Federal Aviation Administration
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
Mechanical System Harmonization Working Group

Task 3 – Airplane Ventilation Systems

Task Assignment

[Federal Register: July 26, 2001 (Volume 66, Number 144)]
[Notices]
[Page 39074-39075]
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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Issues--New Task

AGENCY: Federal Aviation Administration (**FAA**), DOT.

ACTION: Notice of new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: The **FAA** assigned the Aviation Rulemaking Advisory Committee a new task to develop recommendations to ensure airplane ventilation systems and cabin environment will provide a suitable environment for crew and passengers following a pressurization system failure resulting in an airplane decompression. This notice is to inform the public of this ARAC activity.

FOR FURTHER INFORMATION CONTACT: Charles Huber, Federal Aviation Administration, Northwest Mountain Region Headquarters, 1601 Lind Avenue, SW. Renton, Washington, (425) 227-2589), charles.huber@**faa**.gov.

SUPPLEMENTARY INFORMATION:

Background

The **FAA** established the Aviation Rulemaking Advisory Committee to provide advice and recommendations to the **FAA** Administrator on the **FAA**'s rulemaking activities with respect to aviation-related issues. This includes obtaining advice and recommendations on the **FAA**'s commitments to harmonize Title 14 of the Code of Federal Regulations (14 CFR) with its partners in Europe and Canada.

The Task

Part 1: Ventilation--Heating and Humidity (Sec. 25.831(g))

Review the current airworthiness standards for transport category airplanes regarding airplane cabin and flight deck environment.

Determine if revisions are needed to ensure the ventilation system, following system failures, will provide a suitable environment for crew and passengers. The assessment should consider:

1. The types of airplane system failure conditions that should be addressed.

2. Setting the appropriate limiting values of cabin and flight-deck temperature, humidity levels, and exposure times to eliminate any unacceptable impact on flight crews and cabin crew performance, disabling any passengers, or creating long-term health problems to passengers or crews.

3. Any relevant National Aeronautics and Space Administration (NASA), United States (US) Armed Forces, National Institute of Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), Federal Aviation Administration (**FAA**), academia and industry standards for pressure, temperature and humidity.

Develop a report based on the review, and recommend any revisions to the rules (including cost estimates) and advisory materials needed to address the above issues.

If as a result of the recommendations in this report, the **FAA** publishes a notice of proposed rulemaking and/or notice of availability of proposed advisory circular for public comment, ARAC may be further tasked to review all comments received and provide the **FAA** with a recommendation for disposition of those comments.

Schedule: This report is to be submitted no later than 24 months after the task is published by the **FAA** in the Federal Register.

Part 2: Cabin Pressurization (Sec. 25.841(a))

Review and current airworthiness standards for transport category airplanes regarding airplane cabin altitudes resulting from cabin decompression.

Determine if revisions are needed to ensure that during certain failure conditions the cabin environment is suitable for crew and passengers. The assessment should consider:

1. The types of airplane system, structure, and/or propulsion failure conditions that should be addressed.

2. The factors that impact the level of severity of the threat, airplane design features, and operation procedures that could be used to moderate the severity of the threat.

3. The recommendation of appropriation cabin pressure standards that would govern cabin air quality following certain failure conditions. These standard should ensure that exposure time to a reduced pressure and the lack of oxygen in the airplane does not reach a level that would:

a. Negatively impact the flight-deck crew's performance to the extent that the flight crew could not safely control the airplane during an emergency descent,

b. Disable any cabin crew member or passenger to the degree that resuscitation techniques would be needed to revive, or

c. Create long term health problems for the crew or passengers.

4. A definition of terms (e.g., ``appreciable rise in the pressure differential'', ``reasonably precludes'', ``rapidly equalized'', ``any delay that would significantly increase the hazards'', etc.) and appropriate pressurization system requirements and practices during all phases of operation.

5. Any relevant NASA, US Armed Forces, NIOSH, OSHA, **FAA**, academia and industry standards.

Develop a report based on the review, and recommend any revisions to the rules (including cost estimates) and advisory materials needed to address the above issues.

If as a result of the recommendations the **FAA** publishes a notice of proposed rulemaking and/or notice of availability of proposed advisory circular, ARAC may be further tasked to review all comments received and provide the **FAA** with a recommendation for disposition of those comments.

Schedule: This report is to be submitted no later than 24 months after the task is published by the **FAA** in the Federal Register.

ARAC Acceptance of Task

ARAC accepted the task and assigned the task to the Mechanical Systems Harmonization Working Group, Transport Airplane and Engine Issues. The working group serves as staff to ARAC and assists in the analysis of assigned task. ARAC must review and approve the working group's recommendations. If ARAC accepts the working group's recommendations, it will forward them to the **FAA**.

Working Group Activity

The Mechanical Systems Harmonization Working Group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working group is expected to:

1. Recommend a work plan for completion of the task, including the rationale supporting such a plan for consideration at the next meeting of the ARAC on Transport Airplane and Engine Issues held following publication of this notice.
2. Give a detailed conceptual presentation of the proposed recommendations prior to proceeding with the work stated in items 3 below.
3. Draft the appropriate documents and required analyses and/or any other related materials or documents.
4. Provide a status report at each meeting of the ARAC held to consider Transport Airplane and Engine Issues.

Participation in the Working Group

The Mechanical Systems Harmonization Working Group is composed of technical experts having an interest in the assigned task. A working group member need not be a representative or a member of the full committee.

An individual who has expertise in the subject matter and wishes to become a member of the working group should write to the person listed under the caption FOR FURTHER INFORMATION CONTACT expressing that desire, describing his or her interest in the task, and stating the expertise he or she would bring to the working group. All requests to participate must be received no later than August 24, 2001. The requests will be reviewed by the assistant chair, the assistant executive director, and the working group co-chairs. Individuals will be advised whether or not their request can be accommodated.

Individuals chosen for membership on the working group will be expected to represent their aviation community segment and actively participate in the working group (e.g., attend all meetings, provide written comments when requests to do so, etc.). They also will be expected to devote the resources necessary to support the working group in meeting any assigned deadlines. Members are expected to keep their management chain and those they may represent advised of working group activities and decisions to ensure that the proposed technical solutions do not conflict with their sponsoring organization's position when the subject being negotiated is presented to ARAC for approval.

Once the working group has begun deliberations, members will not be added or substituted without the approval of the assistant chair, the assistant executive director, and the working group co-chairs.

The Secretary of Transportation determined that the formation and use of the ARAC is necessary and in the public interest in connection with the performance of duties imposed on the **FAA** by law.

Meetings of the ARAC will be open to the public. Meetings of the Mechanical Systems Harmonization Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. The **FAA** will make no public announcement of working group meetings.

Issued in Washington, DC, on July 23, 2001.

Anthony F. Fazio,

Executive Director, Aviation Rulemaking Advisory Committee.

[FR Doc. 01-18674 Filed 7-25-01; 8:45 am]

BILLING CODE 4910-13-M

Recommendation Letter

Pratt & Whitney
400 Main Street
East Hartford, CT 06108

Pratt & Whitney
A United Technologies Company

October 21, 2003

Federal Aviation Administration
800 Independence Avenue, SW
Washington, D.C. 20591

Attention: Mr. Nicholas Sabatini, Associate Administrator for Regulation and Certification

Subject: ARAC Recommendations, Mechanical Systems

Reference: ARAC Tasking, Federal Register, dated July 26, 2001

Dear Nick,

The Transport Airplane and Engine Issues Group is pleased to submit the following as a recommendation to the FAA in accordance with the reference tasking. This information has been prepared by the Mechanical Systems Harmonization Working Group.

- MSHWG Report – FAR/JAR 25.831(g)

The Working Group did reach consensus on this task and the report was unanimously approved by the Transport Airplane and Engine Issues Group.

Sincerely yours,

Craig R. Bolt

C. R. Bolt
Assistant Chair, TAEIG

Copy: Dionne Krebs – FAA-NWR
Mike Kaszycki – FAA-NWR
Effie Upshaw – FAA-Washington, D.C.
Pat Waters - Boeing

Acknowledgement Letter

MAR 8 2004

Mr. Craig Bolt
Assistant Chair, Transport Airplanes and
Engines Issues Area
400 Main Street, MS 162-14
East Hartford, CT 01608

Dear Mr. Bolt,

This letter responds to several letters from the Aviation Rulemaking Advisory Committee (ARAC) on Transport Airplanes and Engines (TAE) during calendar year 2003.

Date of Letter: May 14

Purpose: A request for economic support for a proposed part 25 rulemaking addressing ice protection systems.

FAA Action/Status: Kathy Ishimaru, the Federal Aviation Administration (FAA) representative on the Ice Protection Harmonization Working Group, and George Thurston of the FAA Policy Office indicated that Mr. Thurston has already provided the economic data to the working group. No further action is warranted.

Date of Letter: July 22

Purpose: Transmittal package with opposing views related to the ease of search task from the members of the Design for Security Harmonization Working Group.

FAA Action/Status: At the June TAE ARAC meeting, after learning the working group could not reach consensus, Mr. Kaszycki asked the working group to document its views and forward the package to the FAA through ARAC. The package has since been forwarded to the Transport Airplane Directorate for review and decision.

We may request the working group to help us dispose of substantive comments once the comment period for the notice of proposed rulemaking closes. Hence, we consider the working group to be in existence, but in-active until further notice.

This letter also acknowledges receipt of several recommendation packages:

Date of Letter	Task No.	Description of Recommendation	Working Group
Sep 18	7	Working group report with a long term plan addressing the effects of multiple complex structural supplemental type certification modifications on the structural integrity and continued safe operations of transport category	Airworthiness Assurance

		airplanes	
Sep 19	11	Working group report that provides language for a requirement to substantiate the operation of the airplane control systems is not adversely affected (jamming, friction, disconnection, damage) by the presence of deflections of the airplane structure due to the separation of pitch, roll, and yaw limit maneuver loads (25.683)	General Structures Harmonization
	9	Working group report that provides harmonized rule language and advisory material for fuel tank access cover impact resistance (§ 25.963(e))	
Oct 21	3, Part 1	Working group report addressing ventilation (heating and humidity), § 25.831(g)	Mechanical Systems Harmonization
Oct 21	3, Part 2	Working group report addressing cabin pressurization, § 25.841(a)	Mechanical Systems Harmonization
Oct 22	5	Working group report that provides harmonized § 25.571 language and accompanying advisory material for damage tolerance and fatigue evaluation of structure	General Structures Harmonization
Oct 22	6	Working group reports on widespread fatigue damage that address training syllabus, multiple element damage, and mandatory modifications	Airworthiness Assurance

I wish to thank ARAC and the working groups for the resources that industry gave to develop these recommendations. Since we consider submittal of the recommendation as completion of the tasks, we have closed the tasks, and placed the recommendations on the ARAC website at http://www1.faa.gov/avr/arm/arac/aracTransportAirplane.cfm?nav=6. The recommendation packages have been forwarded to the Transport Airplane Directorate for review and decision. We will continue to keep you apprised of our efforts on the ARAC recommendation at the regular ARAC meeting.

Sincerely,

Original Signed By
Nicholas A. Sabatini

Nicholas A. Sabatini
Associate Administrator for Regulation
and Certification

ARM-209:Eupshaw;fs:1/9/04; PC Docs #20579
cc: ARM-1/20/200/209; AIR-100; ANM-110
File #ANM-01-024-A; ANM-00-083-A; ANM-98-466-A; ANM-01-111-A; ANM-95-195-A.; ANM-99-969-A
Control Nos. 20032768-0, 20033095-0, 20033096-0, 20033097-0, 20033098-0, 20033099-0

Recommendation

Mechanical Systems Harmonization Working Group (MSHWG) Final Report on

FAR/JAR 25.831(g)

July 24, 2003

Draft 25.831(g) Working Group Report

Harmonization (Category 3) and New Projects

1 - What is underlying safety issue to be addressed by the FAR/JAR? [Explain the underlying safety rationale for the requirement. Why should the requirement exist? What prompted this rulemaking activity (e.g., new technology, service history, etc.)?]

The intent of the specific § 25.831(g) is to ensure that in the event of ventilation system failure the temperature and humidity within the airplane shall not exceed values that are hazardous to the occupants.

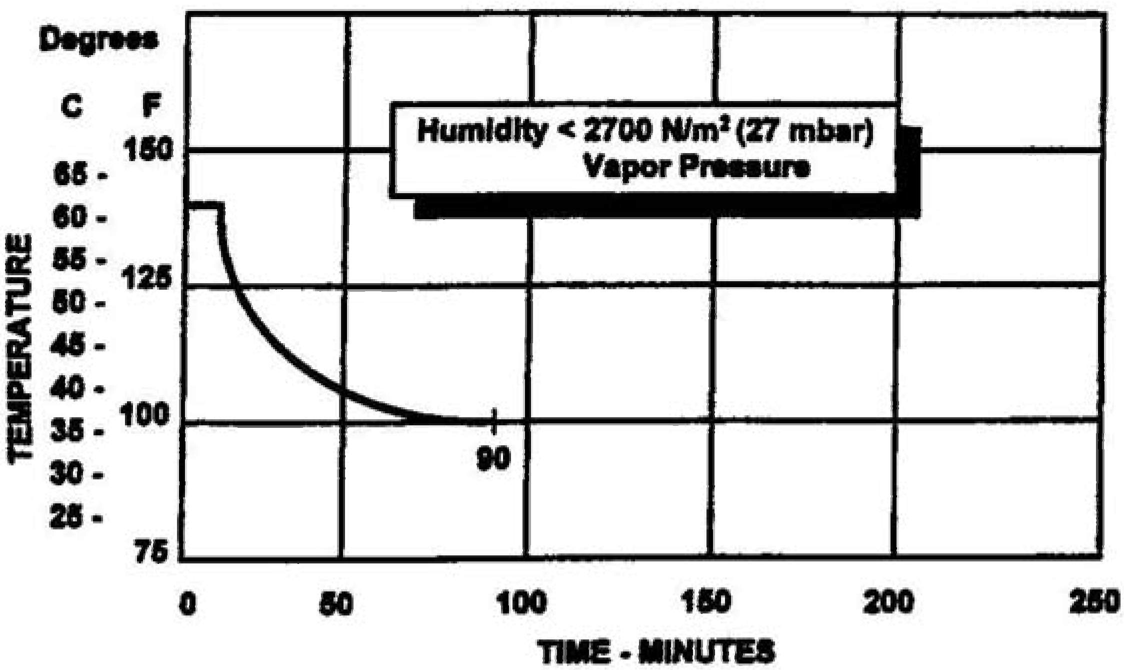
As noted in the preamble to Amendment 25-87, during the Supersonic Transport (SST) review in the 1960s, it was noted that certain pressurization system failures, whether considered alone or in combination with the use of hot ram air for emergency pressurization, could lead to cabin temperatures exceeding human tolerance. The FAA therefore concluded that any failure or combination of failures that could lead to temperature exposures that would cause undue discomfort must be shown to be improbable. Minor corrective actions (e.g., selection of alternate equipment or procedures) would be allowed if necessary for probable failures. The FAA also concluded that any failure or combination of failures that could lead to intolerable temperature exposures must be extremely improbable. Major corrective actions (e.g., emergency descent, configuration changes) would be allowed for an improbable failure condition. Temperature limits were incorporated into the special conditions imposed on executive transport airplanes when approved for high altitude operation. The SST and executive transport special conditions contained two graphs that explained the requirements for the probable and improbable cases. In formulating this amendment, the FAA has determined that the public interest is served by adopting the time-temperature limits associated with improbable failure conditions, and they were adopted in FAR 25.831(g). This amendment does not allow the time of exposure at any given temperature to exceed the values given in the associated graph.

Amendment 25-87 incorporated a time-temperature relationship containing a single-point humidity requirement. Manufacturers have found this difficult or impossible to comply with under the assumption of loss of all conditioned airflow for flight following failure, including descent and landing. It should be noted that no mention of the 27 mBar limit appears in Amendment 25-87. It has been speculated that the fixed humidity level of 27 mBar appears to be a reasonable limit for altitude conditions around 10,000 feet. Unfortunately this humidity level is often exceeded at lower altitudes at and near sea level for airport ambient conditions. Thus, this requirement would prohibit the use of outside air to ventilate the aircraft during high humidity conditions above 27 mBar. It is this restriction to any fixed humidity limit that has created the need for rulemaking in this section of Part 25.

2 - What are the current FAR and JAR standards relative to this subject? [Reproduce the FAR and JAR rules text as indicated below.]

Current FAR text:

Sec. 25.831 (g) The exposure time at any given temperature must not exceed the values shown in the following graph after any improbable failure condition.



TIME–TEMPERATURE RELATIONSHIP]

Current JAR text:
There is no JAR 25.831(g) regulation.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed? [Reproduce text from issue papers, special conditions, policy, certification action items, etc., that have been used relative to this issue]

Historically, the FAA, JAA, and Transport Canada have issued special conditions for aircraft certificated for flight above 41000 feet. These special conditions have been used on a number of certification programs albeit with some inconsistency (i.e. some large transport category aircraft have been approved for flight above 41000 feet without the imposition of any similar special conditions). Subsequently, FAR Part 25 has been revised at amendment 87 to incorporate the special conditions to the rule that resulted in part to the formation of a new paragraph, 25.831(g). Transport Canada has since adopted and is applying the standards of amendment 87. The JAA do not currently have an equivalent rule in JAR 25 but continue to impose special conditions to address this issue. Nonetheless, the current standards contained in the JAA special conditions provide an equivalent level of safety to FAR 25 at amendment 87 with respect to § 25.831(g) at or above 15,000 feet.

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?: [Explain the differences in the standards or policy, and what these differences result in relative to (as applicable) design features/capability, safety margins, cost, stringency, etc.]

Historically, the FAA, JAA and Transport Canada have issued special conditions for aircraft certificated for flight above 41000 feet. These special conditions have been used on a number of certification programs albeit with some inconsistency (i.e. some large transport category aircraft have been approved for flight above 41000 feet with and without the application of any special conditions).

