



Change Order #6734

## Design Criteria and Installation and Extraction Procedure For Lee Hydraulic Inserts

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## 1.0 Introduction

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This process specification is a comprehensive design and procedural guide to the installation and extraction of Lee Inserts.

Section 2.0, entitled Lee Terms and Definitions provides a description and explanation of commonly used terms that may be unique to Lee Company hydraulic inserts.

Section 3.0, entitled Design Information, gives extensive information and recommendations to aid in safely designing housings for Lee Insert installations. This section recommends installation hole parameters and discusses stress corrosion cracking and the prevention thereof.

Section 4.0, entitled Inspection and Handling, discusses Lee Quality Control procedures, certifications, and important handling requirements.

Section 5.0, entitled Installation and Extraction of Lee Inserts, describes the installation techniques for Lee Inserts.

Section 6.0, entitled Extraction of Lee Pins and Inserts, describes the extraction techniques for Lee Pins and Inserts.

Section 7.0, entitled Recommendations and Troubleshooting, describes recommended practices to ensure best Insert performance and troubleshooting information for common issues.

The tool set drawings pertaining to installation and extraction of Lee Inserts can be found on the applicable Lee Inspection Print.

The information found here is more extensive than that found in the Lee Technical Hydraulic Handbook. Compliance with the more detailed procedures and recommendations provided in this report will ensure maximum performance.



## 2.0 Lee Terms and Definitions

**Lee Insert** – The Lee Company’s specialized miniature hydraulic components are designed to be installed directly into hydraulic manifolds, fittings, and other hydraulic circuits.

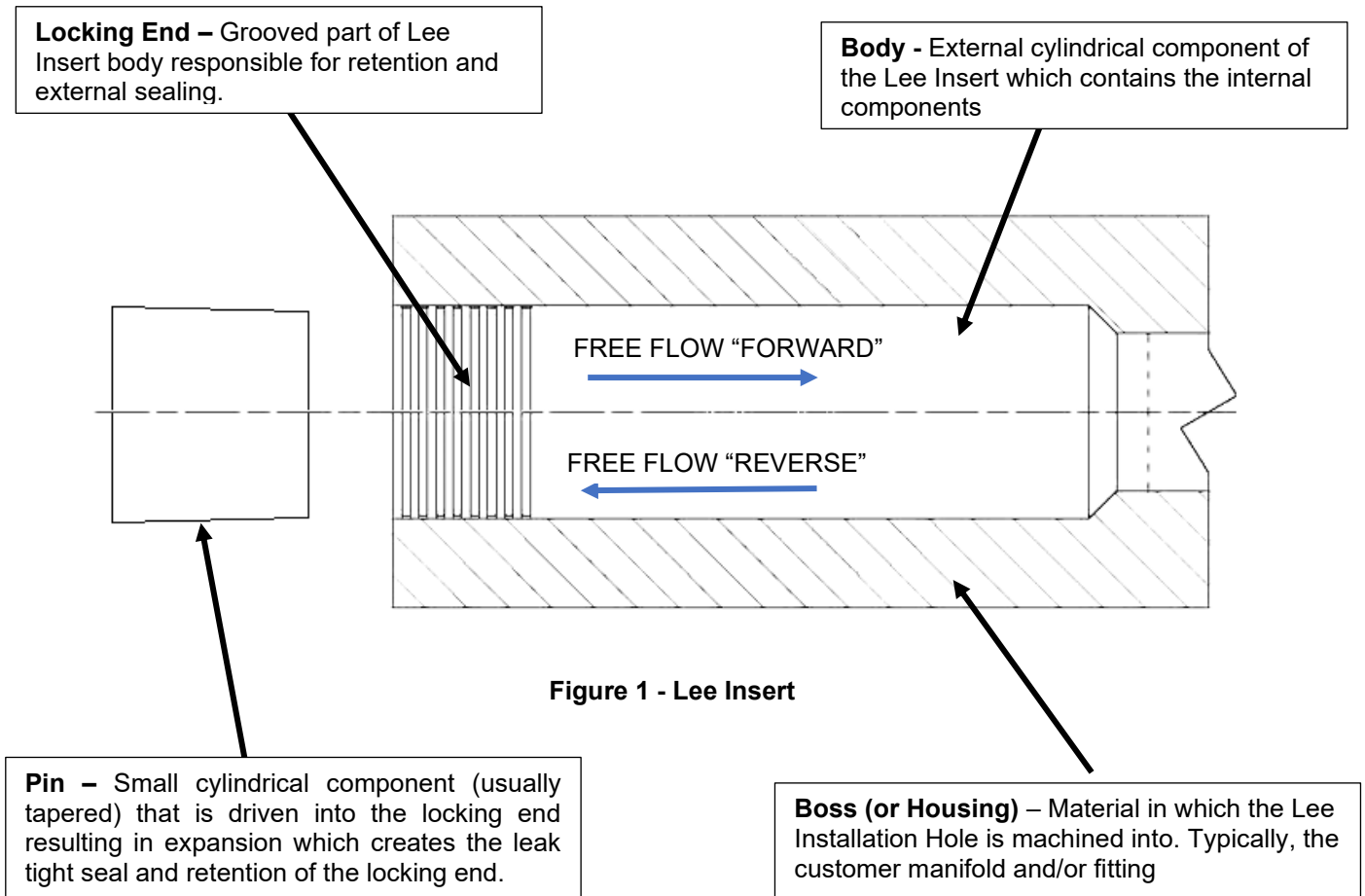


Figure 1 - Lee Insert



### 3.0 Design Information

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#### 3.1 Proof, Burst, and Retention Pressure Ratings

Conventional (with the outlet port capped) hydrostatic proof and burst pressure testing applies equal pressure to all parts of a Lee Restrictor, Flosert, or Flow Control Insert. The Lee Insert is therefore unaffected. Maximum hydrostatic pressure in this condition is limited only by the strength of the housing into which the Lee Insert is installed.

With pressure applied in the flowing direction, conventional (with the outlet port capped) hydrostatic proof and burst pressure testing applies equal pressure to all parts of a check valve; in the case of a pressure relief valve, a pressure differential equal to the shutoff pressure will result. The check or relief valve is therefore mostly unaffected. The maximum hydrostatic pressure in this condition is also limited only by the strength of the housing into which the Insert is installed.

A hydrostatic test for proof or burst pressure applied in the opposite direction (i.e. the checked direction) will stress the seat of a check or pressure relief valve.

Applying a pressure differential that significantly exceeds the proof pressure may result in permanent deformation or damage of Lee Inserts.

Table 1 lists the proof and burst pressures for Lee Inserts. These pressures are per SAE AS 5440.

**Table 1 - Proof and Burst Pressures**

Nominal System Pressure	3,000 psid (21 MPa dif)	4,000 psid (28 MPa dif)	5,000 psid (34 MPa dif)	8,000 psid (55 MPa dif)
System Peak Pressure	4,050 psid (28 MPa dif)	5,400 psid (37 MPa dif)	6,750 psid (47 MPa dif)	9,600 psid (66 MPa dif)
Proof Pressure	4,500 psid (31 MPa dif)	6,000 psid (41 MPa dif)	7,500 psid (52 MPa dif)	12,000 psid (83 MPa dif)
Burst Pressure	7,500 psid (52 MPa dif)	10,000 psid (69 MPa dif)	12,500 psid (86 MPa dif)	16,000 psid (110 MPa dif)



### 3.2 Retention Pressure

Each Lee Insert has a specified maximum working pressure or nominal system pressure. This is stated in the Lee Technical Hydraulic Handbook and on all Lee Inspection Prints. Table 2 gives the locking end minimum retention pressure for every Insert. This pressure will always be sufficient to withstand full burst pressure per SAE AS 5440.

**Table 2 - Retention Pressures**

Insert Maximum Working/Nominal System Pressure	3,000 psid (21 MPa dif)	4,000 psid (28 MPa dif)	5,000 psid (34 MPa dif)	8,000 psid (55 MPa dif)
Retention Pressure	7,500 psid (52 MPa dif)	10,000 psid (69 MPa dif)	12,500 psid (86 MPa dif)	16,000 psid (110 MPa dif)

### 3.3 Temperature Limits

Lee Insert locking ends will show no degradation in retention pressure when exposed to temperatures in the range of -65°F (-54°C) to 275°F (135°C). If the temperatures are expected to be outside this range, more information on the housing material and the overall application would have to be considered by The Lee Company. Contact your local sales office for assistance.

