EASA
European Union Aviation Safety Agency

Structural aspects of cabin installations

v1.4

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STC WORKSHOP

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Motivation

- Highlight structure-related issues
  - STCs dealing with cabin installations (CS-25 driven)
  - topics popping up frequently

- For YOU to benefit from
  - streamlined interpretation
  - common understanding
  - lessons-learned

  to mitigate resource consuming discussions / document update loops.

STC Supplemental Type Certificate

Content

- Loads
  - Load Envelope
  - (E)TSO approved equipment
  - Abuse Loads
- Compliance by Similarity
- Joint Allowables
- Certification Basis
- Check against Ultimate and Limit Load
- Miscellaneous
  - STC installation and accessibility
  - STC installation and compatibility with ADs
  - STC installation and design status
  - STC installation and 25.571
  - STC installation and applied design data / analysis methods
- Reference / Resources
- Abbreviations

Loads / Load Envelope (1)

CS Certification Specification

- Load Envelope
  - CS 25.307 Proof of structure
  - Compliance with strength and deformation requirements must be shown for each critical loading condition.

    Develop *maximum load envelope* from
    - Emergency landing loads (CS 25.561)
    - Flight (manoeuvre, gust) loads (CS 25.321 to CS 25.427)
    - Ground loads (CS 25.471 to CS 25.519)
    - other, e.g.
      - Pressure (decompression) loads (CS 25.365)
      - Abuse loads (CS 25.601/.803/.785/.1309)
  - additional factors (e.g. 25.561, 25.619 to .625, 25.785 etc.)

Loads / Load Envelope (2)

- 25.561 loads may <u>not</u> envelope all of above load conditions.

  For example, max. z-loads may result from gust or ground load conditions

  - difficult (or: impossible) to derive without TCH support/data as A/C flexibility/dynamic response typically not known

    (e.g. CS 25.341 'Gust and turbulence loads': "…by dynamic analysis"; CS 25.473 'Landing load conditions and assumptions': "…structural dynamic response of the airframe")

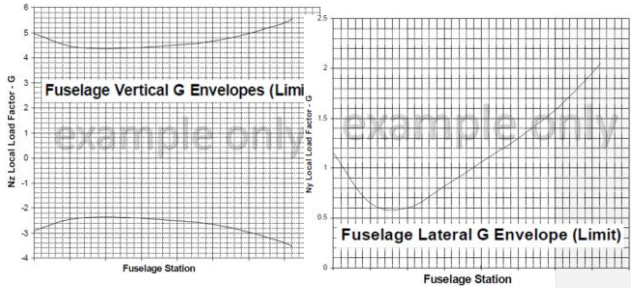
  - refer to TCH data (e.g. IF loads document, installation manual, frame specification etc.)

TCH	Type Certificate Holder
A/C	aircraft
IF	Interface

Load Direction	Envelope to comply with	Emergency Landing Conditions	Max. flight and / or Landing Loads		
		JAR 25.561	model 1	model 2	model 3
Upward	**4,2 g**	3,0 g	3,30 g	3,9 g	4,2 g
Forward	**9,0 g**	9,0 g	1,63 g	1,61 g	1,4 g
Sideways	**4,0 g *)**	4,0 g *)	1,94 g	2,3 g	2,38 g
Downward	**8,1 g**	6,0 g	8,10 g	7,0 g	7,3 g
Rearward	**1,5 g**	1,5 g	1,06 g	1,09 g	1,08 g

*) Includes 1.33 fitting factor; required for passenger seats

example only



proposed for a CS-<u>25</u> A/C:

"Note: Given that not enough data is provided to evaluate the gusts, the method acc. <u>23</u>.341 is going to be used."

This is <u>not</u> acceptable!

☞ For max. load envelope, check 25.561 loads <u>and</u> flight/ground loads (typical TCH data!)

☞ Consider additional factors, e.g. wear & tear, fitting factor etc.

Loads / (E)TSO approved equipment (3)

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(E)TSO approved equipment

Can (E)TSO approved equipment in general be installed on specific aircraft *without* further checks?

No!

- ETSO authorisation is outcome of independent process for equipment qualification.
- Only *Minimum* Performance Specifications are addressed (e.g. SAE, EUROCAE, RTCA), as referenced in applicable ETSO standard.
- Since most ETSO'd equipment is intended for installation on aircraft, ETSO qualification process may be influenced to certain extent by installation aspects (e.g. test set-up representative of installation).