Subsequently, Part 25 has been revised at amendment 87 to incorporate the special conditions to the rule that resulted in part to the formation of a new paragraph, 25.831(g). Transport Canada has since adopted and is applying the standards of amendment 87. The JAA do not currently have an equivalent rule in JAR 25 but continue to impose special conditions to address this issue. Nonetheless, the current standards contained in the JAA special conditions are identical to FAR 25 at amendment 87 with respect to 25.831(g) at or above 15,000 feet. On this basis, there should exist no differences between regulatory authorities with respect to design requirements, safety margins or cost.

4 - What, if any, are the differences in the current means of compliance? [Provide a brief explanation of any differences in the current compliance criteria or methodology (e.g., issue papers), including any differences in either criteria, methodology, or application that result in a difference in stringency between the standards.]

The Special Conditions and means of compliance have been similar for FAA, JAA, and Transport Canada application as applied to business jets. Issue papers for large transport aircraft have resulted in the manufacturers obtaining exceptions to FAR 25.831(g). Instead of showing compliance to FAR 25.831(g), the large transport manufacturers have been providing analysis for Equivalent Safety Findings under FAR/JAR 25.1309.

Transport Canada has adopted the FAR 25.831(g), including Amendment 25-87. The JAA has a generic Special Condition, see Reference (2), which retains the main intent of the previous Special Conditions. The main area of difference in terms of means of compliance between the FAA and JAA is application of the rule below 15,000 feet altitude. The JAA generic Special Condition is limited to at or above 15,000 feet, whereas the FAA rule is applied to all altitudes.

5 – What is the proposed action? [Describe the new proposed requirement, or the proposed change to the existing requirement, as applicable. Is the proposed action to introduce a new standard, or to take some other action? Explain what action is being proposed (not the regulatory text, but the underlying rationale) and why that direction was chosen for each proposed action.]

The proposed action is to harmonize on a new, performance-based standard for failure conditions not shown to be extremely improbable. The objective of this standard is to preserve a tolerable environment by limiting the metabolic and environmental heat loads to passengers and crew during exposures to a potential heat stress event. Compliance to this new regulation will require a combination of quantitative and qualitative means to demonstrate compliance. This is not unlike the requirements that exist in 14 CFR Part 25.671 or 25.1309.

6 - What should the harmonized standard be? [Insert the proposed text of the harmonized standard here]

While the task of this working group was limited to the working group report, the working group recommends that the regulatory authorities consider the following harmonized rule and preamble in promulgating a new regulation on § 25.831(g).

RULE

The airplane design must accommodate any environmental control system failure condition not shown to be extremely improbable, such that:

- **(a) Flight deck and cabin environmental conditions shall not adversely affect crew performance that results in a hazardous condition.**
- **(b) No occupant shall sustain permanent physiological harm.**

PREAMBLE
Note: The "… environmental control system failure condition not shown to be extremely improbable …" referenced in the above proposed rule (including loss of inflow) shall be referred to as the "event" hereafter.

It should be noted that the proposed rule is based on human performance. The intent of the rule is to provide flight deck and cabin environments that do not result in crew mental errors or physical exhaustion that prevent the crew from successfully completing their assigned tasks – continued safe flight and landing. This includes the cabin crew being able to initiate and direct a cabin evacuation. Analysis showing the flight deck and cabin crew performance is not degraded is an acceptable means of demonstrating compliance.

Further, while it is recognized there is a lack of data for infants and frail passengers, the cabin environment resulting from an event shall be conservatively specified such that no permanent physiological harm shall be incurred by any occupant. Provided it can be shown that the passenger cabin remains a safe environment for the cabin crew, it is assumed to be an acceptable limit for sedentary passengers since it is acceptable for cabin crew members working at higher metabolic rates in the same environment. The environmental and physiological performance limits used for demonstrating compliance must originate from recognized and cognizant authorities as accepted by the regulatory authority reviewing the compliance finding.

While the rule is supposed to be based on human performance, the reviewers of the reference material should note that all the presented data relates human performance to time-temperature-humidity exposure. The MSHWG notes that none of the data links human performance with these parameters in combination with a low flight deck/cabin ambient pressure characteristic of operating altitudes to which the occupants are not acclimated. Consequently with the paucity of data available in conjunction with low flight deck/cabin ambient pressure the selection of the limiting cabin environmental conditions should be conservative until new data shows otherwise.

The proposed rule utilizes the phrase "…failure conditions not shown to be extremely improbable …" The intent of this being included in the rule is to address such events and the resulting operation of the aircraft. Unrelated failures not tied to the event need not be considered; for example, cargo fire or failure of the in-flight entertainment system. Aircraft systems required for safe flight and landing must be evaluated for continued operation during the event environment under the applicable FAR/JAR(s) (e.g. FAR/JAR 25.1309).

The entire flight profile of the aircraft during the event is to be considered. This includes cruise and transient conditions during descent, approach, landing and rollout to a stop on the runway. Taxi is not included in compliance considerations since the aircraft is on the ground and can be evacuated, or flight deck windows and cabin doors opened for ventilation. The intent of having to consider the condition from initiation of the event to the termination of the landing roll is to make sure the entire event is accounted for until it is safe to depart the airplane.

The words "… shall not adversely affect crew performance …" have been chosen to indicate the crew can be expected to reliably perform their published and/or trained duties to complete a safe flight and landing. This has been measured in the past by a person's ability to track and perform their tasks. The event should not result in expecting the crew to perform tasks beyond the procedures defined by the manufacturer, or required by existing regulations.

The phrase "No occupant shall sustain permanent physiological harm" is intended to mean that the occupants who may have required some form of assistance, once treated, shall be expected to return to their normal activities.

In showing compliance to the proposed rule, the applicant should consider the consequential airplane and system effects of the event. Operational provisions, which provide for, or mitigate the resulting environmental effects to airplane occupants, may be considered. If the manufacturer provides an approved procedure(s) for the event, the flight deck and cabin crew may configure the aircraft to moderate temperature and/or humidity extremes on the flight deck and in the cabin. This may include turning off non-critical electrical equipment and opening the flight deck door, or opening the flight deck window(s).

Thermal comfort and lower (cold stress) temperatures are outside the scope of this rule.

7 – How does this proposed standard address the underlying safety issue (identified under #1)? [Explain how the proposed standard ensures that the underlying safety issue is taken care of.]

The current regulation limits the humidity to an absolute moisture content - approximately 120 grains of moisture per pound of air (27 mBar). If this moisture content limit is applied at saturation (RH=100%), the corresponding air temperature limit is 72 Deg F (22 Deg C) dry-bulb temperature. These temperature/humidity limits are unrealistic when applied to tropical latitudes following a failure event during low altitude flight, descent and landing. Furthermore, these limits are significantly less than those accepted by recognized cognizant authorities. For example, NIOSH, see reference (3), advises that 86 Deg F (30 Deg C) WBGT (equivalent to 86 deg F dry bulb temperature at saturation) is acceptable for continuous light work by unacclimated individuals (NIOSH "Occupational Exposure to Hot Environments;" p 90 dated 1986).

The proposed standard ensures the flight deck and cabin crew's ability to perform their assigned tasks and not compromise safe flight and landing of the aircraft. The proposed standard utilizes data as accepted by recognized cognizant authorities to ensure the crew is provided a safe working environment.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain. [Explain how each element of the proposed change to the standards affects the level of safety relative to the current FAR. It is possible that some portions of the proposal may reduce the level of safety even though the proposal as a whole may increase the level of safety.]

The new rule will propose a harmonized performance based regulation and an acceptable means of compliance to this standard.

The current regulation limits the humidity to an absolute moisture content - approximately 120 grains of moisture per pound of air (27 mBar). If this moisture content limit is applied at saturation (RH=100%), the corresponding air temperature limit is 72 Deg F (22 Deg C) dry-bulb temperature. These temperature/humidity limits are unrealistic when applied to tropical latitudes following a failure event during low altitude flight, descent and landing. Furthermore, these limits are significantly less than those accepted by recognized cognizant authorities. For example, NIOSH, see Reference (3), advises that 86 Deg F (30 Deg C) WBGT (equivalent to 86 deg F dry bulb temperature at saturation) is acceptable for continuous light work by unacclimated individuals (NIOSH "Occupational Exposure to Hot Environments;" p 90 dated 1986).

Therefore, relative to the current FAR 25.831(g), and considering the inapplicability of its humidity requirements, the proposed regulation does not reduce the current level of safety.

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain. [Since industry practice may be different than what is required by the FAR (e.g., general industry practice may be more restrictive), explain how each element of the proposed change to the standards affects the level of safety relative to current industry practice. Explain whether current industry practice is in compliance with the proposed standard.]

Relative to current industry practice, the proposed standard maintains an equivalent level of safety. The proposed standard adheres to recognized industry and regulatory guidelines and preserves the crew's ability to perform their expected duties, as defined in Question 6 above, while maintaining an acceptable level of safety and health for all aircraft occupants during the event. The proposed standard recommends consideration of the effects on crew performance of all relevant heat sources and sinks, humidity levels, barometric pressures and contaminants. The proposed regulation requires a comprehensive, performance-based analysis, and therefore has greater credibility and scientific basis than the existing regulation, which is based on simplistic, independent limits of humidity and temperature.

10 - What other options have been considered and why were they not selected?: [Explain what other options were considered, and why they were not selected (e.g., cost/benefit, unacceptable decrease in the level of safety, lack of consensus, etc.) Include the pros and cons associated with each alternative.]

Among the proposed alternatives to a performance based regulation that have been discussed and eliminated are; basing the analysis on dry bulb temperature, omitting analysis of the approach and landing phase of the mission, skipping the ETOPS airport and flying a longer distance to a cooler airport, and limiting the environment the airplane flies in and is analyzed for. Each represents a compromise of the intent of the original rule. Dry bulb temperature analysis does not account for the effects of humidity that contribute to stress on the human physiology. Diverting to another airport could exceed the ETOPS range capability of the airplane. Omitting the approach and landing phase of the mission is not realistic in that eventually the airplane has to land. Each proposal potentially compromised the crew's ability to perform their duties to complete a safe flight and landing as intended by the original regulation. Another option discussed is to recommend repealing FAR 25.831(g) for new Type Certificate aircraft, and then showing compliance under FAR 25.1309 as has been done in the past for Amended Type Certificate aircraft. Discussions between the FAA and the manufacturers came to the conclusion that a specific FAR was still needed to address the event as a result of industry experience. Consequently it was concluded that a rewriting of the FAR 25.831(g) regulation was necessary.

11 - Who would be affected by the proposed change? [Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.]

Airplane manufacturers and suppliers will benefit from the single well-defined harmonized ruling thereby reducing certification costs. The proposed change would affect the airplane manufacturers by having a regulation that defines a reasonable means for showing compliance. It would also establish a consistent rule as applied to all manufacturers. There is a potential design savings for the manufacturer by not having to design the aircraft systems to accommodate the fixed humidity limit of 27 mbar. Added standby equipment would have to be incorporated to the aircraft to condition the air drawn into the airplane to an acceptable humidity level under the 27 mbar limit during an event in hot and humid conditions. This equipment would be an operational weight penalty to the airlines that do not operate in such hot and humid conditions when industry data has shown it is not necessary for providing working conditions conducive for the crew to complete safe flight and landing operation of the aircraft.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble? [Does any existing advisory material include substantive requirements that should be contained in the regulation? This may occur because the regulation itself is vague, or if the advisory material is interpreted as providing the only acceptable means of compliance.]

The relevant advisory material is AC 25-20, which does not contain any additional information that needs to be included in the rule text or preamble. Issues significant in showing compliance to the proposed rule are identified in the response provided for Question 6, above.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted? [Indicate whether the existing advisory material (if any) is adequate. If the current advisory material is not adequate, indicate whether the existing material should be revised, or new material provided. Also, either insert the text of the proposed advisory material here, or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, policy, Order, etc.)]

The existing FAA advisory material is not considered adequate. AC 25-20 contains guidance material for pressurized compartment loads (§ 25.365(d)), ventilation (§ 25.831), pressurized cabins (§ 25.841) and equipment standards for oxygen dispensing units (§ 25.1447), that were introduced at Amendment 25-87. However, only those portions of AC 25-20 that provide guidance to 25.831(g) are addressed in this report.

The working group recommends the FAA consider the following material in promulgating new regulatory material.

Portions of existing Advisory Circular AC 25-20 should be retained. Some sections should be modified slightly while others require major rewrite. The group recommends the following changes:

Portions of AC 25-20 that need minor modification are:
Section 3 Background section should be modified to add the information on the new standard and information gained with respect to Amendment 25-87 regulation.
Section 7 Failure Conditions needs to reflect the proposed modification of the standard.
Section 12 Glossary needs to reflect the new standard and definitions of terms.

Portions of AC 25-20 that will need a complete rewrite:
Section 5, Ventilation, sub-part (f) needs to reflect the proposed modification of the new standard and explain the acceptable means of compliance.

As the existing FAA advisory material is not considered adequate, the following material is recommended for inclusion in the advisory material.

A transient heat stress analysis can be used as a means of compliance. For applicable failure events prior to final descent, an acceptable means of compliance (MOC) is considered to be a 1 deg C rise, not to exceed 38 deg C body core temperature see page 2 of Reference 3. As discussed in the report this is a conservative criteria for exposure of unacclimatized people working for long periods of time in a hot environment. It is acknowledged that occupants will be able to receive appropriate medical treatment immediately after landing. Therefore, a 38.5 deg C body core temperature limit is acceptable, only for final approach and landing, during any time period not to exceed 20 minutes. 38.5 deg C body core temperature shall not be exceeded or sustained for any amount of time.

Following the event, a safe cabin environment still must be maintained. Therefore, consideration, based upon available data, shall be given to the additional effects of elevated levels of air contaminants and cabin pressure altitude.

In showing compliance to the proposed rule, the applicant should consider the consequential airplane and system effects of the event. Operational provisions, which provide for, or mitigate the resulting environmental effects to airplane occupants, may be considered. If the manufacturer provides an approved procedure(s) for the event, the flight deck and cabin crew may configure the aircraft to moderate temperature and/or humidity extremes on the flight deck and in the cabin. This may include turning off non-critical electrical equipment and opening the flight deck door, or opening the flight deck window(s).

Due to the unique design of each type of aircraft, the mission profile resulting from an event must take into consideration the flight profile that results from the event. This includes longer cruise times that result from having to operate at lower altitudes and slower speeds. Such flight profiles shall consider the longest potential exposure times, including the critical diversion point with respect to temperature/humidity.

Residual heat from equipment exposed to the flight deck or cabin will be included in the evaluation. For example the residual heat from electronic equipment that has been shut down and activated chemical oxygen systems will be included in the compartment heat load considerations.

The condition shall be assumed to take place under the maximum solar load conditions taking into account geographical and calendar considerations for the environment the aircraft was designed to operate in. A recognized source such as MIL-HDBK-310 provides guidance for determining hot day extremes. The direction of flight and solar orientation should be considered in determining the time-dependent solar load into the airframe. For compliance purposes an emergency descent at maximum rate of descent speed can be assumed.

The solar load must be included in the respective cabin/flight deck heat load calculations based on aircraft heat transfer properties. This includes solar heat through the skin and windows of the aircraft. If so equipped, window shades or other equipment may be utilized to reduce window solar load. But the calculated heat transfer through the shade (or equipment) must be considered as a general compartment heat load much as is done for the skin of the airplane.

The use of fans (i.e. recirculation, or lav/galley, etc.), if available to distribute the heat loads throughout the aircraft shall be taken into consideration when assessing aircraft compartment temperatures and occupant convective cooling.

The maximum occupancy shall be the basis of calculating the aircraft heat load.

Occupants of the aircraft will be assumed to be able to shed layers of clothing down to a level equivalent to “light summer clothing” in an attempt to remain comfortable.

14 - How does the proposed standard compare to the current ICAO standard? [Indicate whether the proposed standard complies with or does not comply with the applicable ICAO standards (if any)]

The proposed standard is in agreement with the intent of International Civil Aviation Organization (ICAO) Annex 8 "Airworthiness of Aircraft" requirements, Reference (1), as there are no specific ICAO requirements defining cabin environmental limits following a failure.

15 - Does the proposed standard affect other HWG's? [Indicate whether the proposed standard should be reviewed by other harmonization working groups and why.]

The proposed standard and the proposed means of compliance are independent of any Harmonization Working Group ARAC activities currently tasked. In addition, the FAA has completed all steps prior to officially tasking the Cabin Environment ARAC HWG. The MSHWG is aware that this tasking is currently on hold pending the results of an industry research activity.

16 - What is the cost impact of complying with the proposed standard [Please provide information that will assist in estimating the change in cost (either positive or negative) of the proposed rule. For example, if new tests or designs are required, what is known with respect to the testing or engineering costs? If new equipment is required, what can be reported relative to purchase, installation, and maintenance costs? In contrast, if the proposed rule relieves industry of testing or other costs, please provide any known estimate of costs.]

All manufacturers agree that adopting the new standard will result in significantly reduced costs. Although quantitative assessments are not available, the following cost reduction measures can be identified:

- Airplane manufacturers and suppliers will benefit from the single well-defined harmonized ruling thereby reducing certification costs.
- There is a potential design savings for the manufacturer by not having to design the aircraft systems to accommodate the fixed humidity limit of 27 mbar. Added standby equipment would have to be incorporated to the aircraft to condition the air drawn into the airplane to an acceptable humidity level under the 27 mbar limit during an event in hot and humid conditions.
- There is a potential operating cost savings for the airlines by not having the additional standby equipment (as a result of weight reduction, and reduced maintenance costs).

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

The proposed advisory material (i.e., Advisory Circular) and issue that should be included in the AC appear in the response to question 13. Below are the guidelines that were used in developing the proposed advisory material and rule. Where disagreements exist, the proposed rules, preamble, and advisory material take precedence.

