

# Design Delegation Seminar 2022

Specification Practices  
Dan Retief



# Dan Retief Biography

- PhD from University of Pretoria (Mechanical Reliability)
- 2 years South African Air Force Design Office at Air Logistics Command: Repair schemes and installation mods.
- 5 years resident DDH at Pacific Aerospace working with and learning from Murray McGregor and Richard Andrews.
- Founded Aero Design in 2008, Part 146 Certification around 2009.
- Founded Aero Composites in 2013, Certified under Part 148 specializing in manufacture of composite aircraft products.  
(Assets of Aero Composites was sold to Oceania Aviation in 2021.)



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# FAR 2X.603 and 2X.605

Specification Practices for Certification and Production in a world with disrupted supply chains.



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- Intent of the rules
- 2X.603 2X.605 compliance challenges
- Proposed solutions
- How to write your own specifications
- Benefits of the proposed solutions
- The role of the design organisation



## Intent of the rules

# FAR 2X.603 Materials

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must

- (a) Be established on the basis of experience or tests;
- (b) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and
- (c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

(and Far 23 Workmanship must be of a high standard.)



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## Intent of the rules

# FAR 27.605/29.605 Fabrication

- a) The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to reach this objective, the process must be performed according to an approved process specification.
- b) Each new aircraft fabrication method must be substantiated by a test program.



## Intent of the rules

# AC 20-107B – Composite Aircraft Structure

All composite materials and processes used in structures are qualified through enough fabrication trials and tests to demonstrate a reproducible and reliable design. One of the unique features of composite construction is the degree of ***care needed in the procurement and processing of composite materials***. The final mechanical behaviour of a given composite material may vary greatly depending on the processing methods employed to fabricate production parts. Special care needs to be taken in ***controlling both the materials being procured and how the material is processed*** once delivered to the fabrication facility. Regulatory requirements in 14 CFR, parts 2X, §§ 2x.603 and 2x.605 ***specify the need to procure and process materials under approved material and process specifications*** that control the key parameters governing performance.



## Intent of the rules

# AC 23-20 – Material and Process Specifications

“manufacturers use the material specification to ensure that the delivered aircraft [product] ***consists of materials that are of the same quality and performance standards achieved in the certification process. Process specifications define and control the processes used to convert materials into structural components.*** The base material properties of composite laminates are directly determined by the specific processes used for their fabrication. ***Quality control procedures, which often make use of the lower levels of building block tests, ensure the material used to fabricate production aircraft parts remains invariant.***”





# 2X.603 2X.605 compliance challenges

## Causes:

- Use of COTS Composite Materials without acquisition specifications.
- Thinking of a Material Technical Data Sheet as a Specification – it is not
- Local Composite Material vendors sourcing their product from various manufacturers resulting in varying quality of the “same material”.
- Supply chain – originally certified/reputable supplier material not obtainable
- Historical precedents perpetuating incorrect thinking
- Desire to use locally available or uncertified materials for commercial and strategic reasons
- Treating secondary structure as non-structural - insufficient failure mode analysis
- Incomplete compliance statements in Technical Assessments

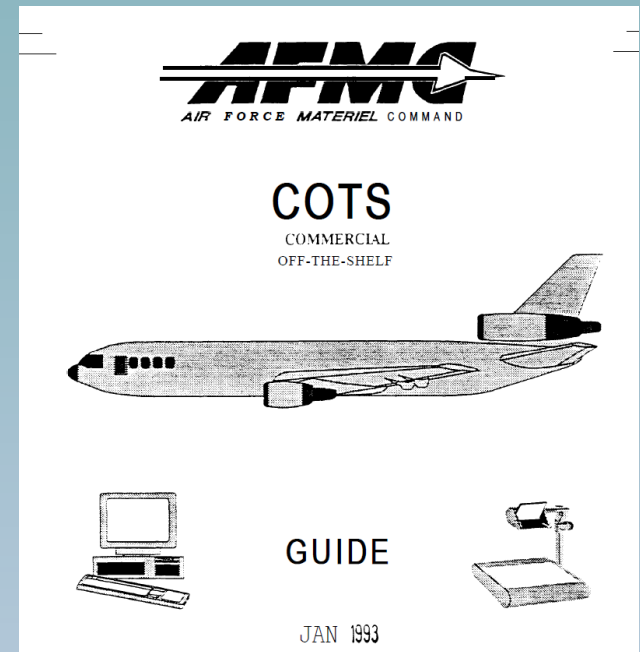


# 2X.603 2X.605 compliance challenges Composite Material as COTS

<https://nepp.nasa.gov/docuploads/1219C61B-7337-48C4-8760E6456F861839/COTS%20guide.pdf>

Thinking of commercially acquired composite materials as COTS conflicts with FAR 2X.603. By definition the user of COTS have no legal right to subject a COTS supplier to his specification or requirements. He simply buys it or not.

