

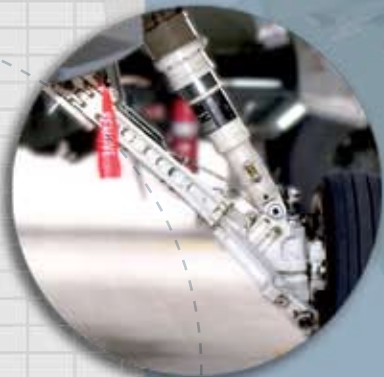
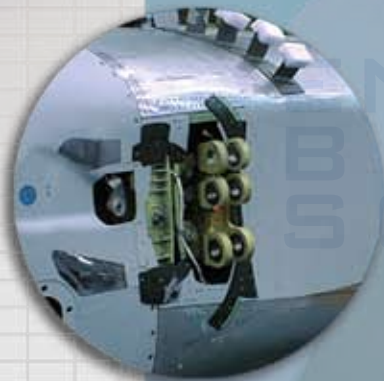
ForceMate®

BUSHING INSTALLATION SYSTEM



ADVANTAGES OVER OTHER BUSHING INSTALLATION SYSTEMS:

- Improves the fatigue life and fatigue strength of the parent structure
- Potential structural weight savings
- Proven increase in damage tolerance
- Resists migration and rotational forces
- Maintains integrity of bushing coatings, platings or corrosion inhibitors
- Reduces labor time and installation costs
- Safer and more consistent installation with minimal operator training



Over 25 Years
of Proven Field
Performance

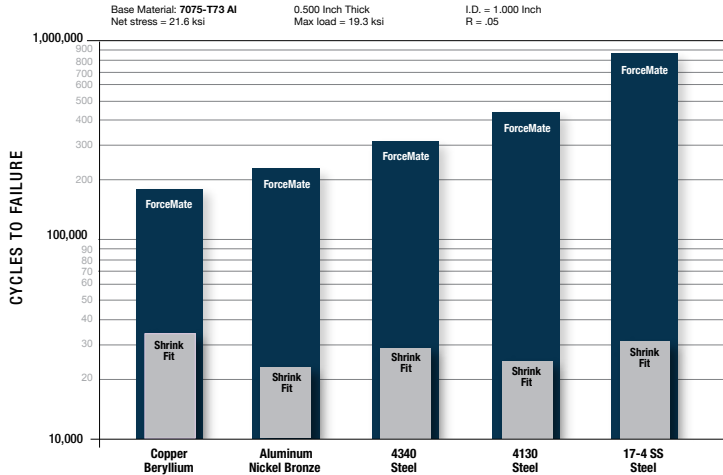


FATIGUE TECHNOLOGY INC.

FORCEMATE OUTPERFORMS OTHER BUSHING INSTALLATION METHODS

Extensive testing and analysis have proven that the ForceMate system is superior to conventional press-fit or shrink-fit bushing installation methods in every respect.

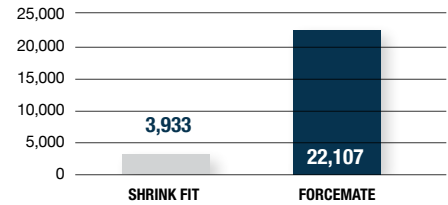
FORCEMATE® VS. SHRINK FIT WITH VARYING BUSHING MATERIALS



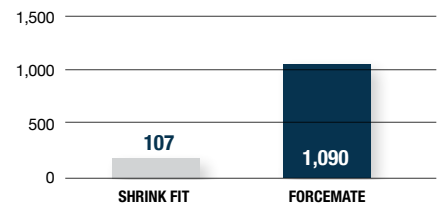
FORCEMATE® VS. SHRINK FIT

Stainless steel cadmium-plated bushing in 7150 aluminum coupon.

