**MODEL NO.** DAI9523

**TITLE:** NTF SPLIT DRAW NUT

**PREPARED BY:** W.M. LANGFORD 11 JUN 95
DATE

**APPROVALS:** W. M. Langford 9 NOV 95
TECHNICAL PROJECT ENGINEER DATE

[signature] GAO 2/15/96
MODEL SYSTEMS ENGINEER DATE

**CONCURRENCE:** [signature]
HEAD, MOES/MOES MODEL MANAGER

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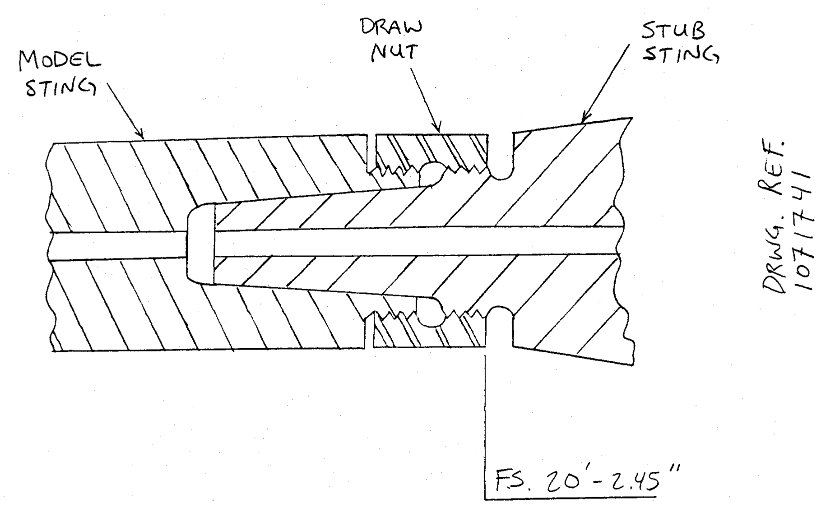
## INTRODUCTION

THIS DOCUMENT VERIFIES THE STRUCTURAL INTEGRITY OF THE NTF SPLIT DRAW NUT AS USED IN THE NATIONAL TRANSONIC FACILITY AT NASA, LARC. THE SPLIT DRAW NUT UTILIZES NITRONIC 60 MATERIAL AND A286 STAINLESS STEEL BOLTS AND PINS TO CLAMP THE ASSEMBLY AROUND THE TAPER JOINT CONNECTION. REFER TO PAGE 4 FOR APPLICABLE STING AND STUB STING COMBINATIONS.

## DESIGN LOADS

MAXIMUM MOMENT IS BASED ON THE DESIGN LOADS OF THE NTF 101B BALANCE AT F.S. 13'-0":

$$M_{MAX} = 674280 \text{ in-lbs} \qquad \text{(REF. PAGE A1)}$$



## DRAWING LIST

LD-1079463 SPLIT NUT DETAILS
LD-1079464 SPLIT NUT ASS'Y

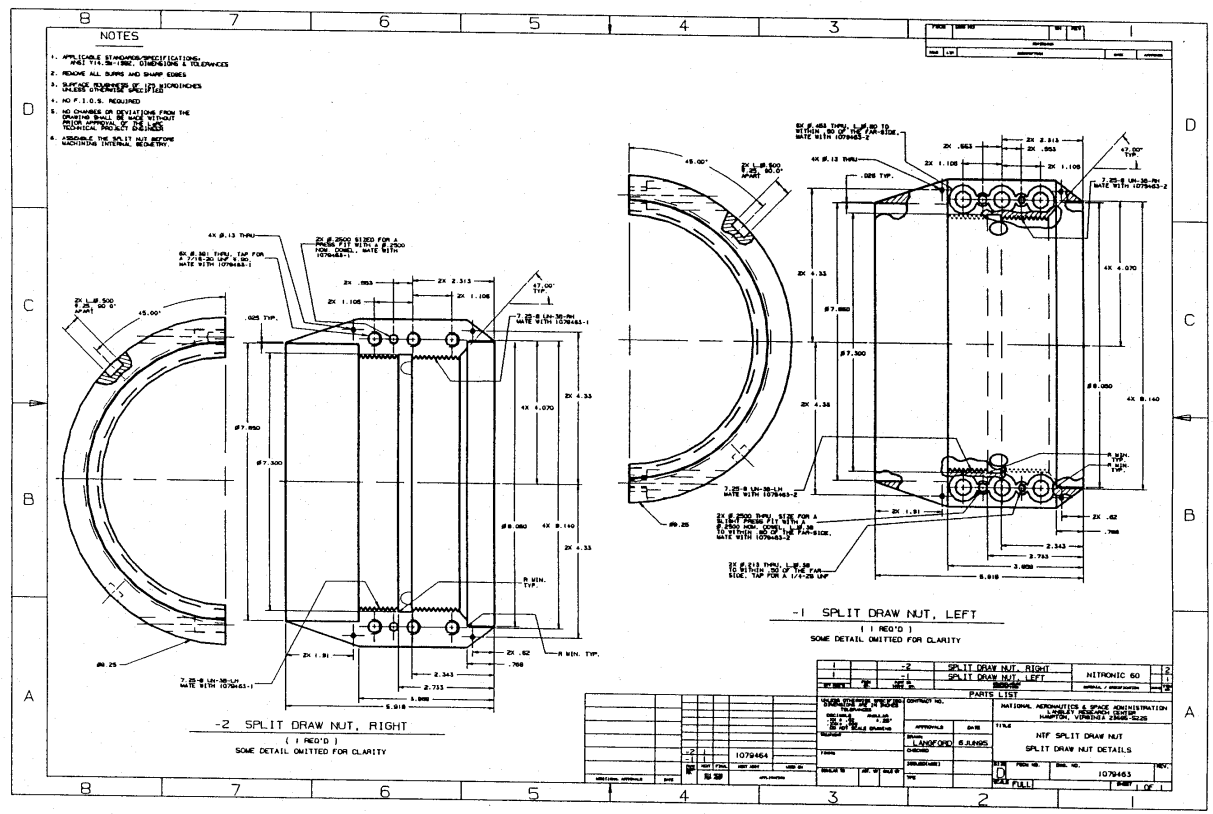
## OTHER DRAWINGS

**MATEABLE STINGS:**

LE-1005569-1B
LE-1005575-1D
LE-1028008-1A
LE-536202-1C
LR-541740-36" STRAIGHT STING
LR-542252-ACB STING

**MATEABLE: STUB STINGS:**

LE-1028005-#1
LE-1005561-#2
LE-1005562-#3
LE-541838-#4
LE-541739-#5, 20° BENT
LD-1077108-#6° OFFSET

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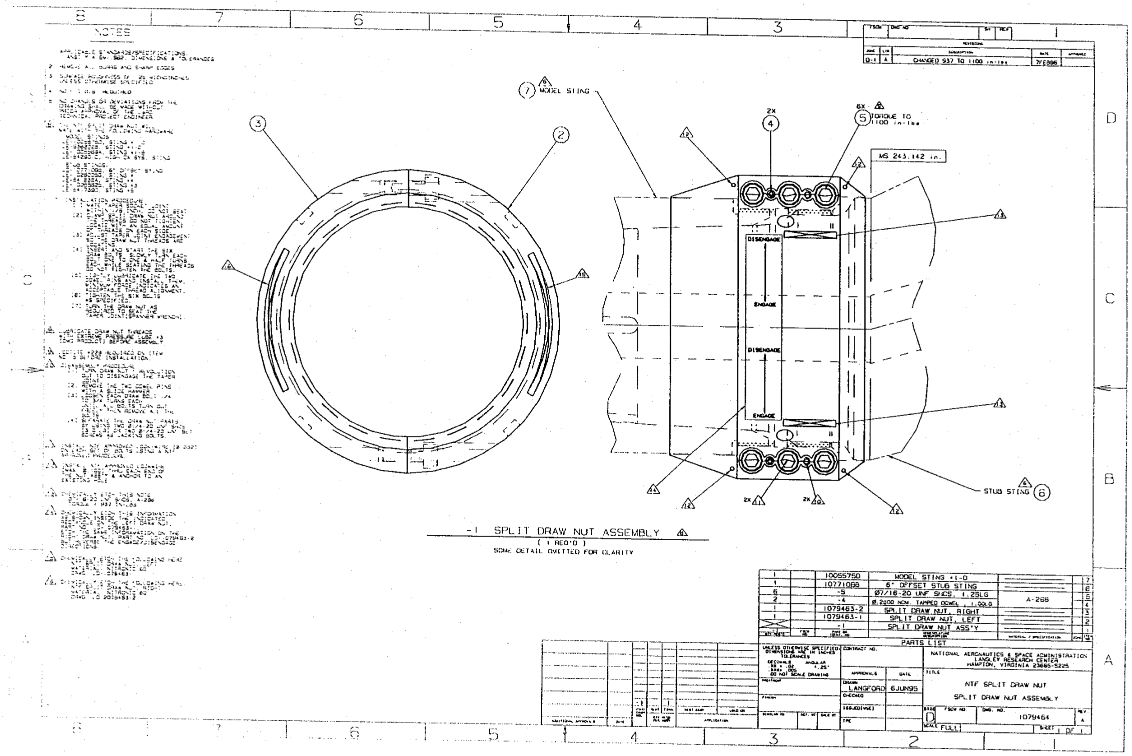


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OF REPORT

6

FACTORS OF SAFETY

| | F.S. | PAGE |
|---|---|---|
| ○ BENDING STRESS (YIELD) | 122 | 8 |
| ○ BOLT TENSION | 6.08 | 10 |
| ○ BOLT TENSION | 4.54 | 19 |
| ○ VON MISES STRESS (YIELD) | 3.14 | 19 |

☐ DRAW NUT BENDING STRESS:

ASSUME 5% OF THE MAXIMUM MOMENT IS THRU THE DRAW NUT AND THE REMAINING 95% LOAD GOES THRU THE TAPER SOCKET JOINT. THE AREA MOMENT OF INERTIA IS TAKEN AT THE MINIMUM CROSS-SECTION OF THE NUT (THREAD RELIEF REGION BETWEEN THE LEFT AND RIGHT HAND THREAD FORMS):

UTILIZING, $\sigma = \frac{Mc}{I}$

WHERE,

$M = (\overset{5\%}{.05})(674280) = 33714$ (PG. 3)

$c = 9.25 \div 2 = 4.63$ IN (PG. 5)

$I = \frac{\pi}{64}(9.25^4 - 7.30^4)$ (PG. 5)

$= 219.9$ IN$^4$

THEN,

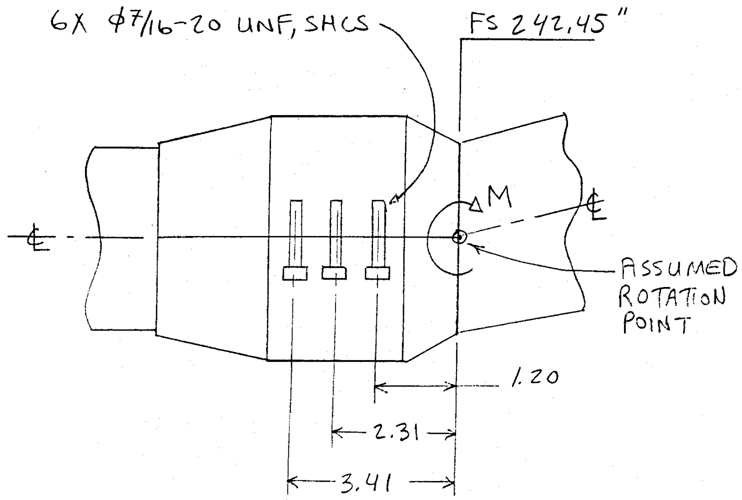
$\sigma = \frac{33714(4.63)}{219.9} = 710$ psi

$\therefore$ F.S. $= \frac{87K}{710}$ ← [NITRONIC 60, YIELD @ −200°F, PG. A4]

$\boxed{F.S. = 122}$

☐ DRAW NUT-BOLT TENSION :

ASSUME 5% OF THE MAXIMUM MOMENT HAPPENS DIRECTLY ACROSS THE BOLT JOINT AS SKETCHED BELOW :




DRWG. REF. LD-1079464-1

APPLYING, $F_{MAX} = \dfrac{M\, r_{MAX}}{\sum_{1}^{3} r_i^2}$

WHERE, $M = .05\,(674280) = 33714$ IN-lbs (PG. 3)

$\leftarrow$ 5%

$r_{MAX} = 3.41$ IN

$\sum r_i^2 = 2\,(1.2^2) + 2\,(2.31^2) + 2\,(3.41^2)$

$= 36.8$ IN$^2$

☐ DRAW NUT-BOLT TENSION : (CON'T)

SO, $F_{MAX} = \dfrac{33714\ (3.41)}{36.8} = 3124\ \text{lbs}$

$\therefore \quad F.S. = \dfrac{19K}{3124}$ ← [ϕ7/16-20 SHCS, A286, TEN. STRGH.; PG. A6]

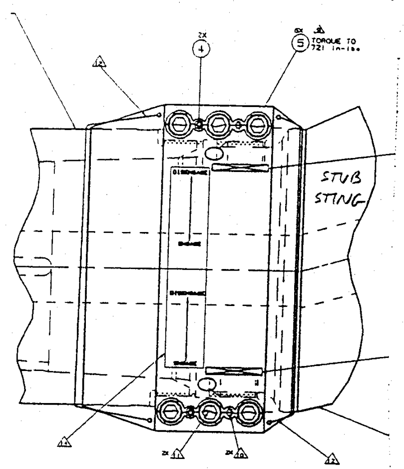
$$\boxed{F.S. = 6.08}$$

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

☐ FINITE ELEMENT ANAYSIS:

THE FOLLOWING IS FINITE ELEMENT ANALYSIS DONE ON THE SPLIT DRAW NUT. PROVIDED BY MIKE LINDELL OF THE ANALYSIS & TEST ENGINEERING BRANCH IN THE AEROSPACE MECHANICAL SYSTEMS DIVISION.
THE SOFTWARE WAS MECHANICA, RELEASE 8.

