

FAI First Article Inspection in production activity

Manuela RUSU^{*,1,2}, Iilca SOARE^{1,2}, Mihail BOTAN², Alina DRAGOMIRESCU²,
Constantin MILITARU¹

*Corresponding author

¹“POLITEHNICA” University of Bucharest,

Splaiul Independenței 313, Bucharest 060042, Romania

²INCAS – National Institute for Aerospace Research “Elie Carafoli”,

B-dul Iuliu Maniu 220, Bucharest 061126, Romania,

rusu.manuela@incas.ro*, soare.ilinca@incas.ro, botan.mihail@incas.ro,
dragomirescu.alina@incas.ro

DOI: 10.13111/2066-8201.2019.11.3.18

Received: 20 May 2019/ Accepted: 24 July 2019/ Published: September 2019

Copyright © 2019. Published by INCAS. This is an “open access” article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

7th International Workshop on Numerical Modelling in Aerospace Sciences “NMAS 2019”

15-16 May 2019, Bucharest, Romania, (held at INCAS, B-dul Iuliu Maniu 220, sector 6)

Section 3 – Modelling of structural problems in aerospace airframes

Abstract: *This article aims to present the First Article Inspection of production activity of the QTS-2 Quick Thermal Shock equipment. First Article Inspection FAI is analyzed using the definition guidance from IAQG - International Aerospace Quality Group, section 3.2. and EN 9102.*

Key Words: *First Article Inspection, FAI, EN 9102:2016, IAQG*

1. INTRODUCTION

Requirement 8.5.1.3 Production process verification in [1] refers to the following: “The organization shall implement production process verification activities to ensure the production process is able to produce products that meet requirements”. This activity can be referred to as First Article Inspection (FAI) [2].

First Article Inspection is a planned, complete, independent, and documented inspection and verification process to ensure that prescribed production processes have produced an item conforming to engineering drawings, DPD (Digital Product Design), planning, purchase order, engineering specifications, and/or other applicable design documents [3].

The primary purpose of FAI is to validate that product realization processes are capable of producing parts and assemblies that meet engineering and design requirements. A well-planned and executed FAI will provide objective evidence the manufacturer’s processes can produce compliant product and that they have understood and incorporated associated requirements. FAI will:

- Provide confidence that the product realization processes are capable of producing conforming product.
- Demonstrate that the manufacturers and processors of the product have an understanding of the associated requirements.

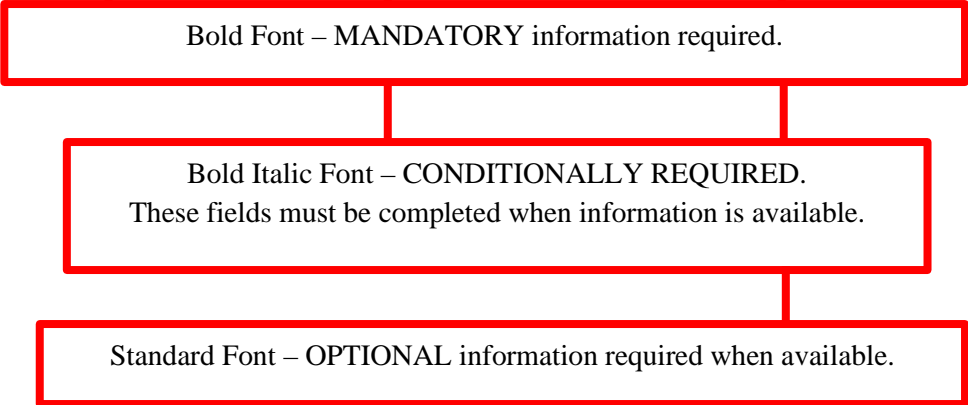
- ❑ Provide objective evidence of process capability.
- ❑ Reduce potential risks associated with production startup and/or process changes.
- ❑ Provide assurance of product conformance at the start of production and after changes outlined in this standard [3].

2. HOW TO WRITE UP A FAI STEP BY STEP [3]

The following figures show how to complete a FAI, the information that must be found in the FAI's content to demonstrate the production process verification requirement.

9102 B Form 1: Part Number Accountability, shall be used to identify the product that is having the First Article Inspection (FAI) conducted on (e.g., detail part, subassembly, assembly); referred to as “FAI part”.

1. Part Number:	2. Part Name:	3. Serial Number:	4. FAIR Number:
5. Part Revision Level:	6. Drawing Number:	7. Drawing Revision Level:	8. Additional Changes:
9. Manufacturing Process Reference:	10. Organization Name:	11. Supplier Code:	12. P.O. Number:
13. Detail Part: ____ Assembly FAI: ____	14. Full FAI: ____ Partial FAI: ____ Baseline Part Number (including revision level): Reason for Partial FAI:		
a) If above part number is a detail part only, go to field 19. b) If above part number is an assembly, go to the "INDEX" section below.			
INDEX of part numbers or sub-assembly numbers required to make the assembly noted above.			



