QUALITY PROCESS GUIDELINES

FOR THE PREVENTION OF NON-CONFORMANCE

OF AIRCRAFT MATERIALS

WITH APPLICABLE FIRE TEST REQUIREMENTS

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AMENDMENT RECORD

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CONTENTS

1 INTRODUCTION

This guidance document is the product of the Quality Assurance Task Group of the International Aircraft Materials Fire Safety Working Group. The mandate of the Task Group was to develop a methodology to prevent the occurrence of non-conformance of materials with pertinent fire test requirements. The Task Group consisted of representatives from Industry and Airworthiness Authorities as indicated in Section 8. This document has been prepared by RGW Cherry & Associates Limited under contract with Transport Canada, in support of the Task Group's mandate, and incorporates the combined experience of the Task Group members.

The procedures and processes adopted by industry vary and hence it would be inappropriate to be prescriptive in any of the recommendations contained in this document. Rather, the present *Guidelines* are intended as a "Checklist" that may be used as a basis for reviewing/correcting existing procedures and processes, or for the formulation of new ones.

The objective of this document is to provide a systematic methodology for reviewing or formulating procedures in order to prevent the risk of installing materials that are non-conformant with pertinent fire test requirements. The procedures considered are predicated on the *Engineering Organisation* being responsible for ensuring that the design data is compliant with the applicable regulations, and the *Manufacturing Organisation* being responsible for conformance to this defined standard.

The methodology adopted by the Task Group for the derivation of the issues addressed in this document was a systematic logic process similar to *fault tree analysis*. This document identifies the following areas that should be subjected to review in an audit:

Section 3 - Engineering
Section 4 - Testing
Section 5 - Manufacture
Section 6 - Materials, Components and Sub-Assembly Suppliers
Section 7 - Storage

Section 2 of the document identifies those elements of the quality process that are applicable to all of the above areas.

Appendices 1 and 2 illustrate the methodology that was employed in producing the guidance material contained in this document. Appendix 1 contains the process used to determine possible safeguards against non-conformance with the applicable fire test

requirements. These safeguards were derived for each of the *Fault Events* resulting from the *Fault Logic Diagram* contained in Appendix 2.

Note that the following terms, used throughout this document, are defined as follows:

'Manufacturer': aircraft constructor or modifier.

'Supplier': an organisation that supplies materials, components or sub-assemblies to the 'Manufacturer'.

2 GENERAL

All persons involved in the process of designing, procuring, manufacturing, assembling or storing materials, components or sub-assemblies should:

1. Function in accord with approved procedures that are regularly amended and audited to ensure that they are understood and being followed. The audits should be carried out according to a pre-defined schedule.

2. Be subjected to a regular training and assessment programme to ensure a full understanding of the *quality procedures* and, where relevant, the *process specifications* and applicable *regulations*.

The *quality procedures* should be regularly audited, appraised and revised as required.

3 ENGINEERING

There should be regular quality audits of *engineering organisations*. Included in the audit should be verification that:

- There is an efficient and effective *quality control system*.
- There are procedures which are being adhered to that contain the appropriate elements defined elsewhere in this document, and also:
  - Instructions on the method to be employed for ensuring that the fire test data supports the appropriate requirements for the materials, components and sub-assemblies specified.
  - A regular review of the drawing checking and modification release system to ensure that there is minimum risk of the design being in error.
  - A procedure for the testing and control of materials, components and sub-assemblies so that a high level of confidence can be attached to the defined *test methods*, *pass/fail criteria*, *process specifications* and *drawings* being correct, clear and unambiguous.
  - A procedure that ensures that all changes to the process from that specified in the *process specifications* or *drawings* are agreed with the appropriate authorising person prior to their being incorporated.
  - A satisfactory *sampling plan* for materials, components and sub-assemblies.
  - A procedure that ensures that the *process specifications* are clearly defined on the design documents.
  - A definition of the policy to be used in qualifying materials, components and sub-assemblies by similarity.

Consideration should also be given, within the procedures, to the following:

- Testing material samples from each batch unless there is a significant margin between the required fire test standard and that exhibited by the materials tested which justifies less frequent testing.

- Obtaining test pieces from actual components that will be used in the build by making the components oversize.