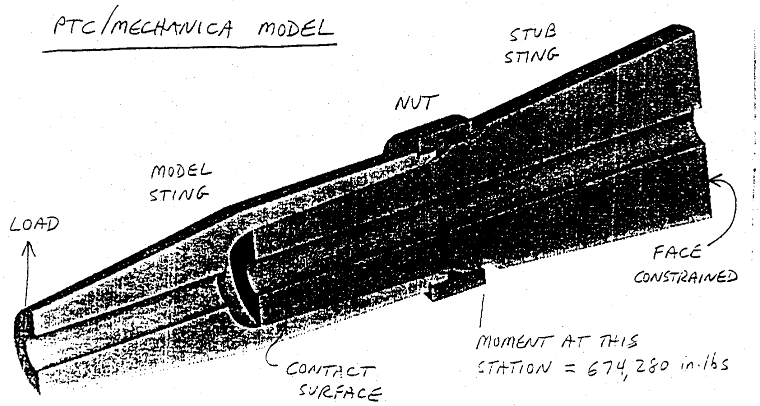
AN ANALYSIS WAS PERFORMED ON THE NTF SPLIT DRAW NUT ASSEMBLY SHOWN TO THE RIGHT TO DETERMINE THE WORST LOADS ON THE BOLTS. CONTACT ANALYSES WERE PERFORMED USING PTC/MECHANICA WITH BOTH FULL AND HALF MODELS OF THE DRAW NUT ASSEMBLY. A HALF MODEL OF THE ASSEMBLY IS SHOWN AT THE BOTTOM OF THE PAGE. IN THE MODEL SHOWN THE BOLTS REACT AT THE NUT SURFACE ON THE SYMMETRY PLANE. THE ORIENTATION OF THE NUT AND THE LOAD SHOWN PRODUCED THE WORST TENSILE LOADS ON THE BOLTS.




MODEL ASSUMPTIONS

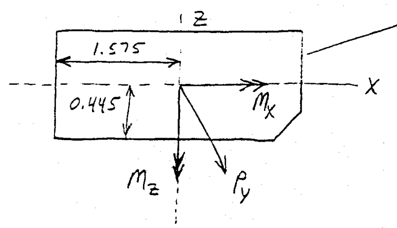
1) A CONTACT SURFACE EXISTS BETWEEN THE MODEL STING AND THE STUB STING. THE SURFACES CAN SEPARATE.
2) CONTINUOUS CONTACT EXISTS BETWEEN THE MODEL STING AND THE NUT, AND BETWEEN THE STUB STING AND THE NUT.
3) THE STUB STING BASE IS CONSTRAINED, THE VERTICAL CUT IS A SYMMETRY PLANE, AND A LOAD IS APPLIED AT THE MODEL TIP TO PRODUCE THE GIVEN MOMENT AT THE STATION SHOWN.

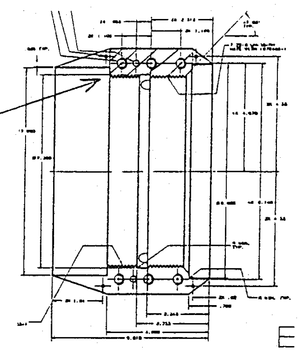
PTC/MECHANICA MODEL



## ANALYSIS RESULTS

THE WORST RESULTANT LOADS ON THE HATCHED AREA SHOWN TO THE RIGHT WERE AS FOLLOWS:




$P_y = 6200$ lb (OUT OF THE PAGE)

$M_x = 1550$ in·lb

$M_z = 2550$ in·lb

ALL OTHER LOAD RESULTANTS WERE NEGLIGIBLE.

BOLT LOAD DUE TO $P_y$: $P_{py} = \frac{1}{3} P_y = \underline{2067}$ lb

BOLT LOAD DUE TO $M_x$:

ASSUME ALL THREE BOLTS REACT THE MOMENT DUE TO PRYING AGAINST THE BOTTOM EDGE.

$$P_{mx} = \frac{1}{3}\frac{M_x}{0.445} = \underline{1161} \text{ lb}$$

BOLT LOAD DUE TO $M_z$:

ASSUME THE BOLT FARTHEST RIGHT REACTS THE MOMENT DUE TO PRYING AGAINST THE LEFT EDGE.

$$P_{mz} = \frac{M_z}{(1.575+1.105)} = \underline{951} \text{ lb}$$

WORST TENSILE BOLT LOAD:

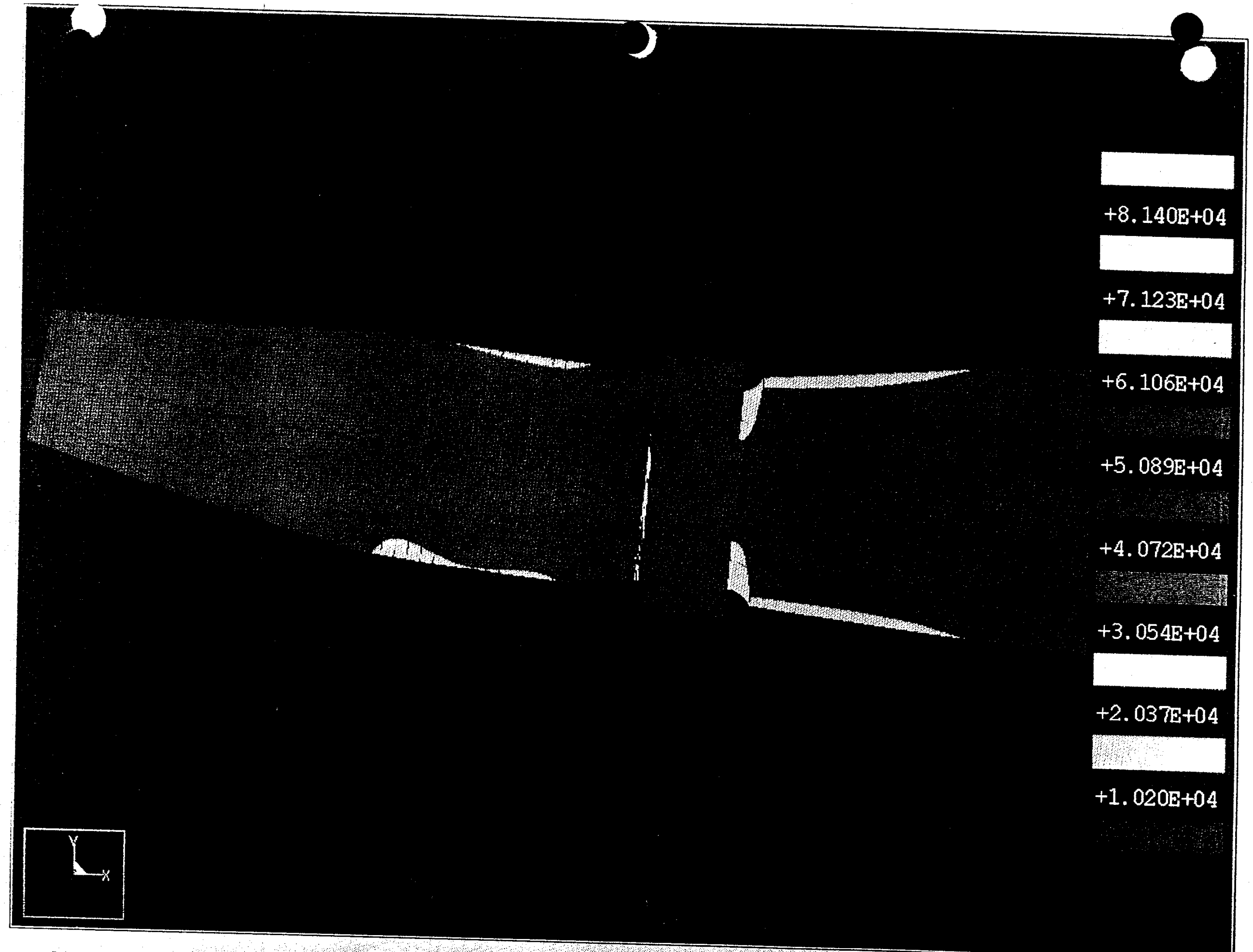
$$P_b = P_{py} + P_{mx} + P_{mz} = \underline{4179 \text{ lb}} \quad \text{ON ONE BOLT}$$

STRESS RESULTS

ATTACHED ARE SEVERAL PLOTS SHOWING STRESS AND EXAGGERATED DEFORMATION OF THE NUT AND THE ASSEMBLY.

THE WORST VON MISES STRESS IN THE NUT WAS:

$$\sigma_{vm} = 27{,}700 \text{ PSI}$$




MECHANICA
Release 8

10/27/95 - 08:09

Split Nut Assembly, Von Mises (psi)

Analysis & Test Engineering Branch
NASA Langley Research Center

PARAMETRIC
TECHNOLOGY
CORPORATION

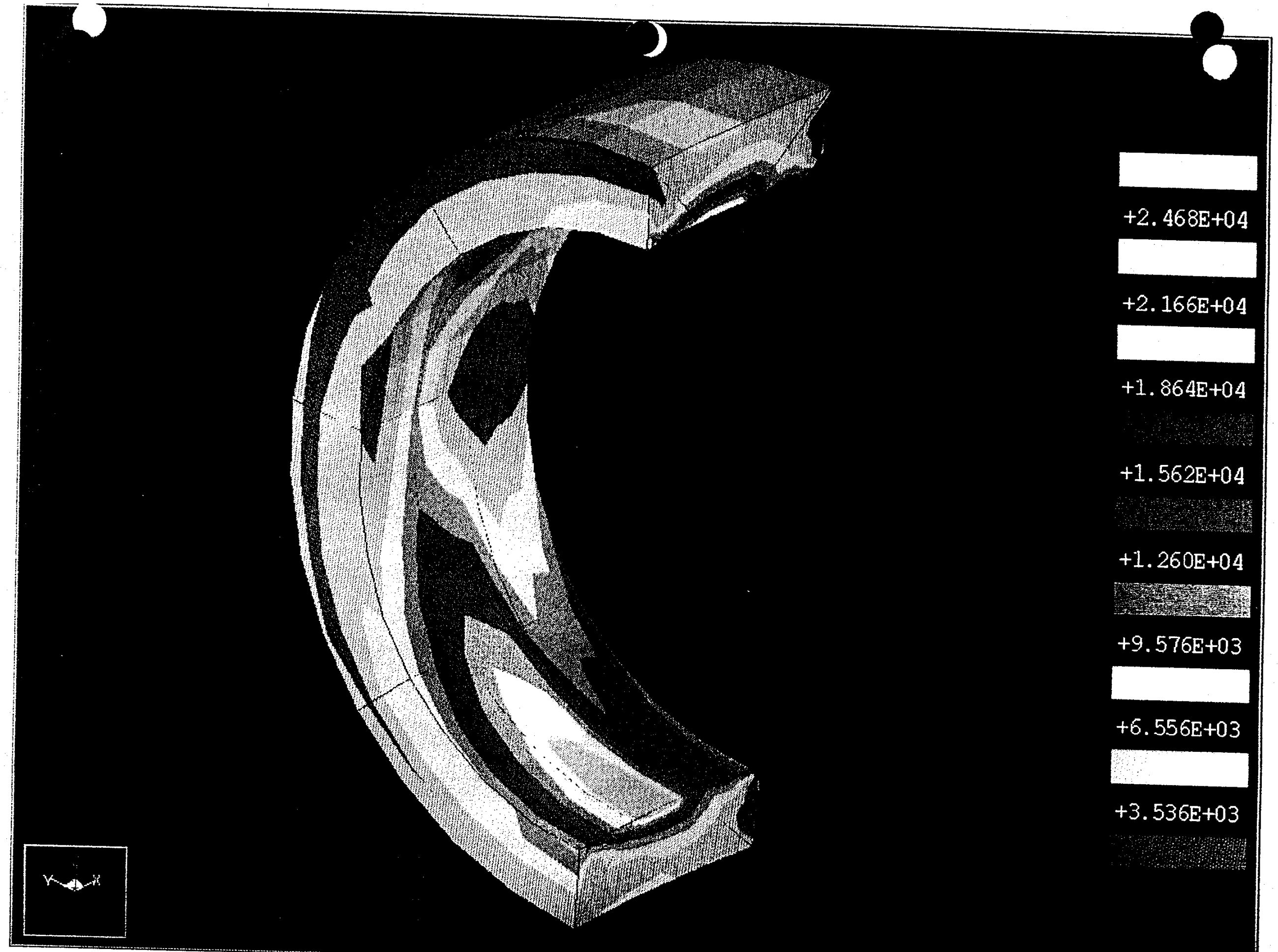

MECHANICA
Release 8

10/27/95 - 11:18

Split Nut Assembly, XX Stress (psi)