### 3.4 Installation Hole Parameters

The Lee locking end is purposely designed to perform well under adverse conditions. Therefore, if the specifications outlined in this section are not followed precisely, the locking end may still perform adequately but the margin of safety will be reduced relative to the degree to which the installation hole is out of specification. Of real concern is an installation hole with many parameters not within the specifications, or when any one parameter is grossly out of specification.

### 3.5 Surface Finish

The installation hole should be clean and dry. Its finish should be between 16 and 63 microinches RMS (0,4 - 1,6 micrometers) circular lay with no longitudinal scratch marks. A smoother finish may result in a reduction in retention pressure capability while rougher finishes may not permit positive sealing.



### 3.6 Surface Treatment

Retention pressure data for Lee components is given for installations in holes that have not had special surface treatment. Passivating stainless steel installation holes per ASTM-A-967 or AMS 2700 has no effect on the performance of Lee components. Passivation per other specifications may be acceptable but should be verified by The Lee Company or by performance testing. For aluminum Lee recommends untreated installation holes. Anodizing aluminum alloy installation holes per MIL-A-8625 Type III (hard coat anodizing) is not approved as it degrades retention pressure and can cause leakage. Lee does not approve of the use of surface treatments which include the deposition of solid lubricants such as PTFE since they drastically reduce the retention ability of Lee Inserts.

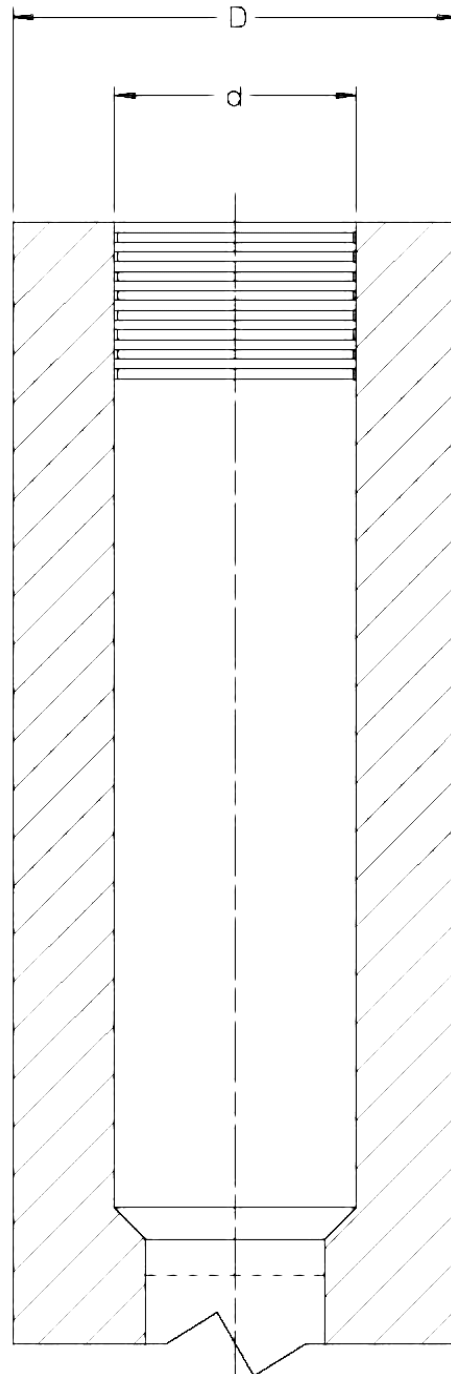
### 3.7 Installation Hole Tolerance

The installation hole diameter and tolerance shall match the requirements listed on the corresponding Lee Inspection Print for any Lee Insert. If the specific installation hole diametral tolerance is not specified on the Lee Inspection Print, the customer should contact the cognizant Lee Sales Engineer for clarification.

### 3.8 Boss Size

The amount of material surrounding the passage has an effect upon the retention performance of the Insert and therefore must be taken into account. To calculate the boss diameter ( $D$ ) as shown in Figure 2, use the boss material yield strength and the given insert diameter ( $d$ ) to find the minimum  $D/d$  ratio given in Figure 3.

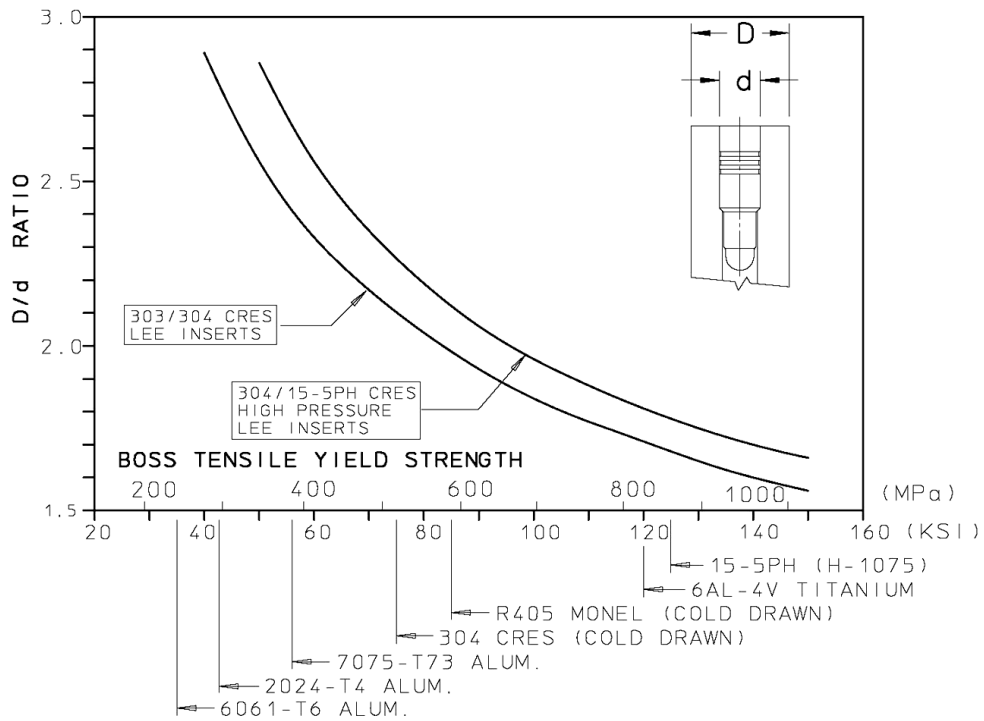
Installation of Lee Inserts into boss materials that have a  $D/d$  less than that recommended in Figure 3 should be substantiated by testing by the customer. During testing the expected conditions should be duplicated.



**Figure 2 - Housing Wall Thickness**



### MINIMUM RECOMMENDED D/d RATIO FOR LEE INSERTS



SKPP0095.2  
03/18/04

Figure 3 - D/d for Dissimilar Material



### 3.9 Web Thickness (Reference Figure 4)

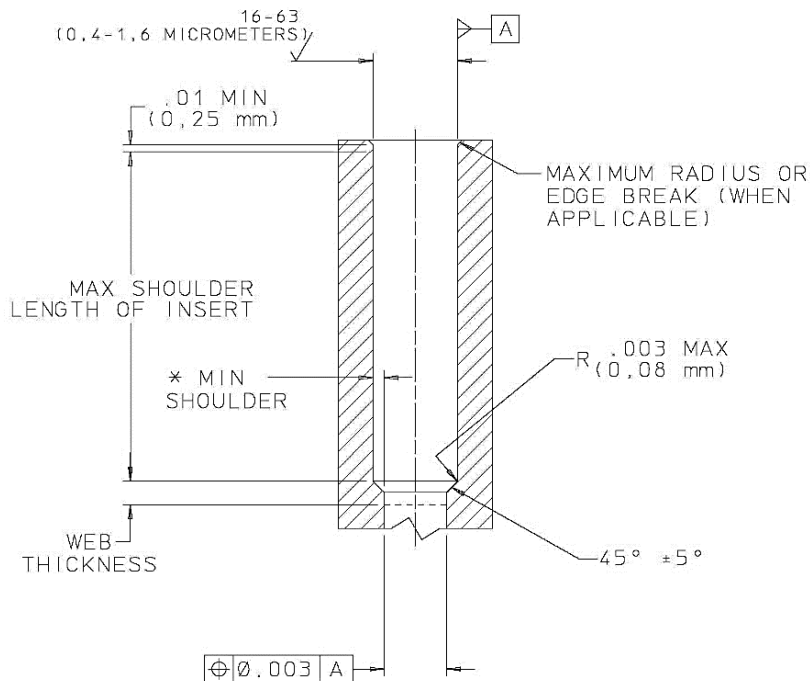
The web (the material directly below the 45 degree shoulder) should be capable of withstanding the force transmitted by driving the pin into the Insert. Generally, a minimum of 0.125" (3,2 mm) should be allowed for aluminum housings and a minimum of 0.063" (1,6 mm) for steel housings. Many Inserts require significantly greater thickness due to their geometry or to protect protruding screens, which is shown on the Lee Inspection Prints for all Inserts. Larger allowances should be made for weaker materials or special situations.