1. Environmental Conditions

1.1 Occupant Exposure Scenario

a. Failure conditions that are not shown to be extremely improbable and that lead to elevated temperatures and/or humidity (excluding fires) in the aircraft shall not permanently harm the occupants nor impair the crew's ability to conduct safe flight and landing.

b. Thermal comfort, lower (cold stress) temperatures, and rates of recompression or re-pressurization after decompression (FAR 25.841(a)(1) and (2)) are outside the scope of this activity on FAR 25.831(g).

c. In a single flight, it is not necessary to consider all combinations of possible effects and environmental conditions. Acceptable failure analyses, such as is described in AC 25.1309-1A or later revision, and AMJ 25.1309 could be used.

d. Consideration should be given to the post failure mission profile such that the conservative condition (e.g., short descent followed by longer "cruise" time) at warmer temperatures and higher humidity are evaluated for occupant exposures.

e. It is understood that for compliance purposes, operating requirements and conditions may vary with different types of airplanes.

1.2 Flight Deck Crew Performance

a. Such an event, as described in a. of 1.1 above, shall not affect the flight deck crew's performance such that continued safe flight, landing and egress from the airplane are adversely affected.

b. The criterion for flight deck crew performance assumes that the flight deck crew is not at rest following a failure of conditioned pack air. Performance deterioration of the flight deck crew will be evaluated during exposures to rising, peak, lowering, and sustained high temperature/humidity conditions. Additional performance deterioration of the flight deck crew due to the combined effects of elevated levels of air contaminants and flight deck pressure altitude will also be evaluated.

1.3 Cabin Crew Performance

a. Such an event, as described in a. of 1.1 above, shall not adversely affect the cabin crew's ability to ensure that continued passenger safety and egress from the airplane are maintained.

b. The criterion for cabin crew performance assumes that the cabin crew is not at rest following a failure of conditioned pack air. Performance deterioration of the cabin crew will also be evaluated during exposures to rising, peak, lowering, and sustained high temperature/humidity conditions. Additional performance deterioration of the cabin crew due to the combined effects of elevated levels of air contaminants and cabin pressure altitude will be evaluated.

1.4 Passenger Heat Stress Tolerance

a. Such an event, as described in a. of 1.1 above, shall not cause permanent physiological harm to the passengers. For most passengers such events shall not prevent safe egress from the airplane. However, due to health conditions, some passengers may be at increased risk, and may experience symptoms consistent with heat exhaustion. These individuals may require assistance to safely egress from the airplane and/or medical attention after landing.

b. The criterion for passenger's heat stress tolerance is based on the assumption that they are at rest. Following such an event, as described in a. of 1.1 above, passenger exposures will be evaluated during rising, peak, lowering, and sustained high temperature and humidity conditions. Additional deterioration of passenger health due to the combined effects of elevated levels of air contaminants and cabin pressure altitude will also be evaluated.

2. Physiological Basis for Standard

The objective of this standard is to preserve a tolerable environment by limiting the metabolic and environmental heat loads to passengers and crew during exposures to a potential heat stress event.

2.1 Requirements

a. As recommended by cognizant authorities, the requirements of this standard for the crewmembers will be physiologically based for unacclimatized workers performing emergency duties in high temperature/humidity environments. Additional performance deterioration of the flight deck and cabin crew due to the combined effects of air contaminants and pressure altitude inside the airplane will also be evaluated.

b. As recommended by cognizant authorities, the requirements of this standard for the passengers will be physiologically based for unacclimatized individuals at rest in high temperature/humidity environments. Additional deterioration of passenger health due to the combined effects of air contaminants and cabin pressure altitude will also be evaluated.

c. The overall heat load will be evaluated over maximum and averaged times to limit potential increases in core or deep body temperatures and ensure crew performance in continued safe flight, landing and egress from the airplane.

d. The cumulative physical effects of exposures to a time-variable heat load profile should at no time adversely affect crew performance, as specified in 3.1 and 3.2 above. Consideration of the cumulative physical effects should be given to their different exposures.

2.2 Heat Load Assessment

a. The metabolic heat load will be estimated considering basal metabolism and pertinent heat/moisture generating activities, such as a seated/mentally active flight deck crew performing both light handwork and leg/footwork, a standing/mentally active cabin crew performing light walking and handwork, and seated/sedentary passengers.

b. Environmental heat loads will be evaluated with due consideration to all parameters affecting the overall heat/moisture transfer between occupants and their respective flight deck and cabin environments, including convection, radiation, conduction and evaporation.

c. Requirements for maximum exposure times and heat loads should consider different physiological thresholds for the flight deck crew, the cabin crew, and the passengers based on their respective roles in supporting continued safe flight, landing and egress from the airplane.

Dehydration due to lack of fluid replenishment is only a factor when considering long term exposures (i.e. on the order of a day or so) thus it should not be a matter of concern for 25.831(g). Medical experts on the MSHWG commented that the duration of exposure in an airplane would not be long enough for dehydration to become a serious health consideration or compromise a person's ability to function. Thus the consensus was that fluid intake during the event, and subsequent flight, approach and landing is not an issue.

18. - -Does the HWG wish to answer any supplementary questions specific to this project? [If the HWG can think of customized questions or concerns relevant to this project, please present the questions and the HWG answers and comments here.]

A supplementary question to be answered regards the relevance of the Packs Off Takeoff operating procedure. The MSHWG considered the material, “Airplane Operation with Air Conditioning Packs-Off” Revision to Memorandum of June 28, 1999, “same subject", September 3, 1999 policy memo. The MSHWG tasking was determined not to be affected based on the memorandums' focus related to "Normal" operations only. This Packs Off Takeoff issue is related to FAR 25.831(a) Ventilation Rate and is for what is considered a normal operational procedure to improve the aircraft performance on hot days or short runways. In contrast, this MSHWG was tasked with the non-normal Loss of Inflow event of 25.831(g). Therefore the referenced memorandums are not applicable.

19. – Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

A Notice is required for the proposed FAR change and the Mechanical Systems Harmonization Working Group should review any draft Notice of Proposed Rulemaking prior to publication in the Federal Register.

No Notice is required for the advisory material. However, it has been the policy of the Transport Airplane Directorate to provide a Notice of Availability of Proposed Advisory Circular (AC) and request for comments prior to issuing advisory material. Therefore, the MSHWG would like to review any draft notice prior to publication in the Federal Register.

20. – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process? Explain. [A negative answer to this question will prompt the FAA to pull the project out of the Fast Track process and forward the issues to the FAA's Rulemaking Management Council for consideration as a "significant" project.]

Harmonization of these regulatory issues is beyond the "Better Plan" for Harmonization tasks that are being handled under the Fast Track ARAC process. This issue has been identified as a Category 3 task, and therefore, should not be a "fast track" process, but instead should follow a normal NPRM process. This issue should be forwarded to the FAA's Rulemaking Management Council for establishment as a "significant" project. It should then be given highest priority to complete as quickly as possible. Failure to do so will increase the cost of the design and manufacture of new commercial airplanes by requiring the manufacturer to apply for an exemption to FAR 25.831(g) on new Type Certificate programs or an exception for Supplemental Type Certificate programs.

Attachment A - Reference List

1. International Civil Aviation Organization, Ninth Edition, July 2001.
2. "Aircraft Standards for Subsonic Transport Aeroplanes to be Operated above an Altitude of 41 000 ft", Generic Special Condition, developed by Panel 08 CSP, JAA/ System D&F Steering group, October 15, 2002.
3. "Criteria for a Recommended Standard; Occupational Exposure to Hot Environments Revised Criteria 1986," National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113, April 1986

Attachment B - Bibliography

1. "2003 Threshold Limit Values and Biological Exposure Indices," ACGIH Worldwide, Section Thermal Stress, pp. 170-178.
2. "Aircraft Standards for Subsonic Transport Aeroplanes to be Operated above an Altitude of 41 000 ft," Generic Special Condition, developed by Panel 08 CSP, JAA/ System D&F Steering group, October 15, 2002.
3. ASHRAE Handbook: Fundamentals, Chapter 8, Society of Heating Refrigerating and Air Conditioning Engineers Inc, 1989 & 1997. (Human Body model for perspiration coverage of the skin.)
4. ASHRAE Handbook: Applications, Chapter 40, American Society of Heating Refrigerating and Air Conditioning Engineers Inc, 1991. (Outdoor CO2 concentration levels).
5. ASHRAE Handbook: Applications, Chapter 41, American Society of Heating Refrigerating and Air Conditioning Engineers Inc, 1995. (Modeling and Control of Contaminants Generated by Metabolic functions).
6. "Combined Effects of Altitude and High Temperature on Complex Performance," FAA-AM-71-17, April 1971.
7. Report AM 69-10, "Complex Performance During Exposure to High Temperatures," DOT, FAA, Office of Aviation Medicine, June 1969.
8. "Criteria for a Recommended Standard; Occupational Exposure to Hot Environments Revised Criteria 1986," National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113, April 1986
9. "Determining Lines of Equal Comfort," F. C. Houghten, and C. P. Yagloglou, Transactions of American Society of Heat-Ventilation Engineers, No. 655, January 1923.
10. "Global Climatic Data for Developing Military Products," MIL-HDBK-310, June 1997
11. International Civil Aviation Organization, Ninth Edition, July 2001.

12. AMRL-TR-102, "A Review of the Effects of High Ambient Temperature on Mental Performance," J. Wing, Aerospace Medical Research Laboratories Aerospace Medical Division, Air Force Systems Command Wright-Patterson Air Force Base, Ohio, September 1965.
13. Amendment 25-87, "Standards for Approval for High Altitude Operation of Subsonic Transport Airplanes"
14. "Task Categorization and the Limits of Human Performance in Extreme Heat," P. A. Hancock; Aviation, Space and Environmental Medicine: August 1982.
15. "Human Cardioaccelerative Responses to Hypoxia in Combination with Heat," H. B. Hale, Aerospace Medicine: April, 1960.

Attachment C - Associated Regulatory and Advisory Material

1. Airworthiness Standards

The pertinent sections from FAA 14 CFR 25, 2001, and JAA JAR-25, 2000 related to the certification of today's aircraft are as follows:

A. Airworthiness Standards, Transport Category Airplanes

FAR 25.831(g)	Ventilation
FAR/JAR 25.831(b)(1&2)	Ventilation
FAR/JAR 25.832(a)(1&2)	Ozone
FAR/JAR 25.1309(b)(1), (b)(2)	Equipment, Systems & Installations

2. Operating Requirements: Domestic, Flag, and Supplemental Operations

U.S. Operators

FAR 121.557	Emergencies: Domestic & Flag Operations

Canadian operators,

Operational Standards-Airline Operations
Operational Standards-Private Operator Passenger Transportation
604.40 Protective Equipment

European operators

JAR-OPS 1.760 First aid oxygen

Airworthiness Standards and References

The pertinent FAA major category, Title 14, 2001, constituting the certification of today's aircraft are as follows:

FAR 25.1309 & ACs Equipment, systems, and installations

Attachment D - Definitions

Body Core Temperature - Temperature of the tissues and organs of the body, also called deep body temperature.

Critical diversion point w.r.t Temperature/Humidity – Point within flight profile in which loss of conditioned airflow failure results in severe environmental exposure related to combined effects of temperature and humidity.

Dry Bulb Temperature – Temperature of air as measured with a bare thermometer exposed to the air protected from any radiation effects.

Final Approach – Flight phase immediately preceding landing.

Heat Stress – The sum of the environmental and metabolic heat load on an individual.

Permanent Physiological Harm – Physical or mental damage (death, injury, or illness) to an organism's healthy or normal functioning that continues or endures without fundamental or marked change.

Time-dependent Solar Load – Solar generated heat load based on applicable window area and solar flux as a function of altitude, time, and solar orientation.

Wet Bulb Globe Temperature (WBGT) – Index developed as a basis for environmental heat-stress monitoring that combines the effects of humidity, air movement, radiation, and air temperature.

Mechanical Systems Harmonization Working Group (MSHWG) Final Report on

FAR 25.841(a)(2,3)

<u>August, 2003</u>

ARAC 25.841(a) WG Report

1 - What is underlying safety issue addressed by the FAR/JAR? [Explain the underlying safety rationale for the requirement. Why does the requirement exist?]

FAR/JAR 25.841(a) contains the requirements that the design and operation of an airplane meet specific performance requirements following failure conditions that can result in a sudden loss of cabin pressure. FAR 25.841(a) intends that the occupants be afforded protection by limiting the exposure to the environment following cabin decompression.

2 - What are the current FAR and JAR standards? [Reproduce the FAR and JAR rules text as indicated below.]

Current FAR text:

Amendment 25-87 established new requirements in 14 CFR Part 25.841 (a) intended to upgrade the airplane and equipment airworthiness standards for subsonic transport airplanes operated above 40,000 feet. These were based in part on special conditions that had been used on type certification of executive business airplanes for many years. Specifically, Amendment 25-87 created three requirements in Part 25.841(a)(2) and (a)(3) governing the cockpit/cabin environment:

> *(2) The airplane must be designed so that occupants will not be exposed to a cabin pressure altitude that exceeds the following after decompression from any failure condition not shown to be extremely improbable:*
> *(i) Twenty-five thousand (25,000) feet for more than 2 minutes; or*
> *(ii) Forty thousand (40,000) feet for any duration.*

(3) Fuselage structure, engine and system failures are to be considered in evaluating the cabin decompression.

The intent of these regulations is to ensure occupant survivability in the event of decompression through establishment of minimum design standards. They require that the occupants be afforded protection by limiting the exposure to the environment following cabin decompression and by stating that this environment will not result in fatalities or permanent physiological harm to any occupant.

Current JAR text:

There is no applicable JAA regulation.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed? [Reproduce text from issue

papers, special conditions, policy, certification action items, etc., that have been used relative to this issue]

While FAR 25.841 (a)(2) and (3), Amendment 25-87 does exist, as mentioned several places, no new wing-mounted engine airplane program has been certified by the FAA to these requirements. FAA currently has several new airplane certification programs underway. Of these, one manufacturer (rear-mounted engine) has said that they will meet the Amendment 25-87 requirements; one (wing-mounted engine) has petitioned for exemption, FAA has not heard from the others.

As the FAR change per Amendment 25-87 became effective in July of 1996, there have been no new wing-mounted engine airplanes certified to this level (although several are currently pending). However, the underlying safety issue has been addressed via special conditions and effectively demonstrated via the associated means of compliance.

For certification with FAA as primary authority, standards were developed in the early 1950s to permit safe operation of early turbojet transport airplanes up to certain maximum operating altitudes - typically 41,000 or 43,000 feet. Subsequent to the type certification of the early turbojet transport airplanes, applicants requested approval to operate certain later airplanes at higher altitudes. These were in most cases small executive transport airplanes, and the requested altitudes ranged up to 51,000 feet.

The operation of these executive transport airplanes at altitudes above 40,000 feet usually involved a number of novel or unusual design features that were not addressed by the airworthiness requirements in the current regulations. In order to ensure a level of safety equivalent to that established by part 25 of the FAR, §§ 21.16 and 21.101 of part 21 require that additional standards be developed in the form of special conditions and that compliance with the special conditions be demonstrated.

The regulatory changes adopted by Amendment 25-87 were intended to codify and consolidate the different high-altitude criteria that have been applied to previously certificated subsonic transport airplanes certified under special conditions.

In the case of the JAA this safety issue is currently addressed through Certification Review Items (CRI), issued separately for each certificated aircraft type, which introduce a Special Condition (SC). The specific SC generally comprised requirements essentially similar to the FAA special conditions, which were the template for the current FAR regulation.

3 - What are the differences in the standards and what do these differences result in?: Explain the differences in the standards, and what these differences result in relative to (as applicable) design features/capability, safety margins, cost, stringency, etc.]

The current rule has not been adopted by the JAA due to its difficulty of implementation for the large transport category aircraft. Consequently, the current status presents a potential for differing requirement by the FAA and the JAA, which could introduce significant differences in design features/capability, safety margin, costs, and stringency.

For executive transport airplanes, the FAA and JAA policies are similar in technical intent, and only differ in their formats. The fundamental problem is that, per FAA interpretation of the provisions of § 25.841 (a)(2) and (3), subsonic transport airplane designs incorporating wing-mounted engines must be evaluated for fuselage penetrations by engine rotor parts following an uncontained event.

Transport Canada and the Brazilian authority are other aviation authorities that have adopted these FAA requirements as conditions for the operation of airplanes at altitudes up to 51, 000 feet.

4 - What, if any, are the differences in the means of compliance? Provide a brief explanation of any differences in the compliance criteria or methodology, including any differences in criteria, methodology, or application that result in a difference in stringency between the standards.]

The differences now between FAR 25 Amendment 87 and the JAA generic Special Conditions (see Reference 1) proposal generally result in making the FAA rule more difficult to comply with. The primary difference regarding failure conditions to consider is that the FAA rule specifically includes engine failures and this in turn includes rotor burst. For aircraft with wing-mounted engines, where the pressurized fuselage is within the debris zone, a possible rapid or instantaneous depressurization to a high cabin altitude causes severe difficulty in demonstrating compliance.

5 – What is the proposed action? [Is the proposed action to harmonize on one of the two standards, a mixture of the two standards, propose a new standard, or to take some other action? Explain what action is being proposed (not the regulatory text, but the underlying rationale) and why that direction was chosen.]

The proposed action is to harmonize on a new, performance-based standard. Compliance to this new regulation will require a combination of quantitative and qualitative means to demonstrate compliance. This is not unlike the requirements that exist in 14 CFR Part 25.671 or 25.1309.

All passengers are at some level of risk for permanent physiological harm. Due to numerous factors, including age, pre-existing medical condition, etc., some passengers will face greater levels of risk than others. The current FAR/JAR 25.1309 categorizes this failure condition as hazardous and acknowledges the potential for incurring injuries and/or fatalities to the airplane occupants, especially those passengers with certain pre-existing medical impairments (i.e. unhealthy passengers), following this failure event as follows:

Harmonized 25.1309 (Reference 2) (Proposed by SDAHWG)

Serious or fatal injury to a relatively small number of the occupants other than the flight crew.

