ORIGINALE ARCHIVIO

CARLO GAVAZZI SPACE SpA	RICH SYSTEM	DOC N°: RICSYS-DC-CGS-002
		ISSUE : 1 DATE: 08/09/05
	DOCUMENT CHANGE NOTICE	PAGE 1 OF 6

DOCUMENT TITLE:	DOCUMENT N°	IS:	DATE:
LOWER TOF STRUCTURAL ANALYSIS REPORT	RICSYS-RP-CGS-012	1	29/06/04

CHANGE AUTHORITY:	CHANGE TITLE:
COMMENTS FROM NASA	UPDATE JOINTS ANALYSES

PAGE	TEXT OF THE CHANGE
80-100	The analysis of the bolts was performed using the approach as per ANNEX 1of the document. Under NASA request the joints are now analyzed using a new approach furnished by NASA, following the NSTS 08307, Criteria For Preloaded Bolts (July 6 1998) and attached to this DCN. The scope of this DCN is to provide the results of the updated analyses of the joints of ~~U~~LTOF All the structural joints presented in this document are analyzed using the new approach and the results of these analyses supersede the joints analyses of the document. The analyses provide the following MoS:

MS1	Joint separation
MS2	Direct Tension Ultimate
MS3	Direct Tension Yield
MS4	Total Tension Ultimate
MS5	Total Tension Yield
MS6	Direct Thread shear Ultimate
MS7	Total Thread shear Ultimate
MS8	Shear Ultimate
MS9	Bending Ultimate
MS10	Combined shear, tension and bending ultimate

Table 0-1: MoS definition

PREPARED BY:	CHECKED BY	PRODUCT ASSURANCE	CONFIG. CONTROL
SIGN	SIGN	SIGN	SIGN
DATE 08/09/05	DATE 08/09/05	DATE 09.09.05	DATE 27/3/5
PROJ. CONTROL	**CONTRACT ADMIN.**	**PROGR. MANAGER**	**DATA MANAGEMENT**
SIGN N.A.	SIGN N.A.	SIGN	SIGN
DATE	DATE	DATE 5/9/05	DATE

COSTUMER APPROVAL (if required)	DATE
SUBCONTRACTOR AGREEMENT (if required)	DATE

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Mod N° DCN-10/01

CONTINUATION SHEET

PAGE	TEXT OF THE CHANGE
	Additional output are implemented for the fracture and fatigue analysis: - Max preload - Stiffness factor - Load in plane factor - Applied tensile force - Applied shear force **FORCES DEFINITION** All the forces used in this document come from the document: all the joints are analyzed using the worst load cases found in the previous analysis. **BOLT SIZE** The size of the bolt is generally the same to the one present in the document, if modifications are required due to the new approach, the difference is highlighted. **MATERIAL** The material of the bolt is generally the same to the one present in the document, if modification are required due to the new approach, the difference is highlighted. **TORQUE** According to NASA indication the applied torque for every joint is defined to have a preload of the 60% of the yield of the bolt material. This preload can be considered as first locking mean. Second locking device is self locking insert or nut; if different locking device is necessary the requirement is highlighted. All the torque values presented in this document are defined as the torque that provide the desired axial preload. The running torque of the self locking feature (when present) must be added as request by the locking feature.

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MOS RESULTS

LOWER TOF

NOMINAL CONFIGURATION

Worst case for MS10=combined ultimate

JOINT #	position	BOLT	TORQUE		APPLIED FORCES		MOS RESULTS											REMARKS
			% Fty	AVERAGE	AXIAL [N]	SHEAR [N]	MS1	MS2	MS3	MS4	MS5	MS6	MS7	MS8	MS9	MS10	Msmin	
JOINT 1	BKT/RING	NAS 1351N5	57%	19.5Nm	2817	5243	2,04	3,18	6	0,14	0,35	5,93	0,88	0,73	10	0,01	0,01	
JOINT 2	USS/UPPER BKT	NAS 1351N6	57%	35.25Nm	12402	478	0,03	1,02	1,42	0,42	0,123	0,47	0,04	28,22	10	0,421	0,03	
JOINT 3	USS/LOWER BKT	NAS 1351N3	66%	4.25Nm	427	924	5,78	12,11	14,73	0,52	0,147	10,4	0,32	2,28	10	0,453	0,15	
JOINT 4	RING/HONEYCOMB	NAS 1351N4	60%	10.25Nm	205	2903	25,81	49,06	59,05	0,55	0,168	39,49	0,26	0,94	10	0,299	0,17	
JOINT 5	SCINTILLATOR	M3 Al 7075	60%	0.6Nm	106	371	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,4	0,40	NON STRUCTURAL analysis not modified with respect the RD 1
JOINT 6	ROD END	NAS 6306DU	30%	18.5Nm	0	10143	10	10	10	0,47	1,34	10	2,7	0,38	10	0,07	0,07	cotter pin required, bolt TYPE MODIFIED