4 TESTING

There should be regular quality audits of *test establishments*. Included in the audit should be verification that:

- There is an efficient and effective *quality control system*.
- There are procedures which are being adhered to that contain the appropriate elements defined elsewhere in this document and ensure that:
  - Regular equipment repair and calibration is being carried out.
  - A satisfactory *sampling plan* for materials, components and sub-assemblies exists.
  - The correct standard of requirements is being maintained.
  - There is a definition of the policy to be used in qualifying materials, components and sub-assemblies by similarity.

Consider incorporating, in the quality audit, the witnessing of some of the tests.

5 MANUFACTURE

There should be regular quality audits of *material, component and sub-assembly facilities*. Included in the audit should be verification that:

- There are procedures which are being adhered to that contain the appropriate elements defined elsewhere in this document and ensure that:
  - All changes to the process from that specified in the *process specifications* or *drawings* are agreed with the appropriate authorising person prior to their being incorporated.
  - There is an efficient and effective *quality control system*.

Consideration should also be given, within the procedures, to the following:

- The creation of a database comprised of "*part families*" that are represented by specific test coupon configurations. These "*families*" may be based upon similarities of materials, components and sub-assemblies together with their configurations and dimensions. All production parts would be traceable to the representative test coupon through this database, thereby allowing all the representative production parts to be traced following a test failure.

6 MATERIALS, COMPONENTS AND SUB-ASSEMBLY SUPPLIERS

There should be regular quality audits of materials, component and sub-assembly suppliers. Included in the audit should be verification that:

- There are procedures which are being adhered to that contain the appropriate elements defined elsewhere in this document and ensure that there is:
  - An adequate *change control procedure* requiring that the manufacturer is informed before the adoption of ALL changes to materials, components or sub-assemblies so that their "implications" may be assessed prior to their incorporation.
  - An acceptable release inspection procedure.
  - A procurement system that ensures the consistent high quality of bought-in materials.
  - A "robust" ordering system, which includes quality checks.
  - A *receipt inspection* procedure that identifies problems with received materials before they are committed to stores.
- The suppliers have been given the correct *standard of instructions* by the manufacturer.

7 STORAGE

There should be regular quality audits of material, component and sub-assembly stores. Included in the audit should be verification that:

- There are procedures which are being adhered to that contain the appropriate elements defined elsewhere in this document and ensure that:
  - There is a policy for the storage conditions, including temperature and humidity, for all pertinent materials, components and sub-assemblies.
  - There is a procedure by which the shelf life for all pertinent materials, components and sub-assemblies is specified and controlled.
  - Receipt inspection is efficient and picks up problems before hardware is released to stores.

8 ACKNOWLEDGEMENTS

The following people participated in this Task Group's work and contributed to the development of this product:

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APPENDIX 1 - Process for the Derivation of Possible Safeguards for the Prevention of Non-Conformance with Applicable Fire Test Requirements

1 INTRODUCTION

This Appendix 1 illustrates the issues addressed, examples of potential problems, and possible safeguards considered by the Task Group.

The methodology adopted for the derivation of the issues addressed in this Appendix was a systematic process similar to *fault tree analysis* described as a *Fault Logic Diagram*.

The top "*undesired event*" used in the *Fault Logic Diagram* is:

AIRCRAFT FEATURE FOUND TO BE NON-CONFORMANT
WITH APPLICABLE FIRE TEST REQUIREMENTS

It is assumed that the feature has been (or is scheduled to be) installed on the aircraft and that testing has indicated that it is non-conformant with applicable fire test requirements.

Only single errors or faults have been considered since the intention is only to identify the critical issues (and possible safeguards) and not to consider how they might combine to produce undesired states.

The *Fault Logic Diagram* is presented in Appendix 2.

2 ISSUES TO BE ADDRESSED

2.1 INCORRECT TEST PROCEDURES

(See Fault Event '1', Figure 1)

Issue

This Fault Event addresses the case where the material is **conformant** but testing has suggested that it is non-conformant due to the test procedures followed being incorrect.

Examples of Problems

- The test pieces are not made to the same standard or configuration as those certificated for installation on the aircraft.
- The number of samples is insufficient.
- Incorrect temperatures or times have been specified for the tests.

Possible Safeguards

- Ensure that those responsible for specifying the tests are familiar with the procedures.
- Ensure that the test procedures are defined correctly.
- Consider cutting the test pieces from the same component that will be used in the build by making the component oversize.
- Regular quality audits of the *test establishment* should be considered in order to verify that:
    - The *test establishment* has an efficient *quality control system* for maintaining the correct *standard of requirements* and conforms to all the pertinent regulations.
    - The test personnel are sufficiently well trained.
    - There is a satisfactory *sampling plan* in existence.

