aluminium facing sheets. Alternative materials and methods of construction should have at least equivalent impact energy absorption characteristics). Failures with the origins in the bore of these same drum sections have resulted in fragments which can be characterised as a single 1/3 disk fragment and multiple smaller fragments. The 1/3 disk fragment may or may not be contained by the thrust reverser structure. The remaining intermediate and small disk fragments, while escaping the engine case, have been contained by the thrust reverser structure.

— Deep Bore Disks (see Figure 4.b.) and Single Disks (see Figure 4.c.) - For compressor drum rotors or spools with deep bore disks, and single compressor and turbine disks, the experience, while limited, indicates either a 1/3 and a 2/3 fragment, or a 1/3 fragment and multiple intermediate and small discrete fragments should be considered. These fragments can be randomly released within an impact area that ranges * 5 degrees from the plane of rotation.

(B) Small Fragments (Debris)

Consider small fragments (reference AMC 20-128A, paragraph 9.d.) that could impact the thrust reverser at * 15 degrees axial spread angle.

8.d.(4)(ii) Minimisation:

Minimisation guidance provided below is for fragments from axial flow rotors surrounded by fan flow thrust reversers located over the intermediate or high-pressure core rotors.

NOTE: See attached Figure 5: Typical High Bypass Turbofan Low and High Pressure Compressor with Fan Thrust Reverser Cross Section

(A) Large Fragments

For the large fragments defined in Section 8.d.(4)(i)(A), above, the thrust reverser retention systems should be redundant and separated as follows:

— Ring Disks Compressor Spools:

Retention systems located in the outer barrel section of the thrust reverser should be separated circumferentially (circumferential distance greater than the 1/3 disk fragment model as described in AMC20 128A) or axially (outside the * 5 degree impact area) so that a 1/3 disk segment can not damage all redundant retention elements and allow thrust reversal (i.e., deployment of a door or translating reverser sleeve half). Retention systems located between the inner fan flow path wall and the engine casing should be located axially outside the + 5 degree impact area.

— Deep-bore Disk Spools and Single Disks:

Retention systems should be separated axially with at least one retention element located outside the * 5 degree impact area.

(B) Small Fragments

For the small fragments defined in Section 8.d.(4)(i)(B), above, thrust reverser retention systems should be provided with either:

— At least one retention element shielded in accordance with AMC 20-128A, paragraph 7(c), or capable of maintaining its retention capabilities after impact; or

— One retention element located outside the * 15 degree impact area.

9. «MIXED CONTROLLABILITY / RELIABILITY» OPTION.

If the aeroplane might experience an unwanted in-flight thrust reversal outside the «controllable flight envelope» anytime during the entire operational life of all aeroplanes of this type, then outside the controllable envelope reliability compliance must be shown, taking into account associated risk exposure time and the other considerations described in Section 8, above.

Conversely, if reliability compliance is selected to be shown within a given limited flight envelope with associated risk exposure time, then outside this envelope controllability must be demonstrated taking into account the considerations described in Section 7, above.

Mixed controllability/reliability compliance should be shown in accordance with guidance developed in Sections 7 and 8, above, respectively.

10. DEACTIVATED REVERSER.

The thrust reverser system deactivation design should follow the same «fail-safe» principles as the actuation system design, insofar as failure and systems/hardware integrity. The effects of thrust reverser system deactivation on other aeroplane systems, and on the new configuration of the thrust reverser system itself, should be evaluated according to Section 8.a., above. The location and load capability of the mechanical lock-out system (thrust reverser structure and lock-out device) should be evaluated according to Sections 8.b. and 8.d., above. The evaluation should show that the level of safety associated with the deactivated thrust reverser system is equivalent to or better than that associated with the active system.

11. CS 25.933(b) COMPLIANCE.

For thrust reversing systems intended for in-flight use, compliance with CS 25.933(b) may be shown for unwanted in-flight thrust reversal, as appropriate, using the methods specified in Sections 7 through 10, above.

12. CONTINUED AIRWORTHINESS.

12.a. Manufacturing/Quality: Due to the criticality of the thrust reverser, manufacturing and quality assurance processes should be assessed and implemented, as appropriate, to ensure the design integrity of the critical components.

