

Comment Document
NPA 25D-256
Change Of Composite Materials

INTRODUCTION

This NPA reflects the views of composites specialists from Authorities and Industry and is the outcome of a working group sponsored by the Structures Study Group. The NPA addresses the problem of a change in material for an already certificated composite structure and advises upon the steps to be taken in obtaining certification of the change. Currently no regulatory guidance material exists to cover this problem which is becoming increasingly common as manufacturers seek alternative sources of materials to be used on aircraft in production.

JUSTIFICATION

Most aircraft composite structures are certificated initially with material supplied from only one source. This can lead the manufacturer into problems of continuity of production if the selected source of material becomes unreliable. To overcome this problem manufacturers are now looking to certificate structures with alternative materials to allow for dual sources of material supply. Although mentioned in the Advisory Circular AC 21-26 paragraph 8.2(5), alternative materials are not directly addressed in the equivalent JAR advisory material of ACJ 25.603. However, ACJ 25.603 paragraphs 5.5 and 6.2.1 state that test articles should be representative of production structures. Consequently, all substantiation provided for the certification is strictly valid only for the material concerned.

Substantiating a composite structure requires a large amount of test data ranging from the coupon level to specimens representative of the most complex features of the structural design. Such testing is time consuming and expensive. In seeking certification for an alternative material manufacturers will want to reduce the amount of new testing by relying as much as possible on the testing done to certificate the structure originally. This NPA gives guidance to the extent of analysis and type and number of tests that should be repeated in order to achieve the necessary level of confidence in structural integrity without undue cost penalties. The need for this advisory material is supported by European industry.

DISPOSITION OF COMMENTS

A number of supportive comments were received indicating acceptance of the proposed amendments without change to the text. Other comments, proposing changes, were considered in detail by the Structures Study Group (SSG) at its Meeting No. 95 held in Toulouse on 29-30 October 1996. These comments were dealt with as follows:–

COMMENT: *As written [ACJ 25.603. para 9.1] minor changes in these areas could generate further testing. The scope of the changes should be defined more clearly.*

SSG RESPONSE: *Comment rejected. The need for further testing is dependent upon the extent and significance of the material change. The scope of changes and the level of resubstantiation are clearly defined in AMJ 25.603 para 2.*

COMMENT: *Revise [ACJ 25.603, para 9.2.2 to read] – “The extent of testing required will depend on the ~~airworthiness significance of the part~~ application and the nature of the material change.”*

REASON: *The term “airworthiness significance” should be deleted because this would make it possible to assess changes that may affect individual parts, as well as material uses. This would allow process or material changes that are targeted towards applications to be taken care of without specifically addressing each part individually. When necessary, individual application reviews would still be applicable.*

SSG RESPONSE: Comment rejected. The suggested term “application” is very general whereas “airworthiness significance” is more specific and targeted. For example, the justification of a material change in a composite wing may need to be more extensive than a similar material change to a secondary fairing.

COMMENT: Revise [ACJ 25.603, para 9.2.3 to read] – “Pass fail targets should be established as part of the agreement to the test programme. Any properties that show a ~~decrease~~ significant change in the replacement material should be given special consideration.”

REASON: Any substantial change in a property, increase or decrease, can have both beneficial and adverse effects depending on the structural applications. Changes in properties can cause load redistribution, changes in failure mode or location which can have an adverse impact on safety, durability or damage tolerance.

SSG RESPONSE: Comment accepted. The suggested change will be made.

COMMENT: Revise [ACJ 25.903, para 9.2.4] to read – “The test substantiation should interrogate the critical failure modes ~~of the structure in question.~~”

REASON: Interrogate all critical failure modes not of just the structure in question. Keep the NPA more generic to the material in question. It may be used in other areas.

SSG RESPONSE: Comment partially accepted. The SSG agree that there is a need to cover load redistribution, changes in failure mode or location that can go beyond the particular element(s) subject to the change. For example, change to the material of a wing spar, may require interrogation of the modes of failure of the wing box, rather than just the spar itself. The SSG propose to modify this sentence to read “The test substantiation should interrogate the critical failure modes of the component.” Here “component” is taken to be consistent with the AMJ 25.603 Figure 1.

COMMENT: Revise [ACJ 25.903, para 9.2.5] to read – “For components substantiated by analysis alone design allowables should be established to the ~~same level of statistical confidence~~ for the replacement material.”