Using COTS composite material for any purpose where strength matters, would be conflicting with FAR 2X.603, unless the COTS material can be conformed to a material specification to meet the intent of the rule.



### MYTH-BUSTERS 4

We'll just demand that the COTS supplier strictly control internal configuration and dutifully let us know every change he makes. Wrong! By definition, the Government takes COTS as it comes, and when it comes to configuration we're just along for the ride like any other customer.

Can only large and powerful material consumers like Boeing use material specifications to force its suppliers to supply conforming qualified materials? What about the small manufacturer in NZ?



## 2X.603 2X.605 compliance challenges – parts classification

FAR 2X.603 and 2X.605 applies to *materials used for parts, the failure of which could adversely affect safety*, which includes **Priority Parts** and **Primary Structural Parts**.

Classification of applicable parts should require some form of FMECA (**Failure Mode Effects and Criticality Analysis**) to be conducted as part of the Technical Assessment.

According to NZ CAA CAR Part 1, a **priority part** is defined as "A part or assembly in a type certified product, the failure of which is likely to cause an unsafe condition in an aircraft, aircraft engine or propeller."

A **primary structural part** is a part 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 airplane. Principal/Primary structural parts include all structure susceptible to fatigue cracking, which could contribute to a catastrophic failure." FAA AC 25.571-1D.



2X.603 2X.605 compliance challenges – parts classification

# Insufficient Failure Analysis



**Continental Express Flight 2574, 11 September 1991**

**Loss of control due to separation of one of the horizontal stabilizer leading edges. Occupants 14, Survivors 0.**

**Do we classify essential aerodynamic fairings as non-primary structure?  
Should be at least priority?**



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## 2X.603 2X.605 compliance challenges

Incomplete compliance statements in Technical Assessments

# Let's look at an example compliance statement

### 27.603 Materials

The materials used are stainless steel, aluminium alloy and carbon fibre, suitability and durability of which has been established on the basis of experience in similar installations.



2X.603 2X.605 compliance challenges

## Example Compliance Statement

Rule Compliant?

### 27.603 Materials

The materials used are stainless steel, aluminium alloy and carbon fibre, suitability and durability of which has been established on the basis of experience in similar installations.



## 2X.603 2X.605 compliance challenges

# Example Compliance Statement

### 27.603 Materials

The materials used are stainless steel, aluminium alloy and carbon fibre, suitability and durability of which has been established on the basis of experience in similar installations.

- **Does not mention any reference to failure analysis or classification.**
- **Does not mention any tests under (a), or;**
- **what similar installations are meant. Similarity claims requires the similar data to be referenced**
- **Does not mention (b) or (c) of 27.603**





# Proposed Solutions

## ☞ Use Pre-qualified Material

- ☞ Conforms to existing approved or recognised specification - e.g. BMS, Mil, CMH-17
- ☞ Statistically significant test data exists showing qualification to the specification.
- ☞ Manufacturer will supply with conformity certificate to the specification and supply batch test data showing conformity.
- ☞ At a price.



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## Proposed Solutions

### ⌘ Qualification of Material from a Reputable Supplier

- ⌘ Material has not been qualified to any recognised specification, but
- ⌘ Manufacturer will supply with batch mill cert.
- ⌘ Manufacturer has recognised quality certification.

#### Solution:

- ⌘ Write own acquisition specification
- ⌘ Do own statistically significant coupon testing to qualify
- ⌘ Order with acquisition spec, conformity with mill cert. and inwards inspection.



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# Proposed Solutions

## Lower Grade Suppliers

- ⌘ Material has not been qualified to any recognised specification,
- ⌘ Mill certificate typically not supplied.
- ⌘ Supplier's quality certification is questionable.

### Can use if we:

- ⌘ Write own acquisition specification
- ⌘ Do own statistically significant test coupon testing to qualify.
- ⌘ Order with acquisition spec, conformity with **testing** and inspection of each batch.
- ⌘ Consider testing each product manufactured.