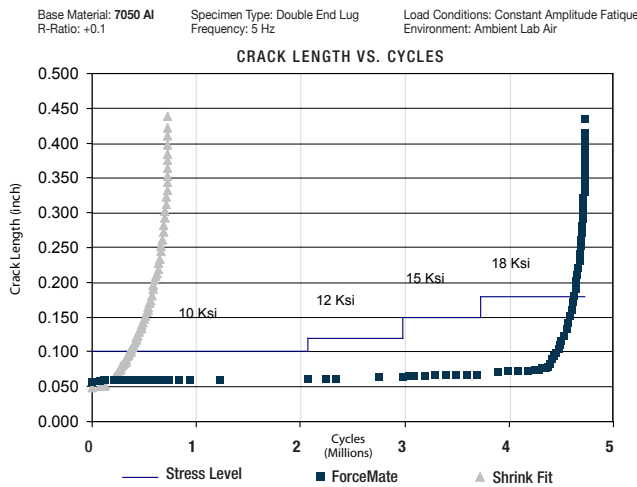
PUSH OUT/REMOVAL FORCE (lbs.) 5.6:1 Improvement



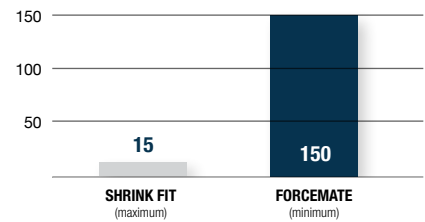
TORQUE/ROTATION TEST (ft.-lbs.) 10.2:1 Improvement



FORCEMATE® VS. SHRINK FIT - FATIGUE AND CRACK GROWTH TESTING

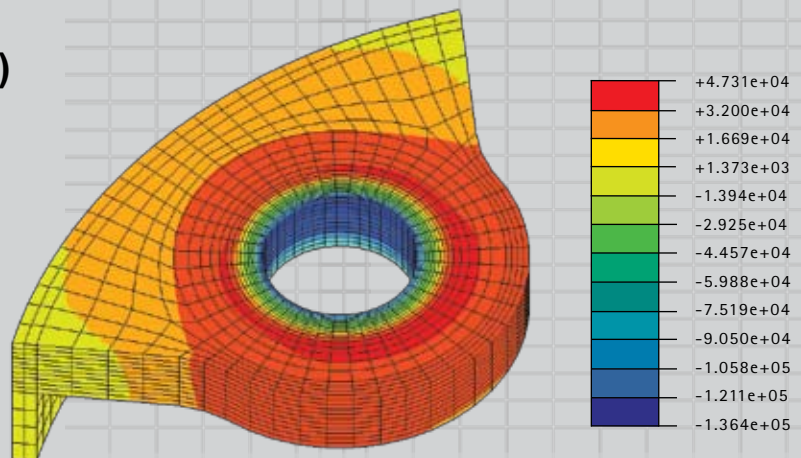


VIBRATION TEST (Minutes) 10:1 Improvement



FINITE ELEMENT ANALYSIS (FEA)

FTI provides Finite Element Analysis to tailor the features of the expanded ForceMate bushing and optimize its performance for structural life and durability. We analyze the performance of different bushing materials in different parent structures and attachment lug configurations, as well as the resistance to bushing migration and push out.



ForceMate®

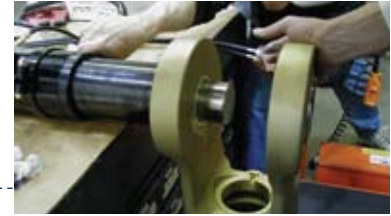
FORCEMATE SYSTEM

FTI's ForceMate system is currently used on over 1,000 bushing applications on commercial and military aircraft and helicopters worldwide.

- In service since 1983
- Backed by solid engineering and manufacturing
- Independently tested and approved by outside agencies, including the FAA
- Currently used by:
 - > Agusta Westland
 - > Airbus
 - > Bell Helicopter Textron
 - > Boeing
 - > Bombardier
 - > EADS
 - > Eurocopter
 - > Lockheed Martin
 - > Northrop Grumman
 - > Sikorsky
 - > U.S. Department of Defense

The ForceMate system is engineered to:

- Improve producibility
 - > Reduce installation costs
 - > Increase throughput in production
- Increase fatigue life
 - > Improve structural durability
 - > Increase damage tolerance
- Reduce life cycle costs
 - > Increase inspection intervals
 - > Lower maintenance costs