Consider witnessing actual test(s) as part of the quality audit.

2.2 FAULTY TEST EQUIPMENT

(See Fault Event '2', Figure 1)

Issues

- This Fault Event addresses the case where the material is **conformant** but testing has suggested that it is non-conformant due to the test equipment being faulty.

Examples of Problems

- Burner (e.g. oil burner) temperatures are too high for the test being performed.
- The temperature measuring equipment/systems are incorrect or improperly calibrated.

Possible Safeguards

- Ensure that the quality audit of the *test establishment* includes a procedure for regular and reliable equipment calibration and repair.

2.3 INCORRECT INTERPRETATION OF TEST RESULTS

(See Fault Event '3', Figure 1)

Issues

- This Fault Event addresses the case where the material is **conformant** but the results have been erroneously reported as a failure.

Examples of Problems

- The vertical and horizontal Bunsen burner test results have been interchanged.
- The heat release requirements have been interchanged, i.e. the wrong criteria have been applied to the test piece (for example the Ohio State University rate of heat release test criteria of 100/100 has been used instead of 65/65).

Possible Safeguards

- Ensure that the *test establishment* procedures include a regular training programme that keeps personnel knowledgeable with all of the pertinent procedures.
- Consider incorporating, in the *quality audit*, the witnessing of some of the tests.

2.4 SUBSTANDARD MATERIAL SUPPLIED

(See Fault Event '4', Figure 3)

Issues

- This Fault Event addresses the case where the material supplied to the Manufacturer is **non-conformant**.

Examples of Problems

- The supplier has changed the manufacturing procedure/process, without advising the manufacturer, and this has resulted in 'below-standard' materials being supplied.
- The supplier's production release inspection is inadequate.
- The supplier has been delivered sub-standard 'Raw' materials.

Possible Safeguards

- Ensure that the supplier follows a *change control procedure* that requires the Manufacturer be informed before the adoption of any/all changes so that their implications may be assessed.
- Ensure that the supplier has a documented release inspection procedure in place and that it is being followed.
- Ensure that the supplier has a high *quality procurement system* that ensures the consistent quality of bought-in materials.

2.5 STOCK CONTROL ERROR

(See Fault Event '5', Figure 3)

Issues

- This Fault Event addresses the case where the material is **non-conformant** due to a problem in the Manufacturers stock control system.

Examples of Problems

- Paints, composites, adhesives, etc. have been issued for use beyond their shelf life.
- Part number records in stores have been interchanged or incorrectly read.
- Faulty materials have been received into the company.
- Materials not stored at the correct temperature and humidity.

Possible Safeguards

- Ensure that there is a robust asset management procedure and that it is being followed. This procedure should include:
    - The policy to be adopted for the storage conditions, including temperature and humidity, for all pertinent materials, components and sub-assemblies.
    - The method by which the shelf life for all pertinent materials, components and sub-assemblies is specified and controlled.
    - Ensure that the stock control personnel are adequately trained.

2.6 PROCUREMENT SYSTEM ERROR

(See Fault Event '6', Figure 3)

Issues

- This Fault Event addresses the case where the material is **non-conformant** due to a problem associated with the Manufacturers procurement system.

Examples of Problems

- The wrong parts have been ordered.
- The ordered parts have not been specified in sufficient detail to the Supplier.

Possible Safeguards

- Ensure that there is a "robust" ordering system, which includes quality checks.
- Ensure that *receipt inspection* procedures identify problems with received materials before they are committed to stores.
- Ensure that the quality audit on the supplier includes a verification of a *release inspection system*.

2.7 INCORRECT MATERIAL SPECIFIED BY DESIGN

(See Fault Event '7', Figure 3)

Issues

- This Fault Event addresses the case where the material is **non-conformant** due to the Manufacturers design definition being in error.

Examples of Problems

- The designer has specified an inappropriate material.
- The designer is using out-dated source information.
- The design is over complicated and lacks essential information.

Possible Safeguards

- Ensure that the *design procedures* are available, up-to-date, and include the following subject matter:
    - A regular training programme that keeps personnel knowledgeable with all of the pertinent requirements.
    - Instructions on the method to be employed for ensuring that the fire test data supports the appropriate requirements for the materials specified.
    - A regular review of the drawing checking and modification release system to ensure that there is minimum risk of the design being in error.

