

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 1</b>

# **PAYLOAD SAFETY AND MISSION SUCCESS CONFERENCE 2004**

**BY**

**RAJIB DASGUPTA**

**MATERIALS BRANCH, NASA-JOHNSON SPACE CENTER**

**(281)483-4739**

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 2</b>

FASTENER LOCKING REQUIREMENTS FOR JSC FLIGHT HARDWARE  
REQUIREMENTS FOR SAFETY CRITICAL FASTENERS IN SPACEFLIGHT HARDWARE

- FASTENERS SHALL HAVE TWO SEPERATE VERIFIABLE LOCKING FEATURES. AT LEAST ONE FEATURE SHALL BE POSITIVE LOCKING AND VIBRATION RATED. JOINT PRELOAD MAY BE USED AS ONE OF THE FEATURES.
- JOINTS SUBJECT TO ROTATION SHALL USE AT LEAST ONE NON-FRICTION LOCKING DEVICE. (EX: COTTER PINS, LOCKWIRE)
- INSTALLATION PROCEDURES SHALL REQUIRE FUNCTIONAL VERIFICATION OF LOCKING FEATURE, SUCH AS MEASUREMENT OF RUNNING (SELF LOCKING) TORQUE
- PRELOAD AND RUNNING (SELF LOCKING) TORQUE SHALL BE SPECIFIED ON THE DRAWING.

**FASTENER RETENTION  
REQUIREMENTS AND PRACTICES IN  
SPACEFLIGHT HARDWARE****STRUCTURAL ENGINEERING  
DIVISION – MATERIALS BRANCH****RAJIB DASGUPTA****04/21/04****PAGE 3**REQUIREMENTS FOR SAFETY CRITICAL FASTENERS IN SPACEFLIGHT HARDWARE (CONTD.)

- EXAMPLES OF APPROVED FRICTION TYPE LOCKING METHODS ARE LOCKING HELICOILS, LOCKING KEE-INSERTS, SLIMSERTS (THIN WALLED INSERTS), LOCKNUTS, NUTPLATES, SELF LOCKING PATCHED SCREWS ETC. LOCKWASHERS ARE NOT APPROVED.
- EXAMPLE OF NON-FRICTION TYPE LOCKING DEVICE IS LOCKWIRE OR SAFETY WIRE.
- LOCKING COMPOUNDS (EX: VIBRATITE OR LOCTITE) SHALL NOT BE USED WITHOUT PRIOR APPROVAL FROM JSC STRUCTURAL ENGINEERING DIVISION.
- JSC 27301 REVISION D (MATERIALS CONTROL PLAN FOR JSC FLIGHT HARDWARE) , SECTION 5.6.5.1 DOCUMENTS THESE REQUIREMENTS (ATTACHED). THESE REQUIREMENTS ARE APPLICABLE TO ALL JSC FLIGHT HARDWARE (GFE AND JSC FURNISHED PAYLOADS).

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 4</b>

IMPLEMENTATION OF THE REQUIREMENTS

- JSC GOVERNMENT FURNISHED EQUIPMENT (GFE) AND JSC FURNISHED PAYLOADS FALL UNDER THE SCOPE OF THESE REQUIREMENTS
- ISS M&P TEAM IS CURRENTLY DRAFTING AN INTERPRETATION LETTER IN ADVANCE OF PROGRAM CHANGES TO SSP 30233, REVISION F (ISS M&P REQUIREMENTS DOCUMENT)
- THE PAYLOAD SAFETY REVIEW PANEL HAS DEVELOPED A POLICY LETTER TO IMPLEMENT THESE REQUIREMENTS, WHICH IS CURRENTLY UNDER REVIEW CYCLE

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 5</b>

## KEY DEFINITIONS

- SAFETY CRITICAL FASTENERS : DEFINED AS THOSE FASTENERS, FAILURE OF WHICH COULD POTENTIALLY RESULT IN A CRITICAL OR CATASTROPHIC HAZARD DUE TO JOINT SEPERATION OR RELEASE OF DEBRIS (THAT CAUSES CONTAMINATION, CREW INJURY, ELECTRICAL SHORT OR A FIRE PROPAGATION HAZARD). HAZARDOUS DEBRIS NEEDS TO BE DEFINED BY SAFETY ENGINEERING DISCIPLINE.
- SELF LOCKING (RUNNING) TORQUE : THE TORQUE REQUIRED TO OVERCOME KINETIC FRICTION OF THE MATING THREADS PLUS THE TORQUE REQUIRED TO OVERCOME THE LOCKING FEATURE WHEN 100 PERCENT OF THE LOCKING FEATURE IS ENGAGED AND THE FASTENER IS UNSEATED. CAN BE MEASURED IN A LOOSENING OR TIGHTENING DIRECTION.
- POSITIVE THREAD LOCKING DEVICE : MECHANICAL DEVICE USED TO PREVENT RELATIVE MOTION BETWEEN MALE AND FEMALE THREADS OF A FASTENED JOINT. POSITIVE THREAD LOCKING IS ONE THAT CAN BE VERIFIED BY VISUAL INSPECTION OF NON-FRICTION LOCKING DEVICES OR MEASUREMENT OF RUNNING TORQUE FOR SELF LOCKING DEVICES