With the type of failure condition defined above, there exists uncertainty with respect to the level of risk to each passenger's survival associated with exposure to the cabin environment following decompression. To satisfy the harmonized FAR/JAR 25.1309 it is necessary to assess the degree of risk in order to minimize the potential for permanent physiological harm to the airplane's occupants. An analysis that defines the envelope of vulnerability of passengers for permanent physiological harm in a decompression and identifies the continuously available design features of the airplane (i.e., aircraft systems) and the operational features (e.g., crew training, Airplane Flight Manual (AFM) limitations, etc.) to enhance the survivability of those passengers at increased levels of risk, would be an acceptable approach towards determining compliance with the harmonized FAR/JAR 25.1309. Note that the measure of adequacy is the presence of aircraft features (e.g., design and operational) that are commensurate with the level of risk associated with the cruise flight altitude.

Healthy passengers will self resuscitate, i.e., regain consciousness without any direct action of the crew and/or other occupants. Passengers must recover sufficient cognitive function to exit the aircraft following emergency descent, safe flight and landing. Some assistance may be required for passengers with pre-existing impairments.

The intent of this new regulation is to afford realistic protection to the occupants while allowing design flexibility to the airplane industry. Therefore, in contrast to Amendment 25-87, the new proposed rule acknowledges the potential for loss of life or permanent physiological harm to a small number of passengers, who are not considered healthy, following the decompression event. It is assumed the flight deck and cabin crew are healthy, and follow appropriate procedures.

It is because of uncertainty in predicting uncontained engine failure (UEF), uncertainty in the potential severity of the cabin environment following decompression at high altitudes, and uncertainty in the response of the occupants to that environment that acceptable means of compliance to this rule will require both quantitative and qualitative means. The underlying rationale is a belief that the cabin pressure field and the duration of the event determine the severity of the exposure to decompression. This is predicated on observations made from flight physiological and medical experiments, conducted during 1939, 1967 and 1969 (References 3, 4, 5) on a human subject and non-human primates, which provide guidance as to the maximum exposure time an unprotected person (i.e., without supplemental oxygen and pressure garment) may be exposed to the rarefied environment without permanent physiological harm. Experimental data on a human subject and non-human primates have shown exposure times that have resulted in fatalities and/or permanent physiological harm or no resultant injuries. There is no corroborated data that establishes the maximum safe exposure time (i.e., the maximum amount of time an unprotected individual may remain in the rarefied environment without incurring any permanent physiological harm). Certain reports have provided some guidance on exposure times that resulted in impairment of mental performance or loss of useful consciousness without resulting in permanent physiological harm. However, these data are at lower altitudes than the maximum certified altitudes for existing commercial airplanes, and are not representative of the extreme environmental conditions that the cabin can be exposed to in the historically rare event of decompression at high altitude.

Research work on non-human primates and a human subject as reported in References 3, 4, and 5 form the basis for this methodology. It was observed and is hypothesized that when the decompression data are evaluated via the use of a Depressurization Exposure Integral (DEI) a trend emerges; the DEI method is described within the draft Advisory Circular in the response provided for Question 13. There appears to be a positive association between the value of the integral and the likelihood of fatalities or permanent physiological harm being sustained by the subjects. The DEI method may provide a quantitative means to estimate the oxygen deprivation and thus, the severity of the exposure.

It was recognized by the working group that an interim policy should be established until validation testing is complete. As additional data are needed to address uncertainties in this method, it is recommended that the FAA and other regulators sponsor additional, independent research. It is recommended that the DEI method be submitted as a concept for peer review and validation to include testing. The DEI method may be validated or modified as a result of peer review.

A properly designed decompression study including human and/or primate subjects would define parameters for an analytical method (such as the DEI method) that are protective of human health. Test conditions should be designed to ensure that there are no fatalities and that the possibility of permanent physiological harm to the test subjects is remote. The decompression study should test at the highest rates of descent first and move to the slower rates as shown in the following Table 1 (for illustrative purposes with exact altitudes to be determined by the sponsors and cognizant medical authorities):

Table 1

Descent Rate / **Altitude**		**40,000 feet**	**43,000 feet**	**45,000 feet**	**51,000 feet**
15,000 ft/min		H & N-HP	H & N-HP	N-HP	N-HP
10,000 ft/min		H & N-HP	N-HP	N-HP	N-HP
8,000 ft/min		N-HP	N-HP	N-HP	

Where: H signifies human subjects and N-HP signifies non-human primates.

All subjects should breathe air at chamber conditions, without pre-breathing oxygen. Safety precautions must be taken to avoid fatalities and permanent physiological harm (i.e., oxygen masks must be available for use by the observer to ensure the safety of the subject). Initial conditions would be set at an 8,000-ft altitude, and final conditions should be established to 10,000 feet. (Note that the chamber ascent rate from initial altitude pressure condition to maximum altitude pressure given in the table should occur within about 20 seconds. This results in rates of chamber pressure altitude rise of 1600, 1750, 1850 and 2150 feet per second, respectively.) The 20 second criterion was based upon the following considerations. For the safety of the subjects, an explosive decompression (i.e. duration of less than a few seconds) should not be simulated. Decompressions longer than the crew reaction time, say 30 seconds, permit crew actions to lower the peak altitude. Much longer times to maximum altitude as observed in the Nicholson & Ernsting, April 1967 data (Reference 4) of about 1.75 min., 3 min., and 5 min., respectively, are not representative of either worst-case decompression or practical airplane response. . A time delay of 20 seconds to decompress from 8, 000-ft altitude to the max altitude is recommended. For comparison purposes, the Nicholson & Ernsting 1967 (Reference 4) data show a chamber rise of approx 390 ft/sec while Brierley & Nicholson 1969 (Reference 5) data was approximately 410 ft/sec. Finally, the H.G. Clamann 1939 per Blockely & Hannifan 1961(Reference 3) data was approximately 6600 ft/sec.

Measurements would be made to determine alveolar oxygen level and other relevant parameters as selected by a group of medical specialists. Non-invasive means (e.g. behavioral tests, computed tomography scans, magnetic resonance imaging scans, and positron emission tomography scans) could be employed to examine the subjects for signs of precursors to permanent physiological harm.

6 - What should the harmonized standard be? [Insert the proposed text of the harmonized standard here]

While the task of this working group was limited to the working group report, the working group recommends that the FAA and other regulatory authorities consider the following material in promulgating a new harmonized rule and preamble to replace 14 CFR Part 25.841(a)(2) and (a)(3).

RULE

Proposed text for the new harmonized 14 CFR Part 25.841(a)(2) and (a)(3) rule:

The airplane must be designed and operated such that after a decompression event, the occupants will not be exposed to transient or steady state cabin pressure altitudes that

i. ***Result in fatalities or permanent physiological harm to any crewmembers, or more than a small number of passengers, following any engine failures that do not result in a catastrophic loss of the airplane;***
ii. ***Result in permanent physiological harm to any occupants following certain structural failure events;***

iii. Result in permanent physiological harm to any occupants following system failure conditions not shown to be extremely improbable.

PREAMBLE
The working group recommends that the FAA and other regulatory authorities consider the following material for use in the preamble for a new regulation.

The original 14 CFR Part 25.841(a) (2) and (3) per earlier amendments had the laudable goal of ensuring no fatalities or permanent physiological harm (brain damage) following a decompression event. However, there is an inherent risk associated with any decompression event over and above that caused by the initiating failure itself. All occupants are at some level of risk during a decompression event. Permanent physiological harm to some occupants may occur during the initial event (i.e., from impact of uncontained engine debris or from being ejected from the airplane). In addition, some cases of permanent physiological harm among unprotected occupants may occur during the airplane descent due to hypoxia. Some occupants may be at increased level of risk because of numerous factors (e.g., age, pre-existing medical conditions, etc.). Those occupants at increased level of risk may suffer permanent physiological harm as a result of exposure to hypoxic conditions during a sudden decompression and the resulting emergency descent, flight and landing.

The current proposed harmonized FAR/JAR 25.1309 requirements allow fatalities or permanent physiological harm for failure conditions categorized as hazardous. It acknowledges the potential for incurring injuries and/or fatalities to the airplane occupants following this type of failure event.

The intent of this new regulation is to afford realistic protection to the occupants while allowing design flexibility to the airplane industry. It should be noted that the "worst-case" decompression events have originated from uncontained engine failures, which are rare, and structural failure events that do not result in catastrophic loss of the airplane. The proposed regulation acknowledges the potential for permanent physiological harm to a small number of passengers, only for structural and engine-related failures. It is because of uncertainty in predicting uncontained engine failure, uncertainty in the potential severity of the cabin environment following decompression at high altitudes, and the uncertainty in the response of the occupants to that environment that acceptable means of compliance to this rule will require both quantitative and qualitative means. This is not unlike the requirements that exist in 14 CFR Part 25.671 or 25.1309.

The FAA, foreign regulators and industry need reasonably accurate quantitative means to assess features incorporated into the design and operation of an airplane. The MSHWG believes that the DEI method as described within the draft Advisory Circular in the response provided for Question 13, provides the quantitative means to ensure that an airplane design, properly operated, meets the intent of Part 1 of the new regulation with respect to protecting human physiology following a rapid decompression. However, it should be noted that the medical community is in disagreement over whether there is sufficient theoretical basis for this approach due to the paucity of useful data. Portions of the medical community are divided, citing a concern over the use of a simplified analysis to determine the severity of the human response to the rarified atmosphere following decompression. In fact, this is a dynamic multi-factorial response to changes in, among other things, the oxygen saturation of the blood, tracheal, alveolar, arterial and end-tidal partial pressure of oxygen, carbon dioxide, water vapor, pH of the blood, arterial blood pressure, cerebral vascular resistance and the local cerebral blood flow. In the opinion of some medical experts, this is a time dependent, multi-variable, highly synergistic problem that is not amenable to simplistic methods of analysis. While we acknowledge these concerns, we believe that through the selection of sufficiently conservative acceptance criteria validated by additional experimental data obtained through an appropriate research program, this approach will permit a realistic numerical appraisal of the severity of the decompression environment.

It is further recommended that the following issues be addressed in the preamble of the regulation:

The application of probability of structural failure is contrary to the basic structural design approach, and therefore probability of structural failure should not be considered in establishing compliance to the subject rule. The regulations governing structures are intended to render structural failures extremely improbable by virtue of choice of design loads, margins of safety, testing, and required maintenance programs, even though a numerical value for extremely improbable is not always computed.

System failure conditions not shown to be extremely improbable and certain structural failures shall not result in fatalities or permanent physiological harm. Therefore, the airplane must be designed so that occupants will not be exposed to cabin pressure altitudes that exceed the following after decompression:
(i) Twenty-five thousand (25,000) feet for more than 2 minutes; or
(ii) Forty thousand (40,000) feet for any duration.

The MSHWG recommends consideration of the structural failures specified in the Amendment 25-87 preamble and AC 25-20 for consideration with the following corrections:

The wheel rim release does not occur in flight condition, based on the very stringent requirements applied to the wheel design and tests and historic data. Also the probability method for fatigue model presented by one manufacturer gives substantiation that wheel failure is extremely improbable, therefore wheel rim release need not be considered.

The tire burst in flight is not extremely improbable as demonstrated by historic data. The ground loads are not applicable in flight and for this condition tires are extremely robust; according to 25.729(f)(1) and historic data, the tire burst occurs in flight and as it is very difficult to demonstrate that tire cannot be burst in case of overheat, it is not possible to demonstrate that this event does not occur in high altitude flight. Therefore, the tire burst event must be considered in the depressurization analysis.

Pressure vessel openings resulting from uncontained engine failure, loss of antennas, or stall warning vanes, or any system failure conditions that are not shown to be extremely improbable must be considered. The effects of such damage while operating under maximum normal cabin pressure differential must be evaluated. It can be assumed that the aircraft is operated as designed. In the event of an uncontained engine failure, manufacturers may assume that other, unrelated system or structural failures do not occur at the same time; however, loss of system capability, linked to the loss of the one engine has to be considered.

The loss of a "typical skin panel" bound by a crack stopper pattern need not be considered. It is assumed that propagation of a crack from stringer to stringer, frame to frame leading to the total loss of a skin panel is prevented by scheduled maintenance programs, and therefore does not occur. Structural cracks will be addressed as per the existing Amendment 25-87 preamble, and repeated below:

> *The maximum pressure vessel opening resulting from an initially detectable crack propagating for a period encompassing four normal inspection intervals. Mid-panel cracks and cracks through skin-stringer and skin-frame combinations must be evaluated.*

It is recommended that the flight deck crew be trained in initiating emergency descent following rapid decompression. It is recommended that flight deck crew flying aircraft certified to fly above 41,000 ft. altitude undergo initial and periodic training in the use of positive pressure breathing masks. In demonstrating compliance with proposed § 25.841, the first priority of the flight deck crew shall be to don oxygen masks. The flight deck crew would then presumably perform an emergency descent in accordance with an approved emergency procedure. In order to maximize occupant survivability following a rapid decompression, the flight deck crew shall descend the airplane at the maximum safe descent speed, which is Vmo/Mmo, assuming structural failure as defined by FAR/JAR 25.571. Any additional training components and flight manual revisions necessary for adoption of the Vmo/Mmo descent criterion shall be required.

In demonstrating compliance with proposed § 25.841, the manufacturers shall account for loss of system capability, based on the specific systems architecture of the aircraft (only the systems that may be lost following an engine failure, as would be done in a hazard analysis, etc.), following loss of an engine.

During rapid and/or explosive decompression at cruise altitudes, flight deck crew would be in a highly chaotic environment with various warning sounds and vision may be severely limited due to fog, etc., in the flight deck air. Similarly, cabin flight attendants would not be able to reliably assess damage and report to flight deck crew. In fact, damage may be hidden from view.

Need to evaluate the effects that immediate exposure to various cabin altitudes will have on flight deck crew cognitive function if not wearing mask and if at least one crewmember will always be wearing oxygen higher than 41,000 ft. as required by FAA regulation (Note: FAA and Transport Canada requirement only. There is no European operational requirement for a crewmember to wear an oxygen mask at flight levels above 41,000 ft.). It is recommended that all regulatory authorities require that at least one flight deck crewmember be always wearing a pressure breathing oxygen mask above 41,000 ft. altitude.

Depending on the size of the hole and the net volume of the aircraft, depressurization may not occur within a few seconds. Therefore, the time to depressurize the aircraft after the hole is created should be considered.

Flight attendants are to put on masks, sit or hold on, and await flight deck crew instructions before attempting to help passengers. It is assumed for the purposes of showing compliance to the design rule that flight attendants are able to don masks and achieve a minimal level of protection within some reasonable number of seconds following mask drop. Following flight deck crew instructions, flight attendants will move about the cabin performing emergency procedures.

It will be assumed that not all passengers are able to effectively don masks. Healthy passengers will self-resuscitate, i.e., regain consciousness without any direct action of the crew and/or other occupants. Passengers must recover sufficient cognitive function to exit the aircraft following emergency descent, safe flight and landing. Some assistance may be required for passengers with pre-existing impairments.

It is understood that the flight deck crew and the way the airplane is operated can affect the survivability of the aircraft and its occupants following decompression. Therefore, requirements may be written into airplane flight manuals (AFM) to mitigate the severity of the post-decompression environment's impact on occupant health. A partial list of operational procedures that may accomplish this are:

- One member of the flight deck crew always wearing O_2 mask for flight above FL 410.
- Initial and recurrent emergency decompression training for all crewmembers.

7 - How does this proposed standard address the underlying safety issue (identified under #1)? [Explain how the proposed standard ensures that the underlying safety issue is taken care of.]

The original 14 CFR Part 25.841(a) (2) and (3) had the goal of ensuring no fatalities or permanent physiological harm following a decompression event. However, as a result of the deliberations within this working group and a review of available research material, the working group believes that there is an inherent risk to occupant health and safety associated with any decompression event. The MSHWG has concluded that all occupants are at some level of risk during a decompression event and the resulting emergency descent, flight, and landing. Fatalities may occur during the initial event (i.e., from impact of uncontained engine debris or from being ejected from the airplane). In addition, some cases of permanent physiological harm could result from hypoxia among those occupants at increased risk due to pre-existing health factors (e.g., age, chronic and acute medical conditions, etc.).

The proposed harmonized rule and advisory material will afford reasonable protection to all occupants on commercial transport aircraft, by ensuring that the duration of exposure to the rarified environment following a decompression at high altitude will be unlikely to result in permanent physiological harm to any more than a small number of passengers. The proposed methodology involves the calculation of the DEI. The working group recommends that the FAA obtain additional data to substantiate that the proposed design factors incorporate appropriate safety margins. This design methodology, combined with the historically observed low probability of occurrence, should provide a reasonable measure of safety for all occupants.

Previously certified large transport aircraft incorporating established design practices have safely operated at altitudes in excess of 40,000 ft. for more than 20 years, representing many millions of flight hours. Historically, relatively few accidents or incidents have occurred during cruise. According to the statistics, only 6 percent of accidents in the worldwide commercial fleet history have occurred during cruise; even though the highest percentage of the flight time (57%) is at cruise (Reference 6).

It should also be remembered that very few decompression incidents, if any, have exposed an aircraft cabin to pressure altitude profiles that run the risk of permanent harm to occupants. Industry experience shows that very few cases of catastrophic decompressions at high altitude have occurred, notably in small business jets. The FAA cited 3 cases as examples of rotor burst in cruise. In one case, a DC-10 crossing New Mexico reported several cases of initial decompression sickness apparently with no permanent injuries. However, it was noted that 24 passengers and crewmembers were brought to the hospital at

Kirtland AFB for treatment of symptoms including hypoxia. Because there was no follow-up on these occupants there is no way to assess the extent of injuries sustained during this decompression event. It is believed in this case rotor burst was induced via crew action. In the second case (Sioux City, Iowa), the aircraft damage was aft of the pressure bulkhead, thus no rapid decompression occurred. The FAA cites this event to estimate the damage if the debris field had been forward of the pressure bulkhead. In the third case (Pensacola, Florida), the airplane was on takeoff when the event occurred (not cruise) and the flight deck crew successfully performed a rejected takeoff. Thus, this case did not encounter a rapid decompression. It should be noted that the FAA cited these three cases (Reference 7) because they were "data rich" events. In addition to the "data rich" events discussed above, there have been another 9 uncontained engine failures at cruise identified to the FAA (Reference 8).