Analysis & Test Engineering Branch
NASA Langley Research Center

PARAMETRIC
TECHNOLOGY
CORPORATION



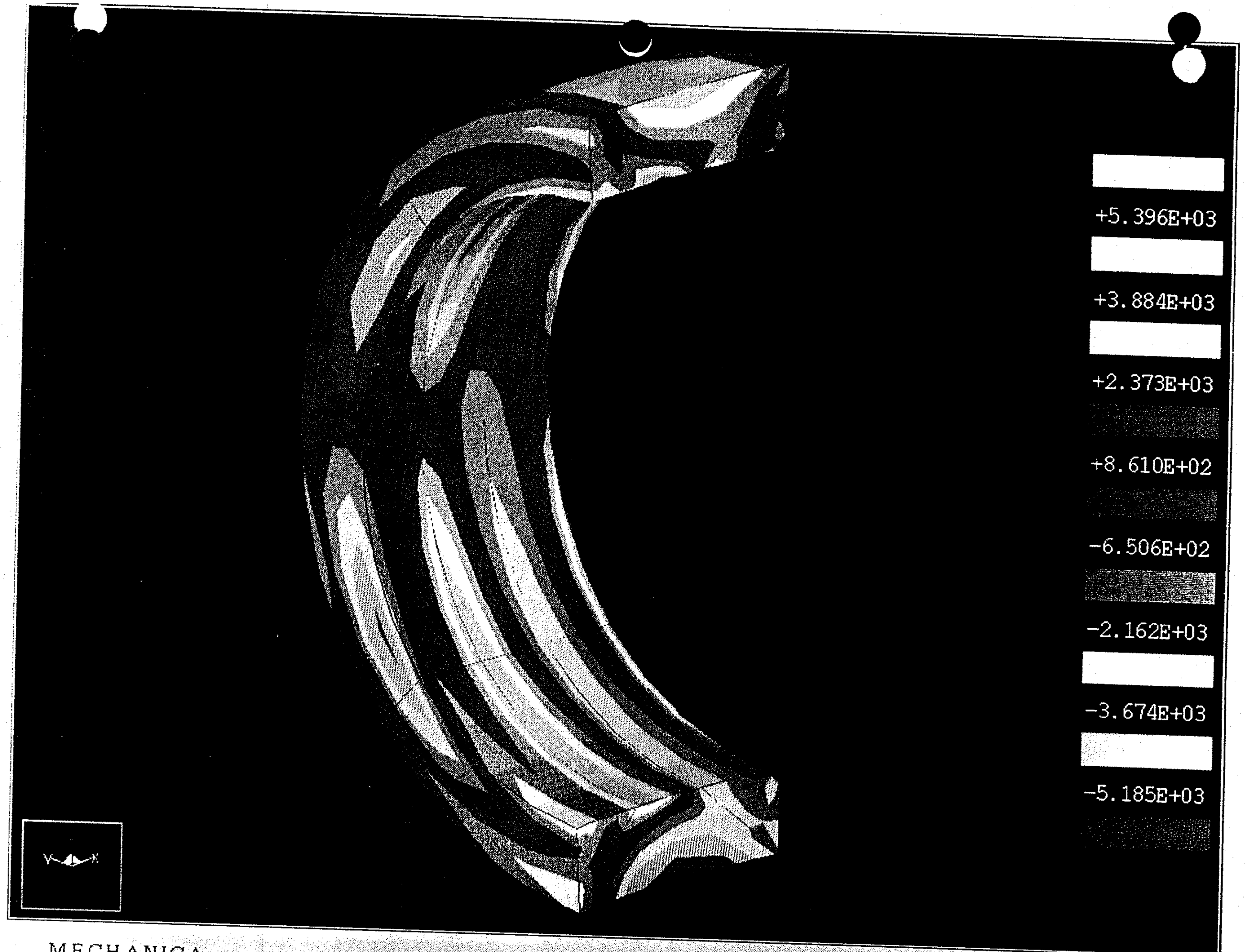

MECHANICA
Release 8

10/31/95 - 15:38

Split Nut Assembly, Von Mises (psi)

Analysis & Test Engineering Branch
NASA Langley Research Center

PARAMETRIC
TECHNOLOGY
CORPORATION




MECHANICA
Release 8

10/31/95 - 15:47

Split Nut Assembly, YY Stress (psi)

Analysis & Test Engineering Branch
NASA Langley Research Center

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TECHNOLOGY
CORPORATION

☐ STRESS & BOLT LOAD, FROM F.E.A.:

FROM PAGE

THE WORST BOLT LOAD IS:

$F = 4179$ lbs. (PG. 13)

$\therefore$ $F.S. = \dfrac{19000}{4179}$ ← [7/16-20UNF, SHCS, A286, TENS., PG. A6]

$\boxed{F.S. = 4.54}$

AND FOR THE WORST STRESS,

$\sigma = 27700$ psi (PG. 14)

SO,

$F.S. = \dfrac{87K}{27.7K}$ ← [NITRONIC 60, YIELD @ -200°F, PG. A4]

$\boxed{F.S. = 3.14}$

☐ TORQUE CALCULATION:

△ $\phi$7/16-20 UNF, SHCS, A286

SINCE THE NITRONIC 60 SPLIT NUT WILL SHRINK MORE THAN THE A286 BOLT THEN IGNORE THE THERMAL TORQUE.

$$T_{INSTALL} = 1100 \text{ in-lbs}$$ (PER C. DAVIDSON, MISB, ETTD)

AND CHECKING BOLT PRELOAD,

$$75\% \text{ OF } 19000 \text{ lbs.} \overset{?}{\geq} \text{PRELOAD} = 1.5\, F_{BOLT}$$

(PG. A6)

$$(.75)(19K) \overset{?}{\geq} 1.5(4179)$$

(PG. 13)

$$14250 \overset{\checkmark}{\geq} 6269 \quad \therefore \text{ O.K.}$$

☐ TORQUE CALCULATION : (VASCO-200 BOLT) ⌀½

COMPUTING THE CHANGE IN LENGTH UNDER THE BOLT HEAD (.50 in.) :

$\Delta \ell_{N60} = 8.8E\text{-}6 (380)(1/2) = .00167"$

$\Delta \ell_{V200} = 5.7E\text{-}6 (380)(1/2) = .00108"$

∴ THE BOLTED JOINT GETS LOOSER AT CRYO! SO, IGNORE THERMAL STRESSES WHEN CALCULATING THE ROOM TEMPERATURE INSTALLATION TORQUE.

ALSO, THE ½-20 BOLT MUST BE TORQUED SO NOT TO STRIP THE TAPPED THREADS IN THE NITRONIC-60 MATERIAL.

FOR NITRONIC-60 (N-60), YLD = 87K (PG. A4)

SO, $\tau_{ULTIMATE} = 87K \div 2$

$\tau_{ULT} = 43500$ psi

AND FOR AN ACCEPTABLE FACTOR OF SAFETY OF 1.33 THEN,

$$\tau_{ALLOWABLE} = \frac{43500}{1.33}$$

$\tau_{ALL.} = 32706$ psi

☐ TORQUE CALCULATION : (V-200 BOLT) CON'T

CALCULATING THE MAXIMUM "ACCEPTABLE" FORCE TO PREVENT THREAD SHEAR PULL-OUT,

$$\tau_{ALL} = \frac{F_M}{A}$$

WHERE,

$\tau_{ALL} = 32706$ psi

$A$ = AREA OF THREAD SHEAR PULL-OUT

$$A = \frac{\pi (B.P.D.) L}{3}$$

$L$ = ENGAGEMENT = .72 IN

B.P.D. = BASIC PITCH DIA. = .405 IN, FOR 7/16-20 UNF, (REF. MACHINIST HDBK., PG. 1267)

$$\therefore A = \frac{\pi(.405)(.72)}{3} = .305 \text{ in.}^2$$

$$\text{SO, } 32706 = \frac{F_M}{.305}$$

$F_M = 9975$ lbs. ← MAX. ALLOWABLE BOLT TENSION

THEREFORE, $T = .2 F_M d$

$T = .2(9975)(7/16)$

$\underline{\underline{T \cong 870 \text{ in-lbs.}}}$

☐ TORQUE CALC.: (V-200 BOLT) CON'T

ALSO, THE BOLT TENSILE STRESS BECOMES,

$$\sigma = \frac{F_m}{A_{TEN.}}$$

$$\sigma = \frac{9975}{.109}$$ ← MINIMUM TENSILE AREA, Ø7/16-20UNF, (REF. MACHINIST HDBK, PG. 1267)

$$\sigma = 91513 \text{ psi}$$

THEREFORE, IT SHOULD BE NOTED THAT THIS STRESS PRODUCES ABOUT 44½% OF THE YIELD STRESS OF THE VASCO-200 METAL.

# APPENDIX A


| | |
|---|---|
| RESEARCH DATA | A1 |
| MATERIAL DATA | A2 |
| FASTENER SPECS | A6 |
| MATERIAL CERTS. | A7 |
| BOLT MAT'L CERTS. | A12 |

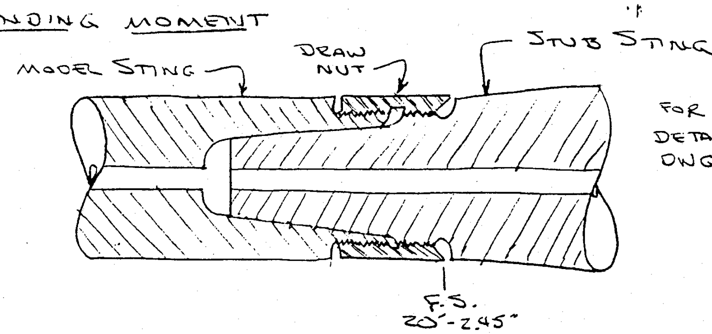
REF. 1: NTF STING MODIFICATION, MODEL SYSTEMS REPORT Nº T860398, FEB 1987 (PREPARED BY C.M. CAGLE).

REF. 2: NTF STING MODIFICATION DRAW NUT, DWG LD-1071741.

REF. 3: NTF STUB STING MODIFICATION, CALCULATIONS PROVIDED BY CHARLIE DAVIDSON, JUNE 17, 1994.

THE FOLLOWING IS AN INDEPENDENT EVALUATION OF THE EFFECT OF ADDING A DRAW NUT TO THE JOINT BETWEEN THE NTF MODEL STINGS AND STUB STINGS AS SHOWN BELOW (ALSO SEE REF 2)

BENDING MOMENT




FOR FURTHER DETAIL SEE DWG (REF 2)

THE MAXIMUM MOMENT IS BASED ON THE DESIGN LOADS OF THE NTF 107B BALANCE ACTING AT F.S. 13'-0"

$$20'\,2.45'' - 13'\,0'' = 7'\,2.45'' \quad (86.45'')$$

$$M_{VERT} = 6500^{\#}(86.45'') + 13000 \text{ IN-LB}$$
$$= 574925 \text{ IN-LB}$$

$$M_{SIDE} = 4000^{\#}(86.45'') + 6500 \text{ IN-LB}$$
$$= 352300 \text{ IN-LB}$$

$$M_{MAX} = \sqrt{574925^2 + 352300^2}$$
$$= 674280 \text{ IN-LB}$$

(MAXIMUM BENDING MOMENT @ F.S. 20'-2.45" & @ 31.5° OFF VERT. ℄ FOR COMBINED VERTICAL & SIDE LOADS)

A2

Table 4-2. Mechanical Properties of Various Metals

| Material | Temperature (deg K) | Yield Stress (ksi) | Ultimate Stress (ksi) | E (Msi) | $\nu$ | $\alpha^t$ in/in/deg F | Cvn ft-lb | $K_{IC}$ ksi-in$^{1/2}$ |
|---|---|---|---|---|---|---|---|---|
| 18 Ni-200 | 300 | 205 | 210 | 27 | 0.311 | --- | 35 | 170 |
| | 78 | 270 | 280 | | 0.306 | $3.4 \times 10^{-6}$ | 25 | 80 |
| 18 Ni-250 | 300 | 250 | 260 | 28.1 | 0.308 | --- | 20 | 100 |
| | 78 | 320 | 330 | 29.4 | 0.304 | $3.4 \times 10^{-6}$ | 10 | 40 |
| A286 | 300 | 100 | 160 | 28.4 | 0.300 | --- | 55 | 120 |
| | 78 | 120 | 215 | $\boxed{29.4}$ | — | $6.8 \times 10^{-6}$ | 50 | 110 |
| AISI 304 | 300 | 35 | 90 | 27.4 | — | --- | 155 | 118 |
| | 78 | 60 | 230 | 29.6 | — | $6.0 \times 10^{-6}$ | 116 | — |
| MP35N | 300 | 215 | 230 | 34.5 | -- | 7.1 | 50 | — |
| | 78 | --- | --- | --- | -- | --- | -- | — |
| MP35N | 300 | 240 | 260 | 34.5 | -- | --- | 23 | — |
| | 78 | --- | --- | --- | -- | --- | — | — |
| MP35N | 300 | 285 | 295 | 34.5 | -- | --- | 17 | — |
| | 78 | 327 | 337 | 35.6 | -- | --- | 16 | — |

# NASA Contractor Report 178214

JAN. 1987

DESIGN STUDY OF ADVANCED MODEL SUPPORT SYSTEMS FOR THE NATIONAL TRANSONIC FACILITY

A3

## CARBURIZATION RESISTANCE

Armco NITRONIC 60 stainless steel retained better strength and ductility than Types 316, 309 and 310 after 2 hours at 1800 F (982 C) in a packed carburizing atmosphere.

## OXIDATION RESISTANCE

Table VI
Oxidation Resistance*

| Temperature F, (C) | Weight Loss in mg/cm²: NITRONIC 60 | Type 304 | Type 310 | Type 333 |
|---|---|---|---|---|
| Static—96 hours in furnace | | | | |
| 2000 (1093) | 11 | 620 | 10 | 6 |
| 2100 (1149) | 14 | 880 | 10 | 8 |
| 2200 (1204) | 16 | — | 13 | 13 |

| Temperature F, (C) | Weight Loss, %: NITRONIC 60 | Type 316 | Type 310 | Type 309 |
|---|---|---|---|---|
| 1800 (982) | 6.1 | 12.1 | 0.2 | 1.7 |
| 1900 (1038) | 10.0 | 23.0 | 2.3 | 5.5 |

## MECHANICAL PROPERTIES

The newton (N) has been adopted by the SI as the metric standard unit of force as discussed in the American Iron and Steel Institute "Metric Practice Guide," 1975. The term for force per unit of area (stress) is the newton per square meter ($N/m^2$). Since this can be a large number, the prefix mega is used to indicate 1,000,000 units and the term meganewton per square meter ($MN/m^2$) is used. The unit ($N/m^2$) has been designated a pascal (Pa). The relationship between the U.S. and the SI units for stress is: 1000 pounds/in² (psi) = 1 kip/in² (ksi) = 6.8948 meganewtons/m² (MN/m² = 6.8948 megapascals (MPa).

