hi-Set®

a shear-type precision fastener

- Provides the Highest Strength-to-Weight Ratio of any Airframe Structural Fastener
- Offers Cost-Savings Through Automated Assembly
- Available in Beta Titanium Alloys, A-286 Alloy and Inconel 718

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The *hi-Set*® Fastener

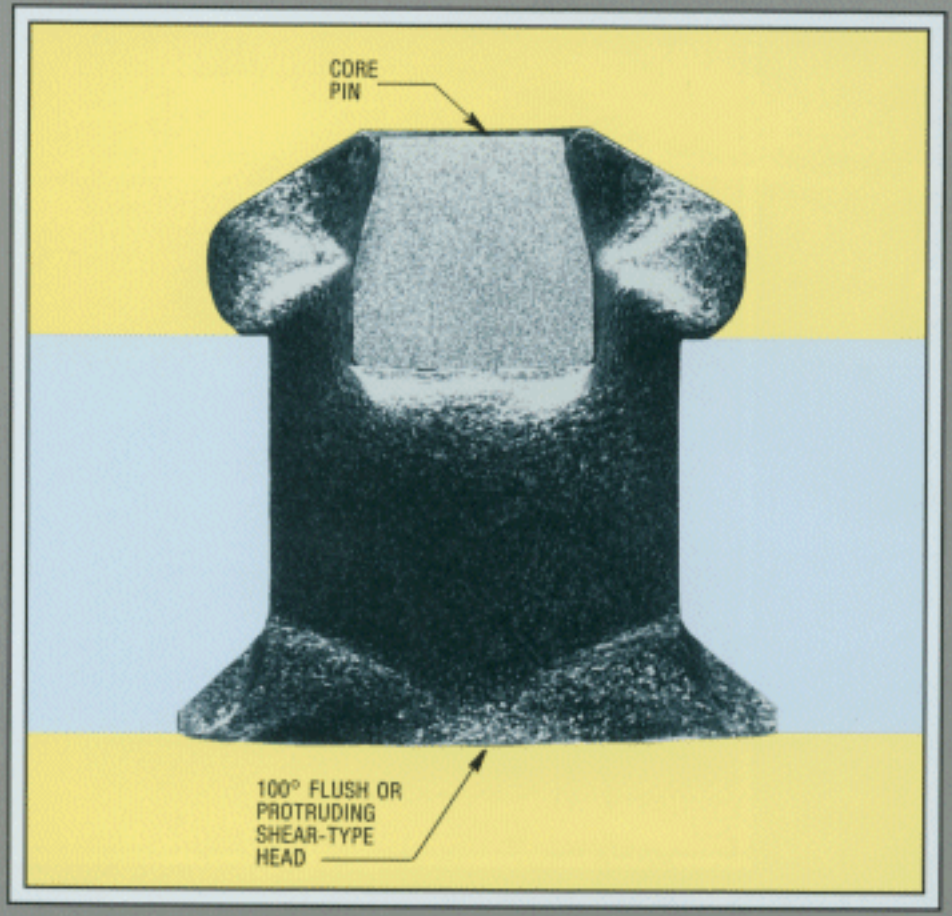


Figure 1. Cross-Sectioned, enlarged view of Hi-Set Rivet.

The Hi-Set Rivet is a shear-type precision fastener having the highest strength-to-weight ratio of any airframe structural fastener or fastening system.

Fabricated from materials with rated shear strength levels of 95,000 psi, such as A-286 and the Beta titanium alloys, and 125,000 psi such as Inconel 718, the Hi-Set Rivet imparts static and dynamic strength characteristics to airframe structures equal to or surpassing the characteristics of heavier and more expensive fasteners.

Airframe weight savings are readily obtainable by use of the Hi-Set Rivet. Extensive use of the rivet, a single element, can reduce airframe weight by several hundred pounds.

Installation is simple. Low installation forces of the Hi-Set Rivet permit use of portable hydraulic squeezer equipment fitted with a Hi-Set Rivet Set. Since the Hi-Set Rivet is a single element, it can be readily adapted to automated installation by equipment such as the Gemcor Drivmatic riveter.

In unit fastener price and installed cost, the Hi-Set rivet is highly competitive with other comparable fasteners.