Date	Title	Remarks	Event Altitude	Cabin Altitude
05/07/75	OTHER	71 YR OLD MAN WITH CARDIAC PROBLEM DIED.	35,000	13,800
11/11/82	SUPERNUMERY CREW FATALITY	STUDENT FLIGHT ENGINEER BECAME INCAPACITATED HOSPITALIZED BUT DIED SOON THEREAFTER. AEROEMBOLISM.	33,000	20,000
03/09/89	CAB PRESS LOSS-PAX ILLNESS	ELDERLY LADY ON OXYGEN. TRANSPORTED TO HOSPITAL WHERE SHE LATER DIED.	31,000	10,000
11/03/77	EMERGENCY DESCENT/FATALITY	ONE PASSENGER DIED BEFORE LANDING	31,000	19,000
02/09/89	PILOT HYPOXIA	CAPTAIN DONNED A PORTABLE OXYGEN MASK WENT INTO MAIN DECK CARGO AREA . LOST CONSCIOUSNESS AND ULTIMATELY DIED OF HYPOXIA.	30,000	30,000
12/31/97	CREW MEMBER DIED IN FLT	CABIN PRESSURIZATION FAILURE. MAINTENANCE ENGINEER FOUND DEAD IN CARGO AREA OF AIRPLANE.		
02/02/95	RAPID DECOMPRESSION-DUCT FAIL	SEVERAL CREW MEMBERS WERE HOSPITALIZED DUE TO EFFECTS OF DECOMPRESSION.	43,100	28,000
11/03/73	ENGINE FAILURE	Aircraft decompressed to 34,000 ft in 26 seconds. Two F/A lost consciousness almost immediately when they stood up. Aircraft occupants were exposed to altitudes above 30,000 ft for about one minute and altitudes above 25,000ft for more than 2 minutes. One passenger ejected.	39,000	34,000
05/05/66	DEPRESSURE-CABIN ALT 34,000	1 F/A PASSED OUT FROM 2-3 MINUTES, 1 F/A GRAYED OUT, NUMEROUS PSGR RECEIVED EAR BLOCKS, ONE PSGR SEVERELY HE WAS HOSPITALIZED FOR 3 DAYS	39,000	34,000
04/24/63	DEPRESSURE-CABIN ALT=18,000 FT	CABIN CREW STEWARD BECAME HYPOXIC.	38,000	18,000

Date	Title	Remarks	Event Altitude	Cabin Altitude
03/18/99	DIV-DUE TO RAPID DECOMPRESSION	Four passengers 3 F/A lost consciousness for approximately 2 to 3 minutes	37,000	10,000
08/21/83	DEPRESSURE-CABIN ALT=30,000 FT	3 F/A'S COLLAPSED FROM LACK OF OXYGEN, AND ONE LAVATORY PSGR. BECAME HYPOXIC.	37,000	30,000
08/13/98	RAPID DECOMPRESSURIZATI ON	Captain and senior F/A lost consciousness.	35,000	20,001
10/03/74	DEPRESSURIZATION	ONE (OR TWO) F/A'S "CONVULSED AND LOST CONSCIOUSNESS." ONE F/A BECAME HYPOXIC.	35,000	25,000
07/22/81	DEPRESSURE-CABIN ALT=26,000 FT	TWO WOMEN PSGR FAINTED AND WERE ATTENDED TO BY AN ONBOARD DOCTOR	35,000	26,000
07/05/78	DEPRESSURE-CABIN ALT>29,000 FT	FEMALE PAX LOST CONSCIOUSNESS NO PULSE NOR BREATHING. F/A ADMINISTERED HEART MESSAGE AND MOUTH-TO-MOUTH RESUSCITATION. FLIGHT CREW TEMPORARILY DEAF.	35,000	29,001
05/12/96	LOSS OF CABIN PRESSURE	Captain, flight engineer and lead flight attendant all become unconsciousness due to hypoxia.	33,000	22,001
03/15/94	Pilot incapacitation - decompression sickness	CLIMBING TO FL350 WITH SUPP OXYGEN,THE CAPT BECAME INCAPACITATED NITROGEN NARCOSIS (BENDS) TAKEN TO A HOSPITAL SERIOUS CONDITION	33,000	33,000
06/08/75	DEPRESSURE-CABIN ALT=16,000 FT	AIRLINE PSGR-EMPLOYEE SUFFERED COLLAPSED LUNG. HOSPITALIZED FOR 69 HOURS.	31,000	16,000
09/18/01	UNCONTAINED ENGINE FAILURE	When the aircraft landed, one passenger was found dead, apparently due to depressurization. Possible ejection.	30,000	30,000

Date	Title	Remarks	Event Altitude	Cabin Altitude
03/03/87	ATB/PRESSURIZATION LOST	TWO PASSENGERS AND ONE FLIGHT ATTENDANT WERE UNCONSCIOUS FOR A SHORT PERIOD.	28,000	8,500
09/17/79	ATB/EXPLOSIVE DECOMPRESSION	F/A FELL TO FLOOR, UNCONSCIOUS FOR ABOUT 15 SECONDS AND SUSTAINED MINOR LEG, HEAD AND HAND INJURIES.	25,000	25,000
04/28/88	FUSELAGE OPENED IN FLIGHT	ONE FLIGHT ATTENDANT WAS LOST OVERBOARD DURING THE DECOMPRESSION. ANOTHER FLIGHT ATTENDANT AND 7 PASSENGERS RECEIVED SERIOUS INJURIES OF LACERATIONS, SKELETAL FRACTURES AND CONCUSSIONS.	24,000	24,000
02/24/89	CARGO DOOR/FUSELAGE OPENED IN FLIGHT	INJURIES SUSTAINED BY THE SURVIVORS WERE CAUSED BY THE EVENTS ASSOCIATED WITH THE DECOMPRESSION, SUCH AS BARO-TRAUMA TO EARS, AND CUTS AND ABRASIONS FROM THE FLYING DEBRIS IN THE CABIN. Nine passengers ejected.	23,000	23,000
04/11/60	DEPRESSURIZATION AT 20,000 FT	ONE CREW MEMBER FAINTED FROM LOSS OF OXYGEN WHILE AIDING PASSENGERS WITH THEIR MASKS.	20,000	20,000
11/23/93	RAPID DECOMPRESSION-ATB	SOME FLIGHT ATTENDANTS WERE LYING ON THE FLOOR.	19,000	19,000
06/10/90	CAPT PARTLY EJECT THRU WINDSHD	CAPTAIN WAS SUCKED PARTWAY OUT OF COCKPIT SUFFERED FACIAL BRUISES, FRACTURED ELBOW, WRIST AND THUMB, AND FROSTBITE	17,000	17,000
08/26/84	CBN PRESS FAILURE	1 PAX SUFFERED HEART ATTACK		

Table 7-1: Significant Pressurization Events

Notes: Based on a Total of 2866 pressurization events reported since 1959. Transport Category Airplanes over 60,000 lbs.
Event Altitude and Cabin Altitude were reported for 873 events.
Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

The above three table sets comprise Table 7-1 and summarize significant transport category decompression events resulting in fatalities (in red) or incapacitation. These events are graphically plotted in Figure 7-1 below. Note that while fatalities were incurred, none are attributable to the scenario identified by FAR 25.841(a), Amendment 25-87 where a large hole is created in the fuselage due to an engine burst, etc.

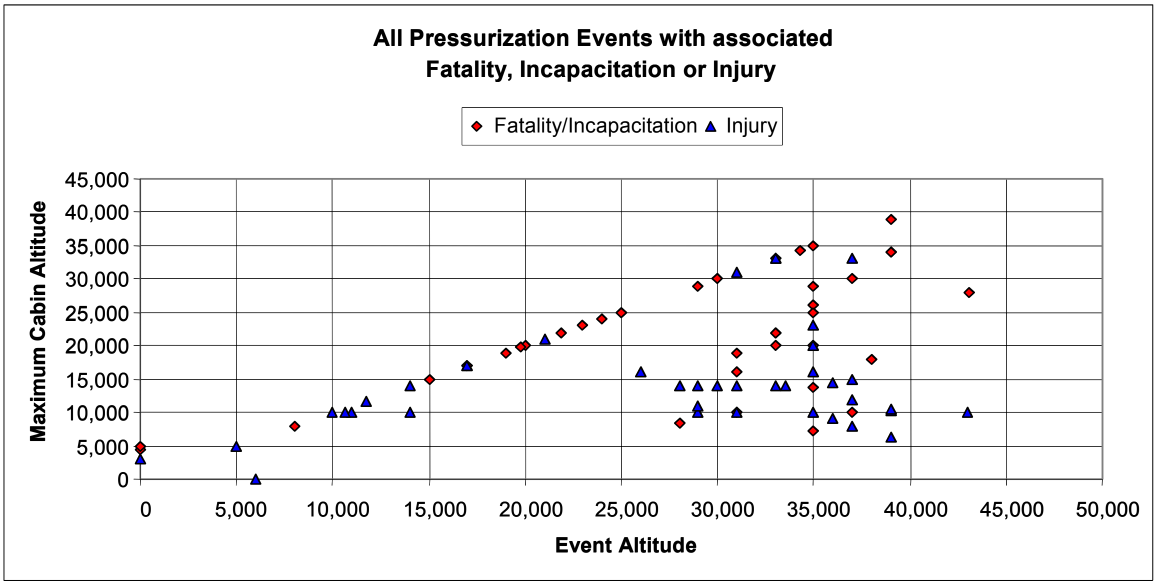


Figure 7-1: Pressurization Events with Fatality, Incapacitation or Injury

Notes: Total of 2866 pressurization events reported since 1959. Transport Category Airplanes over 60,000 lbs.

Event Altitude and Cabin Altitude were reported for 873 events.

Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

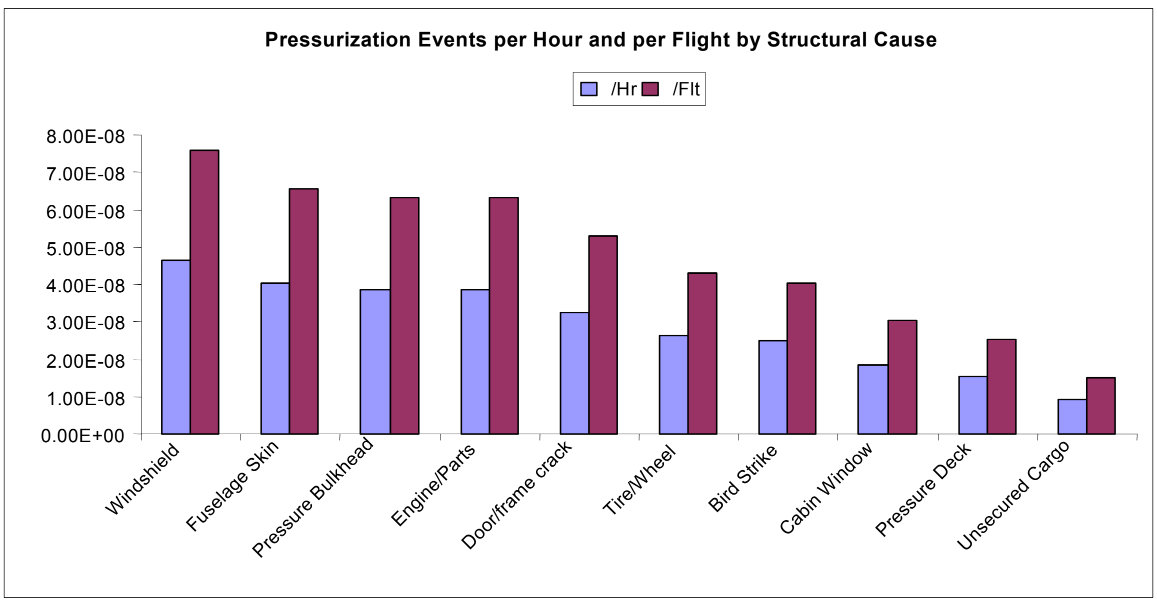


Figure 7-2: Pressurization Events by Structural Cause

Notes: Total of 2866 pressurization events reported since 1959. Transport Category Airplanes over 60,000 lbs.

Event Altitude and Cabin Altitude were reported for 873 events.

Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Figure 7-2 portrays pressurization events per hour and per flight due to structural cause. Note that the probability in all cases is on the order of 10^{-8}.

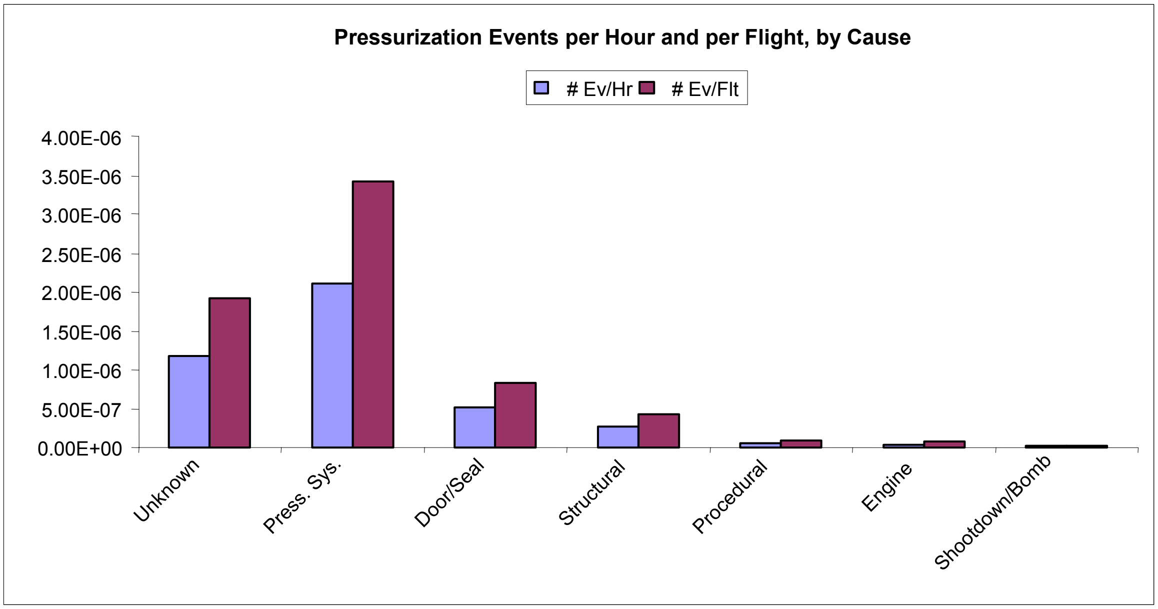


Figure 7-3: Pressurization Events by Cause

Notes: Total of 2866 pressurization events reported since 1959. Transport Category Airplanes over 60,000 lbs.
Event Altitude and Cabin Altitude were reported for 873 events.
Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Figure 7-3 depicts pressurization events by cause. Note that those caused by engine uncontained failures contribute very little to the total.

- Pressurization system faults predominate in the identified causes of decompression events
  - During initial climb up to and including maximum pressure differential (as pressure differential increases),
  - In cruise (flight phase with longest time duration),
  - At/after top of descent (pressurization system mode changes, idle engine operation)
- Maintenance and operational procedure errors are important contributors to events (doors/seals, crew management of ECS)
- Decompressions due to engine rotor bursts are rare, albeit highly unpredictable events