However, ETSO process does <u>not</u> formally approve installation aspects at aircraft level.

- Certification Basis of A/C might be more stringent than ETSO specification.
- In terms of loads: (E)TSO load requirements might not meet max. load envelope of a specific A/C.

(E)TSO (European) Technical Standard Order
A/C aircraft

☞ Check (E)TSO specification against individual A/C requirements (Certification Basis).

Loads / Abuse Loads (4)

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- Abuse Loads
  - CS 25.601 Design and Construction - General
- No hazardous or unreliable design feature.
  - Standard scenarios and applicable loads

    EASA CM-S-009 'Loading Conditions for Occupant Safety in Cabin Interiors'[1]
    - Cabin interior and their components (e.g. doors, drawers, handles, curtain rails, glass items etc.) easily accessible to passengers/crew should be capable of withstanding random direction "assist and abuse" loads (e.g. grasping, pulling, pushing, standing or sitting) during in-flight turbulence, emergency scenarios etc.
    - provide robust design
  - Abuse loads become certification requirement, if equipment
    - could block egress or could become potential safety issue

CM Coordination Memorandum

☞ Consider abuse loads specific to installation scenario. For guidance: CM 'Abuse Loads'.

Compliance by Similarity (1)

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(S)TC (Supplemental) Type Certificate
A/C aircraft
MOD Modification
CertBasis Certification Basis

- Compliance by Similarity
  - § Part 21.A.113 Application for a supplemental type-certificate
  - Compliance showing to applicable CertBasis either by own resources or arrangement with (S)TC holder.

    Take credit from already approved configuration installed on other aircraft.

  Is referenced installation comparable in all relevant aspects?
  - assess any design or installation difference!
  - same TC basis? (e.g. changed through major significant MOD)
  - same design status? (e.g. local or in proximity)
  - same load factors? (e.g. could vary depending on installation location in fuselage)

Compliance by Similarity (2)

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- same installation conditions?
  (e.g. max. deformation vs. required gaps btw. adjacent monuments, 2nd load path upon contact!; different accessibility might trigger different abuse loads)
- related design changes?
  (e.g. any prerequisite, incorporated through other STC/MOD, additional reinforcement etc.)

If not own data, access to foreign design data must be properly arranged:

- *full compliance showing* is required (all compliance documents!)
- access to latest and full set of design data (e.g. Service Bulletin, incl. revisions)
- information loop for continuous airworthiness issues (e.g. in-service events, ADs)
- access to related data (e.g. ICA, CMM etc., incl. revisions)
- intellectual property (legal issue)

MOD	Modification
ICA	Instructions for Continuous Airworthiness
CMM	Component Maintenance Manual
AD	Airworthiness Directive

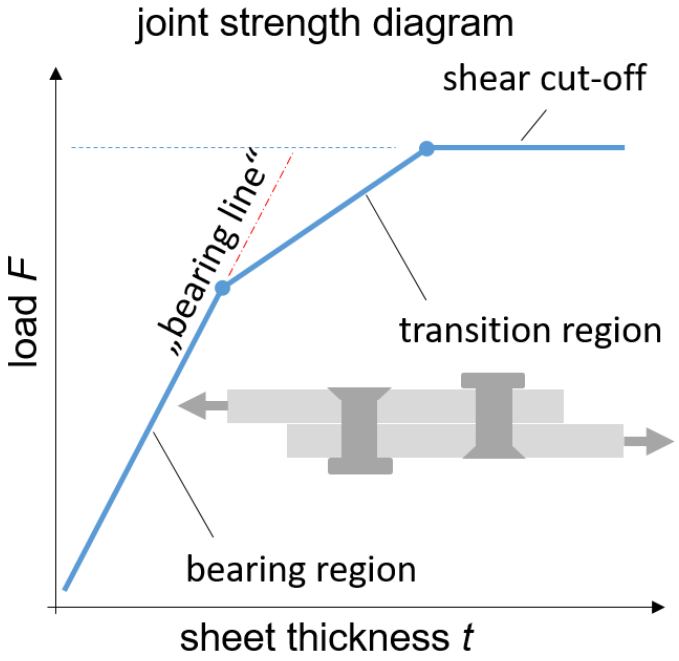
☞ For compliance by similarity, own design data or arrange proper agreement. Copy & paste of foreign data <u>not</u> acceptable! Assess any design or installation difference.