### 3.10 Support Shoulder (Reference Figure 4)

The support shoulder against which the Insert is to be driven should be 45 degrees, otherwise the Insert or nose seal may deform causing leakage. Insert movement during installation may result in low proof pressures and /or high installation forces. The minimum allowable width of the support shoulder is 0.011" (0,28 mm). This is necessary to resist the axial force transmitted while driving the pin.

### 3.11 Depth of Insert (Reference Figure 4)

The minimum depth of the installation hole should be such that the back of an Insert having the maximum shoulder length will still be at least 0.010" (0,25 mm) below the surface of the boss material. This will allow the last land of the locking end to contribute to the holding capability. Some users may put a radius at the top of the installation hole as part of their machining process. If this is the case, the minimum hole depth should take this into account such that the Insert is at least 0.010" (0,25 mm) below the maximum radius.



\*SEE APPROPRIATE INSPECTION DRAWING FOR DIMENSION.

**Figure 4 - Installation Hole**



### 3.12 Thin-Walled Bosses

Lower installation forces occur when Lee Inserts are installed in thin-walled bosses such as tubing, small diameter protruding bosses, or thin-walled sections between adjacent passages. Low installation forces may be a sign that the boss is too thin and is deformed as a result of the expanded locking end after the pin has been installed. If this is the case, there may not have been positive sealing of the Insert, and leakage or low retention pressures may result. In brittle housings, cracking may occur. Whenever possible, the D/d chart provided in Figure 3 should be used when determining wall thickness. This will help to avoid a thin wall condition.

### 3.13 Boss Stresses

The control of stresses at the Inside Diameter (ID) of a Lee Insert boss is of little concern to the designer, provided that the housing material has an elongation of 3% or greater. Housings that fall into this category will not crack due to the installation of a Lee Insert. The control of boss stresses on the Outside Diameter (OD) is important in those applications where Stress Corrosion Cracking (SCC) can be a problem. SCC is a failure caused by the combined action of a corrosive agent and tensile stress. Although most alloys are susceptible to SCC, each material has a threshold stress value below which cracking does not occur. The customer should account for SCC if the boss material is susceptible.

The expansion of a Lee Insert in an installation hole causes an increase in the ID of the boss and thus induces a tensile tangential stress on the OD of the boss. The factors which influence the magnitude of the boss stresses are the amount of interference, the Insert material, the boss material, and the OD of the boss.

When the pin is driven into the Insert, the Insert expands causing the ID of the boss to be plastically deformed. If the boss diameter (D) is relatively small compared to the Insert diameter (d), the plastic region will extend to the OD of the boss. If the boss diameter is larger, the plastic region extends only partially through the boss and the remainder is elastically deformed.



### 3.14 Calculation of Boss Stresses

The boss stresses, both tangential tensile and the radial compressive, vary throughout the boss. The radial stress reaches a maximum at the hole ID and drops to zero at the OD of the boss. The tangential stress (assuming a plastic/elastic situation) is low at the ID of the boss, reaches its maximum at the plastic/elastic interface, and drops to some intermediate value at the OD of the boss. When a Lee Insert is installed in a boss material of dissimilar mechanical properties, the stress on the OD of the boss will be below 40% of the tensile yield strength of the boss material by observing the  $D/d$  ratios shown in Figure 3. In most cases, the factor limiting the boss diameter will be the retention pressure requirements and not the stresses.

### 3.15 Stresses in Non-Uniform Bosses (Reference Figure 5)

The stress situation is different for bosses having a non-uniform wall thickness. Installing Inserts in this type of boss results in a stress concentration adjacent to the minimum wall thickness. This is obtained because the thicker (and therefore stiffer) section of the boss resists deformation, thus concentrating the effects of Insert expansion in the thinner section of the boss. Detailed testing at The Lee Company has determined the necessary  $T/d$  ratios for some non-uniform bosses. For wall thickness  $T$  and Insert diameter  $d$ , the minimum recommended  $T/d$  ratios for several boss configurations are as shown in Figure 5.

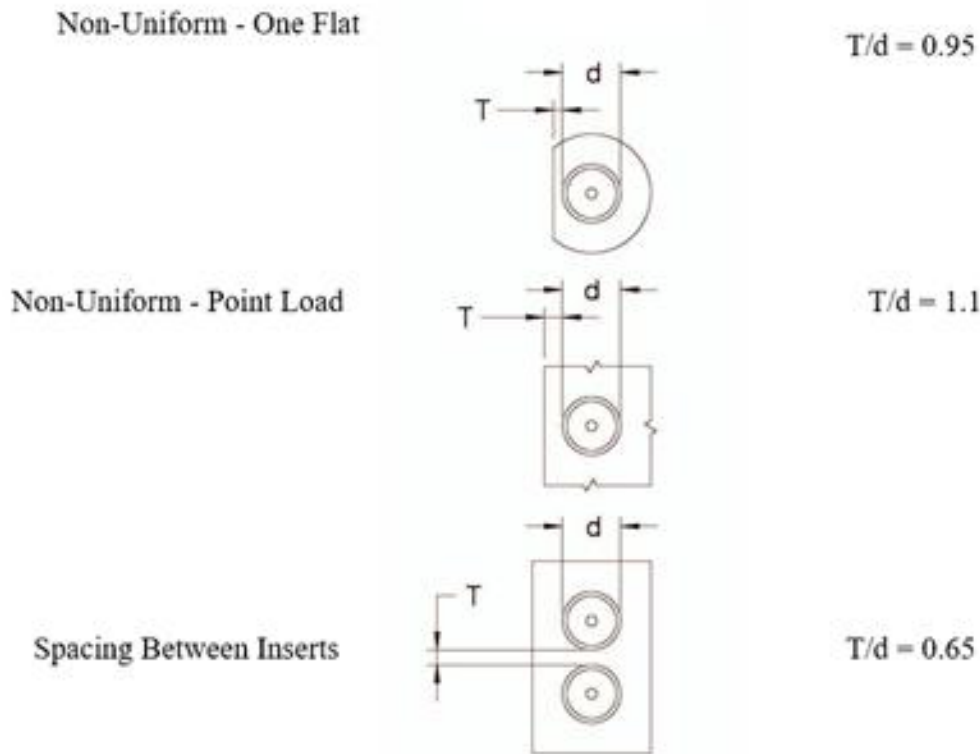


Figure 5 – Non-Uniform Bosses



## 4.0 Inspection and Handling

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### 4.1 Lee Q.C. Procedures

All inserts are visually and dimensionally inspected per The Lee Company sampling plan, unless otherwise specified.

### 4.2 Lot Control Certification

All Lee Pins and Inserts are manufactured and controlled by lots. These lot numbers are marked on the package so the Insert body and pin can be traced back to the material certification from the mill. The material lot numbers and certificates of material certification are kept on file.

### 4.3 Wax Coating

Most Lee Insert Pins are coated with a wax that produces a thin solid lubricant film. This film has proven to reduce friction and prevent galling and seizing sufficiently to permit the pin to be driven flush with the back of the Insert. The handling of pins should be kept to a minimum. In addition, Lee Insert Pins are not to be stored at temperatures exceeding 150°F (65°C). **Do not degrease the pins as this voids our warranty and may render the pin unable to be installed.**

**In special Lee Engineering approved applications additional lubricant may be applied (such as water or grease per MIL-PRF-27617).** Although the taper angles of pins and Inserts are small, the coefficient of friction can be reduced sufficiently by additional lubricants to cause properly installed pins to back out of the Insert. Installation forces for pins are high by design. By following these lubrication/coating requirements the critical situation of pin backout can be avoided.



## 5.0 Installation of Lee Inserts

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The performance of the Lee locking end is due to the independent seals and retaining rings created by the controlled expansion of the Insert. Therefore, it is important that proper care is taken during installation. When using threaded installation or extraction tools, it is important to ensure that the pin is threaded all the way onto the tool so that the pin bottoms on the shoulder of the tool, thus avoiding thread damage.