Table VII
Typical Room Temperature Tensile Properties*

| Condition | Size | Hardness | UTS ksi (MPa) | 0.2% YS ksi (MPa) | Elongation % in 4XD | Reduction of Area, % |
|---|---|---|---|---|---|---|
| Annealed | 1" (25.4 mm) ø | $R_B$ 95 | 103 (710) | 60 (414) | 64 | 74 |
| Annealed | 1-3/4" (44.4 mm) ø | $R_B$ 100 | 101 (696) | 56 (386) | 62 | 73 |
| Annealed | 2-1/4" (57.2 mm) ø | $R_B$ 100 | 101 (696) | 60 (414) | 60 | 76 |
| Annealed | 3" (76.2 mm) ø | $R_B$ 97 | 113 (779) | 65 (448) | 55 | 67 |
| Annealed | 4-1/8" (104.8 mm) ø | $R_B$ 95 | 106 (731) | 56 (386) | 57 | 67 |
| 10% Cold Drawn | .442" (11.2 mm) ø | $R_C$ 24 | 120 (827) | 91 (627) | 51 | 68 |
| 20% Cold Drawn | Start Size | $R_C$ 31 | 140 (965) | 112 (772) | 35 | 65 |
| 30% Cold Drawn | | $R_C$ 34 | 161 (1110) | 132 (910) | 26 | 62 |
| 40% Cold Drawn | | $R_C$ 37.5 | 195 (1344) | 153 (1055) | 20 | 57 |
| 50% Cold Drawn | | $R_C$ 41 | 217 (1496) | 174 (1200) | 15 | 53 |
| 60% Cold Drawn | | $R_C$ 43 | 240 (1655) | 195 (1344) | 12 | 48 |
| 70% Cold Drawn | | $R_C$ 46 | 263 (1813) | 217 (1496) | 10 | 40 |

* Data based on duplicate tests

SOURCE: ARMCO PRODUCT DATA, S-56A

A4

Table XIV
Cryogenic Tensile Properties*

| Condition | Size | Temperature, F (C) | UTS ksi (MPa) | 0.2% YS ksi (MPa) | Elongation % in 4XD | Reduction of Area, % |
|---|---|---|---|---|---|---|
| Annealed | 3/8" (9.5 mm) ø | -100 ( -73) | 155 (1069) | 76 (524) | 57 | 69 |
| | 3/8" (9.5 mm) ø | -200 (-129) | 170 (1172) | $\boxed{87}$ (600) | 56 | 71 |
| | 1"(25.4 mm) ø | -320 (-196) | 213 (1469) | 109 (752) | 60 | 67 |
| Cold Swaged 54% | .700" (17.8 mm) ø | -320 (-196) | 322 (2220) | 272 (1875) | 10 | 53 |
| | .700" (17.8 mm) ø | -200 (-129) | 287 (1979) | 250 (1724) | 13 | 62 |

*Duplicate tests

Table XV
Double Shear Strength*
(Cold Drawn — 0.442" [11.23 mm] start size)

| % Cold Drawn | Shear Strength, ksi (MPa) |
|---|---|
| 10 | 89 (614) |
| 20 | 98 (676) |
| 30 | 106 (731) |
| 40 | 113 (779) |
| 50 | 122 (841) |
| 60 | 130 (896) |

*Triplicate tests

Table XVI
Fatigue Strength
(R.R. Moore Machine)

| Condition | Size | Hardness | Endurance Limit, ksi (MPa) $10^8$ Cycles |
|---|---|---|---|
| Annealed | 1" (25.4 mm) ø | $R_B$ 95 | 37.5 (258) |
| Cold Worked 54.6% | 0.70" (17.3 mm) ø | $R_C$ 44 | 72.5 (500) |

SOURCE: ARMCO PRODUCT DATA, S-56A

A5

Table XVII

Room Temperature Compression Strength

| Condition | Size | 0.2% Compressive YS, ksi (MPa) |
|---|---|---|
| Annealed | 0.500" ⌀ (12.7 mm) | 67.6 (466) |
| Cold Drawn 39% | 0.440" ⌀ (11.2 mm) | 121.0 (834) |

## PHYSICAL PROPERTIES

Table XVIII

Physical Properties

Density at 75 F (24 C)—7.622 gm/cm³
Electrical Resistivity—98.2 microhm-cm
Modulus of Elasticity—26.2 x $10^6$ psi
Poisson's Ratio—0.298

Table XIX

Mean Coefficient of Thermal Expansion

| Temperature, F (C) | in/in/°F (µm/m • K) |
|---|---|
| 75- 200 (24-93) | 8.8 x $10^{-6}$ (15.8) |
| 75- 400 (24-204) | 9.2 x $10^{-6}$ (16.6) |
| 75- 600 (24-316) | 9.6 x $10^{-6}$ (17.3) |
| 75- 800 (24-427) | 9.8 x $10^{-6}$ (17.6) |
| 75-1000 (24-538) | 10.0 x $10^{-6}$ (18.0) |
| 75-1200 (24-649) | 10.3 x $10^{-6}$ (18.5) |
| 75-1400 (24-760) | 10.5 x $10^{-6}$ (18.9) |
| 75-1600 (24-871) | 10.7 x $10^{-6}$ (19.3) |
| 75-1800 (24-982) | 11.0 x $10^{-6}$ (19.8) |

Table XX

Magnetic Permeability

| Condition | Magnetic Permeability |
|---|---|
| Annealed | 1.02 max |
| 10% Cold Drawn | 1.02 max |
| 20% Cold Drawn | 1.02 max |
| 30% Cold Drawn | 1.02 max |
| 40% Cold Drawn | 1.02 max |
| 50% Cold Drawn | 1.05 max |
| 60% Cold Drawn | 1.05 max |
| 70% Cold Drawn | 1.05 max |

## MACHINABILITY

Table XXI

Machinability*

| AISI B 1112 | Type 304 | Armco NITRONIC 60 |
|---|---|---|
| 100% | 45% | 23% |

*1" ⌀ (25.4 mm)—annealed—Rb 95
Five-hour form tool life using high-speed tools
Data based on duplicate tests



SOURCE: ARMCO PRODUCT DATA, S-56A

A6

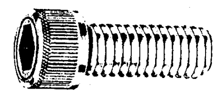
# SOCKET HEAD CAP SCREWS

1960 Series ▫ High Performance ▫ KS 812, KS 1216, M254

## HIGH PERFORMANCE

Socket screw users often require capabilities exceeding those of standard UNBRAKO socket head cap screws. In many cases the near standard items listed can fulfill the requirements of beyond-normal applications or environments, and at considerably lower cost than outright specials. If they cannot, however, a diversity of special materials (covering temperatures from -450° to 2400°F.), finishes, processing and configurations to specification is available on order. For more about UNBRAKO socket head cap screw specials, see pages 14 and 15.

## KS 812 SERIES — HIGHER TENSILE EXCELLENT CORROSION RESISTANCE



NOTE: Identification groove: denotes high tensile, 125,000 psi
Heads shall be forged; hex socket machined or forged at manufacturer's option.

**BASIC PART NUMBER**
56350 — socket head cap screw — high strength stainless steel (see page 12 for applicable dash numbers, etc.).

UNBRAKO KS 812 screws solve the problem of combining good corrosion resistance with higher tensiles than those of standard stainless steel screws.

**corrosion resistance** — KS 812 screws have excellent resistance to salt solutions, acids and high temperatures.

**non-magnetic** — Magnetic permeability of KS 812 is only 1.2.

**temperature usage** — Usable from —300° to +800°F. High percentage of tensile retained at elevated temperatures.

**increased strength** — Over 50% more strength than standard stainless screws (KS 812 is certified 125,000 psi min.) provides extra clamping force that reduces number of screws, tapped holes and assembly time.

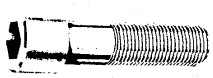
**extended service life** — Fatigue endurance limit exceeds that of alloy steel screws. High clamping force retained at high temperatures because of excellent resistance to stress relaxation.

### MECHANICAL PROPERTIES AND SEATING TORQUES

| nom. size | basic screw diameter | tensile strength lbs. min. | | tensile strength psi. min. | yield strength psi. min. | double shear strength of body lbs. min. | recommended* seating torques inch-lbs. | | max. length |
|---|---|---|---|---|---|---|---|---|---|
| | | UNRC | UNRF | | | | UNRC | UNRF | |
| #8 | .164 | 1,750 | 1,840 | 125,000 | 80,000 | 3,160 | 31 | 33 | 1.500 |
| #10 | .190 | 2,190 | 2,500 | 125,000 | 80,000 | 4,260 | 45 | 51 | 2.000 |
| 1/4 | .250 | 3,980 | 4,550 | 125,000 | 80,000 | 7,360 | 107 | 123 | 2.500 |
| 5/16 | .312 | 6,550 | 7,250 | 125,000 | 80,000 | 11,500 | 221 | 245 | 3.000 |
| 3/8 | .375 | 9,690 | 10,980 | 125,000 | 80,000 | 16,560 | 392 | 445 | 3.250 |

Dimensions will be found on page 8. *See Note, page 17.

## KS 1216 HIGH TENSILE STRENGTH EXCELLENT CORROSION RESISTANCE



NOTE: Parts to be stamped KS1216 on face or head O.D. at manufacturer's option. KS1216 socket screws are manufactured from UNS-S-66286 alloy. This non-magnetic material is a corrosion resistant austenitic-alloy that develops its high strenth from a combination of cold working and heat treatment.

These screws have high tensile and shear strengths and good fatigue resistance. The minimum ultimate tensile strength of these screws is double that of standard austenitic (300 series) stainless steel screws.

The useful temperature range is from —400°F to 1200°F, which makes them suitable for both cryogenic and high temperature applications.

### MECHANICAL PROPERTIES AND SEATING TORQUES

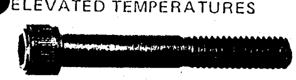
| nom. size | basic screw diameter | tensile strength lbs. min. | | tensile strength psi. min. | yield strength psi. min. | double shear str. of body lbs. min. | recom. seating* torques inch-lbs. | |
|---|---|---|---|---|---|---|---|---|
| | | UNRC | UNRF | | | | UNRC | UNRF |
| #4 | .112 | 966 | 1,060 | 160,000 | 120,000 | 1,730 | 15 | 17 |
| #5 | .125 | 1,270 | 1,330 | 160,000 | 120,000 | 2,160 | 22 | 23 |
| #6 | .138 | 1,450 | 1,620 | 160,000 | 120,000 | 2,630 | 28 | 31 |
| #8 | .164 | 2,240 | 2,360 | 160,000 | 120,000 | 3,720 | 51 | 54 |
| #10 | .190 | 2,800 | 3,200 | 160,000 | 120,000 | 4,990 | 75 | 85 |
| 1/4 | .250 | 5,090 | 5,820 | 160,000 | 120,000 | 8,640 | 152 | 174 |
| 5/16 | .312 | 8,380 | 9,280 | 160,000 | 120,000 | 13,500 | 314 | 347 |
| 3/8 | .375 | 12,400 | 14,000 | 160,000 | 120,000 | 19,400 | 465 | 527 |
| 7/16 | .437 | 17,000 | 19,000 | 160,000 | 120,000 | 26,500 | 743 | 830 |
| 1/2 | .500 | 22,700 | 25,600 | 160,000 | 120,000 | 34,600 | 1140 | 1,280 |
| 5/8 | .625 | 36,200 | 41,000 | 160,000 | 120,000 | 54,000 | 2260 | 2,560 |
| 3/4 | .750 | 53,500 | 59,700 | 160,000 | 120,000 | 77,800 | 4010 | 4,480 |
| 7/8 | .875 | 73,900 | 81,500 | 160,000 | 120,000 | 106,000 | 6460 | 7,130 |
| 1 | 1.000 | 96,900 | 106,000 | 160,000 | 120,000 | 138,000 | 9690 | 10,600 |

For dimensions see page 8. *See Note, page 17.

Corrosion resistance is comparable to 316 stainless steel.

**BASIC PART NUMBER**
78794 — socket head cap screw — high strength corrosion and heat resistant alloy (see page 12 for applicable dash numbers, etc.).

## UNBRAKO/SPS M-254 SERIES ELEVATED TEMPERATURES



UNBRAKO M-254 socket screws, made from a special aerospace-proven alloy, are available for high-temperature applications such as jet engines, steam turbines, plastic extrusion equipment, forming presses or any applications where temperatures exceed the maximum recommended operating temperature for standard socket screws.

**BASIC PART NUMBER**
73015 — socket head cap screw — temperature-resistant chrome-moly vanadium steel (see page 12 for applicable dash numbers, etc.).

