.
- Pilot diameter (customer supplied) is equal to the minimum existing hole diameter minus approximately .001 inch (in .001 inch increments).
- For other sizes please contact our Technical Sales Staff.

Model Number Key:

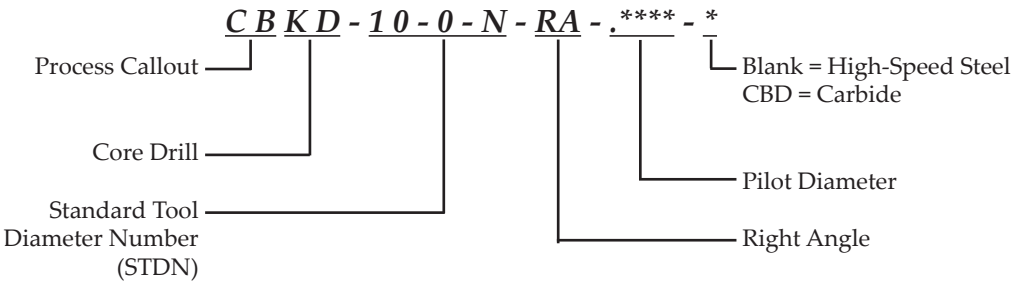

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Table 2.3-12
CB Tooling

STDN	Model Number
4-0-N	CBKD-4-0-N-RA-.****
4-1-N	CBKD-4-1-N-RA-.****
4-2-N	CBKD-4-2-N-RA-.****
4-3-N	CBKD-4-3-N-RA-.****
4-4-N	CBKD-4-4-N-RA-.****
6-0-N	CBKD-6-0-N-RA-.****
6-1-N	CBKD-6-1-N-RA-.****
6-2-N	CBKD-6-2-N-RA-.****
6-3-N	CBKD-6-3-N-RA-.****
8-0-N	CBKD-8-0-N-RA-.****
8-1-N	CBKD-8-1-N-RA-.****

STDN	Model Number
8-2-N	CBKD-8-2-N-RA-.****
8-3-N	CBKD-8-3-N-RA-.****
10-0-N	CBKD-10-0-N-RA-.****
10-1-N	CBKD-10-1-N-RA-.****
10-2-N	CBKD-10-2-N-RA-.****
10-3-N	CBKD-10-3-N-RA-.****
12-0-N	CBKD-12-0-N-RA-.****
12-1-N	CBKD-12-1-N-RA-.****
12-2-N	CBKD-12-2-N-RA-.****
12-3-N	CBKD-12-3-N-RA-.****

Table 2.3-13
CA Tooling

STDN	Model Number
20	CAKD-20-RA-.****
21	CAKD-21-RA-.****
22	CAKD-22-RA-.****
23	CAKD-23-RA-.****
30	CAKD-30-RA-.****
31	CAKD-31-RA-.****
32	CAKD-32-RA-.****
33	CAKD-33-RA-.****
40	CAKD-40-RA-.****
41	CAKD-41-RA-.****
42	CAKD-42-RA-.****
43	CAKD-43-RA-.****
50	CAKD-50-RA-.****
51	CAKD-51-RA-.****
52	CAKD-52-RA-.****
53	CAKD-53-RA-.****
60	CAKD-60-RA-.****
61	CAKD-61-RA-.****
62	CAKD-62-RA-.****
63	CAKD-63-RA-.****
70	CAKD-70-RA-.****

Table 2.3-14
KB2 Tooling

STDN	Model Number
40-****-0	KB2KD-40-****-0-RA-.****
41-****-0	KB2KD-41-****-0-RA-.****
42-****-0	KB2KD-42-****-0-RA-.****
43-****-0	KB2KD-43-****-0-RA-.****
60-****- 0	KB2KD-60-****-0-RA-.****
61-****-0	KB2KD-61-****-0-RA-.****
62-****-0	KB2KD-62-****-0-RA-.****
63-****-0	KB2KD-63-****-0-RA-.****
80-****-0	KB2KD-80-****-0-RA-.****
81-****-0	KB2KD-81-****-0-RA-.****
82-****-0	KB2KD-82-****-0-RA-.****
83-****-0	KB2KD-83-****-0-RA-.****
100-****-0	KB2KD-100-****-0-RA-.****
101-****-0	KB2KD-101-****-0-RA-.****
102-****-0	KB2KD-102-****-0-RA-.****
103-****-0	KB2KD-103-****-0-RA-.****
120-****-0	KB2KD-120-****-0-RA-.****
121-****-0	KB2KD-121-****-0-RA-.****
122-****-0	KB2KD-122-****-0-RA-.****
123-****-0	KB2KD-123-****-0-RA-.****

**** Refer to Cx2s Tooling for complete STDN information.

Detailed Tooling
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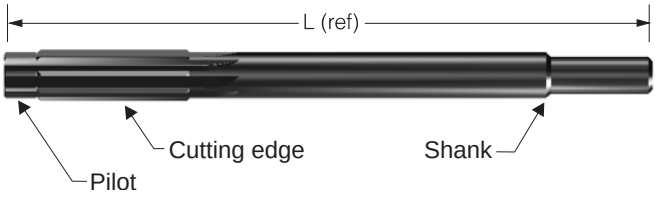

Figure 2.3-5
Starting Reamer

- Designed principally for starting hole sizing where only a moderate amount of stock removal is required (typically .010 inch to .015 inch).
- Used to produce holes of superior dimensional accuracy and surface finish.
- Starting reamers feature a pilot which is sized to the drilled pilot hole.
- Identification is provided by an electroetched model number and two electroetched lines.
- High-Speed steel reamers are standard. Cobalt and carbide reamers are available for special applications.
- For other types or sizes, please contact our Technical Sales Staff.

Model Number Key:

C B S R - 1 0 - 0 - N - 1 - *

Process Callout — CB

Starting Reamer — SR

Standard Tool Diameter Number (STDN) — 10

Blank = High-Speed Steel
C = Cobalt
CBD = Carbide — *

1 = Straight Shank
2 = Tapered Shank — 1

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Table 2.3-15
CB Tooling

STDN	Model Number	L (Ref. Fig. 2.3-5) (inch)
4-0-N	CBSR-4-0-N-1	3.50
4-1-N	CBSR-4-1-N-1	3.50
4-2-N	CBSR-4-2-N-1	4.00
4-3-N	CBSR-4-3-N-1	4.50
4-4-N	CBSR-4-4-N-1	4.50
6-0-N	CBSR-6-0-N-1	4.50
6-1-N	CBSR-6-1-N-1	5.00
6-2-N	CBSR-6-2-N-1	5.00
6-3-N	CBSR-6-3-N-1	6.00
8-0-N	CBSR-8-0-N-1	6.00
8-1-N	CBSR-8-1-N-1	6.00
8-2-N	CBSR-8-2-N-1	6.00
8-3-N	CBSR-8-3-N-1	6.00
10-0-N	CBSR-10-0-N-1	6.00
10-1-N	CBSR-10-1-N-1	6.00
10-2-N	CBSR-10-2-N-1	6.00
10-3-N	CBSR-10-3-N-1	7.00
12-0-N	CBSR-12-0-N-1	7.00
12-1-N	CBSR-12-1-N-1	7.00
12-2-N	CBSR-12-2-N-1	7.00
12-3-N	CBSR-12-3-N-1	7.00
14-0-N	CBSR-14-0-N-1	7.00
14-1-N	CBSR-14-1-N-1	7.00
14-2-N	CBSR-14-2-N-1	7.00
14-3-N	CBSR-14-3-N-1	7.00
16-0-N	CBSR-16-0-N-1	8.00
16-1-N	CBSR-16-1-N-1	8.00
16-2-N	CBSR-16-2-N-1	8.00
16-3-N	CBSR-16-3-N-1	8.00

STDN	Model Number	L (Ref. Fig. 2.3-5) (inch)
18-0-N	CBSR-18-0-N-1	8.00
18-1-N	CBSR-18-1-N-1	8.00
18-2-N	CBSR-18-2-N-1	8.00
18-3-N	CBSR-18-3-N-1	8.00
20-0-N	CBSR-20-0-N-1	9.00
20-1-N	CBSR-20-1-N-1	9.00
20-2-N	CBSR-20-2-N-1	9.00
20-3-N	CBSR-20-3-N-1	9.00
22-0-N	CBSR-22-0-N-1	9.00
22-1-N	CBSR-22-1-N-1	9.00
22-2-N	CBSR-22-2-N-1	9.00
22-3-N	CBSR-22-3-N-1	9.00
24-0-N	CBSR-24-0-N-1	9.00
24-1-N	CBSR-24-1-N-1	9.50
24-2-N	CBSR-24-2-N-1	9.50
24-3-N	CBSR-24-3-N-1	9.50
26-0-N	CBSR-26-0-N-1	9.50
26-1-N	CBSR-26-1-N-1	9.50
26-2-N	CBSR-26-2-N-1	9.50
26-3-N	CBSR-26-3-N-1	9.50
28-0-N	CBSR-28-0-N-1	10.00
28-1-N	CBSR-28-1-N-1	10.00
28-2-N	CBSR-28-2-N-1	10.00
28-3-N	CBSR-28-3-N-1	10.00
30-0-N	CBSR-30-0-N-1	10.00
30-1-N	CBSR-30-1-N-1	10.00
30-2-N	CBSR-30-2-N-1	10.00
30-3-N	CBSR-30-3-N-1	10.00

Detailed Tooling
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Table 2.3-16
CA Tooling

STDN	Model Number	L (Ref. Fig. 2.3-5) (inch)
20	CASR-20-1	3.50
21	CASR-21-1	3.50
22	CASR-22-1	4.00
23	CASR-23-1	4.00
30	CASR-30-1	4.50
31	CASR-31-1	4.50
32	CASR-32-1	5.00
33	CASR-33-1	5.00
40	CASR-40-1	6.00
41	CASR-41-1	6.00
42	CASR-42-1	6.00
43	CASR-43-1	6.00
50	CASR-50-1	6.00
51	CASR-51-1	6.00
52	CASR-52-1	6.00
53	CASR-53-1	6.00
60	CASR-60-1	7.00
61	CASR-61-1	7.00
62	CASR-62-1	7.00
63	CASR-63-1	7.00
70	CASR-70-1	7.00
71	CASR-71-1	7.00
72	CASR-72-1	7.00
73	CASR-73-1	7.00
80	CASR-80-1	8.00
81	CASR-81-1	8.00
82	CASR-82-1	8.00
83	CASR-83-1	8.00
90	CASR-90-1	8.00
91	CASR-91-1	8.00
92	CASR-92-1	8.00
93	CASR-93-1	8.00
100	CASR-100-1	8.00
101	CASR-101-1	9.00
102	CASR-102-1	9.00
103	CASR-103-1	9.00
110	CASR-110-1	9.00
111	CASR-111-1	9.00

Table 2.3-17
KB2 Tooling

STDN	Model Number	L* (Ref. Fig. 2.3-5) (inch)
40-****-0	KB2SR-40-****-0-1	4.00
41-****-0	KB2SR-41-****-0-1	4.00
42-****-0	KB2SR-42-****-0-1	4.00
43-****-0	KB2SR-43-****-0-1	4.50
60-****- 0	KB2SR-60-****-0-1	4.50
61-****-0	KB2SR-61-****-0-1	5.00
62-****-0	KB2SR-62-****-0-1	5.00
63-****-0	KB2SR-63-****-0-1	6.00
80-****-0	KB2SR-80-****-0-1	6.00
81-****-0	KB2SR-81-****-0-1	6.00
82-****-0	KB2SR-82-****-0-1	6.00
83-****-0	KB2SR-83-****-0-1	6.00
100-****-0	KB2SR-100-****-0-1	6.00
101-****-0	KB2SR-101-****-0-1	6.00
102-****-0	KB2SR-102-****-0-1	6.00
103-****-0	KB2SR-103-****-0-1	7.00
120-****-0	KB2SR-120-****-0-1	7.00
121-****-0	KB2SR-123-****-0-1	7.00
122-****-0	KB2SR-122-****-0-1	7.00
123-****-0	KB2SR-123-****-0-1	7.00

* Lengths may vary depending on tooling type.
**** Refer to Cx2s Tooling for STDN information.

Table 2.3-18
CR Tooling

STDN	Model Number	L (Ref. Fig. 2.3-5) (inch)
R30	CRSR-R30-1	4.50
R32	CRSR-R32-1	5.00
R40	CRSR-R40-1	6.00
R42	CRSR-R42-1	6.00
R50	CRSR-R50-1	6.00
R52	CRSR-R52-1	6.00
R60	CRSR-R60-1	7.00
R62	CRSR-R62-1	7.00

Detailed Tooling
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2.3.6 RIGHT ANGLE STARTING REAMERS

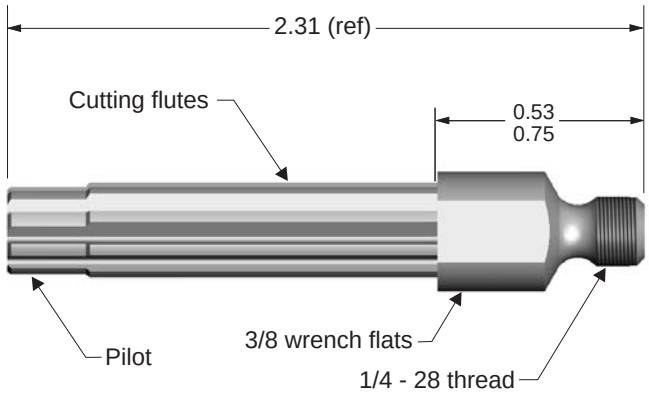

Figure 2.3-6
Right Angle Starting Reamer

- Designed principally for sizing starting holes where only a moderate amount of stock removal is required (typically .010 inch to .015 inch).
- Used only in restricted front-side clearance applications.
- High-Speed steel reamers feature a pilot which is sized to the drilled pilot hole.
- High-Speed steel reamers are standard. Cobalt and carbide reamers are available for special applications.
- Identification is provided by an electroetched STDN and two lines ground or electroetched mark on wrench flat, indicating the second cutting tool operation.

Model Number Key:

C B S R - 1 0 - 0 - N - RA - *

- Process Callout — C B
- Starting Reamer — S R
- Standard Tool Diameter Number (STDN) — 1 0 - 0
- Right Angle — RA
- Blank = High-Speed Steel; C = Cobalt; CBD = Carbide — *

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Table 2.3-19
CB Tooling

STDN	Model Number
4-0-N	CBSR-4-0-N-RA
4-1-N	CBSR-4-1-N-RA
4-2-N	CBSR-4-2-N-RA
4-3-N	CBSR-4-3-N-RA
4-4-N	CBSR-4-4-N-RA
6-0-N	CBSR-6-0-N-RA
6-1-N	CBSR-6-1-N-RA
6-2-N	CBSR-6-2-N-RA
6-3-N	CBSR-6-3-N-RA
8-0-N	CBSR-8-0-N-RA
8-1-N	CBSR-8-1-N-RA
8-2-N	CBSR-8-2-N-RA
8-3-N	CBSR-8-3-N-RA
10-0-N	CBSR-10-0-N-RA
10-1-N	CBSR-10-1-N-RA
10-2-N	CBSR-10-2-N-RA
10-3-N	CBSR-10-3-N-RA
12-0-N	CBSR-12-0-N-RA
12-1-N	CBSR-12-1-N-RA
12-2-N	CBSR-12-2-N-RA
12-3-N	CBSR-12-3-N-RA

Table 2.3-20
CA Tooling

STDN	Model Number
20	CASR-20-RA
21	CASR-21-RA
22	CASR-22-RA
23	CASR-23-RA
30	CASR-30-RA
31	CASR-31-RA
32	CASR-32-RA
33	CASR-33-RA
40	CASR-40-RA
41	CASR-41-RA
42	CASR-42-RA
43	CASR-43-RA
50	CASR-50-RA
51	CASR-51-RA
52	CASR-52-RA
53	CASR-53-RA
60	CASR-60-RA
61	CASR-61-RA
62	CASR-62-RA
63	CASR-63-RA
70	CASR-70-RA

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2.3.6 RIGHT ANGLE STARTING REAMERS

Table 2.3-21 KB2 Tooling

STDN	Model Number
40-****-0	KB2SR-40-****-0-RA
41-****-0	KB2SR-41-****-0-RA
42-****-0	KB2SR-42-****-0-RA
43-****-0	KB2SR-43-****-0-RA
60-****-0	KB2SR-60-****-0-RA
61-****-0	KB2SR-61-****-0-RA
62-****-0	KB2SR-62-****-0-RA
63-****-0	KB2SR-63-****-0-RA
80-****-0	KB2SR-80-****-0-RA
81-****-0	KB2SR-81-****-0-RA
82-****-0	KB2SR-82-****-0-RA
83-****-0	KB2SR-83-****-0-RA
100-****-0	KB2SR-100-****-0-RA
101-****-0	KB2SR-101-****-0-RA
102-****-0	KB2SR-102-****-0-RA
103-****-0	KB2SR-103-****-0-RA
120-****-0	KB2SR-120-****-0-RA
121-****-0	KB2SR-121-****-0-RA
122-****-0	KB2SR-122-****-0-RA
123-****-0	KB2SR-123-****-0-RA

**** Refer to Cx2s Tooling for STDN information.

Table 2.3-22 CR Tooling

STDN	Model Number
R30	CRSR-30-RA
R32	CRSR-32-RA
R40	CRSR-40-RA
R42	CRSR-42-RA
R50	CRSR-50-RA
R52	CRSR-52-RA
R60	CRSR-60-RA
R62	CRSR-62-RA

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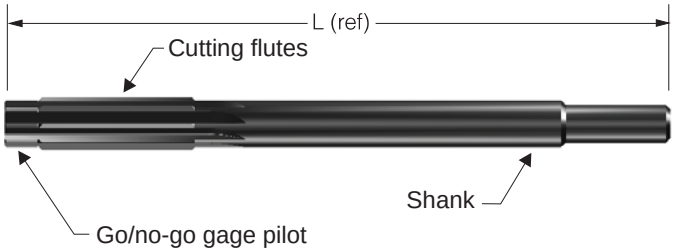

Figure 2.3-7
Gage Finish Reamer

- Designed principally for hole sizing after cold expansion where only a moderate amount of stock removal is required (typically .010 inch to .015 inch).
- All gage finish reamers feature a non-cutting pilot that is sized to the cold expansion verification pin diameter, which verifies the hole has been cold expanded (see combination gage section). The pilot will not fit into a non-cold expanded hole.
- Identification provided by an electroetched model number and three electroetched lines.
- High-Speed steel reamers are standard. Cobalt and carbide reamers are available for special applications.
- When possible, final hole diameter should be a multiple of .0005 inch.
- Final reamers are sized to the minimum final hole diameter unless otherwise specified.
- For other sizes, please contact our Technical Sales staff.

Model Number Key:

C B R - 1 0 - 0 - N - 1 - .* - ****

Process Callout — CBR

Gage Finish Reamer — CBR

Standard Tool Diameter Number (STDN) — 10-0

N

1 = Straight Shank
2 = Tapered Shank — 1

Desired Minimum Final Hole Diameter (customer specified) — .****

Blank = High-Speed Steel
C = Cobalt
CBD = Carbide — *

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Table 2.3-23
CB Tooling

STDN	Model Number	L* (Ref. Fig. 2.3-7) (inch)
4-0-N	CBR-4-0-N-1-.****	3.50
4-1-N	CBR-4-1-N-1-.****	3.50
4-2-N	CBR-4-2-N-1-.****	4.00
4-3-N	CBR-4-3-N-1-.****	4.50
4-4-N	CBR-4-4-N-1-.****	4.50
6-0-N	CBR-6-0-N-1-.****	4.50
6-1-N	CBR-6-1-N-1-.****	5.00
6-2-N	CBR-6-2-N-1-.****	5.00
6-3-N	CBR-6-3-N-1-.****	6.00
8-0-N	CBR-8-0-N-1-.****	6.00
8-1-N	CBR-8-1-N-1-.****	6.00
8-2-N	CBR-8-2-N-1-.****	6.00
8-3-N	CBR-8-3-N-1-.****	6.00
10-0-N	CBR-10-0-N-1-.****	6.00
10-1-N	CBR-10-1-N-1-.****	6.00
10-2-N	CBR-10-2-N-1-.****	6.00
10-3-N	CBR-10-3-N-1-.****	7.00
12-0-N	CBR-12-0-N-1-.****	7.00
12-1-N	CBR-12-1-N-1-.****	7.00
12-2-N	CBR-12-2-N-1-.****	7.00
12-3-N	CBR-12-3-N-1-.****	7.00
14-0-N	CBR-14-0-N-1-.****	7.00
14-1-N	CBR-14-1-N-1-.****	7.00
14-2-N	CBR-14-2-N-1-.****	7.00
14-3-N	CBR-14-3-N-1-.****	8.00
16-0-N	CBR-16-0-N-1-.****	8.00
16-1-N	CBR-16-1-N-1-.****	8.00
16-2-N	CBR-16-2-N-1-.****	8.00
16-3-N	CBR-16-3-N-1-.****	8.00
18-0-N	CBR-18-0-N-1-.****	8.00
18-1-N	CBR-18-1-N-1-.****	8.00
18-2-N	CBR-18-2-N-1-.****	8.00
18-3-N	CBR-18-3-N-1-.****	9.00
20-0-N	CBR-20-0-N-1-.****	9.00
20-1-N	CBR-20-1-N-1-.****	9.00
20-2-N	CBR-20-2-N-1-.****	9.00
20-3-N	CBR-20-3-N-1-.****	9.00
22-0-N	CBR-22-0-N-1-.****	9.00
22-1-N	CBR-22-1-N-1-.****	9.00
22-2-N	CBR-22-2-N-1-.****	9.00
22-3-N	CBR-22-3-N-1-.****	9.50
24-0-N	CBR-24-0-N-1-.****	9.50
24-1-N	CBR-24-1-N-1-.****	9.50
24-2-N	CBR-24-2-N-1-.****	9.50
24-3-N	CBR-24-3-N-1-.****	9.50
26-0-N	CBR-26-0-N-1-.****	9.50
26-1-N	CBR-26-1-N-1-.****	9.50
26-2-N	CBR-26-2-N-1-.****	9.50
26-3-N	CBR-26-3-N-1-.****	10.00
28-0-N	CBR-28-0-N-1-.****	10.00
28-1-N	CBR-28-1-N-1-.****	10.00
28-2-N	CBR-28-2-N-1-.****	10.00
28-3-N	CBR-28-3-N-1-.****	10.00
30-0-N	CBR-30-0-N-1-.****	10.00
30-1-N	CBR-30-1-N-1-.****	10.00
30-2-N	CBR-30-2-N-1-.****	10.00
30-3-N	CBR-30-3-N-1-.****	10.50

*Actual length may vary depending on final hole size.
**** Cutting diameter.

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Table 2.3-24
CA Tooling

STDN	Model Number	L* (Ref. Fig. 2.3-7) (inch)
20	CAR-20-1-.****	3.50
21	CAR-21-1-.****	3.50
22	CAR-22-1-.****	4.00
23	CAR-23-1-.****	4.00
30	CAR-30-1-.****	4.50
31	CAR-31-1-.****	4.50
32	CAR-32-1-.****	5.00
33	CAR-33-1-.****	6.00
40	CAR-40-1-.****	6.00
41	CAR-41-1-.****	6.00
42	CAR-42-1-.****	6.00
43	CAR-43-1-.****	6.00
50	CAR-50-1-.****	6.00
51	CAR-51-1-.****	6.00
52	CAR-52-1-.****	6.00
53	CAR-53-1-.****	6.00
60	CAR-60-1-.****	7.00
61	CAR-61-1-.****	7.00
62	CAR-62-1-.****	7.00
63	CAR-63-1-.****	7.00
70	CAR-70-1-.****	7.00
71	CAR-71-1-.****	7.00
72	CAR-72-1-.****	7.00
73	CAR-73-1-.****	7.00
80	CAR-80-1-.****	8.00
81	CAR-81-1-.****	8.00
82	CAR-82-1-.****	8.00
83	CAR-83-1-.****	8.00
90	CAR-90-1-.****	8.00
91	CAR-91-1-.****	8.00
92	CAR-92-1-.****	8.00
93	CAR-93-1-.****	8.00
100	CAR-100-1-.****	9.00
101	CAR-101-1-.****	9.00
102	CAR-102-.****	9.00
103	CAR-103-1-.****	9.00
110	CAR-110-1-.****	9.00
111	CAR-111-1-.****	9.00

*Actual length may vary depending on the final hole size.

Table 2.3-25
CR Tooling

STDN	Model Number	L* (Ref. Fig. 2.3-7) (inch)
R30	CRR-R30-1-****	4.50
R32	CRR-R32-1-****	5.00
R40	CRR-R40-1-****	6.00
R42	CRR-R42-1-****	6.00
R50	CRR-R50-1-****	6.00
R52	CRR-R52-1-****	6.00
R60	CRR-R60-1-****	6.00
R62	CRR-R62-1-****	7.00

*Actual length may vary depending on the final hole size.

Detailed Tooling
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2.3.8 Right Angle Gage Finish Reamers

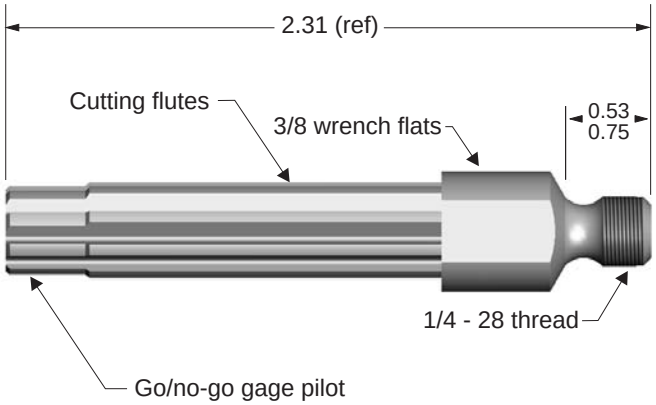

Figure 2.3-8
Right Angle Gage Finish Reamer

- Designed principally for hole sizing after cold expansion where only a moderate amount of stock removal is required (typically .010 inch to .015 inch).
- Used in restricted front-side clearance applications.
- All gage finish reamers feature a non-cutting pilot sized to the cold expansion verification pin diameter to verify the hole has been cold expanded (see verification gage section). The pilot will not fit into a non-cold expanded hole.
- High-Speed steel reamers are standard. Cobalt and carbide reamers are available for special applications.
- When possible, final hole diameter should be a multiple of .0005 inch.
- Identification is provided by an electroetched STDN and three lines ground or electroetched mark on wrench flat.

Model Number Key:

C B R - 1 0 - 0 - N - RA - .* - ****

- Process Callout
- Gage Finish Reamer
- Standard Tool Diameter Number (STDN)
- Right Angle
- Desired Minimum Final Hole Diameter (customer specified)
- Blank = High-Speed Steel
  C = Cobalt
  CBD = Carbide

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Table 2.3-26
CB Tooling

STDN	Model Number
4-0-N	CBR-4-0-N-RA-.****
4-1-N	CBR-4-1-N-RA-.****
4-2-N	CBR-4-2-N-RA-.****
4-3-N	CBR-4-3-N-RA-.****
4-4-N	CBR-4-4-N-RA-.****
6-0-N	CBR-6-0-N-RA-.****
6-1-N	CBR-6-1-N-RA-.****
6-2-N	CBR-6-2-N-RA-.****
6-3-N	CBR-6-3-N-RA-.****
8-0-N	CBR-8-0-N-RA-.****
8-1-N	CBR-8-1-N-RA-.****
8-2-N	CBR-8-2-N-RA-.****
8-3-N	CBR-8-3-N-RA-.****
10-0-N	CBR-10-0-N-RA-.****
10-1-N	CBR-10-1-N-RA-.****
10-2-N	CBR-10-2-N-RA-.****
10-3-N	CBR-10-3-N-RA-.****
12-0-N	CBR-12-0-N-RA-.****
12-1-N	CBR-12-1-N-RA-.****
12-2-N	CBR-12-2-N-RA-.****
12-3-N	CBR-12-3-N-RA-.****

Table 2.3-27
CA Tooling

STDN	Model Number
20	CAR-20-RA-.****
21	CAR-21-RA-.****
22	CAR-22-RA-.****
23	CAR-23-RA-.****
30	CAR-30-RA-.****
31	CAR-31-RA-.****
32	CAR-32-RA-.****
33	CAR-33-RA-.****
40	CAR-40-RA-.****
41	CAR-41-RA-.****
42	CAR-42-RA-.****
43	CAR-43-RA-.****
50	CAR-50-RA-.****
51	CAR-51-RA-.****
52	CAR-52-RA-.****
53	CAR-53-RA-.****
60	CAR-60-RA-.****
61	CAR-61-RA-.****
62	CAR-62-RA-.****
63	CAR-63-RA-.****
70	CAR-70-RA-.****

**** Cutting diameter.

Table 2.3-28
CR Tooling

STDN	Model Number
R30	CRR-30-RA-.****
R32	CRR-32-RA-.****
R40	CRR-40-RA-.****
R42	CRR-42-RA-.****
R50	CRR-50-RA-.****
R52	CRR-52-RA-.****
R60	CRR-60-RA-.****
R62	CRR-62-RA-.****

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2.3.9 COMBINATION GAGES

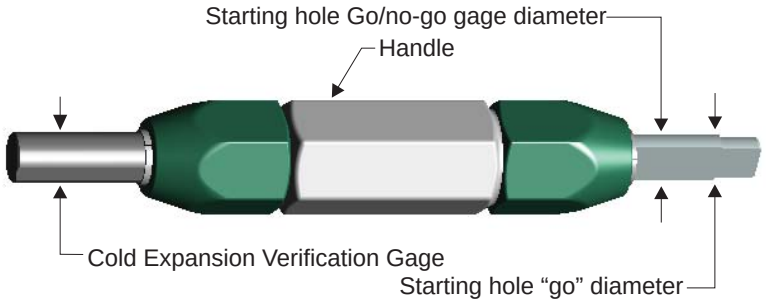

Figure 2.3-9
Combination Gage

Figure 2.3-10
Right Angle Combination Gage

- A stepped go/no-go configuration pin allows one end to ensure starting hole is within the specification tolerance prior to cold expansion.
- The cold expansion verification end confirms the hole has been cold expanded prior to final reaming.
- Starting hole diameter gage pin is a blade configuration to detect hole ovality.
- Cold expansion verification pin has flats to allow clearance past sleeve ridge.
- Identification is provided by a stamped model number on the handle and electro-etched diameters on the pins.
- Made of long wearing, hardened tool steel pins with an aluminum handle.
- For other sizes, please contact our Technical Sales staff.

Model Number Key:

C B G - 1 0 - 0 - N - 1

Process Callout — CBG

Combination Gage — G

Standard Tool Diameter Number (STDN) — 10

Detailed Tooling
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Table 2.3-29
CB Tooling

STDN	Model Number
4-0-N	CBG-4-0-N-1
4-1-N	CBG-4-1-N-1
4-2-N	CBG-4-2-N-1
4-3-N	CBG-4-3-N-1
4-4-N	CBG-4-4-N-1
6-0-N	CBG-6-0-N-1
6-1-N	CBG-6-1-N-1
6-2-N	CBG-6-2-N-1
6-3-N	CBG-6-3-N-1
8-0-N	CBG-8-0-N-1
8-1-N	CBG-8-1-N-1
8-2-N	CBG-8-2-N-1
8-3-N	CBG-8-3-N-1
10-0-N	CBG-10-0-N-1
10-1-N	CBG-10-1-N-1
10-2-N	CBG-10-2-N-1
10-3-N	CBG-10-3-N-1
12-0-N	CBG-12-0-N-1
12-1-N	CBG-12-1-N-1
12-2-N	CBG-12-2-N-1
12-3-N	CBG-12-3-N-1
14-0-N	CBG-14-0-N-1
14-1-N	CBG-14-1-N-1
14-2-N	CBG-14-2-N-1
14-3-N	CBG-14-3-N-1
16-0-N	CBG-16-0-N-1
16-1-N	CBG-16-1-N-1
16-2-N	CBG-16-2-N-1
16-3-N	CBG-16-3-N-1
18-0-N	CBG-18-0-N-1
18-1-N	CBG-18-1-N-1
18-2-N	CBG-18-2-N-1
18-3-N	CBG-18-3-N-1
20-0-N	CBG-20-0-N-1
20-1-N	CBG-20-1-N-1
20-2-N	CBG-20-2-N-1
20-3-N	CBG-20-3-N-1
22-0-N	CBG-22-0-N-1
22-1-N	CBG-22-1-N-1
22-2-N	CBG-22-2-N-1
22-3-N	CBG-22-3-N-1
24-0-N	CBG-24-0-N-1
24-1-N	CBG-24-1-N-1
24-2-N	CBG-24-2-N-1
24-3-N	CBG-24-3-N-1
26-0-N	CBG-26-0-N-1
26-1-N	CBG-26-1-N-1
26-2-N	CBG-26-2-N-1
26-3-N	CBG-26-3-N-1
28-0-N	CBG-28-0-N-1
28-1-N	CBG-28-1-N-1
28-2-N	CBG-28-2-N-1
28-3-N	CBG-28-3-N-1
30-0-N	CBG-30-0-N-1
30-1-N	CBG-30-1-N-1
30-2-N	CBG-30-2-N-1
30-3-N	CBG-30-3-N-1

Table 2.3-30
CA Tooling

STDN	Model Number
20	CAG-20
21	CAG-21
22	CAG-22
23	CAG-23
30	CAG-30
31	CAG-31
32	CAG-32
33	CAG-33
40	CAG-40
41	CAG-41
42	CAG-42
43	CAG-43
50	CAG-50
51	CAG-51
52	CAG-52
53	CAG-53
60	CAG-60
61	CAG-61
62	CAG-62
63	CAG-63
70	CAG-70
71	CAG-71
72	CAG-72
73	CAG-73
80	CAG-80
81	CAG-81
82	CAG-82
83	CAG-83
90	CAG-90
91	CAG-91
92	CAG-92
93	CAG-93
100	CAG-100
101	CAG-101
102	CAG-102
103	CAG-103
110	CAG-110
111	CAG-111

Detailed Tooling
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2.3.9 COMBINATION GAGES

Table 2.3-31 KB2 Tooling

STDN	Model Number
40-****-0	KB2G-40-****-0
41-****-0	KB2G-40-****-0
42-****-0	KB2G-40-****-0
43-****-0	KB2G-40-****-0
60-****-0	KB2G-60-****-0
61-****-0	KB2G-61-****-0
62-****-0	KB2G-62-****-0
63-****-0	KB2G-63-****-0
80-****-0	KB2G-80-****-0
81-****-0	KB2G-81-****-0
82-****-0	KB2G-82-****-0
83-****-0	KB2G-83-****-0
100-****-0	KB2G-100-****-0
101-****-0	KB2G-101-****-0
102-****-0	KB2G-102-****-0
103-****-0	KB2G-103-****-0
120-****-0	KB2G-120-****-0
121-****-0	KB2G-121-****-0
122-****-0	KB2G-122-****-0
123-****-0	KB2G-123-****-0

**** Refer to Cx2s Tooling for complete STDN information.

Table 2.3-32 CR Tooling

STDN	Model Number
R30	CRG-30
R32	CRG-32
R40	CRG-40
R42	CRG-42
R50	CRG-50
R52	CRG-52
R60	CRG-60
R62	CRG-62

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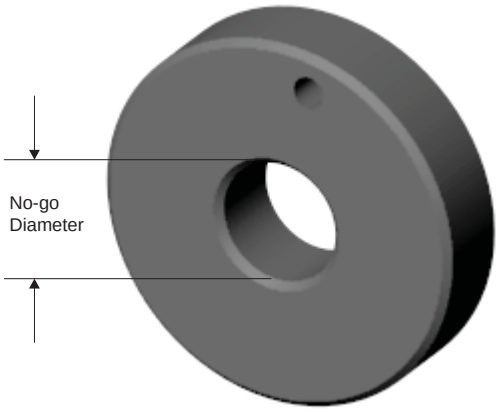

Figure 2.3-11
Mandrel Gage

- No-go feature indicates that the mandrel is within the specification tolerance.
- Identification is provided by a machined model number on the front of the mandrel gage.
- Made from hardened steel.
- Sized to the minimum allowable major diameter of the mandrel.

Model Number Key:

C B MG - 1 0 - 0 - N

Process Callout

Mandrel Gage

Standard Tool Diameter Number (STDN)

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Table 2.3-33
CB Tooling

STDN	Model Number
4-0-N	CBMG-4-0-N
4-1-N	CBMG-4-1-N
4-2-N	CBMG-4-2-N
4-3-N	CBMG-4-3-N
4-4-N	CBMG-4-4-N
6-0-N	CBMG-6-0-N
6-1-N	CBMG-6-1-N
6-2-N	CBMG-6-2-N
6-3-N	CBMG-6-3-N
8-0-N	CBMG-8-0-N
8-1-N	CBMG-8-1-N
8-2-N	CBMG-8-2-N
8-3-N	CBMG-8-3-N
10-0-N	CBMG-10-0-N
10-1-N	CBMG-10-1-N
10-2-N	CBMG-10-2-N
10-3-N	CBMG-10-3-N
12-0-N	CBMG-12-0-N
12-1-N	CBMG-12-1-N
12-2-N	CBMG-12-2-N
12-3-N	CBMG-12-3-N
14-0-N	CBMG-14-0-N
14-1-N	CBMG-14-1-N
14-2-N	CBMG-14-2-N
14-3-N	CBMG-14-3-N
16-0-N	CBMG-16-0-N
16-1-N	CBMG-16-1-N
16-2-N	CBMG-16-2-N
16-3-N	CBMG-16-3-N
18-0-N	CBMG-18-0-N
18-1-N	CBMG-18-1-N
18-2-N	CBMG-18-2-N
18-3-N	CBMG-18-3-N
20-0-N	CBMG-20-0-N
20-1-N	CBMG-20-1-N
20-2-N	CBMG-20-2-N
20-3-N	CBMG-20-3-N
22-0-N	CBMG-22-0-N
22-1-N	CBMG-22-1-N
22-2-N	CBMG-22-2-N
22-3-N	CBMG-22-3-N
24-0-N	CBMG-24-0-N
24-1-N	CBMG-24-1-N
24-2-N	CBMG-24-2-N
24-3-N	CBMG-24-3-N
26-0-N	CBMG-26-0-N
26-1-N	CBMG-26-1-N
26-2-N	CBMG-26-2-N
26-3-N	CBMG-26-3-N
28-0-N	CBMG-28-0-N
28-1-N	CBMG-28-1-N
28-2-N	CBMG-28-2-N
28-3-N	CBMG-28-3-N
30-0-N	CBMG-30-0-N
30-1-N	CBMG-30-1-N
30-2-N	CBMG-30-2-N
30-3-N	CBMG-30-3-N

Table 2.3-34
CA Tooling

STDN	Model Number
20	CAMG-20
21	CAMG-21
22	CAMG-22
23	CAMG-23
30	CAMG-30
31	CAMG-31
32	CAMG-32
33	CAMG-33
40	CAMG-40
41	CAMG-41
42	CAMG-42
43	CAMG-43
50	CAMG-50
51	CAMG-51
52	CAMG-52
53	CAMG-53
60	CAMG-60
61	CAMG-61
62	CAMG-62
63	CAMG-63
70	CAMG-70
71	CAMG-71
72	CAMG-72
73	CAMG-73
80	CAMG-80
81	CAMG-81
82	CAMG-82
83	CAMG-83
90	CAMG-90
91	CAMG-91
92	CAMG-92
93	CAMG-93
100	CAMG-100
101	CAMG-101
102	CAMG-102
103	CAMG-103
110	CAMG-110
111	CAMG-111

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Table 2.3-35
KB2 Tooling

STDN	Model Number
40-****-0	KB2MG-40-****-0
41-****-0	KB2MG-41-****-0
42-****-0	KB2MG-42-****-0
43-****-0	KB2MG-43-****-0
60-****-0	KB2MG-60-****-0
61-****-0	KB2MG-61-****-0
62-****-0	KB2MG-62-****-0
63-****-0	KB2MG-63-****-0
80-****-0	KB2MG-80-****-0
81-****-0	KB2MG-81-****-0
82-****-0	KB2MG-82-****-0
83-****-0	KB2MG-83-****-0
100-****-0	KB2MG-100-****-0
101-****-0	KB2MG-101-****-0
102-****-0	KB2MG-102-****-0
103-****-0	KB2MG-103-****-0
120-****-0	KB2MG-120-****-0
121-****-0	KB2MG-121-****-0
122-****-0	KB2MG-122-****-0
123-****-0	KB2MG-123-****-0

**** Refer to Cx2s Tooling for complete STDN information.

Table 2.3-36
CR Tooling

STDN	Model Number
R30	CRMG-R30
R32	CRMG-R32
R40	CRMG-R40
R42	CRMG-R42
R50	CRMG-R50
R52	CRMG-R52
R60	CRMG-R60
R62	CRMG-R62

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2.3.11 FINAL HOLE GAGES

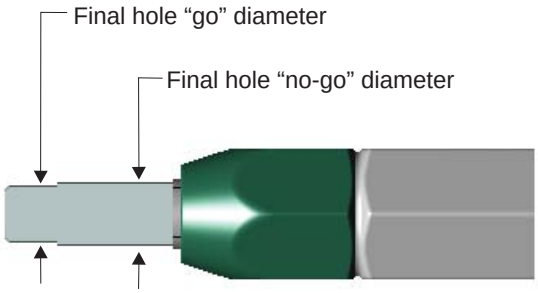

Figure 2.3-12
Final Hole Gage

- Designed with a go/no-go feature to verify that the final hole has been properly reamed.
- Final hole gages are made from a hardened steel pin and an aluminum handle.
- Identification is provided by a stamped model number on the handle and electro-etched final hole diameters on the pin.
- For other sizes and tool systems, contact our Technical Sales staff.

Model Number Key:

C R FG - R50 - 1 - .* / .****

Process Callout

Final Hole Gage

Final Hole Diameter (customer specified)

Standard Tool Diameter Number (STDN)

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Figure 2.3-13
Stamp Gage

- Used to identify discrepant starting hole diameters, and to verify and mark holes that have been cold expanded.
- A stepped go/no-go configuration allows one end to ensure starting hole is within the specification tolerance prior to cold expansion and stamps the part with "SHD" and an arrow to identify the hole if oversized.
- The opposite end verifies the hole has been properly cold expanded prior to final reaming and marks the part CXD with an arrow pointing toward the cold expanded hole.
- The pin configuration is flat to detect hole ovality.
- Identification is provided by a stamped model number on the handle and electro-etched diameters on the pins.
- Stamp gages are made of long wearing, hardened steel pins with an aluminum handle.
- Supplied with felt stamp pad, ink not included.
- For other sizes or series of tooling, please contact our Technical Sales staff.

Model Number Key:

CBSG-10-0-N-2

Process Callout (CB or CA)

Stamp Gage

Standard Tool Diameter Number (STDN)

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Table 2.3-37
CB Tooling

STDN	Model Number
4-0-N	CBSG-4-0-N-2
4-1-N	CBSG-4-1-N-2
4-2-N	CBSG-4-2-N-2
4-3-N	CBSG-4-3-N-2
4-4-N	CBSG-4-4-N-2
6-0-N	CBSG-6-0-N-2
6-1-N	CBSG-6-1-N-2
6-2-N	CBSG-6-2-N-2
6-3-N	CBSG-6-3-N-2
8-0-N	CBSG-8-0-N-2
8-1-N	CBSG-8-1-N-2
8-2-N	CBSG-8-2-N-2
8-3-N	CBSG-8-3-N-2
10-0-N	CBSG-10-0-N-2
10-1-N	CBSG-10-1-N-2
10-2-N	CBSG-10-2-N-2
10-3-N	CBSG-10-3-N-2
12-0-N	CBSG-12-0-N-2
12-1-N	CBSG-12-1-N-2
12-2-N	CBSG-12-2-N-2
12-3-N	CBSG-12-3-N-2
14-0-N	CBSG-14-0-N-2
14-1-N	CBSG-14-1-N-2
14-2-N	CBSG-14-2-N-2
14-3-N	CBSG-14-3-N-2
16-0-N	CBSG-16-0-N-2
16-1-N	CBSG-16-1-N-2
16-2-N	CBSG-16-2-N-2
16-3-N	CBSG-16-3-N-2
18-0-N	CBSG-18-0-N-2
18-1-N	CBSG-18-1-N-2
18-2-N	CBSG-18-2-N-2
18-3-N	CBSG-18-3-N-2
20-0-N	CBSG-20-0-N-2
20-1-N	CBSG-20-1-N-2
20-2-N	CBSG-20-2-N-2
20-3-N	CBSG-20-3-N-2
22-0-N	CBSG-22-0-N-2
22-1-N	CBSG-22-1-N-2
22-2-N	CBSG-22-2-N-2
22-3-N	CBSG-22-3-N-2
24-0-N	CBSG-24-0-N-2
24-1-N	CBSG-24-1-N-2
24-2-N	CBSG-24-2-N-2
24-3-N	CBSG-24-3-N-2
26-0-N	CBSG-26-0-N-2
26-1-N	CBSG-26-1-N-2
26-2-N	CBSG-26-2-N-2
26-3-N	CBSG-26-3-N-2
28-0-N	CBSG-28-0-N-2
28-1-N	CBSG-28-1-N-2
28-2-N	CBSG-28-2-N-2
28-3-N	CBSG-28-3-N-2
30-0-N	CBSG-30-0-N-2
30-1-N	CBSG-30-1-N-2
30-2-N	CBSG-30-2-N-2
30-3-N	CBSG-30-3-N-2

Table 2.3-38
CA Tooling

STDN	Model Number
20	CASG-20-2
21	CASG-21-2
22	CASG-22-2
23	CASG-23-2
30	CASG-30-2
31	CASG-31-2
32	CASG-32-2
33	CASG-33-2
40	CASG-40-2
41	CASG-41-2
42	CASG-42-2
43	CASG-43-2
50	CASG-50-2
51	CASG-51-2
52	CASG-52-2
53	CASG-53-2
60	CASG-60-2
61	CASG-61-2
62	CASG-62-2
63	CASG-63-2
70	CASG-70-2
71	CASG-71-2
72	CASG-72-2
73	CASG-73-2
80	CASG-80-2
81	CASG-81-2
82	CASG-82-2
83	CASG-83-2
90	CASG-90-2
91	CASG-91-2
92	CASG-92-2
93	CASG-93-2
100	CASG-100-2
101	CASG-101-2
102	CASG-102-2
103	CASG-103-2
110	CASG-110-2
111	CASG-111-2

Detailed Tooling
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- Used with a split sleeve to cold expand a hole.
- Identification is provided by an electroetched model number on the shank of the mandrel. (refer to B, Figure 2.3-14).
- Manufactured from high-strength, high-toughness alloy tool steel.
- Finished to a close diametrical tolerance of +/-.0002 inch or tighter.
- Typically endures 1,000 to 5,000 applications before the major diameter becomes worn beyond limits (depends on material being cold worked).
- -V2 denotes increased material strength for use with titanium or high strength steel applications.

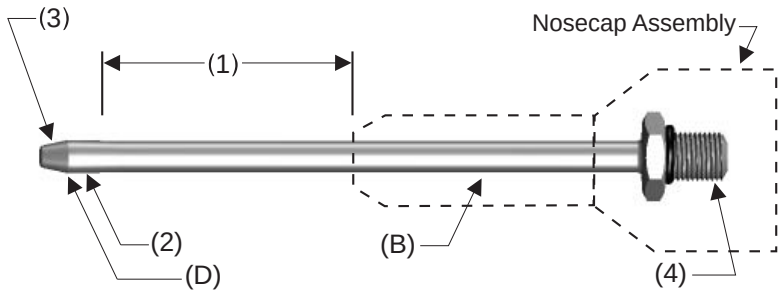

Figure 2.3-14
Parts of the Mandrel

- The major diameter (D) in conjunction with the thickness of the split sleeve provides the radial expansion required by the cold expansion system. This dimension is specified by the appropriate process.
- The minor diameter (B) is sized so that when the appropriate sleeve is placed on the mandrel, it will fit into the correct starting hole.
- The stackup length (1) is the maximum material stackup that can be cold expanded with the mandrel.
- The back taper (2) is controlled to provide the optimal pull force.
- The front taper (3) aids in loading the sleeve onto the mandrel and facilitates insertion of the mandrel into the hole. A single witness mark ground in the front taper denotes the V2 configuration.
- The attachment (4) is the means by which the mandrel is attached to the puller unit. A hex nut is provided for finger tightening of the mandrel attachment, while the O-ring provides an air seal and friction to lock the mandrel in the puller unit.

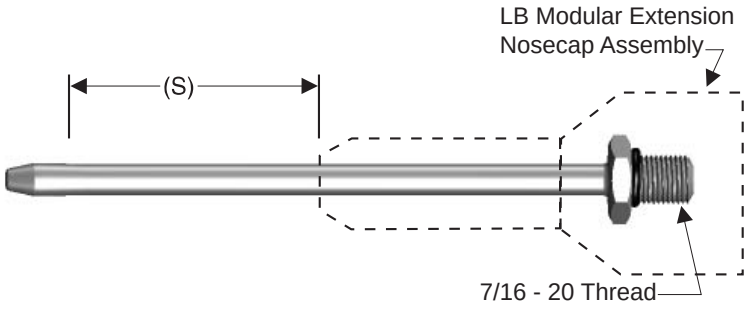

Figure 2.3-15
Little Brute Mandrel

Table 2.3-39
Stackup Callout

With 2-inch Extension Nosecap S (Ref. Fig. 2.3-15) (inch)	With Flush Nosecap S (Ref. Fig. 2.3-15) (inch)	With CsCx Nosecap S (Ref. Fig. 2.3-15) (inch)	Mandrel Stackup Callout
-----	0.5	-----	5
-----	1.0	-----	10
-----	1.5	-----	15
-----	2.0	-----	20
0.5	2.5	-----	25
1.0	3.0	1.3	**30**
1.5	3.5	1.8	35
2.0	-----	2.3	**40**
2.5	-----	2.8	45
3.0	-----	3.3	50
3.5	-----	-----	55

Other lengths can be provided; please contact our Technical Sales Staff for more information.

Model Number Key:

C B M - 1 0 - 0 - N - 1 - 30 - V1

- Process Callout
- Mandrel
- Standard Tool Diameter Number (STDN)
- Attachment Callout 7/16 - 20 Thread
- Stackup Callout (see Table 2.3-39)
- Material Callout
  V1= Aluminum or Mild Steel
  V2= High Strength Steel or Titanium

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Table 2.3-40
CR Tooling

STDN	Restricted Access Mandrel	Standard Mandrel
R30	CRM-R30-1-10-V1	KRM-R30-1-35-V1
R32	CRM-R32-1-10-V1	KRM-R32-1-35-V1
R40	CRM-R40-1-20-V1	KRM-R40-1-35-V1
R42	CRM-R42-1-20-V1	KRM-R42-1-35-V1
R50	CRM-R50-1-20-V1	KRM-R50-1-35-V1
R52	CRM-R52-1-20-V1	KRM-R52-1-35-V1
R60	CRM-R60-1-20-V1	KRM-R60-1-35-V1
R62	CRM-R62-1-20-V1	KRM-R62-1-35-V1

Table 2.3-41
STDN Range

Mandrel PRef.ix	Allowable STDN Range
CBM	4-0-N to 16-3-N
CAM	20 to 53
KBM	4-4-N to 12-3-N
KB2M	40-****-0 to 123-****-0
BLM	3 to 805
FTM	3-0-1 to 8-1-3

**** Refer to Cx2s Tooling for complete STDN information.

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2.3.15 MEDIUM BRUTE MANDRELS

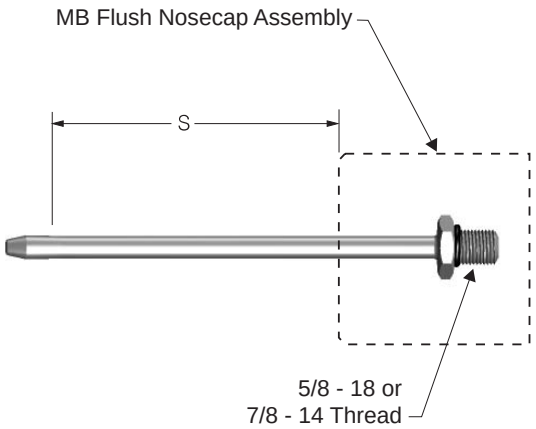

Figure 2.3-16
Medium Brute Mandrel

Table 2.3-42
Stackup Callout

With Flush Nosecap (Ref. Fig. 2.3-16) (inch)	With 3-inch Extension Nosecap (inch)	Mandrel Stackup Callout
0.5	-----	5
1.0	-----	10
1.5	-----	15
2.0	-----	20
2.5	-----	25
3.0	-----	30
3.5	.05	35
4.0	1.0	40
4.5	1.5	45
5.0	2.0	50
5.5	2.5	55
6.0	**3.0**	**60**
6.5	3.5	65
7.0	4.0	70

Other lengths can be provided; please contact our Technical Sales Staff for more information.