12.b. Reliability Monitoring: An appropriate system should be implemented for the purpose of periodic monitoring and reporting of in-service reliability performance. The system should also include reporting of in-service concerns related to design, quality, or maintenance that have the potential of affecting the reliability of the thrust reverser.

12.c. Maintenance and Alterations: The following material provides guidance for maintenance designs and activity to assist in demonstrating compliance with Sections 7 through 10, above (also reference CS 25.901(b)(2) and CS 25.1529/Appendix H). The criticality of the thrust reverser and its control system requires that maintenance and maintainability be emphasised in the design process and derivation of the maintenance control program, as well as subsequent field maintenance, repairs, or alterations.

12.c.(1) Design: Design aspects for providing adequate maintainability should address :

12.c.(1)(i) Ease of maintenance. The following items should be taken into consideration:

— It should be possible to operate the thrust reverser for ground testing/trouble shooting without the engine operating.

— Lock-out procedures (deactivation for flight) of the thrust reverser system should be simple, and clearly described in the maintenance manual. Additionally, a placard describing the procedure may be installed in a conspicuous place on the nacelle.

— Provisions should be made in system design to allow easy and safe access to the components for fault isolation, replacement, inspection, lubrication, etc. This is particularly important where inspections are required to detect latent failures. Providing safe access should include consideration of risks both to the mechanic and to any critical design elements that might be inadvertently damaged during maintenance.

— Provisions should be provided for easy rigging of the thrust reverser and adjustment of latches, switches, actuators, etc.

12.c.(1)(ii) Fault identification and elimination:

— System design should allow simple, accurate fault isolation and repair.

— System design personnel should be actively involved in the development, documentation, and validation of the troubleshooting/fault isolation manual and other maintenance publications. The systems design personnel should verify that maintenance assumptions critical to any SSA conclusion are supported by these publications (e.g., perform fault insertion testing to verify that the published means of detecting, isolating, and eliminating the fault are effective).

— Thrust reverser unstowed and unlocked indications should be easily discernible during pre-flight inspections.

— If the aeroplane has onboard maintenance monitoring and recording systems, the system should have provisions for storing all fault indications. This would be of significant help to maintenance personnel in locating the source of intermittent faults.

12.c.(1)(iii) Minimisation of errors: Minimisation of errors during maintenance activity should be addressed during the design process. Examples include physical design features, installation orientation markings, dissimilar connections, etc. The use of a formal «lessons learned»-based review early and often during design development may help avoid repeating previous errors.

12.c.(1)(iv) System Reliability: The design process should, where appropriate, use previous field reliability data for specific and similar components to ensure system design reliability.

12.c.(2) Maintenance Control:

12.c.(2)(i) Maintenance Program: The development of the initial maintenance plan for the aeroplane, including the thrust reverser, should consider, as necessary, the following:

— Involvement of the manufacturers of the aeroplane, engine, and thrust reverser.

— The compatibility of the SSA information and the Maintenance Review Board Report, Maintenance Planning Document, Master Minimum Equipment List, etc. (ref AMC 25.19).

— Identification by the manufacturer of all maintenance tasks critical to continued safe flight. The operator should consider these tasks when identifying and documenting Required Inspection Items.

— The complexity of lock-out procedures and appropriate verification.

— Appropriate tests, including an operational tests, of the thrust reverser to verify correct system operation after the performance of any procedure that would require removal, installation, or adjustment of a component; or disconnection of a tube, hose, or electrical harness of the entire thrust reverser actuation control system.

12.c.(2)(ii) Training: The following considerations should be taken into account when developing training documentation:

— The reason and the significance of accomplishing critical tasks as prescribed. This would clarify why a particular task needs to be performed in a certain manner.

— Instructions or references as to what to do if the results of a check or operational test do not agree with those given in the Aeroplane Maintenance Manual (AMM). The manual should recommend some corrective action if a system fails a test or check. This would help ensure that the critical components are not overlooked in the trouble shooting process.

— Emphasis on the total system training by a single training source (preferably the aeroplane manufacturer) to preclude fragmented information without a clear system understanding. This training concept should be used in the initial training and subsequent retraining.