REASON: Vague statement. This needs to be defined. Does a comparability study satisfy statistical confidence? This statement will cause a major cost and time impact to implementing any changes. It also implies that we could trade off the cost and time of testing a component rather than doing the large coupon allowables test program required to do the analysis.

SSG RESPONSE: Comment partially accepted. The SSG believes that is quite normal to have a statistical analysis of design allowables. MIL-HDBK-17, for example, uses statistical analysis as a fundamental approach. Therefore, the reference to statistical confidence will be retained. Nevertheless, there is no intention to encourage trade-off in testing a component against a coupon allowables test program, since both approaches might be needed. To address this point, the SSG proposes to modify the sentence to read: “Design allowables should be established to the same level of statistical confidence for the replacement material.”

COMMENT: Revise [AMJ 25.603, Background, second paragraph.] by deleting – “~~The problem with composites is much more complex than with metallic materials, because their performance is much more process dependent. So, until we are capable of accurately identifying the key material parameters governing processability ...~~” Change “there will be a need for tests ...” to “There is a need for tests ...”

REASON: The structure and performance of metallic materials are no less process dependent than those of composite materials. We have a lot more history with the processing of metals.

SSG RESPONSE: Comment rejected. This may be true at the materials level. However, the performance of a composite structure is more process dependent than metallic structure because of the more integrated nature of the materials, process and design aspects of a composite structure. However, by way of improvement the SSG propose to amend the first sentence to read “The problem is more complex with composite materials than with metallic materials because composite structural performance is dependent to a greater degree on the integrated nature of the materials, process and design aspects.”

COMMENT: Delete the entire paragraph [AMJ 25.603, Background, fourth paragraph] beginning “Such diversity ...”

REASON: This paragraph is unnecessary. The tests required for composite structure are no more diverse than for other types of structure. All material properties (for all materials) are dependent on the processing of the material.

SSG RESPONSE: Comment rejected. The SSG maintain that there is greater diversity in testing of composite structures. The need to consider the effects of impact damage, environment, porosity and delamination, leads naturally to a greater number of test conditions to select from.

COMMENT: Delete the entire paragraph [AMJ 25.603, Background, fifth paragraph] beginning “To give a more ...”

REASON: This statement is not entirely true. New airplane structure does typically use the “pyramid” approach for testing purposes but the airplane is certified by analysis supported by test evidence. Once the analytical methods are verified, the pyramid approach would not be used. Changes in geometry or materials can be done by comparative study and a modified testing approach would be adopted. Many composite analytical models have become accurate in predicting the behaviour of complex specimens. Future designs will rely less on the pyramid approach and more on analysis modelling.

SSG RESPONSE: Comment rejected. The SSG are not convinced that, at this point in time, analytical methods alone are sufficiently accurate for certification, without supporting test evidence.

COMMENT: Delete the entire paragraph [AMJ 25.603, Background, eighth (last) paragraph] beginning “But interchangeability ...” Replace with “In addition, qualification procedures include allowables and design values testing to insure that materials meeting the same manufacturing specifications are interchangeable.”

REASON: This provides a clearer rationale for the guidelines in the following sections.

SSG RESPONSE: Comment rejected. Examples exist that show materials manufactured to the same manufacturing specification are not interchangeable. Furthermore, the proposed replacement paragraph implies in the context of the previous text that every manufacturer already includes procedures to ensure interchangeability. This is not the case.

COMMENT: Revise [AMJ 25.603, paragraph 2C] to read – “~~(as far as~~ if the modification to the processing route governs eventual composite mechanical properties)”.

REASON: Identify the changes affecting material properties.

SSG RESPONSE: Comment accepted. The proposed change will be adopted.

COMMENT: Delete the entire paragraph [AMJ 25.603, Definition of material change, third paragraph].

REASON: None given.

SSG RESPONSE: Comment rejected.

COMMENT: Move entire paragraph [AMJ 25.603, Definition of material change, fourth paragraph] to section 3.a., second paragraph, also change as follows: – “~~Some~~ Changes within this class may not interact with structural performances (e.g. prepreg release papers, some bagging materials etc.) and ...”

REASON: “Some” – This is not needed. Examples are not needed. Paragraph should be a generic statement applying to all changes and included under compliance philosophy.