Table 2.3-43
Attachment Callout

Mandrel PRef.ix	Allowable STDN Range	Thread Size	Attachment Callout
CBM	10-3-N to 24-2-N	5/8 - 18	2
CBM	22-3-N to 30-3-N	7/8 - 14	5
CAM	60 to 93	5/8 - 18	2
CAM	60 to 111	7/8 - 14	5
KBM	14-0-N to 20-3-N	5/8 - 18	2

* The tooling adapters are provided with a MB-30.

Model Number Key:

C B M - 1 8 - 0 - N - 2 - 60 - V1

- Process Callout (CB or CA)
- Mandrel
- Standard Tool Diameter Number (STDN)
- Material Callout V1= Aluminum or Mild Steel V2= High Strength Steel or Titanium
- Stackup Callout (see Table 2.3-42)
- Attachment Callout (See Table 2.3-43)

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Note: The **bold** callouts are for use with the standard MB-30 Puller Unit and standard MB nosecaps.

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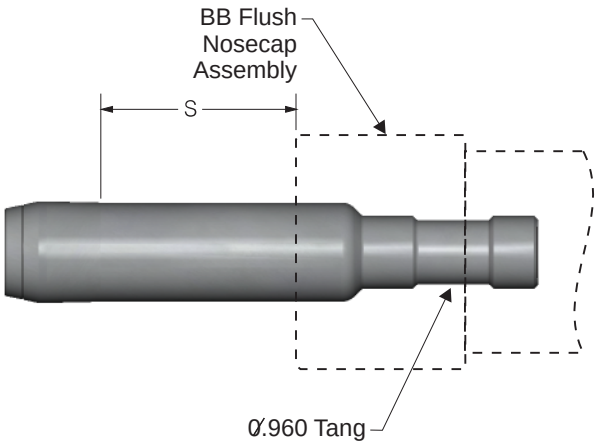

Figure 2.3-17
Big Brute Mandrel

Table 2.3-44
Stackup Callout

With Flush Nose-cap (Ref. Fig. 2.3-17) (inch)	Mandrel Stackup Callouts
1.0	10
1.5	15
2.0	20
2.5	25
3.0	**30**
3.5	35
4.0	40
4.5	45
5.0	50
5.5	55
6.0	60
6.5	65
7.0	70

Table 2.3-45
Attachment Callout

Mandrel PRef.ix	Allowable STDN Range	Attachment Type	Attachment Callout
CB	32-0-N to 56-3-N	.960 inch tang	3
CB	32-0-N to 56-3-N	7/8 - 14 Thd 2 piece	4
CB	26-3-N to 56-3-N	1 - 14 Thd 1 piece	9
FM	-14 to -20 OS	.960	3

* The tooling adapters are provided with a BB-30.

Model Number Key:

C B M - 3 6 - 0 - N - 3 - 30 - V1

- Process Callout
- Mandrel
- Standard Tool Diameter Number (STDN)
- Attachment Callout (See Table 2.3-45)
- Stackup Callout (see Table 2.3-44)
- Material Callout
  V1 = Aluminum or Mild Steel
  V2 = High-Strength Steel or Titanium

Note: The **bold** callouts are for use with the standard BB-30 Puller Unit and flush BB nosecaps.

2.3.17 OFFSET MANDRELS

- Used with a split sleeve to cold expand a restricted access hole.
- Identification is provided by an electroetched model number on the shank of the mandrel.
- Manufactured from high-strength, high-toughness alloy tool steel.
- Finished to a close diametrical tolerance of +/-.0002 inch or tighter.
- Typically endures 1,000 to 5,000 applications before the major diameter becomes worn out (depends on material being cold worked).
- Short front taper (SFT) mandrels can be provided when backside clearance is limited.
- -V2 denotes increased material strength for use with titanium or high-strength steel applications.
- A barrel nut is provided on the LBOA mandrels, for sizes 14-0-N to 16-3-N, to ensure the mandrel is properly lined up with the puller unit and workpiece.

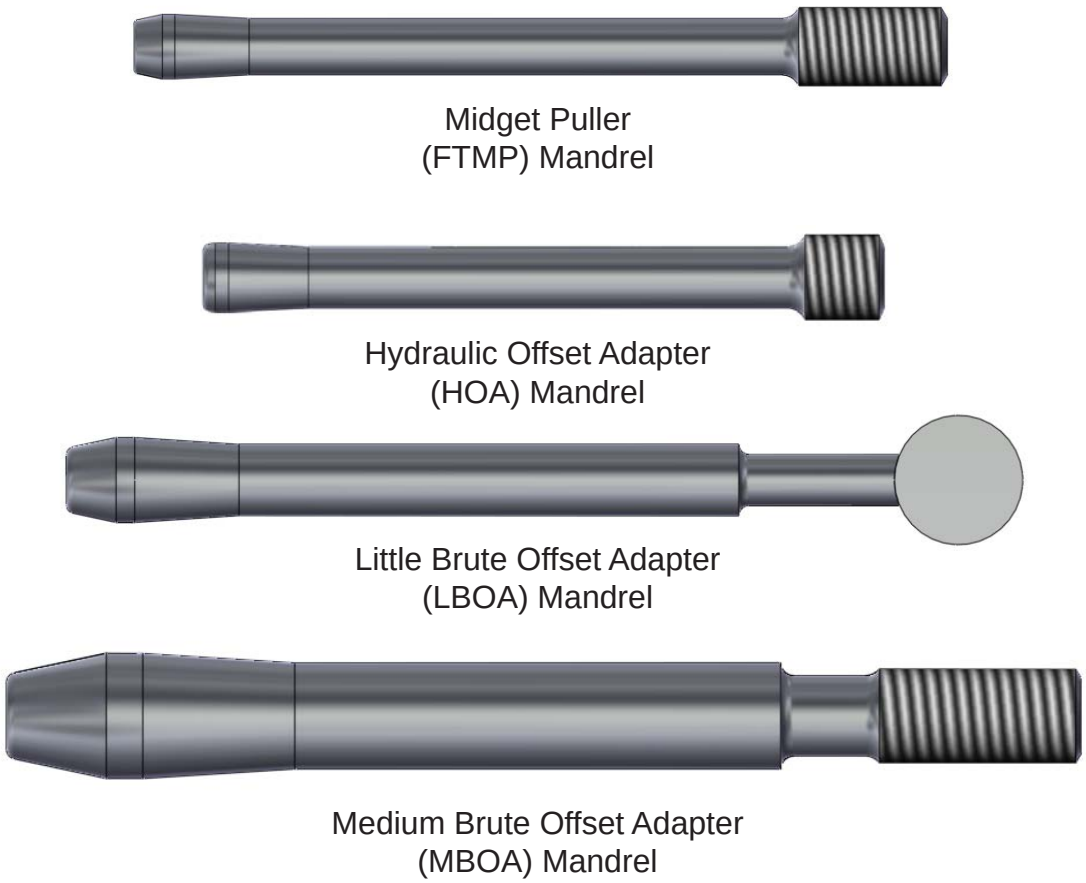

Figure 2.3-18
Offset Mandrels

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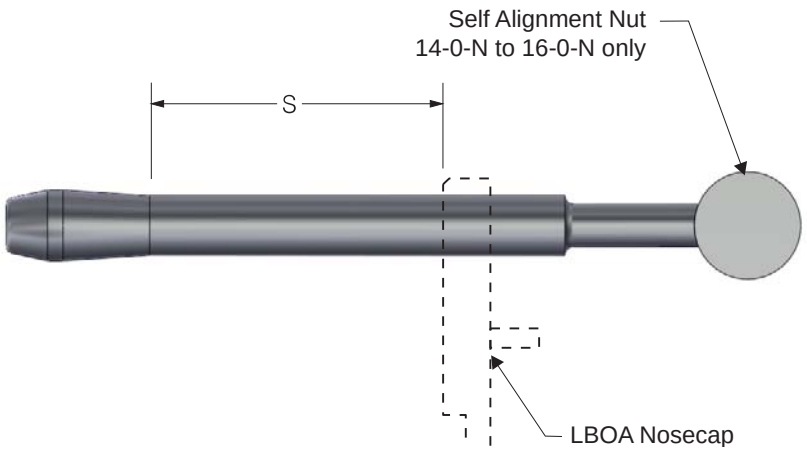

Figure 2.3-19
LBOA Mandrel

Table 2.3-46
Stackup Callout

With 2-inch Extension Nosecap (inch)	Standard Flush Nosecap S (Ref. Fig. 2.3-19) (inch)	Stackup Callout
-----	0.5	5
-----	1.0	10
-----	1.5	15
-----	**2.0**	**20**
0.5	2.5	25
1.0	3.0	30
1.5	3.5	35
2.0	-----	**40**
2.5	-----	45
3.0	-----	**50**
3.5	-----	55

Table 2.3-47
STDN Range

Material Callout	Allowable STDN Range	Attachment Callout
Aluminum Mild Steel (-V1)	4-0-N to 12-3-N	1
Aluminum Mild Steel (-V1)	14-0-N to 16-3-N	10A
Titanium, High Strength Steel (-V2)	20 to 72	1

Note: The **bold** callouts are most common for use with the LBOA-20 Offset Adapter, LB-20 Puller Unit, and LBOA flush nosecaps.

Model Number Key:

C B M - 1 4 - 0 - N - 1OA - 20 - V1

- Process Callout
- Mandrel
- Standard Tool Diameter Number (STDN)
- Attachment Callout (See Table 2.3-47)
- Stackup Callout (see Table 2.3-46)
- Material Callout
  V1= Aluminum or Mild Steel
  V2= High-Strength Steel or Titanium

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2.3.19 Medium Brute Offset Adapter Mandrels

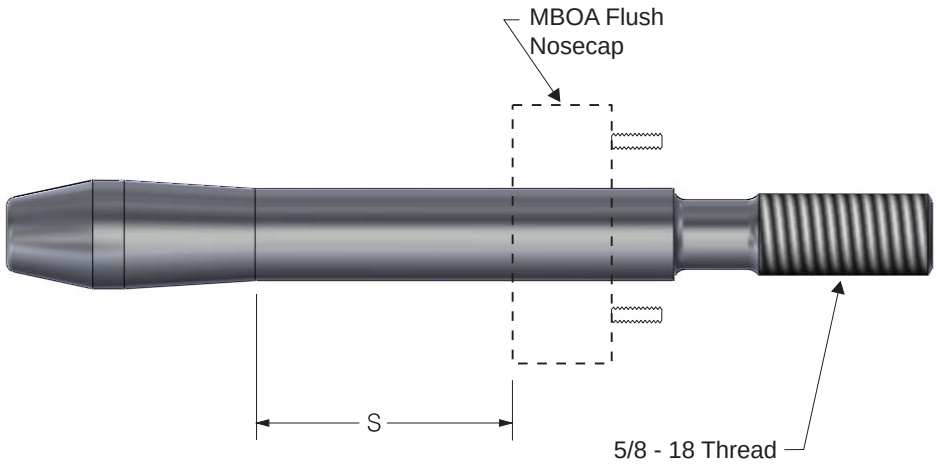

Figure 2.3-20
MBOA Mandrel

Table 2.3-48
Stackup Callout

With Flush Nosecap S (Ref. Fig. 2.3-20) (inch)	With 3-inch Extension Nosecap S (Ref. Fig. 2.3-20) (inch)	Mandrel Stackup Callout
1.0	-----	10
1.5	-----	15
2.0	-----	20
2.5	**-----**	25
3.0	-----	**30**
3.5	0.5	35
4.0	1.0	40
4.5	1.5	45
5.0	2.0	50
5.5	2.5	55
6.0	3.0	60
6.5	3.5	65
7.0	4.0	70

Table 2.3-49
STDN Range

Material Callout	Allowable STDN Range
Aluminum, Mild Steel (-V1)	12-0-N to 24-2-N
Titanium, High Strength Steel (-V2)	60 to 111

Note: The **bold** callouts are most common for use with the MBOA-30 Offset Adapter, MB-30 Puller Unit, and MBOA flush nosecaps.

Model Number Key:

C B M - 1 8 - 3 - N - 2OA - 30 - V1

- Process Callout
- Mandrel
- Standard Tool Diameter Number (STDN)
- Attachment Callout (see Table 2.3-49)
- Stackup Callout (see Table 2.3-48)
- Material Callout
  - V1= Aluminum or Mild Steel
  - V2= High Strength Steel or Titanium

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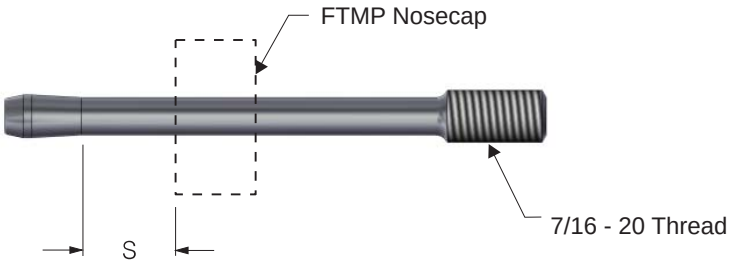

Figure 2.3-21
Midget Puller Mandrel

Table 2.3-50
Stackup Callout for FTMP-7 and FTMP-12

With 1-inch Extension Nosecap (inch)	With Flush Nosecap S (Ref. Fig. 2.3-21) (inch)	Mandrel Stackup Callout
-----	**0.75**	**7**
0.75	-----	17

Table 2.3-51
STDN Range

Material Callout	Allowable STDN Range
Aluminum, Mild Steel (-V1)	4-0-N to 12-0-N
Titanium, High Strength Steel (-V2)	20 to 33

Note: Use Midget Puller Units and Little Brute flush nosecap or extension nosecap jaws. The FTMP-8 requires special mandrel lengths. The FTMP-12 can use Little Brute mandrels, but one inch is lost to the puller.

Model Number Key:

C B M - 6 - 1 - N - 1MP - 7 - V1

- Process Callout
- Mandrel
- Standard Tool Diameter Number (STDN)
- Material Callout V1= Aluminum or Mild Steel V2= High Strength Steel or Titanium
- Stackup Callout (see Table 2.3-50)
- Attachment Callout (see Table 2.3-51)

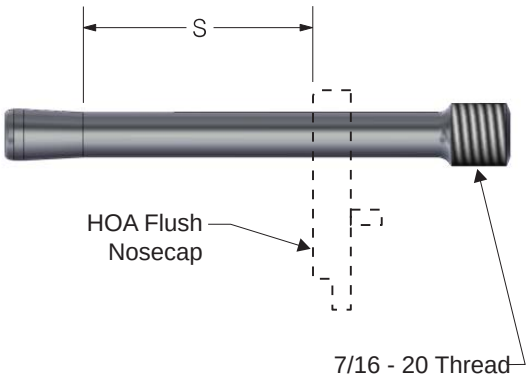

Figure 2.3-22
HOA Mandrel

Table 2.3-52
Stackup Callout

With 2-inch Extension Nosecap S (Ref. Fig. 2.3-22) (inch)	With Flush Nosecap S (Ref. Fig. 2.3-22) (inch)	Mandrel Stackup Callout
-----	0.5	5
-----	1.0	10
-----	1.5	15
-----	**2.0**	**20**
0.5	2.5	25
1.0	-----	30
1.5	-----	35
2.0	-----	40
2.5	-----	45

Table 2.3-53
STDN Range

Material Callout	Allowable STDN Range
Aluminum, Mild Steel (-V1)	4-0-N to 14-3-N
Titanium, High Strength Steel (-V2)	CA-20 to CA-50

Note: The **bold** callouts are most common for use with the Hydraulic Offset Adapter and LBOA/HOA flush nosecaps.

Model Number Key:

C B M - 6 - 1 - N - 1HOA - 20 - V1

- Process Callout
- Mandrel
- Standard Tool Diameter Number (STDN)
- Material Callout
  V1 = Aluminum or Mild Steel
  V2 = High Strength Steel or Titanium
- Stackup Callout (see Table 2.3-52)
- Attachment Callout (see Table 2.3-53)

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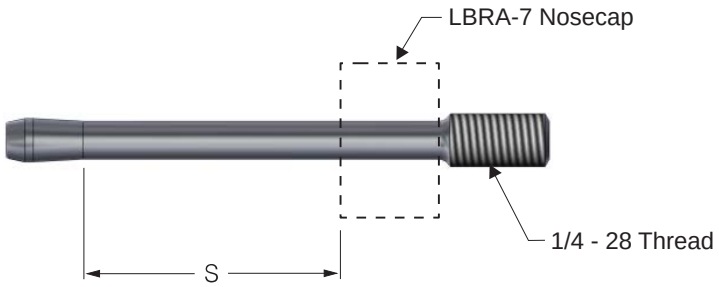

Figure 2.3-23
Right-Angle Puller Mandrel

Table 2.3-54
Right-Angle Puller Mandrel Selection

Model Number	STDN	Maximum Mandrel Length	Maximum Sleeve Length	Maximum Material Stackup (inch)
LBRA-7	4-0-N	CBM-4-0-N-7-8-V1	CBS-4-0-N-12F	0.750
	4-1-N	CBM-4-1-N-7-8-V1	CBS-4-1-N-12F	0.750
	4-2-N	CBM-4-2-N-7-7.5-V1	CBS-4-2-N-12F	0.750
	4-3-N	CBM-4-3-N-7-7.5-V1	CBS-4-3-N-12F	0.750
	4-4-N	CBM-4-4-N-7-7.5-V1	CBS-4-4-N-12F	0.750
	6-0-N	CBM-6-0-N-7-7.5-V1	CBS-6-0-N-12F	0.750
	6-1-N	CBM-6-1-N-7-7.5-V1	CBS-6-1-N-12F	0.750
	6-2-N	CBM-6-2-N-7-7-V1	CBS-6-2-N-10F	0.625
	6-3-N	CBM-6-3-N-7-7-V1	CBS-6-3-N-10F	0.625
	8-0-N	CBM-8-0-N-7-7-V1	CBS-8-0-N-10F	0.625
	8-1-N	CBM-8-1-N-7-7-V1	CBS-8-1-N-10F	0.625
	8-2-N	CBM-8-2-N-7-6.5-V1	CBS-8-2-N-10F	0.625
	8-3-N	CBM-8-3-N-7-6.5-V1	CBS-8-3-N-10F	0.625
	10-0-N	CBM-10-0-N-7-6.5-V1	CBS-10-0-N-10F	0.625
	10-1-N	CBM-10-1-N-7-6.5-V1	CBS-10-1-N-10F	0.625
	10-2-N	CBM-10-2-N-7-6.5-V1	CBS-10-2-N-10F	0.625
	10-3-N	CBM-10-3-N-7-6.5-V1	CBS-10-3-N-10F	0.625
	12-0-N	CBM-12-0-N-7-6-V1	CBS-12-0-N-8F	0.500
	12-1-N	CBM-12-1-N-7-6-V1	CBS-12-1-N-8F	0.500
	12-2-N	CBM-12-2-N-7-6-V1	CBS-12-2-N-8F	0.500
	12-3-N	CBM-12-3-N-7-6-V1	CBS-12-3-N-8F	0.500

Model Number Key:

C B M - 6 - 1 - N - 7- 7.5 - V1

- Process Callout
- Mandrel
- Standard Tool Diameter Number (STDN)
- Material Callout V1= Aluminum or Mild Steel
- Stackup Callout
- Attachment Callout

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2.3.23 MODULAR EXTENSION NOSECAP ASSEMBLY

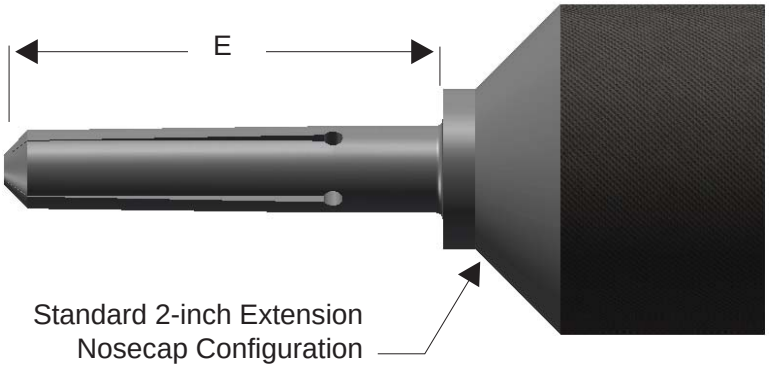

Figure 2.3-24
Modular Extension Nosecap

- This product is designed as an improvement to standard CBCE nosecaps. It is the preferred extension nosecap assembly, with interchangeable jaws.
- Single jaw and cap can be used together with tube and mandrel extension tooling to create a variety of lengths (see following pages).
- Can be extended in length for use when cold exanding holes through a drill fixture/ drill bushing, or when an obstruction is adjacent to the hole.
- Identification is provided by an electroetched model number on each piece.

Jaw

Model Number Key:

MJ - A 4 - XXXXF

- MJ — Modular Jaw
- A — Thread:
  - A = 5/8 inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-3/8 inches
- 4 — Length (Figure 2.3-24)
  - 4 = 2 inches
  - 6 = 3 inches
- XXXXF — Jaw Size

Cap

Model Number Key:

MC - 1 A

- MC — Modular Cap
- 1 — Puller Callout
  - 1 = LB
  - 2 = MB
  - 4 = LBOA/HOA
  - 5 = MBOA
  - 9 = MBHO
- A — Thread
  - A = 5/8 inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-3/8 inches

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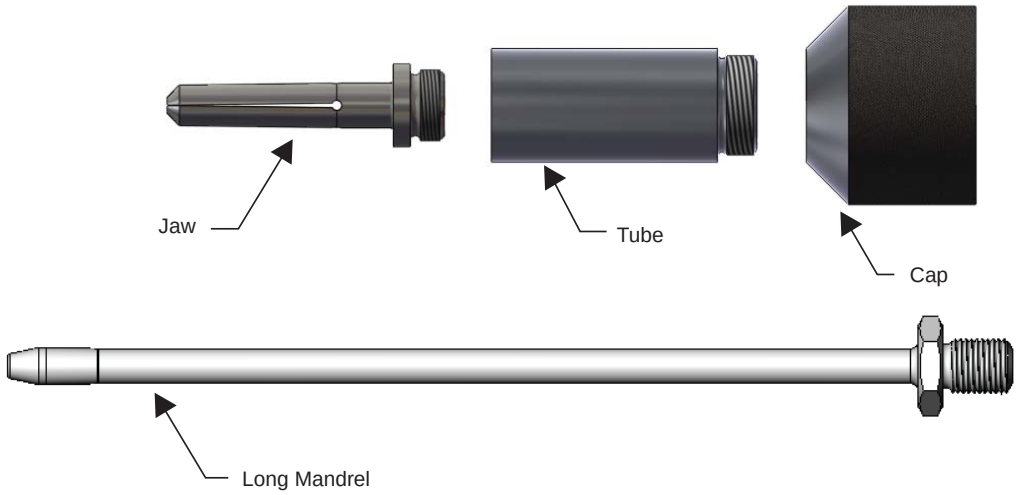

Figure 2.3-25
Modular Extension Nosecap
Option 1

- Mandrel lengths will vary according to overall length of noscap. Main feature of this product is the **extension tube** (in diagram), which is used to increase the overall length of nosecap. The CBCE system requires purchase of an entire new nosecap when different nosecap lengths are necessary.

Tube

Model Number Key:

MT - A - XX

Modular Tube

Thread
A = 5/8 inch
B = 7/8 inch
C = 1-1/8 inches
D = 1-3/8 inches

Tube Length
Length = 2 x inch
4 = 2 inches
20 = 10 inches

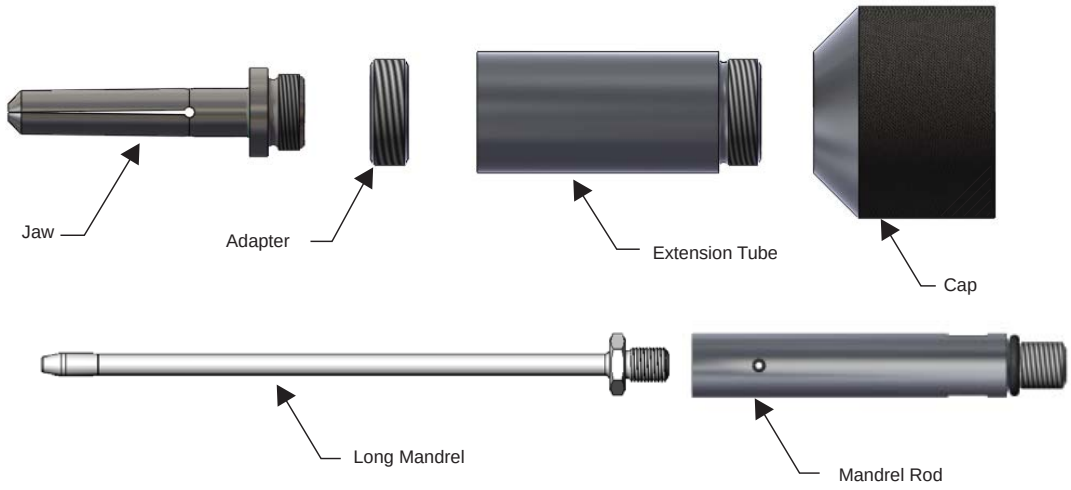

Figure 2.3-26
Modular Extension Nosecap
Option 2

- This configuration utilizes a larger diameter tube, mandrel rod, and an adapter. This option allows the use of shorter length mandrels when using the MEN assembly. For example, the same mandrel can be used for both the 2-inch and 4-inch extension nosecaps when the correct rod is used.
- The adapter is required whenever a extension rod and tube are used.
- Uses interchangeable jaw, cap, and tube.

Rod

Model Number Key:

MR - 1 1 - 20

- MR — Mandrel Rod
- 1 — Internal Thread, Mandrel: 1 = 7/16 inch; 2 = 5/8 inch; 5 = 7/8 inch
- 1 — External Thread, Puller: 1 = 7/16 inch; 2 = 5/8 inch; 5 = 7/8 inch
- 20 — Length: 2 x inch; 2 inch = 4; 10 inch = 20

Adapter

Model Number Key:

MA - A B

- MA — Modular Adapter
- A — Adapter Internal Thread, Jaw External Thread: A = 5/8 inch; B = 7/8 inch; C = 1-1/8 inches
- B — Adapter External Thread, Tube Internal Thread: B = 7/8 inch; C = 1-1/8 inches; D = 1-3/8 inches

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Table 2.3-55
Modular Nosecaps for Use with Single Piece Mandrel for Little Brute and Medium Brute Pullers

CB STDN Range	CA STDN Range	CR STDN Range	KB2 STDN Range	Puller	Cap	Jaw Thread Callout	Extension Tube Fig. 2.3-26	Applicable Mandrels
4-0-N thru 12-3-N	20 thru 63	R30 thru R-62	40-****-0 to 123-****-0	LB	MC-1A	A	MT-A-XX (dia. = .73)	CBM-X-X-N-1-XX-VX
14-0-N thru 16-3-N	70 thru 83	-----	-----	LB	MC-1B	B	MT-B-XX (dia. = 1.10)	CBM-X-X-N-1-XX-VX
10-0-N thru 20-1-N	50 thru 101	-----	-----	MB	MC-2B	B	MT-B-XX (dia. = 1.10)	CBM-X-X-N-2-XX-VX
20-2-N thru 24-2-N	102 thru 111	-----	-----	MB	MC-2C	C	MT-C-XX (dia. = 1.29)	CBM-X-X-N-2-XX-VX
22-3-N thru 30-1-N	-----	-----	-----	MB	MC-2C	C	MT-C-XX (dia. = 1.29)	CBM-X-X-N-5-XX-VX
30-2-N thru 30-3-N	-----	-----	-----	MB	MC-2D	D	MT-D-XX (dia. = 1.57)	CBM-X-X-N-5-XX-VX

Table 2.3-56
Modular Nosecaps for Use with Extension Rod for Little Brute and Medium Brute Pullers

CB STDN Range	CA STDN Range	CR STDN Range	KB2 STDN Range	Puller	Cap	Jaw Thread Callout	Extension Tube	Modular Tube Adapter	Mandrel Rod	Applicable Mandrels
4-0-N thru 12-3-N	20 thru 63	R30 thru R-62	40-****-0 to 123-****-0	LB	MC-1B	A	MT-B-XX (dia. = 1.10)	MA-AB	MR-11-XX	CBM-X-X-N-1-XX-VX
10-0-N thru 16-3-N	50 thru 83	-----	-----	LB	MC-1B	B	MT-B-XX (dia. = 1.10)	N/A	MR-11-XX	CBM-X-X-N-1-XX-VX
10-0-N thru 20-1-N	50 thru 101	-----	-----	MB	MC-2C	C	MT-B-XX (dia. = 1.29)	MA-BC	MR-22-XX	CBM-X-X-N-2-XX-VX
20-2-N thru 24-2-N	102 thru 111	-----	-----	MB	MC-2C	C	MT-C-XX (dia. = 1.29)	N/A	MR-22-XX	CBM-X-X-N-2-XX-VX
22-3-N thru 30-1-N	-----	-----	-----	MB	MC-2D	C	MT-D-XX (dia. = 1.57)	MA-CD	MR-55-XX	CBM-X-X-N-5-XX-VX
30-2-N thru 30-3-N	-----	-----	-----	MB	MC-2D	D	MT-D-XX (dia. = 1.57)	N/A	MR-55-XX	CBM-X-X-N-5-XX-VX

2.3.24 MEN Assemblies for Option 1

2.3.24 MEN Assemblies for Option 2

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Table 2.3-57
Little Brute and Medium Brute Modular Extension Nosecaps Assemblies

CB Tooling STDN Range	CA Tooling STDN Range	CR Tooling STDN Range	KB2 Tooling STDN Range	Little Brute Assembly Model No.	Medium Brute Assembly Model No.	Max. Jaw Dia. Ref. Fig. 2.3-26
4-0-N to 4-1-N	20 to 21	-----	40-****-0 to 41-****-0	MEN-14A-0401F	-----	0.358
4-2-N to 4-3-N	22 to 23	R30	42-****-0 to 43-****-0	MEN-14A-0423F	-----	0.400
4-4-n to 6-1-N	30 to 31	-----	60-****-0 to 61-****-0	MEN-14A-0601F	-----	0.425
6-2-N to 6-3-N	32 to 33	R32	62-****-0 to 63-****-0	MEN-14A-0623F	-----	0.458
8-0-N to 8-1-N	40 to 41	R40	80-****-0 to 81-****-0	MEN-14A-0801F	-----	0.481
8-2-N to 8-3-N	42 to 43	R42	82-****-0 to 83-****-0	MEN-14A-0823F	-----	0.514
10-0-N to 10-1-N	50 to 51	R50	100-****-0 to 101-****-0	MEN-14A-1001F	-----	0.565
10-2-N to 10-3-N	52 to 53	R52	102-****-0 to 103-****-0	MEN-14A-1023F	MEN-26B-1023F	0.593
12-0-N to 12-1-N	60 to 61	R60	120-****-0 to 121-****-0	MEN-14A-1201F	MEN-26B-1201F	0.625
12-2-N to 12-3-N	62 to 63	R62	122-****-0 to 123-****-0	MEN-14A-1223F	MEN-26B-1223F	0.657
14-0-N to 14-1-N	70 to 71	-----	-----	MEN-14B-1401F	MEN-26B-1401F	0.689
14-2-N to 14-3-N	72 to 73	-----	-----	MEN-14B-1423F	MEN-26B-1423F	0.718
16-0-N to 16-1-N	80 to 81	-----	-----	MEN-14B-1601F	MEN-26B-1601F	0.760
16-2-N to 16-3-N	82 to 83	-----	-----	MEN-14B-1623F	MEN-26B-1623F	0.792
18-0-N to18-1-N	90 to 91	-----	-----	-----	MEN-26B-1801F	0.825
18-2-N to 18-3-N	92 to 93	-----	-----	-----	MEN-26B-1823F	0.856
20-0-N to 20-1-N	100 to 101	-----	-----	-----	MEN-26B-2001F	0.882
20-2-N to 20-3-N	102 to 103	-----	-----	-----	MEN-26C-2023F	0.916
22-0-N to 22-1-N	110 to 111	-----	-----	-----	MEN-26C-2201F	.945
22-2-N to 22-3-N	-----	-----	-----	-----	MEN-26C-2223F	.998
24-0-N to 24-1-N	-----	-----	-----	-----	MEN-26C-2401F	1.027
24-2-N to 24-3-N	-----	-----	-----	-----	MEN-26C-2423F	1.053
26-0-N to 26-1-N	-----	-----	-----	-----	MEN-26C-2601F	1.087
26-2-N to 26-3-N	-----	-----	-----	-----	MEN-26C-2623F	1.116
28-0-N to 28-1-N	-----	-----	-----	-----	MEN-26C-2801F	1.147
28-2-N to 28-3-N	-----	-----	-----	-----	MEN-26C-2823F	1.186
30-0N to 30-1-N	-----	-----	-----	-----	MEN-26C-3001F	1.210
30-2-N to 30-3-N	-----	-----	-----	-----	MEN-26D-3023F	1.241

Assembly*

Model Number Key:

MEN - 1 4 A - XXXXF

- Modular Nosecap Assembly
- Puller
  - 1 = LB
  - 2 = MB
  - 4 = LBOA/HOA
  - 5 = MBOA
  - 9 = MBHO
- Extension Length in 1/2-inch increments
- Thread on Cap and Jaw
  - A = 5/8 inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-1/4 inches
- Tool Code
- * Assemblies are not marked with assembly model number. Each component is marked with its own model number.

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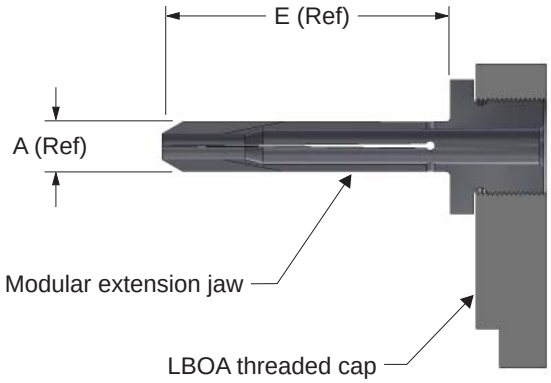

Figure 2.3-27
LBOA Modular Extension Nosecap

- Jaw is a standard modular extension configuration and can be used with other puller caps with same jaw thread.
- Designed to hold flared split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece .
- Assembly consists of two-pieces: Cap and one-piece jaw that extends a minimum of two inches from the front of the cap.
- Jaws and modular caps can be ordered separately.
- Identification is provided by an electroetched model number on each component.
- Other lengths available (E Ref. Figure 2.3-27). Please contact our Technical Sales Staff.

Cap

Model Number Key:

MC-4A

- Modular Cap
- Length
  - 4 = 2 inches
  - 6 = 3 inches
- Thread:
  - A = 5/8 inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-3/8-inches

Jaw

Model Number Key:

MJ - A 4 - XXXXF

- Modular Jaw
- Thread:
  - A = 5/8 inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-3/8-inches
- Length
  - (E Ref. Fig. 2.3-27)
  - 4 = 2 inch
  - 6 = 3 inch
- Jaw Size

*Nosecap Assembly**

Model Number Key:

MEN - 44A - XXXXF

- Modular Extension Nosecap
- Attachment
- Length
- Thread
  - A = 5/8 inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-1/4-inches
- Jaw Size

* Parts are not marked with assembly number. Each component is marked with its own model number.

Table 2.3-58
STDN Range

CB Tooling	KB2 Tooling	CR Tool STDN	CA Tooling	A Max. (Ref. Fig. 2.3-27) (inch)	Jaw Model Number	Modular Cap/Jaw Attachment Plate	Modular Assembly
4-0-N to 4-1-N	40-****-0 to 41-****-0	-----	20 to 21	0.358	MJ-A4-0401F	MC-4A	MEN-44A-0401F
4-2-N to 4-3-N	42-****-0 to 43-****-0	-----	22 to 23	0.400	MJ-A4-0423F	MC-4A	MEN-44A-0423F
4-4-n to 6-1-N	60-****-0 to 61-****-0	R30	30 to 31	0.425	MJ-A4-0601F	MC-4A	MEN-44A-0601F
6-2-N to 6-3-N	62-****-0 to 63-****-0	R32	32 to 33	0.458	MJ-A4-0623F	MC-4A	MEN-44A-0623F
8-0-N to 8-1-N	80-****-0 to 81-****-0	R40	40 to 41	0.481	MJ-A4-0801F	MC-4A	MEN-44A-0801F
8-2-N to 8-3-N	82-****-0 to 83-****-0	R42	42 to 43	0.514	MJ-A4-0823F	MC-4A	MEN-44A-0823F
10-0-N to 10-1-N	100-****-0 to 101-****-0	R50	50 to 51	0.565	MJ-A4-1001F	MC-4A	MEN-44A-1001F
10-2-N to 10-3-N	102-****-0 to 103-****-0	R52	52 to 53	0.593	MJ-A4-1023F	MC-4A	MEN-44A-1023F
12-0-N to 12-1-N	120-****-0 to 121-****-0	R60	-----	0.625	MJ-A4-1201F	MC-4A	MEN-44A-1201F
12-2-N to 12-3-N	122-****-0 to 123-****-0	R62	-----	0.657	MJ-A4-1223F	MC-4A	MEN-44A-1223F
14-0-N to 14-1-N	-----	-----	-----	0.689	MJ-A4-1401F	MC-4B	MEN-44B-1401F
14-2-N to 14-3-N	-----	-----	-----	0.718	MJ-B4-1423F	MC-4B	MEN-44B-1423F
16-0-N to 16-1-N	-----	-----	-----	0.760	MJ-B4-1601F	MC-4B	MEN-44B-1601F
16-2-N to 16-3-N	-----	-----	-----	0.762	MJ-B4-1623F	MC-4B	MEN-44B-1623F
18-0-N to18-1-N	-----	-----	-----	0.825	MJ-B6-1801F*	MC-4B	MEN-46B-1801F
18-2-N to 18-3-N	-----	-----	-----	0.856	MJ-B6-1823F*	MC-4B	MEN-46B-1823F

*18-0-N through 18-3-N jaws are 3-inch minimum extension lengths.
**** Refer to Cx2s Tooling for complete STDN information

Table 2.3-59
Extension Callouts

Extension Callouts	E (Ref. Fig. 2.3-27) (inches)
4*	2.0
6	3.0

*Only available up to 16-3-N.

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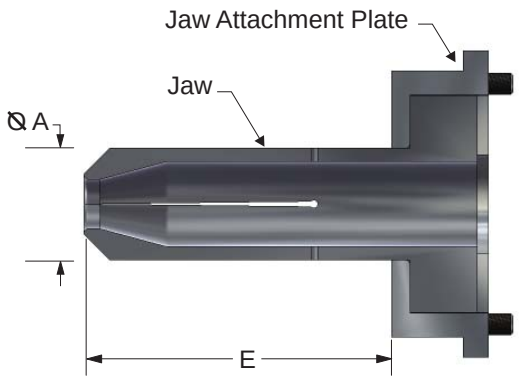

Figure 2.3-28
MBOA Modular Extension Nosecap

- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- For cold expanding holes in aluminum up to 15/16-inch diameter and up to 1/2-inch diameter in steel and titanium in restricted access areas.
- Assembly consists of a two-pieces: one-piece jaw and jaw attachment plate.
- Jaws and attachment plates can be ordered separately (see Table 2.3-61).
- Identification is provided by an electroetched model number.
- Other sizes are available. Please contact our Technical Sales Staff for information.

Table 2.3-60
Extension Callouts

Extension Callouts	E (Ref. Fig. 2.3-28) (inches)
4*	2.0
6	3.0

*Only available up to 16-3-N.

Cap

Model Number Key:

MC-5 A

- MC: Modular Cap
- 5: Puller Callout
- A: Thread: A = 5/8 inch, B = 7/8 inch, C = 1-1/8 inches, D = 1-3/8 inches

Nosecap Assembly*

Model Number Key:

MEN - 5 6 B - XXXXF

- MEN: Modular Extension Nosecap
- 5: Puller Callout
- 6: Length
- B: Thread: A = 5/8 inch, B = 7/8 inch, C = 1-1/8 inches, D = 1-1/4 inches
- XXXXF: Jaw Size

* Parts are not marked with assembly number. Each component is marked with its own model number.

Jaw

Model Number Key:

MJ - A 4 - XXXXF

- MJ: Modular Jaw
- A: Thread: A = 5/8 inch, B = 7/8 inch, C = 1-1/8 inches, D = 1-3/8 inches
- 4: Length: 4 = 2 inches, 6 = 3 inches
- XXXXF: Jaw Size

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Table 2.3-61
MBOA Modular Extension Nosecap Specifications

CB Tooling	CA Tooling	A Diameter (Ref. Fig. 2.3-28) (inch)	Jaw Model Number	Jaw Attachment Plate	Modular Assembly
10-0-N	50	0.565	MJ-B6-1001F	MC-5B	MEN-56B-1001F
10-1-N	51	0.565	MJ-B6-1001F	MC-5B	MEN-56B-1001F
10-2-N	52	0.593	MJ-B6-1023F	MC-5B	MEN-56B-1023F
10-3-N	53	0.593	MJ-B6-1023F	MC-5B	MEN-56B-1023F
12-0-N	60	0.625	MJ-B6-1201F	MC-5B	MEN-56B-1201F
12-1-N	61	0.625	MJ-B6-1201F	MC-5B	MEN-56B-1201F
12-2-N	62	0.657	MJ-B6-1223F	MC-5B	MEN-56B-1223F
12-3-N	63	0.657	MJ-B6-1223F	MC-5B	MEN-56B-1223F
14-0-N	70	0.689	MJ-B6-1401F	MC-5B	MEN-56B-1401F
14-1-N	71	0.689	MJ-B6-1401F	MC-5B	MEN-56B-1401F
14-2-N	72	0.718	MJ-B6-1423F	MC-5B	MEN-56B-1423F
14-3-N	73	0.718	MJ-B6-1423F	MC-5B	MEN-56B-1423F
16-0-N	80	0.760	MJ-B6-1601F	MC-5B	MEN-56B-1601F
16-1-N	81	0.760	MJ-B6-1601F	MC-5B	MEN-56B-1601F
16-2-N	82	0.792	MJ-B6-1623F	MC-5B	MEN-56B-1623F
16-3-N	83	0.792	MJ-B6-1623F	MC-5B	MEN-56B-1623F
18-0-N	90	0.825	MJ-B6-1801F	MC-5B	MEN-56B-1801F
18-1-N	91	0.825	MJ-B6-1801F	MC-5B	MEN-56B-1801F
18-2-N	92	0.856	MJ-B6-1823F	MC-5B	MEN-56B-1823F
18-3-N	93	0.856	MJ-B6-1823F	MC-5B	MEN-56B-1823F
20-0-N	100	0.882	MJ-B6-2001F	MC-5B	MEN-56B-2001F
20-1-N	101	0.882	MJ-B6-2001F	MC-5B	MEN-56B-2001F
20-2-N	102	0.916	MJ-C6-2023F	MC-5C	MEN-56C-2023F
20-3-N	103	0.916	MJ-C6-2023F	MC-5C	MEN-56C-2023F
22-0-N	110	0.946	MJ-C6-2201F	MC-5C	MEN-56C-2201F
22-1-N	111	0.946	MJ-C6-2201F	MC-5C	MEN-56C-2201F
22-2-N	-----	0.998	MJ-C6-2223F	MC-5C	MEN-56C-2223F
22-3-N	-----	0.998	MJ-C6-2223F	MC-5C	MEN-56C-2223F
24-0-N	-----	1.027	MJ-C6-2401F	MC-5C	MEN-56C-2401F
24-1-N	-----	1.027	MJ-C6-2401F	MC-5C	MEN-56C-2401F
24-2-N	-----	1.053	MJ-C6-2423F	MC-5C	MEN-56C-2423F
24-3-N	-----	1.053	MJ-C6-2423F	MC-5C	MEN-56C-2423F
26-0-N	-----	1.087	MJ-C6-2601F	MC-5C	MEN-56C-2601F
26-1-N	-----	1.087	MJ-C6-2601F	MC-5C	MEN-56C-2601F
26-2-N	-----	1.116	MJ-C6-2623F	MC-5C	MEN-56C-2623F
26-3-N	-----	1.116	MJ-C6-2623F	MC-5C	MEN-56C-2623F
28-0-N	-----	1.147	MJ-C6-2801F	MC-5C	MEN-56C-2801F
28-1-N	-----	1.147	MJ-C6-2801F	MC-5C	MEN-56C-2801F
28-2-N	-----	1.186	MJ-C6-2823F	MC-5C	MEN-56C-2823F
28-3-N	-----	1.186	MJ-C6-2823F	MC-5C	MEN-56C-2823F
30-0-N	-----	1.210	MJ-C6-3001F	MC-5C	MEN-56C-3001F
30-1-N	-----	1.210	MJ-C6-3001F	MC-5C	MEN-56C-3001F
30-2-N	-----	1.241	MJ-C6-3023F	MC-5D	MEN-56D-3023F
30-3-N	-----	1.241	MJ-C6-3023F	MC-5D	MEN-56D-3023F

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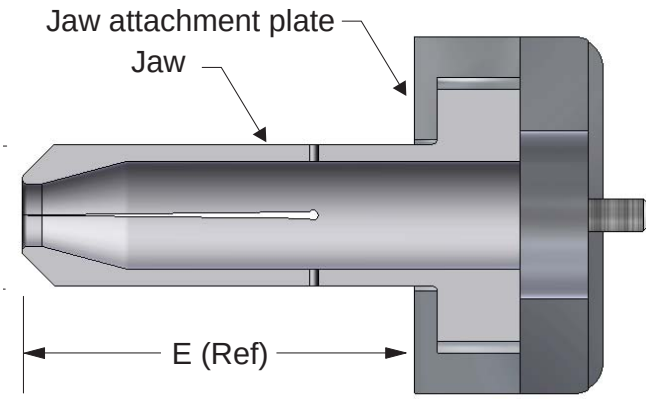

Figure 2.3-29
MBHO Modular Extension Nosecap

- Jaw is the same as standard MEN, thus they are interchangeable.
- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- For cold expanding holes in aluminum up to 15/16-inch diameter and up to 1/2-inch diameter in steel and titanium in restricted access areas.
- Assembly consists of a two-pieces: one-piece jaw and modular cap.
- Jaws and modular cap can be ordered separately (see Table 2.3-63).
- Identification is provided by an electroetched model number.
- Other sizes are available. Please contact our Technical Sales Staff for information.

Table 2.3-62
Extension Callouts

Extension Callouts	E (Ref. Fig. 2.3-29) (inches)
4*	2.0
6	3.0

*Only available up to 16-3-N.

Cap

Model Number Key:

MC-9 B

- MC: Modular Cap
- 9: Puller Callout
- B: Thread:
  - A = 5/8-inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-3/8-inches

Jaw

Model Number Key:

MJ - B 6 - XXXXF

- MJ: Modular Jaw
- B: Thread:
  - A = 5/8 inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-3/8 inches
- 6: Length
  - 4 = 2 inches
  - 6 = 3 inches
- XXXXF: Jaw Size

Nosecap Assembly*

Model Number Key:

MEN - 9 6 B - XXXXF

- MEN: Modular Extension Nosecap
- 9: Puller Callout
- 6: Length
- B: Thread
  - A = 5/8 inch
  - B = 7/8 inch
  - C = 1-1/8 inches
  - D = 1-1/4 inches
- XXXXF: Jaw Size

* Parts are not marked with assembly number. Each component is marked with it's own model number.

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Table 2.3-63
MBHO Modular Extension Nosecap Specifications

CB Tooling	CA Tooling	A Diameter (Ref. Fig. 2.3-29) (inch)	Jaw Model Number	Jaw Attachment Plate	Modular Assembly
10-0-N	50	0.565	MJ-B6-1001F	MC-9B	MEN-96B-1001F
10-1-N	51	0.565	MJ-B6-1001F	MC-9B	MEN-96B-1001F
10-2-N	52	0.593	MJ-B6-1023F	MC-9B	MEN-96B-1023F
10-3-N	53	0.593	MJ-B6-1023F	MC-9B	MEN-96B-1023F
12-0-N	60	0.625	MJ-B6-1201F	MC-9B	MEN-96B-1201F
12-1-N	61	0.625	MJ-B6-1201F	MC-9B	MEN-96B-1201F
12-2-N	62	0.657	MJ-B6-1223F	MC-9B	MEN-96B-1223F
12-3-N	63	0.657	MJ-B6-1223F	MC-9B	MEN-96B-1223F
14-0-N	70	0.689	MJ-B6-1401F	MC-9B	MEN-96B-1401F
14-1-N	71	0.689	MJ-B6-1401F	MC-9B	MEN-96B-1401F
14-2-N	72	0.718	MJ-B6-1423F	MC-9B	MEN-96B-1423F
14-3-N	73	0.718	MJ-B6-1423F	MC-9B	MEN-96B-1423F
16-0-N	80	0.760	MJ-B6-1601F	MC-9B	MEN-96B-1601F
16-1-N	81	0.760	MJ-B6-1601F	MC-9B	MEN-96B-1601F
16-2-N	82	0.792	MJ-B6-1623F	MC-9B	MEN-96B-1623F
16-3-N	83	0.792	MJ-B6-1623F	MC-9B	MEN-96B-1623F
18-0-N	90	0.825	MJ-B6-1801F	MC-9B	MEN-96B-1801F
18-1-N	91	0.825	MJ-B6-1801F	MC-9B	MEN-96B-1801F
18-2-N	92	0.856	MJ-B6-1823F	MC-9B	MEN-96B-1823F
18-3-N	93	0.856	MJ-B6-1823F	MC-9B	MEN-96B-1823F
20-0-N	100	0.892	MJ-B6-2001F	MC-9B	MEN-96B-2001F
20-1-N	101	0.892	MJ-B6-2001F	MC-9B	MEN-96B-2001F
20-2-N	102	0.916	MJ-C6-2023F	MC-9C	MEN-96B-2023F
20-3-N	103	0.916	MJ-C6-2023F	MC-9C	MEN-96B-2023F
22-0-N	110	0.946	MJ-C6-2201F	MC-9C	MEN-96B-2201F
22-1-N	111	0.946	MJ-C6-2201F	MC-9C	MEN-96B-2201F
22-2-N	-----	0.998	MJ-C6-2223F	MC-9C	MEN-96C-2223F
22-3-N	-----	0.998	MJ-C6-2223F	MC-9C	MEN-96C-2223F
24-0-N	-----	1.027	MJ-C6-2401F	MC-9C	MEN-96C-2401F
24-1-N	-----	1.027	MJ-C6-2401F	MC-9C	MEN-96C-2401F
24-2-N	-----	1.053	MJ-C6-2423F	MC-9C	MEN-96C-2423F
24-3-N	-----	1.053	MJ-C6-2423F	MC-9C	MEN-96C-2423F
26-0-N	-----	1.087	MJ-C6-2601F	MC-9C	MEN-96C-2601F
26-1-N	-----	1.087	MJ-C6-2601F	MC-9C	MEN-96C-2601F
26-2-N	-----	1.116	MJ-C6-2623F	MC-9C	MEN-96C-2623F
26-3-N	-----	1.116	MJ-C6-2623F	MC-9C	MEN-96C-2623F
28-0-N	-----	1.147	MJ-C6-2801F	MC-9C	MEN-96C-2801F
28-1-N	-----	1.147	MJ-C6-2801F	MC-9C	MEN-96C-2801F
28-2-N	-----	1.186	MJ-C6-2823F	MC-9C	MEN-96C-2823F
28-3-N	-----	1.186	MJ-C6-2823F	MC-9C	MEN-96C-2823F
30-0-N	-----	1.210	MJ-C6-3001F	MC-9C	MEN-96C-3001F
30-1-N	-----	1.210	MJ-C6-3001F	MC-9C	MEN-96C-3001F
30-2-N	-----	1.241	MJ-D6-3023F	MC-9D	MEN-96D-3023F
30-3-N	-----	1.241	MJ-D6-3023F	MC-9D	MEN-96D-3023F

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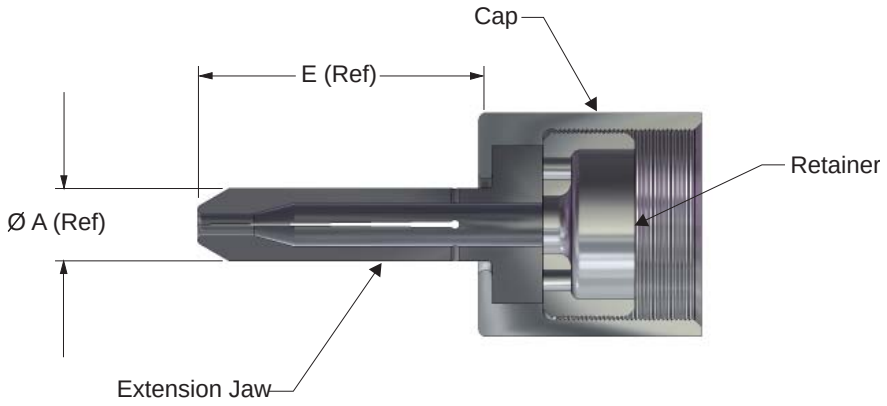

Figure 2.3-30
Little Brute Nosecap Assembly

- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- Can also be used when cold expanding holes through a drill fixture/drill bushing, or when an obstruction reduces access to the hole.
- Nosecap consists of a three-piece assembly including a cap, a one-piece jaw set that protrudes two inches from the front of the cap, and a retainer.
- Replacement jaws can be ordered separately.
- Identification is provided by an electroetched model number.
- Special extension lengths of other than two inches are available, please refer to Table 2.3-64.