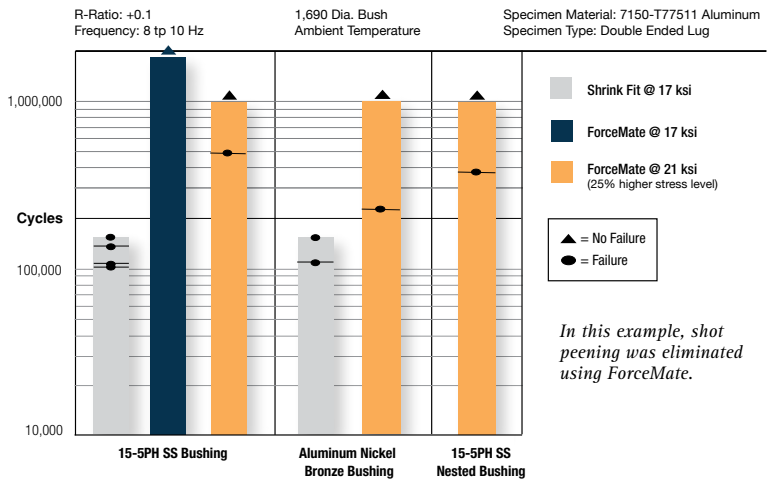
Using the ForceMate system to increase fatigue life and reduce structural weight

When attaching major structure or components to an aircraft (engines, landing gear, weapons pylons, etc.) lugs and clevises are usually sized to meet the high cyclic tensile stress levels they endure. Meeting these objectives can impose a significant weight penalty.

Using ForceMate can greatly increase the fatigue life and damage tolerance of the lug/clevis by the synergistic high interference fit and the beneficial residual stresses induced around the bushing. The increase in life of the assembly can significantly extend or eliminate the need to inspect the bushed joint under normal service load conditions.

Testing has confirmed that ForceMate can be used to reduce the thickness of lugs designed under fatigue constraints by allowing operation at higher stress levels.

FORCEMATE® VS. SHRINK FIT ON SHOT-PEENED LUG



ForceMate offers higher allowable stresses with no decrease in component life, therefore thinner lug design may be used (less weight).

MANUFACTURING EASEMENT

Using the ForceMate system reduced a 2-man, 2-day operation into a 1-man, 2-hour operation.



Rework of engine pylon.

Commercial engine pylon with ForceMate bushings installed.

FORCEMATE INSTALLATION

The ForceMate system can be used in virtually all typical bushing installation applications.

GUIDELINES

STANDARD BUSHING MATERIALS

- 15-5 PH stainless steel
- Aluminum-Nickel-Bronze
- 17-4 PH stainless steel
- Copper Beryllium
- Titanium
- AISI 4340 steel
- AISI 4130 steel

PARENT MATERIALS

- Aluminum (Alloys)
- Titanium
- Steel
- High-strength steel alloys
- Composites

HOLE SIZES (INSIDE DIAMETER)

- From 3/16 to 6 inches (4.8mm to 150mm)
- Sizes in excess of 6 inches have been custom engineered

The standard ForceMate system is designed for use in plain structure or in lug-type geometries. The system has been optimized for lug geometries with width-to-diameter ratios (W/D) of 1.8 or greater, and diameter-to-thickness ratios (D/t) of 4 or less. ForceMate is also effective in geometries other than those stated above but certain tooling or procedural changes may be required.

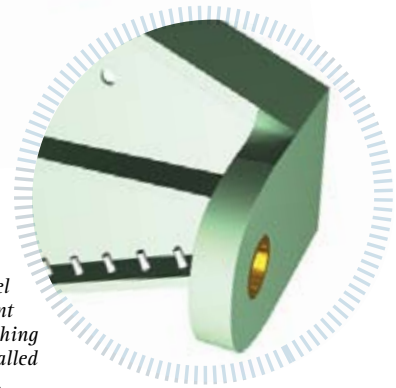
PROCEDURE



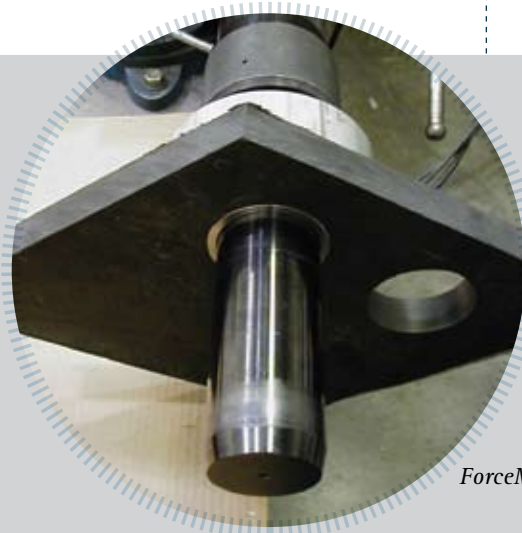
A specially sized bushing is placed over a tapered expansion mandrel. The mandrel is inserted into a puller unit.