### 5.1 Lee Insert Installation (Reference Figure 6)

Pins may be driven into the Insert using an arbor press, hydraulic press, or hammer. If a hydraulic or other type of press is used, adjust the stroke by setting a mechanical stop to press the pin to the flush position. For experimental or prototype work, The Lee Company recommends using a properly sized hammer.

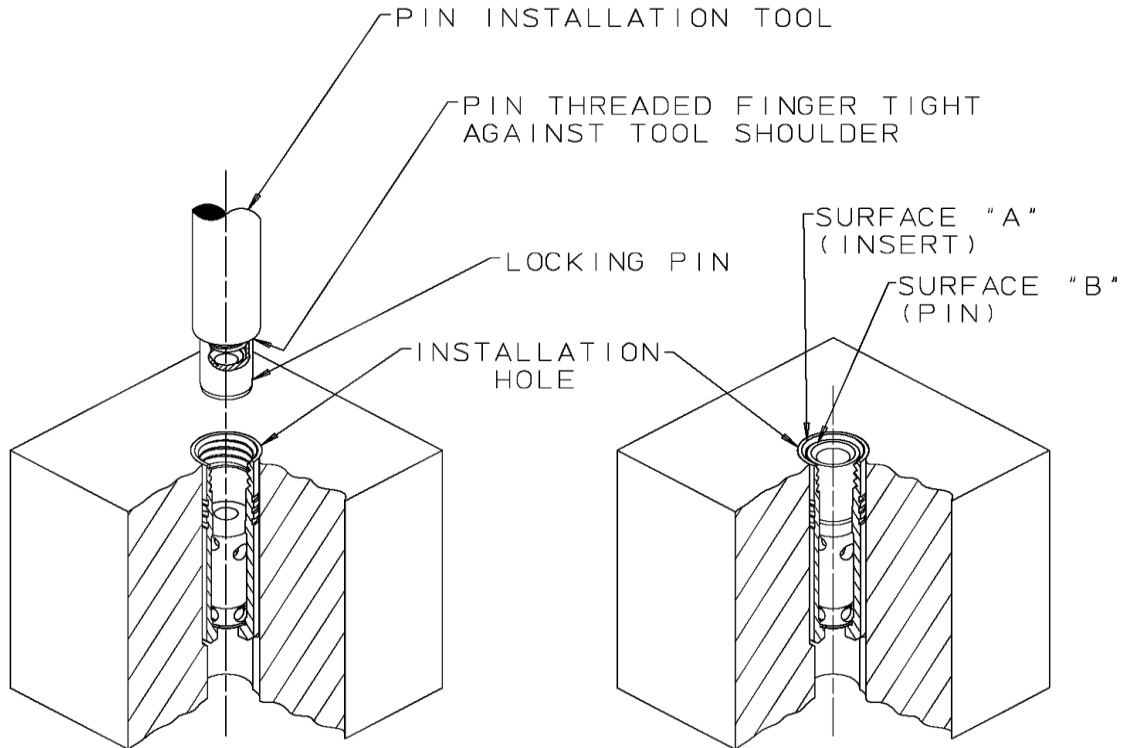
The standard installation procedure should be followed for most Lee Inserts. Below are also some special cases for installation procedure that vary from the standard procedure.

### 5.2 Standard Installation

- 5.2.1 Firmly support the item in which the Insert is to be installed.
- 5.2.2 Slip the Insert into the hole until it is firmly seated on the support shoulder in the installation hole. If there is a slight interference fit, thread the appropriate body extraction tool from the tool set listed on the appropriate Lee Inspection Print into the Insert and lightly press the Insert until it is bottomed. Remove the extraction tool.
- 5.2.3 Thread the pin, larger end first, onto the appropriate pin installation tool from the tool set listed on the appropriate Lee Inspection Print. Press or drive the installation tool, which must be held square to the Insert, until the pin is driven flush (to within  $\pm 0.005$ " (0,13mm)) with the back of the Insert

### 5.3 Installation of 0.093 (0.23mm), 0.125 (3.17mm) and 0.156 (3.96mm) Diameter Inserts

- 5.3.1 Firmly support the item in which the Insert is to be installed.
- 5.3.2 Slip the Insert into the hole until it is firmly seated on the support shoulder in the mounting hole. If the insert doesn't drop freely into the installation hole, it may be pressed lightly to seat it against the shoulder at the bottom of the installation hole. Significant force should not be required and may indicate an installation hole issue or other issue. There are no extraction threads in the body, therefore, in order to get the Insert flush it may be necessary to push lightly on the back of the Insert with the pin installation tool. **Care must be taken, as it is possible to overload and crush the back of the body.**
- 5.3.3 Place the pin, smaller end first, into the body. There are no extraction threads in the pin and therefore, the installation tool has only a smooth protrusion to help locate the center of the pin. With the installation tool from the appropriate tool set listed on the Lee Inspection Print held against the pin and square to the back of the Insert, drive or press the pin until it is flush (to within  $\pm 0.005$ " (0,13 mm)) with the back of the Insert.



**Figure 6 - Installation of Lee Inserts**

Notes:

Surface "A" to be .010" (0,25mm) minimum below surface of housing.  
Surfaces "A" and "B" to be flush within  $\pm .005$ " (0,13 mm).



#### 5.4 Lee Multi-port Valves

Many Lee multi-port valves include a nose seal or compression seal that is required to isolate two ports from one another. When the valve is installed, the compression seal is forced up the taper, causing it to expand and seal on the ID of the installation hole. It is important that the seal be preset prior to the installation of the pin into the Insert. Any movement of the Insert during the pin installation can shear the grip that the Insert had initiated thus greatly reducing the blowout pressure. The standard procedure for the installation of multi-port valves is provided in the following steps. Reference Lee PSJ2374.

- 5.4.1 The tapered ID of the seal should already be placed over the tapered nose on the valve. The seal is installed onto the valve such that the outer dimension of the seal does not exceed the dimension found on the appropriate Lee Inspection Print.
- 5.4.2 Thread the Insert onto the body installation tool from the appropriate tool set found on the Lee Inspection Print. Gently push the Insert until it is against the shoulder.
- 5.4.3 Apply an axial force per the appropriate Lee Inspection Print. This force will expand the nose seal employing the locking end principle to provide an effective seal.
- 5.4.4 Thread the pin, larger end first, onto the appropriate pin installation tool from the tool set listed on the appropriate Lee Inspection Print. Press or drive the installation tool, which must be held in line with the Insert, until the pin is driven flush (to within + 0.005" (0,13 mm) with the back of the Insert.

#### 5.5 Lee Shuttle Valves

- 5.5.1 Thread the Insert onto the body installation tool from the appropriate tool set listed on the appropriate Lee Inspection Print. Gently push the Insert until it is against the shoulder.
- 5.5.2 Apply axial force as provided in the notes of the appropriate Lee Inspection Print. The forces in Table 3 are for Lee Standard Shuttle Valves and are provided for reference. This seal preload force will expand the nose or compression seal, employing the locking end principle to effectively seal the nose. It is typically preferred to use a press and load cell to accurately apply the pre-load.
- 5.5.3 Thread the pin, larger end first, onto the appropriate pin installation tool from the tool set listed on the appropriate Lee Inspection Print. Press or drive the installation tool, which must be held squared with the Insert, until the pin is driven flush (to within  $\pm 0.005$ " (0,13 mm) with the back of the Insert.



**Table 3 - Nose/Compression Seal Preloads**

<b>Insert Diameter (inches)</b>	<b>Seal Design</b>	<b>Seal Preload Force (lbf)</b>	<b>Seal Preload Force (N)</b>
0.187 (4,75 mm)	Aluminum Nose Seal	200 - 250	900 - 1100
0.281 (7,14 mm)	Aluminum Nose Seal	400 - 500	1800 - 2200
0.500 (12,70 mm)	Aluminum Nose Seal	800 - 900	3600 - 4000
0.281 (7,14 mm) 0.375 (9,53 mm) 0.500 (12,70 mm)	Polymer Compression Seal	500 - 700	2200 - 3100

**Note:** This table is to be used as a reference, the Lee Inspection Print for the respective Insert specifies the proper Seal Preload and takes precedence over this table.



### 5.6 Dual Insert Adapters

It is possible to stack two Lee Inserts of the same diameter in series with the use of the Lee Dual Insert Adapter. The adapter eliminates the need to machine an additional shoulder, which normally would be required to place a second Insert behind the first. The second Insert is no longer required to be a larger diameter than the first, allowing for a smaller boss. Machining is simplified and space and weight are reduced.

Dual Insert adapters are offered in two versions: one with cross port flow capability and the other without. They are not to be used in conjunction with Lee plugs.