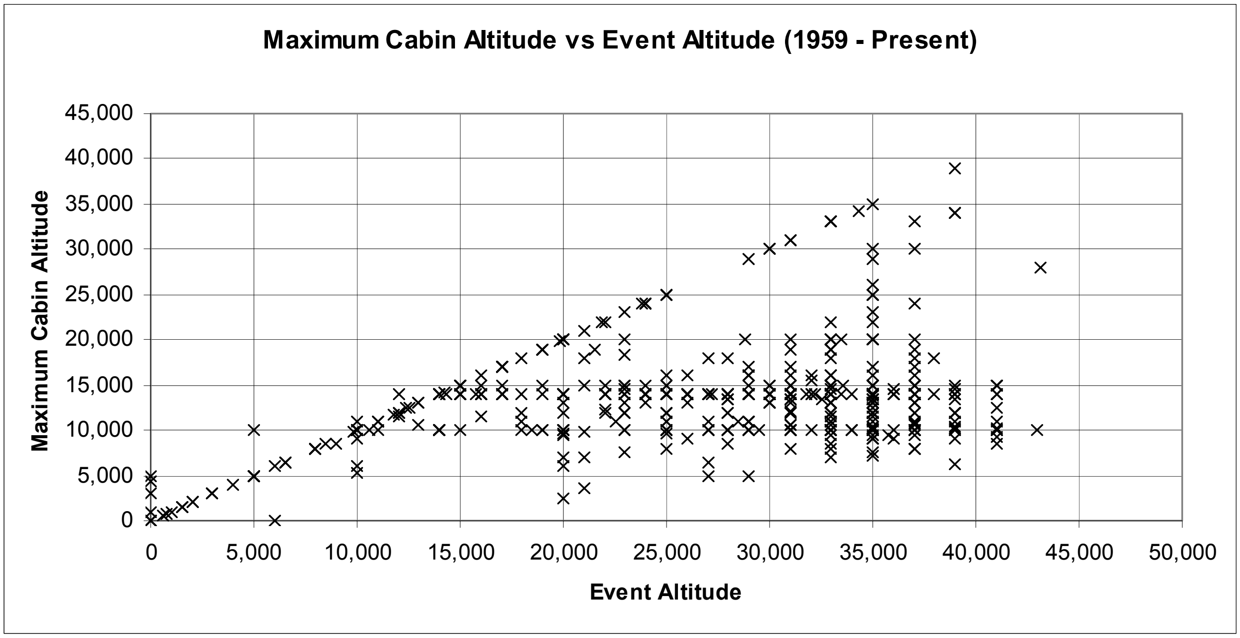
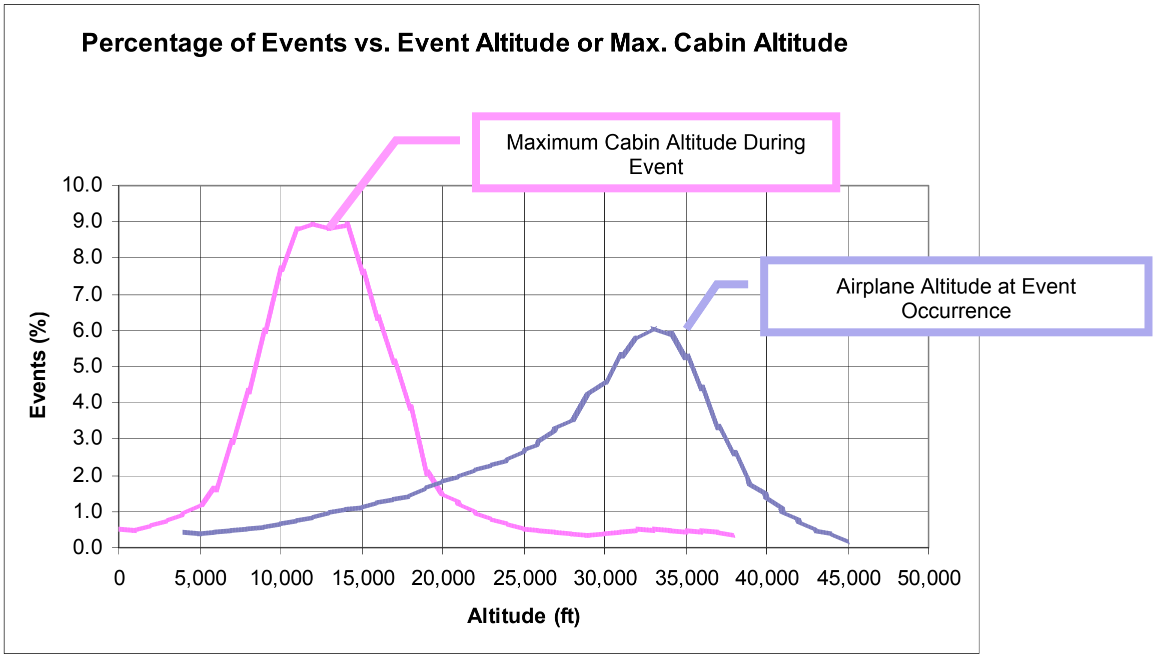


Figure 7-4: Pressurization Events from 1959 to 2001

Notes: Total of 2866 pressurization events reported from 1959 to 2001. Transport Category Airplanes over 60,000 lbs.
All points in which the cabin altitude is shown as zero, the airplane altitude is unknown.
Event Altitude and Cabin Altitude were reported for 873 events.
Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

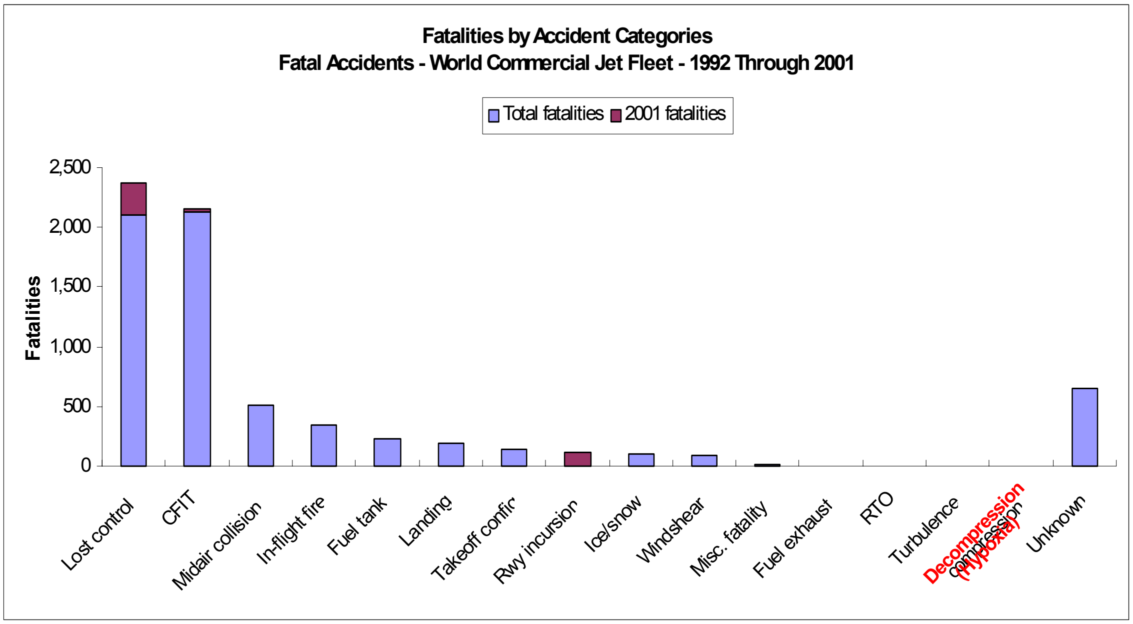
Figure 7-4 presents decompression events that have occurred from 1959 to 2001 in transport category airplanes. It depicts the maximum cabin altitude reached during a decompression event vs. the airplane flight altitude. Note that no decompression event has resulted in a maximum cabin altitude above 40,000 ft, although it should be noted that the vast majority of flight hours in transport category aircraft since 1959 have been at altitudes below 40,000 feet.



Notes: Total of 2866 pressurization events reported from 1959 to 2001.
Airplane altitude is the primary parameter, since it defines the pressure differential, time duration of exposure to potentially unsafe cabin pressure altitudes, and emergency descent performance. Cabin altitude is a secondary parameter, since it is the resultant of airplane design, maintenance practices and operational procedures Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Figure 7-5: Pressurization Events: Percentage of Events vs. Altitude

This figure depicts the distribution of cabin altitude and airplane altitude during decompression events. Note that the average cabin altitude reached is well below the average airplane altitude. Note also that cabin altitude has rarely ever exceeded 25,000 ft.



Sources: Boeing Airplane Safety Engineering (ASE) and Safety Information System (SIS), National Transportation Safety Board (NTSB)

Figure 7-6: Fatal Accidents by Category

This figure shows fatal accidents by category for the world commercial jet fleet for the period of 1992 to 2001. Note that no hypoxia related fatalities were due to in-flight decompression events. Relative to other causes, decompressions resulting in hypoxic fatalities are not a significant accident contributor. Of 7,171 fatalities for the period of 1992 – 2001, no hypoxia related fatalities were due to in-flight decompression events.

Due to the uncertainty in the potential severity of the cabin environment following decompression and the uncertainty in the response of the occupants to that environment, the MSHWG recommends that regulatory authorities impose both quantitative and qualitative means to demonstrate compliance. This is not unlike the requirements that exist in 14 CFR Part 25.671 or 25.1309.

Other design solutions such as improved passenger masks, improved engine fragment shielding, emergency ram air pressurization system, or advanced engine blade failure warning devices may exist in the future that will afford additional mitigation strategies to be utilized. The measure of severity of the environment may include the use of an uncontained engine failure debris model validated by existing data, that provides a realistic pressure vessel cumulative hole area and damage to the associated aircraft systems. Consideration must be given to loss of those systems that directly impact cabin pressurization and airplane descent.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintains the same level of safety? Explain. [Explain how each element of the proposed change to the standards affects the level of safety relative to the current FAR. It is possible that some portions of the proposal may reduce the level of safety even though the proposal as a whole may increase the level of safety.]

Amendment 25-87 was developed using one researcher's work (Reference 9) that focused on a concept called, "Time of Safe Unconsciousness"(TSU) as applied to passengers. Data described within this report is in relationship to the "Time of Useful Consciousness" (TUC) that is applicable to pilots or "time of consciousness". The author selects 25,000 feet pressure altitude as a reference state because most subjects can tolerate several minutes of hypoxia up to this altitude. The author concludes, "a relatively safe time may be considered as 1 minute and 40 seconds to 2 minutes" (above 25,000 feet). Dr Gaume's paper did not refer to, nor reference the experimental data utilized by this ARAC working group to formulate the DEI methodology.

In addition, the FAA in promulgating this regulation did not refer to, nor reference the experimental data utilized by this ARAC working group to formulate the DEI methodology.

The overall level of safety for systems failure conditions may be increased. As this rule allows the use of probability for systems failure analysis, the manufacturer may be motivated to meet higher reliability levels.

The effects of this rule is that future large transport airplanes may cruise at higher altitudes and for longer periods of time than airplanes compliant to FAR 25.841(a)(2) & (3). If the rate of occurrence of decompression events remains constant, than this carries with it an increase in the future probability of exposing crewmembers and passengers to a high altitude atmosphere following a rapid decompression. This implies a potential reduction in the safety level relative to the current regulation.

The proposed standard has limited data to support it, but it may be validated through further testing and rigorous, critical peer review. In addition, while it is not possible at this time to use a probability argument as a sole means of compliance to the regulation, cabin decompressions resulting from UEF are a rare event. Over the last nearly 30 years of commercial air travel the relative probability of an uncontained engine failure was 6.2×10^{-7} per engine hour (Reference 10). Furthermore, there are indications of a reduction in this probability with newer turbofan engines that could result in even lower overall probability of such an occurrence [See Figures 8-1 and 8-2]. Therefore, it is believed that the new standard affords reasonable protection given the rarity of the threat.

Relative to the current standard, the new standard allows exposure of all occupants to higher cabin altitude with a potential increased level of risk and a decrease in safety for the uncontained engine failure decompression scenarios. However, the new standard maintains the same level of safety with respect to system and structural failures. For the UEF scenarios, a new means of compliance is permitted by theoretical means to be validated via additional experimental data in conjunction with the probability of a hole large enough to cause the rapid decompression.

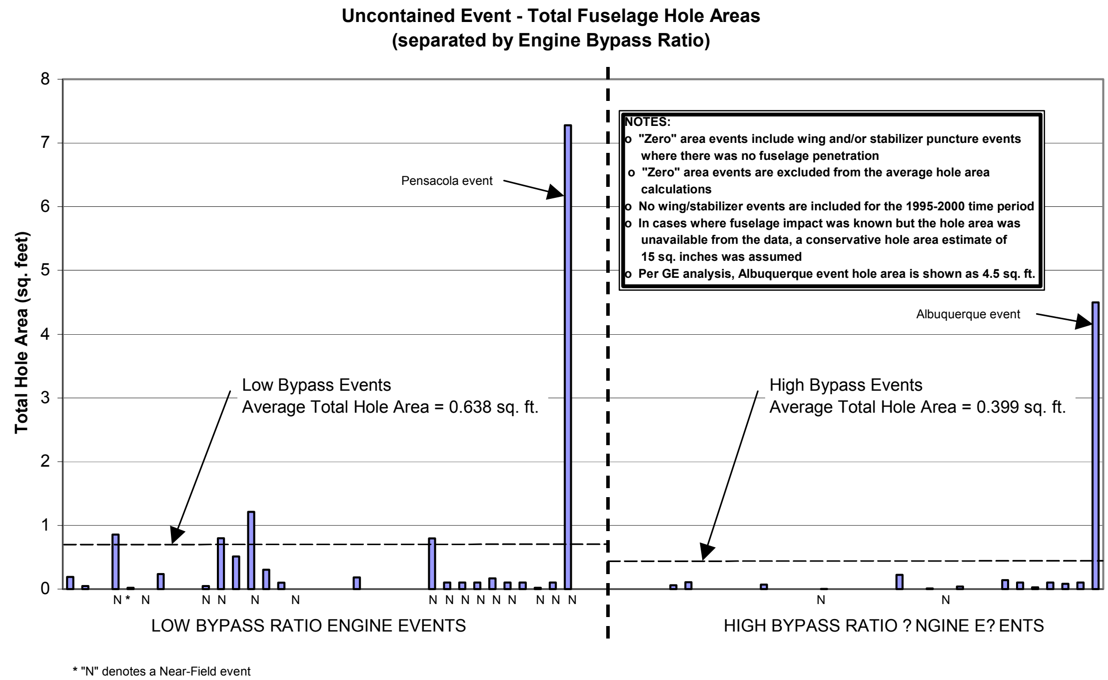


Figure 8-1: Historical Uncontained Engine Failure Total Fuselage Hole Areas Shown with Pensacola and Albuquerque Events Included.

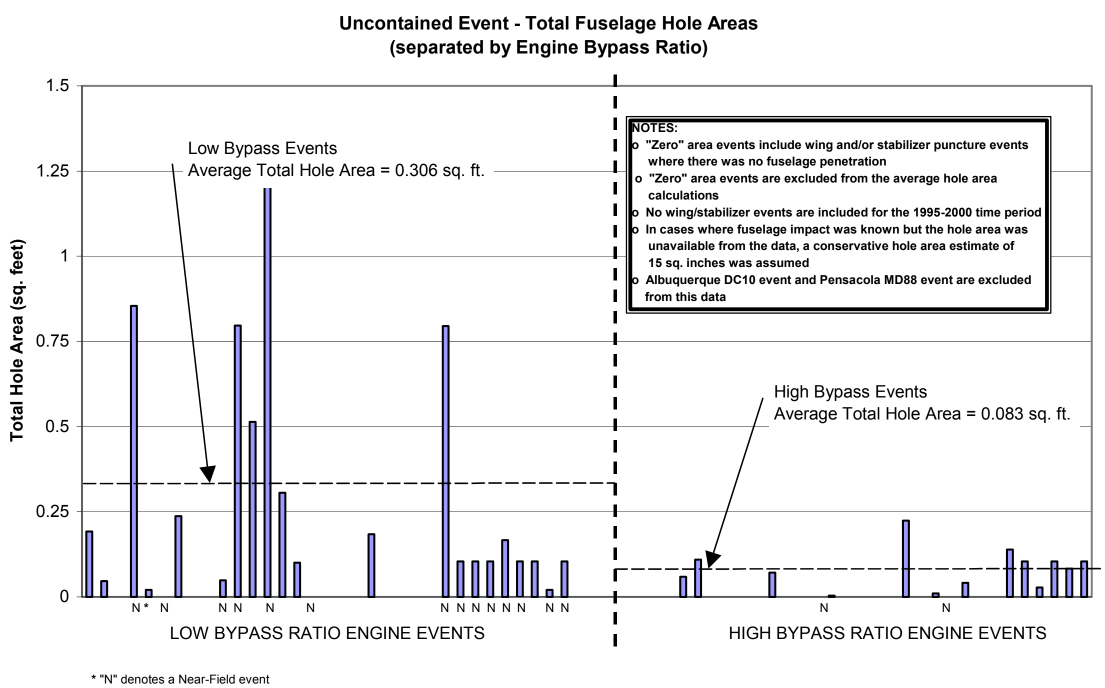


Figure 8-2: Historical Uncontained Engine Failure Total Fuselage Hole Areas Shown with Pensacola and Albuquerque Events Excluded

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintains the same level of safety? Explain. [Since industry practice may be different than what is required by the FAR (e.g., general industry practice may be more restrictive), explain how each element of the proposed change to the standards affects the level of safety relative to current industry practice. Explain whether current industry practice is in compliance with the proposed standard.]

Transport category airplanes certified previous to introduction of Amendment 25-87 in 1996 have been certified up to altitudes of 45,000 feet. Current design practices for large commercial transports have evolved such that placement of the engines is accomplished via attachment to pylons located underneath the wings. While permitting benefits to stability and airplane performance, this feature exposes a large area to potential penetration of the pressurized vessel in the event of an UEF. Smaller commercial airplanes have typically attached the engines to the fuselage. The aft-pressurized bulkhead has been placed immediately forward of the rotor burst zone (a hypothetical cone, approximately 3 degrees from the rotational plane of the engine). Traditionally this has limited pressurized fuselage penetrations to no more than a few small fragments on the smaller commercial airplanes.

Current airplanes with wing-mounted engines would not meet the requirements of 25.841(a) as modified by Amendment 25-87 at present certified altitudes. Nevertheless, current industry practice maintains an excellent level of safety with respect to rapid decompression at high altitudes. As for the world commercial jet fleet for the period of 1992 to 2001, no hypoxia related fatalities were due to in-flight decompression events (see Figure 7-6). This safety record has been maintained despite the fact that newer airplanes fly at these higher altitudes more often than older airplanes (see Figure 9-1).