1. Part Number:	2. Part Name:	3. Serial Number:	4. FAIR Number:
5. Part Revision Level:	6. Drawing Number:	7. Drawing Revision Level:	8. Additional Changes:
9. Manufacturing Process Reference:	10. Organization Name:	11. Supplier Code:	12. P.O. Number:
Box 1. Part Number of the FAI part.			
13. Detail Part: _____	14. Full FAI: _____	15. Partial FAI: _____	
Assembly FAI: _____		Baseline Part Number (including revision level):	
Box 2. Name of the FAI part.			
a) If above part number is a detail part only, go to field 19			
b) If above part number is an assembly, go to the "INDEX" section below.			
INDEX of part		above.	
15. Part Number:	Box 3. Serial number of the FAI part.		ber:
Box 4. Reference number that identifies the First Article Inspection Report (FAIR).			

1. Part Number:	2. Part Name:	3. Serial Number:	4. FAIR Number:
5. Part Revision Level:	6. Drawing Number:	7. Drawing Revision Level:	8. Additional Changes:
9. Manufacturing Process Reference:	10. Organization Name:	11. Supplier Code:	12. P.O. Number:
Box 5. Latest revision that affects the FAI part being inspected. If the part has not been revised, indicate as such (e.g., N/C, No Change). Note: The latest revision (Box 7) does not always affect all parts contained on a drawing.			
a) If above part number is a detail part only, go to field 19			
b) If above part number is an assembly, go to the "INDEX" section below			
Box 6. The drawing number or DPD data set associated with the FAI part.			
13. Detail Part: _____	14. Full FAI: _____	15. Partial FAI: _____	16. FAI Number: _____
Box 7. The revision level of the drawing or DPD data set associated with the FAI part.			
Box 8. Provide reference numbers of any changes that are incorporated in the product, but not reflected in referenced drawing/part revision level.			

1. Part Number:	2. Part Name:	3. Serial Number:	4. FAIR Number:
5. Part Revision Level:	6. Drawing Number:	7. Drawing Revision Level:	8. Additional Changes:
9. Manufacturing Process Reference:	10. Organization Name:	11. Supplier Code:	12. P.O. Number:
Box 9. Reference number that provides traceability to the manufacturing record of the FAI part.			
Reason for Partial FAI:			
a) <input type="checkbox"/>	Box 10. Name of the organization performing the FAI.		
b) <input type="checkbox"/>	If above part number is an assembly, go to the "INDEX" section below.		
INDEX of part numbers or sub-assembly numbers required to make the assembly noted above.			
15. Part Number:	Box 11. A unique number given by customer to the organization.		
Box 12. Customer Purchase Order number.			

1. Part Number:	2. Part Name:	3. Serial Number:	4. FAIR Number:
5. Part Revision Level:	6. Drawing Number:	7. Drawing Revision Level:	8. Additional Changes:
9. Manufacturing Process Reference:	10. Organization Name:	11. Supplier Code:	12. P.O. Number:
13. Detail Part: <input type="checkbox"/>	14. Full FAI: <input type="checkbox"/> Partial FAI: <input type="checkbox"/> Assembly FAI: <input type="checkbox"/> Baseline Part Number (including revision level): Reason for Partial FAI:		
a) <input type="checkbox"/>	Box 13. Check as appropriate.		
b) <input type="checkbox"/>			
INDEX of part numbers or sub-assembly numbers required to make the assembly noted above.			
15. Part Number:	16. Part Name:	17. Part Serial Number:	18. FAIR Number:
Box 14. Check as appropriate. For a partial FAI, provide the previous part number, including revision level to which this partial FAI is performed and the reason for the current FAI. For partial FAIs based on similar parts provide the approved configuration FAI part number, including revision level.			

9102 B Form 2: Product Accountability –Materials, Special Processes, and Functional Testing, shall be used if any materials, special processes, or functional testing is/are defined as a design characteristic.

1. Part Number:	2 Part Name:	3. Serial Number:	4. FAIR Number:
5. Material or Process Name:	6. Specification Number:	7. Code:	8. Supplier:
			9. Customer Approval Verification:
			10. Certificate of Conformance Number:

Boxes 1-4 are repeated on all forms for convenience and traceability.

Box 5. Name of applicable materials or special processes.

5. Material or Process Name:	6. Specification Number:	7. Code:	8. Supplier:	9. Customer Approval Verification:	10. Certificate of Conformance Number:

Box 6. Material specifications and material form for all materials incorporated into the FAI part. Special process specifications; including class, if applicable, and permitted substitutions. If standard catalogue items or COTS are modified, then list that standard hardware or COTS item.