#### TYPICAL INSTALLATION

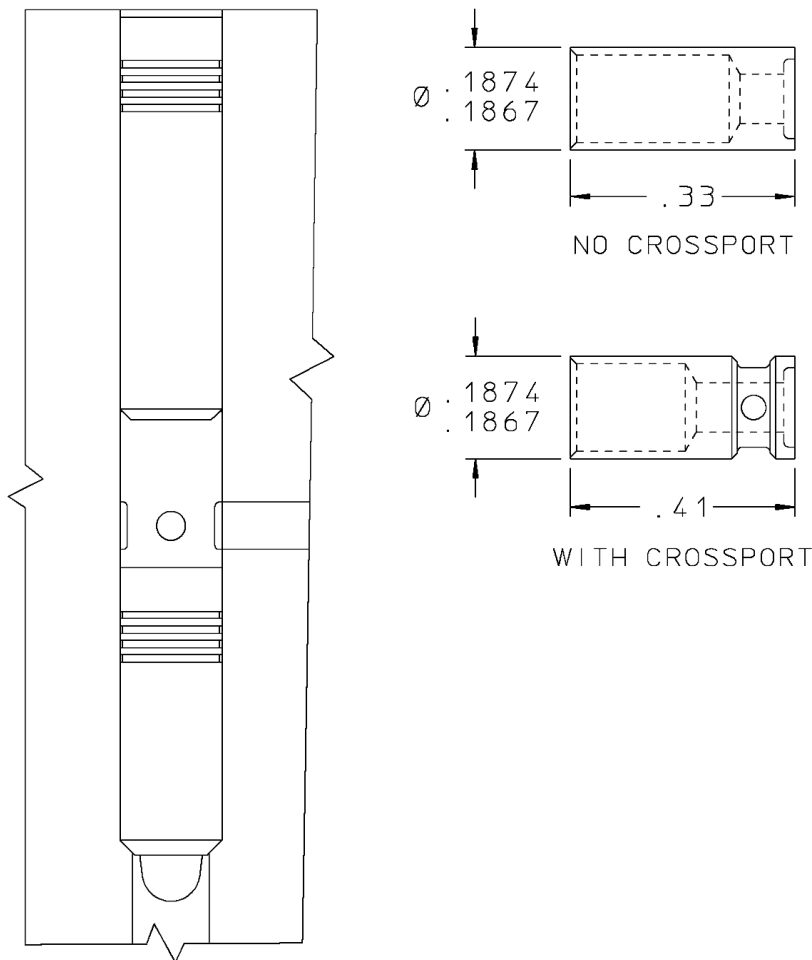


Figure 7 - Lee Dual Insert Adapter



## 6.0 Extraction of Lee Pins and Inserts

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It is sometimes necessary to remove Inserts. The following procedures may permit removal of Lee Inserts without requiring rework of the boss or contamination of the passage. The proper extraction procedure may allow the user to avoid the high cost of having housings reworked.

### 6.1 Pin Extraction

There are three methods to remove a Lee Insert Pin. The preferred methods use pin jacking tools, where the extraction forces react against the rear of the Insert. The two types of pin jacking tools available are the Rivet Tool and the T-Handle. At times the bolt and striker method may remove the Insert with the pin which can be more likely to cause damage to the installation hole. The pin jacking tools will prevent the body from being extracted with the pin and therefore leave the installation hole in better condition to receive another Insert. Pin jacking tools are not available for all Lee Inserts.

#### 6.1.1 Pin Extraction - Rivet Tool (Reference Figure 8)

6.1.1.1 Thread the appropriate stud from the tool set into the pin to be removed.

6.1.1.2 Slide the sleeve down over the stud until it is seated against the end of the body.

6.1.1.3 Engage the pin end of the stud with the rivet tool and squeeze the handle until the pin is free..

#### 6.1.2 Pin Extraction – T-Handle (Reference Figure 9)

6.1.2.1 Select the appropriate T-Handle pin jacking tool based on the extraction thread of the pin and the Lee Insert diameter. For more information, contact the Lee Sales Engineering for assistance.

6.1.2.2 Run the drive nut up the drive shaft until the extractor stud threads are clear of the extractor guide sleeve.

6.1.2.3 Hold the T-Handle to prevent the stud from turning and run the wrenching nut down the drive shaft thread until the face of the extractor guide sleeve bears against the exposed face of the Insert body.

6.1.2.4 While grasping the T-Handle, use an open-end wrench to turn the drive nut in a counter-clockwise direction.

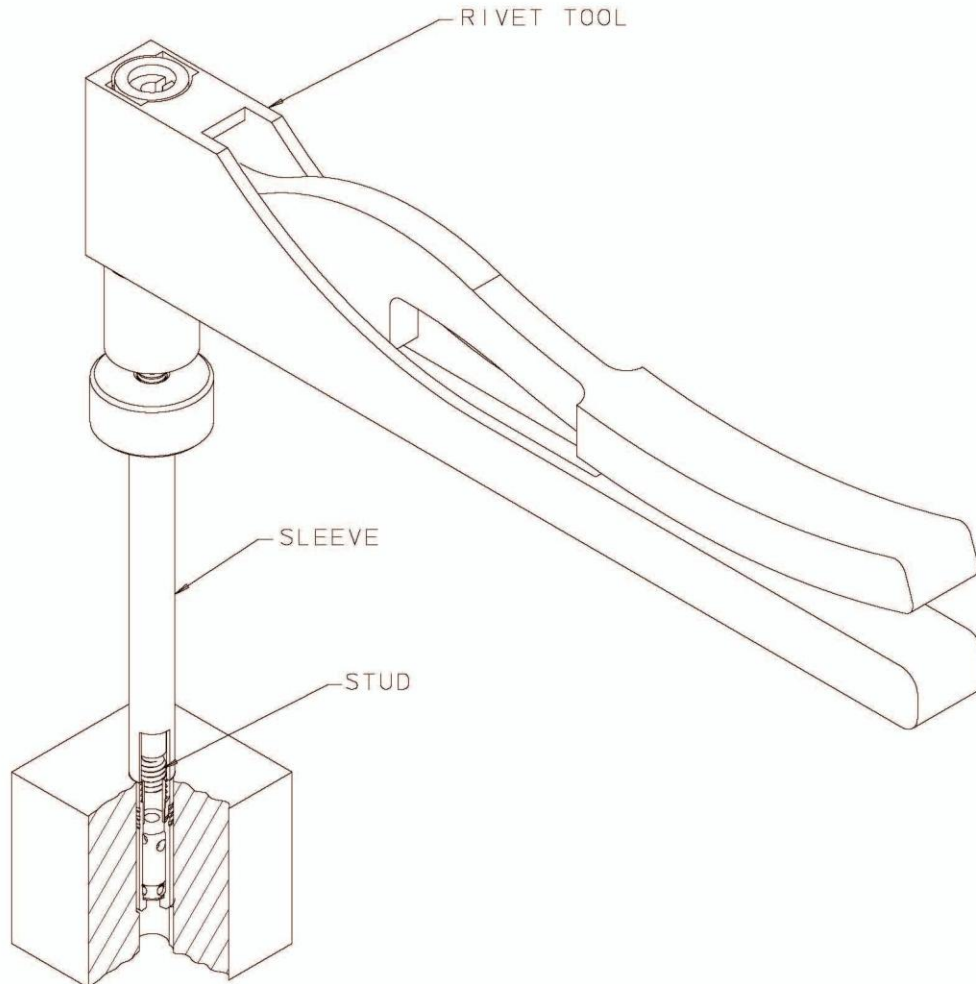
6.1.2.5 Diminished drive nut wrenching force indicates that the pin is free.

