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1. NOMENCLATURE

Dimensions

	Symbol	Units
Length of Structure	l	mm
Height of Structure	h	mm
Depth of Structure	d	mm
Length of panel	a	mm
Width of panel	b	mm
Thickness of panel	t	mm
Radius	r	mm
Diameter	D	mm
Pitch of rivets or bolts	s	mm
Effective width of skin	w	mm
Eccentricity	e	mm
Edge of distance of rivet or bolt	e	mm
Distance from Neutral axis to extreme fibre	y	mm
Area	A	mm^2
Volume	V	mm^3
Constant	K	-

1. NOMENCLATURE (cont.d)

Subscripts

	Symbol
Maximum	max
Minimum	min
Total	tot
Tension, Torsion	t
Compression	c
Shear	s
Bending,	b
Bearing	br
Ultimate	u
Yield	y
Critical	cr
Eulers formula	e
Polar	p
Radial	r
Resultant	res
Outer	o
Inner	i
Average	av
Allowable	All

Material properties

	Symbol	Units
Ultimate tensile strength	σ_{tu}	N/mm^2
Tensile yield strength	σ_{ty}	"
Compressive yield strength	σ_{cy}	"
Ultimate shear strength	τ_u	"
Ultimate bearing strength	σ_{bru}	"
Bearing yield strength	σ_{bry}	"
Youngs Modulus (tension)	E	"
Youngs Modulus (Compression)	Ec	"

1. NOMENCLATURE (cont.d)
Material Properties (cont.d)

	Symbol	Units
Tangent Modulus (direct)	E_t	"
Secant Modulus (direct)	E_s	"
Shear Modulus	G	"
Tangent Modulus (Shear)	G_t	"
Secant Modulus (Shear)	G_s	"
Poissons ratio	ν	
Elongation	δ	%

Section properties

Area	A	mm^2
Moment of Inertia (Second moment of area)	I	mm^4
Polar moment of inertia	Ip	mm^4
Modulus of section	Z	mm^3
Torsion constant	J	mm^4
Primary warping constant	R	mm^5
Secondary warping constant	r	mm^6
1st moment of Area	S	mm^3
Radius of Gyration	ρ	mm

Abbreviations

Reserve Factor	RF
Fatigue Quality Factor	FQF

Loads

	Symbol	Units
Axial load	P	N
Shear load	Q	N
Pressure	p	kPa
Running load or shear flow	q	N/mm
Bending Moment	M	N.mm or kNm
Torque	T	N.mm or kNm

1. NOMENCLATURE (cont.d)

Stress and Strain

	Symbol	Units
Direct stress	σ	N/mm^2
Applied shear stress	τ	"
Principal stresses	σ_1 σ_2	"
Max. shear stress	τ_{max}	"
Equivalent stress	σ_{eq}	"
Strain	ε	
Shear strain	γ	

Composite Notation

	Symbol	Units
Longitudinal modulus	E_{11}	N/mm^2
Transverse modulus	E_{22}	N/mm^2
In-plane shear modulus	G_{12}	N/mm^2
Longitudinal tensile strength	F_{1T}	N/mm^2
Transverse tensile strength	F_{2T}	N/mm^2
Longitudinal compressive strength	F_{1C}	N/mm^2
Transverse compressive strength	F_{2C}	N/mm^2
In-plane shear strength	F_{12}	N/mm^2
Interlaminar shear strength	F_{13}	N/mm^2
Open Hole Tension	OHT	
Filled Hole Compression	FHC	
Compression After Impact	CAI	
Room Temperature/As Received	RT/AR	
Coefficient of Thermal Expansion		
Longitudinal	α_{11}	$mm/mm/^oC$
Transverse	α_{22}	$mm/mm/^oC$
Barely Visible Impact Damage	BVID	
Uni-directional	U/D	

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2. DESIGN LOADS AND F.E.M. IDEALIZATION

The design load are coming out from the compound list reported in document:

JST-GEN-163/90
Dated 14 September 1990

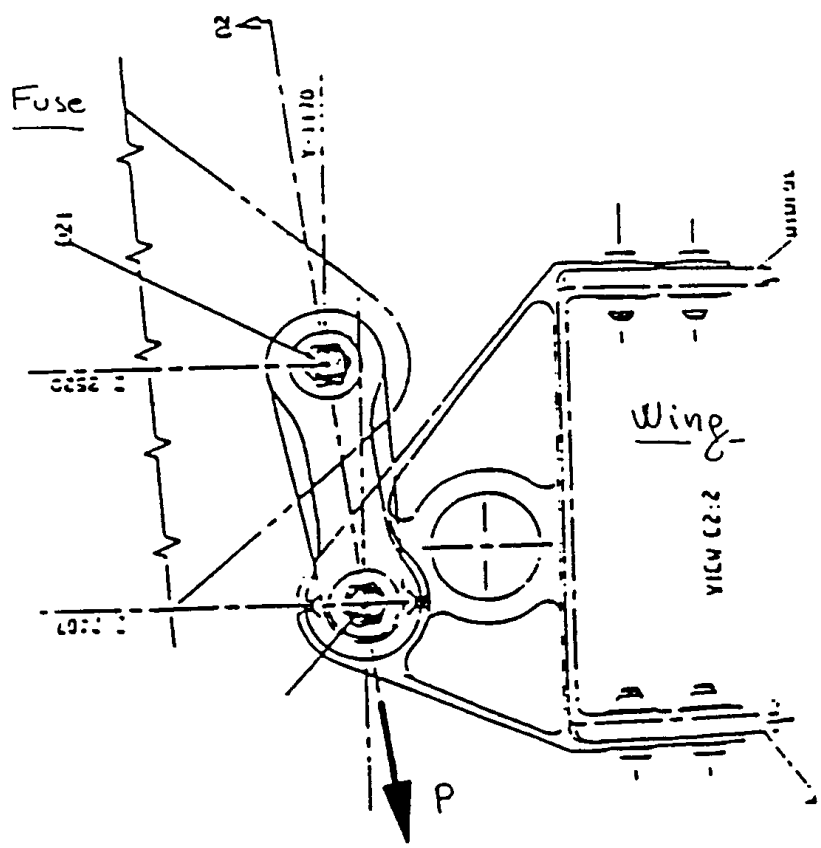
The worst case selected is:

C0242906 (REVERSED) R/TR JOINT CASE 6

Ultimate load

P = 175000 N
(applied to the
Wing Fitting
as shown)

Safety factor = 1.4
(ref JST-D-004)

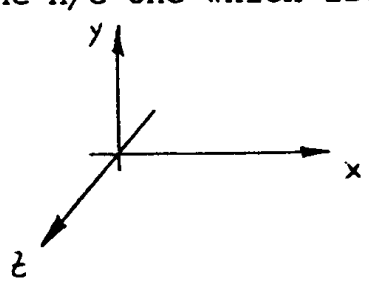


The coordinate system of reference is the A/C one which is:

X aft

Y starboard

Z up



2. DESIGN LOADS AND F.E.M. IDELIZATION (cont.d)

Aft shr attachment F.E.M. Idealization

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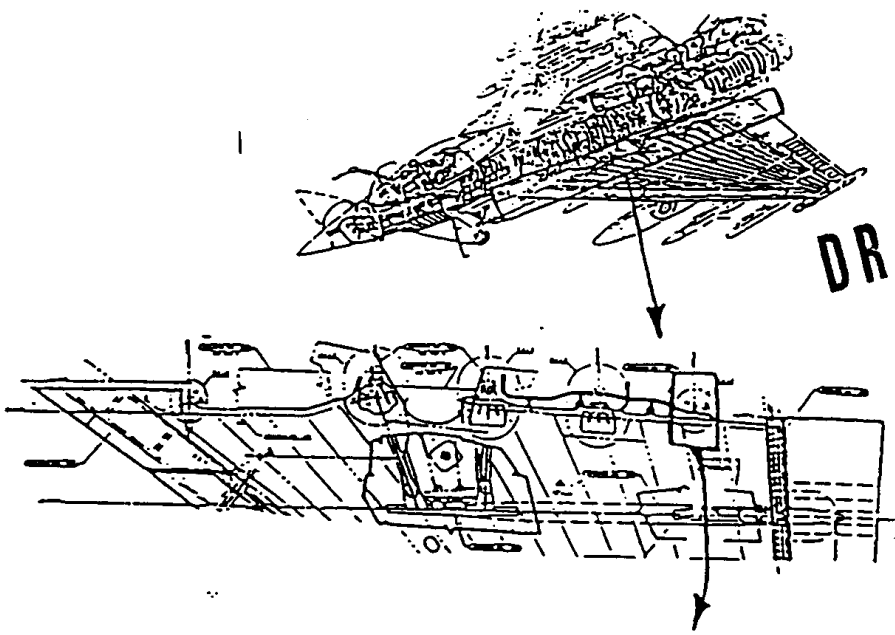
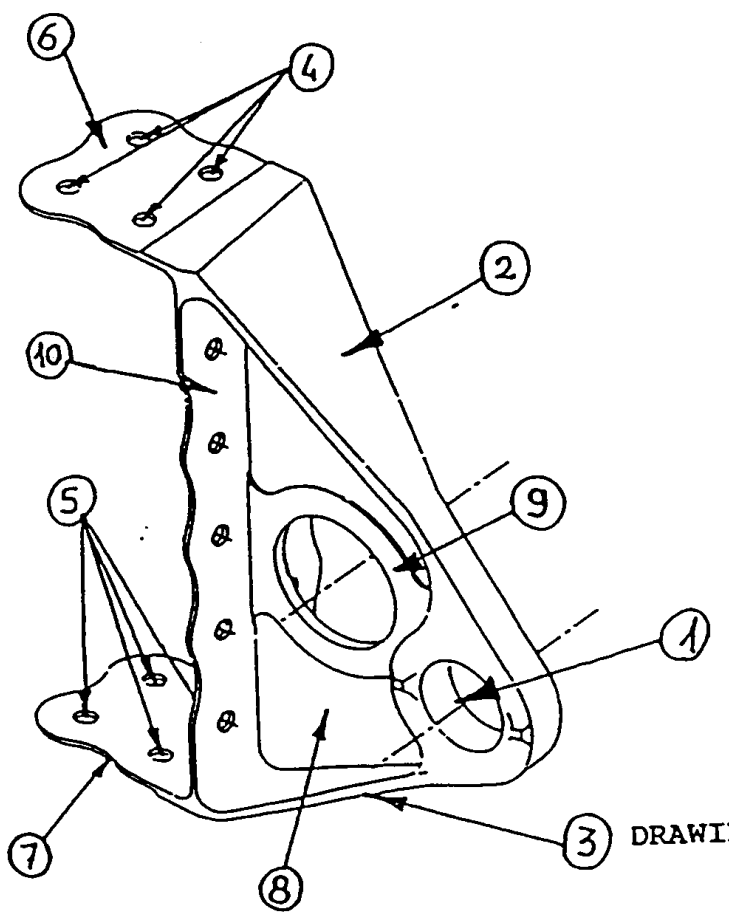
3. RESERVE FACTORS (RF) SUMMARY

Aft Shear Fitting





DRAWING N°: J5714242

DRAWING ISSUE: A 2 May1989

ASSY: DRG:

3. RESERVE FACTORS (RF) SUMMARY (cont.d)

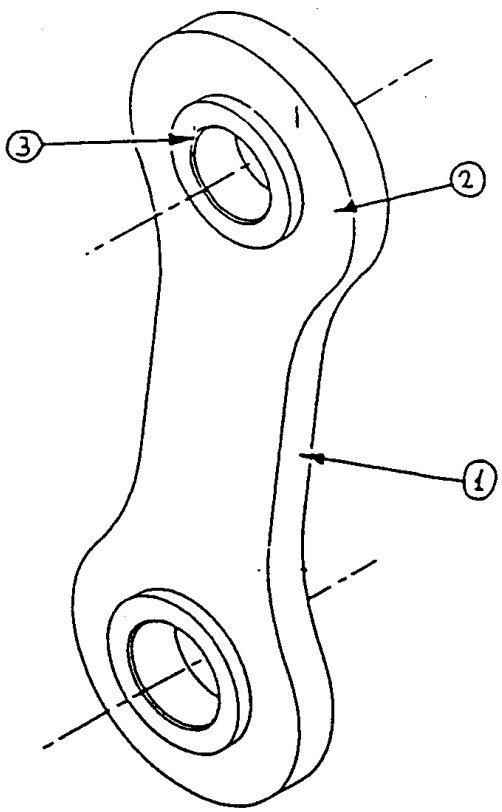
Aft Shear Fitting (cont.d)

DRAFT COPY

EFA AFTER SHEAR ATTACHMENT				SHEAR FITTING				DATE: 15 Feb 1991
ITEM	DIAGRAM LOCATION	DRAWING PART N° & ISSUE	MATERIAL	LOAD CASE	ALLOW LOAD / STRESS APPL LOAD / STRESS	REMARKS	R.F.	FILE PAGE REFERENCE
LUG	1	J 5714242 A	Ti Alloy 6Al-4V	C0242906 REVERSED R/TR JOINT CASE 6	401212 , 258000 190823 , 27960	ULTIMATE TENSILE LOAD	2	5.8
LUG	1				890 481	NET TENSION CHECK	1.85	5.9
UPPER FLANGE	2				890 506	TENSION CHECK	1.76	5.10
LOWER FLANGE	3				890 569	TENSION CHECK	1.56	5.11
FITTING UPPER SKIN	4				1680 1078	BEARING	1.56	5.12
FITTING LOWER SKIN	5				1680 1195	BEARING	1.41	5.12
UPPER SKIN JUNCTION	6				890 690	NET TENSION CHECK	1.3	5.13
LOWER SKIN JUNCTION	7				890 765	NET TENSION CHECK	1.2	5.14
FITTING WEB	8				520 463	SHEAR CHECK	1.12	5.14
STRESS CONCENTR	9				890 494		1.8	5.16
VERTICAL JUNCTION	10				890 381	NET TENSION CHECK	>2	5.17
LOWER FLANGE	3				5877 452	COMPRESS CRIPPLIN	1.3	5.19

3. RESERVE FACTORS SUMMARY (cont.d)

Link



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DRAWING N° : J5704245
DRAWING ISSUE: A
ASSY: DRG:

EFA AFTER SHEAR ATTACHMENT				LINK				REF DATE: 15 Feb 1991
ITEM	DIAGRAM LOCATION	DRAWING PART N° & ISSUE	MATERIAL	LOAD CASE	ALLOW LOAD STRESS / APPL LOAD STRESS	REMARKS	R.F.	FILE PAGE REFERENCE
LINK	1	J 5704245 A	Ti Alloy 6Al-4V	C0242906 REVERSED R/TR JOINT CASE 6	445 / 401	BUCKLING CHECK	1.1	6.8
LINK	2				890 / 463	NET TENSION CHECK	1.92	6.8
LUG	3				168459 / 96250	ULTIMATE TENSION	1.75	6.10
LUG					139654 / 96250	ULTIMATE SHEAR	1.45	6.10
LUG					520 / 301	SHEAR OUT	1.73	6.10