Grip Variation

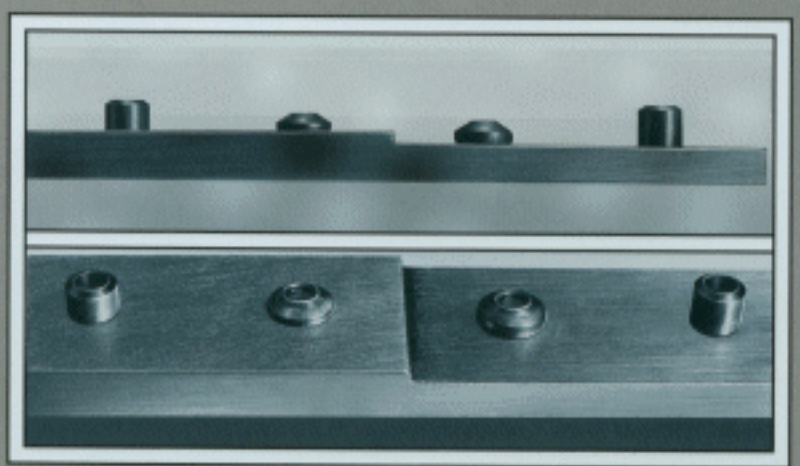


Figure 2. Grip conditions maximum (left) minimum (right).

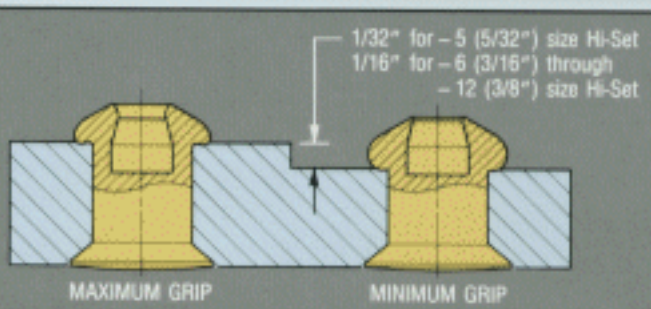


Figure 3. Allowable variation in material thickness accommodated by a single Hi-Set Rivet without changing grip lengths.

How the *hi-Set*® Works

The Hi-Set Rivet consists of a semi-tubular rivet with a core pin of equal or higher strength which is mechanically encapsulated at the base of the tubular recess. The rivet is solid through the major portion of its shear bearing length. The expansion of the rivet in softer aluminum materials is precisely controlled by the relatively low driving forces allowed by the rivet's semi-tubular design. During installation, see Figure 4, the core pin prevents buckling and eccentric movement of the tubular portion of the rivet as upsetting occurs. The core pin provides central support to the upset portion of the rivet after installation, providing tensile strength capability equal to that of the manufactured shear head.

Due to its tubular construction and the influence of mating Hi-Set installation tooling, the upset portion of the rivet has an extremely low profile permitting easier passage of electrical, pneumatic or hydraulic systems through the structure.

Available in five diameters from 5/32" through 3/8", the Hi-Set Rivet will accommodate normal variations in material thickness. The 5/32" diameter rivet accommodates a 1/32" grip variation while the larger diameter rivets accommodate a 1/16" variation in grip range. See Figures 2 and 3.