Table 2.3-64
Extension Callouts

Extension Callouts	E (Ref. Fig. 2.3-30) (inches)
4	**2.0**
5	2.5
6	3.0

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SUPERSEDED BY MODULAR EXTENSION NOSECAP

Table 2.3-65
CB and KB2 Tooling

CB Tooling STDN Range	KB2 Tooling STDN Range	A Diameter (Ref. Fig. 2.3-30) (inch)	Assembly Model Number
4-0-N to 4-1-N	40-****-0 to 41-****-0	0.490	CBCE-14A-0401F
4-2-N to 4-3-N	42-****-0 to 43-****-0	0.490	CBCE-14A-0423F
6-2-N to 6-1-N	60-****-0 to 61-****-0	0.490	CBCE-14A-0601F
6-2-N to 6-3-N	62-****-0 to 63-****-0	0.490	CBCE-14A-0623F
8-0-N to 8-1-N	80-****-0 to 81-****-0	0.490	CBCE-14A-0801F
8-2-N to 8-3-N	82-****-0 to 83-****-0	0.490	CBCE-14A-0823F
10-0-N to 10-1-N	100-****-0 to 101-****-0	0.615	CBCE-14B-1001F
10-2-N to 10-3-N	102-****-0 to 103-****-0	0.615	CBCE-14B-1023F
12-0-N to 12-1-N	120-****-0 to 121-****-0	0.615	CBCE-14B-1201F
12-2-N to 12-3-N	122-****-0 to 123-****-0	0.615	CBCE-14B-1223F
14-0-N to 14-1-N	-----	0.741	CBCE-14C-1401F
14-2-N to 14-3-N	-----	0.741	CBCE-14C-1423F
16-0-N to 16-1-N	-----	0.741	CBCE-14C-1601F
16-2-N to 16-3-N	-----	0.741	CBCE-14C-1623F

**** Refer to Cx2s Tooling for complete STDN information.

Table 2.3-66
CA Tooling

STDN Range	A Diameter (Ref. Fig. 2.3-30) (inch)	Assembly Model Number
20 to 21	0.490	CBCE-14A-0401F
22 to 23	0.490	CBCE-14A-0423F
30 to 31	0.490	CBCE-14A-0601F
32 to 33	0.490	CBCE-14A-0623F
40 to 41	0.615	CBCE-14B-0801F
42 to 43	0.615	CBCE-14B-0823F
50 to 51	0.615	CBCE-14B-1001F
52 to 53	0.615	CBCE-14B-1023F

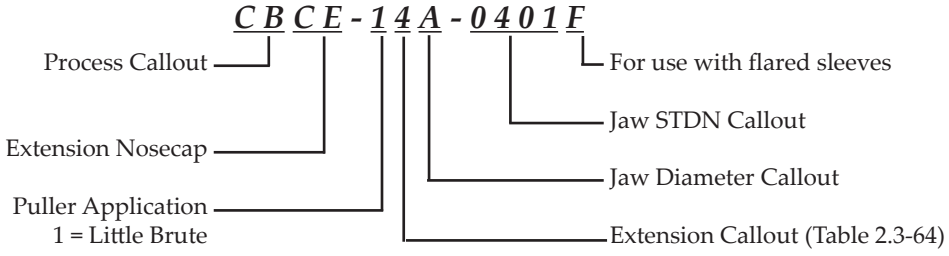
Note: When ordering replacement jaws, add -JO to the assembly model number.

Table 2.3-67
CR Tooling

STDN Range	A Diameter (Ref. Fig. 2.3-30) (inch)	Assembly Model Number
R30	0.490	CRCE-R30-1
R32	0.490	CRCE-R32-1
R40	0.490	CRCE-R40-1
R42	0.490	CRCE-R42-1
R50	0.615	CRCE-R50-1
R52	0.615	CRCE-R52-1
R60	0.615	CRCE-R60-1
R62	0.615	CRCE-R62-1

Note: CR nosecaps have a 2-inch extension callout.

Model Number Key:



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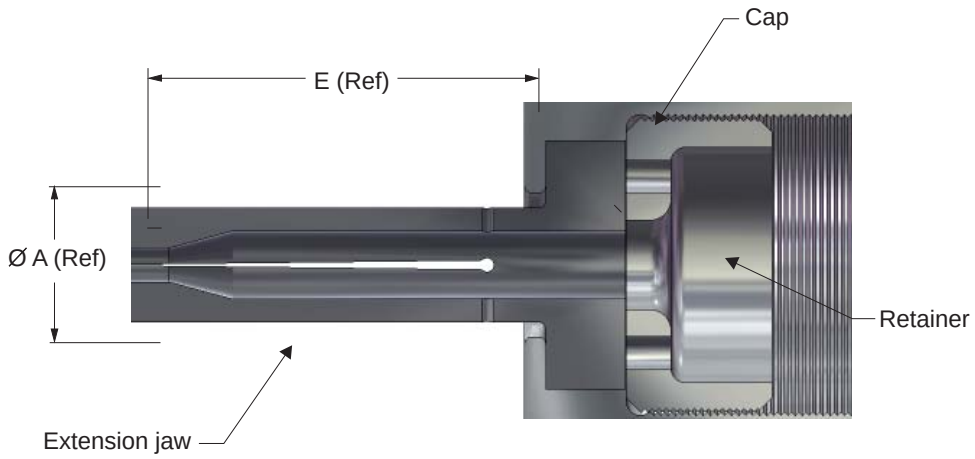

Figure 2.3-31
Medium Brute Extension Nosecap

- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- Can also be used when cold expanding holes through a drill fixture/drill bushing or when an obstruction is adjacent to the hole.
- Consists of a three-piece assembly including a cap, a one-piece jaw set that protrudes from the front of the cap, and a retainer.
- Identification is provided by an electroetched model number.
- Replacement jaws can be ordered separately.
- For other sizes and extension lengths, please contact our Technical Sales Staff.

Model Number Key:

C B C E - 2 6 D - 16 - 0 - N F

- Extension Nosecap
- Medium Brute
- Jaw Diameter Callout
- Extension Callout (Table 2.3-69)
- Jaw STDN Callout
- For use with flared sleeves

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2.3.29 MEDIUM BRUTE EXTENSION NOSECAPS

SUPERSEDED BY MODULAR EXTENSION NOSECAP

Table 2.3-68 Medium Brute Extension Nosecap

CB Tooling	CA Tool-ing	A Diameter (Ref. Fig. 2.3-31) (inches)	Assembly Model Number
10-3-N	60	0.865	CBCE-26D-10-3-NF
12-0-N	61	0.865	CBCE-26D-12-0-NF
12-1-N	62	0.865	CBCE-26D-12-1-NF
12-2-N	63	0.865	CBCE-26D-12-2-NF
12-3-N	70	0.865	CBCE-26D-12-3-NF
14-0-N	71	0.865	CBCE-26D-14-0-NF
14-1-N	72	0.865	CBCE-26D-14-1-NF
14-2-N	73	0.865	CBCE-26D-14-2-NF
14-3-N	80	0.865	CBCE-26D-14-3-NF
16-0-N	81	0.865	CBCE-26D-16-0-NF
16-1-N	82	0.865	CBCE-26D-16-1-NF
16-2-N	83	0.865	CBCE-26D-16-2-NF
16-3-N	90	0.865	CBCE-26D-16-3-NF
18-0-N	91	0.865	CBCE-26D-18-0-NF
18-1-N	92	0.865	CBCE-26D-18-1-NF
18-2-N	93	0.865	CBCE-26D-18-2-NF
18-3-N	100	0.865	CBCE-26D-18-3-NF
20-0-N	101	0.865	CBCE-26D-20-0-NF
20-1-N	102	0.865	CBCE-26D-20-1-NF
20-2-N	103	1.105	CBCE-26E-20-2-NF
20-3-N	110	1.105	CBCE-26E-20-3-NF
22-0-N	111	1.105	CBCE-26E-22-0-NF
22-1-N	-----	1.105	CBCE-26E-22-1-NF
22-2-N	-----	1.105	CBCE-26E-22-2-NF
22-3-N	-----	1.105	CBCE-26E-22-3-NF
24-0-N	-----	1.105	CBCE-26E-24-0-NF
24-1-N	-----	1.105	CBCE-26E-24-1-NF
24-2-N	-----	1.105	CBCE-26E-24-2-NF
24-3-N	-----	1.105	CBCE-26E-24-3-NF
26-0-N	-----	1.105	CBCE-26E-26-0-NF
26-1-N	-----	1.105	CBCE-26E-26-1-NF
26-2-N	-----	1.105	CBCE-26E-26-2-NF
26-3-N	-----	1.105	CBCE-26E-26-3-NF
28-0-N	-----	1.235	CBCE-26F-28-0-NF
28-1-N	-----	1.235	CBCE-26F-28-1-NF
28-2-N	-----	1.235	CBCE-26F-28-2-NF
28-3-N	-----	1.235	CBCE-26F-28-3-NF
30-0-N	-----	1.235	CBCE-26F-30-0-NF
30-1-N	-----	1.235	CBCE-26F-30-1-NF
30-2-N	-----	1.235	CBCE-26F-30-2-NF
30-3-N	-----	1.235	CBCE-26F-30-3-NF

Table 2.3-69 Extension Callouts

Extension Callouts	E (Ref. Fig. 2.3-31) (inches)
4*	2.0
5	2.5
6	3.0

* STDNs 20-2-N through 30-3-N are not available with an extension callout of "4."

Note: When ordering replacement jaws, add -JO to the assembly model number.

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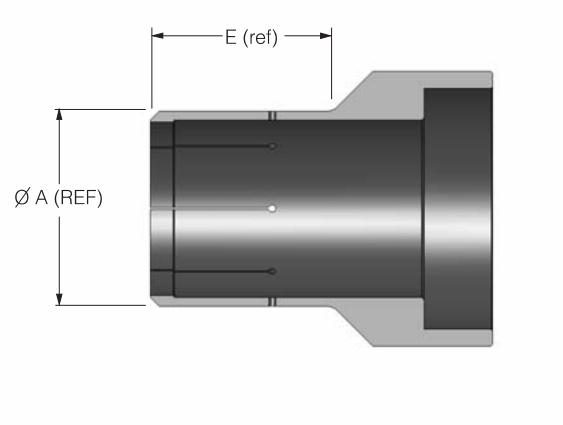

Figure 2.3-32
Big Brute Extension Nosecap

- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- Can also be used when cold expanding holes through a drill fixture/drill bushing or when an obstruction is adjacent to the hole.
- Unique one-piece design.
- Identification is provided by an electroetched model number.
- For use with flared sleeves only.
- Three-inch extension (E (Ref.) is standard).
- For other sizes and extension lengths, please contact our Technical Sales Staff.

Model Number Key:

C B C E - 3 801 F - 3 - 6

- C B C E — Extension Nosecap
- 3 801 — Jaw STDN Callout
- F — Designates Flared Sleeve
- 3 — Designates Big Brute Puller Unit
- 6 — Extension Callout: 6 = 3 inches

SUPERSEDED BY MODULAR EXTENSION NOSECAP

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SUPERSEDED BY
MODULAR EXTENSION NOSECAP

Table 2.3-70
Big Brute Extension Nosecap

CB Tooling STDN Range	A Diameter (Ref. Fig. 2.3-32) (inch)	Assembly Model Number
28-0-N to 28-1-N	1.205	CBCE-2801F-3-6
28-2-N to 28-3-N	1.216	CBCE-2823F-3-6
30-0-N to 30-1-N	1.275	CBCE-3001F-3-6
30-2-N to 30-3-N	1.302	CBCE-3023F-3-6
32-0-N to 32-1-N	1.336	CBCE-3201F-3-6
32-2-N to 32-3-N	1.369	CBCE-3223F-3-6
34-0-N to 34-1-N	1.395	CBCE-3401F-3-6
34-2-N to 34-3-N	1.423	CBCE-3423F-3-6
36-0-N to 36-1-N	1.451	CBCE-3601F-3-6
36-2-N to 36-3-N	1.483	CBCE-3623F-3-6
38-0-N to 38-1-N	1.505	CBCE-3801F-3-6
38-2-N to 38-3-N	1.546	CBCE-3823F-3-6
40-0-N to 40-1-N	1.581	CBCE-4001F-3-6
40-2-N to 40-3-N	1.611	CBCE-4023F-3-6
42-0-N to 42-1-N	1.640	CBCE-4201F-3-6
42-2-N to 42-3-N	1.669	CBCE-4223F-3-6
44-0-N to 44-1-N	1.700	CBCE-4401F-3-6
44-2-N to 44-3-N	1.732	CBCE-4423F-3-6
46-0-N to 46-1-N	1.757	CBCE-4601F-3-6
46-2-N to 46-3-N	1.785	CBCE-4623F-3-6
48-0-N to 48-1-N	1.814	CBCE-4801F-3-6
48-2-N to 48-3-N	1.846	CBCE-4823F-3-6
50-0-N to 50-1-N	1.885	CBCE-5001F-3-6
50-2-N to 50-3-N	1.912	CBCE-5023F-3-6
52-0-N to 52-1-N	1.955	CBCE-5201F-3-6
52-2-N to 52-3-N	1.978	CBCE-5223F-3-6
54-0-N to 54-1-N	2.014	CBCE-5401F-3-6
54-2-N to 54-3-N	2.045	CBCE-5423F-3-6
56-0-N to 56-1-N	2.076	CBCE-5601F-3-6
56-2-N to 56-3-N	2.108	CBCE-5623F-3-6

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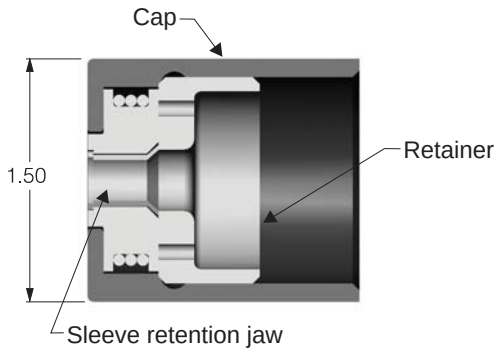

Figure 2.3-33
Flush Nosecap Assembly

- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- Consists of a three-part assembly including a cap, sleeve retention jaw set, and a retainer.
- Used where access restricts length of puller/nosecap assembly.
- Configurations are available for use with either flared or straight sleeves.
- Flared sleeve configuration is recommended for holes of 1/2-inch or smaller.
- Each nosecap or jaw size covers the nominal hole diameter and its associated oversizes.
- Replacement jaw sets can be ordered separately.
- Identification is provided by an electroetched model number.

Table 2.3-71
Little Brute Flush Nosecap Assemblies, CB, KB2, and CA Tooling

CB Tooling STDN Range	KB2 Tooling STDN Range	CA Tooling STDN Range	Assembly Model Number	Replacement Jaw Model Number
4-0-N to 4-4-N	40-****-0 to 43-****-0	20 to 30	CBC-11-04F	CBC-10-04F
4-4-N to 6-3-N	43-****-0 to 63-****-0	30 to 40	CBC-11-06F	CBC-10-06F
6-3-N to 8-3-N	63-****-0 to 83-****-0	40 to 50	CBC-11-08F	CBC-10-08F
8-3-N to 10-3-N	83-****-0 to 103-****-0	50 to 53	CBC-11-10F	CBC-10-10F
10-3-N to 12-3-N	103-****-0 to 123-****-0	-----	CBC-12-12F	CBC-10-12F
12-3-N to 14-3-N	123-****-0	-----	CBC-12-14F	CBC-10-14F
14-3-N to 16-3-N	-----	-----	CBC-13-16F	CBC-10-16F

Model Number Key:

C B C - 1 2 - 1 2 F

- Flush Nosecap
- Puller Unit: 1 = Little Brute, 2 = Medium Brute, 3 = Big Brute
- Cap Callout
- Jaw STDN Callout
- F = Flared Sleeves, S = Straight Sleeves

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2.3.32 Medium and Big Brute Flush Nosecap Assemblies

Table 2.3-72
Medium Brute Flush Nosecap Assemblies
CB and CA Tooling

CB Tooling STDN Range	CA Tooling STDN Range	Assembly Model Number	Replacement Jaw Model Number
10-3-N to 12-3-N	60 to 70	*CBC-22-12F	CBC-20-12F
14-0-N to 14-3-N	70 to 80	*CBC-22-14F	CBC-20-14F
16-0-N to 16-3-N	80 to 90	*CBC-23-16F	CBC-20-16F
18-0-N to 18-3-N	90 to 100	*CBC-23-18F	CBC-20-18F
20-0-N to 20-3-N	100 to 103	*CBC-23-20F	CBC-20-20F
22-0-N to 22-3-N	103 to 111	*CBC-24-22F	CBC-20-22F
24-0-N to 24-3-N	-----	*CBC-24-24F	CBC-20-24F
26-0-N to 26-3-N	-----	*CBC-24-26F	CBC-20-26F
28-0-N to 28-3-N	-----	*CBC-25-28F	CBC-20-28F
30-0-N to 30-3-N	-----	*CBC-25-30F	CBC-20-30F

* These nosecaps can cover one oversize smaller, e.g., CBC-38-0-N.

Figure 2.3-34
Medium/Big Brute Flush Nosecap

Table 2.3-73
Big Brute Flush Nosecap Assemblies CB Tooling

CB Tooling STDN Range	Assembly Model Number	Replacement Jaw Model Number
30-0-N to 30-3-N	CBC-31-30S	CBC-30-30S
32-0-N to 32-3-N	CBC-31-32S	CBC-30-32S
34-0-N to 34-3-N	CBC-31-34S	CBC-30-34S
36-0-N to 36-3-N	CBC-31-36S	CBC-30-36S
38-0-N to 38-3-N	*CBC-31-38S	CBC-30-38S
40-0-N to 40-3-N	*CBC-31-40S	CBC-30-40S
42-0-N to 42-3-N	*CBC-32-42S	CBC-30-42S
44-0-N to 44-3-N	*CBC-32-44S	CBC-30-44S
46-0-N to 46-3-N	*CBC-32-46S	CBC-30-46S
48-0-N to 48-3-N	*CBC-32-48S	CBC-30-48S
50-0-N to 50-3-N	*CBC-33-50S	CBC-30-50S
52-0-N to 52-3-N	*CBC-33-52S	CBC-30-52S
54-0-N to 54-3-N	*CBC-33-54S	CBC-30-54S
56-0-N to 56-3-N	*CBC-33-56S	CBC-30-56S
58-0-N to 58-3-N	*CBC-34-58S	CBC-30-58S
60-0-N to 60-3-N	*CBC-34-60S	CBC-30-60S
62-0-N to 62-3-N	*CBC-34-62S	CBC-30-62S
64-0-N to 64-3-N	*CBC-35-64S	CBC-30-64S
66-0-N to 66-3-N	*CBC-35-66S	CBC-30-66S
68-0-N to 68-3-N	*CBC-35-68S	CBC-30-68S
70-0-n to 70-3-N	*CBC-35-70S	CBC-30-70S

* These nosecaps can cover one oversize smaller, e.g., STDN 36-3-N can be used with CBC-31-38S.

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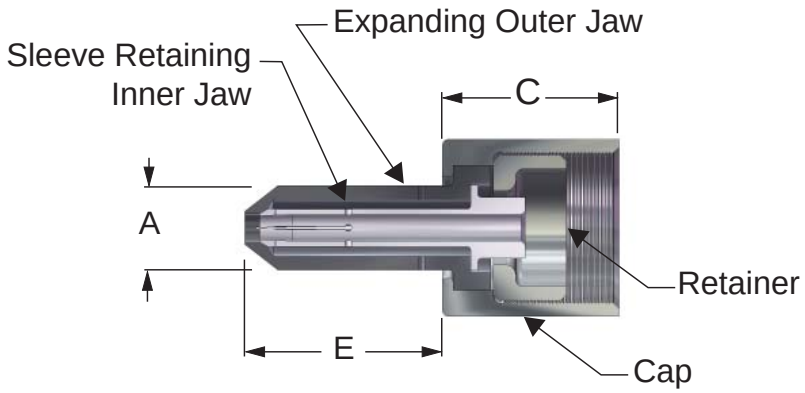

Figure 2.3-35
Little Brute CsCx Nosecap Assembly

- The FTI patented countersink nosecap assemblies permit the simultaneous cold expansion of the straight and countersunk portions of pre-countersunk holes.
- Designed to hold the split sleeve in the hole during puller operation and to concurrently transfer the reactive forces from the puller into the countersink portion of the workpiece.
- Used for cold expansion of 3/16 through 27/64 inch 100-degree countersunk holes in aluminum alloys, using Little Brute Puller (Tables 2.3-75 and 2.3-76).
- Multi-material stackups may be cold expanded using the CsCx nosecap assembly provided the countersink portion of the hole is in the aluminum part of the stackup.
- Consists of a four-part assembly including cap, retainer, sleeve retention (inner) jaw, and expanding (outer) jaw which extends 1-5/8 inches from the face of the cap for the Little Brute Puller (Figure 2.3-35).
- Replacement inner and outer jaws are available. Please contact our Technical Sales department for more information.

Table 2.3-74
Little Brute/Medium Brute
CsCx Nosecap Assembly

Puller Unit	Ref. A Jaw Diameter	Ref. C Cap Length	Ref. E Jaw Length
Little Brute	0.71	1.50	1.69
Medium Brute	1.23	2.37	1.89

Model Number Key:

K B C - 0 6 3 - 1A

CsCx Nosecap Assembly

Size Code

1A = Little Brute 100° Countersink Callout

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2.3.34 Medium Brute Countersink Nosecap Assemblies

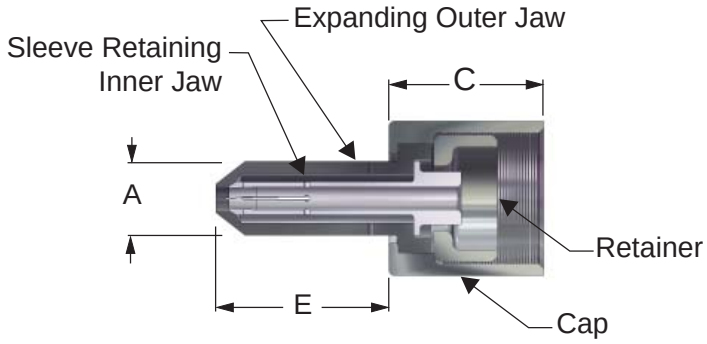

Figure 2.3-36
Medium Brute CsCx Nosecap Assembly

- The FTI patented countersink nosecap assemblies permit the simultaneous cold expansion of the straight and countersunk portions of pre-countersunk holes.
- Designed to hold the split sleeve in the hole during puller operation and to concurrently transfer the reactive forces from the puller into the countersink portion of the workpiece.
- Used for cold expansion of 3/16 through 27/64-inch 100-degree countersunk holes in aluminum alloys, using Medium Brute Puller (Table 2.3-77).
- Multi-material stackups may be cold expanded using the CsCx nosecap assembly provided the countersink portion of the hole is in the aluminum part of the stackup.
- Consists of a four-part assembly including cap, retainer, sleeve retention (inner) jaw, and expanding (outer) jaw that extends 1-5/8 inches from the face of the cap for the Medium Brute Puller (Figure 2.3-36).
- Replacement inner and outer jaws are available, please contact our Technical Sales department for more information.

**** Refer to Cx2s Tooling for complete STDN information.

Table 2.3-75 Countersink Nosecap Assembly KB and KB2 Tooling For Use with Little Brute

KB Tooling	KB2 Tooling	Assembly Model Number
4-0-N	-----	KBC-040-1A
4-1-N	-----	KBC-041-1A
4-2-N	-----	KBC-042-1A
4-3-N	-----	KBC-043-1A
4-4-N	-----	KBC-044-1A
6-0-N	60-****-0	KBC-060-1A
6-1-N	61-****-0	KBC-061-1A
6-2-N	62-****-0	KBC-062-1A
6-3-N	63-****-0	KBC-063-1A
8-0-N	80-****-0	KBC-080-1A
8-1-N	81-****-0	KBC-081-1A
8-2-N	82-****-0	KBC-082-1A
8-3-N	83-****-0	KBC-083-1A
10-0-N	100-****-0	KBC-100-1A
10-1-N	101-****-0	KBC-101-1A
10-2-N	102-****-0	KBC-102-1A
10-3-N	103-****-0	KBC-103-1A
12-0-N	120-****-0	KBC-120-1A
12-1-N	121-****-0	KBC-121-1A
12-2-N	122-****-0	KBC-122-1A
12-3-N	123-****-0	KBC-123-1A

**** Refer to Cx2s tooling for complete STDN information.

Table 2.3.76 LB CsCx Nosecap Assemblies for CR Tooling

CR Tooling	Assembly Model Number
R30	KRC-R30-1A
R32	KRC-R32-1A
R40	KRC-R40-1A
R42	KRC-R42-1A
R50	KRC-R50-1A
R52	KRC-R52-1A
R60	KRC-R60-1A
R62	KRC-R62-1A

Table 2.3.77 MB CsCx Nosecap Assemblies for CB Tooling

CR Tooling	Assembly Model Number
14-0-N	KBC-140-2A
14-1-N	KBC-141-2A
14-2-N	KBC-142-2A
14-3-N	KBC-143-2A
16-0-N	KBC-160-2A
16-1-N	KBC-161-2A
16-2-N	KBC-162-2A
16-3-N	KBC-163-2A
18-0-N	KBC-180-2A
18-1-N	KBC-181-2A
18-2-N	KBC-182-2A
18-3-N	KBC-183-2A
20-0-N	KBC-200-2A
20-1-N	KBC-201-2A
20-2-N	KBC-202-2A
20-3-N	KBC-203-2A

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2.3.36 OFFSET ADAPTER FLUSH NOSECAPS

Figure 2.3-37
LBOA and HOA Offset Adapter Flush Nosecaps

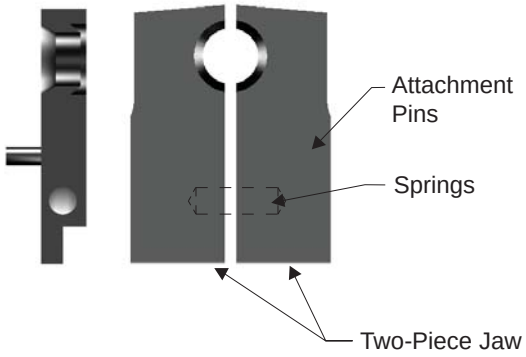


Figure 2.3-38
MBOA Flush Nosecaps

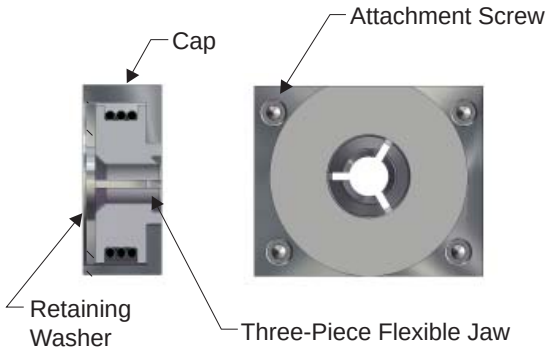
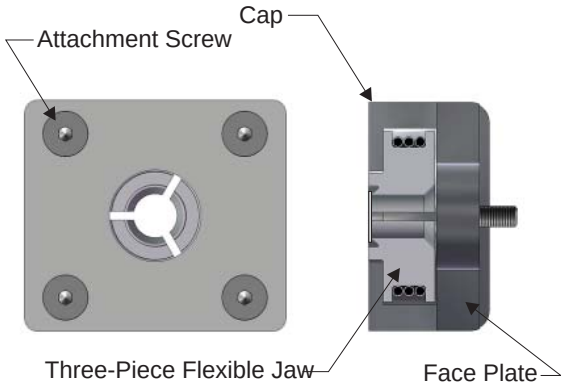


Figure 2.3-39
MBHO Flush Nosecaps



- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece in restricted access areas.
- The LBOA and the HOA nosecaps consist of a two-part set which is spring loaded against the minor diameter of the mandrel.
- The LBOA and HOA jaws use flared sleeves.
- The MBOA and MBHO nosecaps use both flared and straight sleeves. See Table 2.3-80.
- Identification is provided by an electroetched model number.
- For other sizes, please contact our Technical Sales Staff.

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Table 2.3-78
LBOA and HOA Flush Nosecaps

CB Tooling	KB2 Tooling	CA Tooling	Jaw Model Number
4-0-N to 4-1-N	40-****-0 to 41-****-0	20 to 21	CBC-40-0401F
4-2-N to 4-3-N	42-****-0 to 43-****-0	22 to 23	CBC-40-0423F
4-4-N to 6-1-N	60-****-0 to 61-****-0	30 to 32	CBC-40-0601F
6-2-N to 6-3-N	62-****-0 to 63-****-0	32 to 40	CBC-40-0623F
6-3-N to 8-1-N	80-****-0 to 81-****-0	40 to 42	CBC-40-0801F
8-2-N to 8-3-N	82-****-0 to 83-****-0	**42 to 50**	CBC-40-0823F
8-3-N to 10-1-N	100-****-0 to 101-****-0	50 to 52	CBC-40-1001F
10-2-N to 10-3-N	102-****-0 to 103-****-0	52 to 53	CBC-40-1023F
10-3-N to 12-1-N	120-****-0 to 121-****-0	-----	CBC-40-1201F
12-2-N to 12-3-N	**122-****-0 to 123-****-0**	-----	CBC-40-1223F
12-3-N to 14-1-N	-----	-----	CBC-40-1401F
14-2-N to 14-3-N	-----	-----	CBC-40-1423F
14-3-N to 16-1-N	-----	-----	CBC-40-1601F
16-2-N to 16-3-N	-----	-----	CBC-40-1623F

**** Refer to Cx2s Tooling for complete STDN information.
Note: Bold STDN notes highest allowable HOA Standard Tool Diameter Number.

Table 2.3-79
CR Tooling-LBOA Flush Nosecaps

STDN	Nosecap Model Number	STDN	Nosecap Model Number
R30	CRC-R30-1	R50	CRC-R50-1
R32	CRC-R32-1	R52	CRC-R52-1
R40	CRC-R40-1	R60	CRC-R60-1
R42	CRC-R42-1	R62	CRC-R62-1

Table 2.3-80
MBOA and MBHO Flush Nosecaps

CB Tooling	CA Tooling	*MBOA Flush Nosecap Model Number	*MBHO Flush Nosecap Model Number	*Replacement Jaw Model Number
12-0-N to12-3-N	60 to 70	CBC-52-12F	CBC-92-12F	CBC-20-12F
14-0-N to 14-3-N	70 to 80	CBC-52-14F	CBC-92-14F	CBC-20-14F
16-0-N to 16-3-N	80 to 90	CBC-53-16F	CBC-93-16F	CBC-20-16F
18-0-N to 18-3-N	90 to 100	CBC-53-18F	CBC-93-18F	CBC-20-18F
20-0-N to 20-3-N	100 to 103	CBC-53-20F	CBC-93-20F	CBC-20-20F
22-0-N to 22-3-N	103 to 111	CBC-54-22F	CBC-94-22F	CBC-20-22F
24-0-N to 24-3-N	-----	CBC-54-24F	CBC-94-24F	CBC-20-24F
26-0-N to 26-3-N	-----	CBC-54-26F	CBC-94-26F	CBC-20-26F
28-0-N to 28-3-N	-----	CBC-55-28F	CBC-95-28F	CBC-20-28F
30-0-N to 30-3-N	-----	CBC-55-30F	CBC-95-30F	CBC-20-30F
32-0-N to 32-3-N	-----	CBC-55-32F	CBC-95-32F	CBC-20-32F
34-0-N to 34-3-N	-----	CBC-55-34F	CBC-95-34F	CBC-20-34F
36-0-N to36-3-N	-----	CBC-55-36F	CBC-95-36F	CBC-20-36F

* Will work with either flared or straight sleeves.

Detailed Tooling
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2.3.37 LITTLE BRUTE OFFSET ADAPTER EXTENSION NOSECAPS

SUPERSEDED BY MODULAR EXTENSION NOSECAP

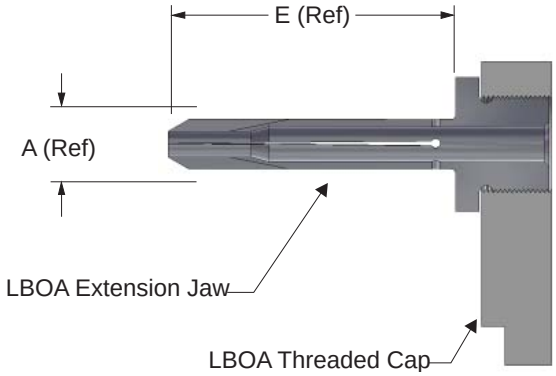

Figure 2.3-40
LBOA Extension Nosecap

- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- Consists of a two-piece assembly including a cap and a one-piece jaw set that extends two inches from the jaw flange.
- Replacement modular jaw sets can be ordered separately. See page 84.
- Other characteristics are similar to standard extension nosecaps.
- Flared sleeves are required.
- Identification is provided by an electroetched model number.
- Other sizes are available (E ref. Figure 2.3-40). Please contact our Technical Sales Staff.

Model Number Key:

C B C E - 4 4 A - 0 8 0 1 F

- C B C E — Extension Nosecap
- 4 — Puller Application: 4 = LBOA or HOA
- 4 — Extension Callout (Table 2.3-82)
- A — Diameter Callout
- 0 8 — Jaw Size Code
- 0 1 — For use with flared sleeves
- F — For use with flared sleeves

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Table 2.3-81
STDN Range

CB Tooling	KB2 Tooling	CA Tooling	A (Ref. Fig. 2.3-40) (inch)	Jaw Model Number
4-0-N to 4-1-N	40-****-0 to 41-****-0	20 to 21	0.49	CBCE-44A-0423F
4-2-N to 4-3-N	42-****-0 to 43-****-0	22 to 23	0.49	CBCE-44A-0423F
4-4-N to 6-1-N	60-****-0 to 61-****-0	30 to 32	0.49	CBCE-44A-0601F
6-2-N to 6-3-N	62-****-0 to 63-****-0	32 to 33	0.49	CBCE-44A-0623F
8-0-N to 8-1-N	80-****-0 to 81-****-0	40 to 41	0.49	CBCE-44A-0801F
8-2-N to 8-3-N	82-****-0 to 83-****-0	42 to 43	0.49	CBCE-44A-0823F
10-0-N to 10-1-N	100-****-0 to 101-****-0	50 to 51	0.61	CBCE-44B-1001F
10-2-N to 10-3-N	102-****-0 to 103-****-0	52 to 53	0.61	CBCE-44B-1023F
12-0-N to 12-1-N	120-****-0 to 121-****-0	-----	0.61	CBCE-44B-1201F
12-2-N to 12-3-N	122-****-0 to 123-****-0	-----	0.61	CBCE-44B-1223F
14-0-N to 14-1-N	-----	-----	0.74	CBCE-44C-1401F
14-2-N to 14-3-N	-----	-----	0.74	CBCE-44C-1423F
16-0-N to 16-1-N	-----	-----	0.74	CBCE-44C-1601F
16-2-N to 16-3-N	-----	-----	0.74	CBCE-44C-1623F

Table 2.3-82
Extension Callouts

Extension Callouts	E (Ref. Fig. 2.3-40) (inch)
4	2.0
5	2.5
6	3.0

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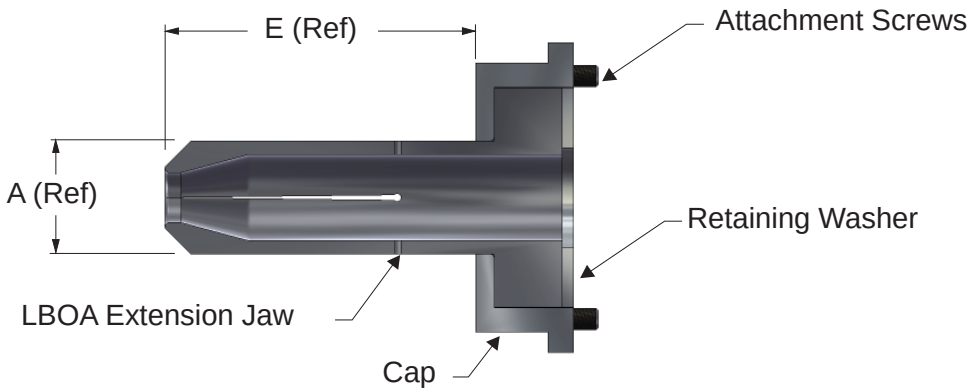

Figure 2.3-41
MBOA Extension Nosecap

- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- For cold expanding holes in aluminum up to 15/16-inch diameter and up to 1/2-inch diameter in steel and titanium in restricted access areas.
- Consist of a three-piece assembly including a cap, a one-piece jaw set that extends from the front of the cap, and a retaining washer to hold the jaw in place.
- Replacement jaws can be ordered separately (see Table 2.3-84).
- Identification is provided by an electroetched model number.
- Other sizes are available. Please contact our Technical Sales Staff for information.

Table 2.3-83
Extension Callout

Extension Callouts	E (Ref. Fig. 2.3-41) (inch)
4	2.0
6	3.0
9	4.5

* STDNs 20-2-N through 30-3-N are not available with a callout of "4."

Model Number Key:

C B C E - 5 6 D - 1 4 - 1 - N F

- Process Callout (CB only)
- Extension Nosecap
- Puller Application 5 = MBOA
- Extension Callout (Table 2.3-83)
- Diameter Callout A (Ref. Fig. 2.3-41)
- Standard Tool Diameter Number (STDN)
- For use with flared sleeves

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SUPERSEDED BY MODULAR EXTENSION NOSECAP

Table 2.3-84
MBOA Extension Nosecap Specifications

CB Tooling	CA Tooling	A Diameter (Ref. Fig. 2.3-41) (inch)	Assembly Model Number	Replacement Jaw Model Number
10-3-N	60	0.86	CBCE-56D-10-3-NF	CBCE-26D-10-3-NF-JO
12-0-N	61	0.86	CBCE-56D-12-0-NF	CBCE-26D-12-0-NF-JO
12-1-N	62	0.86	CBCE-56D-12-1-NF	CBCE-26D-12-1-NF-JO
12-2-N	63	0.86	CBCE-56D-12-2-NF	CBCE-26D-12-2-NF-JO
12-3-N	70	0.86	CBCE-56D-12-3-NF	CBCE-26D-12-3-NF-JO
14-0-N	71	0.86	CBCE-56D-14-0-NF	CBCE-26D-14-0-NF-JO
14-1-N	72	0.86	CBCE-56D-14-1-NF	CBCE-26D-14-1-NF-JO
14-2-N	73	0.86	CBCE-56D-14-2-NF	CBCE-26D-14-2-NF-JO
14-3-N	80	0.86	CBCE-56D-14-3-NF	CBCE-26D-14-3-NF-JO
16-0-N	81	0.86	CBCE-56D-16-0-NF	CBCE-26D-16-0-NF-JO
16-1-N	82	0.86	CBCE-56D-16-1-NF	CBCE-26D-16-1-NF-JO
16-2-N	83	0.86	CBCE-56D-16-2-NF	CBCE-26D-16-2-NF-JO
16-3-N	90	0.86	CBCE-56D-16-3-NF	CBCE-26D-16-3-NF-JO
18-0-N	91	0.86	CBCE-56D-18-0-NF	CBCE-26D-18-0-NF-JO
18-1-N	92	0.86	CBCE-56D-18-1-NF	CBCE-26D-18-1-NF-JO
18-2-N	93	0.86	CBCE-56D-18-2-NF	CBCE-26D-18-2-NF-JO
18-3-N	100	0.86	CBCE-56D-18-3-NF	CBCE-26D-18-3-NF-JO
20-0-N	101	0.86	CBCE-56D-20-0-NF	CBCE-26D-20-0-NF-JO
20-1-N	102	0.86	CBCE-56D-20-1-NF	CBCE-26D-20-1-NF-JO
20-2-N	103	1.10	CBCE-56E-20-2-NF	CBCE-26E-20-2-NF-JO
20-3-N	110	1.10	CBCE-56E-20-3-NF	CBCE-26E-20-3-NF-JO
22-0-N	111	1.10	CBCE-56E-22-0-NF	CBCE-26E-22-0-NF-JO
22-1-N	-----	1.10	CBCE-56E-22-1-NF	CBCE-26E-22-1-NF-JO
22-2-N	-----	1.10	CBCE-56E-22-2-NF	CBCE-26E-22-2-NF-JO
22-3-N	-----	1.10	CBCE-56E-22-3-NF	CBCE-26E-22-3-NF-JO
24-0-N	-----	1.10	CBCE-56E-24-0-NF	CBCE-26E-24-0-NF-JO
24-1-N	-----	1.10	CBCE-56E-24-1-NF	CBCE-26E-24-1-NF-JO
24-2-N	-----	1.10	CBCE-56E-24-2-NF	CBCE-26E-24-2-NF-JO
24-3-N	-----	1.10	CBCE-56E-24-3-NF	CBCE-26E-24-3-NF-JO
26-0-N	-----	1.10	CBCE-56E-26-0-NF	CBCE-26E-26-0-NF-JO
26-1-N	-----	1.10	CBCE-56E-26-1-NF	CBCE-26E-26-1-NF-JO
26-2-N	-----	1.10	CBCE-56E-26-2-NF	CBCE-26E-26-2-NF-JO
26-3-N	-----	1.10	CBCE-56E-26-3-NF	CBCE-26E-26-3-NF-JO
28-0-N	-----	1.10	CBCE-56E-28-0-NF	CBCE-26E-28-0-NF-JO
28-1-N	-----	1.23	CBCE-56F-28-1-NF	CBCE-26F-28-1-NF-JO
28-2-N	-----	1.23	CBCE-56F-28-2-NF	CBCE-26F-28-2-NF-JO
28-3-N	-----	1.23	CBCE-56F-28-3-NF	CBCE-26F-28-3-NF-JO
30-0-N	-----	1.23	CBCE-56F-30-0-NF	CBCE-26F-30-0-NF-JO
30-1-N	-----	1.23	CBCE-56F-30-1-NF	CBCE-26F-30-1-NF-JO
30-2-N	-----	1.23	CBCE-56F-30-2-NF	CBCE-26F-30-2-NF-JO
30-3-N	-----	1.23	CBCE-56F-30-3-NF	CBCE-26F-30-3-NF-JO

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SUPERSEDED BY MODULAR EXTENSION NOSECAP

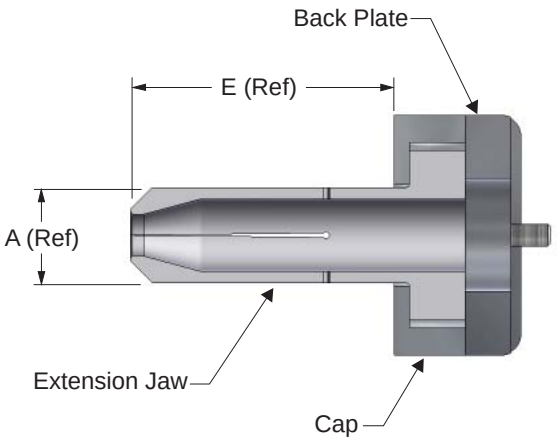

Figure 2.3-42
MBHO Extension Nosecap

- Designed to hold the split sleeve in the hole during puller operation and to transfer the reactive forces from the puller to the workpiece.
- Capable of cold expanding holes in aluminum and mild steel up to 15/16-inch diameter and up to 1/2-inch diameter in steel and titanium in restricted access areas.
- Consist of a three-piece assembly including a cap, a one-piece jaw that extends from the front of the cap, and a back plate that holds the jaw to the puller unit.
- Replacement jaws can be ordered separately (see Table 2.3-84).
- Identification is provided by an electroetched model number.
- Other sizes are available. Please contact our Technical Sales Staff for information.

Table 2.3-85
Extension Callout

Extension Callouts	E (Ref. Fig. 2.3-42) (inch)
*4	2.0
6	3.0
9	4.5

* STDNs 20-2-N through 30-3-N are not avaiable with a callout of "4."

Model Number Key:

C B C E - 9 6 D - 14 - 0 - N F

- Extension Nosecap
- Puller Application 9 = MBHO
- Extension Callout (Table 2.3-84)
- Diameter Callout A (Ref. Fig. 2.3-42) D = 0.820 inch E = 1.100 inches F = 1.230 inches
- Standard Tool Diameter Number (STDN)
- For use w/flared sleeves

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SUPERSEDED BY MODULAR EXTENSION NOSECAP

Table 2.3-86
STDN Range

CB Tooling	CA Tooling	A Diameter (Ref. Fig. 2.3-42) (inch)	Assembly Model Number	Replacement Jaw Model Number
10-3-N	60	0.86	CBCE-96D-10-3-NF	CBCE-26D-10-3-NF-JO
12-0-N	61	0.86	CBCE-96D-12-0-NF	CBCE-26D-12-0-NF-JO
12-1-N	62	0.86	CBCE-96D-12-1-NF	CBCE-26D-12-1-NF-JO
12-2-N	63	0.86	CBCE-96D-12-2-NF	CBCE-26D-12-2-NF-JO
12-3-N	70	0.86	CBCE-96D-12-3-NF	CBCE-26D-12-3-NF-JO
14-0-N	71	0.86	CBCE-96D-14-0-NF	CBCE-26D-14-0-NF-JO
14-1-N	72	0.86	CBCE-96D-14-1-NF	CBCE-26D-14-1-NF-JO
14-2-N	73	0.86	CBCE-96D-14-2-NF	CBCE-26D-14-2-NF-JO
14-3-N	80	0.86	CBCE-96D-14-3-NF	CBCE-26D-14-3-NF-JO
16-0-N	81	0.86	CBCE-96D-16-0-NF	CBCE-26D-16-0-NF-JO
16-1-N	82	0.86	CBCE-96D-16-1-NF	CBCE-26D-16-1-NF-JO
16-2-N	83	0.86	CBCE-96D-16-2-NF	CBCE-26D-16-2-NF-JO
16-3-N	90	0.86	CBCE-96D-16-3-NF	CBCE-26D-16-3-NF-JO
18-0-N	91	0.86	CBCE-96D-18-0-NF	CBCE-26D-18-0-NF-JO
18-1-N	92	0.86	CBCE-96D-18-1-NF	CBCE-26D-18-1-NF-JO
18-2-N	93	0.86	CBCE-96D-18-2-NF	CBCE-26D-18-2-NF-JO
18-3-N	100	0.86	CBCE-96D-18-3-NF	CBCE-26D-18-3-NF-JO
20-0-N	101	0.86	CBCE-96D-20-0-NF	CBCE-26D-20-0-NF-JO
20-1-N	102	0.86	CBCE-96D-20-1-NF	CBCE-26D-20-1-NF-JO
20-2-N	103	1.10	CBCE-96E-20-2-NF	CBCE-26E-20-2-NF-JO
20-3-N	110	1.10	CBCE-96E-20-3-NF	CBCE-26E-20-3-NF-JO
22-0-N	111	1.10	CBCE-96E-22-0-NF	CBCE-26E-22-0-NF-JO
22-1-N	-----	1.10	CBCE-96E-22-1-NF	CBCE-26E-22-1-NF-JO
22-2-N	-----	1.10	CBCE-96E-22-2-NF	CBCE-26E-22-2-NF-JO
22-3-N	-----	1.10	CBCE-96E-22-3-NF	CBCE-26E-22-3-NF-JO
24-0-N	-----	1.10	CBCE-96E-24-0-NF	CBCE-26E-24-0-NF-JO
24-1-N	-----	1.10	CBCE-96E-24-1-NF	CBCE-26E-24-1-NF-JO
24-2-N	-----	1.10	CBCE-96E-24-2-NF	CBCE-26E-24-2-NF-JO
24-3-N	-----	1.10	CBCE-96E-24-3-NF	CBCE-26E-24-3-NF-JO
26-0-N	-----	1.10	CBCE-96E-26-0-NF	CBCE-26E-26-0-NF-JO
26-1-N	-----	1.10	CBCE-96E-26-1-NF	CBCE-26E-26-1-NF-JO
26-2-N	-----	1.10	CBCE-96E-26-2-NF	CBCE-26E-26-2-NF-JO
26-3-N	-----	1.10	CBCE-96E-26-3-NF	CBCE-26E-26-3-NF-JO
28-0-N	-----	1.10	CBCE-96E-28-0-NF	CBCE-26E-28-0-NF-JO
28-1-N	-----	1.23	CBCE-96F-28-1-NF	CBCE-26F-28-1-NF-JO
28-2-N	-----	1.23	CBCE-96F-28-2-NF	CBCE-26F-28-2-NF-JO
28-3-N	-----	1.23	CBCE-96F-28-3-NF	CBCE-26F-28-3-NF-JO
30-0-N	-----	1.23	CBCE-96F-30-0-NF	CBCE-26F-30-0-NF-JO
30-1-N	-----	1.23	CBCE-96F-30-1-NF	CBCE-26F-30-1-NF-JO
30-2-N	-----	1.23	CBCE-96F-30-2-NF	CBCE-26F-30-2-NF-JO
30-3-N	-----	1.23	CBCE-96F-30-3-NF	CBCE-26F-30-3-NF-JO

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2.3.40 Right-Angle Puller Nosecap

SUPERSEDED BY MODULAR EXTENSION NOSECAP

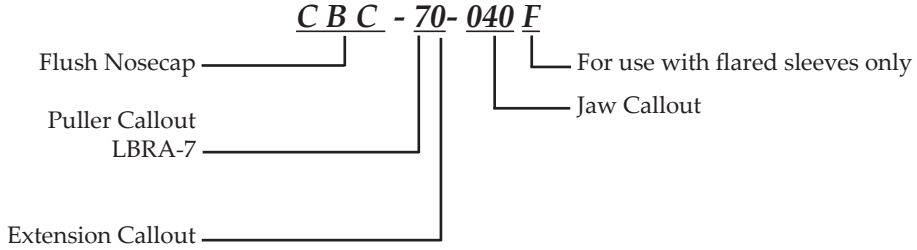
Figure 2.3-43
Right-Angle Puller Nosecap

- For cold expansion of holes with access restrictions such as drain holes, holes in pockets, and other areas with limited front-side access.
- Capable of cold expanding up to 3/8-inch diameter holes in aluminum and 1/4-inch diameter holes in steel or titanium. Stackup capability of up to 0.8 inch, depending on material.
- Can be used for all FTI processes.

