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CIVIL AVIATION AUTHORITY
SAFETY REGULATION GROUP

CABIN WATER SPRAY SYSTEMS FOR FIRE SUPPRESSION
CABIN WATER SPRAY SYSTEMS

COMMENTS AND VIEWS EXPRESSED ON TECHNICAL AND REGULATORY ISSUES AT THE INDUSTRY CONSULTATIVE CONFERENCE ON 29 - 30 MAY 1991

OCTOBER 1991

FUNCTION SPECIFICATION

Introduction

On 29 and 30 May 1991 the CAA convened a Consultative Conference with Industry at the Hilton International Hotel, Gatwick, to discuss technical and regulatory issues associated with Cabin Water Spray Systems.

The discussions were divided into two main areas:

(i) Function Specification, which defines the design features and operation of the system.

(ii) Performance Specification, which defines the test article and the method by which an agreed standard of system performance may be assessed.

This document presents the issues raised by the CAA and the remarks made by the attendees.

CABIN WATER SPRAY SYSTEMS

FUNCTION SPECIFICATION

GENERAL SYSTEM DESIGN

APPLICABLE REQUIREMENTS (SEE APPENDIX FOR DETAILS)

JAR 25.601 **General**

Requirements for good and well established design practices.

JAR 25.853 **Compartment interiors (materials)**

Suitable materials for the intended function of the system must be chosen. In particular the critical parts of the distribution system should be protected from the effects of fire. Non-metallic items should also not propagate a fire.

JAR 25.611 **Accessibility provisions**

Requirements to facilitate effective maintenance.

JAR 25.1301 **Function and installation**

Each item of installed equipment must -

(a) Be of a kind and design appropriate to its intended function:

(b) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors.

(c) Be installed according to limitations specified for that equipment; and

(d) Function properly when installed.

JAR 25.1309 **Equipment, systems and installations**

System function safety objectives

JAR 25.1351 **Electrical systems (General)**

General requirements for electrical capacity, generation, wiring etc.

JAR 25.1353 **Electrical equipment and installations**

General installation requirements.

CABIN WATER SPRAY SYSTEMS

GENERAL SYSTEM DESIGN (continued)

JAR 25.1435 Hydraulic systems

Requirements for the design and strength of hydraulic systems.

Note - A water spray system can be considered as a form of hydraulic system. Therefore some of the requirements for hydraulic systems will be applicable, i.e. (a)(1), (5), (6), and (10).

JAR 25.1436 Pneumatic systems-high pressure

Requirements for the design and strength of high pressure pneumatic systems.

Note - It is anticipated that some types of water spray systems will be pressurised and therefore will have to satisfy this requirement.

JAR 25X1524 Systems and equipment limitations

Note - Any limitations associated with the function of the water spray system will need to be established.

CONFERENCE REMARKS

One commentor suggested the inclusion of a requirement to cover the possible use of chemical pyrotechnic generators to pressurise a CWSS. Certain applicable SAE standards may be invoked.

One commentor raised the subject of the use of inhibitors to prevent algae growth etc. At present only the general requirements, JAR 25.1301 and 25.1309, may deal with this subject.

CABIN WATER SPRAY SYSTEMS

ENVIRONMENT

APPLICABLE REQUIREMENTS

JAR 25.1301	(SEE APPENDIX FOR DETAILS)
JAR 25.1309	(SEE APPENDIX FOR DETAILS)
DO 160	It is envisaged that DO 160 Environmental Conditions and Test Procedures for Airborne Equipment or its equivalent would form the basis of the general environmental requirements. The installation of equipment will determine the severity of the associated environmental test.

Examples of environmental conditions which will probably need to be considered are:-

(i) Temperature
(ii) Altitude
(iii) Vibration
(iv) Humidity
(v) Sand and Dust
(vi) Magnetic Effect
(vii) Fungus Resistance

CABIN WATER SPRAY SYSTEMS

ENVIRONMENT (continued)

TEMPERATURE (DO 160 SECTIONS 4.0 AND 5.0)

ISSUES ARISING

The following forms of temperature protection may be needed for flight and/or ground standing in winter conditions:

(a) Heating, as with potable water systems.

(b) Anti-freezes, however no anti-freeze agents have been found with acceptable levels of toxic thermal break-down products. The use of anti-freezes may preclude the use of the potable water supply as the source of water for the system.

(c) Drainage, for long periods of inactivity (e.g. overnight) at temperatures below freezing point.

Some form of protection may also be required for the distribution system which, if cold, could cause the water to freeze before reaching the nozzles in the cabin.

CONFERENCE REMARKS

One commentor suggested that some form of pre-flight test may be needed to check that a system was not frozen. This problem has arisen when ground crews forget to drain potable water systems overnight.

Another commentor stated that drainage overnight was not a problem but delays caused by loading cargo with a charged water system did give time for the water to freeze.

Another commentor added that once a system had been drained a pre-flight check would need to be made to ensure that the system had been re-filled (see section on Serviceability).

CABIN WATER SPRAY SYSTEMS

ENVIRONMENT (continued)

ALTITUDE (DO 160 SECTION 4.0)

ISSUES ARISING

The system will probably be within a pressure cabin and therefore, generally, experience cabin altitudes between sea level to 8000 ft. The system will therefore need to withstand the effects of:

(a) cabin pressure cycling - sea level to 8000ft

(b) cabin decompression - maximum certificated altitude

(c) cabin pressure test - maximum differential pressure

CONFERENCE REMARKS

No comments received.

VIBRATION (DO 160 SECTION 8.0)

ISSUES ARISING

The system and its installation will need to satisfy the appropriate vibration conditions.

There may be a conflict of interest between crashworthiness (i.e. need for flexibility and extensibility in the distribution system) versus adequate support to protect against resonant vibrations resulting in dormant failures within the distribution system.

CONFERENCE REMARKS

One commentor, a system manufacturer, stated that vibration testing should be done although vibration may not be a problem for some systems by design.

CABIN WATER SPRAY SYSTEMS

CRASHWORTHINESS REQUIREMENTS

APPLICABLE REQUIREMENTS (SEE APPENDIX)

JAR 25.561(B)(3) **Emergency landing conditions**

It is expected that the system will be required to function after it has been subjected to the inertia forces specified.

JAR 25.789 **Retention of items of mass in passenger and crew compartments and galleys**

No part of the system which is in the occupied compartments may become a hazard by shifting under the load conditions detailed in JAR 25.561(b)(3).

DO 160 Section 7.0 **Shock**

In addition to the JAR requirements, the system may need to withstand the shock conditions specified in DO 160.

CONFERENCE REMARKS

One commentor stated that logically the system should meet the requirements of JAR 25.562 for dynamic landing conditions. There may be little point in the passenger surviving an impact in his seat but the system provided for his safety has collapsed around him.

ISSUES ARISING

FUSELAGE BREAK-UP

The design should cater for fuselage break-up. The maximum number of breaks to be considered will be determined by a review of the Net Safety Benefit Study. The requirements associated with fuselage break-up will be tailored either to characteristics of specific aircraft or an arbitrary rule. This rule will be applied to determine the required number and form of storage tanks, pumping systems and distribution systems.

There will be a need for flexibility/extensibility of the distribution system and self-sealing break-away couplings or restrictors.

The location of the system components should not make it vulnerable to damage in a survivable accident.

CABIN WATER SPRAY SYSTEMS

CRASHWORTHINESS REQUIREMENTS (Continued)

CABIN INTERIORS

The security of the cabin interior and its effect, if deranged, on the water spray should be considered (e.g. overhead bin doors opening on impact).

CONFERENCE REMARKS

FUSELAGE BREAK-UP

The CAA stated that their Net Safety Benefit Analysis had indicated that fuselage break up was related to the type of aircraft:

(i) In general, narrow body aircraft split into three sections fore and aft of the wing box.

(ii) Wide body aircraft tended not to break up but to suffer localised crushing etc.

One commentor asked about the difference between a low and a high wing aircraft. The CAA stated that in their analysis high winged aircraft tended to have the wing torn off leaving an "open-top" fuselage.

CABIN INTERIORS

One commentor questioned whether nozzles in the ceiling are absolutely essential for system operation so that the problem of overhead bin doors disappears.