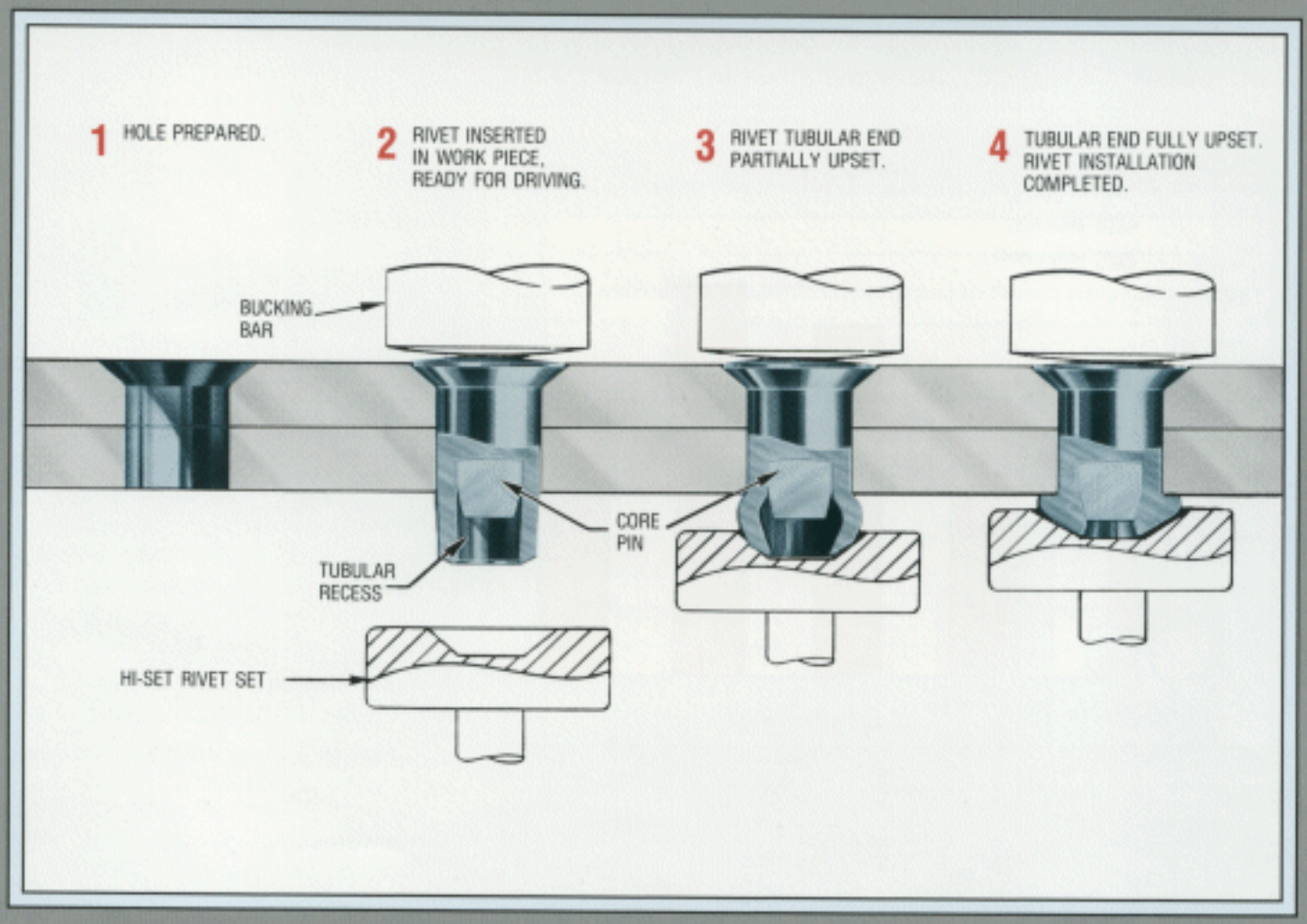
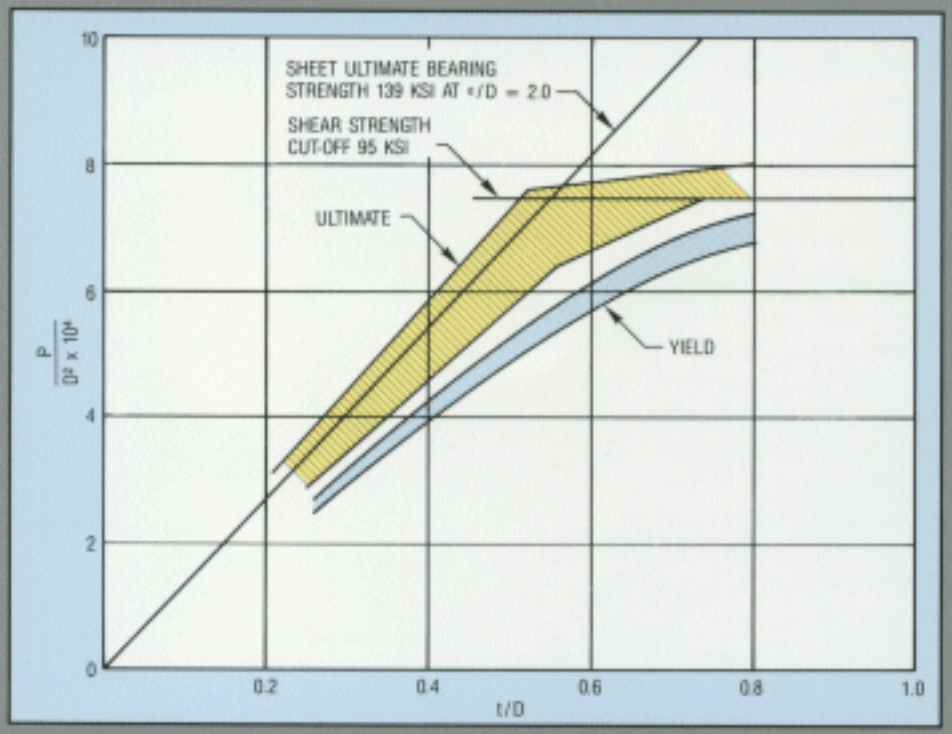
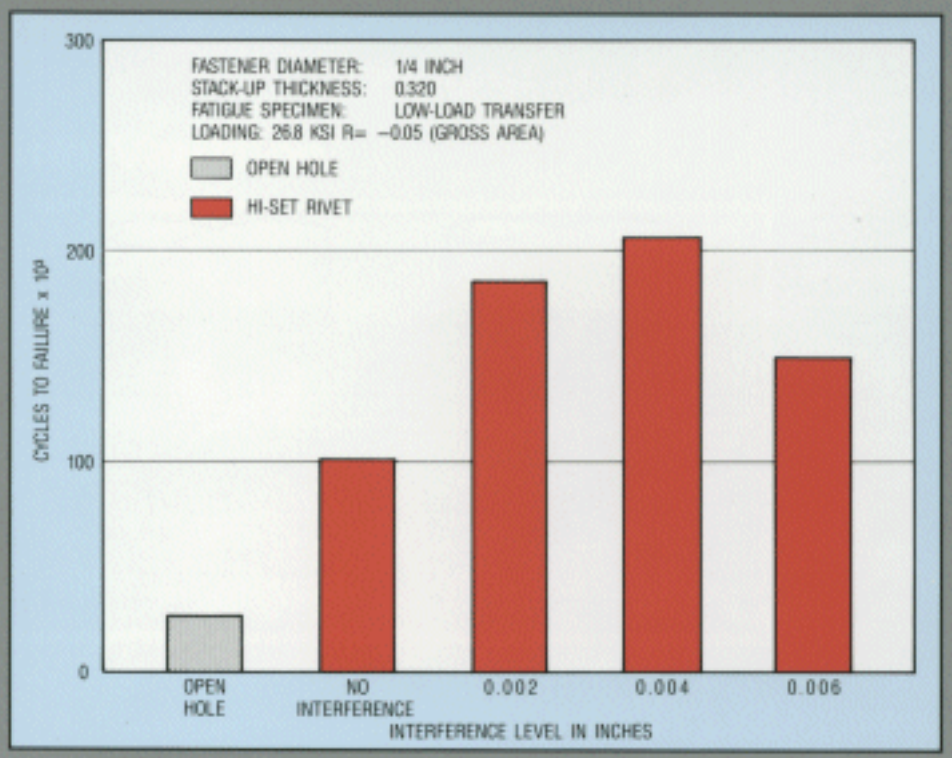