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## How to write your own specifications


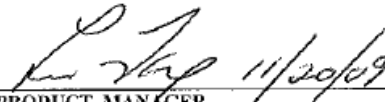

- Mil STD 490A – Specification Practices
  - Section 1 - SCOPE
  - Section 2 - APPLICABLE DOCUMENTS
  - Section 3 – REQUIREMENTS
  - Section 4 - QUALITY ASSURANCE PROVISIONS
  - Section 5 - PREPARATION FOR DELIVERY



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## Examples:

QUALITY ASSURANCE  11/20/09	<b>THE HENKEL CORPORATION</b> <b>AEROSPACE GROUP.</b> Bay Point, California, 94565-0031  <b>AEROSPACE PRODUCT</b> <b>SPECIFICATION</b>	SPECIFICATION  <b>HS – AS9354</b>
RESEARCH & DEVELOPMENT   11/20/09		REVISION  <b>B</b>
PRODUCT MANAGER  		
PRODUCT  <b>Hysol® EA 9309.3NA Paste Adhesive</b>		Issue Date November 20, 2009  <b>PAGE 1 OF 2</b>
<p><b>DESCRIPTION:</b>          Hysol® EA 9309.3NA is a toughened two-part epoxy paste adhesive. It contains 5 mil glass beads for bondline thickness control. Hysol® EA 9309.3NA bonds metal skins and honeycomb core to yield tough, permanently flexible joints that are resistant to humidity, water and most common fluids. Its outstanding feature is high shear and peel strength to aluminum.</p> <p><b>SPECIFICATIONS:</b>          Henkel Corporation will test all batches to the requirements of this specification, and will certify that, on date of shipment from its Bay Point facility or from an authorized distributor<sup>1</sup>, each batch of EA 9309.3NA meets the following requirements:</p>		



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<u>TEST</u>	<u>UNITS</u>	<u>REQUIREMENT</u>
<b><u>Part A</u></b>		
Color	N/A	Pink-red paste
Appearance	N/A	No foreign matter
Viscosity @ 25°C	poise Pa.s	1500 – 3800 150 – 380
<b><u>Part B</u></b>		
Color	N/A	Blue Liquid
Appearance	N/A	No foreign matter
Viscosity @ 25°C	poise Pa.s	0.10 – 0.20 0.01 – 0.02
<b><u>Combination Testing(Mix ratio:100:22 by wt)</u></b>		
Shore D Hardness	N/A	70 minimum
Tensile Lap Shear @ 180°F (82°C)	psi	600 minimum/725 average
Pot Life/Tensile Lap Shear @ 77°F (25°C)	psi MPa	4000 average 27.5 average
T-Peel @ 77°F (25°C)	lbs/in N/25mm	30 minimum/ 35 average 135 minimum/158 average
Bell Peel @ 77°F (25°C)	lbs/in N/25mm	36 minimum/ 50 average 163 minimum/226 average



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**TEST METHODS:**

<u>TEST</u>	<u>DESCRIPTION</u>	<u>REFERENCES</u>
Color and Appearance	Visual examination.	
Viscosity	Brookfield viscometer per ASTM D-1824. Part A using Model HBT, spindle #7 at 20 rpm; Part B using Model LVF, spindle #1 at 60 rpm. Temperature shall be $25.0 \pm 0.5^{\circ}\text{C}$ .	ASTM D-1824
Tensile Lap Shear	Specimen preparation per ASTM D-1002. For normal tests, use .063" 2024T3 Alclad aluminum, FPL-etched per ASTM D-2651. Cure for 72 hours at 75°F with mechanical pressure of 10 psi.	ASTM D-1002 ASTM D-2651
T-Peel	Specimen preparation per ASTM-D1876. For normal tests, use 2024 T3 Alclad aluminum, phosphoric acid anodized per ASTM D-3933. Cure for 72 hours at 75°F under 25" Hg vacuum.	ASTM D-1876 ASTM D-3933
Bell Peel	Specimen preparation per ASTM D-3167. For normal tests, use 2024 T3 bare aluminum, phosphoric acid anodized per ASTM D-3933. Cure for 72 hours at 75°F under 25" Hg vacuum.	ASTM D-3167 ASTM D-3933