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 6</b>

### LOCKING HELICOILS – DESIGN GUIDELINES

- THIS IS A PRECISION COIL OF DIAMOND SHAPED CRES 300 WIRES THAT FORMS BOTH EXTERNAL AND INTERNAL THREADS. COIL SLIGHTLY OVERSIZED TO HAVE INTERFERENCE FIT IN TAPPED HOLE. SOME INSERTS ARE AVAILABLE WITH DEFORMED COIL WHICH HELPS PROVIDING SECONDARY LOCKING TO BOLTS AND SCREWS WITH A POSITIVE AND MEASURABLE SELF LOCKING (RUNNING) TORQUE.
- IT SHOULD BE ALWAYS VERIFIED THAT THE RUNNING TORQUE PROVIDED BY THE LOCKING FEATURE IS BETWEEN THE MAX. LOCKING TORQUE AND THE MINIMUM BREAKAWAY TORQUE SPECIFIED IN TABLE II OF NASM 8846. VERIFICATION NOTE IS STANDARD ON JSC DRAWINGS PER PRC 9007.
- NASM 8846 IS PROCUREMENT SPECIFICATION. AEROSPACE QUALIFIED PART NUMBER FOR LOCKING HELICOILS IS NASM 21209XX-XXL. THE “L” AT THE SUFFIX INDICATES DRY FILM LUBRICATED. RECOMMENDATION IS TO ALWAYS USE DRY FILM LUBRICANT TO AVOID BINDING.

**FASTENER RETENTION  
REQUIREMENTS AND PRACTICES IN  
SPACEFLIGHT HARDWARE****STRUCTURAL ENGINEERING  
DIVISION – MATERIALS BRANCH****RAJIB DASGUPTA****04/21/04****PAGE 7**LOCKING HELICOILS –DESIGN GUIDELINES (CONTD.)

- RECOMMENDED TO USE CAUTION WHEN USING HELICOILS IN JOINTS THAT ARE PRE-LOAD CRITICAL. THESE ARE JOINTS THAT ARE SENSITIVE TO GAPPING. HIGH PRE-LOAD SOMETIMES LEADS TO BINDING OF THREADS, IF IT IS NOT PROPERLY LUBRICATED.
- IT IS BETTER TO USE HELICOILS IN A BLIND HOLE RATHER THAN A THROUGH HOLE. IF USED IN THROUGH HOLE, IT IS ESSENTIAL TO INSPECT BACK SIDE OF HELICOIL AFTER EACH FASTENER INSTALLATION.
- IN VERY CORROSIVE ENVIRONMENT, CAUTION SHOULD BE USED WHEN USING HELICOILS. APPLICATION OF CORROSION PROTECTION SEALANT IS A TRICKY PROCESS IN HELICOILS. EXCESSIVE SEALANT GOES THROUGH COILS AND MAY AFFECT RUNNING TORQUE MEASUREMENT. TOO LESS SEALANT DOES NOT SERVE CORROSION PROTECTION FUNCTION.
- IT IS RELATIVELY EASIER TO REPLACE HELICOILS AND RE-INSTALL COMPARED TO KEY LOCKED INSERTS

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 8</b>

LOCKING HELICOILS –DESIGN GUIDELINES (CONTD.)

- HELICOILS WORKS BEST FOR RELATIVELY SMALL SIZE SCREWS (GUIDELINE FOR USE OF HELICOIL IS # 10 AND SMALLER), WHICH ARE UNDER SMALL TENSION LOADS. FOR LARGER SIZE AND HEAVY DUTY TENSION BOLTS, USE OF KEE-INSERT IS RECOMMENDED.
- LENGTH OF HELICOIL SHOULD BE AT LEAST 1.5 D, WHERE THE “D” IS THE DIAMETER OF THE BOLT. LESS THAN 1.5D LENGTH MAY RESULT IN SHEARING OF THE THREADS AND BACK-OFF OF THE HELICOIL.
- RECOMMENDED TO USE HELICOILS IN ALUMINUM STRUCTURE. IT EXPANDS BETTER IN ALUMINUM AND HELD BY FRICTION. WE HAVE ENCOUNTERED PROBLEMS INSTALLING HELICOILS IN STEEL STRUCTURES. HELICOIL COMPANY RECOMMENDS A SPECIAL TiN COATED TAP FOR STEEL.
- INSTALLATION OF HELICOILS REQUIRES BREAKING THE TANGS. CAUTION SHOULD BE TAKEN SUCH THAT THE TANGS ARE NOT LEFT INSIDE THE HARDWARE. THIS MAY CREATE A SAFETY OR FUNCTIONALITY PROBLEM.



<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 9</b>

LOCKING HELICOILS –DESIGN GUIDELINES (CONTD.)