SOURCE: UNBRAKO HANDBOOK © 1988

A7

LANGLEY RESEARCH CENTER
MATERIAL RELEASE ORDER

DATE: 1996/02/01
TIME: 10:36

S K NUMBER: 9515-01-LC6-6329

PRIORITY:

DOCUMENT NUMBER: 199602010218001

ORIGINAL DOC.NO: GHE 1297-1

P/O REQUEST NUMBER: L-63160D

RECEIVING LOCATION: ______________

;ENERIC NAME: METAL STOCK

:ECHNICAL NAME: N/A

'ECHNICAL DESCRIPTION: N/A

'TY RELEASED: 4 - UNIT OF ISSUE: EA SHELF LIFE EXPIRATION: ___/___/___

OT NR: TRACEABLE QUANTITY: 0
OT NR: TRACEABLE QUANTITY: 0
OT NR: TRACEABLE QUANTITY: 0

̣AREHOUSE LOCATION: N/A SECONDARY WAREHOUSE LOCATION: N/A

ELECTED BY : __________________ J.R. DATE: 2/1/96

: ERED BY: ______________________ DATE: ___/___/___

IIP TO:

ME : BRUCE LITTLE

ILDING: 1225 ROOM: 106

DRESS: N/A
:

LEPHONE: 864-2729 JOB ORDER: R20805

:T PRICE: 1085.00 TOTAL VALUE: 4340.00 -

:EIVED BY : ______________________ DATE: ___/___/___

K ORDER NUMBER: N/A

[redacted]

8054

A8

# ~~ORIGINAL INVOICE~~

B & S AIRCRAFT ALLOYS, INC.
10 Aerial Way
Syosset, New York 11791
(516) 681-2400 TELEX: 645527
FAX: (516) 681-2439
800-645-2401

Invoice Date: 01/23/96

Invoice Number: 8327 MG C01 Page 1

SOLD TO:
NASA Langley
COMM. ACCT. SECT.
Mail Stop 175
Hampton, VA 23681

SHIP TO:
NASA LANGLEY

TWS, BLDG. 1206
HAMPTON, VA 23681

SHIP VIA : ABF

FOB : PPD

Customer's P. O. #: L63160D    Terms: 1/2 % 20 NET 30

| AMOUNT | QUANT. | DESCRIPTION |
|---|---|---|
| 4 | 4 PCS | UT PER MIL-STD 2154 TY II CL.AA FORGED: 5" X 7" X 10" |

[redacted]

Completes Purchase Order

Certs with material. Copy enclosed.

A monthly periodic rate of 1.5% will be added to the unpaid balance of this invoice. If any l[redacted] collection of the invoice, B & S AIRCRAFT shall be entitled to reasonable attorney fees. This [redacted] governed by the laws of the State of New York. Should a dispute arise here-under, the parties he[redacted] [...]t to the jurisdiction of the courts of New York State.
[...] claim that material fails to conform to specifications or is defective shall be deemed waiv[redacted] within 90 days from the date of shipment of the material to which claim relates.
CONDITION OF SALE: Defective material will, at the option of the seller, be replaced or credit [redacted] upon its return, but the seller shall not be liable for labor or consequential damages.

A9

# CERTIFICATION

## B & S AIRCRAFT ALLOYS, INC.

10 Aerial Way
Syosset, New York 11791

(516) 681-2400
800 645-2401
FAX • (516) 681-2439

see attached

B & S AIRCRAFT ALLOYS INC. OF N.Y. WE CERTIFY THIS IS A TRUE COPY OF MILL CERTIFICATE OR TEST DATA ON MATERIAL USED TO FILL YOUR ORDER
BY: S Freedman DATE 1-23-96

L63160D

| CUSTOMER ORDER NO. | DATE SHIPPED | HEAT NO. | SPECIFICATION-GRADE |
|---|---|---|---|
| 8327 MG | 01-23-96 | 24863 | Nitronic 60 |

| ITEM | QUANTITY | DESCRIPTION |
|---|---|---|
| | 4- | Block forgings made and solution annealed, and sandblasted.<br>5" x 7" x 10"<br>The forgings were heated to 1950°F, 3 Hours, Water-Quenched. |

REPORTED LADLE ANALYSIS (*LESS THAN)

| C | Mn | P | S | Si | Ni | Cr | Mo | V | Cu | Co | Cb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .073 | 7.96 | .025 | .002 | 3.93 | 8.16 | 16.45 | .54 | | .42 | | |
| Ta | Al | Sn | Fe | Ti | B | Pb | W | Cb + Ta | N | | |
| | | | | | | | | | .14 | | |

MECHANICAL PROPERTIES FROM:
☐ SEPARATELY FORGED COUPON ☐ EXTRA FORGING ☐ PROLONGATION ☐ MILL CAPABILITIES

| TYPE TEST | TEMP °F | STRESS/ULT PSI | 0.2% YIELD PSI | LIFE HRS | % ELONG IN 2" | RA % | HARDNESS | CONDITION |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

| HARDNESS OF FORGING(S) | MILL SOURCE | ULTRASONIC TEST RESULTS |
|---|---|---|
| 187 BHN | Electralloy<br>STARTING BILLET SIZE<br>10" RCS | U.T. Per MIL-STD-2154, Cl. AAType 2 : Satisfactory ( See attached U.T. Report ) |

A10

JAN 22 '96 13:42

# ULTRASONIC TEST REPORT

Street____________________

City & State____________________

Test Observed by____________________

Reflectoscope Style No. UJ-106324-7

Serial No.____________________

Reference Standard MIL-STD-2154 CL. AAType 2

| Search Unit | Beam | Size | Frequency |
|---|---|---|---|
| GBM CIL-2.25-11 | Straight | 1" DIA. | 2.25 MHZ |
| | | | |
| | | | |

Couplant SAE 30 Wt. Oil    Line Stabilizer YES

| Item No. | Quantity | Description | Test Results |
|---|---|---|---|
| | 4- | Nitronic 60, Block forgings made and solution annealed, and sandblasted.<br>5" x 7" x 10"<br>P.O.# 8327 MG HT# 24863 | No reportable indications noted. |

Remarks Artificial defect set at 75% full screen height.

1-29-96 ; 2:01PM ; R&S AIRCRAFT ALLOYS-CHARLES LARSON & SON:# 3/ 4

*000045 A11

# NASA LANGLEY FORM 124, ELECTRONIC PURCHASE ORDER (PO) / DELIVERY ORDER (DO)

SHIP TO: [X] NASA Langley Research Center, TWS, BLDG 1206, Hampton, VA 23681-0001
[ ] Wyle Laboratories, 3200 Magruder Blvd., Hampton, VA 23666

Mark For Order L63160D

MAIL INVOICE TO: NASA Langley Research Center, M/S 175/Comm. Acctg. Section, Hampton, VA 23681-0001
Order No. L63160D

| DATE OF ORDER | PPC | ORDER NUMBER | PAGE OF |
|---|---|---|---|
| 12/5/95 | KRL | L63160D | 1 / 1 |

DELIVERY REQ'D BY: 1/20/96

DISCOUNT TERMS: N30

FOB POINT: DEST

SHIP VIA:

SELLER:
B&S AIRCRAFT
10 AERIAL WAY
SYOSSET, NY 11791

**This Purchase Order No. must appear on all invoices, packages, and papers relating to credit. Failure to cite no. may result in rejection of shipment and will delay payment.**

Unless provided for herein, no partial shipments will be accepted, and no partial payments will be made.

| ITEM | TOXIC / HAZARD | ARTICLES OR SERVICES Show name of item, description, and specifications | QTY | UNIT | UNIT PRICE | AMOUNT |
|---|---|---|---|---|---|---|
| | NO | 5 in. x 7 in. x 10 in., metal stock, nitronic 60 | 4 | EA | 1085.00 | $4340.00 |
| | | UT PER MIL STD 2154, type II, class AA, | | | | |
| | | material certification paperwork required. | | | | |

This contract is a rated order under DMS (15 CFR 350) C9

**SALES TAXES —— DO NOT BILL SALES TAX**
NASA is a Federal Government Agency and is not subject to sales taxes.
TAX EXEMPTION NO. 54-1344524

TOTAL COST

Accounting and Appropriation Data

| PR Number | Object Class | Job Order | Program Number | Partial/Complete | PR Number | Object Class | Job Order | Program Number | Partial/Complete |
|---|---|---|---|---|---|---|---|---|---|
| HE .1297 | 2611 | R20805 | 50559850100 | C | | | | | |

[ ] DELIVERY ORDER — This delivery order is subject to instructions herein and to the terms and conditions of Contract No. ____

[✓] PURCHASE — Reference your WRITTEN QUOTE. Please furnish the above on the terms specified on the attached sheets, including delivery as indicated.

DELIVER TO: BRUCE LITTLE  BUILDING: 1225  ROOM: 106  EXTENSION: 42729

INFORMATION CONTACT

E. Gale Poulson
Contracting Officer
(804) 864-2433, M.S. 138

UNITED STATES OF AMERICA BY: Contracting Officer — Gale Poulson  DATE 12/5/95

Langley Electronic Form 124 - Rev. 12/93  Prescribing Documents LMI 5000.2 and LHB 5000.2

ADVEX CORPORATION

M/S 222B

**Support Services Contract NAS1-19235-4920 Task**

INSPECTION DATA

Sheet 1 of 1

Inspection Location: Advex Corporation and/or NASA/LaRC    Visual and/or Dimensional Inspection

| Drawing No. | Item No. | Qty. | Description and Inspection Remarks |
|---|---|---|---|
| 1080730 | | 12 | NTF SPLIT DRAW NUT<br><br>MODE # DAI9523 |

☐ Partial ☑ Conform to drawing.

☑ Complete ☐ See attached sketch/back of sheet

Distribution:

Original - NASA/LaRC Monitor
Copy - Advex Task File

Inspector/Inspection Date: [signature] 6-17-96

Date Shipped/Monitor: David White 6-18-96

A13

# MATERIAL VERIFICATION

**PROJECT:** NTF SPLIT DRAW NUT

**DATE:** 6-5-96

**JOB ORDER NO.:** R20805

**ITEM NAME:** ONC COUPON VASCOMAX 200C 1½" x 2½" x ⅛"

**FABRICATION WORK ORDER NO.:** 51431

**IDENTIFICATION NO.:** LD1090230-1 7/16-20 SHCS

**SHOP ORDER TRAVELER NO.:** 23804

## METHODS OF ANALYSIS AND RESULTS

**CHEMICAL SPOT TEST:**

**PERCENT CARBON BY DIRECT COMBUSTION:**

**HARDNESS TEST:** HRC 27 *

**X-RAY SPECTROCHEMICAL:** Indicates VASCO 200C

| ELEMENT | WEIGHT % CONCENTRATION |
|---|---|
| Ti | .25 |
| Cr | .14 |
| MN | .01 |
| Co | 8.43 |
| Ni | 19.23 |
| Mo | 3.06 |
| | |
| | |
| | |
| | |
| | |
| | |

## REMARKS

* Finished Bolts must be Heat Treated To HRc 43-47

**REQUESTED BY:** DAVID WHITE

**SECTION:** RMSS

**VERIFIED BY:** Bill Drummond

**SECTION:** QAIB

NASA Langley (June 1988)
Previously LF-60

Prescribing Document LHB 5300.1

FD N-1545

# Heat Treatment Report

*NDES*, *Bldg. 1267A*

A14

**Requestor :** D.White

**Phone:** 42729 **MS:** 222

**Description / No. pcs. :**

| material | number of parts | sizes |
|---|---|---|
| Vasco200 | 12 | |

**W. O. :** 52076 **J. O. :** R-20805

| Furnace | Heat Treatment Temp. | / Time | / Quench | Rockwell Hardness Before | After |
|---|---|---|---|---|---|
| Lindberg2 | 900f | 3hrs | A/c | | |
| | | | | | R/c45 |

Remarks:

**Replier :** L..B.Cooper

**Signature:** L.B. Cooper

**Title:** Engr. Tech.

**Date Completed:** 6/19/96

**S.O.T. No. :** **Dwg. No. :**

**Q.A. Signature:** **Date:**

A15

# RI/QA LAB MATERIAL RELEASE

| | |
|---|---|
| Test Number | S-185 |
| Certification Number | |
| Stock Number (NSN) | Bill Drummond |
| Material Description | 7/16-20 x 1 1/2 Socket Hd Cap Screw |
| Quantity Ordered | |
| Quantity Received | 3 ea |
| Quantity Tested | 3 ea (3 ea Destroyed) |
| Type Test Performed | Tensile |
| Ref. Specification | 210 KPSI |
| Order Number | |
| Results | |
| Date | 6/27/96 |

Special Test for Bil Drummond.

RELEASED BY: ____________________ Date: ________ RI/QA Form 2 - 3/94

A16

Mason & Hanger Services, Inc.
R & I/QA Lab
NASA Langley Research Center

## Tensile Test - Material Verification

| | | | |
|---|---|---|---|
| Load Range, lbf | 30000sp | Results Filename | Loncite |
| Stress Range, psi | | Test Parameters | |
| Strain Rng, % | 2 | Material | Socket Head Cap Screw |
| Extensometer MR%/GL(in) | 20 / 1.5 | Size | 7/16-20x1.5 |
| | | Heat Number | |
| | | Cert Number | |

| Test Number | Spec ID | THD DIA Inches | THD per Inches | AREA Sq. in | MODULUS Mpsi | .2% YD lbf | .2% YD kpsi | .5% EUL lbf | ULT kpsi | R/A % | EL % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S185 | | .438 | 20 | .1187 | -342 | 0 | 0 | 0 | 213 | 43.3 | 11 |
| S185a | | .438 | 20 | .1187 | 42.2 | 0 | 0 | 0 | 212 | 55.5 | 10.33 |
| S185b | | .438 | 20 | .1187 | -490 | 0 | 0 | 0 | 217 | 37.3 | 10.53 |
| AVERAGE | | .438 | 20 | .1187 | -263 | | 0 | | 216 | 45.4 | 10.62 |
| SD. DEV | | 0 | 0 | 0 | 275 | | 0 | | 3.52 | 0.33 | .342 |

6-27-1996 13:32:01

est Conducted By C. Forrest Jr.