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# Examples

 AERO DESIGN LTD		Detail Specification		AD004-CF-002 ISS7	
Prepared By	L K Boyd	Prepared Date	04/07/2022	<b>ISS7</b>	
Checked By	B R Rietema	Checked Date	6/07/2022		
Approved By	D A Retief	Approved Date	6/07/2022		
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<b>NON-PRIMARY STRUCTURE CARBON FIBRE FABRIC</b>					
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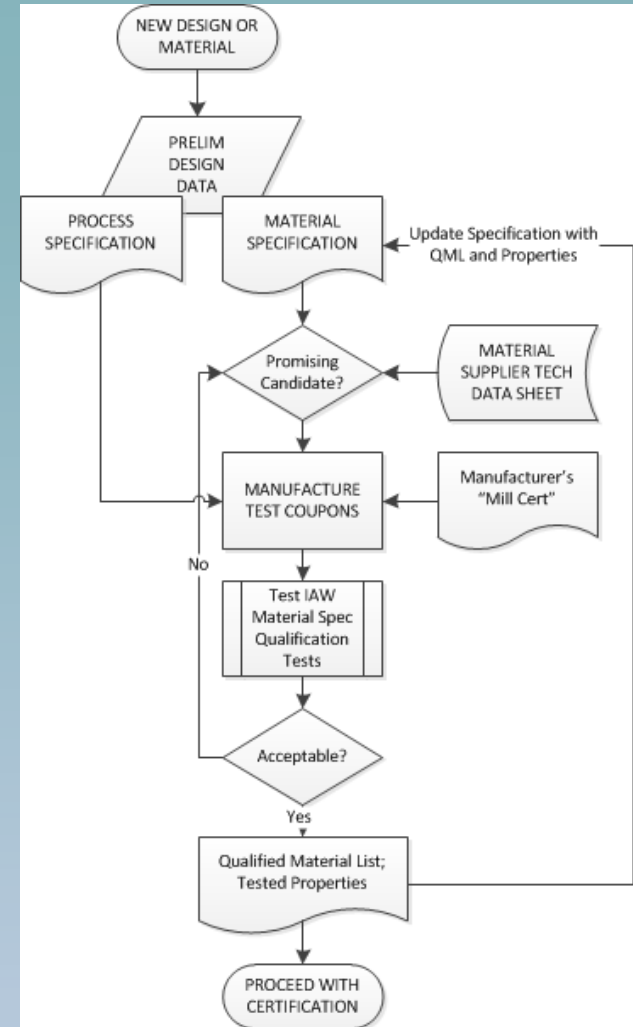
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# Material Qualification Process

- Draft material specification and process specification
- Specify the material properties that must be met.
- Specify the qualification test method
- Specify required quality Controls and batch certificate/test/inspection requirements for conformity
- Manufacture test coupons IAW Process Specification
- Test IAW material specification
- Update specification with test results
- Add material to QML



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# Benefits of Complying with FAR 2X.603 and 2X.605

- ✓ Compliance
- ✓ Improved control of material properties
- ✓ Simplification of drawings
- ✓ Ease of adding alternative materials
- ✓ Improved part quality
- ✓ Reduced Scrap
- ✓ Reduced failures, rework and warranty claims
- ✓ Increased profitability
- ✓ Increased safety



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## ✓ Simplification of drawings

5. LAYUP AS FOLLOWS:

$[0/90/+45/-45]_S$

ALL 0/90 AND 90/0 IS AD4PPISMTW2EP4 PRE-PREG

ALL +45/-45 IS AD4PPISMBD3EP4 PRE-PREG

ALL -45/+45 IS AD4PPISMBD3EP4 PRE-PREG CUT AT 90° ALONG THE LENGTH C

6. APPLY A STRIP OF TAPING ALONG THE AFT CUTOUT 4" WIDE CONSITING OF THE

$[+45/-45/0/90]_T$

SAME MATERIALS AS IS USED IN NOTE 5.

7. APPLY 2.0" STRIP OF AD4PP4PWIEP4 GLASS FIBRE PRE-PREG  
AS AN ISOLATING LAYER CENTRED ON EACH ANCHOR  
NUT FASTENER LOCATION.

8. APPLY VACUUM IN ACCORDANCE WITH AD022-VAC-001 AND CURE IN  
ACCORDANCE WITH AD022-CURE-001.



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# Role of the Design Organisations

- ✓ Carry out FMECA to determine part classification.
- ✓ Encourage compliance – help industry with material qualification process and specifications or select qualified materials.
- ✓ Refer to AC 23-20 and AC 20-107B.
- ✓ Carefully consider compliance with FAR 2X.603 and 2X.605 when preparing technical assessments.
- ✓ Let's discuss the topic and standardise the approach?