Box 7. Any required code from the customer for material or process listing.

Box 8. Identify supplier name, address and code performing special processes or supplying material.

Box 9. Indicate if the special process(es) or material sources are approved by the customer.

Box 10. The applicable certificate number.

1. Part Number				2. Part Name			3. Serial Number	4. FAIR Number
Characteristic Accountability				Inspection / Test Results				
5. Char. No.	6. Reference Location	7. Characteristic Designator	8. Requirement	9. Results	10. Designed / Qualified Tooling	11. Nonconformance Number	14. Additional Data / Comments	

Box 5. Unique assigned number for each design characteristic.
 NOTE: A single design callout that applies to multiple characteristics may be recorded as one characteristic number.

Box 6. Location of the design characteristic.

Box 7. If applicable, record characteristic type.

1. Part Number				2. Part Name			3. Serial Number	4. FAIR Number
Characteristic Accountability				Inspection / Test Results				
5. Char. No.	6. Reference Location	7. Characteristic Designator	8. Requirement	9. Results	10. Designed / Qualified Tooling	11. Nonconformance Number	14. Additional Data / Comments	

Box 8. Specified requirement for the design characteristic.

Box 9. List measurement(s) obtained for the design characteristics.

- For multiple characteristics list each characteristic as individual values or list once with the minimum and maximum of measured values attained. If a characteristic is found to be nonconforming, then that characteristic shall be listed separately with the measured value noted.
- When qualified tooling (e.g., radius gauges) is used as a go/no-go gauge (reference 9102, 4.7.3.b), record the results as an attribute (e.g., pass / fail).
- When automated inspection tooling produces measurement results, those results may be referenced on 9102 Form 3, identified as pass/fail, and attached only when:
 - The characteristic numbers are clearly linked in the attached report.
 - The results in the attached reports are clearly traceable to the characteristic numbers.
 - The results are directly comparable to the design characteristic.
- If a design requirement requires verification testing, record the actual results on the form. If a laboratory report or certificate of test is included in the FAIR, the results may be recorded as an attribute (e.g., pass / fail) and the test reference number recorded on the forms. The laboratory report or certificate of test shall show specific values for requirements and actual results.
- For characteristics with visual verification requirements that are rated against standard photographs, list the photo number of the closest comparison. A statement of conformance is acceptable; record the reference number on the forms.
- For processes that require verification per design characteristics, include a statement of conformance (e.g., certification of conformance, verification indicator - accept).
- For characteristics verified by attribute inspection include statement of conformance (e.g., accept).

1. Part Number				2. Part Name			3. Serial Number	4. FAIR Number
Characteristic Accountability				Inspection / Test Results				
5. Char. No.	6. Reference Location	7. Characteristic Designator	8. Requirement	9. Results	10. Designed / Qualified Tooling	11. Nonconformance Number	14. Additional Data / Comments	

Box 10. When design tooling or specially designed tooling, including NC programming as a media of inspection, is used for attribute acceptance of the characteristic, record the tool identification number. When qualified tooling is used for attribute acceptance, record the gauge value or range, as applicable.

Box 11. If the characteristic is found to be nonconforming, record a nonconformance document reference number.

Box 14. This area is reserved for optional fields; add additional columns, as required, by the organization or customer.

12. Signature							13. Date

Box 12. Printed name or unique identification, and signature of the person who prepared and approved this form. Signature indicates that all applicable design characteristics are accounted for and meet requirements or are properly documented.

Box 13. Date when field 12 was signed.

How production activity on QTS-2 has met the requirements:

- All engineering, design, contractual and specification requirements are correctly understood, accounted for, verified and recorded.
- Materials, tooling, processes, documentation and personnel are capable of consistently producing compliant hardware.
- Part is 100% compliant, defined, base-lined and repeatable.

The organization should consider the following activities during FAI planning and coordinate planning with the customer, if required:

- Determination of design characteristic inspection and sequencing for inspection of characteristics not measurable in the final product.

Form 2: Product Accountability - Raw Material, Specifications and Special Process(es), Functional Testing