# NOTES

1. APPLICABLE STANDARDS/SPECIFICATIONS:
   ANSI Y14.5M-1982, DIMENSIONS & TOLERANCES
2. REMOVE ALL BURRS AND SHARP EDGES
3. SURFACE ROUGHNESS OF 125 MICROINCHES
   UNLESS OTHERWISE SPECIFIED

. NO F.I.O.S. REQUIRED

5. NO CHANGES OR DEVIATIONS FROM THE DRAWING SHALL BE MADE WITHOUT PRIOR APPROVAL OF THE LaRC TECHNICAL PROJECT ENGINEER

6. THE NTF SPLIT DRAW NUT WILL MATE WITH THE FOLLOWING HARDWARE:

   MODEL STINGS:
   LE-1005575D, STING #1-D
   LE-536202B, STING #1-C
   LE-1005569A, STING #1-B
   LE-542901C, HIGH OX SYS. STING

   STUB STINGS:
   LD-1077108B, 6° OFFSET STING
   LE-1028005G, STING #1
   LE-541838A, STING #4
   LE-1005562B, STING #3
   LE-541739D, STING #5

7. INSTALLATION PROCEDURE:
   (1) MATE TAPER SOCKET JOINT WITHIN 1/8 INCH. DO NOT SEAT.
   (2) CLAMP SPLIT DRAW NUT AROUND THE THREADS DO NOT TIGHTEN, LOCATE WITH AN EQUAL AMOUNT OF THREADS ON EACH SIDE.
   (3) ADJUST TAPER JOINT ENGAGEMENT SO THE DRAW NUT THREADS ARE LOCATING.
   (4) INSERT AND START THE SIX DRAW BOLTS. SLOWLY TURN EACH BOLT ONE TO ONE & HALF TURNS EACH WHILE SEATING THE THREADS. DO NOT TIGHTEN THE BOLTS.
   (5) LIGHTLY LUBRICATE THE TWO DOWEL PINS AND INSTALL THEM, MINIMUM FORCE INDICATES AN ACCEPTABLE THREAD ALIGNMENT.
   (6) TIGHTEN THE SIX BOLTS AS SPECIFIED.
   (7) TURN THE DRAW NUT AS REQUIRED TO SEAT THE TAPER JOINT (SPANNER WRENCH).

8. LUBRICATE DRAW NUT THREADS WITH EXTREME PRESSURE LUBE #3 (CMD PRODUCT) BEFORE ASSEMBLY.

9. LOCTITE #229 REQUIRED ON ITEM NO. 5 OR NO. 8 BEFORE INSTALLATION. C

DISASSEMBLY PROCEDURE:
   (1) TURN DRAW NUT 1 REVOLUTION OUT TO DISENGAGE THE TAPER JOINT.
   (2) REMOVE THE TWO DOWEL PINS WITH A SLIDE HAMMER.
   (3) LOOSEN EACH DRAW BOLT 1/4 TO 3/4 TURNS EACH UNTIL ALL BOLTS TURN OUT FREELY THEN REMOVE ALL THE BOLTS.
   (4) SEPARATE THE DRAW NUT PARTS BY USING TWO Ø1/4-20 UNF SHCS (3.0 LG) OR TWO Ø1/4-20 UNF SET SCREWS AS JACKING BOLTS.

11. INSTALL NTF APPROVED LOCK-WIRE (Ø.032) ON EACH SET OF BOLTS USING A NTF APPROVED PROCEDURE.

12. INSTALL NTF APPROVED LOCKWIRE (MAX. Ø.100) THRU EACH END OF THE NUT ASS'Y & ANCHOR TO AN EXISTING HOLE.

13. CHEMICALLY ETCH THIS NOTE:
    Ø7/16-20 UNF SHCS, 1.50 LONG C
    MAT'L: A286 OR VASCO-200

14. CHEMICALLY ETCH THIS INFORMATION AS SHOWN INSIDE THE INDICATED RECTANGLE ON THE LEFT DRAW NUT, PART NO. LD-1079463-1.
    ETCH THE SAME INFORAMATION ON THE RIGHT DRAW NUT, PART NO. LD-1079463-2.

15. CHEMICALLY ETCH THE FOLLOWING HERE:
    NTF SPLIT DRAW NUT, LEFT
    MATERIAL: NITRONIC 60
    DRWG. LD-1079463-1

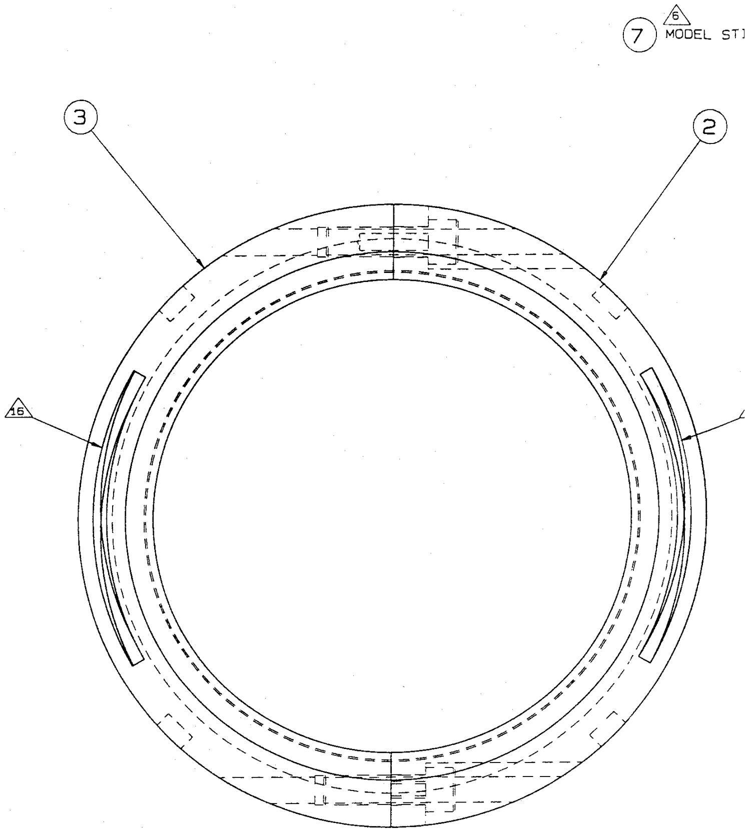
16. CHEMICALLY ETCH THE FOLLOWING HERE:
    NTF SPLIT DRAW NUT, RIGHT
    MATERIAL: NITRONIC 60
    DRWG. LD-2079463-2

17. MATERIAL CERTIFICATIONS REQUIRED. C

18. CHEMICALLY ETCH EACH SET OF NUT ASSEMBLIES: C
    ASS'Y #1 OR ASS'Y #2 OR ASS'Y #3, ETC.

19. ANY TORQUE CHANGE OF ITEMS NO. 5 OR 8 MUST BE APPROVED BY THE LaRC NTF FACILITY SAFETY HEAD & THE APPROPRIATE ENGINEERING OFFICERS. C

DEPENDING ON THE ASS'Y NUMBER (I.E. PROTOTYPE, #1 OR #2) THIS PIN SHOULD BE CUSTOM FIT TO THE HOLE DIAMETER. D



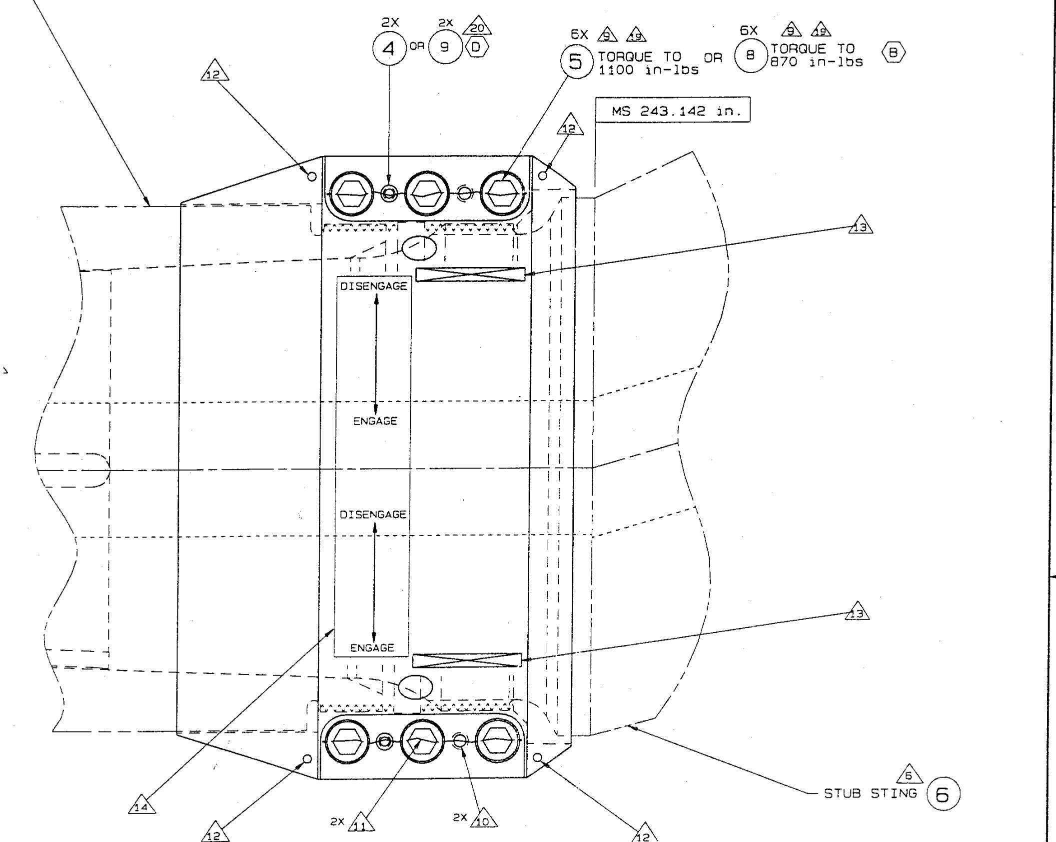

-1 SPLIT DRAW N

( 1 REQ'D

SOME DETAIL OMITTED

8 | 7 | 6 | 5

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | LTR | DESCRIPTION | DATE | APPROVED |
| D-1 | A | CHANGED 937 TO 1100 in-lbs | 7FEB96 | |
| D-1 | B | ADDED VASCO-200 BOLT & ITS TORQUE | 27JUN96 | |
| B-8 | C | DELETED TORQUE SPEC (1100) & ADDED "OR VASCO-200". ADDED NOTES 17, 18 & 19. CHANGED 1.25 TO 1.50 (BOLT LENGTH) | 23JUN97 | |
| A-1 | D | ADDED NOTE 20, & ITEM NO. 9 | 9OCT97 | WMJ |




T ASSEMBLY B

OR CLARITY

| QTY REQ'D | FSCM NO. | PART OR IDENT. NO. | NOMENCLATURE DESCRIPTION | MATERIAL / SPECIFICATION | ZONE | ITEM NO. |
|---|---|---|---|---|---|---|
| 2 | | -9 | Ø.2500 NOM. DOWEL, 1.00 LONG | 304 STAINLESS STEEL | | 9 |
| 6 | | 1080730-1 | 7/16-20 UNF SHCS. 1.50 LG | VASCO-200 | | 8 |
| 1 | | 1005575D | MODEL STING #1-D | ——— | | 7 |
| 1 | | 1077108B | 6° OFFSET STUB STING | ——— | | 6 |
| 6 | | -5 | Ø7/16-20 UNF SHCS. 1.50LG | A-286 | | 5 |
| 2 | | -4 | Ø.2500 NOM. TAPPED DOWEL, 1.00LG | | | 4 |
| 1 | | 1079463-2 | SPLIT DRAW NUT, RIGHT | ——— | | 3 |
| 1 | | 1079463-1 | SPLIT DRAW NUT, LEFT | ——— | | 2 |
| | | -1 | SPLIT DRAW NUT ASS'Y | ——— | | 1 |
| -1 | | | | | | |

PARTS LIST

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS .XX ± .02 .XXX ± .005 ANGULAR ± .25°
DO NOT SCALE DRAWING

TREATMENT

FINISH

| PART DASH NO | NEXT ASSY | FINAL | NEXT ASSY | USED ON |
|---|---|---|---|---|
| -1 | 1 | | | |
| | QTY REQD PER ASSY | | APPLICATION | |

CONTRACT NO.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23665-5225

| APPROVALS | DATE |
|---|---|
| DRAWN LANGFORD | 6JUN95 |
| CHECKED | |
| ISSUED (MSE) | |
| WMJ | 9OCT97 |

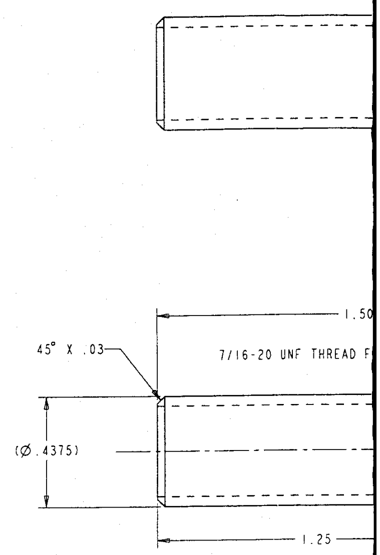
TITLE
NTF SPLIT DRAW NUT
SPLIT DRAW NUT ASSEMBLY

| SIZE | FSCM NO. | DWG. NO. | REV |
|---|---|---|---|
| D | | 1079454 | D |
| SCALE FULL | | SHEET 1 OF 1 | |

4 3 2 1

NOTES

1. INTERPRET THIS DRAWING PER DOD-D-1000 AND DOD-STD-100
2. INTERPRET DIMENSIONS AND TOLERANCES PER ANSI Y14.5M-1982
3. REMOVE ALL BURRS AND SHARP EDGES
4. SURFACE ROUGHNESS OF 63 MICROINCHES UNLESS OTHERWISE SPECIFIED
5. NO FIOS REQUIRED
6. NO DEVIATIONS WITHOUT APPROVAL OF TPE
7. MATERIAL CERTIFICATION & TRAVELERS REQUIRED.
8. PULL TEST REQUIREMENTS:
   (1) TEST AT LEAST 3 BOLTS IN TENSION
   (2) CERTIFICATION PAPER-WORK ON EACH TEST REQ'D.