Another commentor stated that further work was needed to show whether or not sprays in the ceiling area are important.

Another commentor suggested that overhead bin doors could be re-designed so as not to affect system performance.

One commentor suggested that having an underbin nozzle may not lead to a fully developed spray due to proximity of the passengers.

One commentor considered that each cabin configuration would need to be assessed on its own merits and amended if necessary.

CABIN WATER SPRAY SYSTEMS

ARMING AND INITIATION

APPLICABLE REQUIREMENTS (SEE APPENDIX FOR DETAILS)

JAR 25.1301 **Function and installation**

This requires that each item of equipment must function properly when installed. It is expected that this requirement will be met by providing a manual and/or automatic means of system initiation.

JAR 25.1309 **Equipment, systems and installation**

The occurrence of any system failure condition which would prevent the continued safe flight of the aeroplane must be extremely improbable. It is expected that this requirement would apply to the inadvertent operation in flight of the water spray system and that to show compliance an "arming" feature will need to be incorporated to limit the flight phase where unintended operation could occur. Similar concept to the arming of escape slide deployment and inflation systems.

JAR 25.1561(a) **Safety equipment**

Each safety equipment control to be operated by the crew in an emergency must be plainly marked as to its method of operation.

CONFERENCE REMARKS

No comments received.

CABIN WATER SPRAY SYSTEMS

ARMING AND INITIATION (continued)

ARMING

ISSUES ARISING

Current consensus of opinion is that an "arming" feature should be incorporated as protection against inadvertent operation and that it should be manual.

It is expected that the flight crew will be preferred to manually arm/disarm the system rather than the cabin crew. It may be desirable to provide some indication or warning to the cabin crew of whether the system is armed/disarmed.

Automatic arming/disarming of the system (e.g. via altitude sensors) may also still need to be considered, if it is considered necessary to reduce the flight crews workload and guard against crew error.

Arming

CONFERENCE REMARKS

One commentor saw no problem with the flight crew arming/disarming the system and that it would take no time as part of the normal crew checks.

Another commentor felt that cabin crew would prefer this function to be the responsibility of the flight crew because they work more rigorously to checklists.

One commentor questioned whether specific reliability figures would be needed for an arming/disarming feature so that it does not adversely affect the functioning of the system when required. The CAA view is that overall system availability objectives must be specified.

One commentor raised the possibility of an aircraft flying into high ground when the system is disarmed. The CAA's Net Safety Benefit Analysis (NSBA) found there to be very few accidents in this category and that in each one there were also very few survivors.

One commentor recommended that once armed the system should remain armed following a major impact, separation of the flight deck etc.

CABIN WATER SPRAY SYSTEMS

ARMING AND INITIATION (continued)

INITIATION

ISSUES ARISING

System initiation may be by manual and/or automatic means.

Manual

Initiation of the system is expected to be the responsibility of the cabin crew and may be determined by the decision to evacuate. Appropriate training in the recognition of real fire threats will have to be provided. It needs to be decided whether system initiation should cover the entire cabin or be zonal, under the control of the local cabin crew. The former may be required for narrow-body aircraft while the latter may be allowed on wide-body aircraft. The means of initiation need to be considered to guard against inadvertent operation by cabin crew, passengers etc.

Automatic

Automatic initiation may be required particularly in the event of crew incapacitation. A combination of initiation means may be required; i.e. 'g' switch, smoke detection, heat sensors, fuselage break detection etc.

Concern has been expressed at the additional complexity and reduced reliability resulting from the incorporation of automatic initiation.

CONFERENCE REMARKS

One commentor asked whether there had been accidents where an impact had not immediately been followed by a fire. The concern being that the system may be automatically initiated by some form of crash switch but that the water would be discharged before the fire had developed. The CAA replied that a concept under review was a two stage sensing system, the first being a "g switch" to detect a crash and the second, sensors, to detect a fire.

One commentor suggested that automatic initiation should be provided for cases where structural break-up could result in aircraft zones where there are no cabin crew to initiate the system. The CAA NSBA found that such a feature would account for about 16% of the potential life saving.

One commentor stated that the introduction of these features will, as a disbenefit, increase the maintenance task.

One commentor considered the use of automatic systems with sensors to determine when/where to spray the water. The specification should ensure the system works under the most adverse conditions, i.e. no cabin crew etc. and include an override to protect against inadvertent operation.

CABIN WATER SPRAY SYSTEMS

ARMING AND INITIATION (continued)

DUMPING

ISSUES ARISING

There may be occasions, e.g. crew inadvertent operation, when the system will need to be deactivated by the flight/cabin crew. It is anticipated that this would require either

(i) incorporation of a means to dump the water supply overboard, or

(ii) provision of a secondary shut-off, allowing subsequent use of the system if required.

It needs to be considered whether either facility should only be available when the system is disarmed, i.e. in flight, nd not when the system is armed while the aircraft is on the ground.

If a zonal system is used then each zone would need a conveniently located dump switch.

CONFERENCE REMARKS

One commentor considered that it should be possible to de-activate the system from the flight deck and at each cabin attendant station.

Another commentor suggested that in a confused situation the system may correctly be initiated but that someone else, in another part of the aircraft, where the hazard is not yet apparent, may dump it believing there to have been an inadvertent operation.

One commentor considered the possibility of an accident occurring after the system had been de-activated. Another commentor felt that one of the benefits of a zonal, or modular, system was that if one element had to be de-activated then others would still remain.

NB See section on Serviceability for comments on dump indication.

CABIN WATER SPRAY SYSTEMS

SERVICEABILITY

APPLICABLE REQUIREMENTS (SEE APPENDIX)

JAR 25.611 Accessibility provisions

The equipments comprising the system must be accessible to allow their inspection, replacement, adjustment etc.

JAR 25.1309 Equipment, systems and installations

System function safety objectives.

JAR 25.1455 Draining of fluids subject to freezing

Overboard drains must prevent the hazardous formation of ice on the aeroplane, in flight or ground operation, as a result of the drainage.

CONFERENCE REMARKS

No comments received.

SERVICEABILITY (continued)

PRE-FLIGHT TEST

ISSUES ARISING

It is expected that some means of checking the serviceability of the system prior to flight, or even prior to allowing passengers on the aircraft, should be provided. This may be achieved by a combination of contents gauging, checking wiring integrity etc.

CONFERENCE REMARKS

The CAA asked if the manufacturers perceived any problems in devising means to determine the serviceability of the system.

One commentor had devised a system where the distribution sub-system was dry allowing air to be blown through. The same commentor did not consider the measurement of water levels, electrical continuity checks etc. to be a problem. One commentor considered that it was the responsibility of the regulatory body to set availability levels for the system designer to achieve. This may lead to some designs not requiring pre-flight checks.

One commentor stated that in the oil industry corrosion and algae growth etc. was a major problem in dry pipework.

A review of the system manufacturers present found that all systems could have a pre-flight check incorporated.

FAILURE WARNING

ISSUES ARISING

An in-flight warning to the flight crew that the system has become inoperable may be required. However, such information may be of little value. Instead it may be more appropriate for an in-flight failure to be recorded for maintenance purposes.

CONFERENCE REMARKS

One commentor considered the need for a position indication for the dump facility and questioned how a successful dump would be detected.

Another commentor considered that for pneumatic systems the same type of gauging as in fire extinguishing systems could be used.

One commentor advised that the airworthiness authorities ensure the wording of the requirement is correct and referred to the problems experienced in the past of having to gauge chemical oxygen generators, which produce oxygen by chemical reaction.

CABIN WATER SPRAY SYSTEMS

SERVICEABILITY (Continued)

MMEL

ISSUES ARISING

It is expected that a return flight to an engineering base with the system partially or wholly inoperative will be allowed. However, this would need detailed agreement with individual operators and be dependent on system reliability/maintainability.

CONFERENCE REMARKS

One commentor noted that if dispatch with the system inoperative were allowed then a second shot system would be unnecessary.

PERIODICAL FUNCTION CHECKS (ROUTINE MAINTENANCE)

ISSUES ARISING

Concern has been expressed that the function of the system may need to be checked periodically, i.e. system initiation. A water discharge would be undesirable from a maintenance point of view and it is expected that alternative media, e.g. air, may be acceptable in determining the serviceability of the system.