Table 2.3-87
Right Angle Puller Nosecap Selection

STDN	Nosecap Model Number
4-0-N	CBC-70-040F
4-1-N	CBC-70-041F
4-2-N	CBC-70-042F
4-3-N	CBC-70-043F
4-4-N	CBC-70-044F
6-0-N	CBC-70-060F
6-1-N	CBC-70-061F
6-2-N	CBC-70-062F
6-3-N	CBC-70-063F
8-0-N	CBC-70-080F
8-1-N	CBC-70-081F
8-2-N	CBC-70-082F
8-3-N	CBC-70-083F
10-0-N	CBC-70-100F
10-1-N	CBC-70-101F
10-2-N	CBC-70-102F
10-3-N	CBC-70-103F
12-0-N	CBC-70-120F
12-1-N	CBC-70-121F
12-2-N	CBC-70-122F
12-3-N	CBC-70-123F

Model Number Key:



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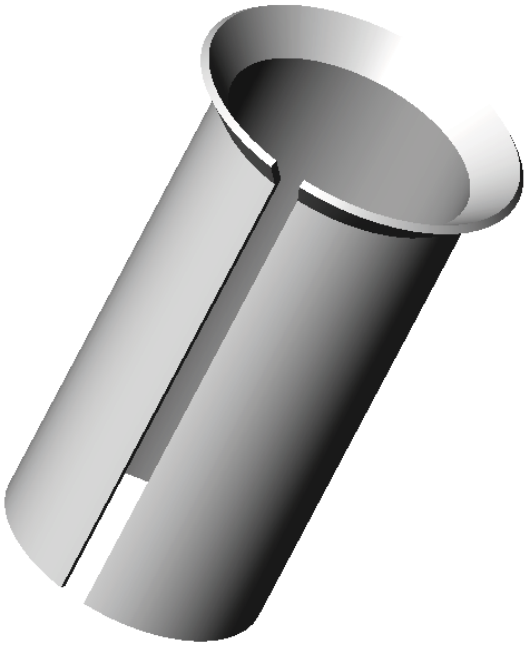
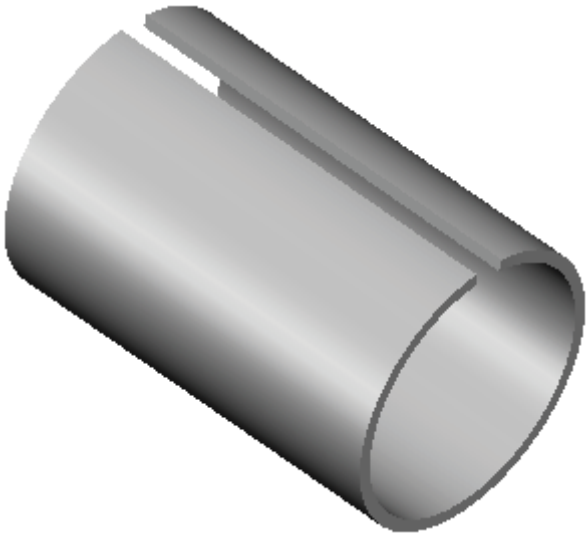
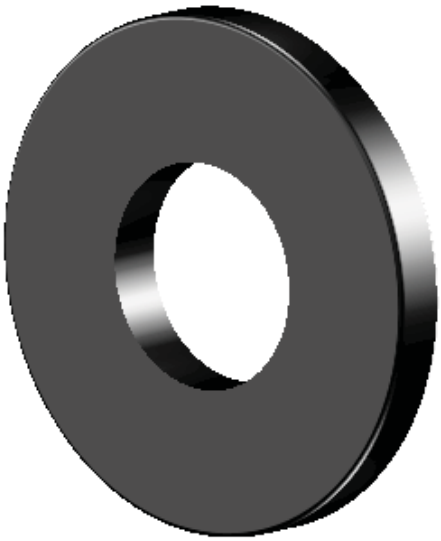


Flared Sleeves

Straight Sleeves





Backup Blocks

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2.4.1 SPLIT SLEEVES

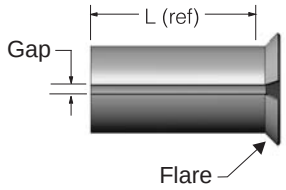

Figure 2.4-1
Flared Sleeve

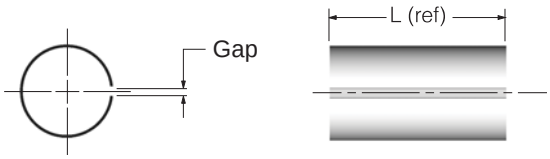

Figure 2.4-2
Straight Sleeve

- Sleeves are used in conjunction with a mandrel to allow a one-sided operation, provide lubrication, ensure that the hole is expanded in a radial direction, and protect the hole from damage.
- A flared sleeve configuration is generally recommended for holes of 1/2-inch diameter or smaller (except when stacking or when using the countersink nosecap).
- Each sleeve may only be used once.
- Manufactured from stainless steel.
- Each sleeve is internally pre-lubricated with a proprietary dry-film lubricant.
- Maximum length is identified in Table 2.4-2, but shorter sleeves may be stacked to provide increased length.
- A flared or straight configuration can be provided.
- Sleeve must be at least 1/32 inch longer than the material stackup with a standard nosecap, 5/32 inch longer with a CsCx nosecap.
- Identification is provided by an electroetched model number on each sleeve (model number may only be STDN).
- Special order sleeve lengths are available.
- For larger sizes, please contact our Technical Sales Staff.

Model Number Key:

CB S - 10 - 0 - N - 16 F

- CB: Process Callout (CB, CA, CR, or KB2)
- S: Sleeve
- 10: Standard Tool Diameter Number (STDN)
- 0: Standard Tool Diameter Number (STDN)
- N: Standard Tool Diameter Number (STDN)
- 16: Sleeve Length in 16ths of an inch
- F: Flared or Straight

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Table 2.4-1
Available Sleeve Lengths

Flared Sleeves		*Straight Sleeves*	
Length Callout	**Effective Length (inch)***	**Length Callout**	**Effective Length (inch)***
-8F	0.50	-8S	0.50
-12F	0.75	-12S	0.75
-16F	1.00	-16S	1.00
-20F	1.25	-20S	1.25
-23F	1.44	-24S	1.50
-32F	2.00	-33S	2.06
-36F	2.25	-37S	2.31
-40F	2.50	-41S	2.56
-48F	3.00	-49S	3.06
-56F	3.50	-57S	3.56
-64F	4.00	-65S	4.06
-72F	4.50	-73S	4.56

* For flared sleeves, the effective length is from the bottom of the flare to the end of the sleeve (refer to Figure 2.4-1).

Table 2.4-2
Maximum Sleeve Lengths

STDN Range	**Maximum Length in 1/16-inch**
4-0-N through 4-4-N	-23F/-24S
6-0-N through 8-3-N	-36F/-37S
10-0-N through 10-2-N	-40F/-41S
10-3-N through 16-1-N	-48F/-49S
16-2-N through 18-2-N	-56F/-57S
18-3-N through 22-3-N	-64F/-65S
24-0-N and larger	-72F/-73S

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Table 2.4-3
CB Tooling

1

STDN	Model Number
4-0-N	CBS-4-0-N-16F
4-1-N	CBS-4-1-N-16F
4-2-N	CBS-4-2-N-16F
4-3-N	CBS-4-3-N-16F
4-4-N	CBS-4-4-N-16F
6-0-N	CBS-6-0-N-16F
6-1-N	CBS-6-1-N-16F
6-2-N	CBS-6-2-N-16F
6-3-N	CBS-6-3-N-16F
8-0-N	CBS-8-0-N-16F
8-1-N	CBS-8-1-N-16F
8-2-N	CBS-8-2-N-16F
8-3-N	CBS-8-3-N-16F
10-0-N	CBS-10-0-N-16F
10-1-N	CBS-10-1-N-16F
10-2-N	CBS-10-2-N-16F
10-3-N	CBS-10-3-N-16F

2

STDN	Model Number
12-0-N	CBS-12-0-N-16F
12-1-N	CBS-12-1-N-16F
12-2-N	CBS-12-2-N-16F
12-3-N	CBS-12-3-N-16F
14-0-N	CBS-14-0-N-16F
14-1-N	CBS-14-1-N-16F
14-2-N	CBS-14-2-N-16F
14-3-N	CBS-14-3-N-16F
16-0-N	CBS-16-0-N-16F
16-1-N	CBS-16-1-N-16F
16-2-N	CBS-16-2-N-16F
16-3-N	CBS-16-3-N-16F
18-0-N	CBS-18-0-N-16F
18-1-N	CBS-18-1-N-16F
18-2-N	CBS-18-2-N-16F
18-3-N	CBS-18-3-N-16F
20-0-N	CBS-20-0-N-16F
20-1-N	CBS-20-1-N-16F
20-2-N	CBS-20-2-N-16F
20-3-N	CBS-20-3-N-16F

3

STDN	Model Number
22-0-N	CBS-22-0-N-16F
22-1-N	CBS-22-1-N-16F
22-2-N	CBS-22-2-N-16F
22-3-N	CBS-22-3-N-16F
24-0-N	CBS-24-0-N-16F
24-1-N	CBS-24-1-N-16F
24-2-N	CBS-24-2-N-16F
24-3-N	CBS-24-3-N-16F
26-0-N	CBS-26-0-N-16F
26-1-N	CBS-26-1-N-16F
26-2-N	CBS-26-2-N-16F
26-3-N	CBS-26-3-N-16F
28-0-N	CBS-28-0-N-16F
28-1-N	CBS-28-1-N-16F
28-2-N	CBS-28-2-N-16F
28-3-N	CBS-28-3-N-16F
30-0-N	CBS-30-0-N-16F
30-1-N	CBS-30-1-N-16F
30-2-N	CBS-30-2-N-16F
30-3-N	CBS-30-3-N-16F

Table 2.4-4
CA Tooling

1

STDN	Model Number
20	CAS-20-16F
21	CAS-21-16F
22	CAS-22-16F
23	CAS-23-16F
30	CAS-30-16F
31	CAS-31-16F
32	CAS-32-16F
33	CAS-33-16F
40	CAS-40-16F
41	CAS-41-16F
42	CAS-42-16F
43	CAS-43-16F

2

STDN	Model Number
50	CAS-50-16F
51	CAS-51-16F
52	CAS-52-16F
53	CAS-53-16F
60	CAS-60-16F
61	CAS-61-16F
62	CAS-62-16F
63	CAS-63-16F
70	CAS-70-16F
71	CAS-71-16F
72	CAS-72-16F
73	CAS-73-16F

3

STDN	Model Number
80	CAS-80-16F
81	CAS-81-16F
82	CAS-82-16F
83	CAS-83-16F
90	CAS-90-16F
91	CAS-91-16F
92	CAS-92-16F
93	CAS-93-16F
100	CAS-100-16F
101	CAS-101-16F
102	CAS-102-16F
103	CAS-103-16F
110	CAS-110-16F
111	CAS-111-16F

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Table 2.4-5
KB2 Tooling

STDN	Model Number
40-****-0	KB2S-40-****-16F
41-****-0	KB2S-41-****-16F
42-****-0	KB2S-42-****-16F
43-****-0	KB2S-43-****-16F
60-****-0	KB2S-60-****-16F
61-****-0	KB2S-61-****-16F
62-****-0	KB2S-62-****-16F
63-****-0	KB2S-63-****-16F
80-****-0	KB2S-80-****-16F
81-****-0	KB2S-81-****-16F
82-****-0	KB2S-82-****-16F
83-****-0	KB2S-83-****-16F
100-****-0	KB2S-100-****-16F
101-****-0	KB2S-101-****-16F
102-****-0	KB2S-102-****-16F
103-****-0	KB2S-103-****-16F
120-****-0	KB2S-120-****-16F
121-****-0	KB2S-121-****-16F
122-****-0	KB2S-122-****-16F
123-****-0	KB2S-123-****-16F

**** Refer to Cx2s Tooling for complete STDN information.

Table 2.4-6
CR Tooling

STDN	Model Number
R30	CRS-R30-16F
R32	CRS-R32-16F
R40	CRS-R40-16F
R42	CRS-R42-16F
R50	CRS-R50-16F
R52	CRS-R52-16F
R60	CRS-R60-16F
R62	CRS-R62-16F

2.4.2 BACKUP BLOCKS

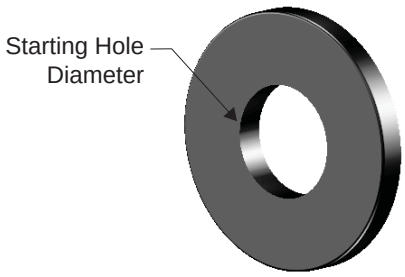

Figure 2.4-3
Backup Block

- Used in the cold expansion process to provide either a higher pull force for countersink cold expansion or in-plane stability to thin structure.
- The inside diameter is manufactured to the same starting hole dimensional requirements as the fastener hole that is being cold expanded.
- The backup block combined with the thickness of the straight portion of the hole must be greater than or equal to the finish hole diameter.
- The outside diameter of the backup block should be at least five times greater than the diameter of the hole.
- Backup blocks can only be used once.

Model Number Key:

K B B B - 10 - 0 - N - 1

Process Callout (CB, KB, KR, or KB2)

Backup Block

Standard Tool Diameter Number (STDN)

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Table 2.4-7
KB Tooling

STDN	Model Number
4-0-N	KBBB-4-0-N-1
4-1-N	KBBB-4-1-N-1
4-2-N	KBBB-4-2-N-1
4-3-N	KBBB-4-3-N-1
4-4-N	KBBB-4-4-N-1
6-0-N	KBBB-6-0-N-1
6-1-N	KBBB-6-1-N-1
6-2-N	KBBB-6-2-N-1
6-3-N	KBBB-6-3-N-1
8-0-N	KBBB-8-0-N-1
8-1-N	KBBB-8-1-N-1
8-2-N	KBBB-8-2-N-1
8-3-N	KBBB-8-3-N-1
10-0-N	KBBB-10-0-N-1
10-1-N	KBBB-10-1-N-1
10-2-N	KBBB-10-2-N-1
10-3-N	KBBB-10-3-N-1

Sizes available up to STDN 20-3-N.
See Model Number Key.

Table 2.4-8
KR Tooling

STDN	Assembly Model Number
R30	KRBB-R30-1
R32	KRBB-R32-1
R40	KRBB-R40-1
R42	KRBB-R42-1
R50	KRBB-R50-1
R52	KRBB-R52-1
R60	KRBB-R60-1
R62	KRBB-R62-1

Table 2.4-9
KB2 Tooling

STDN	Model Number
40-****-0	KB2BB-40-****-0
41-****-0	KB2BB-41-****-0
42-****-0	KB2BB-42-****-0
43-****-0	KB2BB-43-****-0
60-****-0	KB2BB-60-****-0
61-****-0	KB2BB-61-****-0
62-****-0	KB2BB-62-****-0
63-****-0	KB2BB-63-****-0
80-****-0	KB2BB-80-****-0
81-****-0	KB2BB-81-****-0
82-****-0	KB2BB-82-****-0
83-****-0	KB2BB-83-****-0
100-****-0	
101-****-0	
102-****-0	
103-****-0	
120-****-0	
121-****-0	
122-****-0	
123-****-0	

**** Refers to Cx2s Tooling for complete STDN information.

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CB Tooling for Cx in Aluminum and Mild Steels

Section **Page**

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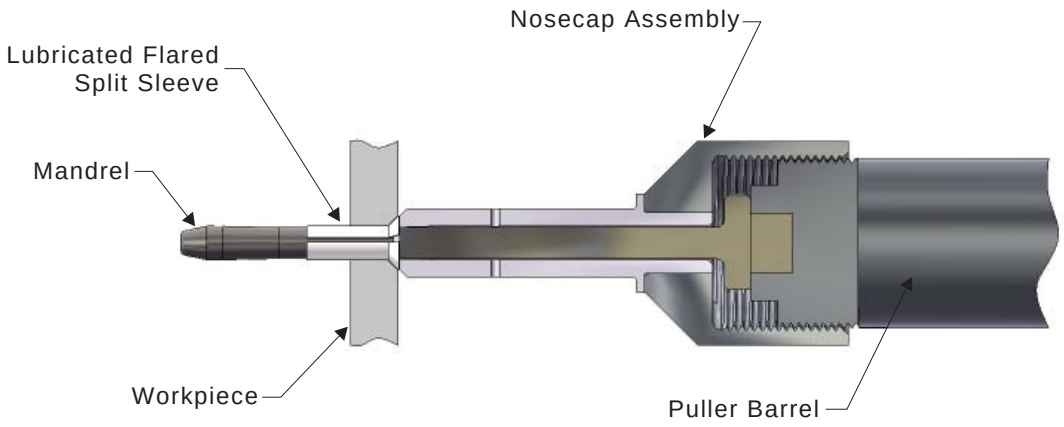


Figure 3.1-1
CB System Components

The FTI basic system of Split Sleeve Cold Expansion (SsCx) tooling, CB series, was designed primarily for production applications in aluminum and mild steel. The process includes development of the starting hole, cold expanding the hole, and post-sizing of the hole to accommodate the required interference fastener or fastening device. The CB series system of tooling is also used for rework applications and has commonly been called out for aircraft service bulletins. For pre-existing countersunk holes, the countersink and straight portion of the hole can be simultaneously cold expanded using a special Countersink Cold Expansion (CsCx) nosecap assembly.

CB tooling is available in nominal and 1/64-inch oversizes from 1/8 inch to 1 inch and larger. Specially designed rework tooling, CR series, is available (refer to Section 6.0). For tooling applicable to high strength steel and titanium, CA series, refer to Section 5.0. For technical assistance outside the scope of this catalog, please contact our Technical Sales staff.

1. Drill starting hole.

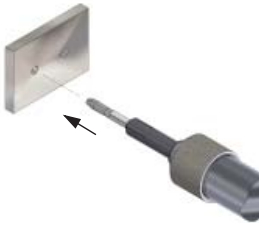
2. Ream starting hole.

3. Check starting hole diameter.

4. Inspect mandrel.

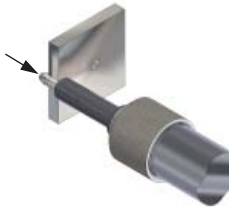
5. Slide split sleeve over mandrel.

6. Insert mandrel and split sleeve.



7. Place nosecap firmly against workpiece.

8. Cold expand hole by pulling the mandrel through the pre-lubricated split sleeve.



9. Remove distorted sleeve.

10. Verify cold expansion.

11. Finish ream hole.

12. Install fastener.

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3.3 STDN Selection Table for New Holes

The "CB" STDN selection tables provide a choice of two final ream allowances **after** cold expansion. Since the process provides a large zone of residual compressive stress, either ream amount can be used without impacting the fatigue life. The smaller ream allowance (OPTION #1) removes less material. The larger ream allowance (OPTION #2) removes more of the surface upset around the hole, which may be more desirable for multi-material stackups. The average ream allowances shown in Table 3.3-1 are based on installation of a typical Hi-Lok fastener.

Note: In column 1A, for a 3/16-inch final fastener you may use either the 4-4-N or 6-0-N tooling depending on your final ream preference.

Table 3.3-1
CB Tooling STDN Selection for New Holes

OPTION #1		OPTION #2			
1A		1B		2	3
Reference Fastener		Reference Fastener			
Diameter	Ave. Ream Allowance	Diameter	Ave. Ream Allowance	Standard Tool Diameter Number (STDN)	Max Finished Hole Diameter Not to Exceed
1/8	.007	1/8	.007	4-0-N	.1370
9/64	.007	9/64	.007	4-1-N	.1560
5/32	.006	5/32	.006	4-2-N	.1760
11/64	.006	11/64	.006	4-3-N	.1920
3/16	.012	3/16	.012	4-4-N	.2026
3/16	.003	13/64	.019	6-0-N	.2130
13/64	.004	7/32	.019	6-1-N	.2300
7/32	.002	15/64	.018	6-2-N	.2490
15/64	.002	1/4	.017	6-3-N	.2650
1/4	.006	17/64	.022	8-0-N	.2790
17/64	.006	9/32	.022	8-1-N	.2950
9/32	.006	19/64	.022	8-2-N	.3128
19/64	.005	5/16	.021	8-3-N	.3306
5/16	.006	21/64	.021	10-0-N	.3490
21/64	.006	11/32	.021	10-1-N	.3650
11/32	.005	23/64	.021	10-2-N	.3852
23/64	.005	3/8	.021	10-3-N	.3996
3/8	.005	25/64	.021	12-0-N	.4190
25/64	.005	13/32	.020	12-1-N	.4350
13/32	.004	27/64	.019	12-2-N	.4538
27/64	.004	7/16	.020	12-3-N	.4710
7/16	.004	29/64	.020	14-0-N	.4860
29/64	.004	15/32	.019	14-1-N	.5020
15/32	.006	31/64	.021	14-2-N	.5150
31/64	.006	1/2	.022	14-3-N	.5300
1/2	.012	33/64	.027	16-0-N	.5390
33/64	.012	17/32	.028	16-1-N	.5550
17/32	.012	35/64	.027	16-2-N	.5700
35/64	.012	9/16	.027	16-3-N	.5860

To properly select the STDN:

- For a smaller ream allowance, use column 1A to determine the final fastener size For a larger ream allowance use column 1B to select the final fastener.
- Move across to Column 2 to select the proper STDN.
- Using this STDN, select the proper set of tooling from Table 3.5-1.
- Column 3 states the maximum diameter the hole can be reamed to before requiring further cold expansion.

Table 3.3-1 (Continued)
CB Tooling STDN Selection for New Holes

OPTION #1		OPTION #2			
1A		1B		2	3
Reference Fastener		Reference Fastener			
Diameter	Ave. Ream Allowance	Diameter	Ave. Ream Allowance	Standard Tool Diameter Number (STDN)	Max Finished Hole Diameter Not to Exceed
9/16	.010	37/64	.026	18-0-N	.6020
37/64	.011	19/32	.026	18-1-N	.6180
19/32	.010	39/64	.026	18-2-N	.6330
39/64	.010	5/8	.026	18-3-N	.6480
5/8	.011	41/64	.026	20-0-N	.6620
41/64	.011	21/32	.026	20-1-N	.6780
21/32	.008	43/64	.023	20-2-N	.6960
43/64	.008	11/16	.024	20-3-N	.7110
11/16	.010	45/64	.025	22-0-N	.7240
45/64	.010	23/32	.025	22-1-N	.7400
23/32	.010	47/64	.025	22-2-N	.7550
47/64	.010	3/4	.025	22-3-N	.7710
3/4	.012	49/64	.027	24-0-N	.7830
49/64	.012	25/32	.028	24-1-N	.7990
25/32	.012	51/64	.027	24-2-N	.8140
51/64	.012	13/16	.027	24-3-N	.8300
13/16	.009	53/64	.025	26-0-N	.8470
53/64	.010	27/32	.025	26-1-N	.8630
27/32	.011	55/64	.027	26-2-N	.8760
55/64	.011	7/8	.027	26-3-N	.8910
7/8	.012	57/64	.027	28-0-N	.9060
57/64	.012	29/32	.028	28-1-N	.9220
29/32	.004	59/64	.020	28-2-N	.9440
59/64	.005	15/16	.020	28-3-N	.9590
15/16	.013	61/64	.028	30-0-N	.9660
61/64	.013	31/32	.029	30-1-N	.9820
31/32	.012	63/64	.028	30-2-N	.9980
63/64	.012	1	.028	30-3-N	1.0140
1	.009	1-1/16	.025	32-0-N	1.0300

Greater than 1 inch contact Fatigue Technology for technical assistance.

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3.4 STDN Selection Table for Rework of Existing Holes

Table 3.4-1 has been designed to assist with STDN selection for existing fastener holes in rework conditions. Every aircraft manufacturer has guidelines for fastener removal, pre-existing crack removal, and hole preparation that should be followed. Use this table to select an STDN using either your existing fastener or required final fastener as a guide. Note that the STDNs listed in Column 3 have been chosen for minimal ream allowances.

Table 3.4-1
CB Tooling STDN Selection for Rework of Existing Holes

1	2	3	4		5	6
Nominal Existing Fastener Diameter	Maximum Allowable Existing Diameter	Standard Tool Diameter Number	Cold Expansion Starting Hole Diameter		Final Fastener Diameter	Maximum Finished Hole Diameter
Inches	Before Cx	(STDN)	Minimum	Maximum	Inches	(not to exceed)
1/8	.134	4-2-N	.144	.146	5/32	.1760
9/64	.150	4-3-N	.160	.162	11/64	.1920
5/32	.159	4-4-N	.169	.171	3/16	.2026
5/32	.167	6-0-N	.177	.180	3/16	.2130
11/64	.182	6-1-N	.192	.195	13/64	.2300
3/16	.199	6-2-N	.209	.212	7/32	.2490
13/64	.215	6-3-N	.225	.228	15/64	.2650
7/32	.225	8-0-N	.235	.238	1/4	.2790
15/64	.241	8-1-N	.251	.254	17/64	.2950
1/4	.256	8-2-N	.266	.269	9/32	.3128
17/64	.273	8-3-N	.283	.286	19/64	.3306
9/32	.287	10-0-N	.297	.300	5/16	.3490
19/64	.303	10-1-N	.313	.316	21/64	.3650
5/16	.318	10-2-N	.328	.331	11/32	.3852
21/64	.334	10-3-N	.344	.347	23/64	.3996
11/32	.349	12-0-N	.359	.362	3/8	.4190
23/64	.365	12-1-N	.375	.378	25/64	.4250
3/8	.381	12-2-N	.391	.394	13/32	.4538
25/64	.396	12-3-N	.406	.409	27/64	.4710
13/32	.411	14-0-N	.421	.424	7/16	.4860
27/64	.427	14-1-N	.437	.440	29/64	.5020
7/16	.440	14-2-N	.450	.453	15/32	.5150
29/64	.455	14-3-N	.465	.468	31/64	.5300
29/64	.464	16-0-N	.474	.477	1/2	.5390
15/32	.480	16-1-N	.490	.493	33/64	.5550
31/64	.495	16-2-N	.505	.508	17/32	.5700

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To select the STDN using Table 3.4-1, use the following steps:

1. Remove the existing fastener and measure the hole diameter.
2. If a minimal amount of material is to be removed, select the STDN from Column 3 that corresponds with the existing hole diameter in Column 2. If a larger final fastener is desired, find the final fastener size in Column 5 and select the corresponding STDN in Column 3.
3. Using the STDN, select the tooling from Table 3.5-1 on the following pages.

Table 3.4-1 (Continued)
CB Tooling STDN Selection for Rework of Existing Holes

1	2	3	4		5	6
Nominal Existing Fastener Diameter Inches	Maximum Allowable Existing Diameter Before Cx	Standard Tool Diameter Number (STDN)	Cold Expansion Starting Hole Diameter Minimum	Cold Expansion Starting Hole Diameter Maximum	Final Fastener Diameter Inches	Maximum Finished Hole Diameter (not to exceed)
1/2	.511	16-3-N	.521	.524	35/64	.5860
33/64	.527	18-0-N	.537	.540	9/16	.6020
17/32	.543	18-1-N	.553	.556	37/64	.6180
35/64	.558	18-2-N	.568	.571	19/32	.6330
9/16	.573	18-3-N	.583	.586	39/64	.6480
37/64	.587	20-0-N	.597	.600	5/8	.6620
19/32	.603	20-1-N	.613	.616	41/64	.6780
39/64	.621	20-2-N	.631	.634	21/32	.6960
5/8	.636	20-3-N	.646	.649	43/64	.7110
41/64	.649	22-0-N	.659	.662	11/16	.7240
21/32	.665	22-1-N	.675	.678	45/64	.7400
43/64	.680	22-2-N	.690	.693	23/32	.7550
11/16	.696	22-3-N	.706	.709	47/64	.7710
45/64	.708	24-0-N	.718	.721	3/4	.7830
23/32	.724	24-1-N	.734	.737	49/64	.7990
47/64	.739	24-2-N	.749	.752	25/32	.8140
3/4	.755	24-3-N	.765	.768	51/64	.8300
49/64	.772	26-0-N	.782	.785	13/16	.8470
25/32	.788	26-1-N	.798	.801	53/64	.8630
51/64	.801	26-2-N	.811	.814	27/32	.8760
13/16	.816	26-3-N	.826	.829	55/64	8910
53/64	.831	28-0-N	.841	.844	7/8	.9060
27/32	.847	28-1-N	.857	.860	57/64	.9220
55/64	.869	28-2-N	.879	.882	28/32	.9440
7/8	.884	28-3-N	.894	.897	59/64	.9590
57/64	.891	30-0-N	.901	.904	15/16	.9660
29/32	.907	30-1-N	.917	.920	61/64	.9820
59/64	.923	30-2-N	.933	.936	31/32	.9980
15/16	.939	30-3-N	.949	.952	63/64	1.0140

3.5 STANDARD TOOLING

1. To select a Standard Tool Diameter Number refer to Table 3.3-1 or 3.4-1.
2. With the STDN, select the system of Standard Tooling from Table 3.5-1.

Table 3.5-1
Standard CB Tooling

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 Starting Drill	 Starting Reamer	 Combination Gage	 Mandrel Gage
4-0-N	CBSD-4-0-N-1	CBSR-4-0-N-1	CBG-4-0-N-1	CBMG-4-0-N-1
4-1-N	CBSD-4-1-N-1	CBSR-4-1-N-1	CBG-4-1-N-1	CBMG-4-1-N-1
4-2-N	CBSD-4-2-N-1	CBSR-4-2-N-1	CBG-4-2-N-1	CBMG-4-2-N-1
4-3-N	CBSD-4-3-N-1	CBSR-4-3-N-1	CBG-4-3-N-1	CBMG-4-3-N-1
4-4-N	CBSD-4-4-N-1	CBSR-4-4-N-1	CBG-4-4-N-1	CBMG-4-4-N-1
6-0-N	CBSD-6-0-N-1	CBSR-6-0-N-1	CBG-6-0-N-1	CBMG-6-0-N-1
6-1-N	CBSD-6-1-N-1	CBSR-6-1-N-1	CBG-6-1-N-1	CBMG-6-1-N-1
6-2-N	CBSD-6-2-N-1	CBSR-6-2-N-1	CBG-6-2-N-1	CBMG-6-2-N-1
6-3-N	CBSD-6-3-N-1	CBSR-6-3-N-1	CBG-6-3-N-1	CBMG-6-3-N-1
8-0-N	CBSD-8-0-N-1	CBSR-8-0-N-1	CBG-8-0-N-1	CBMG-8-0-N-1
8-1-N	CBSD-8-1-N-1	CBSR-8-1-N-1	CBG-8-1-N-1	CBMG-8-1-N-1
8-2-N	CBSD-8-2-N-1	CBSR-8-2-N-1	CBG-8-2-N-1	CBMG-8-2-N-1
8-3-N	CBSD-8-3-N-1	CBSR-8-3-N-1	CBG-8-3-N-1	CBMG-8-3-N-1
10-0-N	CBSD-10-0-N-1	CBSR-10-0-N-1	CBG-10-0-N-1	CBMG-10-0-N-1
10-1-N	CBSD-10-1-N-1	CBSR-10-1-N-1	CBG-10-1-N-1	CBMG-10-1-N-1
10-2-N	CBSD-10-2-N-1	CBSR-10-2-N-1	CBG-10-2-N-1	CBMG-10-2-N-1
10-3-N	CBSD-10-3-N-1	CBSR-10-3-N-1	CBG-10-3-N-1	CBMG-10-3-N-1
12-0-N	CBSD-12-0-N-1	CBSR-12-0-N-1	CBG-12-0-N-1	CBMG-12-0-N-1
12-1-N	CBSD-12-1-N-1	CBSR-12-1-N-1	CBG-12-1-N-1	CBMG-12-1-N-1
12-2-N	CBSD-12-2-N-1	CBSR-12-2-N-1	CBG-12-2-N-1	CBMG-12-2-N-1
12-3-N	CBSD-12-3-N-1	CBSR-12-3-N-1	CBG-12-3-N-1	CBMG-12-3-N-1
14-0-N	CBSD-14-0-N-1	CBSR-14-0-N-1	CBG-14-0-N-1	CBMG-14-0-N-1
14-1-N	CBSD-14-1-N-1	CBSR-14-1-N-1	CBG-14-1-N-1	CBMG-14-1-N-1
14-2-N	CBSD-14-2-N-1	CBSR-14-2-N-1	CBG-14-2-N-1	CBMG-14-2-N-1
14-3-N	CBSD-14-3-N-1	CBSR-14-3-N-1	CBG-14-3-N-1	CBMG-14-3-N-1
16-0-N	CBSD-16-0-N-1	CBSR-16-0-N-1	CBG-16-0-N-1	CBMG-16-0-N-1
16-1-N	CBSD-16-1-N-1	CBSR-16-1-N-1	CBG-16-1-N-1	CBMG-16-1-N-1
16-2-N	CBSD-16-2-N-1	CBSR-16-2-N-1	CBG-16-2-N-1	CBMG-16-2-N-1
16-3-N	CBSD-16-3-N-1	CBSR-16-3-N-1	CBG-16-3-N-1	CBMG-16-3-N-1

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3. Refer to Section 2.0, Detailed Tooling for complete description of part.

4. Replace **** in gage finish reamer model number with the minimum final hole diameter.

Table 3.5-1 (Continued)
Standard CB Tooling

	6	7	8	9
Standard Tool Diameter Number (STDN)	 Flared Sleeve	 Mandrel	 Nosecap Assembly	 Gage Finish Reamer
4-0-N	CBS-4-0-N-16F	CBM-4-0-N-1-30-V1	MEN-14A-0401F	CBR-4-0-N-1-****
4-1-N	CBS-4-1-N-16F	CBM-4-1-N-1-30-V1	MEN-14A-0401F	CBR-4-1-N-1-****
4-2-N	CBS-4-2-N-16F	CBM-4-2-N-1-30-V1	MEN-14A-0423F	CBR-4-2-N-1-****
4-3-N	CBS-4-3-N-16F	CBM-4-3-N-1-30-V1	MEN-14A-0423F	CBR-4-3-N-1-****
4-4-N	CBS-4-4-N-16F	CBM-4-4-N-1-30-V1	MEN-14A-0601F	CBR-4-4-N-1-****
6-0-N	CBS-6-0-N-16F	CBM-6-0-N-1-30-V1	MEN-14A-0601F	CBR-6-0-N-1-****
6-1-N	CBS-6-1-N-16F	CBM-6-1-N-1-30-V1	MEN-14A-0601F	CBR-6-1-N-1-****
6-2-N	CBS-6-2-N-16F	CBM-6-2-N-1-30-V1	MEN-14A-0623F	CBR-6-2-N-1-****
6-3-N	CBS-6-3-N-16F	CBM-6-3-N-1-40-V1	MEN-14A-0623F	CBR-6-3-N-1-****
8-0-N	CBS-8-0-N-16F	CBM-8-0-N-1-40-V1	MEN-14A-0801F	CBR-8-0-N-1-****
8-1-N	CBS-8-1-N-16F	CBM-8-1-N-1-40-V1	MEN-14A-0801F	CBR-8-1-N-1-****
8-2-N	CBS-8-2-N-16F	CBM-8-2-N-1-40-V1	MEN-14A-0823F	CBR-8-2-N-1-****
8-3-N	CBS-8-3-N-16F	CBM-8-3-N-1-40-V1	MEN-14A-0823F	CBR-8-3-N-1-****
10-0-N	CBS-10-0-N-16F	CBM-10-0-N-1-40-V1	MEN-14A-1001F	CBR-10-0-N-1-****
10-1-N	CBS-10-1-N-16F	CBM-10-1-N-1-40-V1	MEN-14A-1001F	CBR-10-1-N-1-****
10-2-N	CBS-10-2-N-16F	CBM-10-2-N-1-40-V1	MEN-14A-1023F	CBR-10-2-N-1-****
10-3-N	CBS-10-3-N-16F	CBM-10-3-N-1-40-V1	MEN-14A-1023F	CBR-10-3-N-1-****
12-0-N	CBS-12-0-N-16F	CBM-12-0-N-1-40-V1	MEN-14A-1201F	CBR-12-0-N-1-****
12-1-N	CBS-12-1-N-16F	CBM-12-1-N-1-40-V1	MEN-14A-1201F	CBR-12-1-N-1-****
12-2-N	CBS-12-2-N-16F	CBM-12-2-N-1-40-V1	MEN-14A-1223F	CBR-12-2-N-1-****
12-3-N	CBS-12-3-N-16F	CBM-12-3-N-1-40-V1	MEN-14A-1223F	CBR-12-3-N-1-****
14-0-N	CBS-14-0-N-16F	CBM-14-0-N-1-40-V1	MEN-14A-1401F	CBR-14-0-N-1-****
14-1-N	CBS-14-1-N-16F	CBM-14-1-N-1-40-V1	MEN-14A-1401F	CBR-14-1-N-1-****
14-2-N	CBS-14-2-N-16F	CBM-14-2-N-1-40-V1	MEN-14A-1423F	CBR-14-2-N-1-****
14-3-N	CBS-14-3-N-16F	CBM-14-3-N-1-40-V1	MEN-14A-1423F	CBR-14-3-N-1-****
16-0-N	CBS-16-0-N-16F	CBM-16-0-N-1-50-V1	MEN-14A-1601F	CBR-16-0-N-1-****
16-1-N	CBS-16-1-N-16F	CBM-16-1-N-1-50-V1	MEN-14A-1601F	CBR-16-1-N-1-****
16-2-N	CBS-16-2-N-16F	CBM-16-2-N-1-50-V1	MEN-14A-1623F	CBR-16-2-N-1-****
16-3-N	CBS-16-3-N-16F	CBM-16-3-N-1-50-V1	MEN-14A-1623F	CBR-16-3-N-1-****

**** Denotes final hole diameter to be determined by customer.

1. To select a Standard Tool Diameter Number, refer to Table 3.3-1 or 3.4-1.
2. With the STDN, select the system of Standard Tooling from Table 3.5-1.

Table 3.5-1 (Continued)
Standard CB Tooling

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 Starting Drill	 Starting Reamer	 Combination Gage	 Mandrel Gage
18-0-N	CBSD-18-0-N-1	CBSR-18-0-N-1	CBG-18-0-N-1	CBMG-18-0-N-1
18-1-N	CBSD-18-1-N-1	CBSR-18-1-N-1	CBG-18-1-N-1	CBMG-18-1-N-1
18-2-N	CBSD-18-2-N-1	CBSR-18-2-N-1	CBG-18-2-N-1	CBMG-18-2-N-1
18-3-N	CBSD-18-3-N-1	CBSR-18-3-N-1	CBG-18-3-N-1	CBMG-18-3-N-1
20-0-N	CBSD-20-0-N-1	CBSR-20-0-N-1	CBG-20-0-N-1	CBMG-20-0-N-1
20-1-N	CBSD-20-1-N-1	CBSR-20-1-N-1	CBG-20-1-N-1	CBMG-20-1-N-1
20-2-N	CBSD-20-2-N-1	CBSR-20-2-N-1	CBG-20-2-N-1	CBMG-20-2-N-1
20-3-N	CBSD-20-3-N-1	CBSR-20-3-N-1	CBG-20-3-N-1	CBMG-20-3-N-1
22-0-N	CBSD-22-0-N-1	CBSR-22-0-N-1	CBG-22-0-N-1	CBMG-22-0-N-1
22-1-N	CBSD-22-1-N-1	CBSR-22-1-N-1	CBG-22-1-N-1	CBMG-22-1-N-1
22-2-N	CBSD-22-2-N-1	CBSR-22-2-N-1	CBG-22-2-N-1	CBMG-22-2-N-1
22-3-N	CBSD-22-3-N-1	CBSR-22-3-N-1	CBG-22-3-N-1	CBMG-22-3-N-1
24-0-N	CBSD-24-0-N-1	CBSR-24-0-N-1	CBG-24-0-N-1	CBMG-24-0-N-1
24-1-N	CBSD-24-1-N-1	CBSR-24-1-N-1	CBG-24-1-N-1	CBMG-24-1-N-1
24-2-N	CBSD-24-2-N-1	CBSR-24-2-N-1	CBG-24-2-N-1	CBMG-24-2-N-1
24-3-N	CBSD-24-3-N-1	CBSR-24-3-N-1	CBG-24-3-N-1	CBMG-24-3-N-1
26-0-N	CBSD-26-0-N-1	CBSR-26-0-N-1	CBG-26-0-N-1	CBMG-26-0-N-1
26-1-N	CBSD-26-1-N-1	CBSR-26-1-N-1	CBG-26-1-N-1	CBMG-26-1-N-1
26-2-N	CBSD-26-2-N-1	CBSR-26-2-N-1	CBG-26-2-N-1	CBMG-26-2-N-1
26-3-N	CBSD-26-3-N-1	CBSR-26-3-N-1	CBG-26-3-N-1	CBMG-26-3-N-1
28-0-N	CBSD-28-0-N-1	CBSR-28-0-N-1	CBG-28-0-N-1	CBMG-28-0-N-1
28-1-N	CBSD-28-1-N-1	CBSR-28-1-N-1	CBG-28-1-N-1	CBMG-28-1-N-1
28-2-N	CBSD-28-2-N-1	CBSR-28-2-N-1	CBG-28-2-N-1	CBMG-28-2-N-1
28-3-N	CBSD-28-3-N-1	CBSR-28-3-N-1	CBG-28-3-N-1	CBMG-28-3-N-1
30-0-N	CBSD-30-0-N-1	CBSR-30-0-N-1	CBG-30-0-N-1	CBMG-30-0-N-1
30-1-N	CBSD-30-1-N-1	CBSR-30-1-N-1	CBG-30-1-N-1	CBMG-30-1-N-1
30-2-N	CBSD-30-2-N-1	CBSR-30-2-N-1	CBG-30-2-N-1	CBMG-30-2-N-1
30-3-N	CBSD-30-3-N-1	CBSR-30-3-N-1	CBG-30-3-N-1	CBMG-30-3-N-1

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3. Refer to Section 2.0, Detailed Tooling for complete description of part.

4. Replace **** in gage finish reamer model number with the minimum final hole diameter.

Note: This tooling may not be maintained in stock.

Table 3.5-1 (Continued)
Standard CB Tooling

	6	7	8	9
Standard Tool Diameter Number (STDN)	 Flared Sleeve	 Mandrel	 Nosecap Assembly	 Gage Finish Reamer
18-0-N	CBS-18-0-N-16F	CBM-18-0-N-2-60-V1	MEN-26B-1801F	CBR-18-0-N-1-****
18-1-N	CBS-18-1-N-16F	CBM-18-1-N-2-60-V1	MEN-26B-1801F	CBR-18-1-N-1-****
18-2-N	CBS-18-2-N-16F	CBM-18-2-N-2-60-V1	MEN-26B-1823F	CBR-18-2-N-1-****
18-3-N	CBS-18-3-N-16F	CBM-18-3-N-2-60-V1	MEN-26B-1823F	CBR-18-3-N-1-****
20-0-N	CBS-20-0-N-16F	CBM-20-0-N-2-60-V1	MEN-26B-2001F	CBR-20-0-N-1-****
20-1-N	CBS-20-1-N-16F	CBM-20-1-N-2-60-V1	MEN-26B-2001F	CBR-20-1-N-1-****
20-2-N	CBS-20-2-N-16F	CBM-20-2-N-2-60-V1	MEN-26C-2023F	CBR-20-2-N-1-****
20-3-N	CBS-20-3-N-16F	CBM-20-3-N-2-60-V1	MEN-26C-2023F	CBR-20-3-N-1-****
22-0-N	CBS-22-0-N-16F	CBM-22-0-N-2-60-V1	MEN-26C-2201F	CBR-22-0-N-1-****
22-1-N	CBS-22-1-N-16F	CBM-22-1-N-2-60-V1	MEN-26C-2201F	CBR-22-1-N-1-****
22-2-N	CBS-22-2-N-16F	CBM-22-2-N-2-60-V1	MEN-26C-2223F	CBR-22-2-N-1-****
22-3-N	CBS-22-3-N-16F	CBM-22-3-N-2-60-V1	MEN-26C-2223F	CBR-22-3-N-1-****
24-0-N	CBS-24-0-N-16F	CBM-24-0-N-2-60-V1	MEN-26C-2401F	CBR-24-0-N-1-****
24-1-N	CBS-24-1-N-16F	CBM-24-1-N-2-60-V1	MEN-26C-2401F	CBR-24-1-N-1-****
24-2-N	CBS-24-2-N-16F	CBM-24-2-N-2-60-V1	MEN-26C-2423F	CBR-24-2-N-1-****
24-3-N	CBS-24-3-N-16F	CBM-24-3-N-5-60-V1	MEN-26C-2423F	CBR-24-3-N-1-****
26-0-N	CBS-26-0-N-16F	CBM-26-0-N-5-60-V1	MEN-26C-2601F	CBR-26-0-N-1-****
26-1-N	CBS-26-1-N-16F	CBM-26-1-N-5-60-V1	MEN-26C-2601F	CBR-26-1-N-1-****
26-2-N	CBS-26-2-N-16F	CBM-26-2-N-5-60-V1	MEN-26C-2623F	CBR-26-2-N-1-****
26-3-N	CBS-26-3-N-16F	CBM-26-3-N-5-60-V1	MEN-26C-2623F	CBR-26-3-N-1-****
28-0-N	CBS-28-0-N-16F	CBM-28-0-N-5-60-V1	MEN-26C-2801F	CBR-28-0-N-1-****
28-1-N	CBS-28-1-N-16F	CBM-28-1-N-5-60-V1	MEN-26C-2801F	CBR-28-1-N-1-****
28-2-N	CBS-28-2-N-16F	CBM-28-2-N-5-60-V1	MEN-26C-2823F	CBR-28-2-N-1-****
28-3-N	CBS-28-3-N-16F	CBM-28-3-N-5-60-V1	MEN-26C-2823F	CBR-28-3-N-1-****
30-0-N	CBS-30-0-N-16F	CBM-30-0-N-5-60-V1	MEN-26C-2801F	CBR-30-0-N-1-****
30-1-N	CBS-30-1-N-16F	CBM-30-1-N-5-60-V1	MEN-26C-2801F	CBR-30-1-N-1-****
30-2-N	CBS-30-2-N-16F	CBM-30-2-N-5-60-V1	MEN-26D-2823F	CBR-30-2-N-1-****
30-3-N	CBS-30-3-N-16F	CBM-30-3-N-5-60-V1	MEN-26D-2823F	CBR-30-3-N-1-****

**** Denotes final hole diameter to be determined by customer.

3.6 COUNTERSINK TOOLING

To cold expand existing countersunk holes, the countersink nosecap, mandrel, and straight sleeve must be used. A backup block may be necessary for countersunk holes in thin material. To assemble tooling for a countersunk hole, substitute the nosecap, mandrel, and sleeve for the STDN found in Table 3.6-1.

For more information on cold expanding countersink holes, refer to Section 8, Countersink Cold Expansion (CsCx).

Table 3.6-1
Alternate Tooling for Countersunk Holes

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 Countersink Nosecap	 Countersink Mandrel	 Straight Sleeve	 Backup Block
4-0-N	KBC-040-1A	KBM-4-0-N-1-35-V1	CBS-4-0-N-24S	KBBB-4-0-N-1
4-1-N	KBC-041-1A	KBM-4-1-N-1-35-V1	CBS-4-1-N-24S	KBBB-4-1-N-1
4-2-N	KBC-042-1A	KBM-4-2-N-1-35-V1	CBS-4-2-N-24S	KBBB-4-2-N-1
4-3-N	KBC-043-1A	KBM-4-3-N-1-35-V1	CBS-4-3-N-24S	KBBB-4-3-N-1
4-4-N	KBC-044-1A	KBM-4-4-N-1-35-V1	CBS-4-4-N-24S	KBBB-4-4-N-1
6-0-N	KBC-060-1A	KBM-6-0-N-1-35-V1	CBS-6-0-N-24S	KBBB-6-0-N-1
6-1-N	KBC-061-1A	KBM-6-1-N-1-35-V1	CBS-6-1-N-24S	KBBB-6-1-N-1
6-2-N	KBC-062-1A	KBM-6-2-N-1-35-V1	CBS-6-2-N-24S	KBBB-6-2-N-1
6-3-N	KBC-063-1A	KBM-6-3-N-1-35-V1	CBS-6-3-N-24S	KBBB-6-3-N-1
8-0-N	KBC-080-1A	KBM-8-0-N-1-35-V1	CBS-8-0-N-24S	KBBB-8-0-N-1
8-1-N	KBC-081-1A	KBM-8-1-N-1-35-V1	CBS-8-1-N-24S	KBBB-8-1-N-1
8-2-N	KBC-082-1A	KBM-8-2-N-1-35-V1	CBS-8-2-N-24S	KBBB-8-2-N-1
8-3-N	KBC-083-1A	KBM-8-3-N-1-35-V1	CBS-8-3-N-24S	KBBB-8-3-N-1
10-0-N	KBC-100-1A	KBM-10-0-N-1-35-V1	CBS-10-0-N-24S	KBBB-10-0-N-1
10-1-N	KBC-101-1A	KBM-10-1-N-1-35-V1	CBS-10-1-N-24S	KBBB-10-1-N-1
10-2-N	KBC-102-1A	KBM-10-2-N-1-35-V1	CBS-10-2-N-24S	KBBB-10-2-N-1
10-3-N	KBC-103-1A	KBM-10-3-N-1-35-V1	CBS-10-3-N-24S	KBBB-10-3-N-1
12-0-N	KBC-120-1A	KBM-12-0-N-1-35-V1	CBS-12-0-N-24S	KBBB-12-0-N-1
12-1-N	KBC-121-1A	KBM-12-1-N-1-35-V1	CBS-12-1-N-24S	KBBB-12-1-N-1
12-2-N	KBC-122-1A	KBM-12-2-N-1-35-V1	CBS-12-2-N-24S	KBBB-12-2-N-1
12-3-N	KBC-123-1A	KBM-12-3-N-1-35-V1	CBG-12-3-N-24S	KBBB-12-3-N-1

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To cold expand existing countersunk holes, the countersink nosecap, mandrel, and straight sleeve must be used. A backup block may be necessary for countersunk holes in thin material. To assemble tooling for a countersunk hole, substitute the nosecap, mandrel, and sleeve for the STDN found in Table 3.6-1.

For more information on cold expanding countersink holes, refer to Section 8.0, Countersink Cold Expansion (CsCx).

