Proposed Equivalent Safety Finding on CS 25.251(b) - "Vibration / buffeting"

Applicable to Large Aeroplanes category fitted with large antenna installation

Introductory note:

The hereby presented Equivalent Safety Finding has been classified as an important Equivalent Safety Finding and as such shall be subject to public consultation, in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) of which states:

"*2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.*"

Statement of Issue

For design changes installing large antenna covered by an aerodynamic fairing (hereafter referred to as the "antenna radome") compliance must be shown to CS 25.251(b), which states that each part of the airplane must be demonstrated in flight to be free from excessive vibration under any appropriate speed and power conditions up to V_{DF}/M_{DF}.

The extent of the airplane modifications, particularly the size and location of the antenna radome with respect to the unmodified airplane, may cause significant changes in the aerodynamic flow field around the airplane at high speed, which may lead to excessive vibration. Potential vibration sources include unsteady flow conditions on the antenna radome, fuselage, tail assembly, or control surfaces arising from shocks, flow separation or other unsteadiness in the flow.

Because of these potential effects, the original demonstration of compliance to CS 25.251(b) may not be valid for the modified airplanes.

The EASA has determined that if it cannot be shown by an acceptable method that the original compliance finding for this rule remains valid (i.e., no vibration/buffet issues exist due to the change), an equivalent level of safety can been shown. However, if the original compliance demonstration for this rule does not remain valid due to potential effects of the external modification, direct compliance with the rule must be re-demonstrated.

Equivalent Safety Finding on CS 25.251(b) – Vibration and buffeting -

Large Aeroplanes category fitted with large antenna installation

EASA proposal :

Unless it can be shown that the modification would not affect the original compliance demonstration to 25.251(b), the applicant must show compliance with CS 25.251 either by flight test up to V_{DF}/M_{DF}, or by using the means of compliance proposed (associated with the interpretative material in Appendix 1) which are considered to provide an equivalent level of safety to flight testing up to V_{DF}/M_{DF}.

For convenience, the full ESF text is presented for this public consultation. However, the Interpretative Materials are provided for the information only.

EASA Safety Equivalency Demonstration proposal :

To evaluate whether the modification could affect the original compliance finding or to extrapolate findings beyond V_{MO}/M_{MO}, the applicant may propose to use any suitable combination of the following:

1. Similarity to other approved designs. (Consider the size, shape, and location of the respective modification, the airplanes they are installed on, the respective VDF/MDF speeds, and the method of compliance used for the approved designs.)

2. Flowfield analysis using an acceptable computational fluid dynamics tool. The applicant must show that the tool is valid for its intended use. For example, the tool must be capable of accurately assessing whether a shock is present, including its strength and location, and the area of separated flow. Generally, a full Navier-Stokes code with robust turbulence modeling is needed for such an analysis. Validation using flight test data is preferred, but suitable wind tunnel data may be acceptable. The applicant should also address other known limitations and characteristics of the code to be used, such as:
   a. Grid sizes and spacing.
   b. Geometric fidelity of the airplane model – the effect of simplifications of the model (e.g., ignoring flap track fairings, vortex generators, small gaps, etc., how the engines are modeled, aeroelastic effects, other differences between the actual airplane and the digital model used in the analysis).
   c. CFD modeling errors, particularly in turbulence modeling.
   d. Location of the trip point from laminar to turbulent flow.
   e. Boundary conditions (e.g., ensuring that far field conditions are applied sufficiently far away).

3. A vibration analysis, usually based on the results of the flowfield analysis addressed in (2).

4. Flight testing to a speed from which the analyses described in paragraph (1), (2) and (3) can be used to extrapolate the findings to V_{DF}/M_{DF}. As a minimum, flight testing must include test points to cover the complete flight domain from low speed to speeds up to and including V_{MO}/M_{MO} and covering high lift configurations and sideslips which could be experienced in service.

Appendix 1

Interpretative Material

CFD Code Validation

To use a CFD tool in showing that the modification does not affect compliance with CS 25.251(b) or to extrapolate findings beyond V_{MO}/M_{MO}, the applicant should show that the tool is valid for its intended use. The CFD tool needs to be capable of accurately assessing whether a shock is present, including its strength and location, and the area of separated flow.
Generally, a full Navier-Stokes code with robust turbulence modelling is needed for such an analysis. Validation using flight test data is preferred, but suitable wind tunnel data may be acceptable.

Code validation includes:

1. Showing that the code accurately models flow phenomena of interest (e.g. transonic shocks, shock induced flow separation, shock-boundary layer interaction and separated flows) that may result from the modification.

2. Showing that the person/organization performing the analysis is experienced and qualified to properly run the code and interpret the results.

The accuracy of the modelling of the flow field phenomena of interest should be demonstrated by comparing flow field characteristics (e.g., pressure distributions, shock strength/location, etc.) predicted by the model to flight test or wind tunnel data for a configuration (including shape, location, and airframe) similar to the modification being evaluated at airspeeds up to V_{DF}/M_{DF}.

In addition, if there are no significant flow field phenomena of interest (e.g. transonic shocks, shock induced flow separation, shock-boundary layer interaction and separated flows) shown with the configuration being evaluated, a comparison should be made to another configuration that does exhibit such phenomena. (The validation depends on the flow phenomena of interest being present to show that the code will accurately model such flow phenomena.)
Known limitations and characteristics of the model should be addressed, such as grid sizes and spacing, geometric fidelity of the airplane model, turbulence modelling fidelity, boundary conditions, and strength and location of shocks/ recovery.

The test cases used to validate the code should be agreed to in advance by the EASA.

Aerodynamic Analysis

An aerodynamic analysis using the validated code may be used to show that compliance with CS 25.251(b) will not be affected by the modification provided the code validation has been accepted by the EASA.

The aerodynamic analysis need not cover all flight conditions. The critical flight conditions should be identified and those that need to be analysed in detail selected. The applicant should document how these critical flight conditions have been identified.

The applicant should analyse the effects of all simplifications or assumptions applied to the aerodynamic model (i.e., the analytical representation of the modified and unmodified airplanes) and show that these simplifications would not lead to an inappropriate conclusion.

After EASA acceptance of both the code validation and the results of the aerodynamic analysis, it is not required to perform a flight test to V_{DF}/M_{DF} to show that the modification did not affect compliance with CS 25.251(b).
However, flight testing to cover the flight domain up to and including V_{MO}/M_{MO} should be performed with a qualitative assessment that no buffeting condition exists up to that speed to show compliance with CS 25.251(d).

The flight testing to cover the flight domain should cover the complete domain from low speed to speeds up to and including V_{MO}/M_{MO} and should cover high lift configurations and sideslips which could be experienced in service.