CONFERENCE REMARKS

One commentor considered that although an air check was possible it may be preferable to have a permanent low flow air bleed to keep the nozzles clear. Another commentor recommended that nozzles should be easily removable to check for blockage etc.

One commentor stated that a common problem may be particulate contamination causing blockage of the nozzles. This may also not be detected by an air test and therefore a liquid may have to be used to occasionally flush the system.

One commentor noted that such maintenance checks may be very expensive given the likely number of nozzles etc. to be checked.

Two commentors recommended the use of nozzle caps which would be blown off upon system initiation but which would keep the nozzles clear from external contamination.

One commentor considered that the quality of water in the system may need to be specified which may lead to problems in availability worldwide. Another commentor suggested that demineralized water would be suitable and that it is readily available.

One commentor considered the need for serviceability to be related to expected reliability. Given the lack of data for a probability analysis it was suggested that a periodic check be required on system introduction to acquire data to establish system reliability.

CABIN WATER SPRAY SYSTEMS

EMERGENCY EVACUATION

APPLICABLE REQUIREMENTS (SEE APPENDIX)

JAR 25.793 Floor surfaces

This requirement for non-slip surfaces is currently limited to areas such as galleys and exit vestibules. It is expected that this will be extended to the whole passenger cabin.

JAR 25.803(a) Emergency evacuation

JAR 25.811 Emergency exit marking

The effect of the system on the visibility of the exit markings must be considered.

JAR 25.812 Emergency lighting

The above problem of visibility will need consideration. The emergency lighting system will be required to function during operation of the water spray system. This may in turn require some redesign of the emergency lighting system.

JAR 25X1362 Electrical supplies for emergency conditions

Electrical supplies that may be used for water spray operation following an emergency landing will have to be of appropriate integrity.

CONFERENCE REMARKS

No comments received.

CABIN WATER SPRAY SYSTEMS

EMERGENCY EVACUATION (continued)

ISSUES ARISING

Emergency evacuation may be affected in a number of ways:-

(i) Effect of a wet cabin interior on evacuation

(ii) Effect of possible reduced visibility in the cabin

(iii) Effect on the deployment and performance of exits and escape slides

(iv) Effect on communication, i.e. public address, megaphones etc. due to the additional noise of the system.

(v) Effect on emergency lighting systems.

In addition, there may be a hazard to wet survivors of evacuation into, for example, a cold environment.

CONFERENCE REMARKS

One commentor considered the effect of water sprays on the emergency exit markings. Tests have indicated that the spray mixes with smoke so that floor level markers may be obscured. Water which falls to the floor is fairly dirty so that low level signs may be overcome by sooty water accumulating on them.

Another commentor reported on tests where standard exit signs in the cabin roof got thoroughly wetted in each test but lasted the test programme. However, the floor proximity lighting lasted one test.

One commentor stated that pneumatic systems do generate considerable noise so that an individual must shout to be heard. In addition, during a fire, smoke tends to deaden sound in the aircraft and water sprays may contribute to this effect.

Another commentor believed that as a proportion of the total noise in an evacuation the contribution from a water spray system is not significant.

One commentor questioned the effect on passenger motivation during an evacuation of their being sprayed with water.

Another commentor considered that a major problem in an emergency evacuation is in its initiation by trying to make people leave their seats. A water spray may provide a good incentive to evacuate the aircraft.

SYSTEM DURATION

APPLICABLE REQUIREMENT

JAR 25.1301(a) **Function and installation**

The system must be of a design appropriate to its function. Consequently the capacity of the system must provide sufficient duration to protect the passengers during an emergency evacuation.

ISSUES ARISING

Current consensus of opinion is that three minutes is appropriate for the minimum duration of the system. This also corresponds to the maximum time required for fire rescue services to reach the site of an accident on an airfield.

The duration of the system could be extended by the use of an external tender but an assessment of the potential benefits is required. This is to be included as part of the Net Safety Benefit. In addition, consideration must be given to:-

(i) Standardisation of the means of connecting to the aircraft would be needed for world-wide adoption.

(ii) The number and location of connections on the aeroplane would also need to be defined.

(iii) Possible provision of dedicated fire appliance for this "tender" function at each airport.

CONFERENCE REMARKS

One commentor suggested that the duration should be linked to the performance requirements. Systems may be designed to meet the performance requirements but in so doing only need to spray for durations considerably less (or more) than three minutes.

One commentor considered that the need for a tender system would dictate the design of the on-board system. Another commentor thought the tender system has the advantage that the fire fighting personnel can prolong a safer environment in the cabin rather than at present.

One commentor suggested that any resources put towards supplying an internal system would have to come from the present limited resources required for general fire fighting. However, the CAA do not consider the supply of, typically, 120 litres per minute from an airport vehicle carrying 9000 litres to be significant. Any water used in the cabin should also reduce the overall amounts required to deal with the fire.

Another commentor suggested that if multiple break up of the fuselage is to be considered a tender would be required for each expected piece, i.e. three fuselage breaks would need three tenders. The CAA stated that airport vehicles can provide up to four lines of hose, of varying lengths, and so one vehicle would probably sufficient.

One commentor added that an advantage of a major break-up is that it generally allows access to the people inside whereas a tender system would be most useful when the fuselage was intact.

CABIN WATER SPRAY SYSTEMS

HAZARDS ASSOCIATED WITH WATER

APPLICABLE REQUIREMENTS (SEE APPENDIX) AND ISSUES ARISING

JAR 25X799 **Water systems**

JAR 25.903(d) **Turbine engine installations**

Location of the distribution and storage systems should consider possible strike by engine rotor debris and hazards of subsequent water release. (Ref. JAR 25.1309)

JAR 25X1360 **Precautions against injury**

The electrical system must be designed to minimise the risk of electric shock particularly when the water spray system is functioning.

JAR 25.1309(a) **Equipment, systems and installations**

The adverse effects of water spray operation on the use of other safety equipments, e.g. escape provisions, crew PBE, megaphones, life-jackets etc. must be considered.

JAR 25.1431(a) **Electronic equipment**

The consequence of inadvertent system operation and the threat of water ingress, e.g. via the ventilation system, must be considered with respect to radio and electronic equipment and their installations.

CONFERENCE REMARKS

One commentor suggested that consideration of engine rotor burst may lead to further modularisation of the system above that which may be required to cater for fuselage break-up.

Another commentor questioned the effect of inadvertent water spray in flight particularly on long flights and especially on more vulnerable passengers such as the elderly.

CABIN WATER SPRAY SYSTEMS

PERFORMANCE SPECIFICATION

SHAPE AND SIZE OF TEST ARTICLE

ISSUES ARISING

- Cross Section (narrow vs wide body etc.)
- Length
- Methods of construction

CONFERENCE REMARKS

One commentor stated that during their system testing, in a test article similar to that proposed by the FAA, they had obtained reproducible results. One commentor questioned the need for the facility to be "a room within a room" and whether this was a critical feature. The FAA stated that the housing around the test article may be as expensive as the rest of the facility but that it will be needed to obtain reproducible results in different parts of the world, different climates and at different times of the year.

Another commentor questioned the proposed size of the test article, approximately 10' x 7' x 30', in that it may prevent designers of staggered systems which have distances greater than 30' between sprays from testing their systems. The FAA considered that such systems would not be acceptable because the protection afforded to passengers must be a maximum of 30' away from them.

One commentor expressed concern that the use of one test article and one threat may lead to systems being designed to pass the test and not to cope with a range of aircraft fires. The FAA considered this problem would need to be taken into account when designing the fire load to represent a combination of threats.

Another commentor questioned what additional testing would be needed for a system to be used in a different installation to one previously found to be acceptable.

The FAA considered that a system should have an associated performance specification which would define its installation. If a different installation was proposed then some form of modelling or retesting may be required to confirm the system is compatible with the installation. The parameters to be specified would depend on the system design, e.g. for a "total flood" system a key parameter is volume, while for a "curtain" system it is surface area.

Several commentors agreed with the principle of using one test article but considered it was too soon to have a single test condition and preferred a series of tests all of which would need to be passed.