- THERE IS NO FIXED CYCLE LIFE FOR HELICOILS. THE ONLY WAY TO DETERMINE IF A HELICOIL LOCKING FEATURE HAS WORN OUT IS BY MEASURING THE RUNNING TORQUE DURING EVERY SINGLE BOLT INSTALLATION AND VERIFYING THAT IT MEETS NASM 8846 REQUIREMENTS.

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 10</b>

### KEY LOCKED INSERTS AND THINWALLED INSERTS

- THESE ARE INSERTS WHICH HAVE A SELF LOCKING FEATURE SIMILAR TO THE HELICOILS TO PROVIDE POSITIVE LOCKING TO THE FASTENER. THE KEY LOCKED INSERTS HAVE AN ADDITIONAL FEATURE OF LOCKING KEYS (USUALLY FOUR) THAT LOCK THE INSERT INSIDE THE HOLE. RUNNING TORQUE VALUES ARE SPECIFIED IN MIL-I-45914, TABLE 1.
- BEST INSERT FOR HEAVY DUTY STRUCTURAL TENSION BOLTS. RECOMMENDED FOR FRACTURE CRITICAL BOLTS. HELICOILS ARE NOT RECOMMENDED FOR FRACTURE CRITICAL (SINGLE POINT FAILURE) BOLTS.
- SOLID INSERTS, SO APPLICATION OF CORROSION PROTECTION SEALANT IS NOT AS TRICKY AS HELICOILS. HENCE, USE IN SEVERE CORROSIVE ENVIRONMENTS IS NOT A PROBLEM, IF PROPER SEALANT IS APPLIED.
- TYPICAL EXAMPLE OF MIL. STANDARD KEY LOCKED INSERTS ARE MS 51830 THRU MS 51832.

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 11</b>

### KEY LOCKED INSERTS AND THINWALLED INSERTS

- THINWALLED INSERTS OR “SLIMSERT” ARE SOLID INSERTS LIKE KEE-INSERTS, BUT WHICH DO NOT HAVE KEYS FOR LOCKING INTO THE TAPPED HOLE. INSTEAD, THEY HAVE A CYLINDRICAL SHOULDER ON THE TOP WHICH IS SWAGED INTO THE PARENT METAL WITH A TOOL. THIS SWAGING ACTION LOCKS THE INSERT INTO THE HOLE.
- AVAILABLE FROM ROSAN INCORPORATED, NEWPORT BEACH, CALIFORNIA . PROCUREMENT SPECIFICATION IS MIL-I-45932. RUNNING TORQUE VERIFICATION PER TABLE 1 OF SPEC. TYPICAL PART NO. IS M45932/1-9CL
- ADVANTAGES OVER KEY-LOCKED INSERTS ARE A) LIGHTER IN WEIGHT B) CAN BE USED IN JOINTS WHICH REQUIRE LESS EDGE DISTANCE. KEE-INSERTS REQUIRE HIGHER EDGE DISTANCE.
- AVAILABLE WITH SILVER PLATED FINISH WHICH ACTS AS A LUBRICANT AND PROVIDES MAXIMUM CYCLE LIFE. KEY LOCKED INSERTS ARE ONLY AVAILABLE WITH DRY FILM, WHICH IS NOT AS GOOD AS SILVER PLATING FOR CYCLE LIFE.

# FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE

**STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH**  
**RAJIB DASGUPTA**      **04/21/04**  
 PAGE 12

### CORRECT METHOD FOR CALLING OUT INSTALLATION DIMENSIONS FOR SLIMSERT® INSERTS ON DRAWINGS

#### MACHINING INFORMATION

FOR (PART NO. OR SPECIFIC APPLICATION) (REF)

DRILL \_\_\_\_\_ DIA. X \_\_\_\_\_ DEEP

C-BORE \_\_\_\_\_ DIA. X \_\_\_\_\_ DEEP

CHAMFER 45° 1/8 CHAMF DIA. \_\_\_\_\_ USE 1 AND 2, OPTIONAL

TAP \_\_\_\_\_ MIN. FULL THD.

STANDARD TAPS ARE USED TO TAP ALL HOLES. THREAD IS ACQUIRED BY CHAMFERED TAP DRILL.

NOTES:

- CONCENTRICITY BETWEEN DRILLED HOLE AND C-BORE MUST BE HELD TO WITHIN .001 T.I.P. MAX.
- DRILL, C-BORE AND CHAMFER MAY BE COMBINED INTO ONE OPERATION BY THE USE OF THE SLIMSERT INSERT STEP DRILL.

#### INSTALLATION INFORMATION

- WRENCH INSERT IN WITH APPLICABLE 4 OR 6 POINT DRIVE WRENCH TO REQUIRED DEPTH. (SEE NOTE 1 BELOW)
- PLACE SHADE BY PART AND APPLY DOWNWARD FORCE SUFFICIENT TO BOTTOM NYLON PROTECTIVE SHOULDER ON SURFACE OF FASTENING MATERIAL, WHICH WILL EFFECT FULL SHADROUT AND INTERNAL LOCK SETTING.
- KOSAN POWER INSTALLATION AND SHADE TOOLS ARE AVAILABLE FOR HIGH SPEED PRODUCTION.