2.8 PARTS DEFICIENT AT SUB-ASSEMBLY STAGE

(See Fault Event '8', Figure 4)

Issues

- This Fault Event addresses the case where the material is **non-conformant** due to a problem in the Manufacturers establishment producing sub-assemblies for the assembly line.

Examples of Problems

- Inefficient quality control in the sub-assembly shop.

Possible Safeguards

- Check that the *sub-assembly quality procedures* exist, are up-to-date, are understood and are being followed.

- Ensure that the *sub-assembly quality procedures* include a regular training programme that keeps personnel knowledgeable with all of the pertinent requirements.

2.9 INCORRECT SUPPLIER BUILD

(See Fault Event '9', Figure 4)

Issues

- This Fault Event addresses the case where the material is **non-conformant** due to the sub-assemblies being deficient as delivered from the Supplier.

Examples of Problems

- Component parts dimensionally incorrect.
- Colours/styles incorrect.
- Unauthorised changes in the design standard by the supplier.
- Vendor product changes without re-test.

Possible Safeguards

- Consider carrying out a quality audit of the supplier.
- Ensure that the supplier has been given the correct *standard of specification*.
- Check that the *receipt inspection* is efficient and identifies problems before hardware is released to stores.
- Ensure that the supplier is familiar with, and follows, a *modification procedure* which ensures that the manufacturer is informed formally of any/all changes/modifications prior to their incorporation, so that the repercussions may be considered and addressed.

2.10 PROCEDURES CORRECT BUT NOT FOLLOWED

(See Fault Event '10', Figure 5)

Issues

- This Fault Event addresses the case where the material is **non-conformant** due to the procedures being incorrectly followed.

Examples of Problems

- Adhesive application incorrect.
- Incorrect curing with respect to time and temperature.
- Misinterpretation of *drawings*.

Possible Safeguards

- Ensure that the *process specifications* and *drawings* are clear and unambiguous.
- Ensure that the *quality procedures* include a regular training programme that keeps personnel knowledgeable with all of the pertinent process specifications and quality procedures.
- Ensure that the *quality procedures* require that any changes to the process from that specified in the *process specifications* or *drawings* be agreed with the appropriate authorising person, prior to their being incorporated.

2.11 INCORRECT ASSEMBLY EQUIPMENT

(See Fault Event '11', Figure 5)

Issues

- This Fault Event addresses the case where the material is **non-conformant** due to the tools and equipment being sub-standard.

Examples of Problems

- Hot adhesive applicators regulating at an incorrect temperature or applying incorrect quantities.
- Incorrect air-gaps.
- Micrometers/verniers out of calibration.

Possible Safeguards

- Ensure that the *quality procedures* require that all tools and equipment are correctly maintained and calibrated regularly.

2.12 PROCEDURES INCORRECT

(See Fault Event '12', Figure 5)

Issues

- This Fault Event addresses the case where the material is **non-conformant** due to the procedures being incorrect.

Examples of Problems

- Adhesive quantities and methods of application incorrect.
- Incorrect curing times and temperatures specified.
- Materials tested are not from the same batch as those installed on the aircraft.
- When a fire test failure is encountered, parts represented by that failure must be identified for evaluation and disposition. Often it is not readily known what parts are represented by the failure, and considerable effort and delay is encountered to make that determination.
- Materials are incorrectly qualified by similarity with other materials.