3. RESERVE FACTORS SUMMARY (cont.d)

Pin

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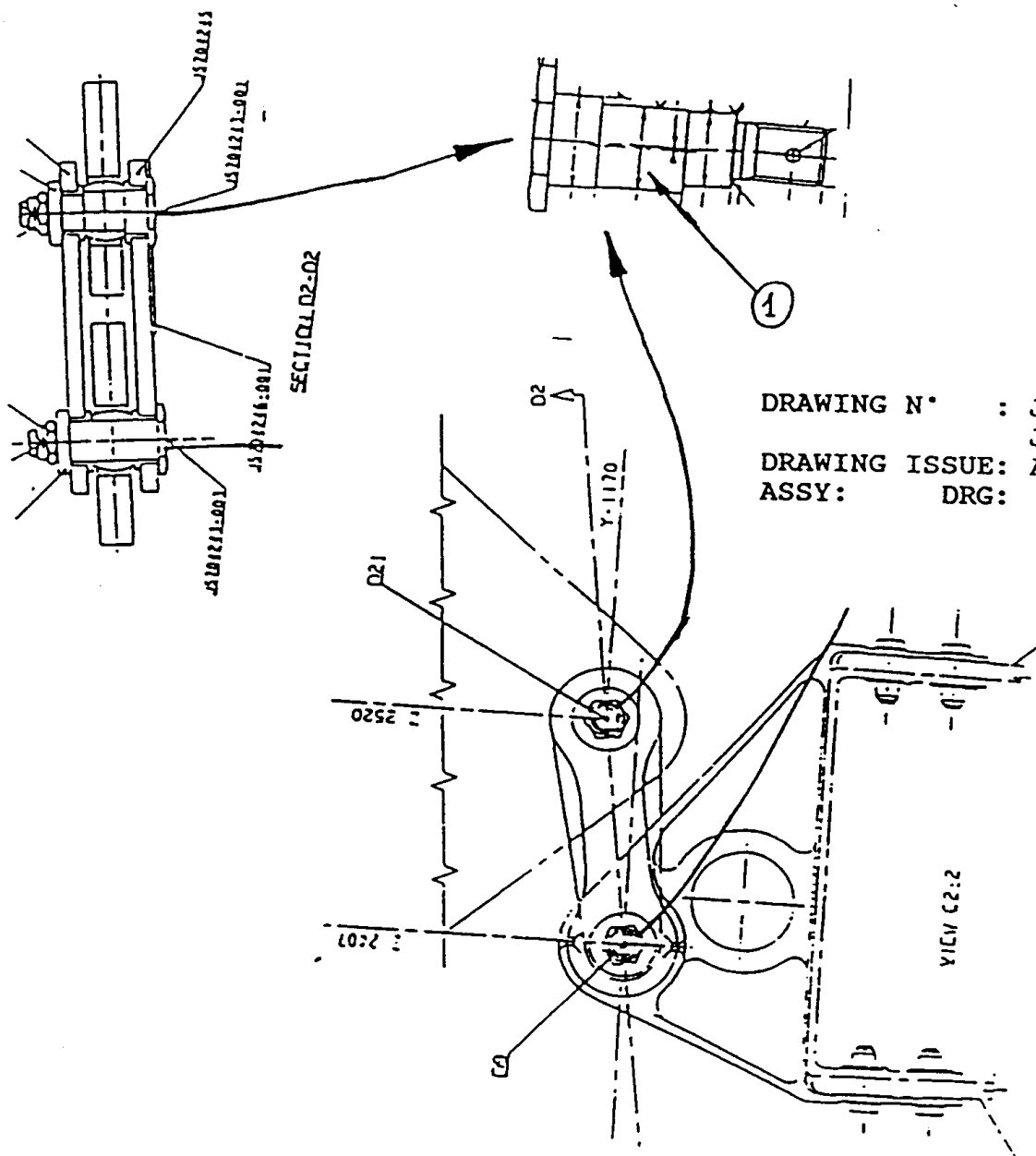