NOTES:

- SEE KOSAN DATA SHEET PS1002 (SR SERIES) AND PS1003 (SRM SERIES) FOR COMPLETE INSTALLATION INSTRUCTIONS.
- ALL DRAWINGS CALLING OUT KOSAN PARTS SHOULD CARRY A NOTE CREDITING SOURCE: KOSAN P.C., HERRINGTON BEACH, CALIFORNIA

PART NO.  
 2,137-104  
 2,137-104  
 2,137-104

SLIMSERT® INSERT  
 ENGINEERING AID

PAGE 10.01

EXAMPLE OF PART NUMBER AND CALLING EXPLANATION:

**SR 194**      **SR 192 L**

SERIES      24 TDS. PER INCH      SERIES      INTERNAL THREAD LOCKING FEATURE

NOMINAL DIA. INT. THD.      NOMINAL DIA. INT. THD.      32 TDS. PER INCH

INTERCHANGEABLE WITH M45632/1 INSERTS PER SPECIFICATION MIL-I-45932/1

NOTES:

- INT. THD. LOCKING FEATURE MEETS REQUIREMENTS OF MIL-I-45932.
- FOR INSTALLATION DATA & INSTALLATION TOOLS REFER TO PAGES 10.03 AND 10.07.1.
- MATERIAL: (2-1/4 PH (A19-434)) STAINLESS STEEL WITH SUPPLEMENTAL SOLID FILM LUBRICANT COATING MEETING THE REQUIREMENTS OF MIL-I-45932.
- HEAT TREAT: CONDITION H1020.
- 1/2" & 1/4" DIMENSIONS APPLY THIS END ONLY.
- THIS IS IN ACCORDANCE WITH MIL-I-45932 & AS NOTED, PRIOR TO THE ADDITION OF SOLID FILM LUBRICANT, EXTERNAL THREAD IS DRY-TAP FORM - HELIX CHAMFER WITH ROUNDED HORN DIA. PER TABLE. HORN DIA. 2.125, 1/8" DIA. TOLERANCE. INTERNAL THREAD HORN DIA. HORN DIA. WILL ACCEPT BOLTS AND SCREWS WITH MIL-I-8839 THREADS.

PART NO. 2,137-104 2,137-104	SLIMSERT® INSERT HI-STRENGTH	SR SERIES PAGE 10.02
------------------------------------	---------------------------------	-------------------------

SLIMSERTS

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 13</b>

### KEY LOCKED INSERTS AND THINWALLED INSERTS

- SILVER PLATING – BEST SURFACE FINISH FOR HIGH CYCLE LIFE OF INSERTS, NUTS ETC. HOWEVER, SILVER PLATING SHOULD NOT BE USED IN CONFIGURATIONS WHERE PLATING IS EXPOSED TO EVA EXTERNAL ENVIRONMENTS. DUE TO DEGRADATION BY AO/VUV RESULTS IN A LOOSE FRIABLE BLACK OXIDE AND RESULTANT CONTAMINATION.
- SLIMSERTS ARE MORE SUITED FOR LIGHT WEIGHT STRUCTURES WHEREAS KEY LOCKED ONES FOR HEAVY DUTY STRUCTURES. FOR LIGHTWEIGHT STRUCTURES, SLIMSERTS ARE PREFERRED OVER HELICOILS.

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 14</b>

### SELF LOCKING SCREWS AND BOLTS

- THESE ARE FASTENERS WHICH HAVE SELF LOCKING THREADS OR SELF LOCKING FEATURES BY MEANS OF A PLASTIC MATERIAL LOCKING ELEMENT CONTAINED IN THE SCREW. THE DESIGN OF THE LOCKING ELEMENT SHOULD MEET THE REQUIREMENTS OF MIL-DTL-18240F. THE DESIGN AND USAGE LIMITATIONS FOR SELF LOCKING EXTERNALLY THREADED FASTENERS ARE IDENTIFIED IN MILITARY SPECIFICATION MS 15981.
- EXAMPLES OF OFF THE SHELF SELF LOCKING SCREWS ARE THE FOLLOWING;
  - (A) NAS 6703 THRU 6720
  - (B) NAS 8100 THRU 8106
  - (C) NAS 600 THRU 606
  - (D) NAS 1189, NAS 1351

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 15</b>

SELF LOCKING SCREWS AND BOLTS (CONTD.)