CABIN WATER SPRAY SYSTEMS

PERFORMANCE SPECIFICATION

FIRE THREAT

ISSUES ARISING

- Size of ignition source
- Type of ignition source

    Radiant heat levels

    Convective heat levels

    Application of direct flame contact on cabin material

CONFERENCE REMARKS

The FAA have not yet defined the fire threat but believe at least the following are needed:

(i) radiant heat through an opening,

(ii) flame impingement on the material fire load and,

(iii) some material at a ceiling level and seat level which would burn to represent what has been found in actual aircraft fires.

One commentor stated that research had indicated the main threat to be an external fire through an aperture in the fuselage rather than the burning of materials in the cabin. This should be represented in the test fire threat but also it should respond to the water spray as would a real fire.

The FAA consider that the duration of the test will have to relate to the test article and the fire load. These must be chosen to give a test of sufficient duration to allow the systems performance to be determined. Typically the FAA have conducted tests for five minutes and a survey of the system manufacturers present showed their tests lasted from three to five minutes.

One commentor questioned whether, if a system had a built-in delay, this would need to be included in the test. The FAA considered that any feature associated with a system would need to be included in the test, so that the complete system design could be assessed.

CABIN WATER SPRAY SYSTEMS

PERFORMANCE SPECIFICATION

WIND CONDITIONS

ISSUES ARISING

- Wind strength/critical direction (to be determined by accident analysis)
- Resultant cabin wind velocity (influenced by wind direction, cabin configuration, exit configuration i.e. number open/closed.
- Results of research

CONFERENCE REMARKS

The FAA have yet to determine the level of wind to be simulated and whether it should be blown in or sucked out. The type of wind will also be related to the test article and choice of fire threat.

The CAA NSBA found that:

(i) 30% of the accidents occurred in still air.

(ii) 65% of the accidents occurred at or below the average speed of 6 knots.

(iii) 90% of the accidents occurred at or below 13 knots.

The orientation of the aircraft, cabin volume and the number of fuselage openings have also been found to affect the ingress of fire.

CABIN WATER SPRAY SYSTEMS

PERFORMANCE SPECIFICATION

CABIN FURNISHINGS

ISSUES ARISING

- Flammability standard
- Use of standard materials
- Furnishings to be simulated

  Seats - how many

  Sidewalls, ceiling, overhead bins etc.

CONFERENCE REMARKS

One commentor considered that the use of aviation materials in fire-testing may require the storage of a very considerable stock of materials. However, it may be possible to use representative materials which are more readily available.

Another commentor considered that the materials used in the test may change because systems would be fitted to aircraft with the "latest standards" of cabin interiors, but also the test article should include some simulation of the passengers, i.e. cottons, nylons, wool and maybe even hair and body fats.

The FAA believe the test should evaluate a systems ability to reduce the hazards such as temperature and toxic gases. Measurements will not be made close to the fire threat because it is assumed that a person will get away from the fire fairly quickly. As for the involvement of peoples' clothing, in the majority of accidents clothing and hair have remained fairly intact and not contributed to the overall hazard in the cabin.

Another commentor considered that a realistic choice of materials should be made to ensure a representative toxic threat is created during the test.

The FAA considered that this would be resolved by the choice of measurements to be taken. The fire load will need to represent the threat from the parameters to be measured, e.g. if acid gases are considered important they may be injected and the materials used to assess the ability of the spray to prevent the spread of flame etc.

PERFORMANCE SPECIFICATION

INSTRUMENTATION

ISSUES ARISING

- Temperature and Gas analysis (O_2, CO, CO_2 etc.)
- Analysis of respirable particulates including small water droplets which have absorbed certain toxic gases

CONFERENCE REMARKS

One commentor suggested the order of importance of parameters to be measured should be:-

(1) Temperature and Carbon Monoxide - Good measures of how well the fire is being controlled.

(2) Particulates - A water soluble dye could be used to simulate the density of particulates during the test.

(3) Washing out of acid gases - If interest is shown in the ability of systems to wash out acid gases then certainly Hydrogen Chloride should be measured. This could be done by having PVC in the fire load or by gas injection.

Another commentor questioned the periodicity of measurement, e.g. continuously or at discrete intervals. The FAA consider this will be determined by whether the test is to be used for comparative purposes or as a regulatory tool with specific pass/fail criteria. If the latter is chosen then the criteria need to be determined. If a Fractional Effective Dose (FED) is chosen then an average measurement over the test would be sufficient or the threat may be required to be within certain limits at particular times. Ideally the criteria to be chosen should be as simple as possible.

CABIN WATER SPRAY SYSTEMS

PERFORMANCE SPECIFICATION

INTERPRETATION OF RESULTS

ISSUE ARISING

- Need for clear and unambiguous pass/fail criteria

CONFERENCE REMARKS

One commentor recommended that previous research on emergency evacuation should be included when determining the pass/fail criteria.

The FAA consider that any system will provide either zero protection (the fire is too severe) or full protection (by extinguishing the fire). However the choice has yet to be made of the system which will be used as the benchmark for determining the pass/fail criteria for other systems.

One commentor considered that the pass/fail criteria should be based on FED measurements. A concern is where in the test article should the measurements be taken to obtain accurate results. One solution may be to duct away the gases to homogenise the fire products prior to measurements.

CABIN WATER SPRAY SYSTEMS

CLOSING REMARKS

The conference was closed by Mr H R F Duffell of the CAA reviewing the anticipated future requirements/rulemaking:-

"Clearly there are a number of apparently conflicting issues to be reviewed.

a) On the one hand we have heard from the researchers how a water spray system can significantly extend survival time.

b) At the same time we have heard from industry of some of the problems (both technical and economic) associated with the installation of such systems into aircraft.

c) We have also heard that the Net Safety Benefit for such a system is somewhat less than many of us would have expected, despite it probably being the most promising cabin fire safety improvement we are pursuing at present.

d) Clearly, in making a decision whether or not we pursue legislation, Authorities need to have considered all the relevant design and certification requirements and issues arising.

It is the CAA's aim to be in a position to make a decision by the end of this year and, if appropriate, by that time, formulate a Draft Notice of Proposed Amendment to the JAR codes. This would be the start of the more formal consultation with industry.

In arriving at such a decision we would clearly be working closely with our Authority colleagues in Europe and in parallel with our FAA and Transport Canada colleagues. Beyond this the crystal ball tends to cloud over. However we can speculate about what might then happen.

For example, the earliest date for the issuing of a final rule, assuming satisfactory consultation, would be somewhere in early 1993.

If we then consider its implementation retrospectively we could anticipate that we would introduce the requirement for aircraft currently in build within, say, 18 months of the final rule and, if deemed appropriate, take fully retrospective action within say 5 years."

CABIN WATER SPRAY SYSTEMS

APPENDIX

EMERGENCY LANDING CONDITIONS

JAR 25.561 General
[(See ACJ 25.561)]

(a) The aeroplane, although it may be damaged in emergency landing conditions on land or water, must be designed as prescribed in this paragraph to protect each occupant under those conditions.

(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a minor crash landing when —

(1) Proper use is made of seats, belts, and all other safety design provisions;

(2) The wheels are retracted (where applicable); and

[(3) The occupant experiences the following ultimate inertia forces acting separately relative to the surrounding structure:

(i) Upward, 3·0g

(ii) Forward, 9·0g

(iii) Sideward, 3·0g on the airframe and 4·0g on the seats and their attachments

(iv) Downward, 6·0g

(v) Rearward, 1·5g]

[(See AMJ 25.561(b)(3).)]

(c) Equipment, cargo in the passenger compartment and other large masses must be positioned [so that if they break loose they will be unlikely to —

(1) Cause direct injury to occupants;

(2) Penetrate fuel tanks or lines or cause fire or explosion hazard by damage to adjacent systems; or

(3) Nullify any of the escape facilities provided for use after an emergency landing.

When such positioning is not practical (e.g. fuselage mounted engines or auxiliary power units) each such item of mass shall be restrained under all loads up to those specified in JAR 25.561(b).]

[If the local attachments for these items are subject to severe wear and tear, these attachments should be designed to withstand 1·33 times the specified loads. (See ACJ 25.561(c).)