#### 6.1.3 Pin Extraction - Bolt and Striker (Reference Figure 10)

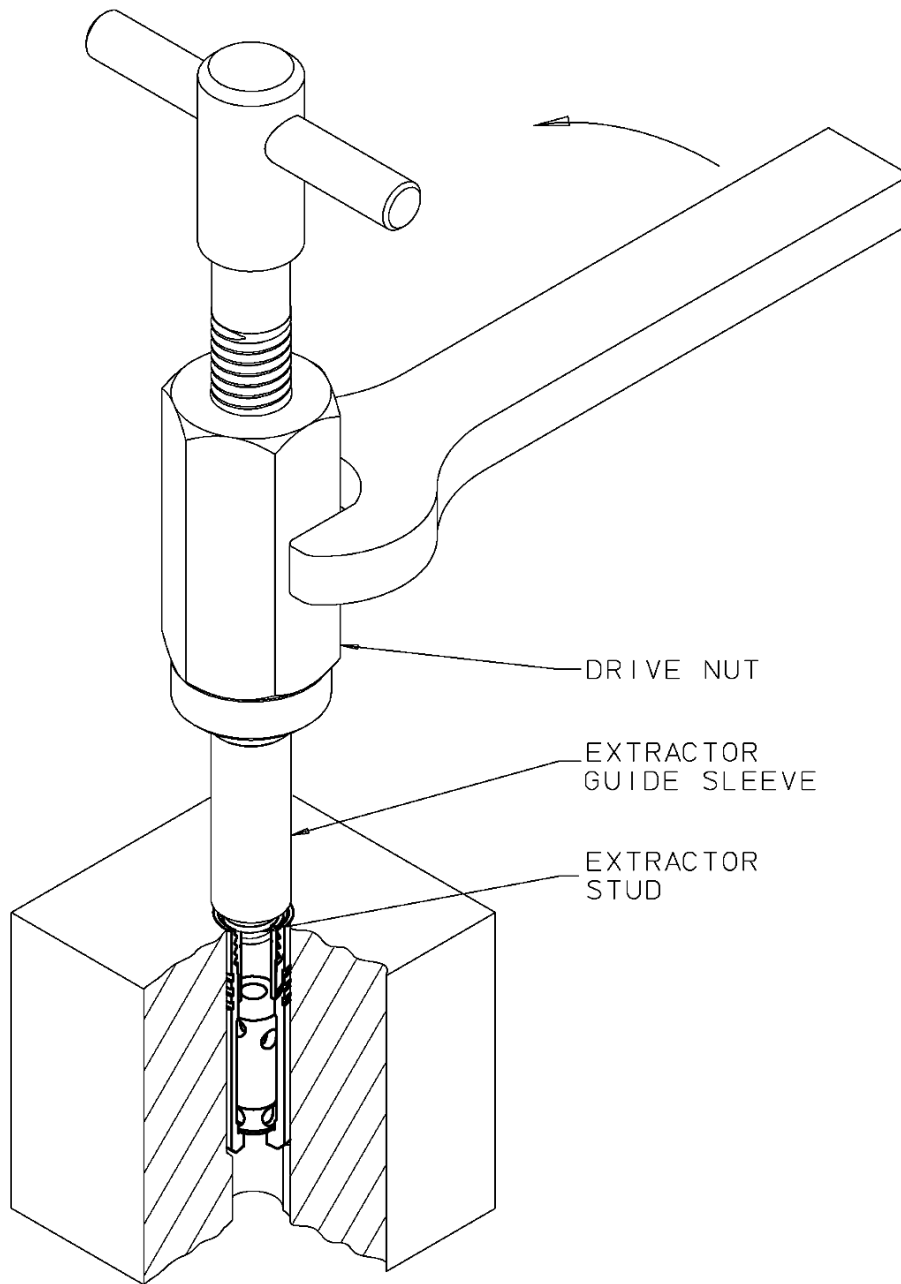
6.1.3.1 Use the extraction tools from the appropriate tool set listed on the Lee Inspection Print.

6.1.3.2 Slide the striker onto the pin extraction tool and thread the extraction tool completely into the pin.

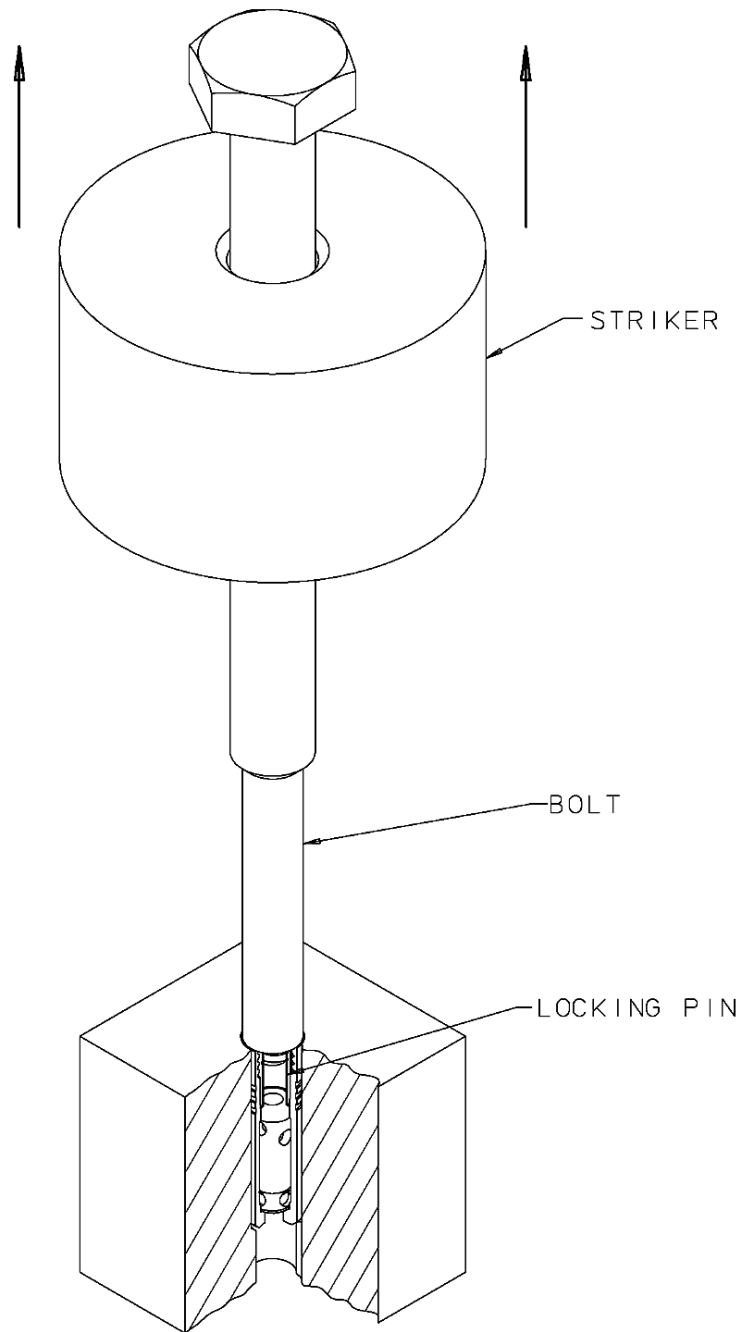
6.1.3.3 Strike the head of the pin extraction tool with the striker until the pin is removed.