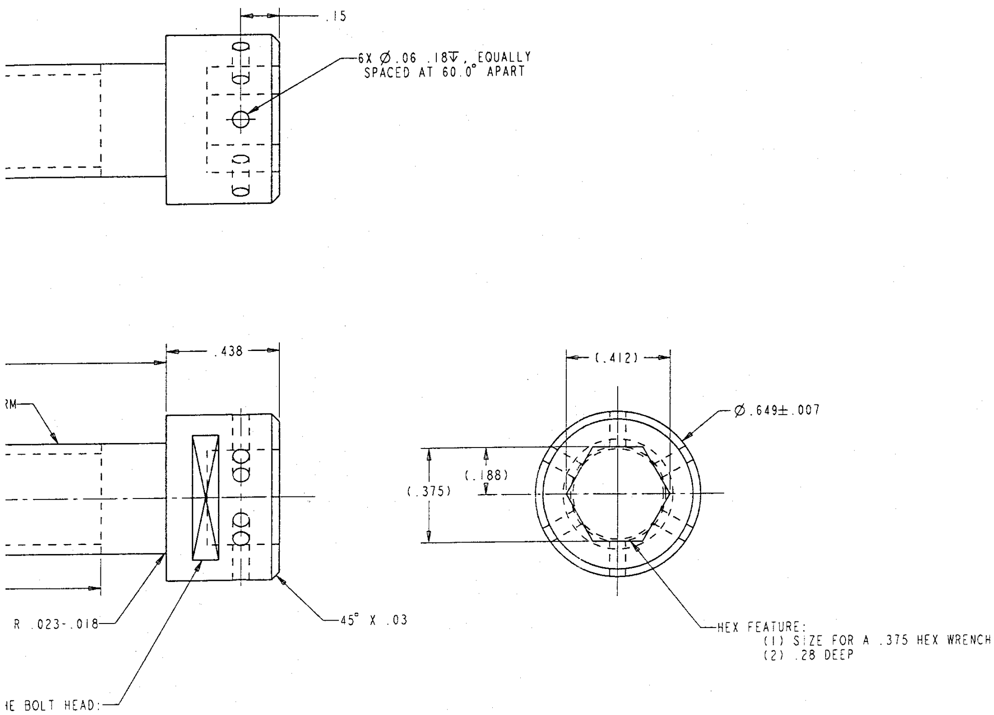



CHEMICALY ETCH THE FOLLOWING AROUND
MAT'L: VASCO-200
Rc = 43/47
LD-1080730-1
MODEL# DA19523
TORQUE = IN-LB

| CAGE | DWG NO. | SH | REV |
|---|---|---|---|
| 54806 | | | |

REVISIONS

| ZONE | LTR | DESCRIPTION | DATE | APPROVED |
|---|---|---|---|---|




-1 7/16 UNF SHCS BOLT
( 12 REQ'D )
SCALE = 4:1

| QTY REQ'D | CAGE CODE | PART OR IDENT NO. | NOMENCLATURE OR DESCRIPTION | MATERIAL / SPECIFICATION | ZONE | ITEM NO |
|---|---|---|---|---|---|---|
| 12 | | -1 | 7/16-20 UNF SHCS BOLT | VASCO-200, Rc=43/47 | | 1 |

PARTS LIST

| PART DASH NO | NEXT | FINAL | NEXT ASSY | USED ON |
|---|---|---|---|---|
| -1 | 12 | | 1079464 | DA19523 |

QTY REQD PER ASSY — APPLICATION

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS .XX ± .02 .XXX± .005
ANGULAR .XX ± 25°
DO NOT SCALE DRAWING

TREATMENT: Rc = 43/47

FINISH

SIMILAR TO | ACT. WT | CALC WT

CONTRACT NO.

| APPROVALS | DATE |
|---|---|
| DRAWN W.M.LANGFORD | 8MAY96 |
| CHECKED | |
| NSE | |
| TPC WMJ | |

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23681-0001

TITLE
NTF SPLIT DRAW NUT
7/16-20 UNF SHCS BOLT DETAILS

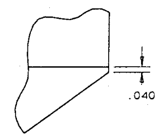
SIZE D | CAGE CODE 54806 | DWG NO. 1080730 | REV
SCALE | SHEET

ENGINEER | APPROVALS | DATE

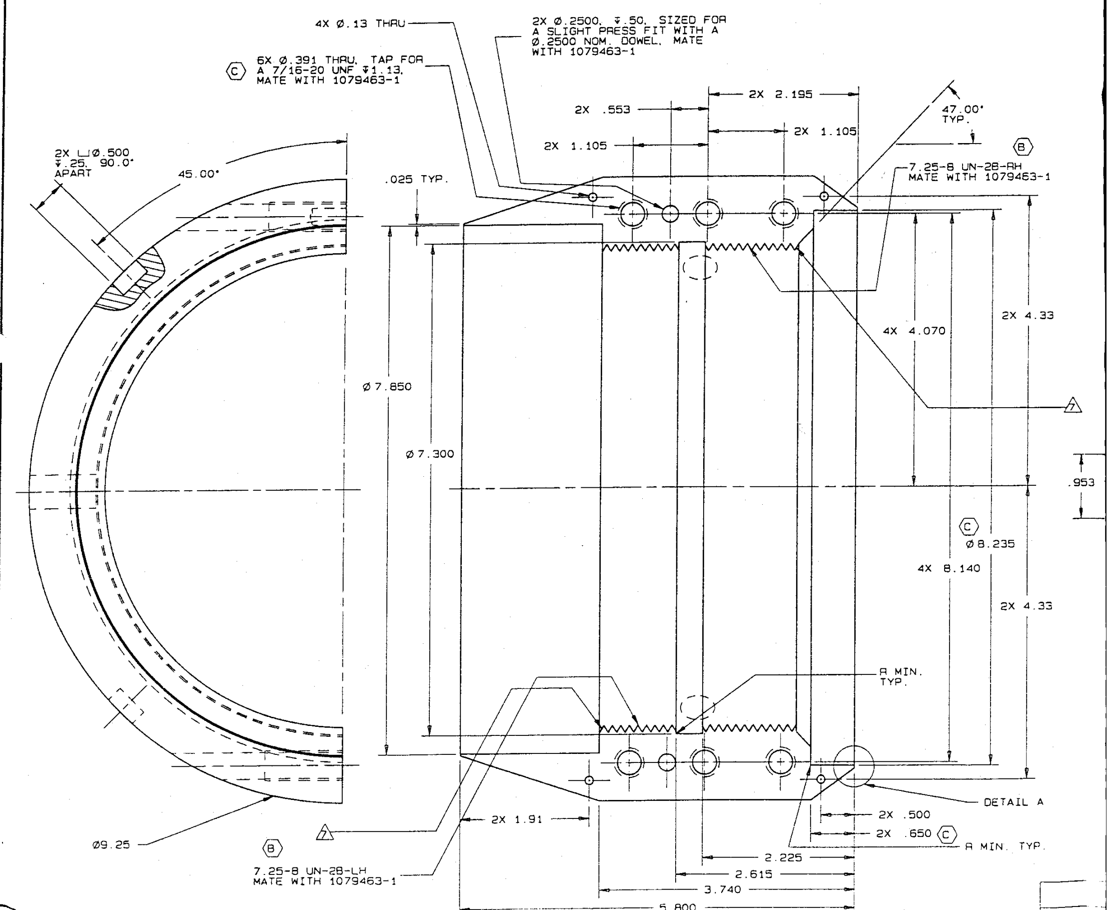
4 3 2 1

## NOTES

1. APPLICABLE STANDARDS/SPECIFICATIONS:
   ANSI Y14.5M-1982, DIMENSIONS & TOLERANCES
2. REMOVE ALL BURRS AND SHARP EDGES
3. SURFACE ROUGHNESS OF 125 MICROINCHES UNLESS OTHERWISE SPECIFIED
4. NO F.I.O.S. REQUIRED
5. NO CHANGES OR DEVIATIONS FROM THE DRAWING SHALL BE MADE WITHOUT PRIOR APPROVAL OF THE LaRC TECHNICAL PROJECT ENGINEER
6. ASSEMBLE THE SPLIT NUT BEFORE MACHINING INTERNAL GEOMETRY.
7. MACHINE A "HIGBEE" THREAD FORM AT THE BEGINNING OF THE THREADED GEOMETRY AFTER ASSEMBLY.




DETAIL A
TYPICAL OF ITEMS NO. -1 & -2
SCALE = 2:1

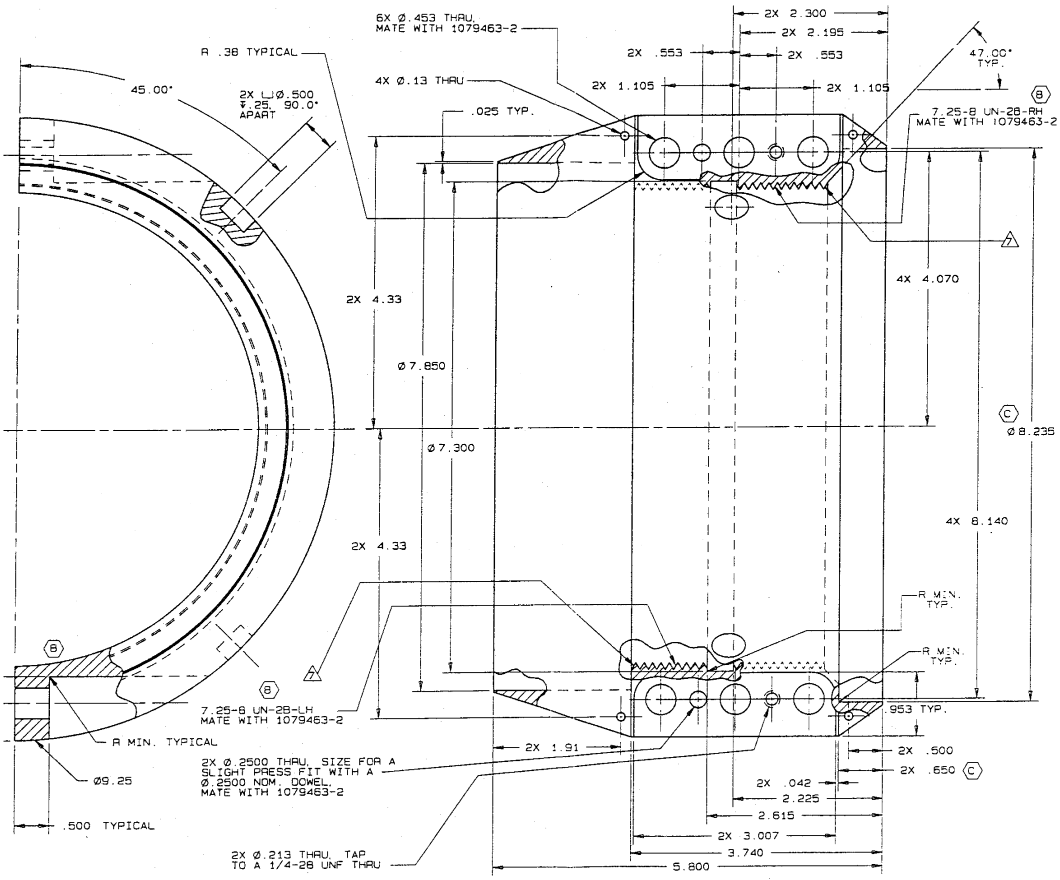



-2 SPLIT DRAW NUT, RIGHT

( 1 REQ'D )

SOME DETAIL OMITTED FOR CLARITY

| REVISIONS | | | | |
|---|---|---|---|---|
| ZONE | LTR | DESCRIPTION | DATE | APPROVED |
| | A | ADDED "ANNEALED CONDITION" | 2MAY96 | |
| | B | ADDED Ø1/2 INSPECTION THRU HOLE<br>ADDED COUNTER-BORE CUT-OUT<br>CHANGED THREAD FIT FROM -3 TO -2 | 20JUL96 | |
| | C | DELETED Ø1/2 INSP. HOLE<br>CHANGED Ø8.050 TO Ø8.235<br>CHANGED ↧.90 TO ↧1.13 | 23JUN97 | WMJ |




## -1 SPLIT DRAW NUT, LEFT

( 1 REQ'D )

SOME DETAIL OMITTED FOR CLARITY

| QTY REQ'D | FSCM NO. | PART OR IDENT NO | NOMENCLATURE DESCRIPTION | MATERIAL / SPECIFICATION | ZONE | ITEM NO |
|---|---|---|---|---|---|---|
| 1 | | -2 | SPLIT DRAW NUT, RIGHT | NITRONIC 60 ANNEALED CONDITION | | 2 |
| 1 | | -1 | SPLIT DRAW NUT, LEFT | | | 1 |

PARTS LIST

| PART DASH NO | QTY REQD PER ASSY | NEXT ASSY | USED ON |
|---|---|---|---|
| -2 | 1 | 1079464 | |
| -1 | 1 | | |

APPLICATION

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS: .XX ± .02, .XXX ± .005
ANGULAR ± .25°
DO NOT SCALE DRAWING

TREATMENT: ANNEALED CONDITION

FINISH

CONTRACT NO.