DRAWING N° : J5704243
J5714005
DRAWING ISSUE: A
ASSY: DRG:

EFA AFTER SHEAR ATTACHMENT				PIN			REF DATE: 15 Feb 1991		
ITEM	DIAGRAM LOCATION	DRAWING PART N° & ISSUE	MATERIAL	LOAD CASE	ALLOW STRESS / APPL STRESS		REMARKS	R.F.	FILE PAGE REFERENCE
PIN	1	J 5704243	15-5 PH (H900)	C0242906 REVERSED R/TR JOINT CASE 6	1310	463	BENDING	1.42	7.9
PIN	1	J 5714005 (2/8)			1170	1097	LIMIT LOAD BENDING	1.96	7.9

5. AFT SHEAR FITTIG CHECK STRESS

Description

The Aft Shear Fitting together with a Link that connects it to the rear fuse Fitting and with the latter itself is the most aft attachment of the total 5 attachment (3 bending) that costitute the Wing to Fuse connection
Such an attachment is denominated "Shear" since the connection Link is allowed to carry loads only along its own axis so that no moments can be introduced and, besides, being the above mentioned axis quasi-vertical (parallel to A/C z axis) only a small amount of tensile (or compressive) load can be introduced.
The fitting is a machined item made of 6Al-4V titanium alloy, fastened on the wing side to the upper and lower skin panels and, via a metallic clit, to the rear spar.