Figure 4. Hi-Set Rivet Installation Steps.

hi-Set® Physical Characteristics



Graph 1. Lap Shear, Static Joint Strength. Average test data for 3/16" and 1/4" dia. Hi-Set Rivets. (MIL-HDBK-5 CRITERIA; 7075 AL. SHEET)



Graph 2. Low-load Transfer Structural Fatigue

Static Strength

The Hi-Set Rivet produced from either A-286 or Beta titanium alloys has a minimum shear strength of 95,000 psi. Tensile strength values of installed rivets exceed the rated strength levels of other comparable shear fasteners.

Of critical concern to airframe engineers is the strength of fastened structural members. Extensive testing of Hi-Set Rivets installed in lap shear specimens reveals that the ultimate joint strength of such assemblies approaches theoretical limits. Graph 1 presents data using the 3/16" and 1/4" Hi-Set Rivets in static joint strength tests using the procedures defined by MIL-HANDBOOK-5.

In thinner structural sections, the rivets developed ultimate strength levels consistent with the bearing allowables for the sheet material. This indicated the Hi-Set Rivet had sufficient strength and ductility to withstand the combined shear and bending stresses developed during testing.

In thicker sections where the fastener is critical, the Hi-Set Rivets developed shear strength levels consistently above the 95,000 psi level.

Structural Fatigue

Since the semi-tubular design of the Hi-Set Rivet and the applied installation force control the diametral expansion of the rivet in the fastener hole, significant improvements in the fatigue strength of fastened assemblies is possible by installing the Hi-Set Rivet at initial interference fit levels of 0.001" to 0.004".

The data presented in Graph 2, using a two-fastener, low load transfer structural fatigue specimen, compares specimens with open holes to others with Hi-Set Rivets installed at varying initial interference fits. Optimum results occur when initial interference fits between 0.001" and 0.004" and prescribed assembly forces are applied.

Vibration Resistance

Solid rivets have a long history of satisfactory service in extreme vibration environments. The Hi-Set Rivet, while similar to a solid rivet, differed enough to warrant extensive testing to ensure that extreme vibration would not free the core pin from the rivet body.

The rigorous vibration test procedure defined in NAS1675 specification requires that a flat plate containing installed fasteners be continuously impacted with a rivet gun. The test setup of such a flat plate containing Hi-Set Rivets is shown in Figure 5. The installed Hi-Set Rivets endured the test series up through 20 minutes of continuous testing without failure or loss of a core pin.

Few structural fasteners are capable of withstanding this level of vibration. The Hi-Set Rivet performance in this condition confirms it suitable for vibration critical assemblies such as vertical stabilizers and engine nacelles.