APPROVALS / DATE
DRAWN: LANGFORD 6JUN95
CHECKED
ISSUED (MSE)
WMJ 9 OCT 97

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
HAMPTON, VIRGINIA 23665-5225

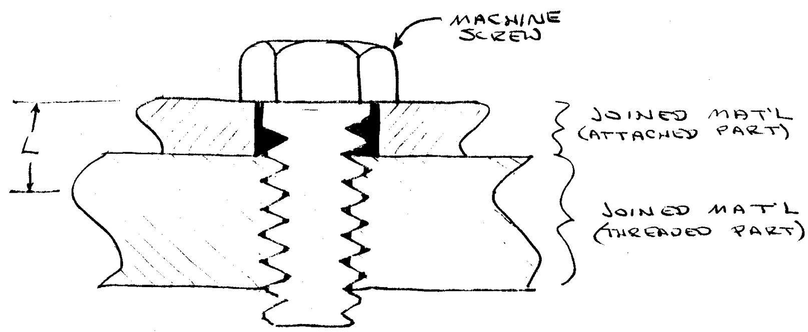
TITLE: NTF SPLIT DRAW NUT
SPLIT DRAW NUT DETAILS

SIZE: D | FSCM NO | DWG NO: 1079463 | REV: C

SCALE: FULL | SHEET 1 OF 1

RELAXATION OF THERMAL STRESS IN SCREWS

THE TYPICAL JOINT FOR WHICH THE RELAXATION TECHNIQUE IS APPLICABLE IS SHOWN BELOW. A GOOD FREE LENGTH TO ASSUME FOR THE SCREW WOULD BE TO USE THE THICKNESS OF THE JOINED MATERIAL PLUS ONE-HALF THE NOMINAL SCREW DIAMETER.

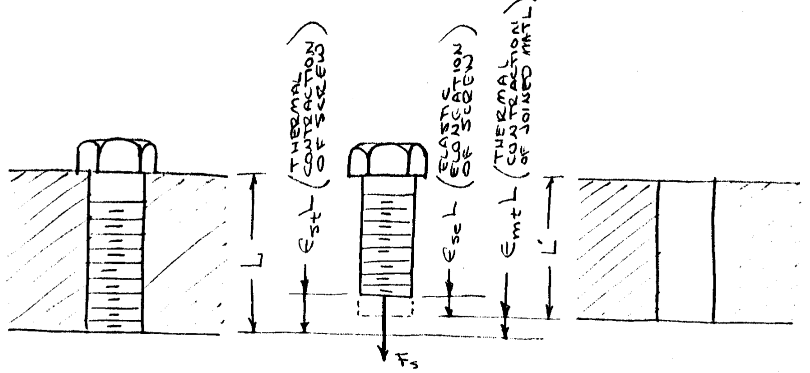



SECTION CUT OF TYPICAL JOINT

STEP 1 - AXIAL STRAIN (CONVENTIONAL ANALYSIS)

THE FOLLOWING DEVELOPMENT ASSUMES TEMPERATURE DIFFERENCES THAT PRODUCE THERMAL CONTRACTIONS BUT THE SAME RESULTS CAN BE OBTAINED FOR EXPANSIONS IF THE DIFFERENCES IN THE THERMAL COEFFICIENTS PRODUCE MORE EXPANSION IN THE JOINED MATERIAL THAN IN THE SCREW.

ASSUME THE SCREW AND THE JOINED MATERIAL ARE FREE TO CONTRACT AND THEN A FORCE IS APPLIED TO THE SCREW TO ELONGATE IT TO THE SAME LENGTH AS THE JOINED MATERIAL (AFTER CONTRACTION), SEE ILLUSTRATIONS ON NEXT SHEET.




ORIGINAL LENGTHS | SCREW AFTER THERMAL CONTRACTION | JOINED MAT'L AFTER THERMAL CONTRACTION

EQUATING FINAL LENGTHS:

$$L' = L - \epsilon_{st}L + \epsilon_{se}L = L - \epsilon_{mt}L$$

$$\therefore -\epsilon_{st} + \epsilon_{se} = -\epsilon_{mt}$$

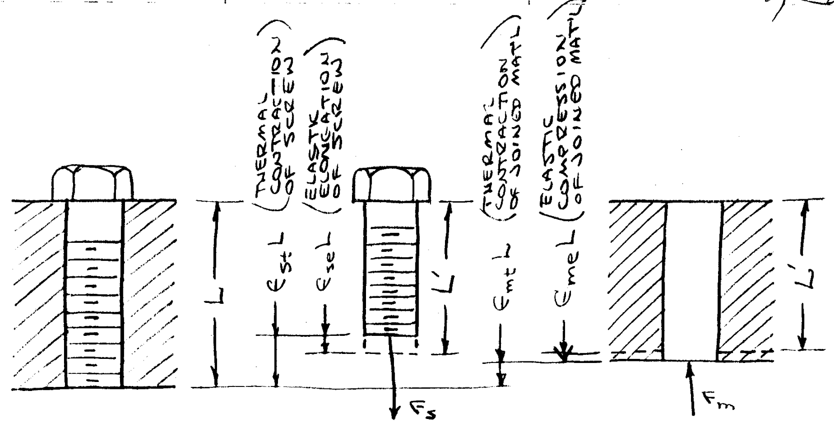
SUBSTITUTING AND SOLVING FOR FORCE:

$$-\alpha_s \Delta T + \frac{F_s}{A_s E_s} = -\alpha_m \Delta T$$

$$\boxed{F_s = (\alpha_m - \alpha_s) A_s E_s \Delta T}$$ (FORCE FROM A CONVENTIONAL ANALYSIS)

STEP 2 - ELASTICITY (INCLUDING JOINED MATERIAL)

AS BEFORE, ASSUME FREE THERMAL CONTRACTION OF THE SCREW AND THE JOINED MATERIAL BUT THEN APPLY A FORCE TO BOTH THE SCREW AND THE JOINED MATERIAL TO ELONGATE THE SCREW AND COMPRESS THE JOINED MATERIAL, SUFFICIENT TO PRODUCE THE SAME FINAL LENGTHS. THE FORCE IN EACH IS THE SAME SINCE ONE IS THE REACTION TO THE OTHER. THE RESPECTIVE STRAINS ARE ILLUSTRATED ON THE NEXT SHEET.




ORIGINAL LENGTHS

SCREW AFTER THERMAL CONTRACTION

JOINED MAT'L AFTER THERMAL CONTRACTION

EQUATING FINAL LENGTHS:

$$L' = L - \epsilon_{st} L + \epsilon_{se} L = L - \epsilon_{mt} L - \epsilon_{me} L$$

$$\therefore \; -\epsilon_{st} + \epsilon_{se} = -\epsilon_{mt} - \epsilon_{me}$$

SUBSTITUTING AND SOLVING FOR FORCE:

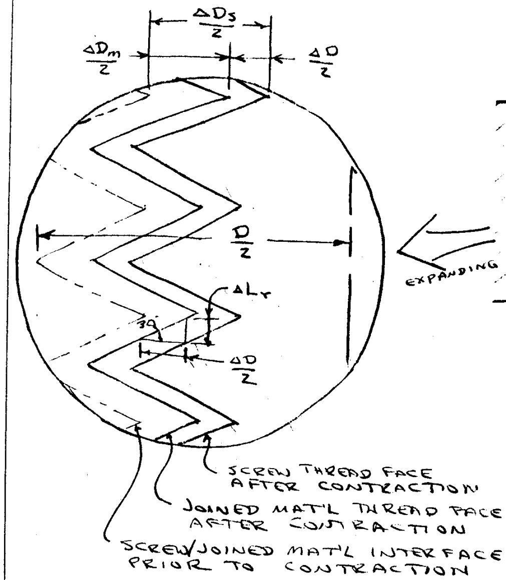
$$-\alpha_s \Delta T + \frac{F_s}{A_s E_s} = -\alpha_m \Delta T - \frac{F_m}{A_m E_m}$$

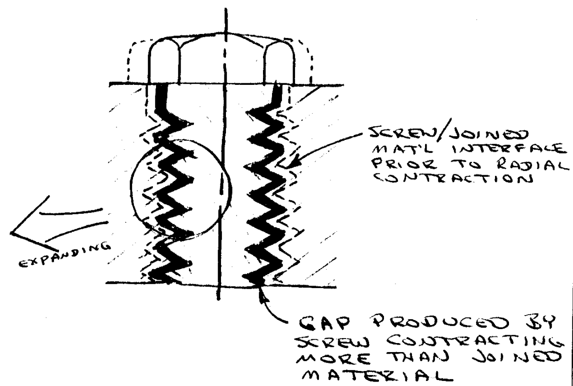
$$F_s = F_m \implies \boxed{F_{se} = \frac{(\alpha_s - \alpha_m)\Delta T}{\frac{1}{A_m E_m} + \frac{1}{A_s E_s}}}$$

(FORCE FROM INCLUDING ELASTICITY OF JOINT)

## STEP 3 – RADIAL CONTRACTION

THE EFFECT OF RADIAL CONTRACTION IS ADDITIVE WITH THE PREVIOUSLY DEVELOPED STRAINS AND CAN BE CONSIDERED AS A RELAXATION IN THE AMOUNT OF ELASTIC STRAIN THAT IS REQUIRED TO ACHIEVE EQUILIBRIUM. WHEN THE SCREW CONTRACTS MORE THAN THE JOINED MATERIAL, A GAP IS PRODUCED RADIALLY THAT CAN BE TRANSPOSED INTO AN AXIAL COMPONENT (USING THE THREAD GEOMETRY) AND USED TO REDUCE THE AMOUNT THAT THE SCREW IS REQUIRED TO ELONGATE, SEE ILLUSTRATIONS ON THE NEXT TWO SHEETS.




NOMENCLATURE:

$\Delta D_s \equiv$ RADIAL CONTRACTION OF SCREW

$\Delta D_m \equiv$ RADIAL CONTRACTION OF JOINED MAT'L

$\Delta D \equiv$ DIFFERENCES IN RADIAL CONTRACTION

$\Delta L_r \equiv$ EFFECTIVE AXIAL CONTRACTION

ILLUSTRATION OF RADIAL CONTRACTION

FOR A SLOPE OF 30° OF THE THREAD FACE, THE EFFECTIVE AXIAL CONTRACTION CAN BE EXPRESSED IN TERMS OF THE DIFFERENCES IN THE RADIAL CONTRACTION OF THE SCREW AND THE JOINED MATERIAL:

$$\tan 30^\circ = \frac{1}{\sqrt{3}} = \frac{\Delta L_r}{\Delta D/2}$$

$$\therefore \Delta L_r = \frac{\Delta D}{2\sqrt{3}}$$

WHERE
$$\begin{aligned}\Delta D &= D_m - D_s \\ &= (D - \Delta D_m) - (D - \Delta D_s) \\ &= \Delta D_s - \Delta D_m \\ &= D\alpha_s \Delta T - D\alpha_m \Delta T \\ &= D(\alpha_s - \alpha_m)\Delta T\end{aligned}$$

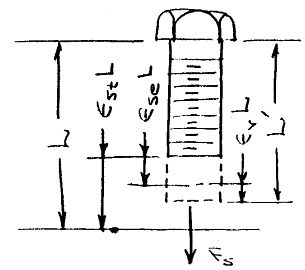
SUBSTITUTING

$$\Delta L_r = \frac{D(\alpha_s - \alpha_m)\Delta T}{2\sqrt{3}}$$

IN TERMS OF STRAIN:

$$\epsilon_r = \frac{\Delta L_r}{L} = \frac{D}{L}(\alpha_s - \alpha_m)\frac{\Delta T}{2\sqrt{3}}$$ (EFFECTIVE AXIAL STRAIN)

THE ADJACENT SKETCH ILLUSTRATES THE EFFECT OF THE AXIAL COMPONENT OF THE DIFFERENTIAL RADIAL CONTRACTION. BASICALLY THE FINAL LENGTH IS ACHIEVED BY A COMBINATION OF THE ELASTIC STRAIN AND THE EFFECTIVE AXIAL STRAIN ATTRIBUTED TO DIFFERENTIAL RADIAL CONTRACTION.




SCREW AFTER THERMAL CONTRACTION

EQUATING FINAL LENGTHS OF THE SCREW AND THE JOINED MATERIAL (REFER TO DEVELOPMENT IN STEP 2):

$$L' = L - \epsilon_{st} L + \epsilon_{se} L + \epsilon_r L = L - \epsilon_{mt} L - \epsilon_{me} L$$

$$\therefore \; -\epsilon_{st} + \epsilon_{se} + \epsilon_r = -\epsilon_{mt} - \epsilon_{me}$$

SUBSTITUTING AND SOLVING FOR FORCE

$$-\alpha_s \Delta T + \frac{F_s}{A_s E_s} + \frac{D}{L}(\alpha_s - \alpha_m)\frac{\Delta T}{2\sqrt{3}} = -\alpha_m \Delta T - \frac{F_m}{A_m E_m}$$

$$\frac{F_s}{A_s E_s} + \frac{F_m}{A_m E_m} = (\alpha_s - \alpha_m)\Delta T - \frac{D}{L}(\alpha_s - \alpha_m)\frac{\Delta T}{2\sqrt{3}}$$

$$F_s = F_m \Rightarrow \boxed{F_{scr} = \frac{\left(1 - \frac{D/L}{2\sqrt{3}}\right)(\alpha_s - \alpha_m)\Delta T}{\frac{1}{A_s E_s} + \frac{1}{A_m E_m}}}$$

(FORCE INCLUDING JOINT ELASTICITY AND RADIAL CONTRACTION)

## STRESS

THE ABOVE FORCES CAN BE CONVERTED TO STRESSES BY DIVIDING WITH THE TENSILE STRESS AREA OF SCREW.

NOTE:

IF ATTACHED PART OF JOINED MAT'L IS OF A THIRD TYPE OF MATERIAL, THE RIGHT SIDE OF THE EQUATION EQUATING FINAL LENGTHS CAN BE ADJUSTED TO REFLECT RESPECTIVE LENGTHS (eg $L - \epsilon_{mt1} L_1 - \epsilon_{me1} L_1 - \epsilon_{mt2} L_2 - \epsilon_{me2} L_2$), CORRESPONDING COEFFICIENTS OF THERMAL EXPANSION SUBSTITUTED, AND EQUATION THEN SOLVED FOR FORCE. DIFFERENCES IN THE THERMAL COEFFICIENTS FOR RADIAL CONTRACTION WOULD NOT CHANGE IN THAT THE EFFECT IS ONLY DEPENDENT ON THE COEFFICIENTS FOR THE SCREW AND THE THREADED PART OF THE JOINED MAT'L.