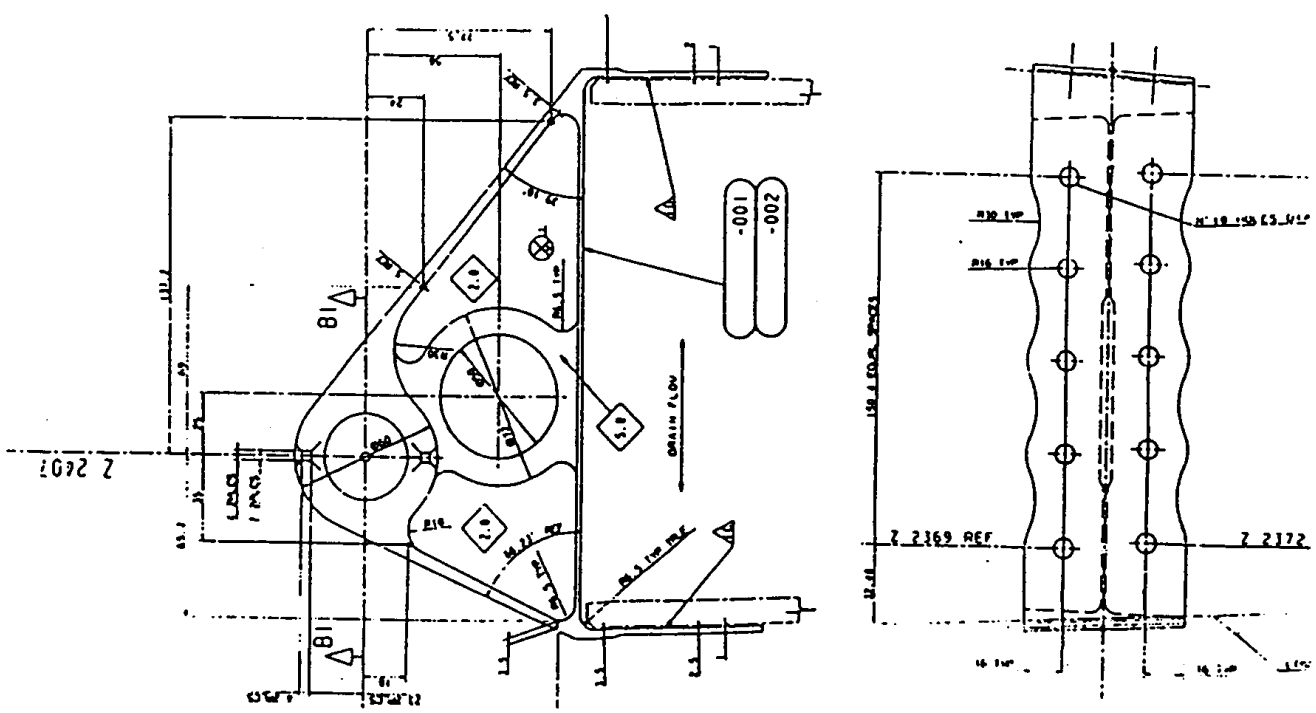
Design requirements and assumption

All the loads applied to the Wing to Fuselage attachments have to be factored in accordance with JST-D-010 (Interface Loads) and the ALN Document "34/FX/T370a/91002".
For the Aft attachment the factor to be considered is 1.10 and it is in addition to the safety factor of 1.4 that is to be used in deriveng Ultimate Loads (U.L.) as estabilished by the JST-D-027 "Stress Design Criteria" Document.
When comparing Design Load/stresses to the allowables one a minimum Reserve Factor (RF) of 1.0 must be achieved (Ref JST-D-027).

In the fitting analysis the critical applied load reported at page 2.1 is assumed to act also in the opposite direction of the one shown in order to perform appropriate check of some Fitting parts (i.e. Net tension check of Lower Flange fastened to skin _ see page 5.14).
This assumption is sligthly conservative since the applied load, obtained by cases giving such a tensile state in the fitting lower region, are not so large as the one assumed.

The Fitting internal loading and stressing derivation is made by means of standard methods as well as particular ones reported in well known literature.
When the latter is the case a reference is called up.
The used literature is summarized below:

JST-D-002	-	Fatigue Allowables
JST-D-004	-	CFC Properties and Allowables
DATA SHEET N. 15.0.1	-	BÃe Method for Lugs Calculation
BOEING BDM-6020	-	Crippling
BOEING BDM-6040	-	Stress Concentration



5. AFT SHEAR FITTIG CHECK STRESS (cont.d)

Drawing reference and Material Properties

Drawing Nr : J5714242 -

Issue A - AFT SHEAR FITTING

Material : TI 6Al - 4V

Properties : EF Standards - J 84.201

EUROFIGHTER GmbH	Metallic Material Selection Data Sheet for Design Purposes only
	For procurement requirements see J80.006

MATERIAL: Ti.Alloy 6Al-4V CONDITION: Annealed
FORM: Plate

Allowable Material Specifications. STRENGTH BASIS: Minimum Strength (see J84.501 for B basis strength)

AECMA -	AIT	BAe	CASA	MBB
EN 3464	MIL-T-9046 Type III Comp C or AMS 4911	BS TA56 or AMS 4911B	MIL-T-9046 Type III Comp C	3.7164.1

Thickness mm		6<a≤100 Unwelded	Welded
Ftu, MPa	L	890	840
	LT	890	
	ST		
Fty, MPa	L	820	780
	LT	820	
	ST		
Fcy, MPa	L	870	
	LT	870	
	ST		
Fsu, MPa		520	
Fbru, e/D=2.0 MPa (e/D=1.5 spec.case only)		1680	
		1310	
Fbry, e/D=2.0 MPa (e/D=1.5 spec.case only)		1360	
		1120	
e, %	L	8	
	LT	8	
	ST		
E, GPa		110	110
Ec, GPa		113	113
G, GPa		43	43
v,		0.32	0.32

REMARKS:
Fusion weldable.
Only to be fusion welded with the prior permission of the relevent Chief Stressman/Material specialist.