- IN CASES WHERE FASTENERS WITH SELF LOCKING ELEMENTS ARE NOT READILY AVAILABLE, NASA-JSC STRUCTURAL ENGINEERING DIVISION RECOMMENDS THE USE OF THE FUSED MYLAR (POLYETHYLENE TETRAPHTHALATE) PATCH. THIS TYPE OF PATCH HAS TEMPERATURE LIMITATIONS OF AROUND + 400F. KEL-F, VESPEL PATCHES ARE OTHER OPTIONS WHICH HAVE WIDER OPERATING TEMPERATURE LIMITS, HOWEVER CYCLE LIFE AND DURABILITY OF THE PATCH IS LOWER THAN MYLAR. NYLON PATCH ALSO HAS LOWER CYCLE LIFE THAN MYLAR.
- MYLAR PATCH APPLICATION PROCESS : THE BOLT IS NORMALLY HEATED UP TO 500F TO 700F (DEPENDING ON BOLT MATERIAL), THE POLYESTER (MYLAR) IS THEN FUSED ON TO THE BOLT AND THEN IT IS QUENCHED.
- NASA-JSC HAS HAD GOOD EXPERIENCE WITH LONG LOK FASTENERS AND NYLOK CORPORATION FOR APPLYING PATCH ON EXISTING FASTENERS. ANY COMPANY LISTED UNDER THE QPL-18240 IS QUALIFIED TO PERFORM THE PATCH APPLICATION PROCESS

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 16</b>

SELF LOCKING SCREWS AND BOLTS (CONTD.)

- IN FRACTURE CRITICAL APPLICATIONS, PLASTIC PATCHES SHOULD NOT BE USED WITH HELICOILS. THIS IS DUE TO BINDING PROBLEMS THAT ARE ENCOUNTERED SOMETIMES WITH USING PATCHES ON HELICOILS. BINDING MAY BE REDUCED BY APPLYING GREASE, BUT THIS REDUCES THE RUNNING TORQUE AND LOCKING EFFICIENCY. ALSO, WHEN APPLYING GREASE, INSTALLATION TORQUE NEEDS TO BE REDUCED TO ACCOUNT FOR LOWER FRICTION FACTOR.
- PLASTIC PATCHES CAN BE SAFELY USED WITH SOLID INSERTS LIKE KEE-INSERTS AND SLIMSERTS.
- DUE TO EXPERIENCE WITH INCONSISTENCIES IN QUALITY OF THE PATCHED SCREWS, WE RECOMMEND DOING BATCH TESTING ON THESE TYPE OF SCREWS TO MEASURE RUNNING TORQUE.
- WHEN SENDING SCREWS TO LONG-LOK CORP. FOR PATCH APPLICATION, IT IS RECOMMENDED TO SEND THEM A SPARE ENGINEERING UNIT OF THE HARDWARE INTO WHICH THE SCREW IS INSTALLED. THIS ENSURES PROPER QUALITY OF PATCH RESULTING IN ADEQUATE RUNNING TORQUE.



<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 17</b>

## LOCKNUTS

- THESE ARE TYPES OF LOCKING ELEMENTS WHICH ACT ON THE PRINCIPLE OF BINDING THE NUT THREAD TO THE BOLT
- SILVER PLATED LOCKNUTS ARE COMMONLY USED IN SPACEFLIGHT HARDWARE FOR IMPROVED DURABILITY AND CYCLE LIFE. HOWEVER, IN EVA HARDWARE, SILVER PLATED LOCKNUTS SHOULD NOT BE USED DUE TO AO/VUV DEGRADATION PROBLEMS.
- DESIGN GUIDELINES AND USAGE LIMITATIONS ARE PROVIDED IN MIL. STANDARD MS 33588.  
EXAMPLES OF LOCKNUTS ARE :  
(A) NAS 1291 (B) MS21043 (C) MS21045 (D) MS21046. PROCUREMENT SPEC. IS NASM 25027
- NO MAJOR LIMITATIONS TO BE NOTED, EXCEPT CYCLE LIFE OF THE LOCKING FEATURE WHICH NEEDS TO BE MEASURED AND VERIFIED AGAINST SPEC. DURING EACH INSTALLATION. ALSO LOCKNUTS WITH SILVER PLATING OR ADEQUATE LUBRICATION SHOULD BE USED

**FASTENER RETENTION  
REQUIREMENTS AND PRACTICES IN  
SPACEFLIGHT HARDWARE****STRUCTURAL ENGINEERING  
DIVISION – MATERIALS BRANCH****RAJIB DASGUPTA****04/21/04****PAGE 18**LOCKING ADHESIVES – LOCTITE

- LOCTITE SHOULD NOT BE USED WITHOUT PRIOR APPROVAL FROM THE JSC STRUCTURAL ENGINEERING DIVISION ON A CASE BY CASE BASIS
- LOCTITE IS A SINGLE COMPONENT ANAEROBIC(CURES IN ABSENCE OF AIR) THREADLOCKING MATERIAL. THE BASIC POLYMER TYPE IS DIMETHACRYLATE ESTER. LOCTITE CURES IN PLACE BETWEEN THE THREADS.
- LOCTITE IS QUALIFIED TO MIL-S-46163A. PREVAILING AND BREAKING TORQUE VALUES ARE AS SPECIFIED IN TABLE 3 OF THIS MILITARY SPECIFICATION (ATTACHED). HOWEVER, THESE VALUES ARE APPLICABLE FOR A 3/8 INCH. HEX. HEAD BOLT ONLY. BREAKING TORQUE VALUES ARE NOT AVAILABLE FOR ALL SIZES OF FASTENERS FROM THE SPECIFICATION. HENCE, THERE IS NO DIRECT WAY OF VERIFYING THAT LOCTITE WILL FUNCTION FOR ANY GIVEN FASTENER SIZE IN A PARTICULAR APPLICATION.