Table 3.6-1 (Continued)
Alternate Tooling for Countersunk Holes

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 **Countersink Nosecap**	 **Countersink Mandrel**	 **Straight Sleeve**	 **Backup Block**
14-0-N	KBC-140-2A	KBM-14-0-N-2-35-V1	CBS-14-0-N-24S	KBBB-14-0-N-1
14-1-N	KBC-141-2A	KBM-14-1-N-2-35-V1	CBS-14-1-N-24S	KBBB-14-1-N-1
14-2-N	KBC-142-2A	KBM-14-2-N-2-35-V1	CBS-14-2-N-24S	KBBB-14-2-N-1
14-3-N	KBC-143-2A	KBM-14-3-N-2-35-V1	CBS-14-3-N-24S	KBBB-14-3-N-1
16-0-N	KBC-160-2A	KBM-16-0-N-2-35-V1	CBS-16-0-N-24S	KBBB-16-0-N-1
16-1-N	KBC-161-2A	KBM-16-1-N-2-35-V1	CBS-16-1-N-24S	KBBB-16-1-N-1
16-2-N	KBC-162-2A	KBM-16-2-N-2-35-V1	CBS-16-2-N-24S	KBBB-16-2-N-1
16-3-N	KBC-163-2A	KBM-16-3-N-2-35-V1	CBS-16-3-N-24S	KBBB-16-3-N-1
18-0-N	KBC-180-2A	KBM-18-0-N-2-35-V1	CBS-18-0-N-24S	KBBB-18-0-N-1
18-1-N	KBC-181-2A	KBM-18-1-N-2-35-V1	CBS-18-1-N-24S	KBBB-18-1-N-1
18-2-N	KBC-182-2A	KBM-18-2-N-2-35-V1	CBS-18-2-N-24S	KBBB-18-2-N-1
18-3-N	KBC-183-2A	KBM-18-3-N-2-35-V1	CBS-18-3-N-24S	KBBB-18-3-N-1
20-0-N	KBC-200-2A	KBM-20-0-N-2-35-V1	CBS-20-0-N-24S	KBBB-20-0-N-1
20-1-N	KBC-201-2A	KBM-20-1-N-2-35-V1	CBS-20-1-N-24S	KBBB-20-1-N-1
20-2-N	KBC-202-2A	KBM-20-2-N-2-35-V1	CBS-20-2-N-24S	KBBB-20-2-N-1
20-3-N	KBC-203-2A	KBM-20-3-N-2-35-V1	CBS-20-3-N-24S	KBBB-20-3-N-1

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CW Tooling for Low Interference Cx in Aluminum
Part Number Cross References

Section **Page**

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4.1 PROCESS DESCRIPTION

The Boeing Low Interference (Class II) Sleeve Cold Working process is very similar to the high interference process. FTI manufactures and markets low interference split sleeve cold working tooling to support the Boeing 5973 Class II cold working specification. FTI's low interference tooling system is called **CW Tooling**.

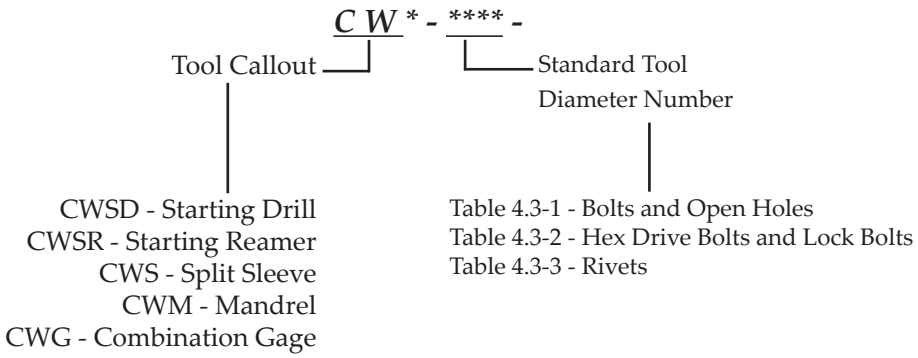
The principal features of the **CW Tooling System** are:

- A medium level of expansion.
- Starting hole and tool diameters are sized to give a finished hole diameter compatible with clearance fits of standard fasteners.
- Standard Tool Diameter Numbers contain the estimated finished cold worked hole diameter.
- Final reaming is not required.

The Basic Part Number:
The basic part number is identical to the Cx Tooling system except for the following differences:

1. A CW prefix is used instead of a CB prefix.
2. The Standard Tool Diameter Number has a different format.

Model Number Key:



Note: Refer to page 133 for ordering examples.

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Recommended Tooling for the Low Interference Split Sleeve Cold Expansion Process (Boeing Class II):

- Puller Unit LB-20/HP-20/ST1350A
- PowerPak .....FT-20 or FT-200
- Starting Drill.....CWSD-*****-1
- Starting Reamer CWSR-*****-1
- Mandrel.....CWM-*****-1-20-V1
- Split Sleeves.....CWS-*****-16F
- Nosecaps.....CBC- (see Table 4.2-1)
- Combination Gage..... CWG-*****

***** = Standard Tool Diameter Number from Tables 4.3-1, 4.3-2, or 4.3-3.

FTI Extension Nosecaps are available for CW Series tooling. Contact FTI for assistance in selecting the applicable extension nosecap for your tooling STDN.

Table 4.2-1
Recommended Nosecaps

Standard Tool Diameter Number ****		
Minimum (inch)	Maximum (inch)	Nosecap Assembly*
0.1267	0.2206	CBC-11-06F
0.2364	0.2990	CBC-11-08F
0.3090	0.3458	CBC-11-10F
0.3615	0.4083	CBC-12-12F
0.4241	0.4708	CBC-12-14F
0.4865	0.5489	CBC-13-16F

Note: ST1350 puller units may be modified to allow use of FTI nosecaps and mandrels. FTI standard puller unit is the LB-20. Refer to Section 2.0 Detailed Tooling for other FTI puller units.

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Table 4.3-1
BAC 5973 Class II Cold Working Requirements for Bolts and Open Holes

Nominal Hole Size		Standard Tool Diameter Number (STDN)		Starting Hole Diameter (inch) +0.0005 / -0.0025	Finished Hole Diameter (inch)	
Standard	Oversize	Nominal	Oversize		Minimum	Maximum
1/8		B1267		0.1250	0.1267	0.1295
	9/64		B1423	0.1406	0.1423	0.1451
	5/32		B1580	0.1562	0.1580	0.1608
	11/64		B1737	0.1719	0.1737	0.1765
3/16		B1894		0.1875	0.1894	0.1922
	13/64		B2050	0.2031	0.2050	0.2078
	7/32		B1580	0.2187	0.2206	0.2234
	15/64		B1737	0.2344	0.2364	0.2392
1/4		B2520		0.2500	0.2520	0.2548
	17/64		B2676	0.2656	0.2676	0.2704
	9/32		B2833	0.2812	0.2833	0.2861
	19/64		B2990	0.2969	0.2990	0.3018
5/16		B3145		0.3125	0.3145	0.3175
	21/64		B3301	0.3281	0.3301	0.3331
	11/32		B3458	0.3437	0.3458	0.3488
	23/64		B3615	0.3594	0.3615	0.3647
3/8		B3771		0.3750	0.3771	0.3803
	25/64		B3928	0.3906	0.3928	0.3960
	13/32		B4083	0.4062	0.4083	0.4117
	27/64		B4241	0.4219	0.4241	0.4275
7/16		B4396		0.4375	0.4396	0.4432
	29/64		B4551	0.4531	0.4551	0.4589
	15/32		B4708	0.4687	0.4708	0.4746
	31/64		B4865	0.4844	0.4865	0.4905
1/2		B5020		0.5000	0.5020	0.5064
	33/64		B5176	0.5156	0.5176	0.5220
	17/32		B5332	0.5312	0.5332	0.5376
	35/64		B5489	0.5469	0.5489	0.5533
9/16		B5647		0.5625	0.5647	0.5691
	37/64		B5803	0.5781	0.5803	0.5847
	19/32		B5959	0.5937	0.5959	0.6003
	39/64		B6116	0.6094	0.6116	0.6160

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Table 4.3-1 (Continued)
BAC 5973 Class II Cold Working Requirements for Bolts and Open Holes

Nominal Hole Size		Standard Tool Diameter Number (STDN)		Starting Hole Diameter (inch) +0.0005 / -0.0025	Finished Hole Diameter (inch)	
Standard	Oversize	Nominal	Oversize		Minimum	Maximum
5/8		B6272		0.6250	06272	0.6316
	41/64		B6429	0.6406	0.6429	0.6473
	21/32		B6585	0.6562	0.6585	0.6629
	43/64		B6742	0.6719	0.6742	0.6786
11/16		B6899		0.6875	0.6899	0.6943
	45/64		B7055	0.7031	0.7055	0.7099
	23/32		B7212	0.7187	0.7212	0.7256
	47/64		B7369	0.7344	0.7369	0.7413
3/4		B7525		0.7500	0.7525	0.7571
	49/64		B7681	0.7656	0.7681	0.7727
	25/32		B7837	0.7812	0.7837	0.7883
	51/64		B7995	0.7969	0.7995	0.8041
13/16		B8151		0.8125	0.8151	0.8197
	53/64		B8307	0.8281	0.8307	0.8353
	27/32		B8464	0.8437	0.8464	0.8510
	55/64		B8621	0.8594	0.8621	0.8667
7/8		B8778		0.8750	0.8778	0.8824
	57/64		B8934	0.8906	0.8934	0.8980
	29/32		B9091	0.9062	0.9091	0.9137
	59/64		B9248	0.9219	0.9248	0.9294
15/16		B9404		0.9375	0.9404	0.9452
	61/64		B9560	0.9531	0.9560	0.9608
	31/32		B9716	0.9687	0.9716	0.9764
	63/64		B9874	0.9844	0.9874	0.9922
1		B10030		1.0000	1.0030	1.0078
	1-1/64		B10187	1.0156	1.0187	1.0235
	1-1/32		B10343	1.0312	1.0343	1.0391

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Table 4.3-2
BAC 5973 Class II Cold Working Requirements for Hex-Drive Bolts and Lock Bolts

Nominal Hole Size		Standard Tool Diameter Number (STDN)		Starting Hole Diameter (inch) +0.0005 / -0.0025	Finished Hole Diameter (inch)	
Standard	Oversize	Nominal	Oversize		Minimum	Maximum
3/16		H1870		0.1855	0.187	0.190
	13/64 7/32		H2000 H2160	0.1985 0.2130	0.200 0.216	0.203 0.219
1/4		H2470		0.2455	0.247	0.250
	17/64 9/32		H2630 H2780	0.2615 0.2750	0.263 0.278	0.266 0.281
5/16		H3090		0.3080	0.309	0.313
	21/64 11/32		H3250 H3410	0.3230 0.3380	0.325 0.341	0.328 0.344
3/8		H3710		0.3695	0.371	0.375
	25/64 13/32		H3880 H4030	0.3865 0.4015	0.388 0.403	0.391 0.406
7/16		H4340		0.4310	0.434	0.438
	29/64 15/32		H4500 H4660	0.4460 0.4625	0.450 0.466	0.453 0.469

Table 4.3-3
BAC 5973 Class II Cold Working Requirements for Rivet Holes

Nominal Hole Size		Standard Tool Diameter Number (STDN)		Starting Hole Diameter (inch) +0.0005 / -0.0025	Finished Hole Diameter (inch)	
Standard	Oversize	Nominal	Oversize		Minimum	Maximum
1/8		R1280		0.1270	0.128	0.1310
	5/32		R1590	0.1580	0.159	0.1620
3/16		R1900		0.1890	0.190	0.1950
	7/32		R2200	0.2185	0.220	0.2345
1/4		R2530		0.2520	0.253	0.2570
	9/32		R2830	0.2810	0.283	0.2860
5/16		R3170		0.3140	0.371	0.3205
	11/32		R3450	0.3435	0.345	0.3480
3/8		R3780		0.3750	0.378	0.3820
	13/32		R4080	0.4060	0.408	0.4120
7/16		R4410		0.4365	0.441	0.4440

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EXAMPLE #1

Requirement:

Low interference coldwork 1/4-inch nominal open hole in 1/2-inch thick aluminum; unrestricted access.

1. Select STDN from Table 4.3-1: B2520.

2. Order standard tooling as per instructions on page 141 of this section.

Puller	LB-20
PowerPak	FT-20 or FT-200
Starting Drill	CWSD-B2520-1
Starting Reamer	CWSR-B2520-1
Mandrel	CWM-B2520-1-20-V1
Split Sleeves	CWS-B2520-16F
Nosecap	CBC-11-08F
Combination Gage	CWG-B2520

EXAMPLE #2

Requirement:

Low interference coldwork 3/8-inch (1/32-oversize) hole intended for a rivet.

1. Select STDN from Table 4.3-3: R4080.

2. Order standard tooling as per instructions on page 141 of this section.

Puller	LB-20
PowerPak	FT-20 or FT-200
Starting Drill	CWSD-R4080-1
Starting Reamer	CWSR-R4080-1
Mandrel	CWM-R4080-1-20-V1
Split Sleeves	CWS-R4080-16F
Nosecap	CBC-12-12F
Combination Gage	CWG-R4080

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4.5 FTI/Boeing Part Number Cross Reference

The tooling described in this section has been adopted by the Boeing Company using the standard tool prefix of ST5300 for sleeves and ST5300P for mandrels, nosecaps, and puller units.

Table 4.5-1
FTI/Boeing Part Number Cross Reference

Description	FTI	Boeing
Sleeves	CBS-**** CWS-****	ST5300-CBS-**** ST5300-CWS-****
Mandrels	CBM-**** CWM-****	ST5300-CBM-XXXX ST5300-CWM-XXXX
Nosecaps	CBC-****	ST5300P-N-XXXX
Extension Nosecaps Two Piece One Piece	 MEN-XX -----	 ----- ST5300P-CBCE-X
Puller Units Little Brute Medium Brute Big Brute Midget Brute	 LB-XX MB-XX BB-XX FTMP-XX	 ST5300P-PA-X ST5300P-PB-X ST5300P-PC-X -----
Offset Adapter Assembly	LBOA-XX MBOA-XX	ST5300P-PG-X

**** Asterisks indicate identical portion of part number.

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There have been three changes to the standard mandrel part numbering system:

1. The (IWMF, IWLB, IWMB, IWBB) prefixes have been deleted.
2. The V1 material callout for aluminum cold expansion has been added.
3. The attachment callout has changed (see below).

OLD PART NUMBER:

Model Number Key:

*IWMF - CBM - ** - * - N - * - ** - **

- (Deleted) — IWMF
- Std. Tool Diameter Number — **
- Attachment (changed, see Table 4.6-1) — *
- Stackup Callout (changed on Ext. Mandrel see Table 4.6-2) — **
- Material code — **

Table 4.6-1
Attachments Callouts

New Attachment Callout	Attachment Description			Old Attachment Callout
1	7/16 - 20	1 piece	threaded	1AB
2	5/8 - 18	1 piece	threaded	5
3	0.960"	1 piece	tang	6
4	7/8 - 14	2 piece	threaded	4
5	7/8 - 14	1 piece	threaded	3

The extension mandrel stackup (length) callouts have been simplified; refer to Table 4.6-2.

Table 4.6-2
Attachments Callouts for Stackups

Old Stackup Callout	New Stackup Callout
10E4	30
10E5	35
10E6	40
15E4	35
15E5	40
15E6	45
20E4	40
20E5	45
20E6	50

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OLD PART NUMBER:

Model Number Key:

IWLB
*IWMB - CBC - * - **** F/S*
IWBB

Deleted

Cap Callout
(changed, see Table 4.7-1)

Jaw Callout
(shortened, see Table 4.7-1)

NEW PART NUMBER:

*CBC - * * - ** F/S*

Puller Model
1 = LB Little Brute
2 = MB Medium Brute
3 = BB Big Brute

Cap Callout
(changed, see Table 4.7-1)

Flared/straight

Jaw Callout
(shortened, see Table 4.7-1)

Table 4.7-1
Nosecap Part Number Cross Reference

LB Nosecaps			
Nominal Size	**Puller**	**New Part Number**	**Old Part Number**
5/32 - 3/16	LB	CBC-11-06F/S	IWLB-CBC-1-0507F/S
1/4	LB	CBC-11-08F/S	IWLB-CBC-1-0809F/S
5/16	LB	CBC-11-10F/S	IWLB-CBC-1-1011F/S
3/8	LB	CBC-12-12F/S	IWLB-CBC-2-1213F/S
7/16	LB	CBC-12-14F/S	IWLB-CBC-2-1416F/S
1/2	LB	CBC-13-16F/S	IWLB-CBC-2-1416F/S*
MB Nosecaps			
Nominal Size	**Puller**	**New Part Number**	**Old Part Number**
3/8	MB	CBC-22-12F/S	IWMB-CBC-2-1213F/S
7/16	MB	CBC-22-14F/S	IWMB-CBC-2-1416F/S
1/2	MB	CBC-23-16F/S	IWMB-CBC-2-1416F/S
9/16	MB	CBC-23-18F/S	IWMB-CBC-3-1821F/S
5/8	MB	CBC-23-20F/S	IWMB-CBC-3-1821F/S
11/16	MB	CBC-24-22F/S	IWMB-CBC-3-2225F/S
3/4	MB	CBC-24-24F/S	IWMB-CBC-3-2225F/S
13/16	MB	CBC-24-26F/S	IWMB-CBC-4-2629F/S
7/8	MB	CBC-25-28F/S	IWMB-CBC-4-2629F/S
15/16	MB	CBC-25-30F/S	IWMB-CBC-4-3032F/S
1	MB	CBC-25-32F/S	IWMB-CBC-4-3032F/S
1-1/16	MB	CBC-25-34F/S	-----
1-1/8	MB	CBC-25-36F/S	-----
BB Nosecaps			
Nominal Size	**Puller**	**New Part Number**	**Old Part Number**
1	BB	CBC-31-32F/S	IWBB-CBC-1-3233F/S
1-1/16	BB	CBC-31-34F/S	IWBB-CBC-1-3435F/S
1-3/16	BB	CBC-31-38F/S	IWBB-CBC-1-3839F/S
1-1/4	BB	CBC-31-40F/S	IWBB-CBC-1-4041F/S
1-5/16	BB	CBC-32-42F/S	IWBB-CBC-2-4243F/S
1-3/8	BB	CBC-32-44F/S	IWBB-CBC-2-4445F/S
1-7/16	BB	CBC-32-46F/S	IWBB-CBC-2-4647F/S
1-1/2	BB	CBC-32-48F/S	IWBB-CBC-2-4849F/S
1-9/16	BB	CBC-33-50F/S	IWBB-CBC-3-5051F/S
1-5/8	BB	CBC-33-52F/S	IWBB-CBC-3-5253F/S
1-11/16	BB	CBC-33-54F/S	IWBB-CBC-3-5455F/S
1/3/4	BB	CBC-33-56F/S	IWBB-CBC-3-5657F/S

* Incompatible with 16-1, 16-2, and 16-3 mandrels.

Table 4.8-1
Standard Tool Diameter Cross Reference
(5/32-inch to 15/16-inch diameter)

Finished Hole Size		Standard Tool Diameter		Boeing Identification	Mc Donnell TD 761D	Northrop T395X9
Nominal	Oversize	Nominal	Oversize			
5/32		4-2-N		5-0-N	050	-1
	11/64		4-3-N	5-1-N	051	
3/16		4-4-N		6-0-N	30	
	13/64		6-0-N	6-1-N	31	-2
	7/32		6-1-N	6-2-N	32	-3
	15/64		6-2-N	6-3-N	NA	-4
1/4		6-3-N		8-0-N	40	-5
	17/64		8-0-N	8-1-N	41	-6
	9/32		8-1-N	8-2-N	42	-7 -8
	19/64		8-2-N	8-3-N	NA	
5/16		8-3-N		10-0-N	50	-9
	21/64		10-0-N	10-1-N	51	-10
	11/32		10-1-N	10-2-N	52	-11 -12
	23/64		10-2-N	10-3-N	NA	
3/8		10-3-N		12-0-N	60	-13
	25/64		12-0-N	12-1-N	61	-14
	13/32		12-1-N	12-2-N	62	-15 -16
	27/64		12-2-N	12-3-N	NA	
7/16		12-3-N		14-0-N	70	-17
	29/64		14-0-N	14-1-N	71	-18
	15/32		14-1-N	14-2-N	72	-19 -20
	31/64		14-2-N	14-3-N	NA	
1/2		14-3-N		16-0-N	80	-21
	33/64		16-0-N	16-1-N	81	-22
	17/32		16-1-N	16-2-N	82	-23 -24
	35/64		16-2-N	16-3-N	NA	
9/16		16-3-N		18-0-N	90	-25
	37/64		18-0-N	18-1-N	91	
	19/32		18-1-N	18-2-N	92	
	38/64		18-2-N	18-3-N	NA	
5/8		18-3-N		20-0-N	100	
	41/64		20-0-N	20-1-N	101	NA
	21/32		20-1-N	20-2-N	102	
	43/64		20-2-N	20-3-N	NA	
11/16		20-3-N		22-0-N	110	
	45/64		22-0-N	22-1-N	111	NA
	23/32		22-1-N	22-2-N	112	
	47/64		22-2-N	22-3-N	NA	
3/4		22-3-N		24-0-N	120	
	49/64		24-0-N	24-1-N	121	NA
	25/32		24-1-N	24-2-N	122	
	51/64		24-2-N	24-3-N	NA	
13/16		24-3-N		26-0-N	130	
	53/64		26-0-N	26-1-N	131	NA
	27/32		26-1-N	26-2-N	132	
	55/64		26-2-N	26-3-N	NA	
7/8		26-3-N		28-0-N	140	
	57/64		28-0-N	28-1-N	141	NA
	29/32		28-1-N	28-2-N	142	
	59/64		28-2-N	28-3-N	NA	
15/16		28-3-N		30-0-N	150	
	61/64		30-0-N	30-1-N	151	NA
	31/32		30-1-N	30-2-N	152	
	63/64		30-2-N	30-3-N	NA	

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Table 4.8-2
Standard Tool Diameter Cross Reference
(1-inch to 1-3/4-inch diameter)

Finished Hole Size		Standard Tool Diameter		Boeing Identification	Mc Donnell TD 761D	Northrop T395X9
Nominal	Oversize	Nominal	Oversize			
1	1-1/64 1-1/23 1-3/64	30-3-N	32-0-N 32-1-N 32-2-N	32-0-N 32-1-N 32-2-N 32-3-N	160 161 162	NA
1-1/16	1-5/64 1-3/32 1-7/64	32-3-N	34-0-N 34-1-N 34-2-N	34-0-N 34-1-N 34-2-N 34-3-N	170 171 172	NA
1-18	1-9/64 1-5/32 1-11/64	34-3-N	36-0-N 36-1-N 36-2-N	36-0-N 36-1-N 36-2-N 36-3-N	180 181 182	NA
1-3/16	1-13/64 1-7/32 1-15/64	36-3-N	38-0-N 38-1-N 38-2-N	38-0-N 38-1-N 38-2-N 38-3-N	190 191 192	NA
1-1/4	1-17/64 1-9/32 1-19/64	38-3-N	40-0-N 40-1-N 40-2-N	40-0-N 40-1-N 40-2-N 40-3-N	200 201 202	NA
1-5/16	1-21/64 1-11/32 1-23/64	40-3-N	42-0-N 42-1-N 42-2-N	42-0-N 42-1-N 42-2-N 42-3-N	210 211 212	NA
1-3/8	1-25/64 1-13/32 1-27/64	42-3-N	44-0-N 44-1-N 44-2-N	44-0-N 44-1-N 44-2-N 44-3-N	220 221 222	NA
1-7/16	1-29/64 1-15/32 1-31/64	44-3-N	46-0-N 46-1-N 46-2-N	46-0-N 46-1-N 46-2-N 46-3-N	230 231 232	NA
1-1/2	1-33/64 1-17/32 1-35/64	46-3-N	48-0-N 48-1-N 48-2-N	48-0-N 48-1-N 48-2-N 48-3-N	240 241 242	NA
1-9/16	1-37/64 1-19/32 1-39/64	48-3-N	50-0-N 50-1-N 50-2-N	50-0-N 50-1-N 50-2-N 50-3-N	250 251 252	NA
1-5/8	1-41/64 1-21/32 1-43/64	50-3-N	52-0-N 52-1-N 52-2-N	52-0-N 52-1-N 52-2-N 52-3-N	260 261 262	NA
1-11/16	1-45/64 1-23/32 1-47/64	52-3-N	54-0-N 54-1-N 54-2-N	54-0-N 54-1-N 54-2-N 54-3-N	270 271 272	NA
1-3/4	1-49/64 1-25/32 1-51/64	54-3-N	56-0-N 56-1-N 56-2-N	56-0-N 56-1-N 56-2-N 56-3-N	280 281 282	NA

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CA TOOLING FOR CX IN TITANIUM AND HIGH STRENGTH STEEL

Section **Page**

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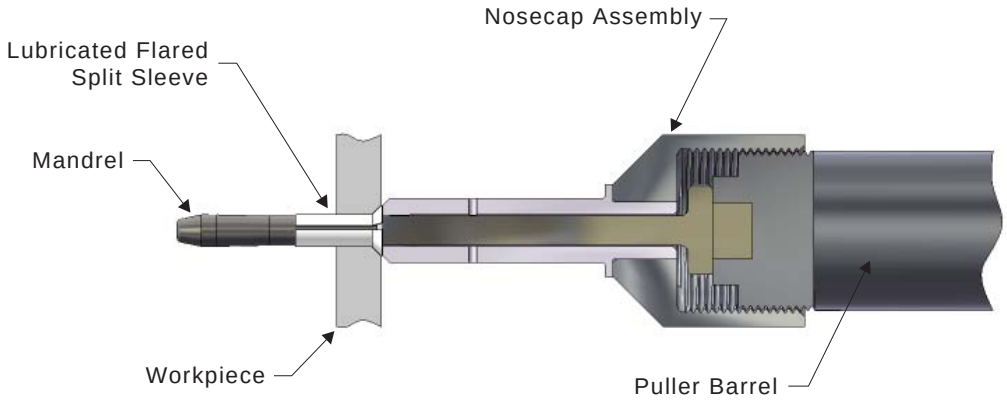

Figure 5.1-1
CA System Components

The CA series of Split Sleeve Cold Expansion (SsCx) tooling is designed to cold expand holes in titanium and high strength steels (up to 240 ksi). A slightly higher applied expansion, as compared to the CB series of tooling for aluminum, is specified for these materials; therefore, requiring special high strength mandrels. This system of tooling is used for both production and rework applications and has been called out for several aircraft service bulletins.

CA tooling is available in nominal and 1/64-inch oversize hole diameters between 1/8 and 45/64 inch. Final hole diameters greater than 45/64 inch require special 2-sided cold expansion tooling and may require applied expansions specifically tailored to the particular application. For special applications or sizes not covered in this Tool Catalog, please contact our Technical Sales Staff for assistance.

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1. Drill starting hole.

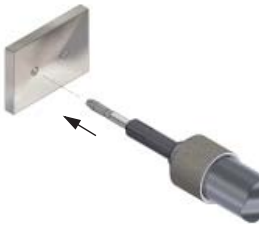
2. Ream starting hole.

3. Check starting hole diameter.

4. Inspect mandrel.

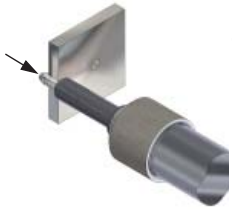
5. Slide split sleeve over mandrel.

6. Insert mandrel and split sleeve.



7. Place nosecap firmly against workpiece.

8. Cold expand hole by pulling the mandrel through the pre-lubricated split sleeve.



9. Remove distorted sleeve.

10. Verify cold expansion.

11. Finish ream hole.

12. Install fastener.

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5.3 STDN Selection Table For New Holes

How to select the Standard Tool Diameter Number:

1. Determine the final fastener diameter in Column 1.
2. Move across to Column 2 to select the proper STDN.
3. Using this STDN, select the proper set of tooling from Tables 5.5-1 and 5.5-2.

Note: For metric conversions refer to Table A-1 in the Appendix.

Table 5.3-1
CA Tooling STDN Selection for New Holes

1	2	3		4
Reference Final Fastener	Standard Tool Diameter Number (STDN)	Starting Hole Diameter (inch)		Maximum Allowable Finished Hole Diameter (inch)
		Minimum	Maximum	
1/8	20	.110	.112	.1331
9/64	21	.125	.127	.1513
5/32	22	.140	.142	.1694
11/64	23	.156	.158	.1888
3/16	30	.170	.172	.2040
13/64	31	.185	.187	.2220
7/32	32	.200	.202	.2400
15/64	33	.216	.218	.2592
1/4	40	.231	.234	.2726
17/64	41	.246	.249	.2903
9/32	42	.261	.264	.3080
19/64	43	.277	.280	.3269
5/16	50	.287	.290	.3358
21/64	51	.302	.305	.3533
11/32	52	.318	.321	.3721
23/64	53	.333	.336	.3896
3/8	60	.348	.351	.4037
25/64	61	.363	.366	.4211
13/32	62	.379	.382	.4396
27/64	63	.394	.397	.4570

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How to select your Standard Tool Diameter Number:

1. Determine the final fastener diameter in Column 1.
2. Move across to Column 2 to select the proper STDN.
3. Using this STDN, select the proper set of tooling from Tables 5.5-1 and 5.5-2.

Note: For metric conversions refer to Table A-1 in the Appendix.

Table 5.3-1 (Continued)
CA Tooling STDN Selection for New Holes

1	2	3		4
Reference Final Fastener	Standard Tool Diameter Number (STDN)	Starting Hole Diameter (inch)		Maximum Allowable Finished Hole Diameter (inch)
		Minimum	Maximum	
7/16	70	.409	.412	.4740
29/64	71	.424	.427	.4890
15/32	72	.440	.443	.5050
31/64	73	.455	.458	.5200
3/16	80	.470	.473	.5350
33/64	81	.486	.489	.5510
17/32	82	.501	.504	.5660
35/64	83	.516	.519	.5810
9/16	90	.531	.534	.5960
37/64	91	.547	.550	.6120
19/32	92	.562	.565	.6270
39/64	93	.577	.580	.6420
5/8	100	.592	.595	.6570
41/64	101	.608	.611	.6730
21/32	102	.623	.626	.6880
43/64	103	.638	.641	.7030
11/16	110	.653	.656	.7180
45/64	111	.669	.672	.7340

Note: For sizes greater than 45/64, contact FTI for technical assistance.

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5.4 STDN Selection Table For Rework of Existing Holes

Table 5.4-1 has been designed to assist with STDN selection for existing fastener holes in rework conditions. Every aircraft manufacturer has guidelines for fastener removal, crack removal, and hole preparation that should be followed. Use this table to select an STDN using either your existing fastener or required final fastener as a guide. Note that the STDNs chosen in Column 3 have been chosen for minimal ream allowances.

Table 5.4-1
CA Tooling STDN Selection for Rework of Existing Holes

1	2	3	4		5	6
Nominal Existing Fastener Diameter (inche)	Allowable Existing Diameter Before Cx (inch)	Standard Tool Diameter Number (STDN)	Starting Hole Diameter		Final Fastener Diameter (inche)	Maximum Finished Hole Diameter (not to exceed) (inch)
			Minimum	Maximum		
1/8	.130	22	.140	.142	5/32	.1694
9/64	.146	23	.156	.158	11/64	.1888
5/32	.160	30	.170	.172	3/16	.2040
11/64	.175	31	.185	.187	13/64	.2220
3/16	.190	32	.200	.202	7/32	.2400
13/64	.206	33	.216	.218	15/64	.2592
7/32	.221	40	.231	.234	1/4	.2726
15/64	.236	41	.246	.249	17/64	.2903
1/4	.251	42	.261	.264	9/32	.3080
17/64	.267	43	.277	.280	19/64	.3269
17/64	.277	50	.287	.290	5/16	.3358
9/32	.292	51	.302	.305	21/64	.3533
19/64	.308	52	.318	.321	11/32	.3721
5/16	.323	53	.333	.336	23/64	.3896
21/64	.338	60	.348	.351	3/8	.4037
11/32	.353	61	.363	.366	25/64	.4211
23/64	.369	62	.379	.382	13/32	.4396

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To select the STDN using Table 5.4-1, use the following steps:

1. Remove the existing fastener and measure the resulting hole diameter.
2. If a minimal amount of material is to be removed, select the STDN from Column 3 that corresponds to the existing hole diameter in Column 2.
3. If you wish to install a larger required final fastener, find the final fastener size in Column 5 and select the corresponding STDN from Column 3.
4. Using the STDN, select the tooling from Tables 5.5-1 and 5.5-2 on the following pages.

Table 5.4-1 (Continued)
CB Tooling STDN Selection for Rework of Existing Holes

1	2	3	4		5	6
Nominal Existing Fastener Diameter (inche)	Allowable Existing Diameter Before Cx (inch)	Standard Tool Diameter Number (STDN)	Starting Hole Diameter		Final Fastener Diameter (inch)	Maximum Finished Hole Diameter (not to exceed) (inch)
			Minimum	Maximum		
3/8	.384	63	.394	.397	27/64	.4570
25/64	.399	70	.409	.412	7/16	.4740
13/32	.414	71	.424	.427	29/64	.4890
27/64	.430	72	.440	.443	15/32	.5050
7/16	.445	73	.455	.458	31/64	.5200
29/64	.460	80	.470	.473	1/2	.5350
15/32	.476	81	.486	.489	33/64	.5510
31/64	.491	82	.501	.504	17/32	.5660
1/2	.506	83	.516	.519	35/64	.5810
33/64	.521	90	.531	.534	9/16	.5960
17/32	.537	91	.547	.550	37/64	.6120
35/64	.552	92	.562	.565	19/32	.6270
9/16	.567	93	.577	.580	39/64	.6420
37/64	.582	100	.592	.595	5/8	.6570
19/32	.598	101	.608	.611	41/64	.6730
39/64	.613	102	.623	.626	21/32	.6880
5/8	.628	103	.638	.641	43/64	.7030
41/64	.643	110	.653	.656	11/16	.7180
21/32	.659	111	.669	.672	45/64	.7340

5.5 STANDARD TOOLING

1. To select a Standard Tool Diameter Number refer to Table 5.5-1 or 5.5-2.

2. With the STDN, select the system of Standard Tooling from Table 5.5-1.

Table 5.5-1
Standard CA Tooling

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 Starting Drill	 Starting Reamer	 Combination Gage	 Mandrel Gage
20	CASD-20-1	CASR-20-1	CAG-20	CAMG-20
21	CASD-21-1	CASR-21-1	CAG-21	CAMG-21
22	CASD-22-1	CASR-22-1	CAG-22	CAMG-22
23	CASD-23-1	CASR-23-1	CAG-23	CAMG-23
30	CASD-30-1	CASR-30-1	CAG-30	CAMG-30
31	CASD-31-1	CASR-31-1	CAG-31	CAMG-31
32	CASD-32-1	CASR-32-1	CAG-32	CAMG-32
33	CASD-33-1	CASR-33-1	CAG-33	CAMG-33
40	CASD-40-1	CASR-40-1	CAG-40	CAMG-40
41	CASD-41-1	CASR-41-1	CAG-41	CAMG-41
42	CASD-42-1	CASR-42-1	CAG-42	CAMG-42
43	CASD-43-1	CASR-43-1	CAG-43	CAMG-43
50	CASD-50-1	CASR-50-1	CAG-50	CAMG-50
51	CASD-51-1	CASR-51-1	CAG-51	CAMG-51
52	CASD-52-1	CASR-52-1	CAG-52	CAMG-52
53	CASD-53-1	CASR-53-1	CAG-53	CAMG-53

* All CA cutting tools are cobalt, unless otherwise specified.

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3. Refer to Section 2.0, Detailed Tooling for complete description of part.

4. Replace **** in gage finish reamer model number with the minimum final hole diameter.

Table 5.5-1 (Continued)
Standard CA Tooling

	6	7	8	9
Standard Tool Diameter Number (STDN)	 Flared Sleeve	 Mandrel	 Nosecap Assembly	 Gage Finish Reamer
20	CAS-20-16F	CAM-20-1-30-V2	MEN-14A-0401F	CAR-20-1-.****
21	CAS-21-16F	CAM-21-1-30-V2	MEN-14A-0401F	CAR-21-1-.****
22	CAS-22-16F	CAM-22-1-30-V2	MEN-14A-0423F	CAR-22-1-.****
23	CAS-23-16F	CAM-23-1-30-V2	MEN-14A-0423F	CAR-23-1-.****
30	CAS-30-16F	CAM-30-1-30-V2	MEN-14A-0601F	CAR-30-1-*.***
31	CAS-31-16F	CAM-31-1-30-V2	MEN-14A-0601F	CAR-31-1-.****
32	CAS-32-16F	CAM-32-1-30-V2	MEN-14A-0623F	CAR-32-1-.****
33	CAS-33-16F	CAM-33-1-30-V2	MEN-14A-0623F	CAR-33-1-.****
40	CAS-40-16F	CAM-40-1-40-V2	MEN-14A-0801F	CAR-40-1-.****
41	CAS-41-16F	CAM-41-1-40-V2	MEN-14A-0801F	CAR-41-1-.****
42	CAS-42-16F	CAM-42-1-40-V2	MEN-14A-0823F	CAR-42-1-.****
43	CAS-43-16F	CAM-43-1-40-V2	MEN-14A-0823F	CAR-43-1-.****
50	CAS-50-16F	CAM-50-1-40-V2	MEN-14A-1001F	CAR-50-1-.****
51	CAS-51-16F	CAM-51-1-40-V2	MEN-14A-1001F	CAR-51-1-.****
52	CAS-52-16F	CAM-52-1-40-V2	MEN-14A-1023F	CAR-52-1-.****
53	CAS-53-16F	CAM-53-1-40-V2	MEN-14A-1023F	CAR-53-1-.****

* All CA cutting tools are cobalt.
**** Denotes final hole diameter to be determined by customer.

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5.5 STANDARD TOOLING

1. To select a Standard Tool Diameter Number refer to Table 5.3-1 and 5.4-1.
2. With the STDN, select the system of Standard Tooling from Table 5.5-2.

Table 5.5-2
Standard CA Tooling

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 **Starting Drill**	 **Starting Reamer**	 **Combination Gage**	 **Mandrel Gage**
60	CASD-60-1	CASR-60-1	CAG-60	CAMG-60
61	CASD-61-1	CASR-61-1	CAG-61	CAMG-61
62	CASD-62-1	CASR-62-1	CAG-62	CAMG-62
63	CASD-63-1	CASR-63-1	CAG-63	CAMG-63
70	CASD-70-1	CASR-70-1	CAG-70	CAMG-70
71	CASD-71-1	CASR-71-1	CAG-71	CAMG-71
72	CASD-72-1	CASR-72-1	CAG-72	CAMG-72
73	CASD-73-1	CASR-73-1	CAG-73	CAMG-73
80	CASD-80-1	CASR-80-1	CAG-80	CAMG-80
81	CASD-81-1	CASR-81-1	CAG-81	CAMG-81
82	CASD-82-1	CASR-82-1	CAG-82	CAMG-82
83	CASD-83-1	CASR-83-1	CAG-83	CAMG-83
90	CASD-90-1	CASR-90-1	CAG-90	CAMG-90
91	CASD-91-1	CASR-91-1	CAG-91	CAMG-91
92	CASD-92-1	CASR-92-1	CAG-92	CAMG-92
93	CASD-93-1	CASR-93-1	CAG-93	CAMG-93
100	CASD-100-1	CASR-100-1	CAG-100	CAMG-100
101	CASD-101-1	CASR-101-1	CAG-101	CAMG-101
102	CASD-102-1	CASR-102-1	CAG-102	CAMG-102
103	CASD-103-1	CASR-103-1	CAG-103	CAMG-103
110	CASD-110-1	CASR-110-1	CAG-110	CAMG-110
111	CASD-111-1	CASR-111-1	CAG-111	CAMG-111

* All CA cutting tools are cobalt, unless otherwise specified.

3. Refer to Section 2.0, Detailed Tooling for complete description of part.

4. Replace **** in gage finish reamer model number with the minimum final hole diameter.

Note: This tooling may not be maintained in stock.

Note: STDN 60 and above use CBCE nosecap assemblies as indicated.

Table 5.5-1 (Continued)
Standard CA Tooling

	6	7	8	9
Standard Tool Diameter Number (STDN)	 Flared Sleeve	 Mandrel	 Nosecap Assembly	 Gage Finish Reamer
60	CAS-60-16F	CAM-60-2-60-V2	MEN-26B-1201F	CAR-60-1-.****
61	CAS-61-16F	CAM-61-2-60-V2	MEN-26B-1201F	CAR-61-1-.****
62	CAS-62--16F	CAM-62-2-60-V2	MEN-26B-1223F	CAR-62-1-.****
63	CAS-63-16F	CAM-63-2-60-V2	MEN-26B-1223F	CAR-63-1-.****
70	CAS-70-16F	CAM-70-2-60-V2	MEN-26B-1401F	CAR-70-1-*.***
71	CAS-71-16F	CAM-71-2-60-V2	MEN-26B-1401F	CAR-71-1-.****
72	CAS-72-16F	CAM-72-2-60-V2	MEN-26B-1423F	CAR-72-1-.****
73	CAS-73-16F	CAM-73-2-60-V2	MEN-26B-1423F	CAR-73-1-.****
80	CAS-81-16F	CAM-80-2-60-V2	MEN-26B-1601F	CAR-80-1-.****
81	CAS-81-16F	CAM-81-2-60-V2	MEN-26B-1601F	CAR-81-1-.****
82	CAS-82-16F	CAM-82-2-60-V2	MEN-26B-1623F	CAR-82-1-.****
83	CAS-83-16F	CAM-83-2-60-V2	MEN-26B-1623F	CAR-83-1-.****
90	CAS-90-16F	CAM-90-2-60-V2	MEN-26B-1801F	CAR-90-1-.****
91	CAS-91-16F	CAM-91-2-60-V2	MEN-26B-1801F	CAR-91-1-.****
92	CAS-92-16F	CAM-92-2-60-V2	MEN-26B-1823F	CAR-92-1-.****
93	CAS-93-16F	CAM-93-2-60-V2	MEN-26B-1823F	CAR-93-1-.****
100	CAS-100-16F	CAM-100-2-60-V2	MEN-26B-2001F	CAR-100-1-.****
101	CAS-101-16F	CAM-101-2-60-V2	MEN-26B-2001F	CAR-101-1-.****
102	CAS-102-16F	CAM-102-2-60-V2	MEN-26C-2023F	CAR-102-1-.****
103	CAS-103-16F	CAM-103-2-60-V2	MEN-26C-2023F	CAR-103-1-.****
110	CAS-110-16F	CAM-110-2-60-V2	MEN-26C-2201F	CAR-110-1-.****
111	CAS-111-16F	CAM-111-2-60-V2	MEN-26C-2201F	CAR-111-1-.****

* All CA cutting tools are cobalt.
**** Denotes final hole diameter to be determined by customer.

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CR Tooling for Rework Cx in Aluminum and Mild Steel

Section		Page

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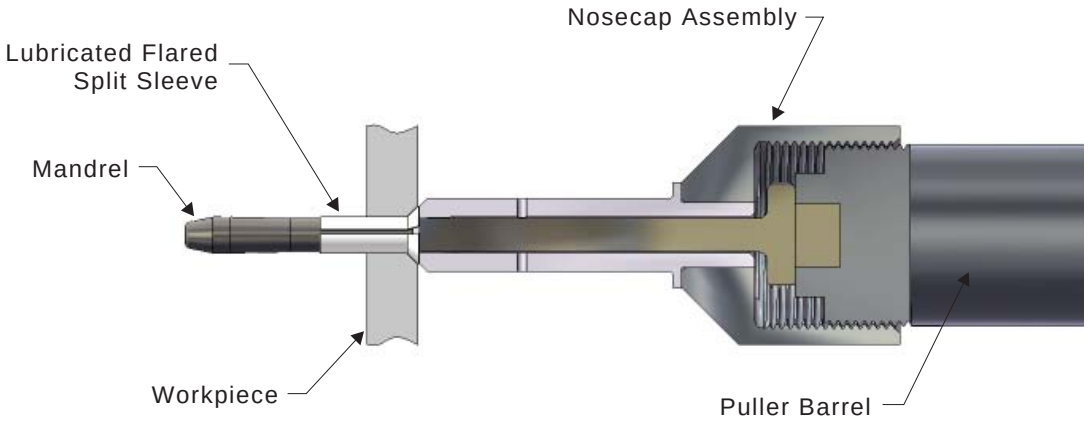

Figure 6.1-1
Rework Cold Expansion System Components

The Rework Cold Expansion (RwCx) tooling system, CR series, was specifically designed for rework applications. However, CR series tooling is also acceptable for new holes in the 3/16 to 3/8-inch diameter range. A system of standard tooling for nominal starting hole diameters has been developed for this split sleeve hole expansion process to simplify the procedure and minimize tooling inventory. (Use of RwCx tooling for new holes is the same as that described for the standard SsCx process using CB tooling.)

In rework, the procedure involves the removal of fasteners, clean up of the hole (and Non Destructive Inspection if applicable), pre-sizing the hole, split sleeve cold expansion, and post-sizing of the hole to accept a nominal 1/32-inch oversize fastener. Previously countersunk holes must be cold expanded using the special CsCx nosecap and straight sleeves.

A special tooling kit of durable and expendable CR tooling required to cold expand the most common hole sizes in aluminum structures may be purchased in a special Cold Expansion Overhaul and Repair Kit (CXORK-2A).

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1. Drill starting hole.

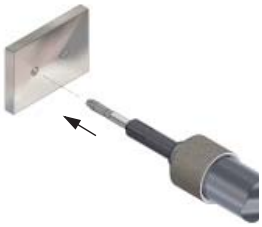
2. Ream starting hole.

3. Check starting hole diameter.

4. Inspect mandrel.

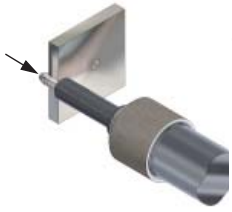
5. Slide split sleeve over mandrel.

6. Insert mandrel and split sleeve into starting hole.



7. Place nosecap firmly against workpiece.

8. Cold expand hole by pulling the mandrel through the pre-lubricated split sleeve.



9. Remove distorted sleeve.

10. Verify cold expansion.

11. Finish ream hole.

12. Install fastener.

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6.3 STDN SELECTION TABLE

How to select the Standard Tool Diameter Number:

1. Determine the final fastener diameter (1), or the existing fastener diameter (4).
2. Select the applicable size from Table 6.3-1.
3. Move across to the Standard Tool Diameter Number (STDN) (3).
4. With STDN go to Table 6.4-1 to determine the proper set of tooling.

Table 6.3-1
CR Tooling STDN Selection

Reference Final Fastener (inch)	Final Hole Diameter Range (inch)	Standard Tool Diameter Number (inch)	Existing Fastener Diameter (inch)	Maximum Existing Hole Diameter (inch)
3/16	.182 to .192	R30	5/32	.164
7/32	.214 to .224	R32	3/16	.194
1/4	.245 to .255	R40	13/64, 7/32	.224
9/32	.276 to .286	R42	1/4	.255
5/16	.307 to .317	R50	17/64, 9/32	.285
11/32	.339 to .349	R52	5/16	.317
3/8	.370 to .380	R60	21/64, 11/32	.347
13/32	.401 to .411	R62	3/8	.378

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1. To select a Standard Tool Diameter Number refer to Table 6.3-1.
2. With the STDN, select the system of Standard Tooling from Table 6.4-1.
3. Refer to Section 2.0, Detailed Tooling for complete description of parts.

Table 6.4-1
Standard CR Tooling

1	2	3	4	5	6
Standard Tool Diameter Number (STDN)	 Starting Drill	 Starting Reamer	 Combination Gage	 Mandrel Gage	 Flared Sleeve
R30	CRSD-R30-1	CRSR-R30-1	CRG-R30	CRMG-R30	CRS-R30-16F
R32	CRSD-R32-1	CRSR-R32-1	CRG-R32	CRMG-R32	CRS-R32-16F
R40	CRSD-R40-1	CRSR-R40-1	CRG-R40	CRMG-R40	CRS-R40-16F
R42	CRSD-R42-1	CRSR-R42-1	CRG-R42	CRMG-R42	CRS-R42-16F
R50	CRSD-R50-1	CRSR-R50-1	CRG-R50	CRMG-R50	CRS-R50-16F
R52	CRSD-R52-1	CRSR-R52-1	CRG-R52	CRMG-R52	CRS-R52-16F
R60	CRSD-R60-1	CRSR-R60-1	CRG-R60	CRMG-R60	CRS-R60-16F
R62	CRSD-R62-1	CRSR-R62-1	CRG-R62	CRMG-R62	CRS-R62-16F

7	8	9	10
Standard Tool Diameter Number (STDN)	 Mandrel	 Nosecap Assembly	 Gage Finish Reamer*	 Final Hole Gage**
R30	CRM-R30-1-30-V1	MEN-14A-0423F	CRR-R30-1-.****	CRFG-R30-1-.****/.****
R32	CRM-R32-1-30-V1	MEN-14A-0623F	CRR-R32-1-.****	CRFG-R32-1-.****/.****
R40	CRM-R40-1-40-V1	MEN-14A-0623F	CRR-R40-1-.****	CRFG-R40-1-.****/.****
R42	CRM-R42-1-40-V1	MEN-14A-0823F	CRR-R42-1-.****	CRFG-R42-1-.****/.****
R50	CRM-R50-1-40-V1	MEN-14A-1001F	CRR-R50-1-.****	CRFG-R50-1-.****/.****
R52	CRM-R52-1-40-V1	MEN-14A-1023F	CRR-R52-1-.****	CRFG-R52-1-.****/.****
R60	CRM-R60-1-40-V1	MEN-14A-1201F	CRR-R60-1-.****	CRFG-R60-1-.****/.****
R62	CRM-R62-1-40-V1	MEN-14A-1223F	CRR-R62-1-.****	CRFG-R62-1-.****/.****

* The diameter of the gage finish reamer, (represented by the last four digits in the model number, .****) is to be specified by customer.

** The go/no-go measurements of the final hole gage (represented by the last eight digits in the model number, .****/.****) are designed to accommodate the final hole diameter.

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6.5 COUNTERSINK TOOLING

To cold expand pre-countersunk holes, substitute the CRM mandrel, CRCE nosecap, and flared sleeve with the KRM mandrel, KRC nosecap, and straight sleeve found in Table 6.5-1.

Table 6.5-1
Alternative Tooling for Countersunk Holes

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 **Countersink Mandrel**	 **Countersink Nosecap Assembly**	 **Straight Sleeve**	 **Backup Block***
R30	KRM-R30-1-35-V1	KRC-R30-1A	CRS-R30-24S	KRBB-R30-1
R32	KRM-R32-1-35-V1	KRC-R32-1A	CRS-R32-24S	KRBB-R32-1
R40	KRM-R40-1-35-V1	KRC-R40-1A	CRS-R40-24S	KRBB-R40-1
R42	KRM-R42-1-35-V1	KRC-R42-1A	CRS-R42-24S	KRBB-R42-1
R50	KRM-R50-1-35-V1	KRC-R50-1A	CRS-R50-24S	KRBB-R50-1
R52	KRM-R52-1-35-V1	KRC-R52-1A	CRS-R52-24S	KRBB-R52-1
R60	KRM-R60-1-35-V1	KRC-R60-1A	CRS-R60-24S	KRBB-R60-1
R62	KRM-R62-1-35-V1	KRC-R62-1A	CRS-R62-24S	KRBB-R62-1

* The backup block is necessary when cold expanding countersunk holes in thin materials. Contact our Technical Sales Staff for more information.