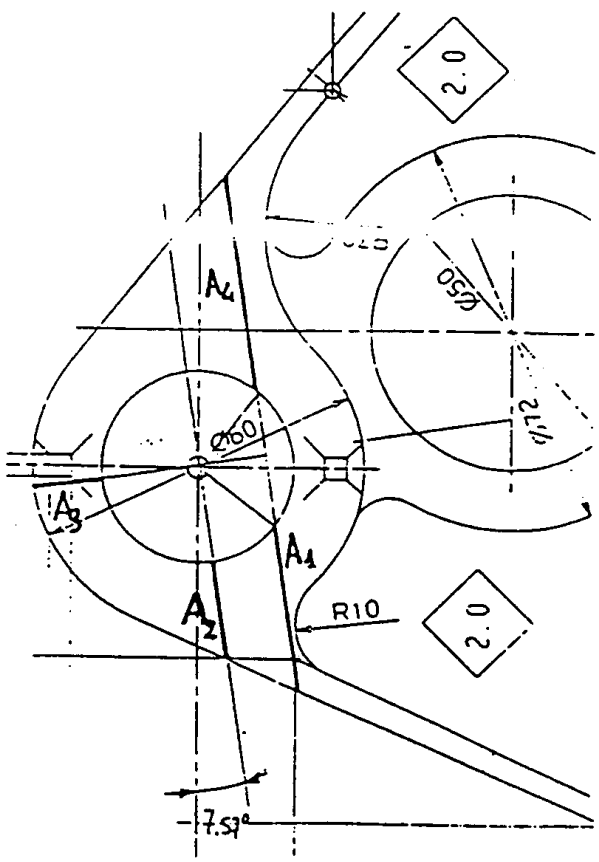
Page	1	2								B	J84.201
Issue	C	C								Edition C	

 For approval signatures see ARS.

5. AFT SHEAR FITTIG CHECK STRESS (cont.d)

Stress calculation

LUG ANALYSIS [1]



A_1 = 30*16 = 480 mm^2

A_2 = 18*16 = 288 mm^2

A_3 = 12.5*16 = 200 mm^2

A_4 = 40*16 = 640 mm^2

$$A_{average} = \frac{6}{\frac{3}{A_1} + \frac{1}{A_2} + \frac{1}{A_3} + \frac{1}{A_4}} = 368.4 \text{ mm}^2$$

[1] BAe method. Data sheet N. 15.0.1

5. AFT SHEAR FITTIG CHECK STRESS (cont.d)

Stress calculation (cont.d)

Lug analysis (cont.d)

$A_{bearing} = 35*16 = 560\ mm^2$

$\frac{A_{average}}{A_{bearing}} = \frac{368.4}{560} = 0.658$

$K_{tru} = 0.805$ (from figure page 15.7.7)

$P_{tru} = K_{tru} \sigma_{tu} A_{br} = 0.805*890*560 = 401212\ N$

$P_{tran} = P \cos 7.57° = 175000\cos 7.57° = 173475\ N$

$R_{tr} = \frac{P_{tran}*1.1}{P_{tru}} = \frac{173475*1.1}{401212} = 0.476$

$R_{tu} = 0.9$ for titanium alloys

$\setminus_T = 0.852$ (from figure page 15.5.2)

$\frac{\setminus_s}{K} = 0.364$ (from figure page 15.5.3)

$K = 0.83$ (from figure page 15.5.1)

ULTIMATE SHEAR LOAD

$P_{su} = \frac{\setminus_s}{K} K 2at\sigma_{tu} = 0.364*0.83*2*30*16*890 = 258000\ N$

ULTIMATE TENSILE LOAD

$P_{tu} = \setminus_T (W-D)t\sigma_{tu} = 0.852*(60-35)*16*890 = 303300\ N$

$P_a = P*1.1 \sin 7.57° = 175000*1.1\sin 7.57° = 25400\ N$

$R.F. = \frac{1}{[R_a^{1.6} + R_{tr}^{1.6}]^{0.625}}$

where

$R_a = \frac{P_a}{P_{su}} = \frac{25400}{258000} = 0.098$

$R.F. = \frac{1}{[0.098^{1.6} + 0.476^{1.6}]^{0.625}} = 2$