SSG RESPONSE: Comment rejected. The SSG believes that these examples are useful.

COMMENT: Revise [AMJ 25.603, Compliance Philosophy, fourth paragraph] to read – “Substantiation ~~shall~~ should be ...”

SSG RESPONSE: Comment accepted. The proposed change will be adopted.

COMMENT: Revise [AMJ 25.603, Compliance Philosophy, fourth paragraph, alternative material (case “A”) second bullet] to read – “Possible effects on the failure prediction models should be evaluated and, if necessary, substantiated by tests.”

SSG RESPONSE: Comment partially accepted. It is not the possible effects on the failure prediction models that needs to be evaluated. Rather, it is the possible effects on strain distribution etc. that needs to be evaluated to check whether the failure prediction models remain valid. To respond to the spirit of the comment, the SSG propose to amend this bullet to read “analytical models, including failure prediction models should be reviewed and, if necessary, substantiated by tests.”

COMMENT: Revise [AMJ 25.603, Compliance Philosophy, fourth paragraph, alternative material (case “A”), third bullet] to read – “The ~~A new~~ procurement specification should be evaluated (or a new specification suited to the selected material should be defined) to ~~adequately~~ ensure control quality variations are adequately controlled.”

SSG RESPONSE: Comment accepted. The bullet will be so amended.

COMMENT: Delete [AMJ 25.603, Compliance Philosophy, fourth paragraph, alternative material (case "A") fourth bullet].

SSG RESPONSE: Comment accepted. This point will be retained as an example, but not as a bullet.

COMMENT: Revise [AMJ 25.603, substantiation method 3b, Tests to be performed, fourth paragraph] to read – "The test programme should ~~will have to~~ be established considering ~~with regard~~ ..."

SSG RESPONSE: Comment accepted. This amendment will be adopted.

COMMENT: Delete from [AMJ 25.603, Substantiation Method 3b, Tests to be performed, last paragraph] – "~~the so-called proof test~~"

REASON: This may not be a universal term, the definition is given which is adequate.

SSG RESPONSE: Comment partially accepted. It is accepted that the term "tool proof test" may not be universal. Therefore, the SSG propose to use the descriptor "(sometimes called the "tool proof test")".

COMMENT: Delete from [AMJ 25.603, Substantiation Method d, Pass Fail Criteria] "a statistical analysis"

REASON: None given.

SSG RESPONSE: Comment rejected.

COMMENT: Revise [AMJ 25.603, Substantiation Method d Pass/Fail criteria, fourth sentence] to read – "At the non-generic level, when only one test article is used ~~may be proposed~~ to assess a structural feature, ~~when~~ the pass criteria should be a result ..."

SSG RESPONSE: Comment accepted. This sentence will be so amended.

COMMENT: Delete from [AMJ 25.603, Substantiation Method, d. Pass/Fail criteria] "~~Therefore, provision should be made for a sufficient number of test specimens to allow for such analysis.~~"

REASON: This is implied in the preceding sentence and is redundant.

SSG RESPONSE: Comment rejected. This is only implied in the preceding sentence and reinforces the intent.

COMMENT: Delete "~~Flutter~~" from Table 1.

REASON: Flutter is not a material property. It is not tested below the airplane level.

SSG RESPONSE: Comment accepted. However, the SSG consider that it is appropriate to include a reminder that consideration should be given to the need for tests of structural properties such as flutter. Therefore, the SSG propose to modify the Table to include a row specific to "Other considerations", with a list of structural properties, other than strength, that may need to be tested. Furthermore, the SSG propose to establish the last sentence of paragraph d as a new paragraph e that reads: – "e. other considerations, For structural characteristics other than strength (all those listed in ACJ 25.603, paragraphs 7 and 8) the substantiation should also ensure an equivalent level of safety."

COMMENT: Change [ACJ 25.603, paragraph 9.2.3, first sentence] as follows: – "Pass/fail targets should be established as part of the test program."

REASON: Only the technical content of the substantiation should be described. What must be submitted to the Authority's agreement is a matter for JAR-21 and will depend on the status of the design organisation.

SSG RESPONSE: Comment accepted. The proposed amendment will be adopted.

COMMENT: Change [AMJ 25.603, Purpose, last line] as follows – "... an acceptable method of showing compliance with JAR 25.603."