Worst case for MS1=separation

JOINT #	position	BOLT	TORQUE		APPLIED FORCES		MOS RESULTS											REMARKS
			% Fty	AVERAGE	AXIAL [N]	SHEAR [N]	MS1	MS2	MS3	MS4	MS5	MS6	MS7	MS8	MS9	MS10	Msmin	
JOINT 1	BKT/RING	NAS 1351N5	57%	19.5Nm	5428	2144	0,58	1,17	2,63	0,08	0,18	2,6	0,8	3,22	10	0,08	0,08	
JOINT 2	USS/UPPER BKT	NAS 1351N6	57%	35.25Nm	12402	478	0,03	1,02	1,42	0,42	0,123	0,47	0,04	28,22	10	0,421	0,03	
JOINT 3	USS/LOWER BKT	NAS 1351N3	66%	4.25Nm	482	703	5,01	10,61	12,93	0,52	0,146	9,1	0,32	3,31	10	0,486	0,15	
JOINT 4	RING/HONEYCOMB	NAS 1351N4	60%	10.25Nm	580	1258	8,48	16,69	20,22	0,54	0,16	13,31	0,24	3,47	10	0,509	0,16	
JOINT 5	SCINTILLATOR	M3 Al 7075	60%	0.6Nm	189	106	0,81	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,81	NON STRUCTURAL analysis not modified with respect the RD 1
JOINT 6	ROD END	NAS 6306DU	30%	18.5Nm	0	10143	10	10	10	0,47	1,34	10	2,7	0,38	10	0,07	0,07	cotter pin required, bolt TYPE MODIFIED

FAIL SAFE CONFIGURATION

Worst case

JOINT #	position	BOLT	TORQUE		APPLIED FORCES		MAX PRELOAD [N]	STIFFNESS FACTOR	LOAD IN PLANE	MOS RESULTS							REMARKS
			% Fty	AVERAGE	AXIAL [N]	SHEAR [N]				MS2	MS4	MS6	MS7	MS8	MS10	Msmin	
JOINT 1	BKT/RING	NAS 1351N5	57%	19.5Nm	2744	5130	22650	0,367	0,50	7,57	0,16	13,23	0,93	2,53	0,14	0,14	
JOINT 2	USS/UPPER BKT	NAS 1351N6	57%	35.25Nm	5238	1704	34950	0,385	0,50	8,54	0,59	5,96	0,16	15,39	0,59	0,16	
JOINT 3	USS/LOWER BKT	NAS 1351N3	66%	4.25Nm	515	1104	8333	0,271	0,50	20,74	0,53	17,9	0,33	4,49	0,51	0,33	
JOINT 4	RING/HONEYCOMB	NAS 1351N4	60%	10.25Nm	211	3460	15105	0,349	0,50	96,26	0,56	77,69	0,26	2,25	0,48	0,26	
JOINT 5	SCINTILLATOR	M3 Al 7075	60%	0.6Nm	212	741	NA	NA	NA	NA	NA	NA	NA	NA	0,54	0,54	NON STRUCTURAL analysis not modified with respect the RD 1
JOINT 6	ROD END	NAS 6306DU	30%	18.5Nm	NA	NA	18450	0,38	0,50	NA	NA	NA	NA	NA	NA	NA	cotter pin required, bolt TYPE MODIFIED

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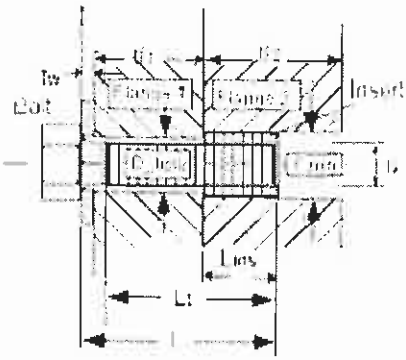
Formula Example



Loads

Applied tensile load [redacted]

Applied shear load $V := 582.6 \cdot N$

Applied bending moment $M := 0 \cdot m \cdot N$

Factors of Safety

Ultimate $SFu := 2.0$ Yield $SFy := 1.25$

Joint Separation $SFsep := 1.2$ Fitting factor $FF := 1.15$

Temperature data

Assembly $Temp_initial := 68 \cdot deg$

Maximum $Temp_max := 122 \cdot deg$

Minimum $Temp_min := 32 \cdot deg$

Bolt and Insert Data

Nominal diameter of bolt [redacted]

Number of threads/inch $Nt := 28 \frac{1}{in}$

Total length of bolt $L := 15.87 \cdot mm$

Length of insert $Lins := 6.35 \cdot mm$

Threaded length [redacted]

Min. external diameter of insert $Fmin := .306 \cdot in$

(If bolt is fully threaded, input Lt = L)

Depth of recess for insert [redacted]

Reference:E:\PROGETTI\AMS\bolt\BOLT_ANALYSIS_050222\thread_data_cgs.mcd

Washer Data

Thickness of washer $tw := 1.6 \cdot mm$

Outer Diameter of washer $Dw := 11.88 \cdot mm$

Inner Diameter of washer $Dwi := 6.47 \cdot mm$

Bolt head dia across flats $dw := 9.271 \cdot mm$ (used only if there is no washer)

Flange data

Thickness of flange 1 $tf1 := 3 \cdot mm$

Thickness of flange 2 [redacted]

Diameter of hole [redacted]

Note: If there is no washer, tw, Dw, and Dwi should be zero.