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 expands the parent material while the bushing is simultaneously installed with high interference.



COMPOSITE INSTALLATION

The ForceMate system has been adapted for use in composites as a means to install interference fit metal inserts and thicker-walled bushings. Because of the relatively low strain capability of composites, lower applied expansion levels are used with these types of installations. FTI has researched and tested this process to ensure a high performance bushing or insert retention without damage to the composite material.

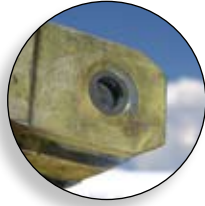
ForceMate bushing being installed in composite.

APPLICATIONS

ForceMate can be used in any structure (new production or rework) where bushings are required, especially those subjected to cyclic fatigue loading or require a damage tolerance capability. ForceMate can also be utilized for resizing fastener holes and access panel attaching holes.



ROTOR SYSTEMS



ENGINE PYLONS



WING ATTACH FITTING



LANDING GEAR



ENGINE COMPRESSOR
DISKS AND BLADES

COMPLEX APPLICATIONS

ForceMate can be uniquely designed to work in complex configurations and other special applications.



LUBRICATION GROOVES



NESTED BUSHINGS



CAPTURED WASHERS



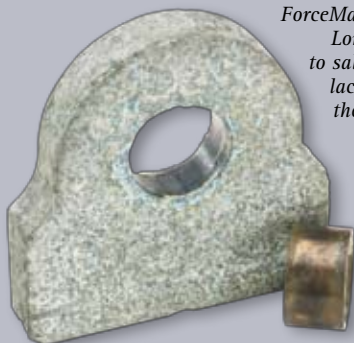
COMPLEX GEOMETRY



SPECIAL COATINGS

CORROSION RESISTANCE

Each ForceMate bushing has a slight clearance fit when first placed in the hole. This small gap allows the use of sealants, platings and coatings that can be applied to the bushing without damaging or scraping them off during installation. Shrink-fit bushings are installed with little or no gap for corrosion preventative compounds or sealants. These protective platings are typically scraped when installed into the hole. Additionally, condensation from the shrink-fit process (liquid nitrogen) remains, which can lead to corrosion.



ForceMate corrosion test: Long-term exposure to salt water. Note the lack of corrosion on the bore from using ForceMate.

STANDARD SYSTEM

The Standard System consists of tooling and technology, which provide installation of bushings in aluminum structure that are equivalent in size to the National Aerospace Standards (NAS) for straight and flanged press-fit bushings.

FTI creates complete and convenient kits (per our customers' request), which include all the necessary tooling required for a certain application.



FTI designs and manufactures a full range of cold expansion products for the aerospace industry. These products are specifically engineered to achieve aircraft production and cost initiatives; meet design goals, production rates and aircraft performance objectives; and provide life-cycle cost savings.

Here are some of FTI's other innovative products:



Split Sleeve Cold Expansion™

Fatigue Life Enhancement of Holes in Metal Structures

- Enhances structural fatigue life
- Increases the durability and damage tolerance of holes
- One-sided operation
- Over 38 years proven service



ForceTec®

Rivetless Nut Plate

- Fast, consistent installation
- Meets or exceeds NASM25027
- Easily replaceable nut element – sealed or non-sealed
- Resists lightning strike damage in composite structures



TukLoc®

Blind Fastening System

- Easy hole preparation
- No additional sealants required
- Rapid installation
- Highly reliable process



Flexmate®

Advanced Aerospace Fitting

- Fatigue life improvement
- Simple one-piece design
- Minimum envelope
- Minimum weight
- Excellent sealing and electrical conductivity



FTI's corporate headquarters and manufacturing plant is located just 5 minutes from the Sea-Tac International Airport and 10 minutes from downtown Seattle, Washington.

FTI SERVICES

Fatigue Technology Inc. is the world leader in cold expansion technology. We have pioneered this science since 1969 and have advanced the cold expansion process to develop cost savings ideas for production simplification, manufacturing and maintenance time-saving, and improved aircraft structural performance. We offer our customers a full range of services to support their applications.

THESE SERVICES INCLUDE:

- On-site product support
- Technical training
- Engineering/design support
- Product and materials testing
- Research and development services
- Field repairs and upgrades

(Please contact us to discuss your current application.)



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