(d) Seats and items of mass (and their supporting structure) must not deform under any loads up to those specified in sub-paragraph (b)(3) of this paragraph in any manner that would impede subsequent rapid evacuation of occupants. (See ACJ 25.561(d).)

GENERAL

JAR 25.601 General

The aeroplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

[**JAR 25.603 Materials** (For Composite Materials see ACJ 25.603)]

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must —

(a) Be established on the basis of experience or tests;

(b) Conform to approved specifications (such as industry or military specifications, or Technical Standard Orders) that ensure their having the strength and other properties assumed in the design data; and

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

JAR 25.611 Accessibility provisions

Means must be provided to allow inspection (including inspection of principal structural elements and control systems), replacement of parts normally requiring replacement, adjustment, and lubrication as necessary for continued airworthiness. The inspection means for each item must be practicable for the inspection interval for the item. Non-destructive inspection aids may be used to inspect structural elements where it is impracticable to provide means for direct visual inspection if it is shown that the inspection is effective and the inspection procedures are specified in the maintenance manual required by JAR 25.1529.

JAR 25.789 Retention of items of mass in passenger and crew compartments and galleys

(a) Means must be provided to prevent each item of mass (that is part of the aeroplane type design) in a passenger or crew compartment or galley from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of JAR 25.561 (b).

(b) Each interphone restraint system must be designed so that when subjected to the load factors specified in JAR 25.561 (b) (3), the interphone will remain in its stowed position.

JAR 25.793 Floor surfaces

The floor surface of all areas which are likely to become wet in service must have slip resistant properties.

JAR 25X799 Water systems

Water systems must not constitute a hazard to the aeroplane. (See ACJ 25X799.)

ACJ 25X799
Water Systems (Acceptable Means of Compliance)
See JAR 25X799

Service connections (filling points) should be of a different type from those used for other services, such that water could not inadvertently be introduced into the systems for other services.

JAR 25.803 Emergency evacuation

(a) Each crew and passenger area must have emergency means to allow rapid evacuation in crash landings, with the landing gear extended and retracted, considering the possibility of the aeroplane being on fire.

JAR 25.811 Emergency exit marking

(a) Each passenger emergency exit, its means of access, and its means of opening must be conspicuously marked.

(b) The identity and location of each passenger emergency exit must be recognisable from a distance equal to the width of the cabin.

(c) Means must be provided to assist the occupants in locating the exits in conditions of dense smoke.

(d) The location of each passenger emergency exit must be indicated by a sign visible to occupants approaching along the main passenger aisle (or aisles). There must be —

(1) A passenger emergency exit locator sign above the aisle (or aisles) near each passenger emergency exit, or at another overhead location if it is more practical because of low headroom, except that one sign may serve more than one exit if each exit can be seen readily from the sign;

(2) A passenger emergency exit marking sign next to each passenger emergency exit, except that one sign may serve two such exits if they both can be seen readily from the sign; and

(3) A sign on each bulkhead or divider that prevents fore and aft vision along the passenger cabin to indicate emergency exits beyond and obscured by the bulkhead or divider, except that if this is not possible the sign may be placed at another appropriate location.

(e) The location of the operating handle and instructions for opening exits from the inside of the aeroplane must be shown in the following manner:

(1) Each passenger emergency exit must have, on or near the exit, a marking that is readable from a distance of 30 inches.

(2) Each Type I and Type A passenger emergency exit operating handle must —

(i) Be self-illuminated with an initial brightness of at least 160 microlamberts; or

(ii) Be conspicuously located and well illuminated by the emergency lighting even in conditions of occupant crowding at the exit.

(3) Each Type III passenger emergency exit operating handle must be self-illuminated with an initial brightness of at least 160 microlamberts. If the operating handle is covered, self-illuminated cover removal instructions having an initial brightness of at least 160 microlamberts must also be provided.

(4) Each Type A, Type I and Type II passenger emergency exit with a locking mechanism released by rotary motion of the

(i) With a red arrow, with a shaft at least three-quarters of an inch wide and a head twice the width of the shaft, extending along at least 70° of arc at a radius approximately equal to three-quarters of the handle length.

(ii) So that the centreline of the exit handle is within ±1 inch of the projected point of the arrow when the handle has reached full travel and has released the locking mechanism, and

(iii) With the word 'open' in red letters 1 inch high, placed horizontally near the head of the arrow.

(f) Each emergency exit that is required to be openable from the outside, and its means of opening, must be marked on the outside of the aeroplane. In addition, the following apply:

(1) The outside marking for each passenger emergency exit in the side of the fuselage must include a 2-inch coloured band outlining the exit.

(2) Each outside marking including the band, must have colour contrast to be readily distinguishable from the surrounding fuselage surface. The contrast must be such that if the reflectance of the darker colour is 15% or less, the reflectance of the lighter colour must be at least 45%. 'Reflectance' is the ratio of the luminous flux reflected by a body to the luminous flux it receives. When the reflectance of the darker colour is greater than 15%, at least a 30% difference between its reflectance and the reflectance of the lighter colour must be provided.

(3) In the case of exits other than those in the side of the fuselage, such as ventral or tail cone exits, the external means of opening, including instructions if applicable, must be conspicuously marked in red, or bright chrome yellow if the background colour is such that red is inconspicuous. When the opening means is located on only one side of the fuselage, a conspicuous marking to that effect must be provided on the other side.

(g) Each sign required by sub-paragraph (d) of this paragraph may use the word 'exit' in its legend in place of the term 'emergency exit'.

JAR 25.812 Emergency lighting

(a) An emergency lighting system, independent of the main lighting system, must be installed. However, the sources of general cabin illumination may be common to both the emergency and the main lighting systems if the power supply to the emergency lighting system is independent of the

power supply to the main lighting system. The emergency lighting system must include:

(1) Illuminated emergency exit marking and locating signs, sources of general cabin [illumination, interior lighting in emergency exit areas, and floor proximity escape path marking.]

(2) Exterior emergency lighting.

(b) Emergency exit signs —

(1) For aeroplanes that have a passenger seating configuration, excluding pilot seats, of 10 seats or more must meet the following requirements:

(i) Each passenger emergency exit locator sign required by JAR 25.811 (d)(1) and each passenger emergency exit marking sign required by JAR 25.811 (d) (2) must have red letters at least 1·5 inches high on an illuminated white background, and must have an area of at least 21 square inches excluding the letters. The lighted background-to-letter contrast must be at least 10:1. The letter height to stroke-width ratio may not be more than 7:1 nor less than 6:1. These signs must be internally electrically illuminated with a background brightness of at least 25 foot-lamberts and a high-to-low background contrast no greater than 3:1.

(ii) Each passenger emergency exit sign required by JAR 25.811 (d) (3) must have red letters at least 1·5 inches high on a white background having an area of at least 21 square inches excluding the letters. These signs must be internally electrically illuminated or self-illuminated by other than electrical means and must have an initial brightness of at least 400 microlamberts. The colours may be reversed in the case of a sign that is self-illuminated by other than electrical means.

(2) For aeroplanes that have a passenger seating configuration, excluding pilot seats, of 9 seats or less, that are required by JAR 25.811 (d) (1), (2), and (3) must have red letters at least 1 inch high on a white background at least 2 inches high. These signs may be internally electrically illuminated, or self-illuminated by other than electrical means, with an initial brightness of at least 160 microlamberts. The colours may be reversed in the case of a sign that is self-illuminated by other than electrical means.

(c) General illumination in the passenger cabin must be provided so that when measured along the centreline of main passenger aisle(s), and cross aisle(s) between main aisles, at seat armrest height

and at 40-inch intervals, the average illumination is not less than 0·05 foot-candle and the illumination at each 40-inch interval is not less than 0·01 foot-candle. A main passenger aisle(s) is considered to extend along the fuselage from the most forward passenger emergency exit or cabin occupant seat, whichever is farther forward, to the most rearward passenger emergency exit or cabin occupant seat, whichever is farther aft.

(d) The floor of the passageway leading to each floor-level passenger emergency exit, between the main aisles and the exit openings, must be provided with illumination that is not less than 0·02 foot-candle measured along a line that is within 6 inches of and parallel to the floor and is centered on the passenger evacuation path.