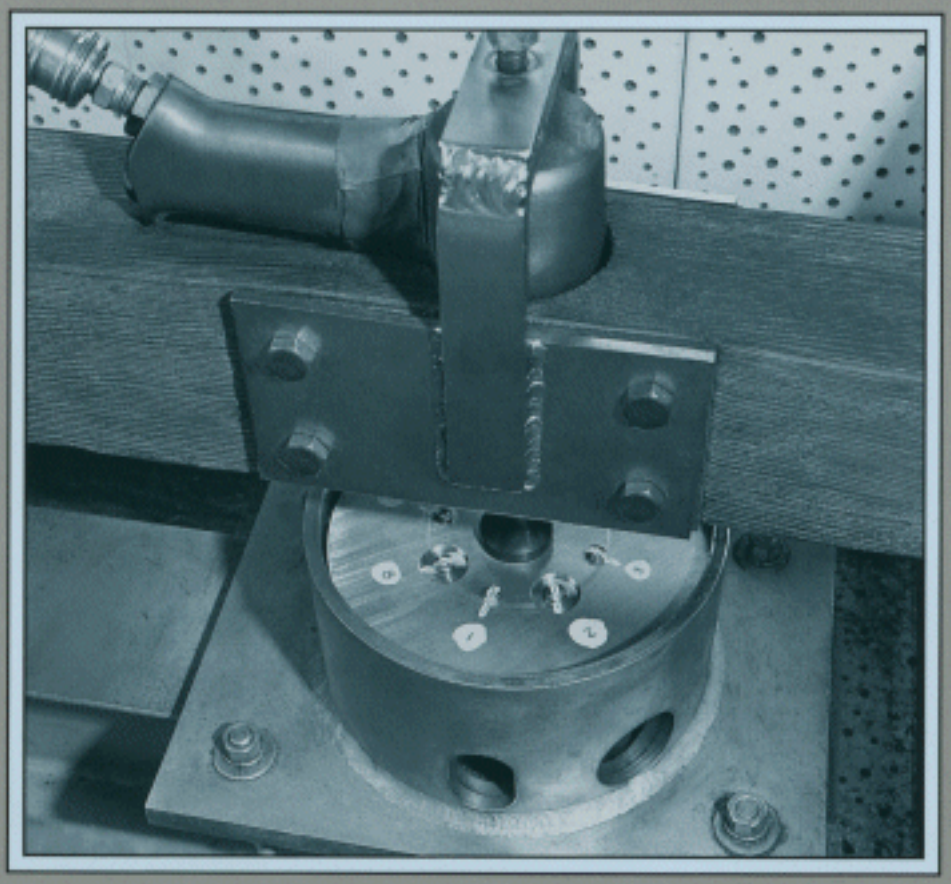
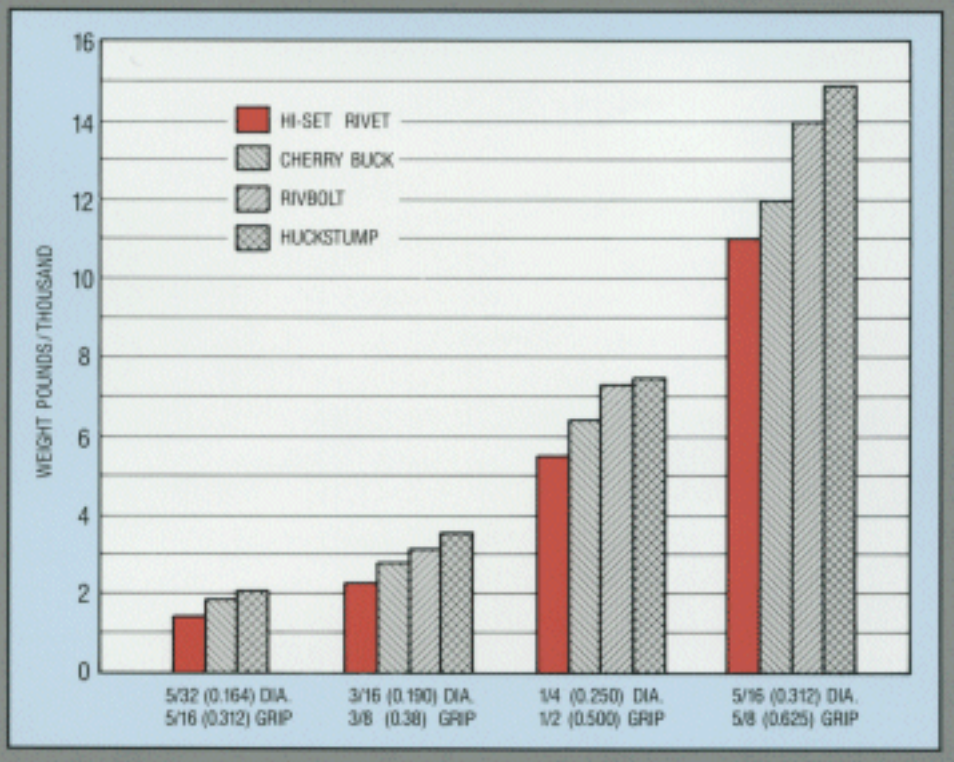


Figure 5. Vibration testing with rivet gun striking suspended plate per Specification NAS1675.

Weight

The Hi-Set Rivet design eliminates all material that is not necessary to its functional usage. As a result materials such as A-286 and the Beta titanium alloys, which provide excellent ductility and highly desirable strength characteristics, can be utilized without a weight penalty.