REASON: Wording consistency.

SSG RESPONSE: Comment accepted. The proposed change will be adopted.

COMMENT: To the bottom of [AMJ 25.603, Purpose] add the following note: – "Note – The procedural requirements for the classification and approval of changes are prescribed in JAR-21, Subparts D and E, to which the reader should refer for the definition of the terms "showing of compliance" "minor change" and "major change" that are used in this AMJ 25.603"

REASON: Clarification.

SSG RESPONSE: Comment rejected. Since the initial draft, the NPA has not used the terms “minor change” and “major change”.

COMMENT: [AMJ 25.603, Paragraph 2, Definition of material change, 3rd bullet before end] should end as follows: – “... will be dealt with as a major change.”

REASON: Wording consistency, clarification.

SSG RESPONSE: Comment rejected. The proposed amendment would not result in wording consistency since the term “major change” is not used elsewhere in the NPA.

COMMENT: Change [AMJ 25.603, paragraph 2, Definition of material change, last but one bullet] as follows: – “Some changes within this class may not interact with structural performances (e.g. prepreg release papers, some bagging materials, etc ...) and are to be classified as minor changes.”

REASON: The approval procedure for minor changes and the organisation requirements are addressed in JAR-21.

SSG RESPONSE: Comment rejected. The term “minor change” is not used elsewhere in the NPA. However, the SSG agree that the NPA should only describe the technical content and not agency approval procedures. Therefore, the SSG propose to amend the subject sentence to read “Some changes within this class may not interact with structural performances (e.g. prepreg release papers, some bagging materials, etc.) and will not need additional substantiation data to be generated.”

COMMENT: The JAR-21 definition of major change is one that has an appreciable effect on the final weight, balance, structural strength or reliability. Under the proposed AMJ a change of composite material could be approved that has no such appreciable effect. However, the analytical and test justification needed to be compiled by the manufacturer just to show that the change of material has no appreciable effect on structural strength or reliability could be considerable. In this sense the change of composite material is a significant change that must be approved by the Authority. To avoid any confusion over definition of a major change it is appropriate that the AMJ should be self contained without referring to the JAR-21 definition of major and minor change. Of course it is understood that the procedural requirements of JAR-21 will be applicable, as they are to all aspects of certification and compliance finding. However, it should not be necessary to treat this AMJ differently from all others by including special notes to this effect.

SSG RESPONSE: Comment accepted. The NPA will be kept self-contained and will not use the terms “minor change” and “major change”.

COMMENT: The material presented in this NPA would benefit greatly by including references to MIL-HDBK-17.

SSG RESPONSE: Comment rejected. The use of MIL-HDBK-17 should not be limited to material changes but would apply equally to substantiation of the original structure. Therefore, the reference should be incorporated into the existing ACJ 25.603. Unfortunately, it is not the purpose of this NPA to change the existing text. However should any changes be made to that text in the future then a reference to MIL-HDBK-17 would be considered at that time.

COMMENT: [The commenter] doubts that the guidance provided in this NPA will achieve the necessary level of confidence in structural integrity in all cases. A complete recertification should be the rule and not the exception, especially in the cases of primary structures. Besides, the NPA covers a common engineering problem equally important to JAR VLA, JAR-22, JAR-23, JAR-25, JAR-27, JAR-29, JAR E and JAR P products. Why address the subject in such a piece meal fashion?

SSG RESPONSE: Comment rejected. The SSG consider this NPA to be necessary since Part 25 manufacturers are already introducing alternative composite materials into previously certificated aircraft. The SSG does not accept that the NPA will lead to any reduction in the level of safety. Indeed, one purpose of the NPA is to ensure that there will be no such reduction. It is unacceptable for the industry to go through a complete re-certification if an alternative, less costly route can be justified.

COMMENT: Based on several years of experience with composite parts, there should be the possibility for approved Design Organisations to handle changes of composite materials within the scope of the approval (part of the privileges as per JAR-21.A263). The proposed addition to the text of AMJ 25.603 Chapter 2 should read as follows: “at all decision levels. JAR approved Design Organisations may handle all material changes of Class B and C to composite parts within the scope of their approval.”

SSG RESPONSE: Comment rejected. The privileges associated with Design Organisation approval is a matter solely for JAR-21. This NPA is restricted to the technical aspects of substantiation.