Joint Allowables

- CS 25.603 Materials
- CS 25.613 Material strength properties and material design values

Bearing strength ≠ joint allowable

- frequently seen for metallic joint analysis: applied shear load checked against bearing strength
- Joint strength values of mechanically fastened metal joints: derived from lap-joint shear tests
  - considering interaction btw. joint members and fastener (e.g. tilting, edge bearing etc.)
- Bearing yield F_{bry} and ultimate F_{bru} are properties of joint member's <u>material</u>
  - compare ASTM E238 'Standard Test Method for Pin-Type Bearing Test of Metallic Materials' using utmost stiff pin to create bearing in material



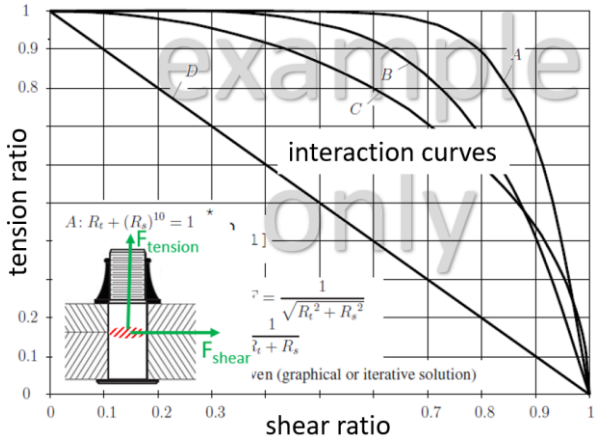
Joint Allowables (2)

- Joint analysis
  - derive joint strength from joint allowable data (e.g. tables)
  - no data available? → CS 25.613: (a) Material strength properties must be based on enough tests of material meeting approved specifications to establish design values on a statistical basis.
  - effect of head type (e.g. protruding, countersunk)
  - tensile strength (fastener, collar/nut)
  - limit load check for general load cases (25.305(a))

  if applicable:
  - consider interaction of combined shear and tensile loads
  - apply fitting factor to each part of joint (CS25.625)

t [mm]	Static joint strength F [kN] per rivet					
	d =2.4 mm	3.2 mm	4.0 mm	4.8 mm	5.6 mm	6.4 mm
0.6	0.40	0.53	0.54[a]	0.54[a]	0.54[a]	0.54[a]
0.8	0.53	0.70	0.88	0.95[a]	0.95[a]	0.95[a]
1.0	0.66	0.88	1.10	1.31	1.49[a]	1.49[a]
1.2	0.79	1.05	1.31	1.57	1.83	2.09
1.4	0.85	1.23	1.53	1.83	2.14	2.44
1.5	0.86	1.32	1.64	1.96	2.29	2.61
1.6	0.88	1.40	1.75	2.10	2.44	2.79
1.8	0.91	1.48	1.97	2.36	2.75	3.14
2.0		1.52	2.19	2.62	3.05	3.48
2.5		1.60	2.36	3.22	3.81	4.35
3.0			2.49	3.39	4.41	5.22
3.2				3.45	4.49	5.57
4.0				3.56	4.79	5.99
5.0					4.84	6.30
FSS	0.91	1.60	2.49	3.56	4.84	6.30
FTS	0.91	1.60	2.49	3.56	4.84	6.30

example only



example only

☞ Use dedicated joint strength data to analyse joints at limit and ultimate load level.

Certification Basis (1)

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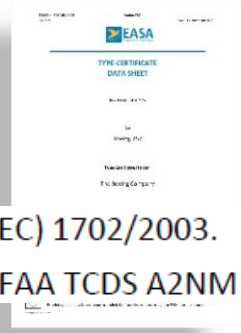
CS Certification Specifications
TCDS Type-Certificate Data Sheet
CertBasis Certification Basis

- Certification Basis
  - § Part 21.A.101 Designation of applicable CS and environmental protection requirements
  - Demonstrate compliance of changed product with applicable CS effect at date of application.
    Derogation possible: non-significant, not affected areas, not contribute materially to level of safety at product level, impracticality.
  - for EASA approval of products where TCDS states
    - EASA CertBasis - whether additional reference to FAA TCDS is given or not
      → EASA CertBasis applies for compliance showing
    - dedicated reference to FAA CertBasis only (e.g. Boeing B757)