Graph 3 compares the weight of Beta titanium Hi-Set Rivets in popular diameters and grip lengths to other titanium fastening devices. Extensive use of Hi-Set Rivets could reduce airframe weight by several hundred pounds.



Graph 3. Weight Comparison Chart.

Hole Preparation and Installation Force

Hole preparation for Hi-Set Rivets is similar to, but less critical than that required for certain structural rivets and threaded fasteners.

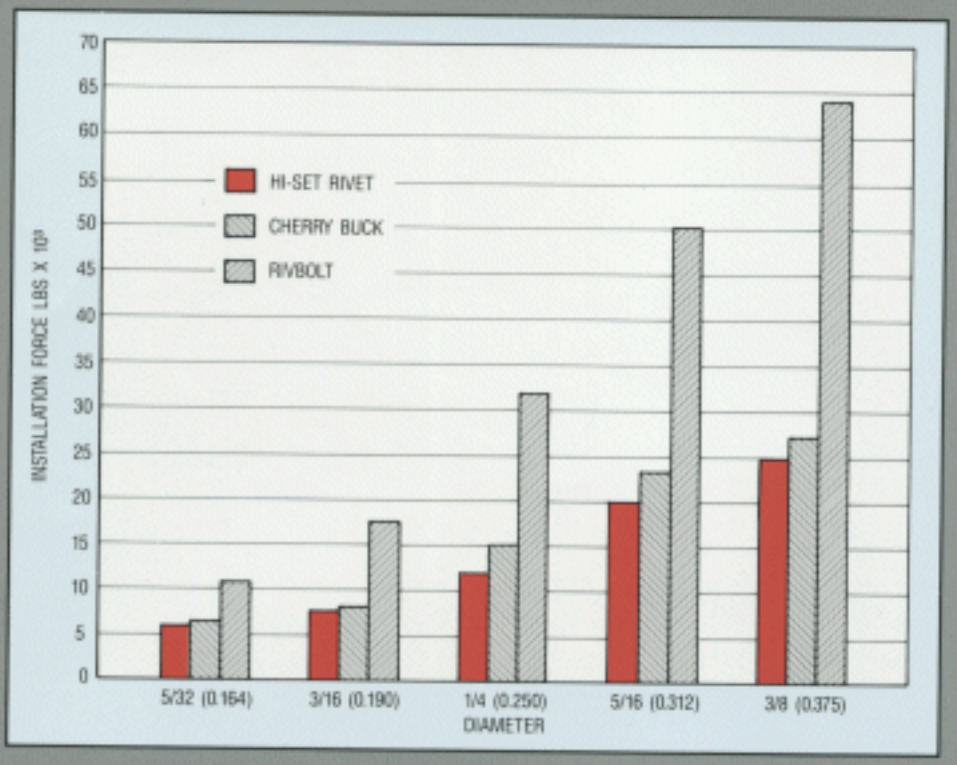
For applications where static strength of the assembly is of prime concern, the Hi-Set Rivet can be installed with initial clearances up to 0.004 inch.

Where the fatigue life of the structure is the decisive factor, the Hi-Set Rivet should be installed at initial interference fits from 0.001 to 0.004 inch depending on design requirements. See graph 2.

This range of fastener fit permits the designer to select a fit to effect the lowest installed cost consistent with efficient airframe design and to suit the available assembly equipment.

The design of the Hi-Set Rivet controls the degree of rivet shank expansion during upsetting so that the final effective interference level is uniform and predictable.

Installation forces applied to the Hi-Set Rivet are constant for each diameter. No adjustment in the upsetting force is required to accommodate changes in fastener length. A comparison of Hi-Set Rivet installation forces with those of other similar fasteners is presented in Graph 4.



Graph 4. Installation Force vs. Diameter.

Automated Assembly

Since the Hi-Set Rivet is a single element fastener, it provides airframe builders with unique opportunities to automate the assembly of structural airframe components. Automatic riveting machines, such as the Gemcor Drivmatic AFM, are capable of drilling the holes and inserting and installing the rivet. The Gemcor AFM fitted with Hi-Set rivet dies in combination with the standard lower ram anvil assembly are all that is needed to install Hi-Set Rivets. The special shape of each die produces the proper upset. With this system, tooling requirements are reduced and control circuitry is simplified. Hi-Set Rivets can be installed in either interference or clearance fit holes. Either way the installation procedure is the same. The hole is drilled, the rivet is inserted, and the Hi-Set die moves upward until the tubular end of the rivet is fully formed.

For manufacturing versatility, Hi-Shear can provide a standard straight anvil as shown above, or an offset anvil as shown below. With the offset anvil Hi-Set rivets can be installed easily in restricted access locations. Another plus is Hi-Set's 1/16" grip variation capability can be accommodated with no change in set-up. The installation can be continuous even with the additional thickness, and will be just as fast and just as reliable.