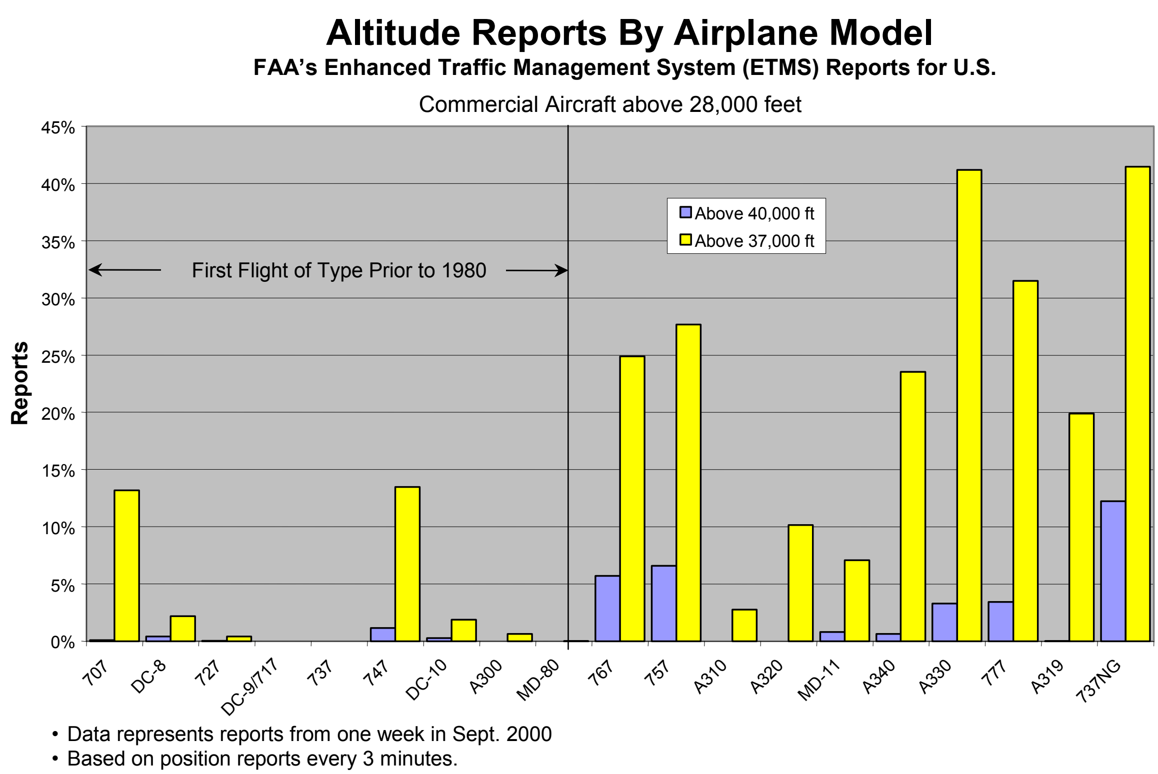


Figure 9-1: Frequency of Flights above 37,000 ft. and 40,000 ft. Altitude of New Design Aircraft vs. Older Design Aircraft.

These newer airplanes incorporated high bypass ratio engines that are designed to reduce the probability of engine rotor burst (see Figures 8-1 and 8-2). In addition, newer airplanes incorporate additional safety features such as quick donning oxygen masks, system separation within the fuselage, and "fail safe" window designs.

The new standard and its means of compliance do not represent the same level of conservatism as present in the existing regulation. However, the proposed standard has corroborating data, albeit limited, to support it and will be validated by further testing. In addition, while not permitted as a sole means of compliance to the regulation, cabin decompressions resulting from UEF are a rare event. Therefore it is believed that the new standard affords reasonable protection given the rarity of the threat. It is believed that newer transport category airplanes in service today could meet the new proposed standards.

The effect of this rule is that future large transport airplanes may cruise at higher altitudes and for longer periods of time than current industry practice. If the rate of decompression events remains constant, then this carries with it an increase in the probability of exposing crewmembers and passengers to a high altitude atmosphere following a rapid decompression. This implies a potential reduction in the safety level relative to current industry practice.

10 - What other options have been considered and why were they not selected?: [Explain what other options were considered, and why they were not selected (e.g., cost/benefit, unacceptable decrease in the level of safety, lack of consensus, etc.]

Use of Video and Sensor Technology:

It was thought that the use of video camera technology could provide the flight deck crew with information regarding the extent of the damage to the airplane to enable them to ascertain if the airplane were capable of a Vmo/Mmo descent and to ascertain the severity of the exposure to the cabin crew and passengers. The consensus was that this technology did not afford sufficient benefits and that while video and sensor technology concepts exist, they are in developmental stages and the technology is not yet mature. Use of data is not established, and training issues further restrict feasibility of damage assessment for maximizing descent rate. In addition, it was determined that, in fact, use of Vmo/Mmo descent is feasible following a survivable decompression event. Finally, concern was also expressed as to whether the flight deck crew could utilize video technology during a rapid decompression event, given the likelihood of condensation fog in the flight deck.

17 Second reaction time:

Another topic that was discussed was the basis of, and possibility of changing, the 17 second reaction time noted in the Advisory Circular. This reaction time includes donning of oxygen mask, isolation of failure and airplane reconfiguration and initiation of emergency descent. Issues that were discussed included the testing of pilot reaction time in donning an oxygen mask and performance of tasks following a simulated decompression (chamber test). The sub-team examined the material and concluded that there was insufficient data to reach a conclusion to shorten this reaction time. The 17 second reaction time is based on mean values from crew responses in simulators from a 1956 study by Dr. E.G. Vail (Reference 11) and further reviewed by Bennett in 1964 (Reference 12).

Emergency Descent Limitation:

Another topic that was discussed was limiting or restricting the descent and concern over the use of this procedure because of possible loss of structural integrity following the UEF. Issues that were considered included dynamic loads during a Vmo/Mmo emergency descent and structural integrity and were conducted with manufacturer's structures and loads engineers. Structural loads following decompression are assessed similar to other "Discrete Damage" (pressurized or unpressurized) type conditions in which the airplane damage is assessed per FAR 25.571(e), i.e. structural damage including non-catastrophic rotor failure. Structural load capabilities of the airplane following a survivable discrete damage event are considered under unpressurized conditions and are associated with reduced inertia load factors (See AC 25.571-1C). However, this does not limit the maximum design descent (Mmo/Vmo) and therefore is not a determining factor in the airplane descent following decompression. The MSHWG examined the material and concluded that if the airplane structure survived the initial UEF event, then per the present regulations there should be sufficient structural integrity of the airplane to enable it to perform a Vmo/Mmo emergency descent.

Use of Probabilities for structural failures:

The application of probability of structural failure is contrary to the basic structural design approach, and therefore probability of structural failure should not be considered in establishing compliance to the subject rule. The regulations governing structures are intended to render structural failures extremely improbable by virtue of choice of design loads, margins of safety, testing, and required maintenance programs, even though a numerical value for extremely improbable is not always computed.

Tire, Wheel and Rim failures**:**

Based on tire, wheel and rim failure data provided by the representative airplane manufacturers, it was determined by the MSHWG that tire failures must be considered, but not wheel and rim failures.

Aerodynamic Suction

The subject of aerodynamic "suction" has been raised in the MSHWG. This is the effect caused by air moving tangentially to an open hole and causing pressure variations in the cavity on the other side of the hole. Its effect on holes produced in the fuselage of an aircraft was analyzed with the help of computational fluid dynamics-knowledgeable engineers.

TYPES of HOLES PRODUCED during DECOMPRESSION

Figure 10-1 shows the type of hole (hereafter referred to as « Type 1 hole ») produced, usually, by some form of structural failure due to the differential pressure between A/P cabin and the outside ambient pressures, and also shows the relative pressure area(s) relative to the geometry of the hole. This is NOT the type of hole that would be produced by penetration by external debris unless the debris was passing out through the far side of the aircraft.

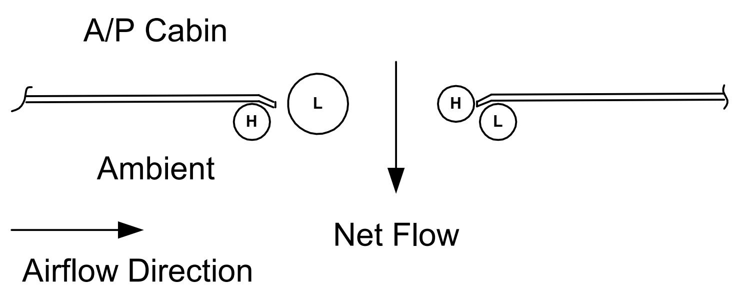


Figure 10-1: Pressure Zones Around a Type 1 Hole

Figure 10-2 shows the type of hole (hereafter referred to as « Type 2 hole ») produced by engine debris penetrating the fuselage structure, and also shows the relative pressure area(s) relative to the geometry of the hole. The figure clearly shows that there is an area of higher pressure towards the aft end of the hole that would result in net air inflow into the cabin at low differential pressures. Any reduction in the net inflow would be as a result of the pressure profile on the outside of the aircraft represented by the coefficient of pressure Cp.

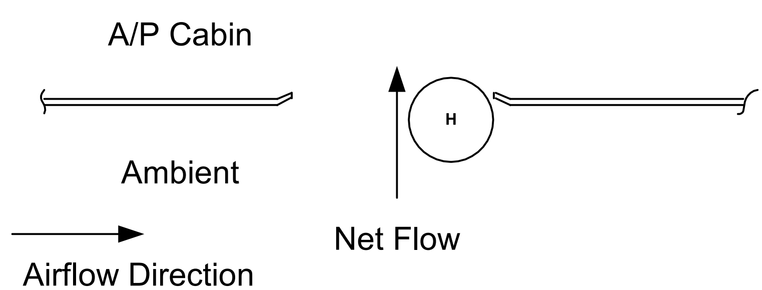


Figure 10-2: Pressure Zones Around a Type 2 Hole

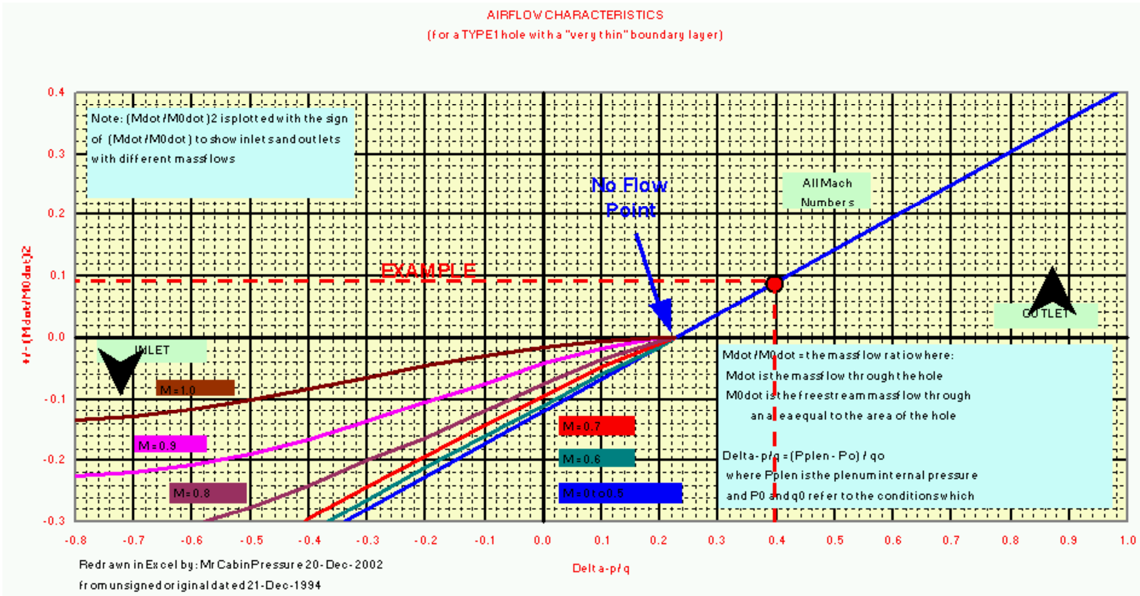


Figure 10-3: Airflow Through a Type 1 Hole

Figure 10-3 describes the pressure and flow relationship for an opening in the fuselage that is parallel to the air stream. The vertical axis is a square of the flow ratio between the predicted flow and the flow that would be obtained if air at free stream conditions were passed through the same area. It is important to note a sign change is carried through to represent flow in or flow out. The horizontal axis is the predicted static pressure across the hole (assuming the hole is connected to a plenum) divided by the free stream (incompressible) velocity pressure, q. The No Flow Point, where $\Delta P/q=0.23$ shows that a certain amount of internal plenum pressure is required to overcome the ram effect of the free stream.

Using Figure 10-3, the following can be considered to be the equilibrium condition:

When a hole has been created, then as time tends to infinity the net mass flow ratio (M/M0)^2 tends to zero. The final equation becomes:

Cpf on fuselage = 0.23 + Cp original

Thus, provided the original Cp on the fuselage before the hole appeared was > -0.23 there will be a net INFLOW into the aircraft cabin. Any inward curvature of the hole will increase the outside Cp on the fuselage.

To convert Cpf into local static pressure, use this formula:

Ps = Pinf [1 + (0.7 * Minf^2 * Cpf)]

Ps = local external static pressure (psia)
Pinf = free stream static pressure (airplane pressure-altitude) (psia)
Minf = free stream Mach number (non-dimensional)
Cpf = net pressure coefficient as described above (non-dimensional)

Conclusion

There is the possibility that some part of the structure of the aircraft could fail due to internal causes (unknown) other than an externally failed engine. The resultant hole would be outwardly bent of the type shown in Figure 10-1. However, due to structural rip-stop fail-safe design, the resultant hole size will usually be small enough that the aircraft will already be well into its emergency descent before the aircraft and cabin altitudes become equalized. Thus, any "suction" effect caused by the hole will not cause the maximum cabin altitude to exceed the cruise altitude of the aircraft prior to its descent. By the time the aircraft levels off at the lowest available en-route altitude, the aircraft will have reduced speed from, say, Mach 0.85 to Mach 0.5, which reduces the effect to negligible levels.

When an engine rotor or fan bursts, the resultant profile of the debris will produce a hole in the fuselage that penetrates from outside to inside the aircraft. This will produce an inwardly bent structure, which is the hole shape shown in Figure 10-2. Obviously, if the debris is large enough and of enough energy, it could exit the fuselage on the opposite side and create a hole of the type shown in Figure 10-1. In this case, it is assumed that the opposing effects of the two holes would cancel out each other and remain neutral. However, there will be more than one piece of debris penetrating the fuselage, most of which will not exit the opposite side of the fuselage. Thus, there will always be a net effect on the flow characteristics out of the aircraft associated with Type 2 holes, which have the "high pressure" characteristic, effectively ensuring that the actual cabin altitude is lower than the aircraft altitude, provided the initial Cp on the area of the fuselage was > -0.23.

For all the DEI analyses, the effect of this is not considered - i.e. the cabin and aircraft altitudes are considered equal in cruise if the hole is large enough to cause the cabin altitude to reach the aircraft altitude prior to initiation of the emergency descent. The only time that the cabin altitude is considered higher than the aircraft altitude is if the aircraft is already in its emergency descent and the aircraft "flies-through-the-cabin". This effect is accounted for in the analysis program.

11 - Who would be affected by the proposed change? [Identify the parties that would be materially affected by the rule change – airplane manufacturers, airplane operators, etc.]

Airplane manufactures and suppliers will benefit from the single well-defined harmonized ruling thereby reducing certification costs. They will also benefit due to allowing the creation of new generation, more efficient airplanes that will give continuity to their business. Their employees will benefit by sustained employment in the airplane manufacturing industry. The public will benefit due to the availability in the future of newer, more efficient airplanes with the possibility of less expensive fares (higher altitudes means less fuel consumption). Newer airplanes should also be more reliable reducing the inconvenience of delays and flight cancellations to the public. Finally, there is a benefit to the public in that newer, more efficient airplanes flying at higher altitudes will burn less fuel with corresponding less emissions of harmful gases and particulates, and the airspace will be more effectively utilized.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble? [Does the existing advisory material include substantive requirements that should be contained in the regulation? This may occur because the regulation itself is vague, or if the advisory material is interpreted as providing the only acceptable means of compliance.]

The relevant advisory material is AC 25-20, which with the exception of structural failure related information, does not contain any additional information that needs to be included in the rule text or preamble. Issues significant in showing compliance to the proposed rule are identified in the response provided for Question 6, above.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted? [Indicate whether the existing advisory material (if any) is adequate. If the current advisory material is not adequate, indicate whether the existing material should be revised, or new material provided. Also, either insert the text of the proposed advisory material here, or summarize the information it will contain, and indicate what form it will be in (e.g., Advisory Circular, policy, Order, etc.)]

While the task of this working group was limited to the working group report, the working group recommends that the FAA consider the following material in promulgating a new Advisory Circular to replace the designated portions of the existing AC 25-20 - PRESSURIZATION, VENTILATION AND OXYGEN SYSTEMS ASSESSMENT FOR SUBSONIC FLIGHT INCLUDING HIGH ALTITUDE OPERATION.

AC 25-20 contains guidance material for pressurized compartment loads (§ 25.365(d)), ventilation (§ 25.831), pressurized cabins (§ 25.841) and equipment standards for oxygen dispensing units (§ 25.1447) that were introduced at Amendment 25-87. However, only those portions of AC 25-20 that provide guidance to 25.841(a)(2) and (3) are addressed in this report.

The working group recommends that the regulatory authorities consider the following material in promulgating new harmonized regulation on 14 CFR Part 25.841 and draft Advisory Material. Portions of existing Advisory Circular AC 25-20 should be retained. Some sections should be modified slightly while others require major rewrite. The group recommends that:

Portions of AC 25-20 that need to be retained in total are:
Section 1 Purpose, Section 2 Associated FARs,

Portions of AC 25-20 that need minor modification are:
Section 3 Background should be modified to add the information on the new standard and information gained with respect to Amendment 25-87 regulation.
Section 10 Emergency Descent should be modified to reflect the group consensus on the use of a Vmo/Mmo descent.
Section 12 Glossary needs to reflect the new standard and definitions of terms.

Portions of AC 25-20 that will need a complete rewrite:
Section 4 Physiological Limiting Criteria needs to reflect the current consensus on the new standard.
Section 6 Pressurization needs to reflect the new standard.
Section 7 Failure Conditions needs to reflect the current consensus on the new standard.
Section 8 Fuselage Structure
Section 9 Engine needs to reflect the current consensus on the new standard and the use of an uncontained engine failure debris analysis based on historical data.

Section 3 Background section should be modified to add the information on the new standard and information gained with respect to Amendment 25-87 regulation.

3. BACKGROUND. Part 25 was amended to include standards for high altitude operation of subsonic transport category airplanes. The adopted standards differ somewhat from those previously contained in special conditions and from previously established part 25 systems and structural integrity requirements. The standards were written to address physiological limitations at high altitudes and changes in equipment technology. The standards adopted as Amendment 25-XXX pertain to operation of subsonic airplanes to a

maximum altitude of 51,000 feet, although many of the requirements addressed therein relate to operations at lower altitudes (below 41,000 feet) as well.

Section 4 Physiological Limiting Criteria needs to reflect the current consensus on the new standard.