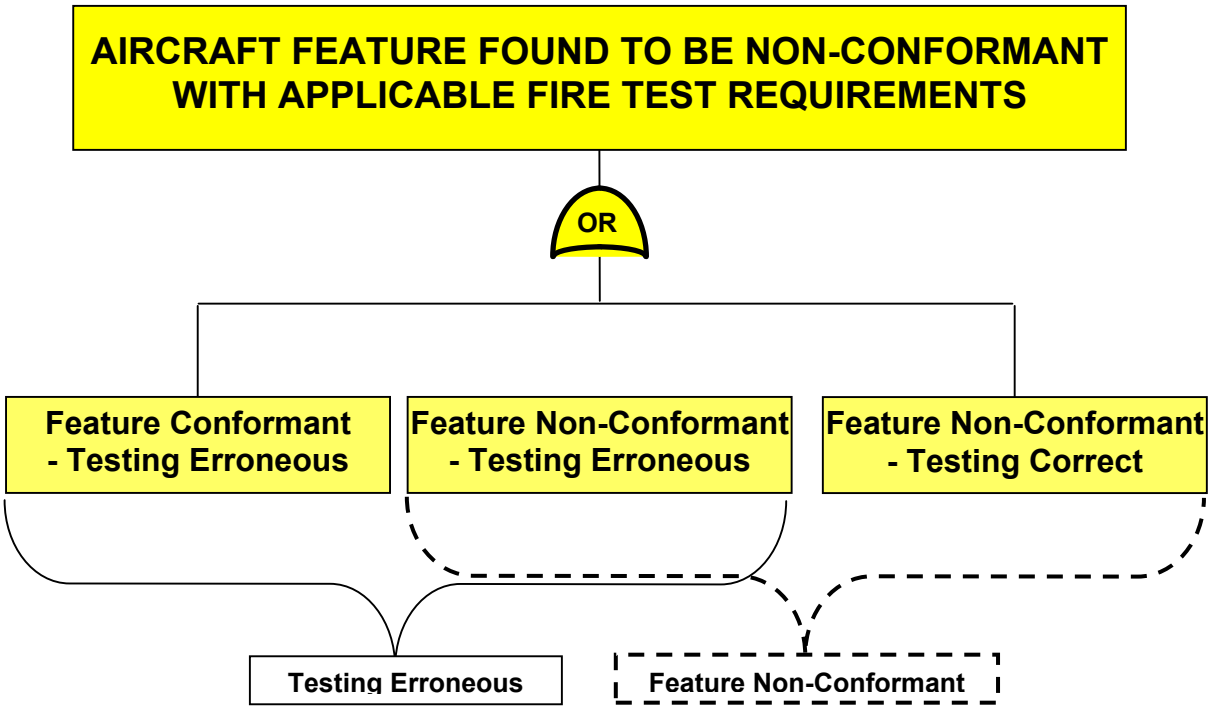
Possible Safeguards

- Ensure that company-approved *process specifications* are clearly defined on the design documents.
- Ensure that the *quality procedures* specify that they need to be regularly appraised and revised as needed.
- Consider testing material samples from each batch unless there is a significant margin between the required fire test standard and that exhibited by the materials tested which justifies less frequent testing.
- Ensure that the *quality procedures* define the policy to be used in qualifying materials by similarity with previously-qualified materials.

- Consideration should be given to the creation of a database comprised of "*parts families*" that are represented by specific test coupon configurations. These "*families*" may be based upon similarities of materials, configurations (laminate vs. sandwich) and part thicknesses. All production parts are then mapped to the representative test coupon through this database, thereby allowing for quick traceability from a test failure to all the representative production parts.

APPENDIX 2 – Fault Logic Diagram for Aircraft Materials Quality Process

Fault Logic Diagram



In order to simplify the *Fault Logic Diagram*, the two basic elements, '***Testing Erroneous***' and '***Feature Non-Conformant***', have been considerd independently. These are further subdivided into the following possible states as shown in Figures 1 to 5:

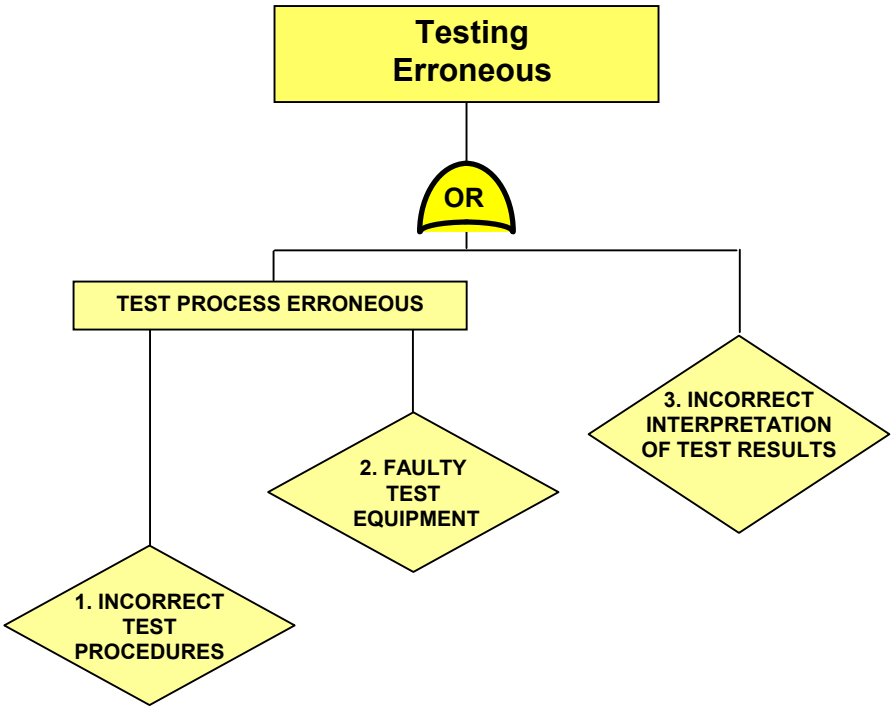


Figure 1 - Expansion of: *'Testing Erroneous'*

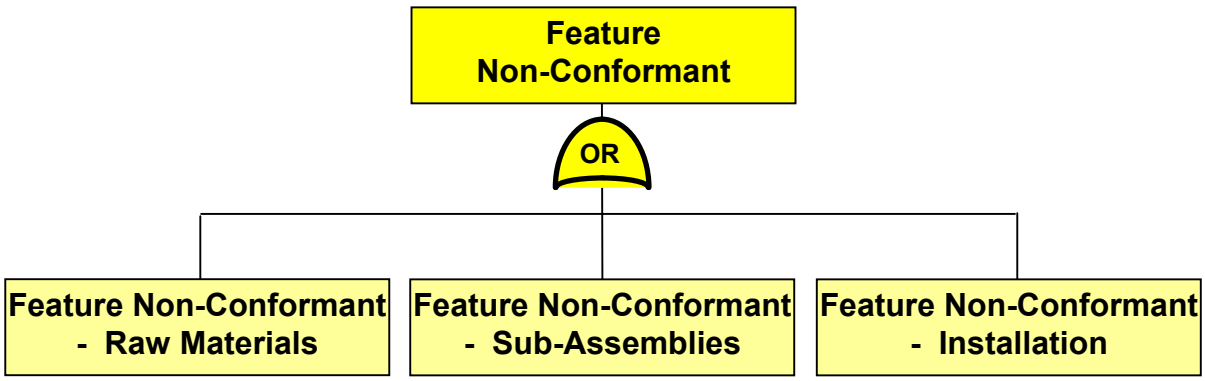


Figure 2 - Expansion of '*Feature Non-Conformant*'