**Figure 8 - Rivet Type Pin Jacking Tool**



**Figure 9 - T-Handle Pin Jacking Tool**



**Figure 10 - Pin Extraction Using Bolt and Striker**

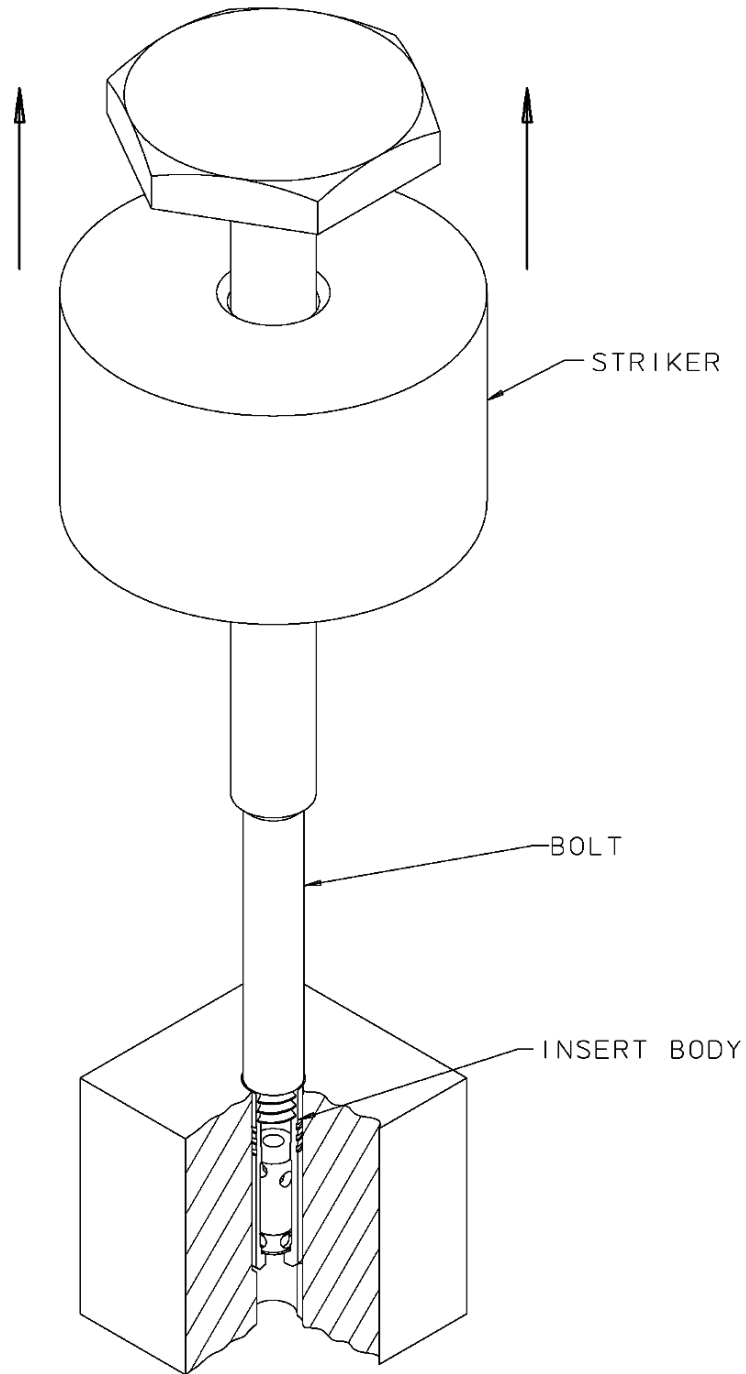


## 6.2 Insert Extraction

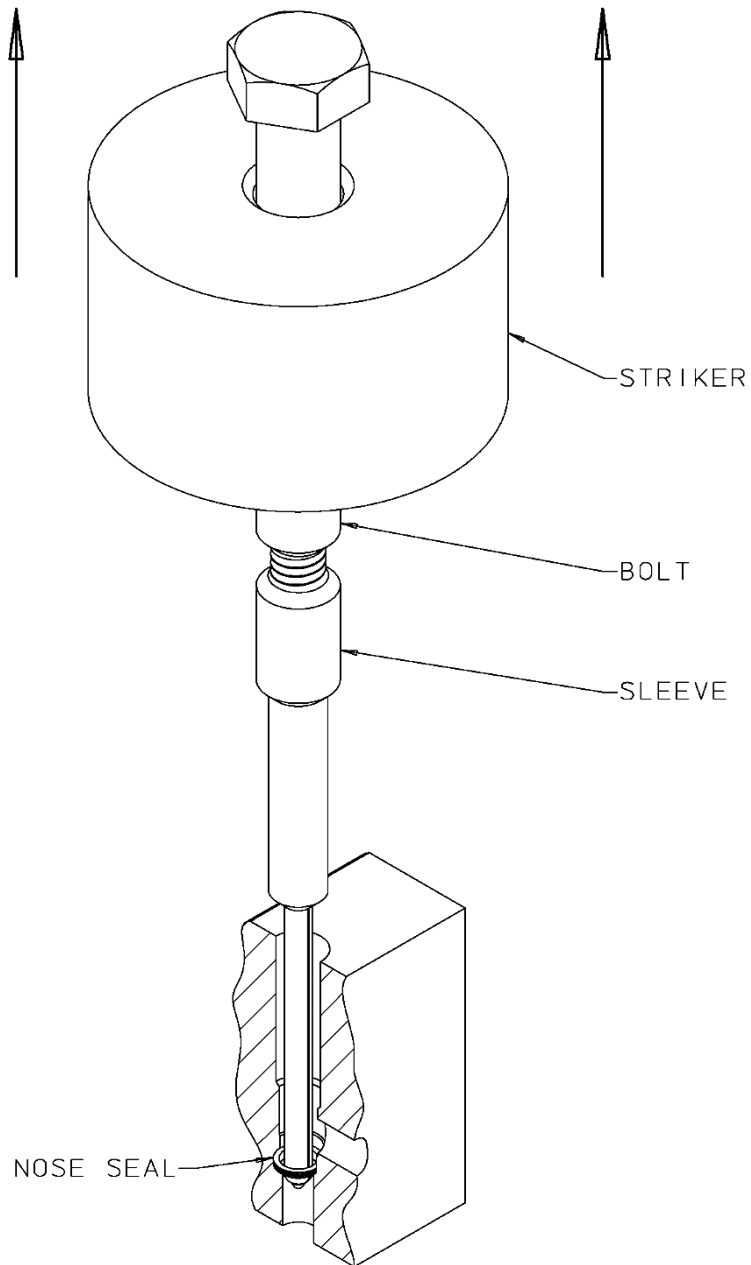
All Lee Inserts are readily removed with a bolt and striker. Some smaller diameter Lee Inserts do not have extraction threads and therefore threads must be tapped prior to extraction. The Some Valves (Shuttle, Pilot Op, etc) require a special tool to remove the nose/compression seal.

### 6.2.1 Extraction Method (Reference Figure 11)

- 6.2.1.1 Use the extraction tools from the appropriate tool set listed on the Lee Inspection Print.
- 6.2.1.2 Slide the striker onto the body extraction tool and thread the tool completely into the body.
- 6.2.1.3 Strike the head of the body extraction tool with the striker until the body is removed.
- 6.2.1.4 Valves with Nose or Compression Seals Only (Reference Figure 12)
  - 6.2.1.4.1 Having already extracted the Insert, thread the nose/compression seal extraction tool assembly such that the sleeve is not expanded by the end of the body and the threads are still engaged.
  - 6.2.1.4.2 Slide the striker onto the tool.
  - 6.2.1.4.3 Insert the tool into the installation hole until the head of the sleeve is through and beyond the nose/compression seal. Thread the tool assembly together expanding the end of the tool sleeve.
  - 6.2.1.4.4 Lightly tap the nose seal from the hole with the striker.



**Figure 11 - Extraction of Lee Insert**



**Figure 12 - Nose/Compression Seal Extraction Tool**



## **7.0 Recommendations and Troubleshooting**

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### **7.1 Insert Retention Testing**

Adherence to the guidelines and procedures presented in this document will result in Insert installations that are highly reliable, strong, and leak-free. Due to the multitude of environments and conditions to which the Lee Inserts may be exposed, retention testing by Lee Insert users is an essential part of the Lee Insert installation process. Retention pressure testing should be conducted by flow testing restrictors and reverse flow valves in the reverse direction at the proof pressure listed in Table 1. Forward flowing valves should be retention pressure tested by hydrostatically pressurizing the valve to the retention pressure listed in Table 2. This testing serves to verify the integrity of the unit and indicates any Inserts which may have been improperly installed. Installations must be fully shielded during testing in case an improperly installed Insert should fail.

### **7.2 Troubleshooting**

Reference Table 4 for common problems and probable causes.

### **7.3 For any additional help or information, please feel free to contact a Lee Sales Engineer at any of the locations listed in Appendix A.**



**Table 4 - Troubleshooting guide**

<u>Problem</u>	<u>Probable cause</u>
High install forces	<ul style="list-style-type: none"> <li>▪ Installation hole out of round.</li> <li>▪ Hardened (anodized or similar) boss/Installation hole</li> <li>▪ Undersized installation hole</li> <li>▪ Housing material too hard</li> </ul>
Pin deformation	<ul style="list-style-type: none"> <li>▪ Pin inserted upside down.</li> <li>▪ Pin mushroomed due to too many light taps.</li> <li>▪ Insufficient or incorrect support shoulder.</li> <li>▪ No wax on pin.</li> </ul>
Low retention pressure	<ul style="list-style-type: none"> <li>▪ Oversized or tapered installation hole.</li> <li>▪ Wall section too thin.</li> <li>▪ Installation hole out of round.</li> <li>▪ Installation hole coating and/or treatment</li> <li>▪ Installation hole too smooth (lower than 16 microinches rms (0,4 micrometers).</li> <li>▪ Use of a lubricant on the installation hole.</li> <li>▪ Improper surface treatment on installation hole.</li> <li>▪ Boss material much harder than insert material.</li> <li>▪ Thermally mismatched insert and boss material in large temperature variation application.</li> </ul>
Leakage	<ul style="list-style-type: none"> <li>▪ Longitudinal scratch marks in installation hole.</li> <li>▪ Wall section too thin.</li> <li>▪ Hole out of round.</li> <li>▪ Insert with a compression or nose seal not bottomed on support shoulder.</li> </ul>
Pin backout	<ul style="list-style-type: none"> <li>▪ Use of a lubricant on the pin.</li> <li>▪ Oversized installation hole.</li> </ul>