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Material Property Data

Bolt

Temperature correction factor for bolt strength ultimate $TSu_bolt := 0.94$ yield $TSy_bolt := 0.94$

Bolt ultimate tensile allowable stress $Ftu_bolt := 1103 \cdot 10^6 \cdot Pa$

Bolt ultimate shear allowable stress $Fsu_bolt := 655 \cdot 10^6 \cdot Pa$

Bolt yield tensile allowable $Fty_bolt := 877 \cdot 10^6 \cdot Pa$

Temperature correction factor for bolt modulus $TE_bolt := .94$

Modulus of elasticity of bolt $E_bolt := (29.1 \cdot 10^6 \cdot psi)$ Thermal coeffecient for bolt: $\alpha_bolt_hot := 9.1 \cdot 10^{-6} \cdot \frac{in}{in} \cdot \frac{1}{deg}$

$\alpha_bolt_cold := 7.8 \cdot 10^{-6} \cdot \frac{in}{in} \cdot \frac{1}{deg}$

Insert

Temperature correction factor for insert strength $TS_ins := 1.0$

Ultimate tensile allowable stress $Ftu_ins := 200000 \cdot psi$

Ultimate shear allowable stress $Fsu_ins := 0.6 \cdot Ftu_ins$

Washer

Temperature correction factor for washer modulus $TE_washer := 1.0$

Modulus of elasticity of washer $E_washer := (29.1 \cdot 10^6 \cdot psi)$

Flanges

Stiffness of the joint depends upon number of members in the grip of the fasteners, Modulus of elasticity of these members, and diameters of the bolt and the washer.

Temperature correction factor for flange 1 $Tf1E := 1.0$ (modulus) $Tf2s := 0.94$ (strength)

Temperature correction factor for flange 2 $Tf2E := 1.0$ (modulus) $Fsu_f2 := 262 \cdot 10^6 \cdot Pa$

Modulus of elasticity for the parts in the joint $E_flange1 := (10.5 \cdot 10^6 \cdot psi)$ $E_flange2 := (10.5 \cdot 10^6 \cdot psi)$

Coefficient of thermal expansion for flanges $\alpha_flange1_hot := 12.15 \cdot 10^{-6} \cdot \frac{in}{in} \cdot \frac{1}{deg}$ $\alpha_flange2_hot := 12.15 \cdot 10^{-6} \cdot \frac{in}{in} \cdot \frac{1}{deg}$

$\alpha_flange1_cold := 11.5 \cdot 10^{-6} \cdot \frac{in}{in} \cdot \frac{1}{deg}$ $\alpha_flange2_cold := 11.5 \cdot 10^{-6} \cdot \frac{in}{in} \cdot \frac{1}{deg}$

Torque/Preload data

Maximum torque $Tmax := 11.10 \cdot m \cdot N$ Loading plane factor: $b := 0.5$

Minimum torque $Tmin := 9.43 \cdot m \cdot N$ Preload Uncertainty: $\Gamma := 0.25$

Torque coefficient: $k := 0.15$

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Reference:E:\PROGETTI\AMS\bolt\BOLT_ANALYSIS_050222\bolt_ stiffness_insert_RevC_cgs.mcd

Bolt Load data

Bolt/joint stiffness factor	$\phi = 0.331$	Preload due to temperature	$Pthr_pos = 563.4 \cdot N$
Max. preload	$PLDmax = 15130.4 \cdot N$		$Pthr_neg = -455.7 \cdot N$
Min. preload	$PLDmin = 6241.2 \cdot N$	Uncertainty factor	$\Gamma = 0.25$
Joint separation load	$Psep = 811.2 \cdot N$	Torque coefficient	$k = 0.15$
Max. load on the bolt(ultimate)	$Pb = 15387.3 \cdot N$	Loading plane factor	$n = 0.5$
Max. load on the bolt(yield)	$Pby = 15291 \cdot N$	Thread shear pullout load of bolt or insert	$Pths = 60004.2 \cdot N$
Bolt ultimate tensile strength	$PAt = 23601.2 \cdot N$	Thread shear pullout load in parent metal	$Ppths = 19093.2 \cdot N$

Length_check = "Bolt length is sufficient"

Summary of Margins for bolt:

Joint separation	$MS_1 = 7.01$	Direct Thread shear Ultimate	$MS_6 = 11.28$
Direct Tension Ultimate	$MS_2 = 14.18$	Total Thread shear Ultimate	$MS_7 = 0.24$
Direct Tension Yield	$MS_3 = 17.21$	Shear Ultimate	$MS_8 = 8.65$
Total Tension Ultimate	$MS_4 = 0.53$	Bending Ultimate	$MS_9 = 10$
Total Tension Yield	$MS_5 = 0.157$	Combined shear, tension and bending ultimate	$MS_{10} = 0.531$

Determination of the smallest margin of safety for the bolt, and the failure mode:

$MSbolt := \min(MS)$

$MSbolt = 0.157$ Failure_Mode = "Total Tension Yield"

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