1. Part Number 17010/4 PN	2 Part Name Mechanical and tribological test		3. Serial Number -		4. FAI Report 17010/4-001
5. Material or Process Name	6. Specification Number	7. Code	8. Special Process Supplier Code	9. Customer Approval (Yes/No/NA)	10. Certificate of Conformance number
NIMONIC 90 alloy	UNS N07090 DIN 2.4632	N/A	BIBUS METAL AG	N/A	AS/17/10/S AS9120B RINA 16.12.2019
Amdry 962	GKN Aerospace	PM819-44	METCO	N/A	
Metco 222A/Ni	GKN Aerospace	PM819-84	METCO	N/A	
YTTRIA STABILIZED ZIRCONIA (8%Y ₂ O ₃ -ZRO ₂)	AVIO 4800M/40 HONEYWELL EMS 57750, Type I, GKN Aerospace				
11. Functional Test Procedure Number	12. Acceptance report number, if applicable				
INC-03-2017H1	N/A				
INC-03-2017H2	N/A				
INC-03-2017H3	N/A				
INC-03-2017H4	N/A				
INC-03-2017H5	N/A				
INC-03-2017H6	N/A				
INC-03-2017H7	N/A				
INC-03-2017H8	N/A				
INC-03-2017H9	N/A				
INC-03-2017H10	N/A				
INC-03-2017H11	N/A				
INC-03-2017H12	N/A				
INC-04-2017H13	N/A				
INC-04-2017H14	N/A				
INC-04-2017H15	N/A				
INC-04-2017H16	N/A				
INC-04-2017H17	N/A				
INC-04-2017H18	N/A				
13. Comments					
14. Prepared By BOTAN MIHAIL			15. Date 14.09.2017		

AS/EN/SJAC 9102 Rev A First Article Inspection							
Form 3: Characteristic Accountability, Verification and Compatibility Evaluation							
1. Part Number			2. Part name		3. Serial Number	4. FAI Report	
17010/4 PN			Mechanical and tribological test		-	17010/4-001	
Characteristic Accountability			Inspection/Test Results			Optional Fields	
5. Character No.	6. Reference Location	7. Characteristic Designator	8. Requirement	9. Results	10. Designed Tooling	11. Non Conformance Number	14. Additional data/Comments
	STAGE 1		Acquisition of materials for the specimens production: Nimonic 90, Amdry 962, Metco 222A/Ni, Metco 204NS.	Accomplished			Certificate of Conformance from supplier
			Cutting Nimonic for thermal shock testing dimensions: 50x25x2 mm	Accept			Visual cutting machine
			Cutting Nimonic for oxidation testing dimensions: 50x20x20 mm. The specimens have parallelepipedic aspect.	Accept			Visual cutting machine
			Verification of specimens dimensions	Accept			Visual - callipers
			Preparing the thermal shock testing duplex specimens by depositing on the surface of the Nimonic 90 alloy the protective layers: Amdry 962 and Metco 204NS.	Accomplished			Supplier

			Thickness verification of the deposited duplex layers	Accept			SEM analysis
			Preparing the thermal shock testing triplex specimens by depositing on the surface of the Nimonic 90 alloy the protective layers: Amdry 962, Metco 222A/Ni and Metco 204NS.	Accomplished			Supplier
			Thickness verification of the deposited triplex layers	Accept			SEM analysis
			Preparing the oxidation testing specimens by depositing on the surface of the Nimonic 90 alloy the protective layers: Amdry 962 and Metco 204NS. The coating deposition is made on 4 of the 6 faces of the parallelepiped.	Accomplished			Supplier
			Thickness verification of the deposited layers for oxidation testing	Accept			SEM analysis
	STAGE 2		Performing thermal shock tests on duplex specimens	Accomplished			Visual
			Performing thermal shock tests on triplex specimens	Accomplished			Visual

	STAGE 3		Performing oxidation tests	Accomp lished			Visual
	STAGE 4		Performing SEM analysis (Scanning Electron Microscopy)	Accomp lished			SEM analysis
	STAGE 5		Reporting the results of thermal testing and SEM analysis	Accomp lished			Electronic and printed reports
12. Signature Botan Mihail					Date: 14.09.2017		

3. CONCLUSIONS

The value of the First Article Inspection is to validate that the product realization processes are capable of producing parts and assemblies that meet engineering, design requirements.

The intent of First Article Inspection is to:

- Reduce future escapes, risks, and total costs.
- Help ensure safety of flight.
- Improve Quality, Delivery, and Customer Satisfaction.
- Reduce costs and production delays associated with product non-conformances.
- Identify non-capable production realization processes, initiate and validate corrective actions [3].

The forms used have demonstrated that FAI production validation can be achieved at both mass production and several dozen pieces.

The thermal testing reports underlined a better resistance of the duplex protection coatings than the triplex ones.

The oxidation tests were carried out at two temperature ranges: 1200 °C and 1100°C.

The oxidation test at 1200 °C did not produce the expected results due to the 97% delamination from the protective coating. Instead, specimens tested at 1100°C have resisted up to 11 cycles of heating-cooling.

REFERENCES

- [1] * * * EN 9100: 2018/AS 9100D - Quality Management Systems. Requirements for Aviation, Space and Defence Organizations.
- [2] * * * EN 9102 :2016 Aerospace series. Quality Systems. First Article Inspection requirements.
- [3] * * * www.iaqg.org/scmh - IAQG SMCH Section 3.2.3, Revision letter: B, Revision Date: 17.10.2017 – Guide for successful completion of first article inspection (FAI) reports.