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Cx2s in Aluminum

Section **Page**

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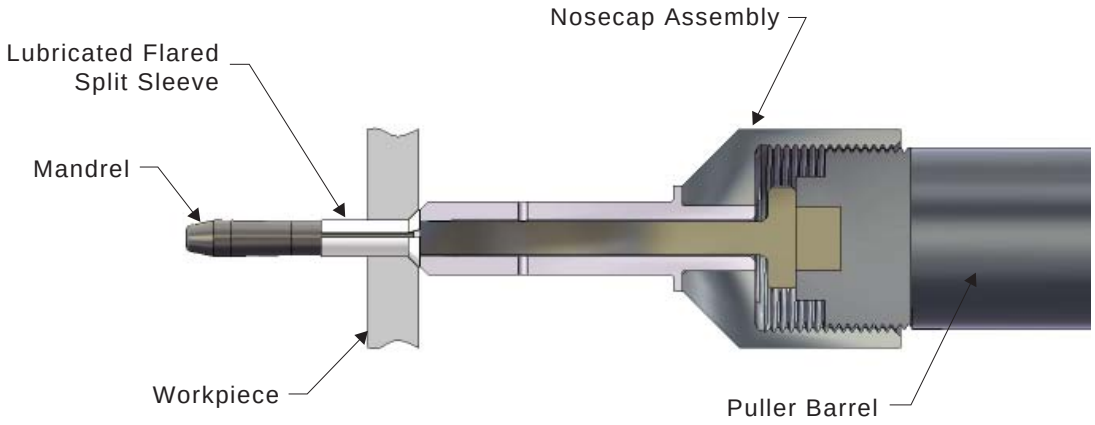

Figure 7.1-1
Cx2s System Components

The Split Sleeve Cold Expansion to Size System (Cx2s) simultaneously cold expands and final sizes holes and, if required, cold expands a countersink using the CsCx nosecap. Standard Cx2s tooling provides holes that result in specific amounts of fastener interference, or clearance, when used with standard fastener diameters (e.g., Hi-Lok™ or equivalent). Use of the Cx2s system reduces cold expansion processing to only one step, as compared to the basic Split Sleeve Cold Expansion system (SsCx). Although the Cx2s system is designed primarily for new production applications it has also been shown to be effective in rework applications. It is ideal for incorporating cold expansion into automated drilling/fastener insertion systems.

Tooling is selected based on:

1. The material(s) being cold expanded to size

2. The required fastener fit

3. The type of fastener system being used

Use of the appropriate Cx2s tooling results in a cold expanded hole with a .0015-inch total tolerance, better than that typically associated with conventional drilling/reaming operations.

This catalog shows Cx2s tooling that is designed to provide fastener fits in most of the common aerospace aluminum alloys. These fasteners range from high interference to clearance fit, Hi-Loks™, Huck blind bolts, and equivalent diameter fasteners for each fastener type. Fatigue Technology can design Cx2s Tooling for special applications. Contact our Technical Sales Staff for more information.

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1. Drill starting hole.

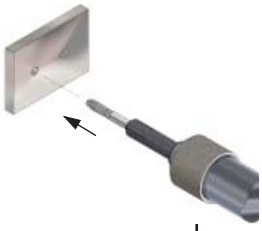
2. Ream starting hole.

3. Check starting hole diameter.

4. Inspect mandrel.

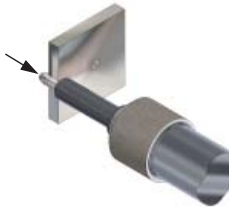
5. Slide split sleeve over mandrel.

6. Insert mandrel and split sleeve into starting hole.



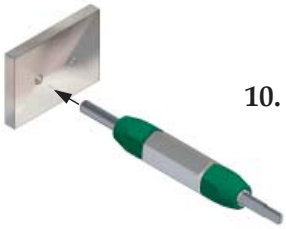
7. Place nosecap firmly against workpiece.

8. Cold expand hole by pulling the mandrel through the pre-lubricated split sleeve.



9. Remove distorted sleeve.

10. Verify cold expansion.



11. Install fastener.

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How to Determine the Standard Tool Diameter Number:

1. Determine the **Material Code** based upon the material to be cold expanded to size.

Table 7.3-1
Cx2s Material Code

Material Code	1	2	3	4	5	6	7
Appicable Material	NA	7178-T6	7075-T6 7050-T73 7150-T6	7075-T73 2014-T6	NA	2024-T3	NA

NA = Not Applicable

2. Determine the **Fastener Code** based upon the fastener system to be used.

Table 7.3-2
Cx2s Fastener Code

Fastener Code	1	2	3
Appicable Material	Hi-Lok or equivalent diameter	NA	Huck blind bolts or equivalent diameter

NA = Not Applicable

3. Determine the **Fastener Interference Level Code** based upon the desired fastener fit.

Table 7.3-3
Cx2s Fastener Interference Code

Fastener Interference Level Code	1 Light	2 High	3 Transition	4 Clearance
Maximum possible fastener interference range, inches (expected range)	.0010 to .0030 (.0015 to .0020)	.0025 to .0050 (.0030 to .0035)	.0005 to .0020 (.0000 to .0005)	.0040 to .0000 (.0015 to .0020)

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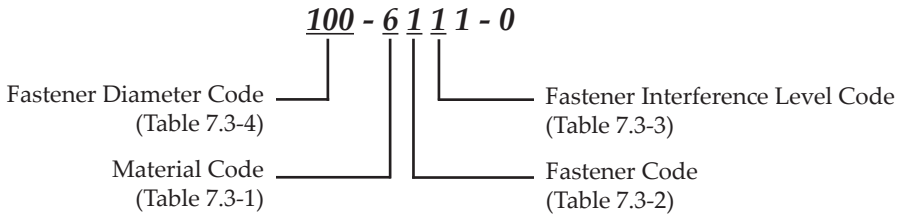
4. Determine the Fastener Diameter Code, based upon the fastener size to be used.

Table 7.3-4
Cx2s Material Code

Reference Final Fastener	Hi-Lok or equivalent diameter	Huck blind bolts or equivalent diameter
1/8	40	NA
9/64	41	NA
5/32	42	42
11/64	43	43
3/16	60	60
13/16	61	61
7/32	62	NA
15/64	63	NA
1/4	80	80
17/64	81	81
9/32	82	NA
19/64	83	NA
5/16	100	100
21/64	101	101
11/32	102	NA
23/64	103	NA
3/8	120	120
25/64	121	121
13/32	122	NA
27/64	123	NA

5. Construct the Cx2s STDN:



6. With STDN go to Table 7.4-1 to determine system of tooling.

7.4 STANDARD TOOLING

1. To select a Standard Tool Diameter Number refer to Tables 7.3-1 through 7.3-4.
2. After choosing the proper STDN, select the system of Standard Tooling from Table 7.4-1.

Table 7.4-1
Standard Cx2s KB2 Tooling

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 Starting Drill	 Starting Reamer	 Combination Gage	 Mandrel Gage
40-****-0	KB2SD-40-****-0-1	KB2SR-40-****-0-1	KB2G-40-****-0	KB2MG-40-****-0
41-****-0	KB2SD-41-****-0-1	KB2SR-41-****-0-1	KB2G-41-****-0	KB2MG-41-****-0
42-****-0	KB2SD-42-****-0-1	KB2SR-42-****-0-1	KB2G-42-****-0	KB2MG-42-****-0
43-****-0	KB2SD-43-****-0-1	KB2SR-43-****-0-1	KB2G-43-****-0	KB2MG-43-****-0
60-****-0	KB2SD-60-****-0-1	KB2SR-60-****-0-1	KB2G-60-****-0	KB2MG-60-****-0
61-****-0	KB2SD-61-****-0-1	KB2SR-61-****-0-1	KB2G-61-****-0	KB2MG-61-****-0
62-****-0	KB2SD-62-****-0-1	KB2SR-62-****-0-1	KB2G-62-****-0	KB2MG-62-****-0
63-****-0	KB2SD-63-****-0-1	KB2SR-63-****-0-1	KB2G-63-****-0	KB2MG-63-****-0
80-****-0	KB2SD-80-****-0-1	KB2SR-80-****-0-1	KB2G-80-****-0	KB2MG-80-****-0
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82-****-0	KB2SD-82-****-0-1	KB2SR-82-****-0-1	KB2G-82-****-0	KB2MG-82-****-0
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100-****-0	KB2SD-100-****-0-1	KB2SR-100-****-0-1	KB2G-100-****-0	KB2MG-100-****-0
101-****-0	KB2SD-101-****-0-1	KB2SR-101-****-0-1	KB2G-101-****-0	KB2MG-101-****-0
102-****-0	KB2SD-102-****-0-1	KB2SR-102-****-0-1	KB2G-102-****-0	KB2MG-102-****-0
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121-****-0	KB2SD-121-****-0-1	KB2SR-121-****-0-1	KB2G-121-****-0	KB2MG-121-****-0
122-****-0	KB2SD-122-****-0-1	KB2SR-122-****-0-1	KB2G-122-****-0	KB2MG-122-****-0
123-****-0	KB2SD-123-****-0-1	KB2SR-123-****-0-1	KB2G-123-****-0	KB2MG-123-****-0

**** Determined using Table 7.3-1 through 7.3-3.

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3. Refer to Section 2.0, Detailed Tooling for complete description of part.
4. To replace ****, refer to Step #5 in How to Construct the STDN.

Table 7.4-1 (Continued)
Standard Cx2s KB2 Tooling

	6	7	8
Standard Tool Diameter Number (STDN)	 Flared Sleeve	 Mandrel	 Nosecap Assembly
40-****-0	KB2S-40-****-0-16F	KB2M-40-****-0-1-35-V1	MEN-14A-0401F
41-****-0	KB2S-41-****-0-16F	KB2M-41-****-0-1-35-V1	MEN-14A-0401F
42-****-0	KB2S-42-****-0-16F	KB2M-42-****-0-1-35-V1	MEN-14A-0423F
43-****-0	KB2S-43-****-0-16F	KB2M-43-****-0-1-35-V1	MEN-14A-0423F
60-****-0	KB2S-60-****-0-16F	KB2M-60-****-0-1-35-V1	MEN-14A-0601F
61-****-0	KB2S-61-****-0-16F	KB2M-61-****-0-1-35-V1	MEN-14A-0601F
62-****-0	KB2S-62-****-0-16F	KB2M-62-****-0-1-35-V1	MEN-14A-0623F
63-****-0	KB2S-63-****-0-16F	KB2M-63-****-0-1-35-V1	MEN-14A-0623F
80-****-0	KB2S-80-****-0-16F	KB2M-80-****-0-1-35-V1	MEN-14A-0801F
81-****-0	KB2S-81-****-0-16F	KB2M-81-****-0-1-35-V1	MEN-14A-0801F
82-****-0	KB2S-82-****-0-16F	KB2M-82-****-0-1-35-V1	MEN-14A-0823F
83-****-0	KB2S-83-****-0-16F	KB2M-83-****-0-1-35-V1	MEN-14A-0823F
100-****-0	KB2S-100-****-0-16F	KB2M-100-****-0-1-35-V1	MEN-14A-1001F
101-****-0	KB2S-101-****-0-16F	KB2M-101-****-0-1-35-V1	MEN-14A-1001F
102-****-0	KB2S-102-****-0-16F	KB2M-102-****-0-1-35-V1	MEN-14A-1023F
103-****-0	KB2S-103-****-0-16F	KB2M-103-****-0-1-35-V1	MEN-14A-1023F
120-****-0	KB2S-120-****-0-16F	KB2M-120-****-0-1-35-V1	MEN-14A-1201F
121-****-0	KB2S-121-****-0-16F	KB2M-121-****-0-1-35-V1	MEN-14A-1201F
122-****-0	KB2S-122-****-0-16F	KB2M-122-****-0-1-35-V1	MEN-14A-1223F
123-****-0	KB2S-123-****-0-16F	KB2M-123-****-0-1-35-V1	MEN-14A-1223F

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7.5 COUNTERSINK TOOLING

To cold expand existing countersunk holes using Cx2s tooling, the countersink nosecap, mandrel, and straight sleeve must be used. A backup block may be necessary for countersunk holes in thin material. To assemble tooling for a countersunk hole, substitute the nosecap, mandrel, and sleeve found in Table 7.5-1 for those found in the same tooling set from Table 7.4-1.

For more information on cold expanding countersunk holes, refer to Section 8.0, Countersink Cold Expansion - CsCx.

Table 7.5-1
Alternative Tooling for Countersunk Holes

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 Countersink Mandrel	 Countersink Nosecap Assembly	 Straight Sleeve	 Backup Block*
40-****-0	KB2M-40-****-0-1-35-V1	KBC-040-1A	KB2S-40-****-0-24S	KB2SBB-40-****-0
41-****-0	KB2M-41-****-0-1-35-V1	KBC-041-1A	KB2S-41-****-0-24S	KB2SBB-41-****-0
42-****-0	KB2M-42-****-0-1-35-V1	KBC-042-1A	KB2S-42-****-0-24S	KB2SBB-42-****-0
43-****-0	KB2M-43-****-0-1-35-V1	KBC-043-1A	KB2S-43-****-0-24S	KB2SBB-43-****-0
60-****-0	KB2M-60-****-0-1-35-V1	KBC-060-1A	KB2S-60-****-0-24S	KB2SBB-60-****-0
61-****-0	KB2M-61-****-0-1-35V1	KBC-061-1A	KB2S-61-****-0-24S	KB2SBB-61-****-0
62-****-0	KB2M-62-****-0-1-35-V1	KBC-062-1A	KB2S-62-****-0-24S	KB2SBB-62-****-0
63-****-0	KB2M-63-****-0-1-35-V1	KBC-063-1A	KB2S-63-****-0-24S	KB2SBB-63-****-0
80-****-0	KB2M-80-****-0-1-35-V1	KBC-080-1A	KB2S-80-****-0-24S	KB2SBB-80-****-0
81-****-0	KB2M-81-****-0-1-35-V1	KBC-081-1A	KB2S-81-****-0-24S	KB2SBB-81-****-0
82-****-0	KB2M-82-****-0-1-35-V1	KBC-082-1A	KB2S-82-****-0-24S	KB2SBB-82-****-0
83-****-0	KB2M-83-****-0-1-35-V1	KBC-083-1A	KB2S-83-****-0-24S	KB2SBB-83-****-0
100-****-0	KB2M-100-****-0-1-35-V1	KBC-100-1A	KB2S-100-****-0-24S	KB2SBB-100-****-0
101-****-0	KB2M-101-****-0-1-35-V1	KBC-101-1A	KB2S-101-****-0-24S	KB2SBB-101-****-0
102-****-0	KB2M-102-****-0-1-35-V1	KBC-102-1A	KB2S-102-****-0-24S	KB2SBB-102-****-0
103-****-0	KB2M-103-****-0-1-35-V1	KBC-103-1A	KB2S-103-****-0-24S	KB2SBB-103-****-0
120-****-0	KB2M-120-****-0-1-35-V1	KBC-120-1A	KB2S-120-****-0-24S	KB2SBB-120-****-0
121-****-0	KB2M-121-****-0-1-35-V1	KBC-121-1A	KB2S-121-****-0-24S	KB2SBB-121-****-0
122-****-0	KB2M-122-****-0-1-35-V1	KBC-122-1A	KB2S-122-****-0-24S	KB2SBB-122-****-0
123-****-0	KB2M-123-****-0-1-35-V1	KBC-123-1A	KB2S-123-****-0-24S	KB2SBB-123-****-0

* The backup block is necessary when cold expanding countersunk holes in thin materials. Contact our Technical Sales Staff for more information.

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CsCx in Aluminum

Section **Page**

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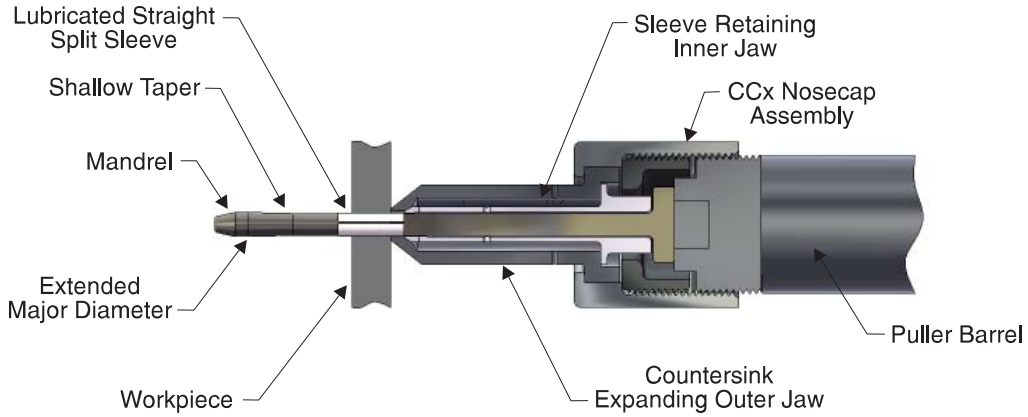


Figure 8.1-1
CsCx System Components

The Countersink Cold Expansion (CsCx) system of tooling is designed to simultaneously cold expand the countersink and the straight portion of a hole in new production or rework applications. The system is designed to be used in aluminum alloys and will coldwork countersunk holes from 3/16 to 27/64 inch diameters. A special nosecap and mandrel is used to cold expand 100-degree countersinks. Use of the CsCx nosecap assembly eliminates the requirement to machine countersinks subsequent to cold expansion as required by the SsCx process. The desired final hole diameter is obtained by reaming of the cold expanded hole, or by use of the Split Sleeve Cold Expansion to Size (Cx2s) system.

For special applications or sizes not covered in this tooling catalog, please contact our Technical Sales Staff.

1. Drill starting hole.

2. Ream starting hole.

3. Cut counter-sink.

4. Check starting hole diameter.

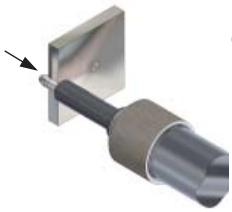
5. Inspect mandrel.

6. Cold expand hole - slide split sleeve over mandrel.

7. Insert mandrel and sleeve into starting hole with backup block (if necessary).

8. Place nosecap firmly against the workpiece.

9. Cold expand hole by pulling the mandrel through the pre-lubricated split sleeve.



10. Remove distorted sleeve.

11. Verify cold expansion.

12. Final ream hole (if necessary).

13. Install fastener.

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8.3 STDN SELECTION TABLES

If you are using CsCx tooling with the SsCx system, use Table 8.3-1 to select the STDN and Table 8.4-1 to select the tooling.

If you are using CsCx tooling with the Cx2s system, use Tables 8.3-2 to 8.3-5 to select the STDN and Table 8.4-2 to select the tooling.

1. Determine the final fastener diameter (1), or the existing fastener diameter (4).
2. Select the applicable size from Table 8.3-1.
3. Move across to the Standard Tool Diameter Number (STDN) (3).
4. With the STDN go to Table 8.4-1 to determine system of tooling.

Note: For metric conversion refer to Table A-1 and A-2 in Appendix A.

Table 8.3-1
CsCx Tooling STDN Selection

1	2	3	4	5
Reference Final Fastener (inch)	Final Hole Diameter Range (inch)	Standard Tool Diameter Number (STDN)	Existing Fastener Diameter (inch)	Maximum Existing Hole Diameter (inch
3/16	.183 to .193	4-4-N	5-32	.159
13/64	.198 to .208	6-0-N	5/32	.167
7/32	.214 to .224	6-1-N	11/64	.182
15/64	.229 to .239	6-2-N	3/16	.199
1/4	.245 to .255	6-3-N	13/64	.215
17/64	.261 to .271	8-0-N	7/32	.225
9/32	.276 to .286	8-1-N	15/64	.241
19/64	.292 to .302	8-2-N	1/4	.256
5/16	.308 to .318	8-3-N	17/64	.273
21/64	.323 to .333	10-0-N	9/32	.287
11/32	.339 to .349	10-1-N	19/64	.303
23/64	.354 to .364	10-2-N	5/16	.318
3/8	.370 to .380	10-3-N	21/64	.334
25/64	.386 to .396	12-0-N	11/32	.349
13/32	.401 to .411	12-1-N	23/64	.365
27/64	.417 to .427	12-2-N	3/8	.381
7/16	.433 to .443	12-3-N	25/64	.396

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If you are using CsCx tooling with the SsCx system, use Table 8.3-1 to select the STDN and Table 8.4-1 to select the tooling.

If you are using CsCx tooling with the Cx2s system, use Tables 8.3-2 to 8.3-5 to select the STDN and Table 8.4-2 to select the tooling.

How to Determine the Standard Tool Diameter Number:

1. Determine the **Material Code** based upon the material to be cold expanded to size.

Table 8.3-2
CsCx (2s) Material Code

Material Code	1	2	3	4	5	6	7
Applicable Material	NA	7178-T6	7075-T6 7050-T73 7150-T6	7075-T73 2014-T6	NA	2024-T3	NA

2. Determine the **Fastener Code** based upon the fastener system to be used.

Table 8.3-3
CsCx (2s) Fastener Code

Fastener Code	1	2	3
Applicable Material	Hi-Lok or equivalent diameter	NA	Huck blind bolts or equivalent diameter

3. Determine the **Fastener Interference Level Code** based upon the desired fastener fit.

Table 8.3-4
CsCx (2s) Fastener Interference Level Code

Fastener Interference Level Code	1 Light	2 High	3 Transition	4 Clearance
Maximum possible fastener interference range, inches (expected range)	.0010 to .0035 (.0015 to .0020)	.0025 to .0050 (.0030 to .0035)	.0005 to .0020 (.0000 to .0005)	.0040 to .0000 (.0015 to .0020)

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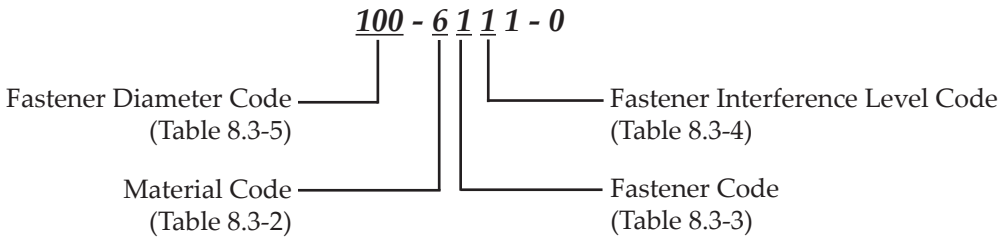
4. Determine the **Fastener Diameter Code** based upon the fastener size to be used.

Table 8.3-5
Fastener Diameter Code

Reference Final Fastener	Hi-Lok or Equivalent Diameter	Huck Blind Bolt or Equivalent Diameter
1/8	40	NA
9/64	41	NA
5/32	42	42
11/64	43	43
3/16	60	60
13/64	61	61
7/32	62	NA
15/64	63	NA
1/4	80	80
17/64	81	81
9/32	82	NA
19/64	83	NA
5/16	10	100
21/64	101	101
11/32	102	NA
23/64	103	NA
3/8	120	120
25/64	121	121
13/32	122	NA
27/64	123	NA

NA = Not Applicable.

5. Construct the Cx2s STDN.



6. With the STDN, go to Table 8.4-1 to determine the system of tooling.

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8.4 STANDARD TOOLING

1. To select a Standard Tool Diameter Number, refer to Table 8.3-1.

2. With the STDN, select the system of Standard Tooling from the table below.

Table 8.4-1
Standard CsCx Tooling

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 Starting Drill	 Starting Reamer	 Combination Gage	 Mandrel Gage
4-0-N	CBSD-4-0-N-1	CBSR-4-0-N-1	CBG-4-0-N-1	CBMG-4-0-N
4-1-N	CBSD-4-1-N-1	CBSR-4-1-N-1	CBG-4-1-N-1	CBMG-4-1-N
4-2-N	CBSD-4-2-N-1	CBSR-4-2-N-1	CBG-4-2-N-1	CBMG-4-2-N
4-3-N	CBSD-4-3-N-1	CBSR-4-3-N-1	CBG-4-3-N-1	CBMG-4-3-N
4-4-N	CBSD-4-4-N-1	CBSR-4-4-N-1	CBG-4-4-N-1	CBMG-4-4-N
6-0-N	CBSD-6-0-N-1	CBSR-6-0-N-1	CBG-6-0-N-1	CBMG-6-0-N
6-1-N	CBSD-6-1-N-1	CBSR-6-1-N-1	CBG-6-1-N-1	CBMG-6-1-N
6-2-N	CBSD-6-2-N-1	CBSR-6-2-N-1	CBG-6-2-N-1	CBMG-6-2-N
6-3-N	CBSD-6-3-N-1	CBSR-6-3-N-1	CBG-6-3-N-1	CBMG-6-3-N
8-0-N	CBSD-8-0-N-1	CBSR-8-0-N-1	CBG-8-0-N-1	CBMG-8-0-N
8-1-N	CBSD-8-1-N-1	CBSR-8-1-N-1	CBG-8-1-N-1	CBMG-8-1-N
8-2-N	CBSD-8-2-N-1	CBSR-8-2-N-1	CBG-8-2-N-1	CBMG-8-2-N
8-3-N	CBSD-8-3-N-1	CBSR-8-3-N-1	CBG-8-3-N-1	CBMG-8-3-N
10-0-N	CBSD-10-0-N-1	CBSR-10-0-N-1	CBG-10-0-N-1	CBMG-10-0-N
10-1-N	CBSD-10-1-N-1	CBSR-10-1-N-1	CBG-10-1-N-1	CBMG-10-1-N
10-2-N	CBSD-10-2-N-1	CBSR-10-2-N-1	CBG-10-2-N-1	CBMG-10-2-N
10-3-N	CBSD-10-3-N-1	CBSR-10-3-N-1	CBG-10-3-N-1	CBMG-10-3-N
12-0-N	CBSD-12-0-N-1	CBSR-12-0-N-1	CBG-12-0-N-1	CBMG-12-0-N
12-1-N	CBSD-12-1-N-1	CBSR-12-1-N-1	CBG-12-1-N-1	CBMG-12-1-N
12-2-N	CBSD-12-2-N-1	CBSR-12-2-N-1	CBG-12-2-N-1	CBMG-12-2-N
12-3-N	CBSD-12-3-N-1	CBSR-12-3-N-1	CBG-12-3-N-1	CBMG-12-3-N

3. Refer to Section 2.0 Detailed Tooling for complete description of part.

4. To replace ****, refer to the subsection on Gage Finish Reamers in Section 2.0, Detailed Tooling.

Table 8.4-1 (Continued)
Standard CsCx Tooling

	6	7	8	9
Standard Tool Diameter Number (STDN)	 Straight Sleeve	 Countersink Mandrel	 Countersink Nosecap	 Gage Finish Reamer
4-0-N	CBS-4-0-N-24S	KBM-4-0-N-1-35-V1	KBC-040-1A	CBR-4-0-N-1-.****
4-1-N	CBS-4-1-N-24S	KBM-4-1-N-1-35-V1	KBC-041-1A	CBR-4-1-N-1-.****
4-2-N	CBS-4-2-N-24S	KBM-4-2-N-1-35-V1	KBC-042-1A	CBR-4-2-N-1-.****
4-3-N	CBS-4-3-N-24S	KBM-4-3-N-1-35-V1	KBC-043-1A	CBR-4-3-N-1-.****
4-4-N	CBS-4-4-N-24S	KBM-4-4-N-1-35-V1	KBC-044-1A	CBR-4-4-N-1-.****
6-0-N	CBS-6-0-N-24S	KBM-6-0-N-1-35-V1	KBC-060-1A	CBR-6-0-N-1-.****
6-1-N	CBS-6-1-N-24S	KBM-6-1-N-1-35-V1	KBC-061-1A	CBR-6-1-N-1-.****
6-2-N	CBS-6-2-N-24S	KBM-6-2-N-1-35-V1	KBC-062-1A	CBR-6-2-N-1-.****
6-3-N	CBS-6-3-N-24S	KBM-6-3-N-1-35-V1	KBC-063-1A	CBR-6-3-N-1-.****
8-0-N	CBS-8-0-N-24S	KBM-8-0-N-1-35-V1	KBC-080-1A	CBR-8-0-N-1-.****
8-1-N	CBS-8-1-N-24S	KBM-8-1-N-1-35-V1	KBC-081-1A	CBR-8-1-N-1-.****
8-2-N	CBS-8-2-N-24S	KBM-8-2-N-1-35-V1	KBC-082-1A	CBR-8-2-N-1-.****
8-3-N	CBS-8-3-N-24S	KBM-8-3-N-1-35-V1	KBC-083-1A	CBR-8-3-N-1-.****
10-0-N	CBS-10-0-N-24S	KBM-10-0-N-1-35-V1	KBC-100-1A	CBR-10-0-N-1-.****
10-1-N	CBS-10-1-N-24S	KBM-10-1-N-1-35-V1	KBC-101-1A	CBR-10-1-N-1-.****
10-2-N	CBS-10-2-N-24S	KBM-10-2-N-1-35-V1	KBC-102-1A	CBR-10-2-N-1-.****
10-3-N	CBS-10-3-N-24S	KBM-10-3-N-1-35-V1	KBC-103-1A	CBR-10-3-N-1-.****
12-0-N	CBS-12-0-N-24S	KBM-12-0-N-1-35-V1	KBC-120-1A	CBR-12-0-N-1-.****
12-1-N	CBS-12-1-N-24S	KBM-12-1-N-1-35-V1	KBC-121-1A	CBR-12-1-N-1-.****
12-2-N	CBS-12-2-N-24S	KBM-12-2-N-1-35-V1	KBC-122-1A	CBR-12-2-N-1-.****
12-3-N	CBS-12-3-N-24S	KBM-12-3-N-1-35-V1	KBC-123-1A	CBR-12-3-N-1-.****

**** Denotes final hole diameter to be determined by customer.

1. To select a Standard Tool Diameter Number, refer to Table 8.3-1.

2. With the STDN, select the system of Standard Tooling from the Table 8.4-2.

Table 8.4-2
Standard CsCx Tooling

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 Starting Drill	 Starting Reamer	 Combination Gage	 Mandrel Gage
14-0-N	CBSD-14-0-N-1	CBSR-14-0-N-1	CBG-14-0-N-1	CBMG-14-0-N
14-1-N	CBSD-14-1-N-1	CBSR-14-1-N-1	CBG-14-1-N-1	CBMG-14-1-N
14-2-N	CBSD-14-2-N-1	CBSR-14-2-N-1	CBG-14-2-N-1	CBMG-14-2-N
14-3-N	CBSD-14-3-N-1	CBSR-14-3-N-1	CBG-14-3-N-1	CBMG-14-3-N
16-0-N	CBSD-16-0-N-1	CBSR-16-0-N-1	CBG-16-0-N-1	CBMG-16-0-N
16-1-N	CBSD-16-1-N-1	CBSR-16-1-N-1	CBG-16-1-N-1	CBMG-16-1-N
16-2-N	CBSD-16-2-N-1	CBSR-16-2-N-1	CBG-16-2-N-1	CBMG-16-2-N
16-3-N	CBSD-16-3-N-1	CBSR-16-3-N-1	CBG-16-3-N-1	CBMG-16-3-N
18-0-N	CBSD-18-0-N-1	CBSR-18-0-N-1	CBG-18-0-N-1	CBMG-18-0-N
18-1-N	CBSD-18-1-N-1	CBSR-18-1-N-1	CBG-18-1-N-1	CBMG-18-1-N
18-2-N	CBSD-18-2-N-1	CBSR-18-2-N-1	CBG-18-2-N-1	CBMG-18-2-N
18-3-N	CBSD-18-3-N-1	CBSR-18-3-N-1	CBG-18-3-N-1	CBMG-18-3-N
20-0-N	CBSD-20-0-N-1	CBSR-20-0-N-1	CBG-20-0-N-1	CBMG-20-0-N
20-1-N	CBSD-20-1-N-1	CBSR-20-1-N-1	CBG-20-1-N-1	CBMG-20-1-N
20-2-N	CBSD-20-2-N-1	CBSR-20-2-N-1	CBG-20-2-N-1	CBMG-20-2-N
20-3-N	CBSD-20-3-N-1	CBSR-20-3-N-1	CBG-20-3-N-1	CBMG-20-3-N

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3. Refer to Section 2.0 Detailed Tooling for complete description of part.

4. To replace ****, refer to the subsection on Gage Finish Reamers in Section 2.0 Detailed Tooling.

Table 8.4-2 (Continued)
Standard CsCx Tooling

	6	7	8	9
Standard Tool Diameter Number (STDN)	 Straight Sleeve	 Countersink Mandrel	 Countersink Nosecap	 Gage Finish Reamer
14-0-N	CBS-14-0-N-24S	KBM-14-0-N-2-35-V1	KBC-140-2A	CBR-14-0-N-1-.****
14-1-N	CBS-14-1-N-24S	KBM-14-1-N-2-35-V1	KBC-141-2A	CBR-14-1-N-1-.****
14-2-N	CBS-14-2-N-24S	KBM-14-2-N-2-35-V1	KBC-142-2A	CBR-14-2-N-1-.****
14-3-N	CBS-14-3-N-24S	KBM-14-3-N-2-35-V1	KBC-143-2A	CBR-14-3-N-1-.****
16-0-N	CBS-16-0-N-24S	KBM-16-0-N-2-35-V1	KBC-160-2A	CBR-16-0-N-1-.****
16-1-N	CBS-16-1-N-24S	KBM-16-1-N-2-35-V1	KBC-161-2A	CBR-16-1-N-1-.****
16-2-N	CBS-16-2-N-24S	KBM-16-2-N-2-35-V1	KBC-162-2A	CBR-16-2-N-1-.****
16-3-N	CBS-16-3-N-24S	KBM-16-3-N-2-35-V1	KBC-163-2A	CBR-16-3-N-1-.****
18-0-N	CBS-18-0-N-24S	KBM-18-0-N-2-35-V1	KBC-180-2A	CBR-18-0-N-1-.****
18-1-N	CBS-18-1-N-24S	KBM-18-1-N-2-35-V1	KBC-181-2A	CBR-18-1-N-1-.****
18-2-N	CBS-18-2-N-24S	KBM-18-2-N-2-35-V1	KBC-182-2A	CBR-18-2-N-1-.****
18-3-N	CBS-18-3-N-24S	KBM-18-3-N-2-35-V1	KBC-183-2A	CBR-18-3-N-1-.****
20-0-N	CBS-20-0-N-24S	KBM-20-0-N-2-35-V1	KBC-200-2A	CBR-20-0-N-1-.****
20-1-N	CBS-20-1-N-24S	KBM-20-1-N-2-35-V1	KBC-201-2A	CBR-20-1-N-1-.****
20-2-N	CBS-20-2-N-24S	KBM-20-2-N-2-35-V1	KBC-202-2A	CBR-20-2-N-1-.****
20-3-N	CBS-20-3-N-24S	KBM-20-3-N-2-35-V1	KBC-203-2A	CBR-20-3-N-1-.****

**** Denotes final hole diameter to be determined by customer.

1. To select a Standard Tool Diameter Number, refer to Table 8.3-2 through 8.3-5.
2. With the STDN, select the system of Standard Tooling from the Table 8.4-3.

Table 8.4-3
Standard CsCx Tooling

1	2	3	4	5
Standard Tool Diameter Number (STDN)	 **Starting Drill**	 **Starting Reamer**	 **Combination Gage**	 **Mandrel Gage**
40-****-0	KB2SD-40-****-0-1	KB2SR-40-****-0-1	KB2G-40-****-0	KB2MG-40-****-0
41-****-0	KB2SD-41-****-0-1	KB2SR-41-****-0-1	KB2G-41-****-0	KB2MG-41-****-0
42-****-0	KB2SD-42-****-0-1	KB2SR-42-****-0-1	KB2G-42-****-0	KB2MG-42-****-0
43-****-0	KB2SD-43-****-0-1	KB2SR-43-****-0-1	KB2G-43-****-0	KB2MG-43-****-0
60-****-0	KB2SD-60-****-0-1	KB2SR-60-****-0-1	KB2G-60-****-0	KB2MG-60-****-0
61-****-0	KB2SD-61-****-0-1	KB2SR-61-****-0-1	KB2G-61-****-0	KB2MG-61-****-0
62-****-0	KB2SD-62-****-0-1	KB2SR-62-****-0-1	KB2G-62-****-0	KB2MG-62-****-0
63-****-0	KB2SD-63-****-0-1	KB2SR-63-****-0-1	KB2G-63-****-0	KB2MG-63-****-0
80-****-0	KB2SD-80-****-0-1	KB2SR-80-****-0-1	KB2G-80-****-0	KB2MG-80-****-0
81-****-0	KB2SD-81-****-0-1	KB2SR-81-****-0-1	KB2G-81-****-0	KB2MG-81-****-0
82-****-0	KB2SD-82-****-0-1	KB2SR-82-****-0-1	KB2G-82-****-0	KB2MG-82-****-0
83-****-0	KB2SD-83-****-0-1	KB2SR-83-****-0-1	KB2G-83-****-0	KB2MG-83-****-0
100-****-0	KB2SD-100-****-0-1	KB2SR-100-****-0-1	KB2G-100-****-0	KB2MG-100-****-0
101-****-0	KB2SD-101-****-0-1	KB2SR-101-****-0-1	KB2G-101-****-0	KB2MG-101-****-0
102-****-0	KB2SD-102-****-0-1	KB2SR-102-****-0-1	KB2G-102-****-0	KB2MG-102-****-0
103-****-0	KB2SD-103-****-0-1	KB2SR-103-****-0-1	KB2G-103-****-0	KB2MG-103-****-0
120-****-0	KB2SD-120-****-0-1	KB2SR-120-****-0-1	KB2G-120-****-0	KB2MG-120-****-0
121-****-0	KB2SD-121-****-0-1	KB2SR-121-****-0-1	KB2G-121-****-0	KB2MG-121-****-0
122-****-0	KB2SD-122-****-0-1	KB2SR-122-****-0-1	KB2G-122-****-0	KB2MG-122-****-0
123-****-0	KB2SD-123-****-0-1	KB2SR-123-****-0-1	KB2G-123-****-0	KB2MG-123-****-0

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3. Refer to Section 2.0 Detailed Tooling for complete description of part.

4. To replace ****, refer to Tables 7.3-1 through 7.3-4 in Section 7.0 Cx2s Tooling.

Table 8.4-3 (Continued)
Standard CsCx Tooling

6	7	8	9
Straight Sleeve	Mandrel	Countersink Nosecap	Backup Block*
KB2S-40-****-0-16S	KB2M-40-****-0-1-35-V1	KBC-040-1A	KB2BB-40-****-0
KB2S-41-****-0-16S	KB2M-41-****-0-1-35-V1	KBC-041-1A	KB2BB-41-****-0
KB2S-42-****-0-16S	KB2M-42-****-0-1-35-V1	KBC-042-1A	KB2BB-42-****-0
KB2S-43-****-0-16S	KB2M-43-****-0-1-35-V1	KBC-043-1A	KB2BB-43-****-0
KB2S-60-****-0-16S	KB2M-60-****-0-1-35-V1	KBC-060-1A	KB2BB-60-****-0
KB2S-61-****-0-16S	KB2M-61-****-0-1-35-V1	KBC-061-1A	KB2BB-61-****-0
KB2S-62-****-0-16S	KB2M-62-****-0-1-35-V1	KBC-062-1A	KB2BB-62-****-0
KB2S-63-****-0-16S	KB2M-63-****-0-1-35-V1	KBC-063-1A	KB2BB-63-****-0
KB2S-80-****-0-16S	KB2M-80-****-0-1-35-V1	KBC-080-1A	KB2BB-80-****-0
KB2S-81-****-0-16S	KB2M-81-****-0-1-35-V1	KBC-081-1A	KB2BB-81-****-0
KB2S-82-****-0-16S	KB2M-82-****-0-1-35-V1	KBC-082-1A	KB2BB-82-****-0
KB2S-83-****-0-16S	KB2M-83-****-0-1-35-V1	KBC-083-1A	KB2BB-83-****-0
KB2S-100-****-0-16S	KB2M-100-****-0-1-35-V1	KBC-100-1A	KB2BB-100-****-0
KB2S-101-****-0-16S	KB2M-101-****-0-1-35-V1	KBC-101-1A	KB2BB-101-****-0
KB2S-102-****-0-16S	KB2M-102-****-0-1-35-V1	KBC-102-1A	KB2BB-102-****-0
KB2S-103-****-0-16S	KB2M-103-****-0-1-35-V1	KBC-103-1A	KB2BB-103-****-0
KB2S-120-****-0-16S	KB2M-120-****-0-1-35-V1	KBC-120-1A	KB2BB-120-****-0
KB2S-121-****-0-16S	KB2M-121-****-0-1-35-V1	KBC-121-1A	KB2BB-121-****-0
KB2S-122-****-0-16S	KB2M-122-****-0-1-35-V1	KBC-122-1A	KB2BB-122-****-0
KB2S-123-****-0-16S	KB2M-123-****-0-1-35-V1	KBC-123-1A	KB2BB-123-****-0

Standard Tool Diameter Number (STDN)

* Backup Block for thin stackup.
**** Denotes final hole diameter to be determined by customer.

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SEMI-AUTOMATIC CX IN ALUMINUM

Section **Page**

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9.1 PROCESS DESCRIPTION

Fatigue Technology's patented Semi-Automatic Cold Expansion (SaCx) procedure is a means of facilitating the implementation of high-volume applications of the Split Sleeve Cold Expansion Systems (Cx Systems). Originally designed for new production operations, the procedure is also adaptable to large rework/repair applications.

General Description

Use of the complete SaCx system provides process implementation assistance for three aspects of Split Sleeve Cold Expansion (Cx) or Split Sleeve Cold Expansion to Size (Cx2s):

- Split sleeve loading
- Split sleeve removal from the cold expanded hole
- Split sleeve disposal

The sleeve loading function of SaCx may be used independently of the sleeve removal/disposal functions if desired, and vice versa.

With the exception of the items noted in this section, all other engineering and tooling requirements of FTI Process Specifications 8101 or 8201, or appropriate corporate process specifications, apply.

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Cold expansion with the SaCx system is performed with conventional Cx or Cx2s tooling with the following additions and substitutions:

1. **SaCx Sleeve Loader:** The sleeve loader is a device for placing split sleeves on the expansion mandrel. To achieve the most efficient utilization of the SaCx system, the sleeve loader is carried on a unique design SaCx operator apron. Each nominal size sleeve loader is also capable of loading the first oversize (1/64) sleeve. Each sleeve loader is configured to accept -24S (1.5 inches) length straight split sleeves but is capable of being re-configured to accommodate -16S (1 inch) length and -37S (2.3 inches) straight split sleeves.

   Although the sleeve loader is designed primarily for use with the complete SaCx system, it can also be used for facilitating straight sleeve loading for other non-automated applications of cold expansion. Contact Fatigue Technology for further information.

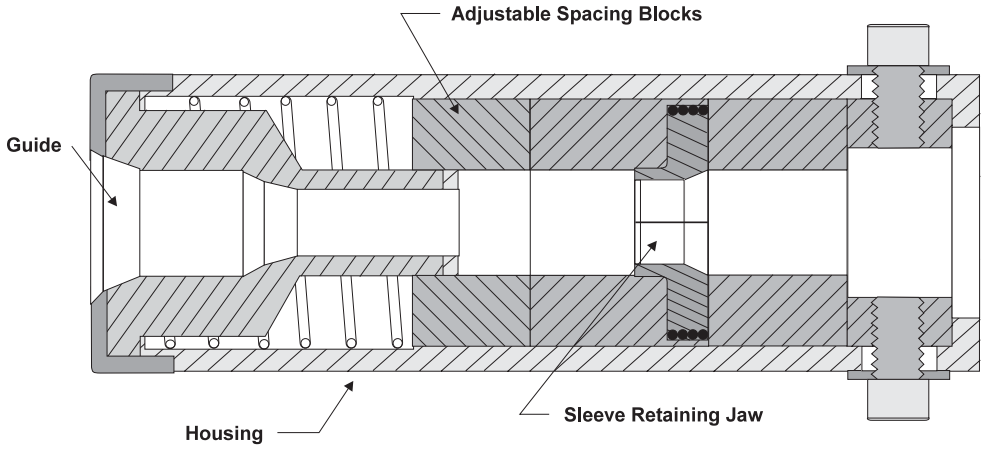

Figure 9.2-1
SaCx Sleeve Loader

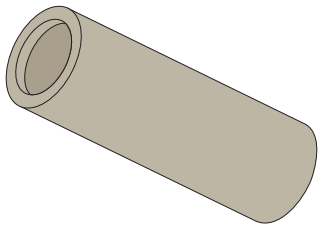

Figure 9.2-2
SaCx Sleeve Loader

2. **SaCx Operator Apron:** The SaCx operator apron is designed to carry the SaCx sleeve loader in the most efficient position for loading and disposing of split sleeves. The apron has pouches for supplies of new sleeves and for disposal of used sleeves. There is also a holder for an FTI combination gage or stamp gage used to check starting hole tolerance and to verify cold expansion. A belt clip is provided for hanging an FTI mandrel gage, so that frequent inspection of the mandrel major diameter can be performed.

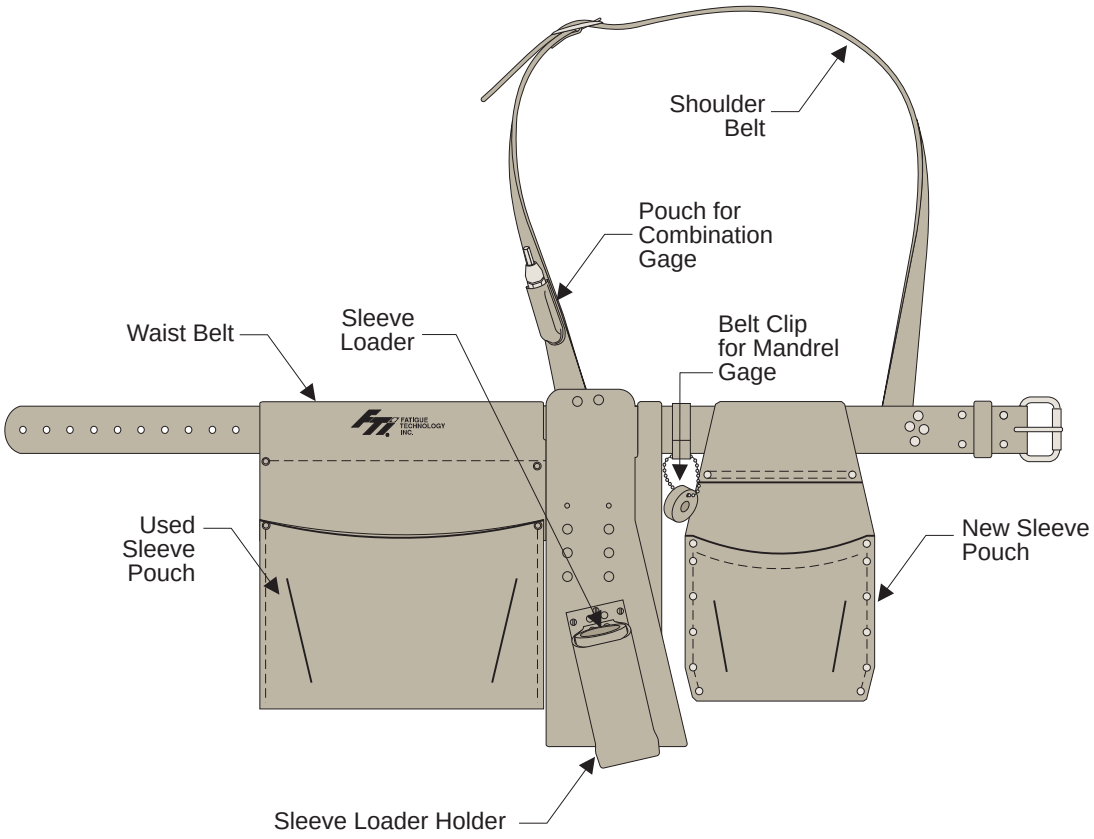

Figure 9.2-3
SaCx Operator Apron

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3. **SaCx Nosecap Assembly:** The SaCx nosecap assembly is used in lieu of the conventional Cx or Countersink Cold Expansion (CsCx) nosecap assemblies called out by the appropriate process specification. The SaCx nosecap removes the used split sleeve from the hole and allows disposal of the used sleeve into the used sleeve pouch on the SaCx operator apron or other suitable receptacle. The SaCx nosecap is used for both straight holes and as a direct substitute for the CsCx nosecap, for holes with existing countersinks.

Figure 9.2-4
SaCx Nosecap Assembly

4. **SaCx Puller Units:** Special design Little Brute Puller Units, series LB-XXAT, are used with the SaCx system in lieu of conventional LB-XX series puller units. The LB-XXAT puller units may also be used for conventional cold expansion.

Figure 9.3-1
SaCx Puller Unit

SYSTEM LIMITATIONS

Cold expansion with the SaCx system is subject to the following limitations:

- The SaCx system can be used with Cx or Cx2s tooling with reference diameters from 3/16 to 3/8 inch, nominal and first oversize (1/64).
- The SaCx system can only be used in aluminum structures.
- The SaCx system requires the use of straight split sleeves.
- Stacking of split sleeves is not permitted (although the sleeve loader can be used to facilitate loading of the first sleeve in a stacked sleeve combination).
- The system can be used with material stackups up to 2.25 inches (through use of -37S split sleeves).

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Incorporation of SaCx into an application of conventional Cx or Cx2s involves the following steps, subject to the limitations noted in section 9.3. These steps assume no restricted access situations or other such limitations (contact Fatigue Technology for assistance). As noted previously, a working knowledge of Cold Expansion systems is presumed.

STEP 1. Determine the proper Cx or Cx2s Standard Tool Diameter Number (STDN) based on normal cold expansion tooling selection criteria, as detailed in FTI Process Specifications 8101 or 8201, corporate process specification, engineering drawing, etc.

STEP 2. Determine maximum stackup to be cold expanded for each STDN and then select minimum required length for straight sleeves per the directions in Appendix A of either 8101 or 8201, paragraph A.3.2.2. FTI recommends the selection of the longest length sleeves for all holes of each STDN, regardless of stackup. This will minimize inventory requirements, eliminate sorting of sleeve lengths at the work site, and eliminate repeated re-configuring of the SaCx sleeve loader. For example, if cold expansion requirements for a particular STDN include -16S (1 inch) and -24S (1.5 inches) length sleeves, it would be more efficient to use the -24S length sleeves for both stackups.

STEP 3. Using Table 9.4-1, determine the mandrel length callout based upon the sleeve length selected in STEP 2. The construction of the remainder of the mandrel model number is explained in FTI 8101. For example, if a -35 length mandrel is required for SaCx with STDN 6-3-N tooling, then the mandrel model number will be CBM-6-3-N-1-35-V1. If a -40 length mandrel is required for SaCx with STDN KB2 100-6111 tooling, then the mandrel model number will be KB2M-100-6111-0-1-40-V1.

Table 9.4-1
Mandrel Length Requirements

Sleeve Length Requirements	Mandrel Length Callout
-16S	-30
-16S, -24S	-35
-16S, -24S, -37S	-40

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STEP 4. Using Table 9.4-2, determine the appropriate LB-XXAT puller unit, based on the mandrel length required. Note that the designated puller units may also be used for applications requiring shorter mandrel/sleeve lengths. For example, if a -35 length mandrel is to be used, then an LB-25AT or an LB-30AT puller unit is required. If a -40 length mandrel is to be used, then an LB-30AT or an LB-35AT puller unit is required. Note also that "AT" series puller units may also be utilized for routine (non-SaCx) cold expansion processing.

Table 9.4-2
Puller Unit Requirements

Mandrel Length Callout	Minimum Stroke Puller Unit
-30	LB-20AT
-35	LB-25AT
-40	LB-30AT LB-35AT

STEP 5. Using Table 9.4-3, select the sleeve loader and nosecap assembly based upon the STDN from STEP 1 above. Note that the sleeve loaders are designed such that a single loader is used for nominal and first oversize.