Use 1) EASA CS-25 at latest amendment (date of application)
2) or - if derogation acc. Part 21.A.101 allowed:
either *initial* FAA CertBasis, or *later* EASA CS-25



4. EASA Airworthiness Requirements
In accordance with Regulation (EC) 1702/2003.
FAA Certification Basis Refer to FAA TCDS A2NM

Certification Basis (2)

- ‘elect to comply’
  - no cherry picking from different amendment levels
    - set of rules must be consistent
      “…applicant shall also comply with any other certification specification that the Agency finds is directly related.”
  - opting for later CertBasis
    - elaborate difference btw. initial CertBasis and elect to comply amendment level for each affected requirement
      i.e. not only list later requirements, but identify differences and - if any - consider accordingly

☞ Changed Product Rule (Part 21.A.101) applies for CertBasis definition

☞ *EASA* Certification Specifications for *EASA* approvals

☞ Elaborate on differences if opting for other amendment levels

Check against Ultimate and Limit Load

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- Check against Ultimate and Limit Load
  - CS 25.305 Strength and Deformation
  - The structure must be able to support…
    - limit loads without detrimental permanent deformation
    - ultimate loads without failure
    - Frequently seen for analysis: ultimate load check *only*

      although dimensioning load case is not prescribed as ultimate load
    - Reminder: metallic structural parts made of raw materials with stress ratios
      - $F_{tu}/F_{ty} \leq 1.5$ strength and deformation requirements under limit load are typically covered by ultimate load analysis
      - $F_{tu}/F_{ty} > 1.5$ limit load analysis required
    - also: yield and ultimate static joint strength

	F_{tu}	F_{ty}	F_{tu}/F_{ty}
2024-T3	440	325	1,35
2024-T42	430	260	1,65

example only

F_{tu} material ultimate strength
F_{ty} material yield strength

☞ Check for ultimate and limit load level - where applicable.

Miscellaneous (1)

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- STC installation and accessibility
  - CS 25.611 Accessibility provisions
  - CS 25.1529 Instructions for Continued Airworthiness
- Means must be provided to allow inspection (…) as necessary for continued airworthiness.

  This concerns
  - new tasks defined for current STC installation
  - existing tasks in the installation area
    i.e. refer to Instructions for Continued Airworthiness

☞ Check that installation does not interfere with accessibility needs of existing inspection tasks nor with those inspections that arise from this STC.

Miscellaneous (2)

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AD	Airworthiness Directive
AMOC	Alternative Method of Compliance
ICA	Instructions for Continued Airworthiness

- STC installation and compatibility with ADs
  - Part 21.A.3B Airworthiness directives
  - Is STC installation compatible with existing ADs?
    - Review ADs applicable to modified aircraft
    - Determine if AD compliance is affected by STC installation
    - If AD compliance is affected
      - include assessment of effect of STC installation on unsafe condition addressed by AD
      - if unsafe condition is not eliminated: include specific proposed actions to address it
      - STC can be accepted as AMOC (=EASA approved deviation to AD)[2]
        (recorded in STC certificate under "Conditions")
      - supplement ICA to include consideration of AMOC

☞ Check for existing ADs and assess any interaction with STC installation.

Miscellaneous (3)

- STC installation and design status
  - Part 21.A.113 Application for a supplemental type-certificate
  - Part 21.A.101 Designation of applicable certification specifications…
- Description of change should clearly elaborate design status.
  - Identify preMOD design status of aircraft, e.g. incorporated MODs/STCs
  - If current STC incorporates additional existing changes:
    - identify which individual change/equipment is substantiated through which STC/MOD
    - assess compatibility with prerequisites/assumptions/limitations of all incorporated changes
    - assess cumulative effect of previous relevant changes for STC classification to determine Certification Basis for affected areas of current STC

☞ Identify prerequisite for STC and state it in Certification Programme & Service Bulletin.

☞ Consider cumulative effect and compatibility of combined changes.