## **Appendix A**

### **Lee Company Sales Offices**



**Lee Company U.S. Sales Offices**

<p align="center"><b>THE LEE COMPANY</b>          Technical Center          P. O. Box 424, 2 Pettipaug Road          Westbrook, CT 06498-0424</p> <p align="center">Tel: (860) 399- 6281          (800) 533-7584 (LEE PLUG)          Fax: (860) 399-7058 Order Entry          (860) 399-7037 Technical Information          (860) 399-2270 Advertising</p> <p align="center">Web: <a href="http://www.theleeco.com">www.theleeco.com</a>          E-mail: <a href="mailto:ct-sales@theleeco.com">ct-sales@theleeco.com</a></p>	
<p><b>THE LEE COMPANY</b>          1511 N. Westshore Blvd.          Suite 200          Tampa, FL 33607</p> <p>Tel: (813) 287- 9293          Fax: (813) 287-9295</p> <p><a href="mailto:fl-sales@theleeco.com">fl-sales@theleeco.com</a></p>	<p><b>THE LEE COMPANY</b>          8600 W. Bryn Mawr Ave.          Suite 160-N          Chicago, IL 60631-3505</p> <p>Tel: (773) 693-0880          Fax: (773) 693-1015</p> <p><a href="mailto:il-sales@theleeco.com">il-sales@theleeco.com</a></p>
<p><b>THE LEE COMPANY</b>          7755 Center Ave.          Suite 1020          Huntington Beach, CA 92647</p> <p>Tel: (714) 899-2177          Fax: (714) 899-2176</p> <p><a href="mailto:ca-sales@theleeco.com">ca-sales@theleeco.com</a></p>	<p><b>THE LEE COMPANY</b>          3000 Town Center          Suite 2580          Southfield, MI 48075</p> <p>Tel: (248) 827-0981          Fax: (248) 827-2144</p> <p><a href="mailto:mi-sales@theleeco.com">mi-sales@theleeco.com</a></p>
<p><b>THE LEE COMPANY</b>          1250 Bayhill Drive          Suite 113          San Bruno, CA 94066</p> <p>Tel: (650) 238-2045          Fax: (714) 899-2176</p> <p><a href="mailto:ca-sales@theleeco.com">ca-sales@theleeco.com</a></p>	<p><b>THE LEE COMPANY</b>          545 E. John Carpenter Fwy.          Suite 875          Irving, TX 75062</p> <p>Tel: (972) 791-1010          Fax: (972) 791-1717</p> <p><a href="mailto:tx-sales@theleeco.com">tx-sales@theleeco.com</a></p>



**International Sales Offices and Distributors**

<p><i>Subsidiary for the United Kingdom and Ireland</i></p> <p><b>LEE PRODUCTS LIMITED (LPL)</b> 3 High Street, Chalfont St. Peter, Gerrards Cross Buckinghamshire SL9 9QE ENGLAND Tel: + 44 1 753-886664 Fax: + 44 1 753-889588 sales@leeproducts.co.uk</p>	<p><i>Subsidiary for Denmark, Sweden, Norway, Finland and Russia</i></p> <p><b>THE LEE COMPANY SCANDINAVIA AB</b> Pajalagatan 56 SE-162 65 Vällingby SWEDEN Tel: + 46 8 579 701 70 Fax: + 46 8 875252 sales@theleeco.se  Helsinki, Finland Tel: + 358 44 0111 246 Fax: + 358 19 331 890 marko.koskinen@theleeco.net</p>
<p><i>Subsidiary for Germany, Austria, Eastern Europe and German speaking Switzerland</i></p> <p><b>LEE HYDRAULISCHE MINIATURKOMPONENTEN, GmbH (LPD)</b> Am Limespark 2 65843 Sulzbach / Taunus Germany Tel: + 49 6196-77369-0 Fax: + 49 6196-77369-69 info@lee.de  Bonn Office: Tel: + 49 22 44 871263 Fax: + 49 22 44 871264</p>	<p><i>Subsidiary for France, Spain and French speaking Switzerland</i></p> <p><b>LEE COMPANY S.A. (LPF)</b> 44 rue Jean Bart 78960 Voisins-le-Bretonneux FRANCE Tel: +33 1 30 64 99 44 Fax: +33 1 30 64 91 26 info@leecompany.fr  Toulouse Office: Tel: +33 5 67 31 00 92 Fax: +33 5 34 60 50 40 h.reberga@leecompany.fr  Madrid Office: SPAIN &amp; PORTUGAL Tel: +34 913 010 572 p.sanchez.martin@leecompany.fr</p>
<p><i>Agent for South America</i></p> <p><b>TRUSTY COMÉRCIO E REPRESENTAÇÕES LTDA.</b> Av. J.K. de Oliveira 580 Sala: 41, Guaratinguetá, São Paulo, 12505-300 BRAZIL Tel: + 55 12 3132-3418 Fax: + 55 12 3132-3560 rui@tcr-brazil.com.br</p>	<p><i>Distributor for Australia and New Zealand</i></p> <p><b>CGB PRECISION PRODUCTS PTY LTD</b> Unit 9, 32 Silkwood Rise Carrum Downs VIC 3201 AUSTRALIA Tel: + 61 3 9775 1125 Fax: + 61 3 9770 8844 info@cgb.com.au</p>
<p><i>Subsidiary for Italy &amp; Italian speaking Switzerland</i></p> <p><b>LEE SRL. (LPI)</b> Via Rondoni, 1 20146 Milano ITALY Tel: + 39 02 43981750 Fax: + 39 02 461050 sales@leesrl.it</p>	<p><i>Distributor for Belgium, Netherlands &amp; Luxemburg</i></p> <p><b>DENIS DE PLOEG BV</b> Geneindestraat 33 6301 HC Valkenburg (L) NETHERLANDS Tel: + 31 43 820 0250 Fax: + 31 43 820 0251 bs.deploeg@ddp.nl</p>



**International Sales Offices and Distributors (Continued)**

<p><i>Agent for Israel</i></p> <p><b>ENL ENGINEERING AND LOGISTICS LTD.</b> 35/8 Hasaifan Street P. O. Box 1074 Ramat-Hasharon 47100 ISRAEL Tel: + 972 3 549 3644 Fax: + 972 3 540 0262 enleng@netvision.net.il</p>	<p><i>Agent for Singapore, Indonesia, Thailand and Malaysia</i></p> <p><b>WINOVA PTE LTD.</b> 31 Toh Guan Road East #05-08 LW Technocentre SINGAPORE 608608 Tel: + 65 6425 2116 Mobile: + 65 9655 9910 Fax: + 65 6425 1109 sales@winova.com.sg</p>
<p><i>Agent for India</i></p> <p><b>HIND INDUSTRIAL AND MERCANTILE CORP. PVT. LTD.</b> 22, Neo Corporate Plaza, Ramchandra Lane - Ext. Kachpada, Malad-West, Mumbai 400 064 INDIA Tel: + 91 22 2809 2447 Fax: + 91 22 2866 1964 info@hindco.net</p>	<p><i>Distributor for Taiwan</i></p> <p><b>LOOP LINK ENTERPRISE, INC.</b> 6F-7, No. 171, Sec. 5 Ming Shen E. Road Taipei, TAIWAN 10589 REPUBLIC OF CHINA Tel: + 886 2 2762 9614 Fax: + 886 2 2761 3407 looplink@ms9.hinet.net</p>
<p><i>Distributor for Japan</i></p> <p><b>JUPITOR CORPORATION</b> 3-17-4 Minami Aoyama Minato-Ku, Tokyo 107-0062 JAPAN Tel: + 81 33 403 1313 Fax: + 81 33 403 1319 t_suzuyama@jupitor.co.jp</p>	<p><i>Distributor for Korea</i></p> <p><b>MIN SUNG GC CORPORATION</b> Minsung Building, Jegi-Dong 89 Yangnyeongjungang – Ro, Dongdaemun – gu, Seoul, KOREA Tel: + 822 961 7833 Fax: + 822 961 6249 minsung@minsunggc.com</p>
<p><i>Distributor for People's Republic of China and Hong Kong</i></p> <p><b>EBS FLOW CONTROL LTD.</b> Suite 2503, Block B Lead International Building No. 2 Zhong Huan Nan Lu Jia Wang Jing, Chaoyang District Beijing 100102 CHINA Tel: + 86 10 84721177 Fax: + 86 10 84721263 info@ebshk.com.cn</p>	