Table 9.4-3
Nosecap/Sleeve Loader Requirements

Reference Diameter	Applicable STDN*	Nosecap Assembly	Sleeve Loader
3/16	CB 4-4-N KB 4-4-N KB2 60-XXXX	KBC-044-AT KBC-044-AT KBC-060-AT	FTSL-60 FTSL-60 FTSL-60
13/64	CB 6-0-N KB 6-0-N KB2 61-XXXX	KBC-060-AT KBC-060-AT KBC-061-AT	FTSL-60 FTSL-60 FTSL-60
1/4	CB 6-3-N KB 6-3-N KB2 80-XXXX	KBC-063-AT KBC-063-AT KBC-080-AT	FTSL-63 FTSL-63 FTSL-80
17/64	CB 8-0-N KB 8-0-N KB2 80-XXXX	KBC-080-AT KBC-080-AT KBC-081-AT	FTSL-80 FTSL-80 FTSL-80
5/16	CB 8-3-N KB 8-3-N KB2 81-XXXX	KBC-083-AT KBC-083-AT KBC-100-AT	FTSL-83 FTSL-83 FTSL-100
21/64	CB 10-0-N KB 10-0-N KB2 101-XXXX	KBC-100-AT KBC-100-AT KBC-101-AT	FTSL-100 FTSL-100 FTSL-100
3/8	CB 10-3-N KB 10-3-N KB2 120-XXXX	KBC-103-AT KBC-103-AT KBC-120-AT	FTSL-103 FTSL-103 FTSL-120

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STEP 6. Select cutting tools, combination gages, stamp gages, and mandrel gages per FTI 8101, 8201, or FTI Tooling Catalog. The model number for the SaCx Operator Apron is:

FTTB-1 Right hand version

FTTB-2 Left hand version

STEP 7. Write manufacturing process documentation, technique sheets, etc. per the process methodology given in FTI Engineering Handbook EH-5.

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10.1 PROCESS DEFINITION

Fatigue Technology's patented ForceMate® system (FmCx™) provides an alternative to traditional interference fit bushing installation methods. Use of the system results in consistent high interference bushing installations and enhanced fatigue life performance at a reduced installation cost. The FmCx system consists of integrated technology and tooling, including FmCx bushings, mandrels, nosecaps, gages, support assemblies, cutting tools, puller units, special fixturing, as well as product training. Successful implementation and process effectiveness are assured through use of the complete FTI FmCx system. Some of the benefits include:

- **Reduced installation cost:**
  Eliminates the need for cryogenic liquids and significantly reduces installation labor.
- **Significant life improvement:**
  Beneficial residual compressive stresses are created around the hole and the bushing is installed with high interference.
- **Increased resistance to corrosion:**
  The high interference fit precludes the intrusion of corrosion products between the bushing and the hole wall. Initial clearance fit ensures that corrosion protection coatings (e.g., cadmium plating) remain intact.
- **High resistance to rotation and pushout:**
  The high interference fit provides for greater resistance to rotation or pushout than conventional bushing installation techniques.

The FmCx system can be used wherever interference fit bushing installation is required, regardless of fatigue enhancement requirements. Although the system has been primarily designed for use in metallic materials, FmCx has demonstrated effectiveness in composite materials.

The FmCx system involves drawing an oversize mandrel through a pre-positioned clearance-fit bushing, internally pre-lubricated by an FTI proprietary process. The bushing is then reamed to the required hole diameter. The resulting interference fit of the bushing, coupled with simultaneous cold working of the metal surrounding the hole, produces a typical fatigue life improvement of 300 percent or better.

The FmCx system consists of two processes:

- The ForceMate standard system
- The ForceMate special system

The FmCx standard system consists of technology that provides installations in aluminum structure that are equivalent in size to the National Aerospace Standards (NAS) for straight and flanged press-fit bushings in both standard and metric sizes.

The FmCx special system consists of technology that allows implementation of the FmCx system for unique applications. Both of these systems are described completely in Fatigue Technology's ForceMate Specification FTI-9901.

Use of the FmCx system involves cold expanding an initially clearance fit bushing into a hole. Typical use of the FmCx system is shown in section 10.1. A specially sized bushing, with a proprietary lubricant on the inside surface, is placed over a tapered expansion mandrel. The attachment end of the mandrel is inserted into a puller unit. The mandrel/bushing assembly is then placed in the hole, and the puller unit is activated to pull the mandrel through the bushing. The expansion of the bushing by the mandrel cold works the base material while the bushing is simultaneously installed with high interference.

The inside surface of the bushing after FmCx processing has a slightly tapered profile. After the mandrel is pulled throught the bushing, the bushing is reamed to the desired final inside diameter. The reaming operation also removes the lubricant residue from the bushing. If the condition of the final bushing inside diameter after FmCx processing is acceptable, the final sizing operation may be eliminated.

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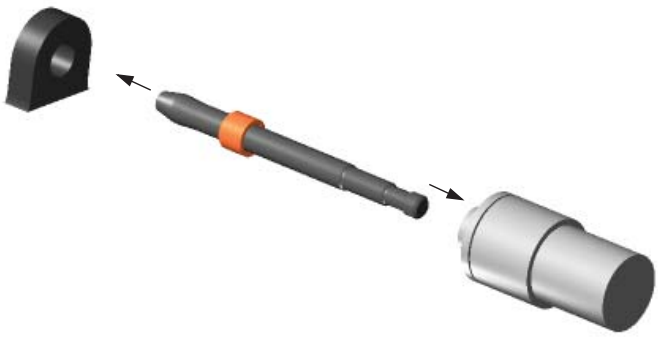
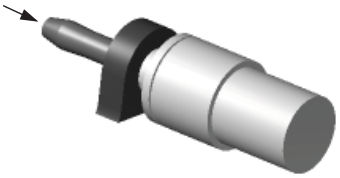
1. Prepare starting hole.

2. Place bushing onto mandrel.

3. Insert mandrel into puller unit. Place mandrel and bushing into the workpiece.



4. Activate puller unit to install the bushing.



5. Machine bushing inside diameter to final size.

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10.4 STANDARD SYSTEM TOOLING REQUIREMENTS

Table 10.4-1
ForceMate Standard System Tooling Requirements

Reference Pin Diameter	Standard Tool Diameter Number	Starting Drill	Starting Reamer	Combination Gage	ForceMate Bushing
3/16	-3 -3OS	FSD-3	FSR-3 FSR-3OS	FCG-3 FCG-3OS	FMB-*-*-3-*-* FMB-*-*-3OS-*-*
1/4	-4 -4OS	FSD-4	FSR-4 FSR-4OS	FCG-4 FCG-4OS	FMB-*-*-4-*-* FMB-*-*-4OS-*-*
5/16	-5 -5OS	FSD-5	FSR-5 FSR-5OS	FCG-5 FCG-5OS	FMB-*-*-5-*-* FMB-*-*-5OS-*-*
3/8	-6 -6OS	FSD-6	FSR-6 FSR-6OS	FCG-6 FCG-6OS	FMB-*-*-6-*-* FMB-*-*-6OS-*-*
7/16	-7 -7OS	FSD-7	FSR-7 FSR-7OS	FCG-7 FCG-7OS	FMB-*-*-7-*-* FMB-*-*-7OS-*-*
1/2	-8 -8OS	FSD-8	FSR-8 FSR-8OS	FCG-8 FCG-8OS	FMB-*-*-8-*-* FMB-*-*-8OS-*-*
9/16	-9 -9OS	FSD-9	FSR-9 FSR-9OS	FCG-9 FCG-9OS	FMB-*-*-9-*-* FMB-*-*-9OS-*-*
5/8	-10 -10OS	FSD-10	FSR-10 FSR-10OS	FCG-10 FCG-10OS	FMB-*-*-10-*-* FMB-*-*-10OS-*-*
11/16	-11 -11OS	FSD-11	FSR-11 FSR-11OS	FCG-11 FCG-11OS	FMB-*-*-11-*-* FMB-*-*-11OS-*-*
3/4	-12 -12OS	FSD-12	FSR-12 FSR-12OS	FCG-12 FCG-12OS	FMB-*-*-12-*-* FMB-*-*-12OS-*-*
7/8	-14 -14OS	FSD-14	FSR-14 FSR-14OS	FCG-14 FCG-14OS	FMB-*-*-14-*-* FMB-*-*-14OS-*-*
1	-16 -16OS	FSD-16	FSR-16 FSR-16OS	FCG-16 FCG-16OS	FMB-*-*-16-*-* FMB-*-*-16OS-*-*
1-1/8	-18 -18OS	FSD-18	FSR-18 FSR-18OS	FCG-18 FCG-18OS	FMB-*-*-18-*-* FMB-*-*-18OS-*-*
1-1/4	-20 -20OS	FSD-20	FSR-20 FSR-20OS	FCG-20 FCG-20OS	FMB-*-*-20-*-* FMB-*-*-20OS-*-*

Model Number Key:

FMB - * - * - ***STDN*** - * - *

ForceMate Bushing

Configuration:
S = Straight
F = Flanged

Material:
1 = AISI 4340
2 = Berylium Copper
3 = 17-4 Ph Stainless H 925 Condition
4 = Aluminum Nickel Bronze
5 = AISI 4130
6 = 17-4 Ph Stainless H 1025 Condition

Plating:
N = No Plating
P = Plated
B = BlueCoated

Minimum Base Material Thickness:
0.000's (0.00's for Metric)

Standard Tool Diameter Number

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Table 10.4-1 (Continued)
ForceMate Standard System Tooling Requirements

Reference Pin Diameter	Standard Tool Diameter Number	Mandrel	Mandrel Gage	Bushing Reamer	Chuck Assembly	Nosecap Assembly	
						Nosecap	Jaw
3/16	-3 -3OS	FMM-3-A	FMG-3	FIR-3	LB-PC-6	FMC-L	FMJ-3
1/4	-4 -4OS	FMM-4-A	FMG-4	FIR-4	LB-CA-4	FMC-L	FMJ-4
5/16	-5 -5OS	FMM-5-A	FMG-5	FIR-5	LB-CA-4	FMC-L	FMJ-5
3/8	-6 -6OS	FMM-6-A	FMG-6	FIR-6	LB-CA-6	FMC-L	FMJ-6
7/16	-7 -7OS	FMM-7-A	FMG-7	FIR-7	MB-CA-8	FMC-M	FMJ-7
1/2	-8 -8OS	FMM-8-A	FMG-8	FIR-8	MB-CA-8	FMC-M	FMJ-8
9/16	-9 -9OS	FMM-9-A	FMG-9	FIR-9	MB-CA-11	FMC-M	FMJ-9
5/8	-10 -10OS	FMM-10-A	FMG-10	FIR-10	MB-CA-11	FMC-M	FMJ-10
11/16	-11 -11OS	FMM-11-A	FMG-11	FIR-11	MB-CA-11	FMC-M	FMJ-11
3/4	-12 -12OS	FMM-12-A	FMG-12	FIR-12	MB-CA-11	FMC-M	FMJ-12
7/8	-14 -14OS	FMM-14-A	FMG-14	FIR-14	BB-CA-16	FMC-B	FMJ-14
1	-16 -16OS	FMM-16-A	FMG-16	FIR-16	BB-CA-16	FMC-B	FMJ-16
1-1/8	-18 -18OS	FMM-18-A	FMG-18	FIR-18	BB-CA-16	FMC-B	FMJ-18
1-1/4	-20 -20OS	FMM-20-A	FMG-20	FIR-20	BB-CA-16	FMC-B	FMJ-20

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Table 10.4-2
ForceMate Standard System Tooling Requirements (Metric)

Standard Tool Diameter Number	Starting Drill	Starting Reamer	Combination Gage	ForceMate Bushing
-5M -5MOS	FSD-5M	FSR-5M	FCG-5M	FMB-*-*-5M-*-* FMB-*-*-5MOS-*-*
-6M -6MOS	FSD-6M	FSR-6M	FCG-6M	FMB-*-*-6M-*-* FMB-*-*-6MOS-*-*
-7M -7MOS	FSD-7M	FSR-7M	FCG-7M	FMB-*-*-7M-*-* FMB-*-*-7MOS-*-*
-8M -8MOS	FSD-8M	FSR-8M	FCG-8M	FMB-*-*-8M-*-* FMB-*-*-8MOS-*-*
-9M -9MOS	FSD-9M	FSR-9M	FCG-9M	FMB-*-*-9M-*-* FMB-*-*-9MOS-*-*
-10M -10MOS	FSD-10M	FSR-10M	FCG-10M	FMB-*-*-10-*-* FMB-*-*-10MOS-*-*
-12M -12MOS	FSD-12M	FSR-12M	FCG-12M	FMB-*-*-12M-*-* FMB-*-*-12MOS-*-*
-14M -14MOS	FSD-14M	FSR-14M	FCG-14M	FMB-*-*-14M-*-* FMB-*-*-14MOS-*-*
-15M -15MOS	FSD-15M	FSR-15M	FCG-15M	FMB-*-*-15M-*-* FMB-*-*-15MOS-*-*
-16M -16MOS	FSD-16M	FSR-16M	FCG-16M	FMB-*-*-16M-*-* FMB-*-*-16MOS-*-*
-18M -18MOS	FSD-18M	FSR-18M	FCG-18M	FMB-*-*-18M-*-* FMB-*-*-18MOS-*-*
-20M -20MOS	FSD-20M	FSR-20M	FCG-20M	FMB-*-*-20M-*-* FMB-*-*-20MOS-*-*
-22M -22MOS	FSD-22M	FSR-22M	FCG-22M	FMB-*-*-22M-*-* FMB-*-*-22MOS-*-*
-25M -25MOS	FSD-25M	FSR-25M	FCG-25M	FMB-*-*-25M-*-* FMB-*-*-25MOS-*-*

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Table 10.4-2 (Continued)
ForceMate Standard System Tooling Requirements (Metric)

Standard Tool Diameter Number	Mandrel	Mandrel Gage	Bushing Reamer	Chuck Assembly	Nosecap Assembly	
					Nosecap	Jaw
-5M -5MOS	FMM-5M	FMG-5M	FIR-5M	LB-PC-6	FMC-L	FMJ-5M
-6M -6MOS	FMM-6M	FMG-6M	FIR-6M	LB-CA-4	FMC-L	FMJ-6M
-7M -7MOS	FMM-7M	FMG-7M	FIR-7M	LB-CA-4	FMC-L	FMJ-7M
-8M -8MOS	FMM-8M	FMG-8M	FIR-8M	LB-CA-4	FMC-L	FMJ-8M
-9M -9MOS	FMM-9M	FMG-9M	FIR-9M	LB-CA-6	FMC-L	FMJ-9M
-10M -10MOS	FMM-10M	FMG-10M	FIR-10M	LB-CA-6	FMC-L	FMJ-10M
-12M -12MOS	FMM-12M	FMG-12M	FIR-12M	MB-CA-8	FMC-M	FMJ-12M
-14M -14MOS	FMM-14M	FMG-14M	FIR-14M	MB-CA-11	FMC-M	FMJ-14M
-15M -15MOS	FMM-15M	FMG-15M	FIR-15M	MB-CA-11	FMC-M	FMJ-15M
-16M -16MOS	FMM-16M	FMG-16M	FIR-16M	MB-CA-11	FMC-M	FMJ-16M
-18M -18MOS	FMM-18M	FMG-18M	FIR-18M	MB-CA-11	FMC-M	FMJ-18M
-20M -20MOS	FMM-20M	FMG-20M	FIR-20M	MB-CA-11	FMC-M	FMJ-20M
-22M -22MOS	FMM-22M	FMG-22M	FIR-22M	BB-CA-16	FMC-B	FMJ-22M
-25M -25MOS	FMM-25M	FMG-25M	FIR-25M	BB-CA-16	FMC-B	FMJ-25M

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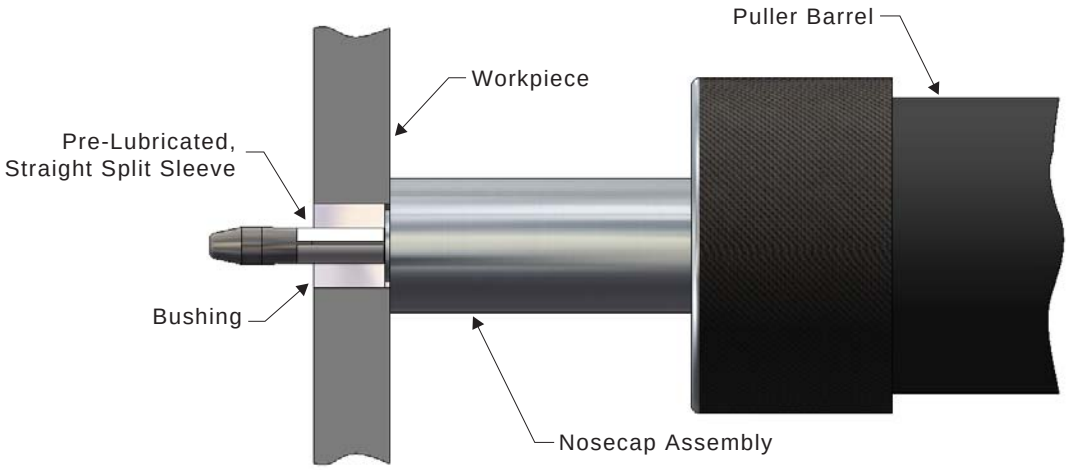

Figure 11.1-1
BushLoc System Components

The Fatigue Technology patented BushLoc System® (BlCx) provides a convenient method for quickly and safely installing interference fit bushings using Split Sleeve Cold Expansion technology. BushLoc has been designed to complement FTI's ForceMate bushing installation process where maximum fatigue life improvement through cold expansion may not be necessary, but high retention force and ease of installation is desired. By using a split sleeve inside a bushing, a customer may manufacture their own bushings. In addition to standard bushing installations in new structure, BushLoc can be used as a method for re-sizing or repairing discrepant or damaged holes in existing structure. The BushLoc System is designed to install bushings ranging from 3/16 to 1-1/4 inches inside diameter. Bushings installed may have a wall thickness as thick as 1/3 the final inside diameter up to a maximum of 0.200 inch. If you require a bushing installation with fatigue life improvement, please refer to the ForceMate System in Section 10.0 of this catalog. For any questions regarding either BushLoc or ForceMate, please contact our Technical Sales Staff.

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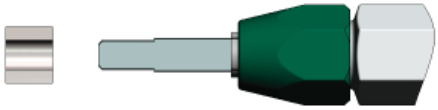
1. Drill and/or ream starting hole.



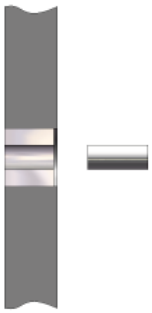
2. Check the inside diameter of the bushing using the bushing gage.

3. Slide the pre-lubricated straight sleeve over the mandrel.

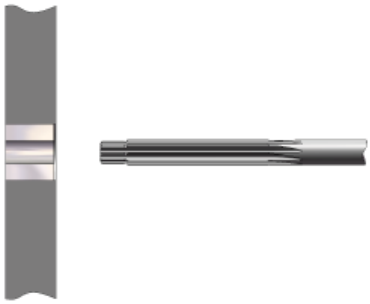
4. Slide the bushing onto the mandrel over the sleeve.

5. Insert the bushing/sleeve/mandrel assembly into the workpiece.

6. While holding the nosecap firmly against the workpiece, activate the puller to pull the mandrel through the sleeve and bushing.



7. Remove the distorted sleeve.



8. Ream the inside of the bushing to obtain the desired final inside diameter.

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11.3 BSN SELECTION TABLE

This overview of STDN selection for BushLoc is intended to be a brief description of the BushLoc process. In order to properly manufacture the bushing, prepare the hole, choose the proper tooling set, and correctly install the bushing, refer to either FTI Specification 9601. Tables in this overview are taken directly from FTI-9601.

Step 1: Select the Proper BushLoc System Number

BlCx durable and expendable tooling is divided into 14 standard sizes and 4 oversizes. Each standard size is designated with a BushLoc System Number (BSN) which refers to the final bushing inside diameter in sixteenths of an inch. Some BSNs allow second oversize tooling to be used. Second oversize BSNs are indicated by the (nominal) BSN followed by "/2".

Example: 4/2 = Second Oversize for BSN 4 tooling

Each second oversize is 1/32 inch larger than the nominal holes of the appropriate nominal BSN. Each BSN represents a tooling set capable of installing a range of bushing sizes. These ranges are shown in Table 11.3-1 (Table 4.1-1 in FTI-9601). All BushLoc tooling is organized around this size code.

Table 11.3-1
BSN Selection

Reference Final Bushing Inside Diameter (inch)	Appropriate BSN
0.183 - 0.213	-3
0.245 - 0.287	-4
0.276 - 0.318	-4/2
0.308 - 0.353	-5
0.339 - 0.384	-5/2
0.370 - 0.416	-6
0.401 - 0.447	-6/2
0.433 - 0.494	-7
0.464 - 0.525	-7/2
0.494 - 0.556	-8
0.555 - 0.614	-9
0.618 - 0.674	-10
0.680 - 0.733	-11
0.743 - 0.792	-12
0.867 - 0.908	-14
0.992 - 1.028	-16
1.117 - 1.150	-18
1.242 - 1.280	-20

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Step 2: Select the Proper Mandrel Length.

The maximum mandrel length is limited by backside clearance. To select the proper length, determine the backside clearance and use Table 11.4-1 (Table 3.4.2-1 in FTI-9601), to determine if the mandrel length must be limited. Next, use the BSN, bushing length, and remaining mandrel length options to determine a suitable mandrel length from Table 11.4-2 (Table 4.5.2-1 in FTI-9601).

Table 11.4-1
Backside Clearance

BSN Range	Mandrel Model Number	Minimum Backside Clearance (inches)
-3 through -8	BLM-X-1-30 BLM-X-1-40 BLM-X-1-50	2.3 3.3 4.3
-9 through -12	BLM-X-2-30 BLM-X-2-40 BLM-X-2-50	2.6 3.6 4.6
-14 through -20	BLM-X-5-30 BLM-X-5-40 BLM-X-5-50	2.6 3.6 4.6

Table 11.4-2
Maximum Bushing Lengths for Mandrels

BSN Range	Maximum Bushing Length (inches)	Mandrel Model Number*
-3 through -8	1.225 2.225 3.225	BLM-X-1-30 BLM-X-1-40 BLM-X-1-50
-9 through -12	1.175 2.175 3.175	BLM-X-2-30 BLM-X-2-40 BLM-X-2-50
-14 through -20	1.125 2.125 3.125	BLM-X-5-30 BLM-X-5-40 BLM-X-5-50

* Xs are in place of BSN sizes.

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Step 3: Select the Appropriate Sleeves.

Split sleeves must be long enough to extend into the nosecap and protrude beyond the bushing by 1/8 inch. Nosecap allowances vary with puller unit series and have been used to calculate the maximum length bushings which can be installed with each sleeve combination listed in Table 11.4-3 (Table 4.5.3-1 from FTI-9601). Sleeves can be stacked to accommodate longer bushings but the splits should be aligned to allow easy removal.

Table 11.4-3
Sleeve Combination Options

BSN Range	Maximum Bushing Length (inches)	Minimum Mandrel Length Code	Total Sleeve Length (inches)	Sleeve Length or Sleeve Lengths to be Stacked
-3 through -8	0.225	-30	0.50	8S
	0.475	-30	0.75	12S
	0.725	-30	1.00	16S
	1.225	-30	1.50	24S
-9 through -12	0.425	-30	0.75	12S
	0.675	-30	1.00	16S
	1.175	-30	1.50	24S
	1.675	-40	2.00	32S
	2.235	-50	2.56	41S
-14 through -20	0.375	-30	0.75	12S
	0.625	-30	1.00	16S
	1.125	-30	1.50	24S
	1.625	-40	2.00	32S
	2.185	-50	2.56	41S

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Step 4: Select a Final Reamer.

BushLoc final reamers are used to size the final inside diameter of the bushing (if necessary) once it has been installed. FTI provides straight fluted, cobalt reamers designed to size the bushing inside diameter in accordance with customer requests. The BushLoc final reamers come in .0005-inch increments. The BSN and the reamer diameter are given in the model number, as shown below.

BLR - 8 - .5000

Step 5: Select the Appropriate Puller Unit and PowerPak.

Two PowerPaks are available for the BushLoc application: the FT-20 and the FT-200B (refer to Section 2.0 Detailed Tooling for more information). The FT-200B is recommended for repeated BlCx installations because of its speed and versatility. The FT-20 is a smaller and more portable unit.

FTI supplies a family of puller units. The Little Brute series is used for BSN -3 through -8, the Medium Brute series for BSN -9 through -12, and the Big Brute series for BSN -14 through -20. Each series of puller units comes in different stroke capacities to accommodate different mandrel lengths (refer to Section 2.0 Detailed Tooling for more information). The maximum mandrel length for each puller unit is shown in Table 11.4-4 (Table 4.2.2-1 from FTI-9601).

Table 11.4-4
Maximum Mandrel Length

Puller Unit Model Number	Maximum Mandrel Length Code
LB-15	-30
LB-20	-30
LB-25	-40
LB-30	-40
LB-35	-50
MB-30	-40
MB-70	-50
BB-30	-50

11.5 TOOLING SET SELECTION

Once you have completed Steps 1 through 5, select the proper tooling set from Table 11.5-1 using the BSN. For further information, refer to the BushLoc Specification 9601 or contact Fatigue Technology's Technical Sales Staff.

Table 11.5-1
Standard BushLoc Tooling

BushLoc Standard Number (BSN)	 Puller Series	 Bushing Gage	 Mandrel	 Mandrel Check Fixture
-3	Little Brute	BLBG-3	BLM-3-1-*	BLMG-3
-4	Little Brute	BLBG-4	BLM-4-1-*	BLMG-4
-4/2	Little Brute	BLBG-4/2	BLM-4/2-1-*	BLMG-4/2
-5	Little Brute	BLBG-5	BLM-5-1-*	BLMG-5
-5/2	Little Brute	BLBG-5/2	BLM-5/2-1-*	BLMG-5/2
-6	Little Brute	BLBG-6	BLM-6-1-*	BLMG-6
-6/2	Little Brute	BLBG-6/2	BLM-6/2-1-*	BLMG-6/2
-7	Little Brute	BLBG-7	BLM-7-1-*	BLMG-7
-7/2	Little Brute	BLBG-7/2	BLM-7/2-1-*	BLMG-7/2
-8	Little Brute	BLBG-8	BLM-8-1-*	BLMG-8
-9	Medium Brute	BLBG-9	BLM-9-2-*	BLMG-9
-10	Medium Brute	BLBG-10	BLM-10-2-*	BLMG-10
-11	Medium Brute	BLBG-11	BLM-11-2-*	BLMG-11
-12	Medium Brute	BLBG-12	BLM-12-2-*	BLMG-12
-14	Big Brute	BLBG-14	BLM-14-5-*	BLMG-14
-16	Big Brute	BLBG-16	BLM-16-5-*	BLMG-16
-18	Big Brute	BLBG-18	BLM-18-5-*	BLMG-18
-20	Big Brute	BLBG-20	BLM-20-5-*	BLMG-20

* For the proper mandrel length, refer to Step 2 on page 203 in this section of the Tooling Catalog or Section 4.3.4 in FTI-9601.

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Table 11.5-1 (Continued)
Standard BushLoc Tooling

BushLoc Standard Number (BSN)	 Nosecap Assembly	 Bushing ID Reamer	 Straight Sleeves
-3	BLN-3	BLN-3-**	BLS-3-***
-4	BLN-4	BLN-4-**	BLS-4-***
-4/2	BLN-4/2	BLN-4/2-**	BLS-4/2-***
-5	BLN-5	BLN-5-**	BLS-5-***
-5/2	BLN-5/2	BLN-5/2-**	BLS-5/2-***
-6	BLN-6	BLN-6-**	BLS-6-***
-6/2	BLN-6/2	BLN-6/2-**	BLS-6/2-***
-7	BLN-7	BLN-7-**	BLS-7-***
-7/2	BLN-7/2	BLN-7/2-**	BLS-7/2-***
-8	BLN-8	BLN-8-**	BLS-8-***
-9	BLN-9	BLN-9-**	BLS-9-***
-10	BLN-10	BLN-10-**	BLS-10-***
-11	BLN-11	BLN-11-**	BLS-11-***
-12	BLN-12	BLN-12-**	BLS-12-***
-14	BLN-14	BLN-14-**	BLS-14-***
-16	BLN-16	BLN-16-**	BLS-16-***
-18	BLN-18	BLN-18-**	BLS-18-***
-20	BLN-20	BLN-20-**	BLS-20-***

** For the proper reamer code, refer to Step 4 on page 205 in this section of the Tooling Catalog, or Section 4.3.5 in the BushLoc Specification 9601.

*** For the proper sleeve combinations available for the BSN and bushing length, refer to Step 3 on pages 204 and 205 in this section of the Tooling Catalog or Section 4.5.3 in the BushLoc Specification 9601.

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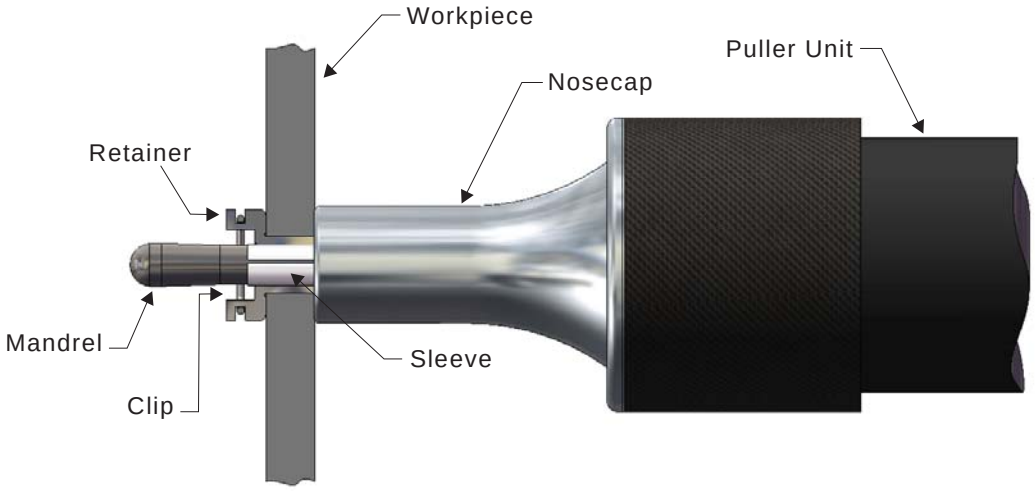

Figure 12.1-1
ForceTec System Components

The Fatigue Technology patented ForceTec® System is designed to quickly and consistently install rivetless nut plates at a high interference using split sleeve cold expansion technology. The ForceTec system is designed to expand a retainer into a single starting hole, eliminating the need for satellite rivet holes, countersinking or swaging. The retainer is capable of holding a range of common thread locking nuts. The fatigue life of the hole is enhanced due to the elimination of the satellite holes and the expansion of the retainer into the hole, imparting residual compressive stresses into the surrounding material. The ForceTec Standard System can accommodate 3/16, 1/4, 5/16, and 3/8-inch fastener diameters in material thicknesses as thin as 0.060 inch for the 3/16-inch size retainer and up to 0.500 inch for all sizes. If you have any questions regarding ForceTec or size requirements outside these parameters, please contact our Technical Sales Department.

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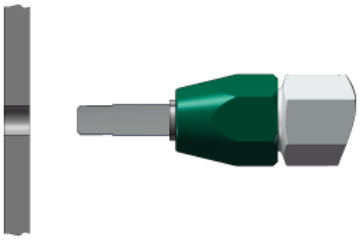


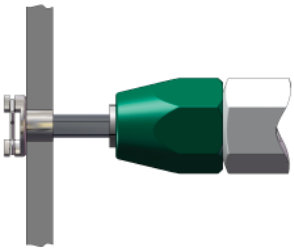
1. Check the starting hole using blade end of the combination gage.

2. Slide the split sleeve over the tapered mandrel.

3. Insert the retainer into the starting hole from the back and insert the mandrel/sleeve assembly through the retainer from the front.

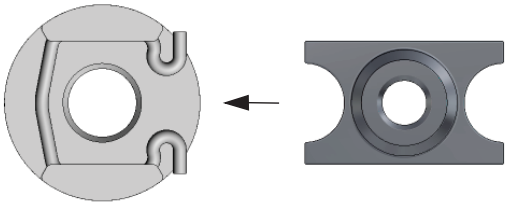
4. Seat the nosecap firmly against the workpiece and activate the puller unit to pull the mandrel through the sleeve/retainer assembly.

5. Remove and discard the used split sleeve.



6. Check the final hole diameter using the round end of the combination gage.

7. If required, trim the protruding portion of the retainer to length using the trimming tool.



8. Install the nut into the retainer without removing the clip.

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12.3 INDIVIDUAL TOOLING SELECTION

This introduction to tooling selection for ForceTec is only intended as an overview. In order to properly prepare the hole, choose the proper tooling, and correctly install the nut plate, follow the detailed instructions in FTI's Engineering Specification 9705. Directions in this overview are taken directly from FTI-9705 and all corresponding tables are referenced.

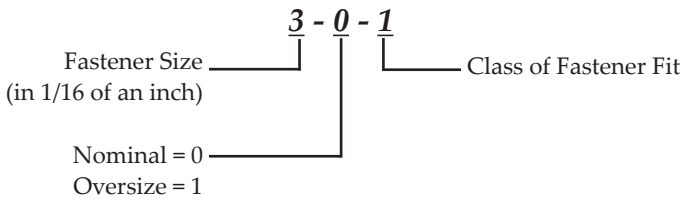
ForceTec System Number

FtCx durable and expendable tooling is available for four fastener sizes and three classes of fastener fit. Each class and size is designated with a ForceTec System Number (FSN). The FSN designates a tooling set capable of installing nominal or oversize retainers (both using nominal fasteners) with a specific final size and class of fit. The FSNs for the standard system are shown below in Table 12.3-1 (Table 3.0-1a or 3.0-1b (for metric) in FTI-9705).

Table 12.3-1
ForceTec Standard System Tooling Requirements

Fastener Size (inches)	Appropriate FSN		
	Class I	Class II	Class III
3/16	3-0-1 3-1-1	3-0-2 3-1-2	3-0-3 3-1-3
1/4	4-0-1 4-1-1	4-0-2 4-1-2	4-0-3 4-1-3
5/16	5-0-1 5-1-1	5-0-2 5-1-2	5-0-3 5-1-3
3/8	6-0-1 6-1-1	6-0-2 6-1-2	6-0-3 6-1-3

Model Number Key:



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ForceTec Retainer

Retainers are designed to hold the nut in place after installation. The interference between the barrel of the retainer and the hole in the parent material secures the retainer while the flat sides of the retainer head prevent the nut from rotating. The clip retains the nut and controls the nut float and keeps it from being forced away from the fastener. Stainless steel and titanium retainers are available for installations into aluminum or titanium structure.

Model Number Key:

FTR - 4 - 0 - 2 - .120 - S

- ***FTR*** — ForceTec Retainer
- ***4*** — Fastener Size
  - 3 = 3/16 inch
  - 4 = 1/4 inch
  - 5 = 5/16 inch
  - 6 = 3/8 inch
- ***0*** — Retainer Size
  - 0 = Nominal Starting Hole
  - 1 = Oversize Starting Hole
- ***2*** — Class of Fastener Fit
  - 1 = Class I
  - 2 = Class II
  - 3 = Class III
- ***.120*** — Barrel Length
  - .000's (inches) in 0.010-inch increments
- ***S*** — S = Stainless Steel, T = Titanium

Clip

Clips are designed to hold the nut in place after installation and control the distance the nut may float. Replacement clips may be ordered if necessary, but they should not be removed during normal operations.

Model Number Key:

FTCR - 4

- ***FTCR*** — ForceTec Replacement Clip
- ***4*** — Fastener Size
  - 3 = 3/16 inch
  - 4 = 1/4 inch
  - 5 = 5/16 inch
  - 6 = 3/8 inch

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Split Sleeve

The split sleeve, made of full hard stainless steel, serves several important functions during the FtCx process. It ensures radial expansion and protects the inside of the retainer by eliminating direct contact between the mandrel and the retainer material. In addition it provides lubrication during installation. Sleeves may only be used once.

Model Number Key:

FTS - 4 - 0 - 2 - 8

ForceTec Sleeve

Fastener Size
3 = 3/16 inch
4 = 1/4 inch
5 = 5/16 inch
6 = 3/8 inch

Class of fit
1 = Class II
2 = Class II
3 = Class III

Retainer Size
Only nominal sleeves are used for nominal and oversize retainers

Length in 1/16-inch increments
2 = up to 1/8 inch long retainers
8 = up to 1/2 inch long retainers

Starting Drill

Twist drills are provided for either nominal or oversize starting holes for each FSN. These are sized such that about 1/64 inch of material will be removed by the starting hole reamer to achieve the starting hole size.

Model Number Key:

FTSD - 4 - 0 - 2 - C

ForceTec Starting Drill

Fastener Size
3 = 3/16 inch
4 = 1/4 inch
5 = 5/16 inch
6 = 3/8 inch

Class of fit
1 = Class I
2 = Class II
3 = Class III

Retainer Size
0 = Nominal
1 = Oversize

C = Cobalt
Blank = High Speed Steel

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Starting Reamer

Starting reamers are available in either cobalt or high-speed steel for all fastener sizes.

Model Number Key:

FTSR - 4 - 0 - 2 - C

- ForceTec Starting Reamer
- Fastener Size
  - 3 = 3/16 inch
  - 4 = 1/4 inch
  - 5 = 5/16 inch
  - 6 = 3/8 inch
- Retainer Size
  - 0 = Nominal
  - 1 = Oversize
- Class of Fit
  - 1 = Class I
  - 2 = Class II
  - 3 = Class III
- C = Cobalt
  - Blank = High-Speed Steel

Finish Reamer

Straight fluted, piloted, finish reamers are designed to cut Class 1 retainers to the sizes listed in FTI-9705. The non-cutting pilot will fit into the retainer only after installation. Finish reamers are not needed for Class II or Class III installations. All finish reamers are cobalt.

Model Number Key:

FTFR - 4 - 0 - 1 - C

- ForceTec Finish Reamer
- Fastener Size
  - 3 = 3/16 inch
  - 4 = 1/4 inch
  - 5 = 5/16 inch
  - 6 = 3/8 inch
- Retainer Size
  - Only nominal reamers are used
- Class of Fit
  - Only Class I retainers are reamed
- C = Cobalt

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Verification Pin

The verification pin is a double-end gage used to check the starting hole and installed retainer inside diameter. The stepped blade end is used to check the starting hole for size and ovality. The other end is used to verify the size of the retainer's inside diameter after installation.

Model Number Key:

FTG - 4 - 0 - 2

- ***FTG*** — ForceTec Verification Pin
- ***4*** — Fastener Size
  - 3 = 3/16 inch
  - 4 = 1/4 inch
  - 5 = 5/16 inch
  - 6 = 3/8 inch
- ***0*** — Retainer Size
  - 0 = Nominal
  - 1 = Oversize
- ***2*** — Class of Fit
  - 1 = Class I
  - 2 = Class II
  - 3 = Class III

Mandrel

While all ForceTec system components perform a specific function, the mandrel is the most critical. It must not only resist fracture but must maintain precise size and shape during the installation process. The mandrel, when drawn through the retainer and sleeve, expands to yield the retainer and the parent material causing residual compressive stresses.

Model Number Key:

FTM - 4 - 0 - 2 - 8

- ***FTM*** — ForceTec Mandrel
- ***4*** — Fastener Size
  - 3 = 3/16 inch
  - 4 = 1/4 inch
  - 5 = 5/16 inch
  - 6 = 3/8 inch
- ***0*** — Retainer Size
  - Only nominal mandrels are used for nominal and oversize retainers
- ***2*** — Class of Fit
  - 1 = Class I
  - 2 = Class II
  - 3 = Class III
- ***8*** — Length
  - 2 = up to 1/8-inch long retainers
  - 8 = up to 1/2-inch long retainers

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Mandrel Check Fixture

The mandrel check fixture is used to verify that the mandrel major diameter is not worn below its minimum allowable dimension. If the mandrel major diameter can slide through the hole in the mandrel check fixture, the mandrel is discarded and replaced.

Model Number Key:

FTMG - 4 - 0 - 2

- ***FTMG*** — ForceTec Mandrel Check Fixture
- ***4*** — Fastener Size
  - 3 = 3/16 inch
  - 4 = 1/4 inch
  - 5 = 5/16 inch
  - 6 = 3/8 inch
- ***0*** — Retainer Size
  - Only nominal mandrel check fixtures are used for nominal and oversize retainers
- ***2*** — Class of Fit
  - 1 = Class I
  - 2 = Class II
  - 3 = Class III

Nosecap Assembly and Jaw Set

The ForceTec nosecap, which is threaded onto the barrel of the puller unit, is designed to allow the retainer flange to be pulled flush during installation. The nosecap also holds the sleeve in place during processing and reacts the pulling force back into the parent material. Jaw sets are designed to last for many installations; however, if they become worn, the sleeve may slip inside the inner jaw during installation. Both the worn jaws should then be replaced.

Model Number Key:

FTN - 4 - 0 - 2 - JS

- ***FTN*** — ForceTec Nosecap
- ***4*** — Fastener Size
  - 3 = 3/16 inch
  - 4 = 1/4 inch
  - 5 = 5/16 inch
  - 6 = 3/8 inch
- ***0*** — Retainer Class
  - 0 = Nominal
  - 1 = Oversize
- ***2*** — Class of Fit
  - 1 = Class I
  - 2 = Class II
  - 3 = Class III
- ***JS*** — Jaw Set - Add this -JS suffix when ordering replacement jaws

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Trimming Tool

Trimming tools incorporate a micro-adjustable cage with a special carbide cutter and pilot sized for an installed retainer. Replacement cutter/pilot assemblies are available from FTI. Contact FTI Technical Sales for selection assistance.

Trimming tools are available for all fastener sizes and are only needed for installations which protrude beyond the material surface.

Model Number Key:

FTTT **-** ***4*** **-** ***0*** **-** ***2***

ForceTec Trimming Tool

Fastener Size
3 = 3/16 inch
4 = 1/4 inch
5 = 5/16 inch
6 = 3/8 inch

Class of Fit
1 = Class I
2 = Class II
3 = Class III

Retainer Size
0 = Nominal
1 = Oversize
(Only the nominal TT is required for both nominal and oversize retainers)

Tooling Selection

Selecting the proper FtCx tooling for any application involves the following steps:

1. Determine an FSN and use it to select a tooling table from Section 3.0 of FTI-9705.

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Table 12.3-2
Tooling Table for 3/16-Inch Fastener

	Class I	Class II	Class III
Starting Drill (oversize)	FTSD-3-0-1(-C) FTSD-3-1-1(-C)	FTSD-3-0-2(-C) FTSD-3-1-2(-C)	FTSD-3-0-3(-C) FTSD-3-1-3(-C)
Starting Reamer (oversize)	FTSR-3-0-1(-C) FTSR-3-1-1(-C)	FTSR-3-0-2(-C) FTSR-3-1-2(-C)	FTSR-3-0-3(-C) FTSR-3-1-3(-C)
Verification Pin (oversize)	FTG-3-0-1 FTG-3-1-1	FTG-3-0-2 FTG-3-1-2	FTG-3-0-3 FTG-3-1-3
Mandrel*	FTM-3-0-1-2 FTM-3-0-1-8	FTM-3-0-2-2 FTM-3-0-2-8	FTM-3-0-3-2 FTM-3-0-3-8
Mandrel Check Fixture	FTMG-3-0-1	FTMG-3-0-2	FTMG-3-0-3
Split Sleeve*	FTS-3-0-1-2 FTS-3-0-1-8	FTS-3-0-2-2 FTS-3-0-2-8	FTS-3-0-3-2 FTS-3-0-3-8
Nosecap (oversize)	FTN-3-0-1 FTN-3-1-1	FTN-3-0-2 FTN-3-1-2	FTN-3-0-3 FTN-3-1-3
Trimming Tool	FTTT-3-0-1	FTTT-3-0-2	FTTT-3-0-3
Finish Reamer	FTFR-3-0-1-C	NA	NA
Retainer Holder	FTRH		

* Mandrel and sleeve length are determined by the regular retainer length.

2. Select the retainer for the application as described in FTI-9705.

3. Select the mandrel length from the tooling table as described in FTI-9705 (Table 8.5-1 duplicated below).

Table 12.3-3
Maximum Retainer Lengths for Mandrels

FSN Range	Maximum Retainer Length (inches)	Mandrel Model number
3-0-*	0.125 0.500	FTM-3-0-*-2 FTM-3-0-*-8
4-0-*	0.125 0.500	FTM-4-0-*-2 FTM-4-0-*-8
5-0-*	0.125 0.500	FTM-5-0-*-2 FTM-5-0-*-8
6-0-*	0.500	FTM-6-0-*-8

* = Class I, II, or III.

5. Assemble the tooling and follow the installation procedures detailed in FTI-9705.

4. Select the sleeve from the tooling table, as described in FTI-9705 (Table 8.5-1 duplicated below).

Table 12.3-4
Sleeve and Mandrel Lengths Options

Maximum Retainer Length (inches)	Mandrel Length Options	Sleeve Length Options
0.125	FTM-(FSN)-2	FTS-(FSN)-2
	FTM-(FSN)-8	FTS-(FSN)-2 OR FTS-(FSN)-8
0.500	FTM-(FSN)-8	FTS-(FSN)-8

12.4 STANDARD FORCETEC TOOLING

Table 12.4-1 shows all durable and expendable tooling for the ForceTec Rivetless nut plate system. First, determine the desired fastener size (3/16 , 1/4, 5/16, or 3/8 inch, nominal or oversize) then move across the table and select the appropriate tooling. Model numbers containing an asterik (*) indicate an option particular to that piece of tooling. For these options, please refer to the bottom of the table and to the individual tooling selection throughout this section on how to select these parts of the model number.

Table 12.4-1
Standard ForceTec Tooling

1	2	3	4	5	6	7
Fastener Sizes	 Starting Drill*			 Starting Reamer*		
	Class I	Class II	Class III	Class I	Class II	Class III
3/16	FTSD-3-0-1(-C)	FTSD-3-0-2(-C)	FTSD-3-0-3(-C)	FTSR-3-0-1(-C)	FTSR-3-0-2(-C)	FTSR-3-0-3(-C)
OS	FTSD-3-1-1(-C)	FTSD-3-1-2(-C)	FTSD-3-1-3(-C)	FTSR-3-1-1(-C)	FTSR-3-1-2(-C)	FTSR-3-1-3(-C)
1/4	FTSD-4-0-1(-C)	FTSD-4-0-2(-C)	FTSD-4-0-3(-C)	FTSR-4-0-1(-C)	FTSR-4-0-2(-C)	FTSR-4-0-3(-C)
OS	FTSD-4-1-1(-C)	FTSD-4-1-2(-C)	FTSD-4-1-3(-C)	FTSR-4-1-1(-C)	FTSR-4-1-2(-C)	FTSR-4-1-3(-C)
5/16	FTSD-5-0-1(-C)	FTSD-5-0-2(-C)	FTSD-5-0-3(-C)	FTSR-5-0-1(-C)	FTSR-5-0-2(-C)	FTSR-5-0-3(-C)
OS	FTSD-5-1-1(-C)	FTSD-5-1-2(-C)	FTSD-5-1-3(-C)	FTSR-5-1-1(-C)	FTSR-5-1-2(-C)	FTSR-5-1-3(-C)
3/8	FTSD-6-0-1(-C)	FTSD-6-0-2(-C)	FTSD-6-0-3(-C)	FTSR-6-0-1(-C)	FTSR-6-0-2(-C)	FTSR-6-0-3(-C)
OS	FTSD-6-1-1(-C)	FTSD-6-1-2(-C)	FTSD-6-1-3(-C)	FTSR-6-1-1(-C)	FTSR-6-1-2(-C)	FTSR-6-1-3(-C)

* Cutters are available in cobalt or high speed steel.

1	2	3	4	5	6	7
Fastener Sizes	 Verification Pin			 Mandrel Check Fixture		
	Class I	Class II	Class III	Class I	Class II	Class III
3/16	FTG-3-0-1	FTG-3-0-2	FTG-3-0-3	FTMG-3-0-1	FTMG-3-0-2	FTMG-3-0-3
OS	FTG-3-1-1	FTG-3-1-2	FTG-3-1-3	FTMG-3-1-1	FTMG-3-1-2	FTMG-3-1-3
1/4	FTG-4-0-1	FTG-4-0-2	FTG-4-0-3	FTMG-4-0-1	FTMG-4-0-2	FTMG-4-0-3
OS	FTG-4-1-1	FTG-4-1-2	FTG-4-1-3	FTMG-4-1-1	FTMG-4-1-2	FTMG-4-1-3
5/16	FTG-5-0-1	FTG-5-0-2	FTG-5-0-3	FTMG-5-0-1	FTMG-5-0-2	FTMG-5-0-3
OS	FTG-5-1-1	FTG-5-1-2	FTG-5-1-3	FTMG-5-1-1	FTMG-5-1-2	FTMG-5-1-3
3/8	FTG-6-0-1	FTG-6-0-2	FTG-6-0-3	FTMG-6-0-1	FTMG-6-0-2	FTMG-6-0-3
OS	FTG-6-1-1	FTG-6-1-2	FTG-6-1-3	FTMG-6-1-1	FTMG-6-1-2	FTMG-6-1-3

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Table 12.4-1 shows all durable and expendable tooling for the ForceTec nut plate system. First, determine the desired fastener size (3/16 , 1/4, 5/16, or 3/8 inch, nominal or oversize) then move across the table and select the appropriate tooling. Model numbers containing asterisks (*) indicate an option unique to that piece of tooling. For these options, please refer to the bottom of the table and to the individual tooling selection on pages 4 through 10 of this section on how to select these parts of the model number.

Table 12.4-1 (Continued)
Standard ForceTec Tooling

1	2	3	4	5	6	7
Fastener Sizes	 Flared Sleeve			 Retainer		
	Class I	Class II	Class III	Class I	Class II	Class III
3/16	FTS-3-0-1-*	FTS-3-0-2-*	FTS-3-0-3-*	FTR-3-0-1-.***-*	FTR-3-0-2-.***-*	FTR-3-0-3-.***-*
OS	FTS-3-1-1-*	FTS-3-1-2-*	FTS-3-1-3-*	FTR-3-1-1-.***-*	FTR-3-1-2-.***-*	FTR-3-1-3-.***-*
1/4	FTS-4-0-1-*	FTS-4-0-2-*	FTS-4-0-3-*	FTR-4-0-1-.***-*	FTR-4-0-2-.***-*	FTR-4-0-3-.***-*
OS	FTS-4-1-1-*	FTS-4-1-2-*	FTS-4-1-3-*	FTR-4-1-1-.***-*	FTR-4-1-2-.***-*	FTR-4-1-3-.***-*
5/16	FTS-5-0-1-*	FTS-5-0-2-*	FTS-5-0-3-*	FTR-5-0-1-.***-*	FTR-5-0-2-.***-*	FTR-5-0-3-.***-*
OS	FTS-5-1-1-*	FTS-5-1-2-*	FTS-5-1-3-*	FTR-5-1-1-.***-*	FTR-5-1-2-.***-*	FTR-5-1-3-.***-*
3/8	FTS-6-0-1-*	FTS-6-0-2-*	FTS-6-0-3-*	FTR-6-0-1-.***-*	FTR-6-0-2-.***-*	FTR-6-0-3-.***-*
OS	FTS-6-1-1-*	FTS-6-1-2-*	FTS-6-1-3-*	FTR-6-1-1-.***-*	FTR-6-1-2-.***-*	FTR-6-1-3-.***-*

* Retainer = S for stainless steel retainers, T for titanium retainers.
* Flared Sleeves = Length, 2 is for up to 1/8 inch long retainers and 8 is for up to 1/2 inch long retainers.
*** Retainer = Barrel Length required in .000s (inch).

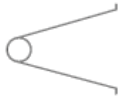
1	2	3	4	5	6	7
Fastener Sizes	 Replacement Clip			 Mandrel		
	Class I	Class II	Class III	Class I	Class II	Class III
3/16	FTCR-3	FTCR-3	FTCR-3	FTM-3-0-1-*	FTM-3-0-2-*	FTM-3-0-3-*
1/4	FTCR-4	FTCR-4	FTCR-4	FTM-4-0-1-*	FTM-4-0-2-*	FTM-4-0-3-*
5/16	FTCR-5	FTCR-5	FTCR-5	FTM-5-0-1-*	FTM-5-0-2-*	FTM-5-0-3-*
3/8	FTCR-6	FTCR-6	FTCR-6	FTM-6-0-1-*	FTM-6-0-2-*	FTM-6-0-3-*

* Mandrel = Length, 2 is for up to 1/8 inch long retainers and 8 is for up to 1/2 inch long retainers.