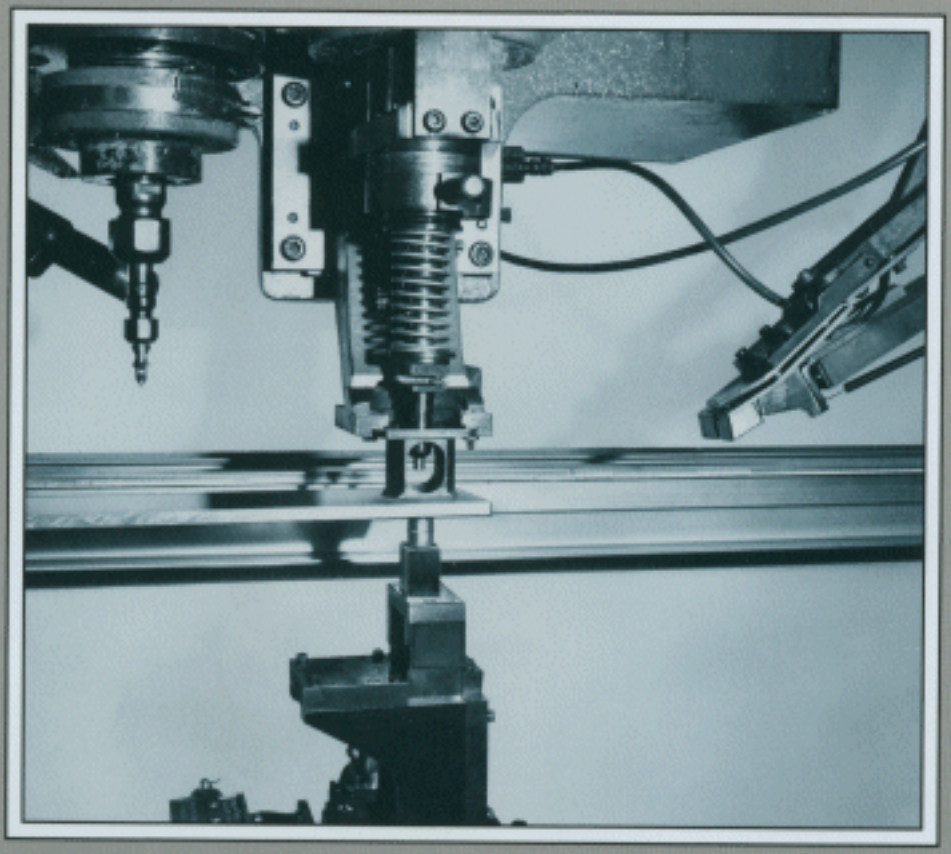


Figure 8. Gemcor Drivmatic automates installation of Hi-Set Rivet

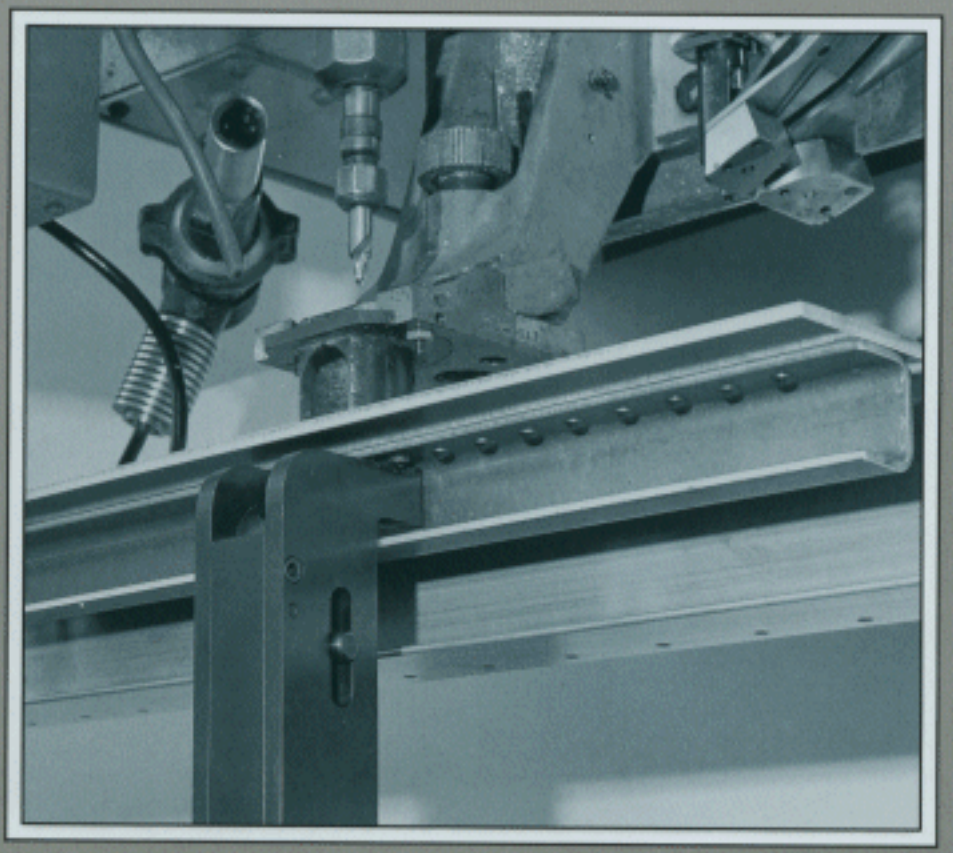


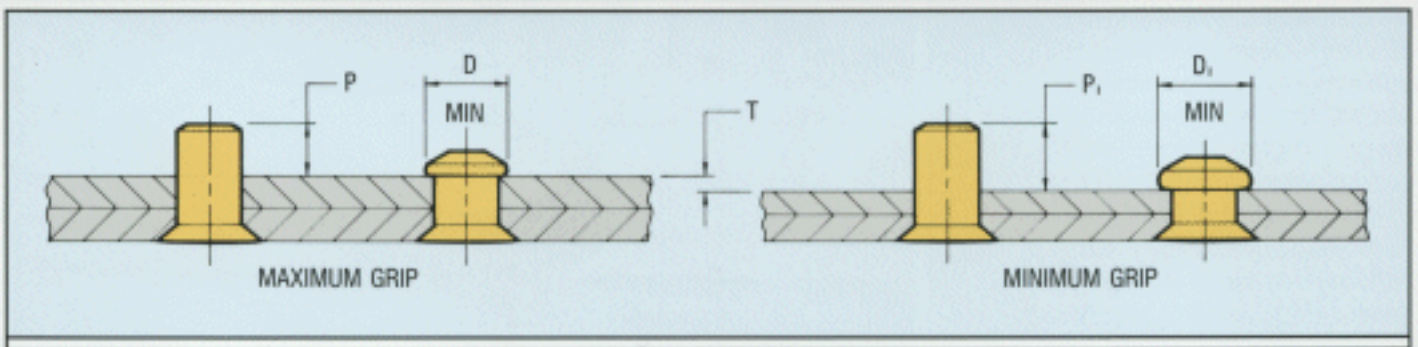
Figure 9. Offset-Anvil installing Hi-Set Rivets in restricted access area.

Inspection during and after Installation

A one-piece Hi-Set inspection gage is used to verify that the Hi-Set Rivet is properly installed.

This simple GO / NO GO device ensures that proper protrusion length before upset and upset diameter is achieved.

Approximately one inch square in size, the gage can be used in the most restricted assembly areas.



First Dash Number	Nominal Diameter	Maximum Permitted thickness Variation per Dia. T	Protrusion Before Upset		Diameter After Upset	
			Max Grip P	Min. Grip P_1	Max. Grip D	Min. Grip D_1
–5	5/32	1/32	.136	.182	.204	.244
–6	3/16	1/16	.138	.216	.236	.283
–8	1/4	1/16	.208	.286	.311	.373
–10	5/16	1/16	.274	.351	.389	.467
–12	3/8	1/16	.339	.416	.468	.561

Fastener Unit Cost / Installed Cost

While the Hi-Set Rivet is manufactured from high strength, lightweight, ductile materials, the Hi-Set unit price is competitive with other comparable shear fasteners.

Fastener installed costs are minimized using Hi-Set Rivets because:

1. Low unit cost of Hi-Set Rivets.
2. It's a single element fastener. No companion parts are purchased, inventoried or handled.
3. Rapid installation rates are easily obtained using portable tools. Even greater installation savings are attainable employing fully automatic installation equipment such as the Gemcor Drivmatic.
4. Shank expansion of the Hi-Set Rivet is controlled and uniform during the upsetting operation, thereby minimizing distortion in the riveted panels.
5. The smooth low profile of the upset end of the Hi-Set Rivet minimizes interference with subsequently installed electrical, pneumatic or hydraulic lines. The low profile contributes to reduced drag in duct areas.
6. Minimum investment is required in installation tooling. Hi-Set Rivet sets fit into conventional squeezers.
7. The quiet squeeze method of installation is well within the allowable standard of OSHA regulations.

How to Order

Currently the Hi-Set Rivet is being produced in corrosion and temperature resistant A-286 alloy and in weight-saving Beta titanium alloy. Head styles include 100° flush and low profile protruding shear head types. Fastener diameters include 5/32, 3/16, 1/4, 5/16 and 3/8 inch.

For specific dimensions, finishes and pertinent specifications of Hi-Set Rivet configurations, refer to the HSR series Standards Pages.

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