**FASTENER RETENTION  
REQUIREMENTS AND PRACTICES IN  
SPACEFLIGHT HARDWARE**
**STRUCTURAL ENGINEERING  
DIVISION – MATERIALS BRANCH**
**RAJIB DASGUPTA**
**04/21/04**
**PAGE 19**

TABLE III - Locking torque of unpolymerized sealing compounds

Type and Grade	Locking torque a/, inch-pounds (newton-metres)			
	Steel		Plated	
	Breakaway	Prevall	Breakaway	Prevall
<u>Type I</u>				
Grade J	100-200 (11.3- 22.6)	50-150 (5.65-16.9)	50-100 (5.65-11.3)	50-150 (5.65-16.9)
Grade K	200-300 (22.6- 33.9)	250-350 (28.2 -39.5)	50-100 (5.65-11.3)	200-300 (22.6 -33.9)
Grade L	250-350 (28.2- 39.5)	200-300 (22.6 -33.9)	50-100 (5.65-11.3)	100-200 (11.3 -22.6)
<u>Type II</u>				
Grade M	50-100 (5.65-11.3)	20- 50 (2.26- 5.65)	10- 40 (1.13- 4.52)	10- 40 (1.13- 4.52)
Grade N	100-200 (11.3 -22.6)	30- 60 (3.39- 6.78)	20-120 (2.26-13.6)	20- 50 (2.26- 5.65)
Grade O	150-250 (16.9 -28.2)	50-150 (5.65-16.9)	50-150 (5.65-16.9)	50-150 (5.65-16.9)
<u>Type III</u>				
Grade P	20-100 (2.26-11.3)	20-100 (2.26-11.3)	20-100 (2.26-11.3)	10- 50 (1.13-5.65)
Grade Q	20-100 (2.26-11.3)	100-200 (11.3 -22.6)	20-100 (2.26-11.3)	20-100 (22.6-11.3)
Grade R	20-100 (2.26-11.3)	200-350 (22.6 -39.5)	10- 50 (1.13- 5.65)	120-300 (13.6-33.9)

a/ 3/8-inch (9.525-mm) bolt (see 4.6.2.1.2)

MIL-S-46163 – TABLE 3

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 20</b>

LOCKING ADHESIVES – LOCTITE

- THERE IS NO VIBRATION TEST REQUIREMENT IN THE MIL-S-46163. THERE IS REFERENCE TO SOME VIBRATION DATA IN LOCTITE LITERATURE. ALL OTHER AEROSPACE TYPE SECONDARY RETENTION METHODS (PATCH, LOCKNUTS ETC.) HAVE VIBRATION TEST REQUIREMENTS IN THE RESPECTIVE PROCUREMENT SPECIFICATION.
- THE LOCKING FEATURE IS NOT VERIFIABLE BECAUSE ONCE IT IS CURED, IT CANNOT BE VERIFIED WITHOUT BREAKING THE BOND. IT CANNOT BE CLASSIFIED AS A VERIFIABLE POSITIVE LOCKING FEATURE. HENCE, USE OF LOCTITE (OR ANY OTHER LOCKING COMPOUND) DOES NOT MEET THE REQUIREMENT OF JSC 27301D (MATERIALS CONTROL PLAN).
- LOCTITE FREQUENTLY HAS CURING PROBLEMS. PROPER APPLICATION PROCEDURE NEEDS TO BE FOLLOWED ALONG WITH USE OF PRIMER. PROPER CURING DEPENDS ON THREAD TOLERANCES, PRIMER, CURE TIME, BASE METAL ETC.

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 21</b>

### LOCKING ADHESIVES – LOCTITE

- GOOD PROCESS STEPS TO FOLLOW: A) SURFACE PREPARATION OR CLEANING B) PRIMER APPLICATION ON BOTH MALE AND FEMALE THREADS C) APPLICATION OF LOCTITE (WHICHEVER GRADE IS SPECIFIED ON DWG.) TO THE MALE THREAD OR BOTH MATING THREADS D) TORQUE THE FASTENER TO ENGINEERING DRAWING TORQUE CALL-OUT. E) WIPE OFF EXCESS LOCTITE ON SURFACE WITH LINT FREE CLOTH.
- PROCESS VERIFICATION : NO STANDARD PRACTISE OF PROCESS VERIFICATION IS PUBLISHED.
- ENGINEERING VERIFICATION TESTS CAN BE PERFORMED ON IDENTICAL MALE AND FEMALE THREAD COMBINATION AS THE FLIGHT HARDWARE. LOCTITE SHOULD BE APPLIED USING THE SAME PROCESS AS THE FLIGHT HARDWARE. ALSO, LOCTITE AND PRIMER USED SHOULD BE FROM THE SAME LOT AS THE FLIGHT HARDWARE.