— Inclusion of fault isolation and troubleshooting using the material furnished for the respective manuals.

— Evaluation of the training materials to assure consistency between the training material and the maintenance and troubleshooting manuals.

12.c.(2)(iii) Repairs and Alterations: The Instructions for Continued Airworthiness essential to ensure that subsequent repairs or alterations do not unintentionally violate the integrity of the original thrust reverser system type design approval should be provided by the original airframe manufacturer. Additionally, the original airframe manufacturer should define a method of ensuring that this essential information will be evident to those that may perform and approve such repairs and alterations. One example would be maintaining the wire separation between relevant thrust reverser control electrical circuits. This sensitivity could be communicated by statements in appropriate manuals such as the Wiring Diagram Manual, and by decals or placards placed on visible areas of the thrust reverser and/or aeroplane structure.

12.c.(2)(iv) Feedback of Service Experience: The maintenance process should initiate the feedback of service experience that will allow the monitoring of system reliability performance and improvements in system design and maintenance practices. Additionally, this service experience should be used to assure the most current and effective formal «lessons learned» design review process possible.

(A) Reliability Performance:

(Operators and Manufacturers should collaborate on these items:)

— Accurate reporting of functional discrepancies.

— Service investigation of hardware by manufacturer to confirm and determine failure modes and corrective actions if required.

— Update of failure rate data. (This will require co-ordination between the manufacturers and airlines.)

(B) Improvements suggested by maintenance experience:

(This will provide data to effectively update these items:)

— Manuals

— Troubleshooting

— Removal/replacement procedures.

12.c.(2)(v) Publications/Procedures: The following considerations should be addressed in the preparation and revisions of the publications and procedures to support the thrust reverser in the field in conjunction with CS 25.901(b)(2) and CS 25.1529(Appendix H).

(A) Documentation should be provided that describes a rigging check, if required after adjustment of any thrust reverser actuator drive system component.

(B) Documentation should be provided that describes powered cycling of the thrust reverser to verify system integrity whenever maintenance is performed. This could also apply to any manual actuation of the reverser.

(C) The reasons and the significance of accomplishing critical tasks should be included in the AMM.

(D) The AMM should include instructions or references as to what to do if the results of a check or operational test do not agree with those given in the AMM.

(E) Provisions should be made to address inefficiencies and errors in the publications:

— Identified in the validation process of both critical and troubleshooting procedures.

— Input from field.

— Operators conferences.

(F) Development of the publications should be a co-ordinated effort between the thrust reverser, engine, aeroplane manufacturers and airline customers especially in the areas of:

— AMM

— Troubleshooting

— Fault isolation

— Maintenance data computer output

— Procedure Validation

— Master Minimum Equipment List

(G) Initial issue of the publication should include the required serviceable limits for the complete thrust reverser system.

13. FLIGHT CREW TRAINING.

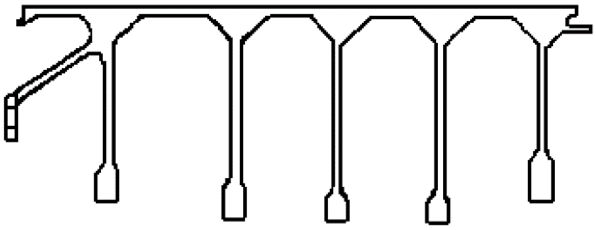
In the case of compliance with the «controllability option,» and when the nature of the in-flight thrust reversal is judged as unusual (compared to expected consequences on the aeroplane of other failures, both basic and recurrent), flight crew training should be considered on a training simulator representative of the aeroplane, that is equipped with thrust reverser in-flight modelisation to avoid flight crew misunderstandings:

13.a. Transient manoeuvre: Recovery from the unwanted in-flight thrust reversal.

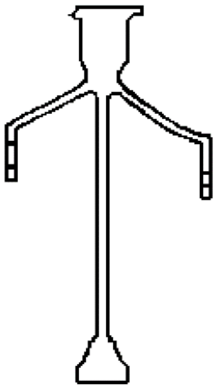
13.b Continued flight and landing: Manoeuvring appropriate to the recommended procedure (included trim and unattended operation) and precision tracking (ILS guide slope tracking, speed/altitude tracking, etc.).