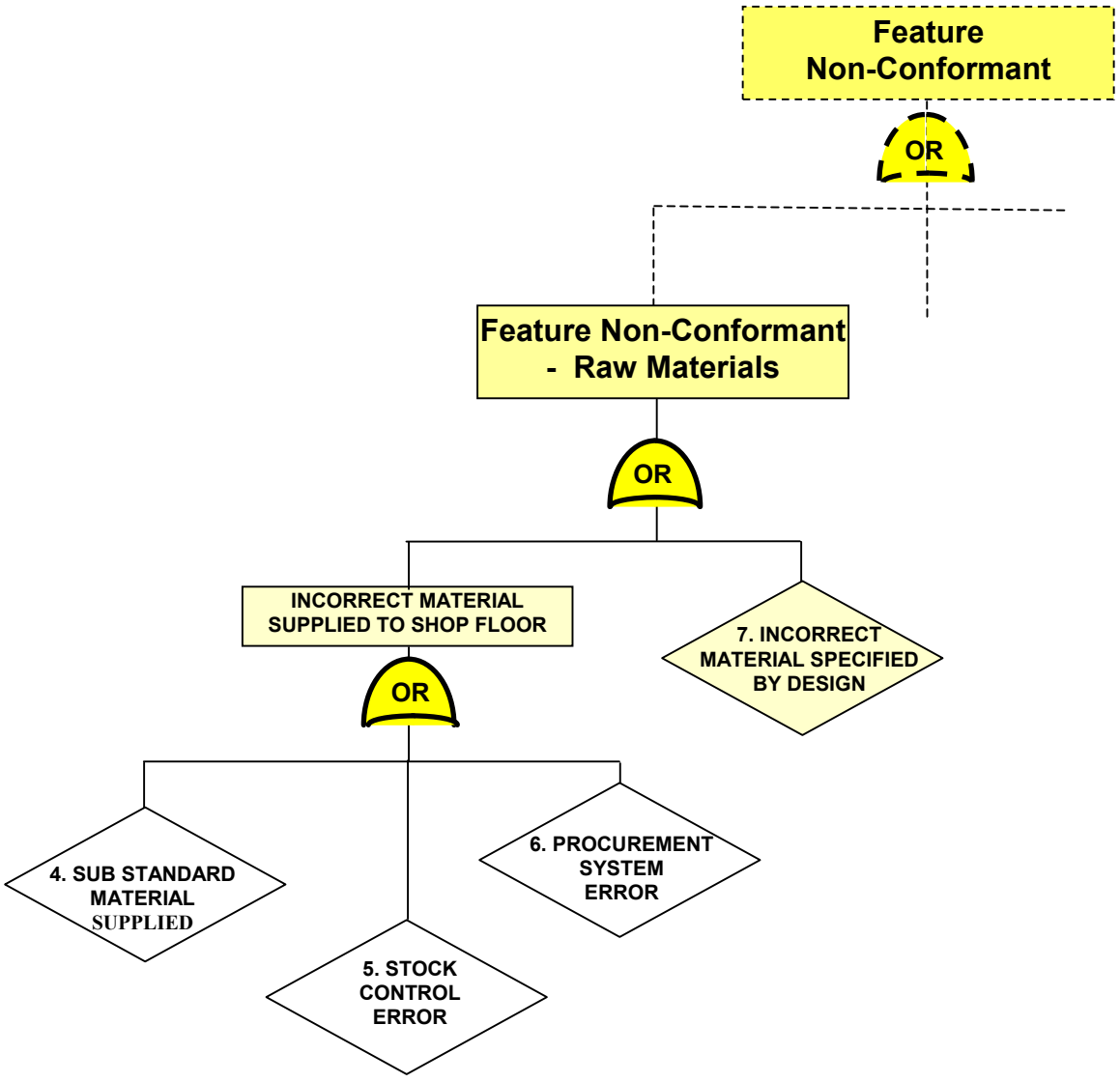


Figure 3 - Expansion of: *'Feature Non-Conformant - Raw Materials'*

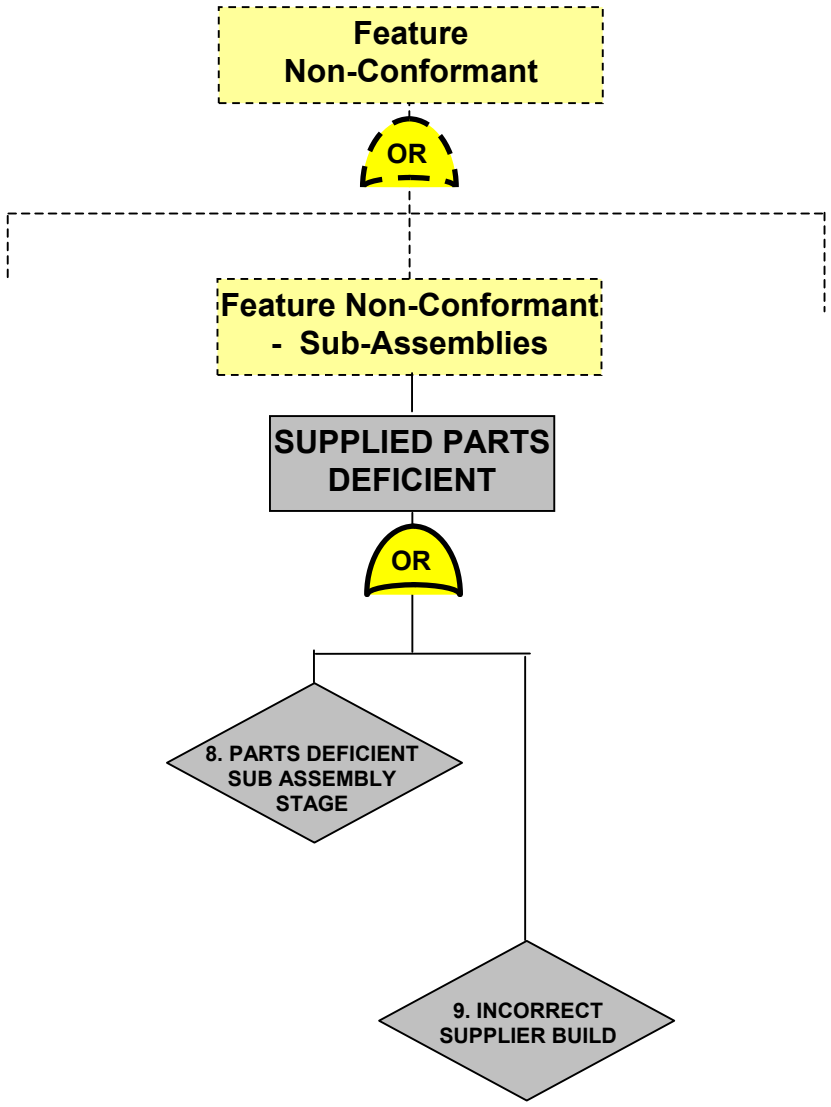