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 22</b>

### LOCKING ADHESIVES – LOCTITE

- MEASURE THE BREAKLOOSE TORQUE AS PART OF THE VERIFICATION TEST. IF THE CORRECT LOCTITE COMPOUND IS USED, THE BREAKLOOSE TORQUE OF THE JOINT SHALL BE AT LEAST EQUAL TO THE TIGHTENING TORQUE. (REFERENCE : LOCTITE CORPORATION LITERATURE ATTACHED). AFTER JOINT IS BROKEN, INSPECT BOLT THREADS FOR ANY UNCURED LOCTITE BY WIPING WITH A CLOTH.
- PROCESS VERIFICATION MAY ALSO BE CARRIED OUT ON A 3/8” BOLT AS SPECIFIED IN SECTION 4.6.2.1 OF MIL-S-46163A. THE BREAKAWAY TORQUE SHALL BE WITHIN THE RANGE SPECIFIED IN TABLE 3 OF THE SPECIFICATION , CORRESPONDING TO THE GRADE OF LOCTITE USED.
- ALL THE ABOVE VERIFICATION METHODS ARE RECOMMENDATIONS FROM LOCTITE LITERATURE AND HAS SELDOM BEEN FOLLOWED AS A STANDARD PROCESS FOR JSC FLIGHT HARDWARE. HENCE, M&P DISCOURAGES USE OF LOCTITE COMPUNDS IN FLIGHT HARDWARE.
- IT IS RECOMMENDED THAT QUALIFICATION OF LOCTITE FOR EACH UNIQUE FLIGHT HARDWARE APPLICATION BE PERFORMED AND MAY INCLUDE VIBRATION AND THERMAL CYCLE TESTING

# FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE

**STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH**  
**RAJIB DASGUPTA**  
**04/21/04**  
**PAGE 23**

**Augmentation**  
 The loosening torque of a UNC bolt will be about 70% of the torque which it has been tightened (UNF = 60%).  
 The application of a threadlocking compound adds to or augments the normal loosening torque. The amount that it does this is called the *torque augmentation*. This is shown in the shaded area in Fig. 19.  
 The torque value of augmentation is related to the breakaway\* torque and may vary between 70 to 140% of the breakaway.  
 Most structural fasteners are torqued to at least 75% of their minimum yield strength (proof load). To prevent shearing of a locked bolt while being loosened, a locking material should be used which has an augmentation or breakaway that would make the break loose torque roughly equal to the tightening torque.  
 Therefore, as a design rule to prevent shearing on loosening, select a material so that  
**BREAKAWAY\* = 100% OF TIGHTENING TORQUE**  
 To find the correct Loctite threadlocker enter the chart Fig. 19 or Fig. 16 with 30% of the bolt tightening torque.

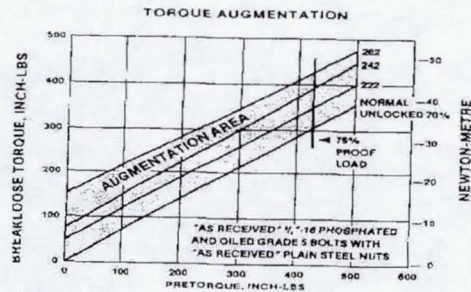


Figure 19  
 \*breakaway torque is the torsional strength of adhesive on an torqued bolt. (eg. Pretorque = zero)

**Selection of Materials for Loosening Severity**  
**Locking**  
 Lateral loosening of threads always starts from sideways sliding of the engaged threads. The side motion is caused by —  
 side forces from applied loads or thermal expansion,  
 bending of parts,  
 rotation of a nut from longitudinal forces or vibration.  
 Lateral loosening can only be prevented by filling the gaps between the threads completely. Fig. 20 shows the relative effectiveness of different locking means to retain the bolt tension under severe side loading (transverse shock and vibration).

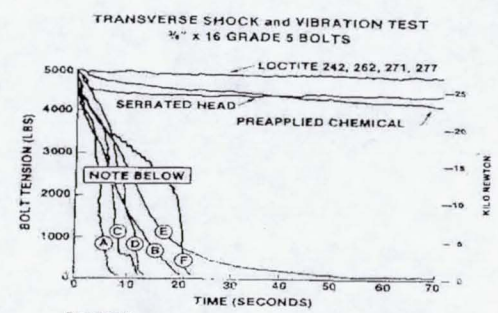


Figure 20  
 Note: Test time to reduce bolt tension by 50%  
 A. Lock Washer 5 - 12 Seconds  
 B. Root Interference Lock Nut 5 - 8 Seconds  
 C. Bolt Patch 8 - 12 Seconds  
 D. Control - No Locking 8 - 12 Seconds  
 E. Distorted Locking 7 - 22 Seconds  
 F. Nylon Ring 16 - 20 Seconds