[(e) Floor proximity emergency escape path marking must provide emergency evacuation guidance for passengers when all sources of illumination more than 4 ft above the cabin aisle floor are totally obscured. In the dark of the night, the floor proximity emergency escape path marking must enable each passenger to —

(1) After leaving the passenger seat, visually identify the emergency escape path along the cabin aisle floor to the first exits or pair of exits forward and aft of the seat; and

(2) Readily identify each exit from the emergency escape path by reference only to markings and visual features not more than 4 ft above the cabin floor.

(f) Except for sub-systems provided in accordance with sub-paragraph (h) of this paragraph] that serve no more than one assist means, are independent of the aeroplane's main emergency lighting system, and are automatically activated when the assist means is erected, the emergency lighting system must be designed as follows.

(1) The lights must be operable manually from the flight crew station and from a point in the passenger compartment that is readily accessible to a normal flight attendant seat.

(2) There must be a flight crew warning light which illuminates when power is on in the aeroplane and the emergency lighting control device is not armed.

(3) The cockpit control device must have an 'on', 'off' and 'armed' position so that when armed in the cockpit or turned on at either the cockpit or flight attendant station the lights will either light or remain lighted upon interruption (except an interruption caused by a transverse vertical separation of the fuselage during crash landing) of the aeroplane's normal electric power

There must be a means to safeguard against inadvertent operation of the control device from the 'armed' or 'on' positions.

[(g)] Exterior emergency lighting must be provided as follows:

(1) At each overwing emergency exit the illumination must be —

(i) Not less than 0·03 foot-candle (measured normal to the direction of the incident light) on a two-square-foot area where an evacuee is likely to make his first step outside the cabin;

(ii) Not less than 0·05 foot-candle (measured normal to the direction of the incident light) for a minimum width of 42 inches for a Type A overwing emergency exit and of 2 ft for all other overwing emergency exits along the 30% of the slip-resistant portion of the escape route required in JAR 25.803 (e) that is farthest from the exit; and

(iii) Not less than 0·03 foot-candle on the ground surface with the landing gear extended (measured normal to the direction of the incident light) where an evacuee using the established escape route would normally make first contact with the ground.

(2) At each non-overwing emergency exit not required by JAR 25.809 (f) to have descent assist means the illumination must be not less than 0·03 foot-candle (measured normal to the direction of the incident light) on the ground surface with the landing gear extended where an evacuee is likely to make his first contact with the ground outside the cabin.

[(h)] The means required in JAR 25.809 (f) (1) and (h) to assist the occupants in descending to the ground must be illuminated so that the erected assist means is visible from the aeroplane. In addition —

(1) If the assist means is illuminated by exterior emergency lighting, it must provide illumination of not less than 0·03 foot-candle (measured normal to the direction of the incident light) at the ground end of the erected assist means where an evacuee using the established escape route would normally make first contact with the ground, with the aeroplane in each of the attitudes corresponding to the collapse of one or more legs of the landing gear.

(2) If the emergency lighting sub-system illuminating the assist means serves no other assist means, is independent of the aeroplane's main emergency lighting system, and is automatically activated when the assist means is erected, the lighting provisions —

(i) May not be adversely affected by stowage; and

(ii) Must provide illumination of not less than 0·03 foot-candle (measured normal to the direction of the incident light) at the ground end of the erected assist means where an evacuee would normally make first contact with the ground, with the aeroplane in each of the attitudes corresponding to the collapse of one or more legs of the landing gear.

(i) The energy supply to each emergency lighting unit must provide the required level of illumination for at least 10 minutes at the critical ambient conditions after emergency landing.

(j) If storage batteries are used as the energy supply for the emergency lighting system, they may be recharged from the aeroplane's main electric power system: *Provided*, that the charging circuit is designed to preclude inadvertent battery discharge into charging circuit faults.

(k) Components of the emergency lighting system, including batteries, wiring relays, lamps, and switches must be capable of normal operation after having been subjected to the inertia forces listed in JAR 25.561 (b).

(l) The emergency lighting system must be designed so that after any single transverse vertical separation of the fuselage during crash landing —

(1) Not more than 25% of all electrically illuminated emergency lights required by this section are rendered inoperative, in addition to the lights that are directly damaged by the separation;

(2) Each electrically illuminated exit sign required under JAR 25.811 (d) (2) remains operative exclusive of those that are directly damaged by the separation; and

(3) At least one required exterior emergency light for each side of the aeroplane remains operative exclusive of those that are directly damaged by the separation.

JAR 25.853 Compartment interiors

Materials (including finishes or decorative surfaces applied to the materials) used in each compartment occupied by the crew or passengers must meet the following test criteria as applicable:

(a) Interior ceiling panels, interior wall panels, partitions, galley structure, large cabinet walls, structural flooring and materials used in the construction of stowage compartments (other than underseat stowage compartments and compartments for stowing small items such as magazines and maps) must be self-extinguishing when tested vertically in accordance with the applicable portions of Appendix F, or other approved equivalent methods. The average burn length may not exceed 6 [inches and the average flame time after removal of the flame source may not exceed 15 seconds.] Drippings from the test specimen may not continue

[(1) For aeroplanes with passenger capacity of 20 or more, interior ceiling and wall panels (other than lighting lenses), partitions and the outer surfaces of galleys, large cabinets and stowage compartments (other than underseat stowage compartments and compartments for stowing small items such as magazines and maps) must also meet the test requirements of Parts IV and V of Appendix F or other approved equivalent method, in addition to the flammability requirements prescribed in sub-paragraph (a) of this paragraph. (See ACJ 25.853 (a) (1).)]

(b) Floor covering, textiles (including draperies and upholstery), seat cushions, padding, decorative and non-decorative coated fabrics, leather, trays and galley furnishings, electrical conduit, thermal and acoustic insulation and insulation covering, air ducting, joint and edge covering, liners of Class B and Class E cargo or baggage compartments, floor panels of Class C or Class D cargo and baggage compartments, insulation blankets, cargo covers, and transparencies, moulded and thermoformed parts, air ducting joints, and trim strips (decorative and chafing), that are constructed of materials not covered in sub-paragraph (b) (2) of this paragraph, must be self-extinguishing when tested vertically in accordance with the applicable portions of Part I of Appendix F, or other approved equivalent methods. The average burn length may not exceed 8 inches and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 5 seconds after falling.

(1) Motion picture film must be safety film meeting an approved Standard. If the film travels through ducts, the ducts must meet the requirements of sub-paragraph (b) of this paragraph.

(2) Acrylic windows and signs, parts constructed in whole or in part of elastomeric materials, edge lighted instrument assemblies consisting of two or more instruments in a common housing, seat belts, shoulder harnesses, and cargo and baggage tiedown equipment, including containers, bins, pallets, etc., used in passenger or crew compartments, may not have an average burn rate greater than 2·5 inches per minute when tested horizontally in accordance with the applicable portions of Appendix F or other approved equivalent methods.

(3) Except for electrical wire and cable insulation, and for small parts (such as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, and small electrical parts) that the Authority finds would not contribute

significantly to the propagation of a fire, materials in items not specified in sub-paragraphs (a), (b), (b) (1), or (b) (2) of this paragraph may not have a burn rate greater than 4·0 inches per minute when tested horizontally in accordance with the applicable portions of Appendix F or other approved equivalent methods.

(c) In addition to meeting the requirements of sub-paragraph (b) of this paragraph, seat cushions, except those on flight crew member seats, must meet the test requirements of Part II of Appendix F, or equivalent.

(d) If smoking is to be prohibited, there must be a placard so stating, and if smoking is to be allowed —

(1) There must be an adequate number of self-contained, removable ashtrays; and

(2) Where the crew compartment is separated from the passenger compartment, there must be at least one sign meeting the 'No Smoking' sign requirements of JAR 25.791 notifying all passengers when smoking is prohibited.

(e) Each disposal receptacle for towels, paper, or waste must be fully enclosed and constructed of at least fire resistant materials, and must contain fires likely to occur in it under normal use. The ability of the disposal receptacle to contain those fires under all probable conditions of wear, misalignment, and ventilation expected in service must be demonstrated by test. A placard containing the legible words 'No Cigarette Disposal' must be located on or near each disposal receptacle door.