Figure 4 - Expansion of: *'Feature Non-Conformant – Sub-Assemblies'*

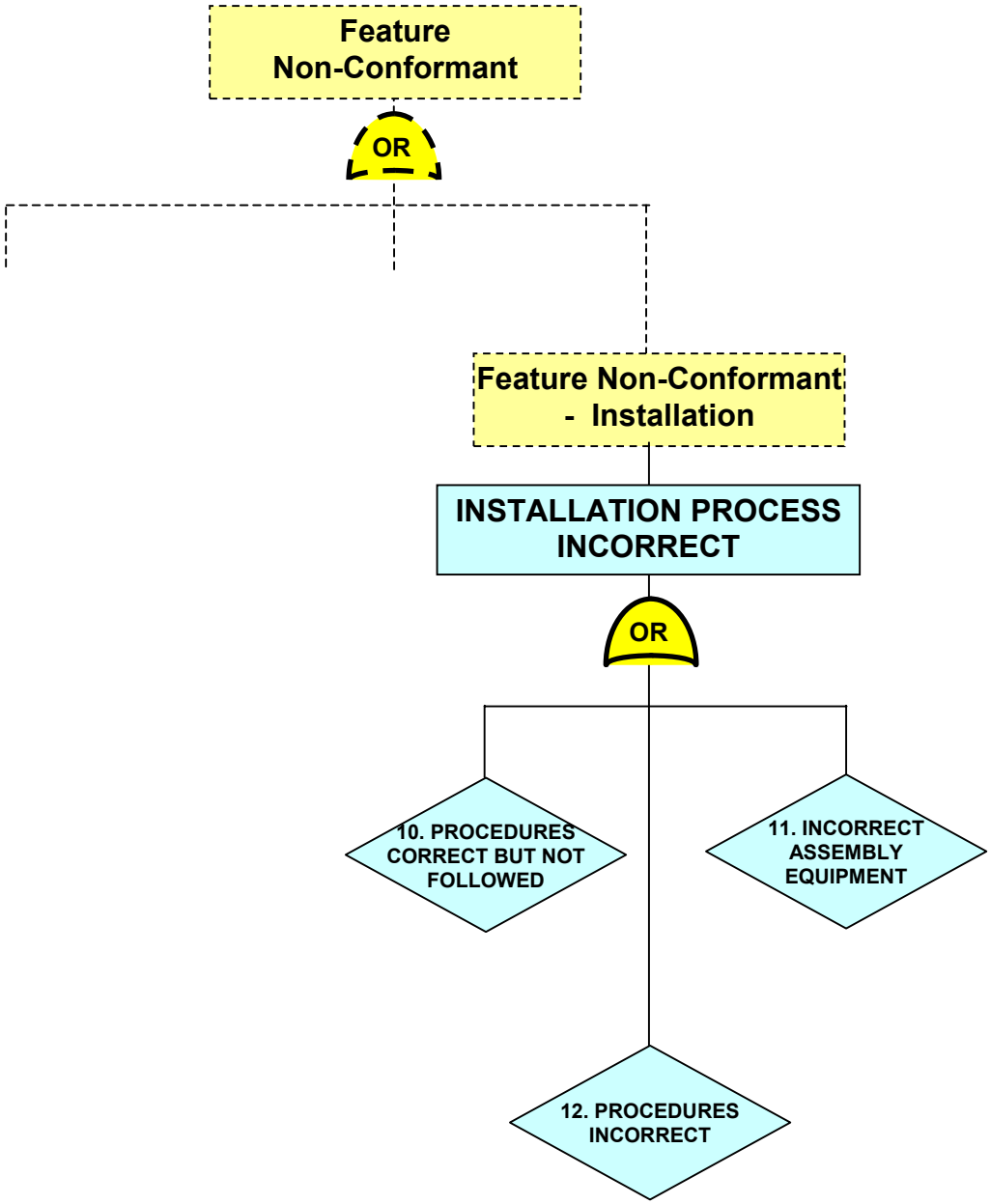


Figure 5 - Expansion of: '*Feature Non-Conformant – Installation*'