Figure 4 - Generic Disk and Rotor terminology used in interim thrust reverser guidance material for minimizing the hazard from engine rotor burst

4.a - Ring Disk Drum Rotor Cross Section



4.b - Deep Bore Disk Drum Rotor Cross Section



4.c - Single Stage Deep Bore Disk Cross Section

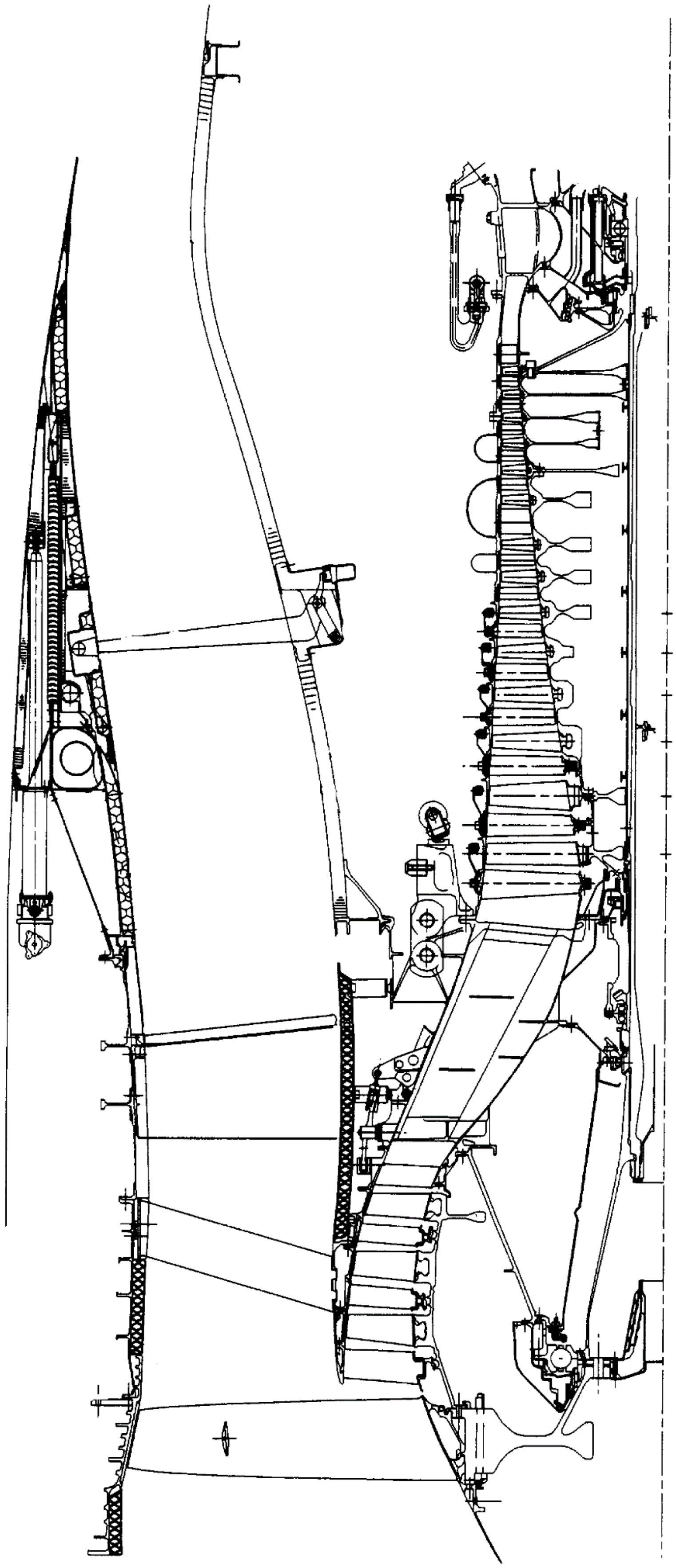


Figure 5: Typical High Bypass Turbofan Low and High Pressure Compressor with Fan Thrust Reverser Cross Section

[Amdt No: 25/1]
[Amdt No: 25/24]

CS 25.934 Turbo-jet engine thrust reverser system tests

ED Decision 2003/2/RM

Thrust reversers installed on turbo-jet engines must meet the requirements of CS-E 890.