(f) Lavatories must have 'No Smoking' or 'No Smoking in Lavatory' placards located conspicuously on each side of the entry door, and self-contained removable ashtrays located conspicuously on or near the entry side of each lavatory door, except that one ashtray may serve more than one lavatory door if the ashtray can be seen readily from the cabin side of each lavatory door served. The placards must have red letters at least 0.5 inches high on a white background of at least 1.0 inches high. (A 'No Smoking' symbol may be included on the placard.)

JAR 25.903 Engines

(d) *Turbine engine installations.* For turbine engine installations —

(1) Design precautions must be taken to minimise the hazards to the aeroplane in the event of an engine rotor failure or of a fire originating within the engine which burns through the engine case. (See ACJ No. 1 and ACJ No. 2 to JAR 25.903 (d) (1).)

(2) The powerplant systems associated with engine control devices, systems, and instrumentation, must be designed to give reasonable assurance that those engine operating limitations that adversely affect turbine rotor structural integrity will not be exceeded in service.

GENERAL

JAR 25.1301 Function and installation

Each item of installed equipment must —

(a) Be of a kind and design appropriate to its intended function;

(b) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors. (See ACJ 25.1301 (b).)

(c) Be installed according to limitations specified for that equipment; and

(d) Function properly when installed.

JAR 25.1309 Equipment, systems and installations

(a) The equipment, systems, and installations whose functioning is required by the JAR and national operating regulations must be designed to ensure that they perform their intended functions under any foreseeable operating conditions. (See ACJ Nos. 1 and 2 to JAR 25.1309.) However, systems used for non-essential services need only comply so far as is necessary to ensure that the installations are neither a source of danger in themselves nor liable to prejudice the proper functioning of any essential service.

(b) The aeroplane systems and associated components, considered separately and in relation to other systems, must be designed so that (see ACJ Nos. 1 and 3 to JAR 25.1309) —

(1) The occurrence of any failure condition which would prevent the continued safe flight and landing of the aeroplane is extremely improbable, and

(2) The occurrence of any other failure condition which would reduce the capability of the aeroplane or the ability of the crew to cope with adverse operating conditions is improbable.

(c) Warning information must be provided to alert the crew to unsafe system operating conditions, and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimise crew errors which could create additional hazards. (See ACJ Nos. 1, 4 and 8 to JAR 25.1309.)

(d) Compliance with the requirements of sub-paragraph (b) of this paragraph must be shown by analysis, and where necessary, by appropriate ground, flight, or simulator tests. The analysis must consider (see ACJ No. 1 to JAR 25.1309) —

(1) Possible modes of failure, including malfunctions and damage from external sources.

(2) The probability of multiple failures and undetected failures.

(3) The resulting effects on the aeroplane and occupants, considering the stage of flight and operating conditions, and

(4) The crew warning cues, corrective action required, and the capability of detecting faults.

JAR 25.1309 (continued)

(e) Each installation whose functioning is required for certification and that requires a power supply, is an 'essential load' on the power supply. The power sources and the system must be able to supply the following power loads in probable operating combinations and for probable durations (see ACJ Nos. 5 and 6 to JAR 25.1309):

(1) Loads connected to the system with the system functioning normally.

(2) Essential loads, after failure of any one prime mover, power converter, or energy storage device.

(3) Essential loads after failure of —

(i) Any one engine on two-engined aeroplanes; and

(ii) Any two engines on three-or-more engined aeroplanes.

After the failure of any two engines on a three-engined aeroplane, those services essential to airworthiness must continue to function and perform adequately within the limits of operation implied by the emergency conditions. (See ACJ No. 7 to JAR 25.1309.)

(4) Essential loads for which an alternate source of power is required by any applicable JAR or national operating regulations, after any failure or malfunction in any one power supply system, distribution system, or other utilisation system.

(f) In determining compliance with sub-paragraphs (e) (2) and (3) of this paragraph, the power loads may be assumed to be reduced under a monitoring procedure consistent with safety in the kinds of operation authorised. Loads not required in controlled flight need not be considered for the two-engine-inoperative condition on aeroplanes with three or more engines.

(g) In showing compliance with sub-paragraphs (a) and (b) of this paragraph with regard to system and equipment design and installation, critical environmental conditions including vibration and acceleration loads, handling by personnel and where appropriate fluid pressure effects, must be considered. For power generation, distribution and utilisation equipment required by or used for certification, the ability to provide continuous safe service under foreseeable environmental conditions may be shown by environmental tests, design analysis or reference to previous comparable service experience on other aeroplanes.

JAR 25.1351 General

(a) *Electrical system capacity.* The required generating capacity, and number and kinds of power sources must —

(1) Be determined by an electrical load analysis; and

(2) Meet the requirements of JAR 25.1309.

(b) *Generating system.* The generating system includes electrical power sources, main power busses, transmission cables, and associated control, regulation, and protective devices. It must be designed so that —

(1) Power sources function properly when independent and when connected in combination;

(2) No failure or malfunction of any power source can create a hazard or impair the ability of remaining sources to supply essential loads;

(3) The system voltage and frequency (as applicable) at the terminals of all essential load equipment can be maintained within the limits for which the equipment is designed, during any probable operating condition; and

(4) System transients due to switching, fault clearing, or other causes do not make essential loads inoperative, and do not cause a smoke or fire hazard.

(5) There are means accessible, in flight, to appropriate crew members for the individual and collective disconnection of the electrical power sources from the system. (See ACJ 25.1351 (b) (5).)

(6) There are means to indicate to appropriate crew members the generating system quantities essential for the safe operation of the system, such as the voltage and current supplied by each generator.

(c) *External power.* If provisions are made for connecting external power to the aeroplane, and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no external power supply having a reverse polarity, or a reverse phase sequence, can supply power to the aeroplane's electrical system.

(d) *Operation without normal electrical power.* It must be shown by analysis, tests, or both, that the aeroplane can be operated safely in VFR conditions, for a period of not less than five minutes, with the normal electrical power (electrical power sources excluding the battery) inoperative, with critical type fuel (from the standpoint of flameout and restart capability), and with the aeroplane initially at the maximum certificated altitude. Parts of the electrical

JAR 25.1351 (d) (continued)

(1) A single malfunction, including a wire bundle or junction box fire, cannot result in loss of the part turned off and the part turned on;

(2) The parts turned on are electrically and mechanically isolated from the parts turned off; and

(3) The electrical wire and cable insulation, and other materials, of the parts turned on are self-extinguishing when tested in accordance with JAR 25.1359 (d).

JAR 25.1353 Electrical equipment and installations

(a) Electrical equipment, controls, and wiring must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other electrical unit or system essential to the safe operation. Any electrical interference likely to be present in the aeroplane must not result in hazardous effects upon the aeroplane or its systems except under extremely remote conditions. (See ACJ 25.1353 (a).)

(b) Cables must be grouped, routed and spaced so that damage to essential circuits will be minimised if there are faults in cables, particularly heavy current-carrying cables.

(c) Storage batteries must be designed and installed as follows:

(1) Safe cell temperatures and pressures must be maintained during any probable charging or discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge) —

(i) At maximum regulated voltage or power;

(ii) During a flight of maximum duration; and

(iii) Under the most adverse cooling condition likely to occur in service.

(2) Compliance with sub-paragraph (1) of this paragraph must be shown by test unless experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures presents no problem.

(3) No explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the charging system or battery installation, may accumulate in hazardous quantities within the aeroplane.

(4) No corrosive fluids or gases that may escape from the battery may damage surrounding aeroplane structures or adjacent essential equipment.

(5) Each nickel cadmium battery installation must have provisions to prevent any hazardous effect on structure or essential systems that may be caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of its individual cells.

(6) Nickel cadmium battery installations that are not provided with low-energy charging means must have —

(i) A system to control the charging rate of the battery automatically so as to prevent battery overheating;

(ii) A battery temperature sensing and over-temperature warning system with a means for disconnecting the battery from its charging source in the event of an over-temperature condition; or

(iii) A battery failure sensing and warning system with a means for disconnecting the battery from its charging source in the event of battery failure.