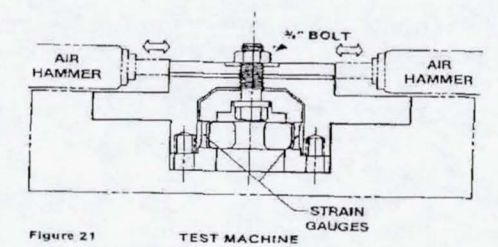


Figure 21

**D. Selection of Viscosity to Assure Thread Filling**  
 Select a viscosity which will apply easily, not run off, and will fill threads which have the maximum clearance (maximum clearance is computed from tables of standard UNC thread dimensions).

Material	Viscosity	Suggested Bolt Range	Maximum Diametral Clearance
222	1000 cP (1 Pa*s)	#2 to 1/2"	.016 in (0.4 mm)
242	1100 cP (1.1 Pa*s)	3/8 to 3/4"	.022 in (0.5 mm)
262	1500 cP (1.5 Pa*s)	3/4 to 1"	.025 in (0.6 mm)
271	750 cP (0.8 Pa*s)	3/8 to 1"	.025 in (0.6 mm)*
277	7000 cP (7 Pa*s)	3/8 to 1 1/2"	.025 in (0.6 mm)*
290	12 cP (12 mPa*s)	#2 to 1/2"	.016 in (0.4 mm)*

\*Loctite® Primer T is recommended to assure cure in gaps. Ask for Product Data Sheet 271 regarding these products.

## LOCTITE LITERATURE REFERENCE

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 24</b>

LOCTITE

- LOCTITE GRADES COMMONLY USED IN JSC FLIGHT HARDWARE ARE
  - (A) LOCTITE 222 : REMOVABLE GRADE FOR UP TO 0.25” SCREWS.
  - (B) LOCTITE 242 : REMOVABLE GRADE FOR UP TO 0.75” BOLTS.
  - (C) LOCTITE 262 : PERMANENT LOCKING FOR UP TO 0.75” BOLTS.



**FASTENER RETENTION  
REQUIREMENTS AND PRACTICES IN  
SPACEFLIGHT HARDWARE****STRUCTURAL ENGINEERING  
DIVISION – MATERIALS BRANCH****RAJIB DASGUPTA****04/21/04****PAGE 25**VIBRATITE

- VIBRATITE SHOULD NOT BE USED WITHOUT PRIOR APPROVAL FROM THE JSC STRUCTURAL ENGINEERING DIVISION ON A CASE BY CASE BASIS. USE IS GENERALLY LIMITED TO NON-STRUCTURAL AND NON-SAFETY CRITICAL FASTENERS (EX: CONNECTOR SCREWS, AVIONICS BOXES), WHICH ARE LAUNCHED IN A LOCKER STOWED CONFIGURATION AND IN WHICH THE FASTENERS ARE NOT IN LOAD PATH OF LAUNCH VIBRATION OR ON-ORBIT VIBRATIONS.
- VIBRATITE IS A BLEND OF ACRYLIC RESINS AND PLASTICIZERS HELD IN LIQUID FORM BY A SOLVENT MEDIUM. IT DOES NOT REQUIRE ANAEROBIC CURE. PRE-APPLIED AND CURED BEFORE INSTALLING FASTENER. HENCE, DOES NOT BOND BETWEEN MATING THREADS.
- VIBRATITE HAS ACCEPTABLE VACUUM OUTGASSING VCM VALUES. OFFGASSING / TOXICITY PROPERTIES SIMILAR TO LOCTITE PRODUCTS.

<b>FASTENER RETENTION REQUIREMENTS AND PRACTICES IN SPACEFLIGHT HARDWARE</b>	<b>STRUCTURAL ENGINEERING DIVISION – MATERIALS BRANCH</b>	
	<b>RAJIB DASGUPTA</b>	<b>04/21/04 PAGE 26</b>

### LIMITATIONS OF VIBRATITE

- PREVAILING TORQUE OF VIBRATITE IS NOT VERIFIABLE. PERFORMANCE SPECIFICATION (MIL-S-28867) DOES NOT SPECIFY ANY VALUES OF BREAKING AND PREVAILING TORQUE. NOT QUALIFIED FOR VIBRATION ENVIRONMENT.
- MANUFACTURER DOES NOT RECOMMEND USE OF VIBRATITE FOR LARGER BOLTS (ABOVE 1/4"). VIBRATITE IS NOT RECOMMENDED FOR LARGER SCREWS EVEN IN NON-STRUCTURAL AND NON-SAFETY CRITICAL APPLICATIONS.
- VIBRATITE IS SOMETIMES USED AS LUBRICANT TO INCREASE CYCLE LIFE OF LOCKING HELICOILS. NASA / JSC DOES NOT RECOMMEND THIS PRACTISE.