12.4 STANDARD FORCETEC TOOLING

Table 12.4-1 shows all durable and expendable tooling for the ForceTec Rivetless nut plate system. First, determine the desired fastener size (3/16 , 1/4, 5/16, or 3/8 inch, nominal or oversize) move across the table and select the appropriate tooling. Model numbers containing asterisks (*) indicate an option unique to that piece of tooling. For these options, please refer to the bottom of the table and to the individual tooling selection throughout this section on how to select these parts of the model number.

Table 12.4-1 (Continued) Standard ForceTec Tooling

1	2	3	4	5	6	7
Fastener Sizes	 Nosecap			 Retainer Holder		
	Class I	Class II	Class III	Class I	Class II	Class III
3/16 OS	FTN-3-0-1 FTN-3-1-1	FTN-3-0-2 FTN-3-1-2	FTN-3-0-3 FTN-3-1-3	FTRH	FTRH	FTRH
1/4 OS	FTN-4-0-1 FTN-4-1-1	FTN-4-0-2 FTN-4-1-2	FTN-4-0-3 FTN-4-1-3	FTRH	FTRH	FTRH
5/16 OS	FTN-5-0-1 FTN-5-1-1	FTN-5-0-2 FTN-5-1-2	FTN-5-0-3 FTN-5-1-3	FTRH	FTRH	FTRH
3/8 OS	FTN-6-0-1 FTN-6-1-1	FTN-6-0-2 FTN-6-1-2	FTN-6-0-3 FTN-6-1-3	FTRH	FTRH	FTRH

1	2	3	4	5	6	7
Fastener Sizes	 Trimming Tool			 Finish Retainer*		
	Class I	Class II	Class III	Class I	Class II	Class III
3/16	FTTT-3-0-1	FTTT-3-0-2	FTTT-3-0-3	FTFR-3-0-1-C	FTFR-3-0-2-C	FTFR-3-0-3-C
1/4	FTTT-4-0-1	FTTT-4-0-2	FTTT-4-0-3	FTFR-4-0-1-C	FTFR-4-0-2-C	FTFR-4-0-3-C
5/16	FTTT-5-0-1	FTTT-5-0-2	FTTT-5-0-3	FTFR-5-0-1-C	FTFR-5-0-2-C	FTFR-5-0-3-C
3/8	FTTT-6-0-1	FTTT-6-0-2	FTTT-6-0-3	FTFR-6-0-1-C	FTFR-6-0-2-C	FTFR-6-0-3-C

* All ForceTec final reamers are cobalt (-C).

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Section		Page
13.X	Process Definition	X
13.X	Process Overview	X
13.X	STDN Selection	X
13.X	Standard Tooling	X

Please contact Fatigue Technology or your nearest FTI representative and ask for the GromEx Process Specification: FTI-2008-01 for more information.

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Enhanced Stop Drill Repair

Stop drilling of a hole at the tip of a crack is frequently used as an interim repair procedure. The **StopCrack** Enhanced Stop Drill Repair (ESDR) procedure is a significant improvement over the traditional stop drilling technique, providing additional structural assurance and damage tolerance until depot-level repair can be performed. It is the result of extensive R&D based upon the Split Sleeve Hole Cold Expansion Process described in FTI Process Instruction EH-1.

Designed as a complete kit for efficient use by mechanics and maintenance personnel, **StopCrack** utilizes a unique, convenient procedure to cold expand a stop drilled hole. This process shields the hole from the effects of cyclic tensile loads by imparting residual compressive stresses around the circumference of the hole.

StopCrack does not replace stop drilling. Instead, it applies proven split sleeve cold expansion technology to substantially increase the likelihood that a stop drilled crack will not re-initiate at the hole. This is accomplished without adding weight to or changing the metallic characteristics of the structure. Included in each kit is all the tooling needed to stop drill and cold expand 3/16 inch, 1/4 inch, and oversize (17/64 inch) holes. Full kit contents are shown in Table 14.1-1.

Table 14.1-1
Tools and Equipment-Enhanced Stop Drill Repair
(Kit #FTI-SCK-A1)

Quantity	Part Number	Description
		3/16-inch Expandable Tool Set
4	CASD-30-1-SCK	Starting Drill
2	CASR-30-1	Starting reamer
1	CAG-30	Combination Gage
1	CAM-30-1-25-V2	Mandrel
50	CAS-30-8F	Split Sleeve
1	CAMG-30	Mandrel Gage
2	CAR-30-1-.1910	Final reamer (for 3/16 inch aluminium rivet)
2	CAR-30-1-.1870	Final reamer (for 3/16 inch lock bolt)
		1/4-inch Expandable Tool Set
4	CASD-40-1-SCK	Starting Drill
2	CASR-40-1	Starting reamer
1	CAG-40	Combination Gage
1	CAM-40-1-25-V2	Mandrel
50	CAS-40-8F	Split Sleeve
1	CAMG-40	Mandrel Gage
2	CAR-40-1-.2500	Final reamer (for 1/4 inch aluminium rivet)
2	CAR-40-1-.2470	Final reamer (for 1/4 inch lock bolt)
		17/64-inch Expandable Tool Set
2	CASR-40-1	Starting reamer
1	CAG-41	Combination Gage
1	CAM-41-1-25-V2	Mandrel
10	CAS-41-8F	Split Sleeve
1	CAMG-41	Mandrel Gage
2	CAR-41-.2656-SCK	Final reamer (for 17/64 inch aluminium rivet)
2	CAR-41-1-.2626-SCK	Final reamer (for 17/64 inch lock bolt)
		Other Tooling
1	HP-20	Hand Puller/Wrench
1	MEN-14A-0601F	3/16 inch Extension Nosecap Assembly
1	MEN-14A-0801F	1/4 inch and 17/64 inch Extension Nosecap Assembly

"Mini" StopCrack Kit

Also available from FTI is the new smaller StopCrack kit designed especially for operators of light aircraft. This kit contains all tooling necessary to cold expand 1/8 inch diameter stop-drill holes in material thicknesses up to 1/4 inch. This kit utilizes a special thin sheet puller that is quicker than the piston-operated hand puller in the standard StopCrack kit.

Table 14.2-1
Tools and Equipment-Thin Sheet StopCrack Kit
(Kit #FTI-SCK-T1)

Quantity	Part Number	Description
2	CASD-20-1	Starting Drill
2	CASR-20-1	Starting Reamer
1	CAG-20	Combination gage
2	CAM-20 -P4-V1	Mandrel
1	CACE-20-1	Nosecap
50	CAS-20-8F	Split Sleeve
1	CAMG-20	Mandrel Gage
2	CAR-20-1-.1250	Final Reamer (for 1/8 inch aluminum rivet)
1	1045-135	Thin Sheet Puller

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14.3 SERVICE BULLETINS

Fatigue Technology provides custom Service Bulletin Kits designed for specific aircraft rework applications. Fatigue Technology is the endorsed and approved supplier of Service Bulletin Cold Working Kits for the following aircraft manufacturers:

The Boeing Company
*** McDonnell Douglas Aircraft Co.**
*** Aerospatiale**
*** Fokker**
*** Lockheed Martin**
*** British Aerospace Airbus**
*** Airbus Industries**
*** ATR**

FTI sells all the necessary tooling in comprehensive kits and will also rent necessary capital tooling to facilitate incorporation of the service bulletin. We maintain a complete inventory of cold working tooling for shipment throughout the world. We can also custom design specified tooling to accommodate any aircraft configuration.

FTI includes all necessary instructions in a customized service bulletin rework procedure, with each kit of tooling. Where necessary, we can also provide on-site training or training at our facility to ensure your personnel are qualified and certified to complete any cold working operation.

Our Technical Group will provide details of all custom tooling kits available and offer assistance in preparing kits for your specific applications. All kits are packaged in durable storage containers and are identified in accordance with your requirements.

* NOTE: FTI is the only approved source for service bulletin tooling and support for these commercial aircraft manufacturers.

14.4 CUSTOM TOOLING KITS

- Custom tooling kits can be provided for easy incorporation of the split sleeve cold expansion process.
- Designed for specific application requirements.
- May be based upon customer-supplied documents, such as Commercial Service Bulletins, Military Air Frame Changes or Tech Orders, or Engineering Change Proposals.
- Customized process instructions detailing complete installation or rework procedures can be provided.
- Kits include capital tooling and/or expendable tooling.
- Kits are packaged in durable storage containers and are identified in accordance with your requirements.
- May be arranged to include training and kit proof engineering support.

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14.5 Cx Overhaul and Repair Kits

Most repair and overhaul sites are now using the Split Sleeve Cold Expansion (SsCx) process for fatigue life enhancement of fastener holes. The FTI Cx Overhaul and Repair Kits are specifically designed to meet the special requirements of these customers. These kits contain all of the tooling required to cold expand existing hole diameters and allow repair of up to 100 holes of any one diameter (kits are configured to accommodate a specific hole size or sizes). Convenient reorder forms facilitate replacement of tooling. Additionally, each kit also contains our enhanced stop drill repair kit, StopCrack (except CxORK-3 and CxORK-4). This process improves the fatigue life of stop-drilled holes by at least 20:1.

Features

- All tooling is based upon the new rework SsCx process allowing optimal airframe rework parameters.
- Tooling comes packaged in a sturdy, mobile cabinet with locking wheels.
- Kits contain additional space available for special tooling sets (service bulletin or other modification kits).
- All instructions, specifications, and reorder forms are provided.
- Kit price is based upon wholesale prices that reflect a substantial savings over our standard retail prices.
- One day of training is included in the price of the kit (not including airfare).
- Includes tooling for nominal hole sizes as well as corresponding oversizes.
- Tooling may also be used for cold expanding reduced edge margin holes, stop drilled holes, countersunk holes, attachment holes in repair doublers, etc.
- Cutting tools, gages, mandrels, nosecaps, and sleeves to treat holes of each size are included.
- Most restricted access holes can be treated using the LBOA offset adapter and extension nosecaps.
- Includes Little Brute Puller Unit and lightweight FT-20 PowerPak.
- Overall dimensions are 42"H X 28"W X 28"L.

See page 232, this section for an example of a typical CXORK Kit (contents list).

Table 14.5-1 lists all Overhaul and Repair Kits currently available from FTI. The kits are broken down into three categories:

1. CB Tooling Series
2. CR Tooling Series
3. CA Tooling Series

The CXORK-1A and 2A kits are complete kits, including countersink tooling. The CXORK-1B and 2B kits do not contain countersink tooling, but can be upgraded to a CXORK-1A or 2A by purchasing the supplemental countersink tooling kits, CXORK-1C or 2C.

Table 14.5-1
Overhaul and Repair Kits

Tooling Series	Kit Number	Existing Hole Diameter Range	Countersink Tooling Included	Applicable Material
CB	CXORK-1A	5/32 to 3/8"	Yes	Aluminium
	CXORK-1B	5/32 to 3/8"	No	Aluminium
	*CXORK-1C	5/32 to 3/8"	Yes	Aluminium
	CXORK-3	7/16 to 1"	No	Aluminium
CR	CXORK-2A	5/32 to 3/8"	Yes	Aluminium
	CXORK-2B	5/32 to 3/8"	No	Aluminium
	*CXORK-2C	5/32 to 3/8"	Yes	Aluminium
CA	CXORK-4	3/16 to 1/2"	No	Steel/Titanium

*CXORK-1C and 2C contain only supplemental countersink tooling sets.

For additional information on standard tooling kits, please contact our Technical Sales Department.

Fatigue Technology reserves the right to change the configuration of standard kits at any time as part of our product improvement policy. Please contact FTI for the latest kit configurations.

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The contents of CXORK - 1A/2A are listed below as an example of a typical CXORK Kit. Additional kits are available for specific applications. See page 231 for additional information on specific kits and series of kits.

CXORK - 1A/2A

1	Four drawer mobile cabinet
1	LB-20 Little Brute hydraulic puller unit
1	FT-20 lightweight hydraulic PowerPak
1	LBOA-20 offset puller adapter
1	Enhanced Stop Drill Repair Kit (StopCrack) for 3/16, 1/4, and 17/64 inch hole diameters

Each StopCrack kit contains:

1	HP-20 mechanical puller
2	Extension nosecaps
8	Starting drills
6	Starting reamers
3	Combination gages
3	Mandrels
3	Mandrel gages
110	Split sleeves
6	Gage finish reamers (rivet holes)
6	Gage finish reamers (lockbolt holes)
8	Tooling Sets (5/32 inch - 3/8 inch, existing holes diameter range)

Each tooling set contains:

1	Tooling set container
2	Starting drills (twist)
2	Starting reamers
1	Combination gage
1	Mandrel gage
3	Mandrels
1	Standard nosecap assembly
100	Split sleeves (flared)
2	Gage finish reamers
1	Final hole gage
1	Offset adapter jaw
1	*Countersink nosecap
100	*Split sleeves (straight)
20	*Backup Blocks

***Note:** These items make up the supplementary countersink tooling sets for CXORK-1C/2C.

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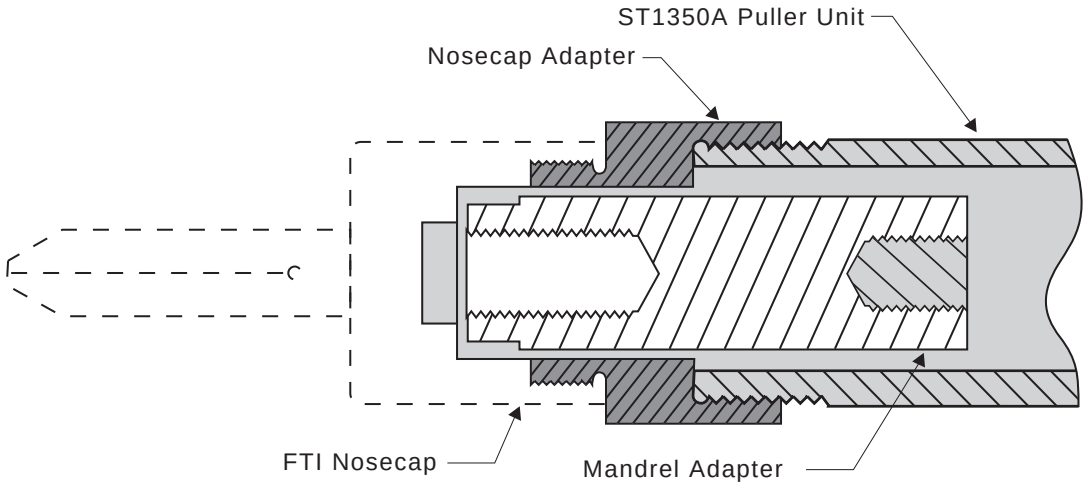

Figure 15.1-1
Assembled Nosecap Adapter and Mandrel Adapter

- Tables 15.1-1, 15.1-2 and 15.1-3 list puller unit adapters for converting various pullers to FTI associated nosecaps and mandrels.
- Each puller unit adapter assembly includes a nosecap adapter and/or mandrel adapter.

Table 15.1-1
Nosecap Adapters

Puller Unit	Model Number	Function
LB-XX	LB/MB-CBC-A2	Allows MB Nosecap to fit LB Pullers
ST1350A-0XX	ST1350A/CBC-1	Allows FTI LB Nosecap to fit Boeing ST1350A Puller
MB-XX	MB/BB-CNC-1	Allows BB Nosecap to fit MB Pullers

Table 15.1-2
Mandrel Adapters

Puller Unit	Model Number	Function
MB-XX	FTI-MB/LB-A2	
MB-XX	MB/BB-1	
MB-XX	FTI-MB/LB-A1	Allows LB Mandrel to -2 MBN mandrel adapter/LB nosecap to MB Puller

Table 15.1-3
Nosecap/Mandrel Adapter Sets

Puller Unit	Model Number	Function
ST1350A-XX	ST1350A/LB-1	Adapts FTI Mandrels (-1) and LB Nosecaps to ST1350A-XX Puller
MB-XX	ST1350C/LB-2	Adapts FTI Mandrels (-1) and LB Nosecaps to -5 MB mandrel adapter/LB nosecap to MB-Z/XX puller

Table 15.1-4
Adapters for Little Brute, Little Brute Offset, Medium Brute, Medium Brute Offset, and Big Brute

	Puller Unit	Model Number	Description	Mandrel Thread	Mandrel/Chuck Assembly
Little Brute	LB-XX	LB-D10	Threaded Adapter	7/16" x 20 UNF	-1-.-10A-HOA
	LB-XX	LB-D10A	Threaded Adapter	1/2" x 20 UNF	-1A-
	LB-XX	LB-PC-1	Pintail Chuck assy	Mandrel "B", .0730-.0859	-----
	LB-XX	LB-PC-2	Pintail Chuck assy	Mandrel "B", .0860-.0989	-----
	LB-XX	LB-PC-3	Pintail Chuck assy	Mandrel "B", .0990-.1119	-----
	LB-XX	LB-PC-4	Pintail Chuck assy	Mandrel "B", .1120-.1249	-----
	LB-XX	LB-PC-5	Pintail Chuck assy	Mandrel "B", .1250-.1379	-----
	LB-XX	LB-PC-6	Pintail Chuck assy	Mandrel "B", .1380-.1639	-----
	LB-XX	LB-PC-8	Pintail Chuck assy	Mandrel "B", .1640-.1899	-----
	LB-XX	LB-PC-10	Pintail Chuck assy	Mandrel "B", .1900-.2159	-----
	LB-XX	LB-PC-12	Pintail Chuck assy	Mandrel "B", .2160-.2499	-----
	LB-XX	LB-PC-14	Pintail Chuck assy	Mandrel "B", .2500-.3124	-----
	LB-XX	LB-PC-16	Pintail Chuck assy	Mandrel "B", .3125-.3250	-----
	LB-XX	LB-CA-4	Tang Chuck assy	Mandrel "B", .2000-.2999	-----
	LB-XX	LB-CA-6	Tang Chuck assy	Mandrel "B", .3000-.3999	-----
	ST1350A-03	ST1350A/CBM1	Threaded Adapter	7/16" x 20 UNF	-1-.-10A-HOA
	ST1350A-05	ST1350A/CBM1	Threaded Adapter	7/16" x 20 UNF	-1
	ST1350A0X	ST5300P-A-1	Threaded Adapter	7/16" x 20 UNF	-1
Little Brute Offset	LBOA-XX	5130-001	Pintail Adapter	12-28 UNF	Pintail
	LBOA-XX	LBOA-SA-NUT	Self Alignment Nut	7/16" x 20 UNF	-10A
Medium Brute	MB-XX	MB-D17	Threaded Adapter	5/8" x 18 UNF	-2-, -2OA
	MB-XX	MB-D18	Threaded Adapter	7/8" x 18 UNF	-54
	MB-XX	MB-CA-8	Chuck Assembly	Mandrel "B", .4000-.5999	-----
	MB-XX	MC-CA-11	Chuck Assembly	Mandrel "B", .6000-.7999	-----
	MB-XX	MB/LB0CBM-A2	Threaded Adapter	7/16" x 20 UNF	-1 to -2
	MB-XX	ST1350AC/LB-A	Threaded Adapter	7/16" x 20 UNF	-1 to -5
	MB-XX	-2579001	Threaded Adapter	1/2" x 20 UNF	ST1350 to -2
Medium Brute Offset	MBOA-XX	2519-001	Threaded Adapter	7/16" x 18 UNF	-5-, -4-
	MBOA-XX	2519-002	Threaded Adapter	5/8" x 18 UNF	-2-, -2OA
	MBOA-XX	2519-003	Threaded Adapter	7/16" x 20 UNF	-1-, -1OA, -HOA
Big Brute	BB-XX	BB-C-D35	Threaded Adapter	7/8" x 14 UNF	-5-, -4-
	BB-XX	BB-C-D35	Threaded Adapter	1" x14 UNS	-9-
	BB-XX	BB-C-D35	Threaded Adapter	7/8" x 14 UNF	-5-, -4-
	BB-XX	BB-C-D35	Threaded Adapter	1" x14 UNS	-9-
	BB-XX	BB-E-D35	Threaded Adapter	5/8" x18 UNF	-2-, -2OA-
	BB-XX	BB-CA-11	Chuck Assembly	-----	-----
	BB-XX	BB-CA-16	Chuck Assembly	-----	-3-
	BB-XX	BB-CA-20	Chuck Assembly	-----	-----

Accessories
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15.2 Support Fixtures

Figure 15.2-1
Expandable Screw Type Support Assembly

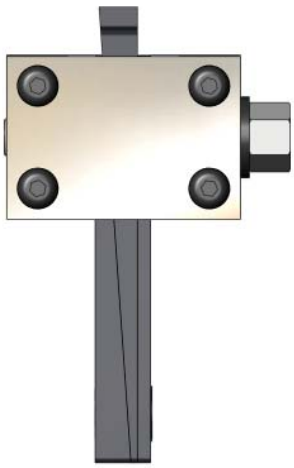

Figure 15.2-2
Wedge Type Support Assembly (For multiple lugs)

- Contact FTI Technical Group for assitance in selecting Support Assemblies.

15.3 Stroke Limiter

Figure 15.3-1
Stroke Limiter

Figure 15.3-2
Adjustable Stroke Limiter

- Artificially reduces stroke of puller unit in restricted access areas.
- Contact FTI Technical Group for assitance in selecting Support Assemblies.

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15.4 Seal Kits and Rework Kits

Table 15.4-1
Seal kits

Model Number	Description
LB-SK	Little Brute Seal kit
MB-SK	Medium Brute Seal Kit
BB-SK	Big Brute Seal Kit

- Contains all wear seals and O-Rings for specified puller units.

Table 15.4-2
Rework kits

Model Number	Description
LB-RK	Little Brute Rework kit
MB-RK	Medium Brute Rework Kit
BB-RK	Big Brute Rework Kit

- Contains seal kit (wear seals and O-Rings for specified puller units), plus wear parts for trigger, new hydraulic adapter, and air seal adapter.

15.5 Replacement Hoses and Extension Hoses

Table 15.5-1
Replacement Hose Assemblies

Model Number	Description
IWZY-10	10' Replacement Hose
IWZY-20	20' Replacement Hose
IWZY-25	25' Replacement Hose
IWZY-30	30' Replacement Hose

Table 15.5-2
Extension Hose Assemblies

Model Number	Description
5005-001	10' Extension Hose
5005-002	30' Extension Hose

- Used to extend existing hose.
- Features two air lines and one hydraulic line.
- Not recommended for use with FT-20 PowerPak due to increased amount of hydraulic fluid required with additional hose length.

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15.6 Cx Detector

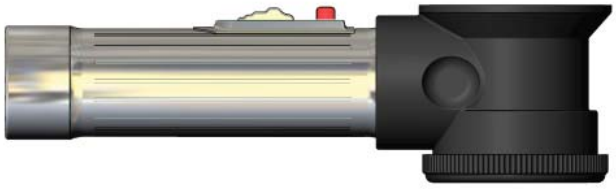

Figure 15.6-1
Cx Detector

- Detects surface upset around a coldworked hole on non-painted and some painted surfaces.
- Can detect Cx before or after the hole has been final reamed.
- Prevents skipping holes that should be cold worked and eliminates need for re-cold expanding holes.
- Portable, hand held, light weight (8.7 ounces).

15.7 HOA Hose Reversal Kit

Table 15.7-1
HOA Hose Reversal Kit

Part Number	Description
2816-001	HOA-6 Reversal Kit
2816-002	HOA-7 Reversal Kit
2816-003	HOA-8 Reversal Kit

Figure 15.7-1
HOA Reversal Assembly

- For use with HOA series of adapters.
- Allows hydraulic hose to be connected at top of adapter in restricted access situations.
- Kit also includes plugs to seal holes on bottom of adapter where hose usually connects.

15.8 REMOTE TRIGGER

Figure 15.8-1
Remote Trigger

- Part number 2049-007
- For use with FTMP-XX, HOA-XL, SB-2.

15.9 BUSHING REMOVAL TOOL

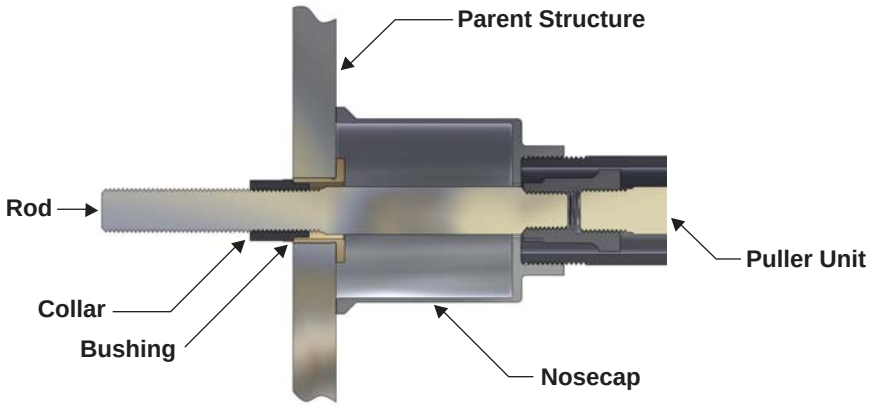

Figure 15.9-1
Bushing Removal Tooling

- Conveniently removes interference fit installed bushing/insert.
- Removes bushings up to 2 inches in diameter.
- Does not damage surrounding structure.
- Compatible with FTI hydraulic puller units.
- Captures the bushing once removed to prevent bushing from being lost inside structure.
- Manufactured from high-strength steel alloy for function and durability.

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15.9 BUSHING REMOVAL TOOL

Table 15.9-1
Bushing Removal Tooling

Bushing Inside Diameter (inches)	Puller Unit Options	Rod Model Number	Collar Model Number	Nosecap Model Number	Tooling kit Model Number
3/16 (.188)	Little Brute	BRR-3-4-1	BRC-3-50	BRN-L-*	BRT-L-3
7/32 (.219)	Little Brute	BRR-3OS-4-1	BRC-3OS-50	BRN-L-*	BRT-L-3OS
1/4 (.219)	Little Brute	BRR-44OS-4-1	BRC-4-50	BRN-L-*	BRT-L-4
9/32 (.281)	Little Brute	BRR-44OS-4-1	BRC-4OS-50	BRN-L-*	BRT-L-4OS
5/16 (.313)	Little Brute	BRR-55OS-4-1	BRC-5-50	BRN-L-*	BRT-L-5
11/32 (.344)	Little Brute	BRR-55OS-4-1	BRC-50OS-50	BRN-L-*	BRT-L-5OS
3/8 (.375)	Little Brute	BRR-66OS-4-1	BRC-6-50	BRN-L-*	BRT-L-6
13/32 (.406)	Little Brute	BRR-66OS-4-1	BRC-6OS-50	BRN-L-*	BRT-L-6OS
7/16 (.438)	Little Brute	BRR-78OS-4-1	BRC-7-50	BRN-L-*	BRT-L-7
15/32 (.496)	Little Brute	BRR-78OS-4-1	BRC-7OS-50	BRN-L-*	BRT-L-OS
1/2 (.500)	Little Brute	BRR-78OS-4-1	BRC-8-50	BRN-L-*	BRT-L-8
17/32 (.531)	Little Brute	BRR-78OS-4-1	BRC-80OS-50	BRN-L-*	BRT-L-8OS
9/16 (.563)	Little Brute	BRR-911OS-4-1	BRC-9-50	BRN-L-*	BRT-L-9
	Medium Brute	BRR-911OS-4-2	BRC-9-50	BRN-M-*	BRT-M-9
19/32 (.594)	Little Brute	BRR-911OS-4-1	BRC-9OS-50	BRN-L-*	BRT-L-9OS
	Medium Brute	BRR-911OS-4-2	BRC-9OS-50	BRN-M-*	BRT-M-9OS
5/8 (.625)	Little Brute	BRR-911OS-4-1	BRC-10-50	BRN-L-*	BRT-L-10
	Medium Brute	BRR-911OS-4-2	BRC-10-50	BRN-M-*	BRT-M-10
21/32 (.656)	Little Brute	BRR-911OS-4-1	BRC-10OS-50	BRN-L-*	BRT-L-10OS
	Medium Brute	BRR-911OS-4-2	BRC-10OS-50	BRN-M-*	BRT-M-10OS
11/16 (.688)	Little Brute	BRR-911OS-4-1	BRC-11-50	BRN-L-*	BRT-L-11
	Medium Brute	BRR-911OS-4-2	BRC-11-50	BRN-M-*	BRT-M-11
23/32 (.719)	Little Brute	BRR-911OS-4-1	BRC-11OS-50	BRN-L-*	BRT-L-11OS
	Medium Brute	BRR-911OS-4-2	BRC-11OS-50	BRN-M-*	BRT-M-11OS
3/4 (.750)	Medium Brute	BRR-1214OS-4-2	BRC-12-50	BRN-M-*	BRT-M-12
25/32 (.781)	Medium Brute	BRR-1214OS-4-2	BRC-12OS-50	BRN-M-*	BRT-M-12OS
13/16 (.813)	Medium Brute	BRR-1214OS-4-2	BRC-13-50	BRN-M-*	BRT-M-13
27/32 (.844)	Medium Brute	BRR-1214OS-4-2	BRC-13OS-50	BRN-M-*	BRT-M-13OS
7/8 (.875)	Medium Brute	BRR-1214OS-4-2	BRC-14-50	BRN-M-*	BRT-M-14
29/32 (.906)	Medium Brute	BRR-1214OS-4-2	BRC-14OS-50	BRN-M-*	BRT-M-14OS
15/16 (.938)	Medium Brute	BRR-1523OS-4-5	BRC-15-50	BRN-M-*	BRT-M-15
	Big Brute	BRR-1523OS-4-5	BRC-15-50	BRN-B-*	BRT-B-15
31/32 (.969)	Medium Brute	BRR-1523OS-4-2	BRC-15OS-50	BRN-M-*	BRT-M-15OS
	Big Brute	BRR-1523OS-4-5	BRC-15OS-50	BRN-B-*	BRT-B-15OS

* There must be at least .030 inch of clearance between the bushing outside diameter (flange if applicable) and nosecap inside diameter.

Accessories
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Table 15.9-1 (Continued)
Bushing Removal Tooling

Bushing Inside Diameter (inches)	Puller Unit Options	Rod Model Number	Collar Model Number	Nosecap Model Number	Tooling kit Model Number
1 (1.000)	Medium Brute	BRR-1523OS-4-2	BRC-16-50	BRN-M-*	BRT-M-16
	Big Brute	BRR-1532OS-4-5	BRC-16-50	BRN-B-*	BRT-B-16
33/32 (1.031)	Medium Brute	BRR-1523OS-4-2	BRC-16OS-50	BRN-M-*	BRT-M-16OS
	Big Brute	BRR-1532OS-4-5	BRC-16OS-50	BRN-B-*	BRT-B-16OS
17/16 (1.063)	Medium Brute	BRR-1523OS-4-2	BRC-17-50	BRN-M-*	BRN-M-17
	Big Brute	BRR-1532OS-4-5	BRC-17-50	BRN-B-*	BRN-B-17
35/32 (1.094)	Medium Brute	BRR-1523OS-4-2	BRC-17OS-50	BRN-M-*	BRN-M-17OS
	Big Brute	BRR-1532OS-4-5	BRC-17OS-50	BRN-B-*	BRN-B-17OS
9/8 (1.125)	Medium Brute	BRR-1523OS-4-2	BRC-18-50	BRN-M-*	BRN-M-18
	Big Brute	BRR-1532OS-4-5	BRC-18-50	BRN-B-*	BRN-B-18
37/32 (1.156)	Medium Brute	BRR-1523OS-4-2	BRC-18OS-50	BRN-M-*	BRN-M-18OS
	Big Brute	BRR-1532OS-4-5	BRC-18OS-50	BRN-B-*	BRN-B-18OS
19/16 (1.188)	Medium Brute	BRR-1523OS-4-2	BRC-19-50	BRN-M-*	BRT-M-19
	Big Brute	BRR-1532OS-4-5	BRC-19-50	BRN-B-*	BRT-B-19
39/32 (1.219)	Medium Brute	BRR-1523OS-4-2	BRC-19OS-50	BRN-M-*	BRT-M-19OS
	Big Brute	BRR-1532OS-4-5	BRC-19OS-50	BRN-B-*	BRT-B-19OS
5/4 (1.250)	Medium Brute	BRR-1523OS-4-2	BRC-20-50	BRN-M-*	BRT-M-20
	Big Brute	BRR-1532OS-4-5	BRC-20-50	BRN-B-*	BRT-B-20
41/32 (1.281)	Medium Brute	BRR-1523OS-4-2	BRC-20OS-50	BRN-M-*	BRT-M-20OS
	Big Brute	BRR-1532OS-4-5	BRC-20OS-50	BRN-B-*	BRT-B-20OS
21/16 (1.313)	Medium Brute	BRR-1523OS-4-2	BRC-21-50	BRN-M-*	BRT-M-21
	Big Brute	BRR-1532OS-4-5	BRC-21-50	BRN-B-*	BRT-B-21
43/32 (1.344)	Medium Brute	BRR-1523OS-4-2	BRC-21OS-50	BRN-M-*	BRT-M-21OS
	Big Brute	BRR-1532OS-4-5	BRC-21OS-50	BRN-B-*	BRT-B-21OS
11/8 (1.375)	Medium Brute	BRR-1523OS-4-2	BRC-22-50	BRN-M-*	BRT-M-22
	Big Brute	BRR-1532OS-4-5	BRC-22-50	BRN-B-*	BRT-B-22
45/32 (1.406)	Medium Brute	BRR-1523OS-4-2	BRC-22OS-50	BRN-M-*	BRT-M-22OS
	Big Brute	BRR-1532OS-4-5	BRC-22OS-50	BRN-B-*	BRT-B-22OS
23/16 (1.438)	Medium Brute	BRR-1523OS-4-2	BRC-23-50	BRN-M-*	BRT-M-23
	Big Brute	BRR-1532OS-4-5	BRC-23-50	BRN-B-*	BRT-B-23
47/32 (1.469)	Medium Brute	BRR-1523OS-4-2	BRC-23OS-50	BRN-M-*	BRT-M-23OS
	Big Brute	BRR-1532OS-4-5	BRC-23OS-50	BRN-B-*	BRT-B-23OS
3/2 (1.500)	Big Brute	BRR-1532OS-4-2	BRC-24-50	BRN-B-*	BRT-B-24
49/32 (1.531)	Big Brute	BRR-1532OS-4-5	BRC-24OS-50	BRN-B-*	BRT-B-24OS

* There must be at least .030 inch of clearance between the bushing outside diameter (flange if applicable) and nosecap inside diameter.

Accessories
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Table 15.9-1 (Continued)
Bushing Removal Tooling

Bushing Inside Diameter (inches)	Puller Unit Options	Rod Model Number	Collar Model Number	Nosecap Model Number	Tooling kit Model Number
25/16 (1.563)	Big Brute	BRR-1532OS-4-5	BRC-25-50	BRN-B-*	BRT-B-25
51/32 (1.593)	Big Brute	BRR-1532OS-4-5	BRC-25OS-50	BRN-B-*	BRT-B-25OS
13/8 (1.625)	Big Brute	BRR-1532OS-4-5	BRC-26-50	BRN-B-*	BRT-B-26
53/32 (.1.656)	Big Brute	BRR-1532OS-4-5	BRC-26OS-50	BRN-B-*	BRT-B-26OS
27/16 (1.688)	Big Brute	BRR-1532OS-4-5	BRC-27-50	BRN-B-*	BRN-B-27
55/32 (1.719)	Big Brute	BRR-1532OS-4-5	BRC-27OS-50	BRN-B-*	BRN-B-27OS
7/4 (1.750)	Big Brute	BRR-1532OS-4-5	BRC-28-50	BRN-B-*	BRN-B-28
57/32 (1.781)	Big Brute	BRR-1532OS-4-5	BRC-28OS-50	BRN-B-*	BRN-B-28OS
29/16 (1.813)	Big Brute	BRR-1532OS-4-5	BRC-29-50	BRN-B-*	BRN-B-29
59/32 (1.844)	Big Brute	BRR-1532OS-4-5	BRC-29OS-50	BRN-B-*	BRN-B-29OS
15/8 (1.875)	Big Brute	BRR-1532OS-4-5	BRC-30-50	BRN-B-*	BRN-B-30
61/32 (1.906)	Big Brute	BRR-1532OS-4-5	BRC-30OS-50	BRN-B-*	BRN-B-30OS
31/16 (1.938)	Big Brute	BRR-1532OS-4-5	BRC-31-50	BRN-B-*	BRT-B-31
63/32 (1.969)	Big Brute	BRR-1532OS-4-5	BRC-31OS-50	BRN-B-*	BRT-B-31OS
2 (2.000)	Big Brute	BRR-1532OS-4-5	BRC-32-50	BRN-B-*	BRT-B-32
65/32 (2.031)	Big Brute	BRR-1532OS-4-5	BRC-32OS-50	BRN-B-*	BRT-B-32OS

* There must be at least .030 inch of clearance between the bushing outside diameter (flange if applicable) and nosecap inside diameter.

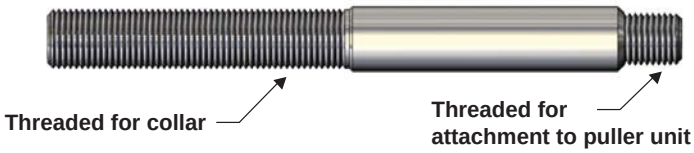
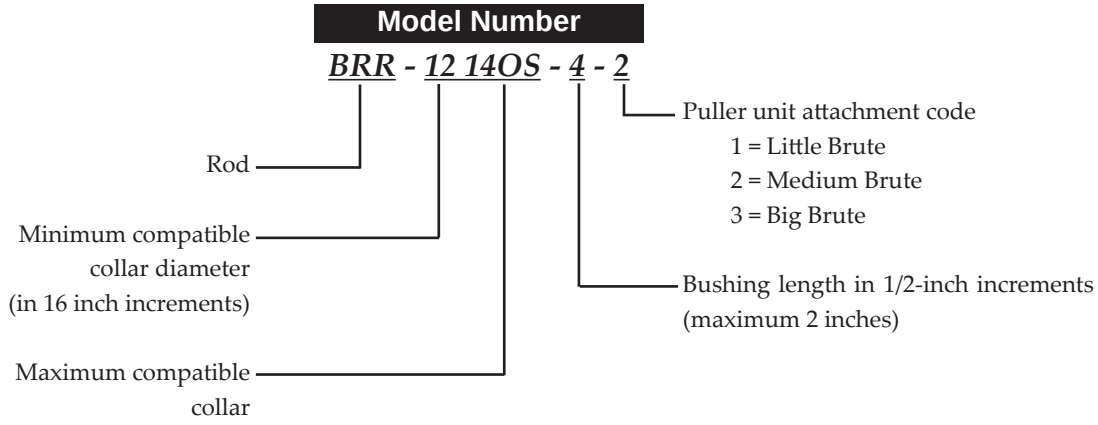


Figure 15.9-2
Bushing Removal Rod



Note: Separate Bushing Removal Rods are required for 3/16 and 7/32 inside diameter bushings. For other sizes, the rods are common to more than one size.

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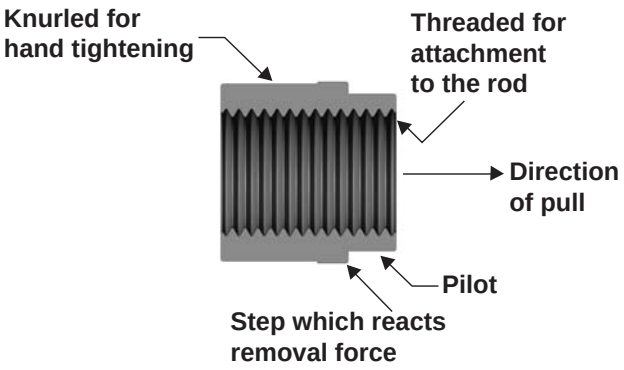

Figure 15.9-3
Bushing Removal Collar

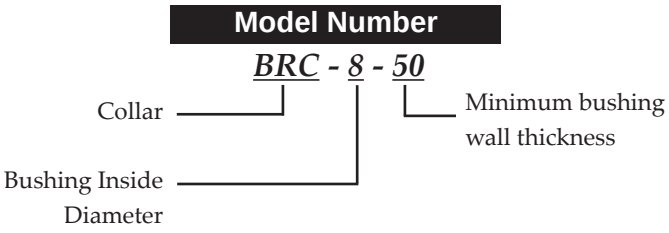

Figure 15.9-4
Bushing Removal Nosecap

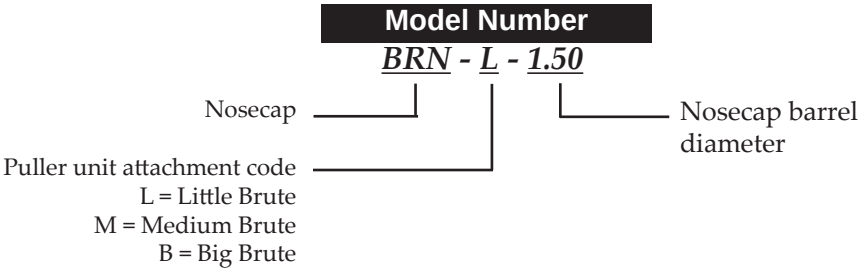

Table 15.9-2
BRT Nosecap Inside Diameter

Applicable Puller Unit Size	Nosecap Inside Diameter	Nosecap Model Number
Little Brute	.75	BRN-L-.75
Little Brute	1.00	BRN-L-1.00
Little Brute	1.50	BRN-L-1.50
Little Brute	2.00	BRN-L-2.00
Medium Brute	1.00	BRN-M-1.00
Medium Brute	1.50	BRN-M-1.50
Medium Brute	2.00	BRN-M-2.00
Medium Brute	2.50	BRN-M-2.50
Medium Brute	3.00	BRN-M-3.00
Big Brute	1.50	BRN-B-1.50
Big Brute	2.00	BRN-B-2.00
Big Brute	2.50	BRN-B-2.50
Big Brute	3.00	BRN-B-3.00
Big Brute	3.50	BRN-B-3.50
Big Brute	4.00	BRN-B-4.00

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APPENDIX

Section Page

A.1 GLOSSARY OF TERMS

Applied Expansion: The total expansion of the hole during cold expansion, expressed as a percentage of the starting hole diameter.

Back Taper: The portion of the mandrel that allows the mandrel to gradually enter a hole when cold expanding.

Backside Clearance: The distance from the back of the hole to the nearest obstruction.

Base Material: The material in which the hole is to be cold worked using the Split Sleeve Cold Expansion or the ForceMate systems.

BlCx: Trademark used to symbolize the FTI BushLoc system.

BushLoc (BlCx): A bushing installation system used to cold expand bushings of varying material type and wall thickness into place utilizing an internally lubricated split sleeve.

CA: Model number prefix for tooling used in titanium and high strength steel.

Capital Tooling: Includes puller units, PowerPaks, and adapters.

CB: Model number prefix for tooling used in aluminum or mild steels.

Cold Expanded Hole Diameter: The diameter of a hole after cold expansion, defined as the minimum diameter measured along an axial line oriented 90 degrees from the location of the axial ridge left by the split in the sleeve.

Cold Expansion System (Cx): A series of patented systems used to extend the fatigue life of metal structures (SsCx, Cx2s, CsCx, FmCx, ScCx, RwCx, FtCx, GrCx, BlCx).

Cold Expansion to Size (Cx2s): A process whereby holes are cold expanded and final sized in one operation, without the need for post sizing (final reaming).

Cold Working (Cold Expansion): A process whereby fatigue or crack growth life of a hole is improved due to the creation of residual compressive stresses around the hole.

Controlling Documents: The engineering specifications used to document the Cx processes.

Countersink Cold Expansion (CsCx): Split Sleeve Cold Expansion of an existing countersunk hole in aluminum.

CR: Model number prefix for tooling used in rework applications in aluminum.

Critical Tooling Dimensions: Any tooling dimension that contributes to the applied expansion of a hole or to a related quality assurance inspection.

CsCx: Trademark used to symbolize the FTI Split Sleeve Countersink Cold Expansion system.

Cx: Trademark used to symbolize all the FTI Cold Expansion systems.

Cx2s: Trademark used to symbolize the FTI Cold Expansion to Size system.

Durable Tooling: Includes cutting tools, mandrels, nosecap assemblies, combination gages, and mandrel gages.

Enhanced Stop Drill Repair: A system using FTI's StopCrack procedure, which extends the fatigue life of stop drilled holes.

Existing Hole Diameter (EHD): The inside diameter of the hole prior to any operation involved in the Cx process.

Expendable Tooling: Includes all split sleeves and backup blocks.

Fatigue: The failure of metal structure due to cyclic tensile stresses which are usually far less than the yield strength of the material and due to stress concentrations such as fastener holes.

Fatigue Life Enhancement: A process that improves the fatigue life of metal structures.

Final Hole Diameter (FHD): The inside hole diameter of the base material after Cx processing and final sizing operations are complete.

FmCx: Trademark used to symbolize the FTI ForceMate system.

ForceMate (FmCx): A system of tooling used to install bushings with high interference while simultaneously cold working the material surrounding the bushed hole.

ForceTec (FtCx): A system of tooling used to install a rivetless nut plate while simultaneously cold working the material surrounding the hole.

Front Taper: The portion of the mandrel that allows the sleeve to slide on easily.

Front Side Clearance: The distance from the front of the hole to the nearest obstruction.

FtCx: Trademark used to symbolize the FTI ForceTec system.

FTI: Fatigue Technology (a Registered Trademark).

GrCx: Trademark used to symbolize the FTI GromEx system.

GromEx (GrCx): A grommet installation system designed to use low applied expansion to install grommets to protect fastener holes in composites.

KB: Model number prefix for tooling used for countersunk applications in aluminum (mandrels and nosecaps only).

KB2: Model number prefix for tooling used for Split Sleeve Cold Expansion to Size in aluminum.

Lateral Clearance: The distance from the edge of the hole to the nearest obstruction.

Mandrel Flat: The length of the major diameter of a mandrel.

Mandrel Nose: The section of the mandrel beyond the stackup portion. Consisting of the back taper, major diameter, and front taper.

Mandrel "B" Diameter: The minor diameter of a mandrel, also where the sleeve is placed prior to cold expanding a hole.

Mandrel "D" Diameter: The major diameter of a mandrel.

A.1 GLOSSARY OF TERMS

Material Stackup: The combined thickness of a structure through which a hole is located; also the total length of a hole.

OAL: Overall length.

Overall Length (OAL): The total length of a tool.

Pull Force: The amount of force required for a puller unit to pull a mandrel through a hole.

RwCx: Trademark used to symbolize the FTI Rework Split Sleeve Cold Expansion system.

ScCx: Trademark used to symbolize the StopCrack Split Sleeve Cold Expansion system.

Short Front Taper: A shortened nose length on a mandrel for severely restricted backside clearance problems.

Split Sleeve Cold Expansion (SsCx): Deep cold expansion of the metal around a hole using FTI's system of tooling.

SsCx: Trademark used to symbolize the FTI Split Sleeve Cold Expansion system.

Standard Tool Diameter Number (STDN): The tool code used to identify a specific size of tooling.

Starting Hole Diameter (SHD): The specified hole diameter, in the base material, before using one of the Cx processes.

STDN: Standard Tool Diameter Number.

StopCrack (ScCx): A system for significantly improving the effectiveness of the stop drill technique used to repair cracks in structural components.

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Table A.2-1
Metric Conversion
Split Sleeve Cold Expansion in Aluminum and Mild Steel

Reference Final Fastener (in MM)	Standard Tool Diameter Number	Existing Fastener Diameter (in MM)	Existing Hole Diameter (in MM)
3.5	4-0-N	2.5	2.75
4.0	4-1-N	2.5	3.00
4.5	4-2-N	3.0	3.40
4.5	4-3-N	3.5	3.81
5.0	4-4-N	4.0	4.04
5.0	6-0-N	4.0	4.24
5.5	6-1-N	4.5	4.62
6.0	6-2-N	5.0	5.05
6.5	6-3-N	5.0	5.46
7.0	8-0-N	5.5	5.72
7.0	8-1-N	6.0	6.12
7.5	8-2-N	6.5	6.50
8.0	8-3-N	6.5	6.93
8.5	10-0-N	7.0	7.29
9.0	10-1-N	7.5	7.70
9.0	10-2-N	8.0	8.08
9.5	10-3-N	8.0	8.48
10.0	12-0-N	8.5	8.86
10.5	12-1-N	9.0	9.27
11.0	12-2-N	9.5	9.68
11.0	12-3-N	10.0	10.06
11.5	14-0-N	10.0	10.44
12.0	14-1-N	10.5	10.85
12.5	14-2-N	11.0	11.18
12.5	14-3-N	11.5	11.56
13.0	16-0-N	11.5	11.79
13.5	16-1-N	12.0	12.19
14.0	16-2-N	12.5	12.57
14.5	16-3-N	12.5	12.98
14.5	18-0-N	13.0	13.39
15.0	18-1-N	13.5	13.79
15.5	18-2-N	14.0	14.17
16.0	18-3-N	14.5	14.55
16.5	20-0-N	14.5	14.91
16.5	20-1-N	15.0	15.32
17.0	20-2-N	15.5	15.77
17.5	20-3-N	16.0	16.15
18.0	22-0-N	16.5	16.45
18.5	22-1-N	16.5	16.89
18.5	22-2-N	17.0	17.27
19.0	22-3-N	17.5	17.68
19.5	24-0-N	17.5	17.98
20.0	24-1-N	18.0	18.39
20.5	24-2-N	18.5	18.77
20.5	24-3-N	19.0	19.18
21.0	26-0-N	19.5	19.61
21.5	26-1-N	20.0	20.02
22.0	26-2-N	20.0	20.35
22.5	26-3-N	20.5	20.73
22.5	28-0-N	21.0	21.11
23.0	28-1-N	21.5	21.51
23.5	28-2-N	22.0	22.07
24.0	28-3-N	22.0	22.45
24.5	30-0-N	22.5	22.63
25.0	30-1-N	23.0	22.04
25.5	30-2-N	23.0	23.44
26.0	30-3-N	23.5	23.85

For complete information on Cx2s engineering requirements, refer to Process Specification FTI-8201.

***Note:** When there are two tooling numbers for the same size reference fastener, the tooling number with the smallest existing fastener diameter should be used if a high fastener interference is desired.

Table A.2-2
Metric Conversion
Split Sleeve Cold Expansion in Titanium and High Strength Steel

Reference Final Fastener (in MM)	Standard Tool Diameter Number	Existing Fastener Diameter (in MM)*	Existing Hole Diameter (in MM)
3.5	20	2.5	2.540
4.0	21	2.5	2.921
4.5	22	3.0	3.302
5.0	23	3.5	3.708
5.0	30	4.0	4.064
5.5	31	4.0	4.445
6.0	32	4.5	4.826
6.5	33	5.0	5.232
7.0	40	5.5	5.613
7.5	41	5.5	5.994
8.0	42	6.0	6.375
8.0	43	6.5	6.782
8.5	50	7.0	7.036
9.0	51	7.0	7.417
9.5	52	7.5	7.823
10.0	53	8.0	8.204
10.5	60	8.5	8.585
11.0	61	8.5	8.966
11.0	62	9.0	9.373
11.5	63	9.5	9.754
12.0	70	10.0	10.135
12.5	71	10.5	10.516
12.5	72	10.5	10.922
13.0	73	11.0	11.303
13.5	80	11.5	11.684
14.0	81	12.0	12.090
14.0	82	12.0	12.471
14.5	83	12.5	12.852
15.0	90	13.0	12.233
15.5	91	13.5	13.640
16.0	92	14.0	14.021
16.0	93	14.0	14.402
16.5	100	14.5	14.783
17.0	101	15.0	15.189
17.5	102	15.5	15.570
17.5	103	15.5	15.951
18.0	110	16.0	16.332
18.5	111	16.5	16.739

***Note:** When there are two tooling numbers for the same size reference fastener, the tooling number with the smallest existing fastener diameter should be used if a high fastener interference is desired.

For complete information on Cx2s engineering requirements, refer to Process Specification FTI-8201.

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