Miscellaneous (4)

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PSE	Principal Structural Element
DT	Damage Tolerance
ICA	Instructions for Continuous Airworthiness

- STC installation and 25.571
  - CS 25.571 Damage tolerance and fatigue evaluation of structure
  - "Touching" primary structure (PSE) typically triggers 571 reassessment
    - "Touching" includes - among others
      - drilling new holes
      - existing holes (left open) after detachment of parts
      - introducing new loads - at new <u>or</u> existing location

        higher loads, different *combination* of load *components* (F_x, F_y, F_z or moments)
    - Products certified acc. Damage Tolerance design philosophy (25.571(b)) require also DT reassessment (i.e. initial flaw, crack growth, residual strength etc.)
    - update to ICA

☞ Check for 25.571 compliance once a PSE gets "touched".

Miscellaneous

(5)

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STC installation and applied design data / analysis methods

- CS 25.307 Proof of structure
- CS 25.613 Material strength properties and Material Design Values

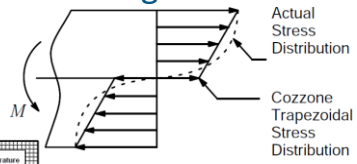
Structural analysis (…) *method* to be *reliable*

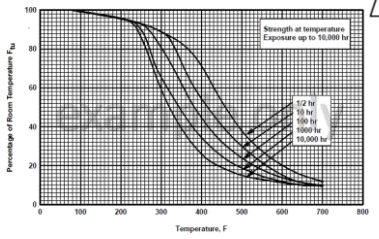
- method suitable for specific purpose?
- all limitations met? (remind the limits!)

Design values and its application range, e.g.

- material properties: effect of environmental conditions? (e.g. elevated temperature, cleaning fluid contamination etc.)
- joint allowables: effect of edge distance, pitch etc.

Just as example…
'Cozzone's method of Plastic Bending Analysis'
not to be used as multipurpose general relief of arbitrary high stressed cross-sections to get nice margins…





example only

valid for $e/D \geq 2$ and $D/t \leq 5.5$

☞ Remind and check validity & limitations of design data and (analysis) methods with respect to specific application.

The End…

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Thank you for your attention.

Questions

Reference / Resources

v1.3

[1] EASA CM-S-009 'Loading Conditions for Occupant Safety in Cabin Interiors', Issue 01, 17 Oct 2018

[2] EASA 'Alternative Method of Compliance (AMOC) with Airworthiness Directive (AD)' (PR.CAP.00008-003)

EASA Part 21 'Certification of aircraft and related products, parts and appliances, and of design and production organisations', Annex I to Commission Regulation (EU) No 748/2012

EASA Easy Access Rules for Airworthiness and Environmental Certification
www.easa.europa.eu/document-library/general-publications

EASA Certification Memorandum (CM)
www.easa.europa.eu/document-library/public-consultations/certification-memoranda

EASA Certification Specification (CS)
www.easa.europa.eu/document-library/certification-specifications

EASA Supplemental Type Certificate (STC)
www.easa.europa.eu/document-library/type-certificates/supplemental-type-certificates

EASA Airworthiness Directive (AD)
www.easa.europa.eu/easa-and-you/aircraft-products/airworthiness-directives-ad

EASA Alternative Method of Compliance (AMOC)
www.easa.europa.eu/the-agency/faqs/alternative-method-compliance-amoc-airworthiness-directive-ad

EASA ETSO authorizations
www.easa.europa.eu/easa-and-you/aircraft-products/etso-authorisations

EASA Type-Certificate Data Sheet (TCDS)
www.easa.europa.eu/document-library/type-certificates

Abbreviation

A/C	Aircraft
AD	Airworthiness Directive
AMOC	Alternative Method of Compliance
CM	Certification Memorandum
CMM	Component Maintenance Manual
CS	Certification Specification
DT	Damage Tolerance
(E)TSO	(European) Technical Standard Order
ICA	Instructions for Continuous Airworthiness
MOD	Modification
OEM	Original Equipment Manufacturer
PSE	Principal Structural Element
(S)TC	(Supplemental) Type Certificate
TCDS	Type-Certificate Data Sheet
TCH	Type Certificate Holder

- Principal Structural Element

Element of structure that contributes significantly to the carrying of flight, ground, or pressurisation loads and whose integrity is essential in maintaining the overall structural integrity of the aeroplane.

[AMC 25.571, Amdt 22]

- Primary structure

Structure which contributes significantly to carry flight, ground and pressurization loads.

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