JAR 25X1360 Precautions against injury

(a) *Shock.* The electrical system must be designed so as to minimise the risk of electric shock to crew, passengers and servicing personnel and also to maintenance personnel using normal precautions. (See ACJ 25X1360 (a).)

(b) *Burns.* The temperature rise of any part, which has to be handled during normal operation by the flight crew, must not be such as to cause dangerous inadvertent movement, or injury to the crew member. (See ACJ 25X1360 (b).)

JAR 25X1362 Electrical supplies for emergency conditions

A suitable supply must be maintained to those services which are required, either by this JAR-25 (e.g. JAR 25.1195) or in order that emergency drills may be carried out, after an emergency landing or ditching. The circuits to these services must be so designed and protected that the risk of their causing a fire, under these conditions, is minimised.

JAR 25.1431 Electronic equipment

(a) In showing compliance with JAR 25.1309 (a) and (b) with respect to radio and electronic equipment and their installations, critical environmental conditions must be considered.

JAR 25.1436 Hydraulic systems

(a) *Design.* Each hydraulic system must be designed as follows: -

(1) Each element of the hydraulic system must be designed to withstand the loads due to the working pressure Pw, in the case of elements other than pressure vessels or to the limit pressure, PL, in the case of pressure vessels, in combination with limit structure loads which may be imposed without deformation that would prevent it from performing its intended function, and to withstand without rupture, the working or limit pressure loads multiplied by a factor of 1·5 in combination with ultimate structural loads that can reasonably occur simultaneously.

(i) *Pw.* The working pressure is the maximum steady pressure in service acting on the element including the tolerances and possible pressure variations in normal operating modes but excluding transient pressures.

(ii) *PL.* The limit pressure is the anticipated maximum pressure in service acting on a pressure vessel, including the tolerances and possible pressure variations in normal operating modes but excluding transient pressures.

(5) Each hydraulic element must be installed and supported to prevent excessive vibration, abrasion, corrosion, and mechanical damage, and to withstand inertia loads. If a hydraulic fluid which could be harmful to occupants when liberated in any form is used, there must be a means to prevent harmful or hazardous concentration of the fluid or vapours in the crew or passenger compartments during flight.

(6) Means for providing flexibility must be used to connect points in a hydraulic fluid line between which relative motion or differential vibration exists.

(10) The elements of the system must be able to withstand the loads due to the pressure given in Appendix J, for the proof condition without leakage or permanent distortion and for the ultimate condition without rupture. Temperatures must be those corresponding to normal operating conditions. Where elements are constructed from materials other than aluminium alloy, tungum, or medium-strength steel, the Authority may prescribe or agree other factors. The materials used must in all cases be resistant to deterioration arising from the environmental conditions of the installation, particularly the effects of vibration.

JAR 25X1436 Pneumatic systems — high pressure

(a) *General.* Pneumatic systems which are powered by, and/or used for distributing or storing, air or nitrogen, must comply with the requirements of this paragraph.

(1) Compliance with JAR 25.1309 for pneumatic systems must be shown by functional tests, endurance tests and analysis. Any part of a pneumatic system which is an engine accessory must comply with the relevant requirements of JAR 25.1163.

(2) No element of the pneumatic system which would be liable to cause hazardous effects by exploding, if subject to a fire, may be mounted within an engine bay or other designated fire zone, or in the same compartment as a combustion heater.

(3) When the system is operating no hazardous blockage due to freezing must occur. If such blockage is liable to occur when the aeroplane is stationary on the ground, a pressure relieving device must be installed adjacent to each pressure source.

(b) *Design.* Each pneumatic system must be designed as follows:

(1) Each element of the pneumatic system must be designed to withstand the loads due to the working pressure, Pw, in the case of elements other than pressure vessels or to the limit pressure, PL, in the case of pressure vessels, in combination with limit structural loads which may be imposed without deformation that would prevent it from performing its intended function, and to withstand without rupture, the working or limit pressure loads multiplied by a factor of 1·5 in combination with ultimate structural loads that can reasonably occur simultaneously.

(i) *Pw.* The working pressure is the maximum steady pressure in service acting on the element including the tolerances and possible pressure variations in normal operating modes but excluding transient pressures.

(ii) *PL.* The limit pressure is the anticipated maximum pressure in service acting on a pressure vessel, including the tolerances and possible pressure variations in normal operating modes but excluding [transient pressures.]

(2) A means to indicate system pressure located at a flight-crew member station, must be provided for each pneumatic system that —

(i) Performs a function that is essential for continued safe flight and landing; or

(ii) In the event of pneumatic system malfunction, requires corrective action by the crew to ensure continued safe flight and landing.

(3) There must be means to ensure that system pressures, including transient pressures and pressures from gas volumetric changes in components which are likely to remain closed long enough for such changes to occur —

(i) Will be within 90 to 110% of pump average discharge pressure at each pump outlet or at the outlet of the pump transient pressure dampening device, if provided; and

(ii) Except as provided in sub-paragraph (b) (6) of this paragraph, will not exceed 125% of the design operating pressure, excluding pressure at the outlets specified in sub-paragraph (b) (3) (i) of this paragraph. Design operating pressure is the maximum steady operating pressure.

The means used must be effective in preventing excessive pressures being generated during ground charging of the system. (See ACJ 25X1436 (b) (3).)

(4) Each pneumatic element must be installed and supported to prevent excessive vibration, abrasion, corrosion, and mechanical damage, and to withstand inertia loads.

(5) Means for providing flexibility must be used to connect points in a pneumatic line between which relative motion or differential vibration exists.

(6) Transient pressure in a part of the system may exceed the limit specified in sub-paragraph (b) (3) (ii) of this paragraph if —

(i) A survey of those transient pressures is conducted to determine their magnitude and frequency; and

(ii) Based on the survey, the fatigue strength of that part of the system is substantiated by analysis or tests, or both.

(7) The elements of the system must be able to withstand the loads due to the pressure given in Appendix J, for the proof condition without leakage or permanent distortion and for the ultimate condition without rupture. Temperatures must be those corresponding to normal operating conditions. Where elements are constructed from materials other than aluminium alloy, tungum, or medium-strength steel, the Authority may prescribe

or agree other factors. The materials used should in all cases be resistant to deterioration arising from the environmental conditions of the installation, particularly the effects of vibration.

(8) Where any part of the system is subject to fluctuating or repeated external or internal loads, adequate allowance must be made for fatigue.

(c) *Tests*

(1) A complete pneumatic system must be static tested to show that it can withstand a pressure of 1·5 times the working pressure without a deformation of any part of the system that would prevent it from performing its intended function. Clearance between structural members and pneumatic system elements must be adequate and there must be no permanent detrimental deformation. For the purpose of this test, the pressure relief valve may be made inoperable to permit application of the required pressure.

(2) The entire system or appropriate sub-systems must be tested in an aeroplane or in a mock-up installation to determine proper performance and proper relation to other aeroplane systems. The functional tests must include simulation of pneumatic system failure conditions. The tests must account for flight loads, ground loads, and pneumatic system working, limit and transient pressures expected during normal operation, but need not account for vibration loads or for loads due to temperature effects. Endurance tests must simulate the repeated complete flights that could be expected to occur in service. Elements which fail during the tests must be modified in order to have the design deficiency corrected and, where necessary, must be sufficiently retested. Simulation of operating and environmental conditions must be completed on elements and appropriate portions of the pneumatic system to the extent necessary to evaluate the environmental effects. (See ACJ 25X1436 (c) (2).)

(3) Parts, the failure of which will significantly lower the airworthiness or safe handling of the aeroplane must be proved by suitable testing, taking into account the most critical combination of pressures and temperatures which are applicable.

JAR 25.1455 Draining of fluids subject to freezing

If fluids subject to freezing may be drained overboard in flight or during ground operation, the drains must be designed and located to prevent the formation of hazardous quantities of ice on the aeroplane as a result of the drainage.

JAR 25X1524 Systems and equipment limitations

All limitations applicable to functional equipment and systems installations, and which are considered necessary for safe operation, must be established. (See ACJ 25X1524.)

JAR 25.1561 Safety equipment

(a) Each safety equipment control to be operated by the crew in emergency, such as controls for automatic liferaft releases, must be plainly marked as to its method of operation.