CS 25.937 Turbo-propeller-drag limiting systems

ED Decision 2003/2/RM

Turbo-propeller powered aeroplane propeller-drag limiting systems must be designed so that no single failure or malfunction of any of the systems during normal or emergency operation results in propeller drag in excess of that for which the aeroplane was designed under CS 25.367. Failure of structural elements of the drag limiting systems need not be considered if the probability of this kind of failure is extremely remote.

CS 25.939 Turbine engine operating characteristics

ED Decision 2003/2/RM

(See AMC 25.939)

(a) Turbine engine operating characteristics must be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flame-out) are present, to a hazardous degree, during normal and emergency operation within the range of operation limitations of the aeroplane and of the engine. (See AMC 25.939(a).)

(b) Reserved.

(c) The turbine engine air inlet system may not, as a result of air flow distortion during normal operation, cause vibration harmful to the engine. (See AMC 25.939(c).)

AMC 25.939(a) Turbine engine operating characteristics

ED Decision 2003/2/RM

The wording 'in flight' should be interpreted to cover all operating conditions from engine start until shut-down.

AMC 25.939(c) Turbine engine operating characteristics

ED Decision 2003/2/RM

1 The investigation should cover the complete range, for which certification is required, of aeroplane speeds, attitudes, altitudes and engine operating conditions including reverse thrust, and of steady and transient conditions on the ground and in flight, including crosswinds, rotation, yaw and stall. Non-critical conditions of operation which need not be considered should be agreed with the Agency.

2 If the airflow conditions at the engine air intake can be affected by the operating conditions of an adjacent engine, the investigation should include an exploration of the effects of running the adjacent engine at the same and at different conditions over the whole range of engine operating conditions, including reverse thrust. An investigation of the effect of malfunctioning of an adjacent engine should also be included.

3 Compliance with the requirement may include any suitable one or combination of the following methods; as agreed with the Agency.

a. Demonstration that the variations in engine inlet airflow distortion over the range defined in 1 are within the limits established for the particular engine type.

b. An investigation of blade vibration characteristics by the method and of the scope indicated in CS-E 650 and AMC E 650 (except that Maximum Take-off rpm need not be exceeded) carried out on –

i A representative installation on the ground using test equipment where the actual conditions of operation in the aeroplane are reproduced, or

ii A representative aeroplane on the ground and in flight as appropriate to the conditions being investigated.

c. The completion of sufficient flying with representative installations prior to certification such as to demonstrate that the vibration levels are satisfactory.

d. Any other method acceptable to the Agency.

AMC 25.939 Turbine engine operating characteristics

ED Decision 2003/2/RM

FAA Advisory Circular 25.939-1 Evaluating Turbine Engine Operating Characteristics, date 19/03/86, is accepted by the Agency as providing acceptable means of compliance with CS 25.939.

CS 25.941 Inlet, engine, and exhaust compatibility

ED Decision 2007/010/R

For aeroplanes using variable inlet or exhaust system geometry, or both –

(a) The system comprised of the inlet, engine (including thrust augmentation systems, if incorporated), and exhaust must be shown to function properly under all operating conditions for which approval is sought, including all engine rotating speeds and power settings, and engine inlet and exhaust configurations;

(b) The dynamic effects of the operation of these (including consideration of probable malfunctions) upon the aerodynamic control of the aeroplane may not result in any condition that would require exceptional skill, alertness, or strength on the part of the pilot to avoid exceeding an operational or structural limitation of the aeroplane; and

(c) In showing compliance with sub-paragraph (b) of this paragraph, the pilot strength required may not exceed the limits set forth in CS 25.143(d) subject to the conditions set forth in sub-paragraphs (e) and (f) of CS 25.143.

[Amdt 25/3]

CS 25.943 Negative acceleration

ED Decision 2003/2/RM

No hazardous malfunction of an engine or any component or system associated with the powerplant may occur when the aeroplane is operated at the negative accelerations within the flight envelopes prescribed in CS 25.333. This must be shown for the greatest duration expected for the acceleration. (See also CS 25.1315.)