The objective of the high altitude standards is to prevent exposing the airplane occupants to environmental conditions that would:

a. Prevent the flight deck crew from safely flying and safely landing the airplane, or
b. Prevent the cabin crew from safely performing their duties, or
c. Result in permanent physiological harm to any occupants for structural and system failure conditions, or
d. Result in permanent physiological harm to more than a small number of passengers as the result of an uncontained engine failure, per the harmonized FAR/JAR 25.1309.

The means of compliance to evaluate crew inflight post-decompression performance shall include:

4.1 Crew Inflight Post-Decompression Performance

Flight Deck Crew Performance

a. The applicant shall evaluate the effects exposures to various cabin altitudes will have on flight deck crew cognitive function if not wearing mask, except if at least one crewmember will always be wearing oxygen higher than 41,000 ft. as required by FAA regulation.

b. The flight deck crew criterion is based on an individual performing useful flying duties in an environment of inadequate oxygen pressure (Reference 13). The applicant shall evaluate increased workload of the flight deck crew following a rapid decompression.

4.2 Cabin Crew Performance

a. The cabin crew criterion is based on assuming the cabin crew is not at rest. Some useful information is contained in Reference 14.
b. Flight attendants are to put on mask, sit or hold on, and await flight deck crew instructions before attempting to help passenger. It is assumed for the purposes of showing compliance to design rule that flight attendants are able to don masks and achieve a minimal level of protection within some reasonable number of seconds following mask drop. Following flight deck crew instructions, flight attendants will move about the cabin performing emergency procedures, as necessary. The applicant shall evaluate increased workload of the cabin crew following a rapid decompression.

4.3 Maximum Operating Altitudes, Cabin and Airplane

Compliance shall be shown for subsonic airplanes at flight altitudes at and below 51,000-feet pressure altitude, and nominal design cabin altitude, per regulations shall be considered up to a maximum of 8,000 feet pressure altitude.

4.4 Passenger Criteria

a. There is the potential that not all passengers will obtain sufficient protection from the cabin supplemental oxygen system. Therefore, it must be assumed that not all passengers are able to effectively don masks.

b. Throughout emergency descent, landing and aircraft egress following a rapid decompression event, all passengers are at some level of risk for permanent physiological harm. Due to numerous factors, including age, pre-existing medical condition, etc., some passengers will face greater levels of risk than others. The current FAR/JAR 25.1309 categorizes this failure condition as hazardous and acknowledges the potential for incurring injuries and/or fatalities to the airplane occupants following this failure event as follows:

Harmonized 25.1309 (Reference 2) (Proposed by SDAHWG)

Serious or fatal injury to a relatively small number of the occupants other than the flight crew.

With the type of failure condition defined above, there exists uncertainty with respect to the level of risk to each passenger's survival associated with exposure to the cabin environment following decompression. To satisfy the harmonized FAR/JAR 25.1309 it is necessary to assess the degree of risk in order to minimize the potential for permanent physiological harm to the airplane's occupants. An analysis that defines the envelope of vulnerability of passengers for permanent physiological harm in a decompression and identifies the continuously available design features of the airplane (i.e., aircraft systems) and the operational features (e.g., crew training, AFM limitations, etc.) to enhance the survivability of those passengers at increased levels of risk, would be an acceptable approach towards determining compliance with the harmonized FAR/JAR 25.1309. Note that the measure of adequacy is the presence of aircraft features (e.g., design and operational) that are commensurate with the level of risk associated with the cruise flight altitude.

Healthy passengers will self resuscitate, i.e., regain consciousness without any direct action of the crew and/or other occupants. Passengers must recover sufficient cognitive function to exit the aircraft following emergency descent, safe flight and landing. Some assistance may be required for passengers with pre-existing impairments.

Section 6 Acceptable Means of Compliance:

a. Sections 25.841 (a)(2)(ii) and (iii) are intended to ensure that system failure conditions not shown to be extremely improbable and certain structural failures shall not result in fatalities or permanent physiological harm. Therefore, the airplane must be designed so that occupants will not be exposed to a cabin pressure altitude that exceeds the following after decompression:
(i) Twenty-five thousand (25,000) feet for more than 2 minutes; or
(ii) Forty thousand (40,000) feet for any duration.

The MSHWG recommends consideration of the following certain structural failures specified in AC 25-20, with the following revisions:

1. Any single failure in the pressurization system combined with the occurrence of a leak produced by the complete loss of a door seal element, or a fuselage leak through an opening having an area 2.0 times the area which produces the maximum permissible fuselage leak rate approved for normal operation.

2. Pressure vessel openings resulting from tire burst, loss of antennas, or stall warning vanes while operating under maximum cabin pressure differential must be considered.
3. The loss of a "typical skin panel" bound by a crack stopper pattern need not be considered. Structural cracks will be addressed as follows:
4. The maximum pressure vessel opening resulting from an initially detectable crack propagating for a period encompassing four normal inspection intervals will be assumed. Mid-panel cracks and cracks through skin-stringer and skin-frame combinations must be evaluated.
5. The wheel rim release need not be considered.

The MSHWG recommends consideration of the uncontained engine failures specified in AC 25-20, with the following revision:

> In the event of an uncontained engine failure, only loss of system capability associated with the failed engine, but not associated with the debris, must be considered.

A means of compliance to the requirements of 25.841(a) may be demonstrated through the use of the Depressurization Exposure Integral (DEI) method, described herein, which provides the quantitative means to ensure that an airplane design meets the intent of the regulation with respect to protecting human physiology following a rapid decompression. The criterion relies upon the use of the DEI method. The foundation of the DEI method is that while human physiological response to a rarefied environment is a dynamic multi-variable problem, the two parameters of dominance are the pressure that the subject is exposed to and the duration of that exposure. Qualitative means could be utilized to assess risk to occupants but the uncertainty of the level of risk necessitates that specific features be incorporated into airplane designs to enhance survivability and lower the risk to the occupants.

The theoretical basis of this approach rests with the results of animal decompression studies (References 4 and 5). Figure 13-1 shows the chamber pressure (in mmHg) time history for both of these experiments [pressure altitude in feet versus time in minutes]. This data provides critical information needed to establish a measure of severity to the occupants of an airplane in the event of a sudden loss of pressure. The first step is obtaining a relationship called the Depressurization Severity Indicator (DSI). This relationship provides a measure of the severity of the depressurization to atmospheric total pressure and was determined from published data (Reference 15) and calculation, see Figure 13-2.

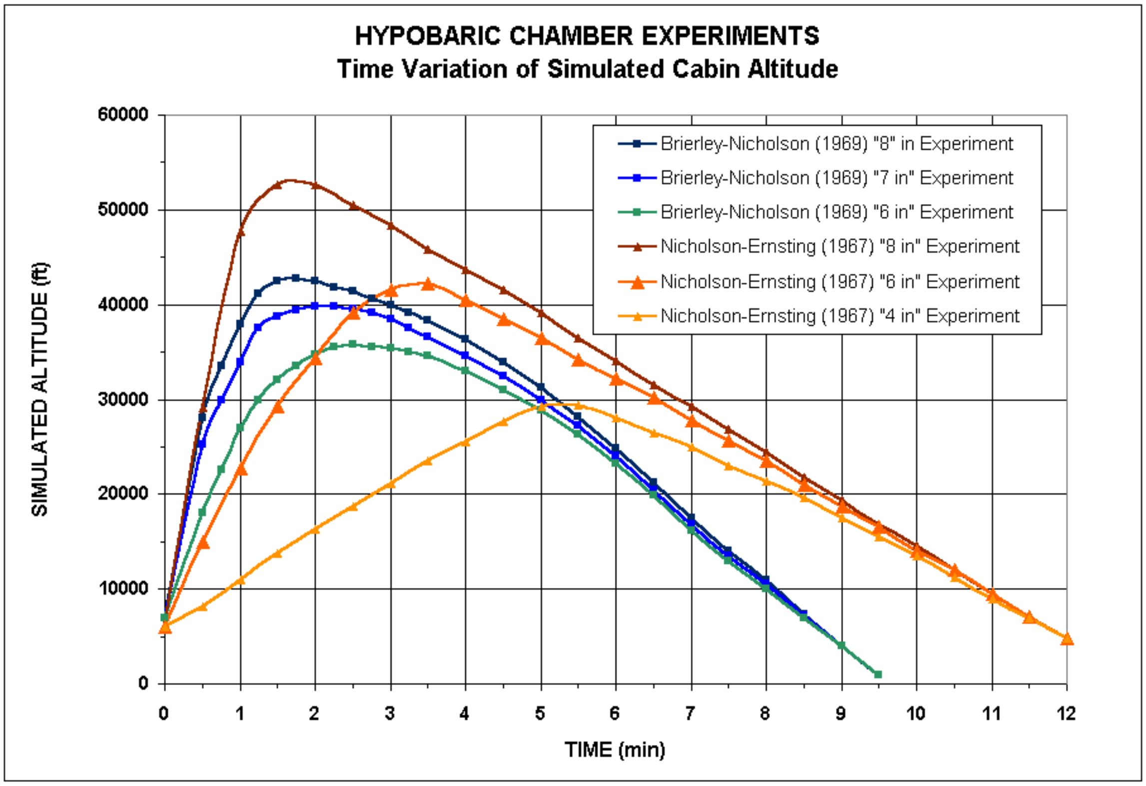


Figure 13-1: Simulated Cabin Altitude versus Time

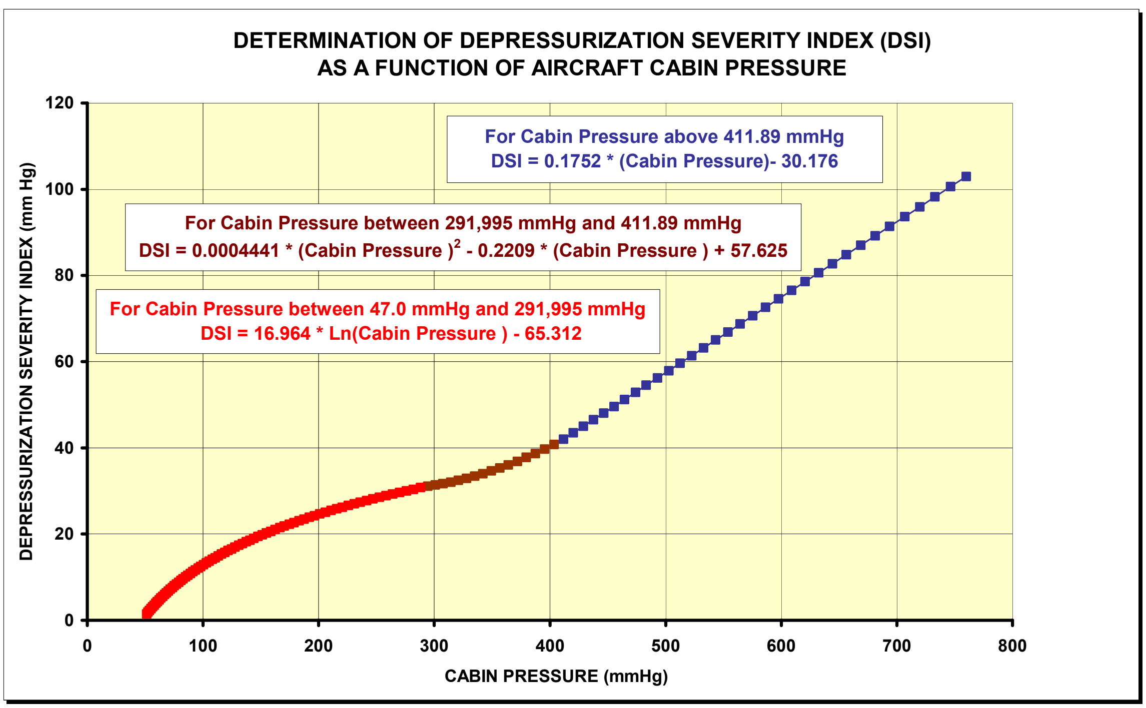


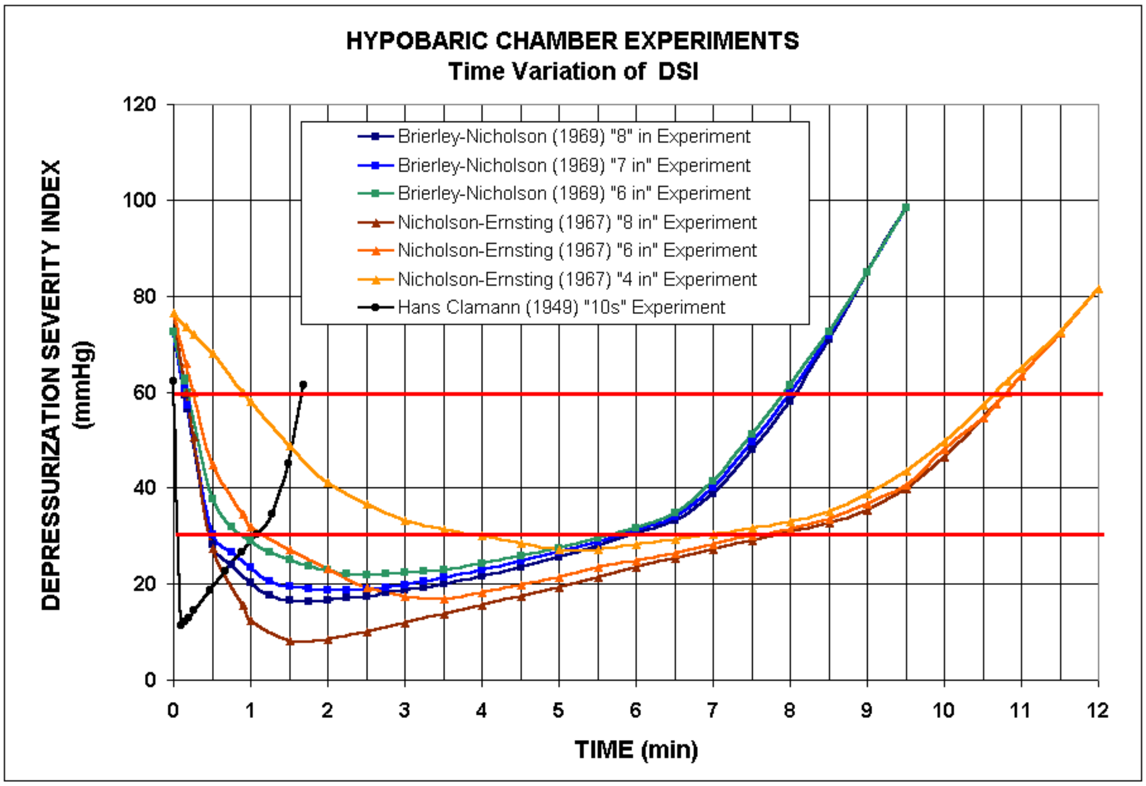
Figure 13-2: Depressurization Severity Indicator (DSI) as a Function of Aircraft Cabin Pressure

Figure 13-2 serves as a mathematical transfer function that converts input from Figure 13-1 [Simulated Cabin Altitude versus Time] into Figure 13-3 [DSI versus time]. The equations that describe the values of DSI as a function of cabin pressure are as follows:

For P_{cabin} greater than or equal to 411.89 mmHg then DSI = (0.1752 * P_{cabin}) - 30.176 [mmHg], based on Table 5-12, pg. 91, Reference 15.
For P_{cabin} greater than or equal to 291.995 AND P_{cabin} less than 411.89 mmHg then DSI = (0.0004441 * P_{cabin} ^2) - (0.2209 * P_{cabin}) + 57.625 [mmHg], based on Table 5-12, pg. 91, Reference 15.
For P_{cabin} greater than or equal to 47 AND P_{cabin} less than 291.995 mmHg then DSI = (16.964 * LN(P_{cabin})) - 65.312 [mmHg], logarithmic extrapolation to zero at 47 mm Hg (62,810 feet altitude), from Table 5-12, pg. 91, Reference 15.
For P_{cabin} less than 47 mmHg then DSI = 0 [mmHg].

In addition, Figure 13-3 includes data from the experiment by Dr. Hans Clamann, (Reference 16), which provides additional corroboration of this approach. Dr. Clamann utilized a chamber to simulate a rapid decompression from 9,800 feet to 49,200 feet (pressure altitude) and then repressurized the chamber at a rate of 24,600 feet per minute (simulating an airplane rate-of-descent). He did not use supplemental oxygen but breathed air at the chamber pressure. It was reported that he retained consciousness during the entire, albeit short, event.

Figure 13-3: Hypobaric Chamber Experiments, Time Variation of DSI



Using the relationship in Figure 13-2, the calculated DSI time history for the experimental results given in Figure 13-1, are presented in Figure 13-3. Historically FAA has referenced 10,000 feet [approximately equivalent to DSI of 60 mmHg] and 25,000 feet [approximately equivalent to DSI of 30 mmHg] as critical points in the cabin pressure altitude, and these were selected as reference conditions. Integrals of the time history of the DSI, defined as Depressurization Exposure Integral (DEI), below 30 mmHg and 60 mmHg provide a measure of the severity of the depressurization event. For the following discussion, the DEI value below 30 mm Hg is defined as DEI30, and the DEI value below 60 mm Hg is defined as DEI60.

It is observed that a direct correlation of the DEI to increasing likelihood of fatalities or permanent physiological harm being sustained by the subjects exists [Figures 13-4 and 13-5]. For example, the experimental data resulted in values ranging from 2,779 mmHg-seconds to 22,241 mmHg-seconds for the integral below 60-mmHg. In addition, data from the experiment by Dr. Hans Clamann as reported in Reference 16 provides additional corroboration of this approach. Dr. Clamann utilized a chamber to simulate a rapid decompression from 9,800 feet to 49,200 feet (pressure altitude) and then repressurized the chamber at a rate of 24,600 feet per minute (simulating an airplane rate-of-descent). He did not use supplemental oxygen but breathed air at the chamber pressure. It was reported that he retained consciousness during the entire, albeit short, event.

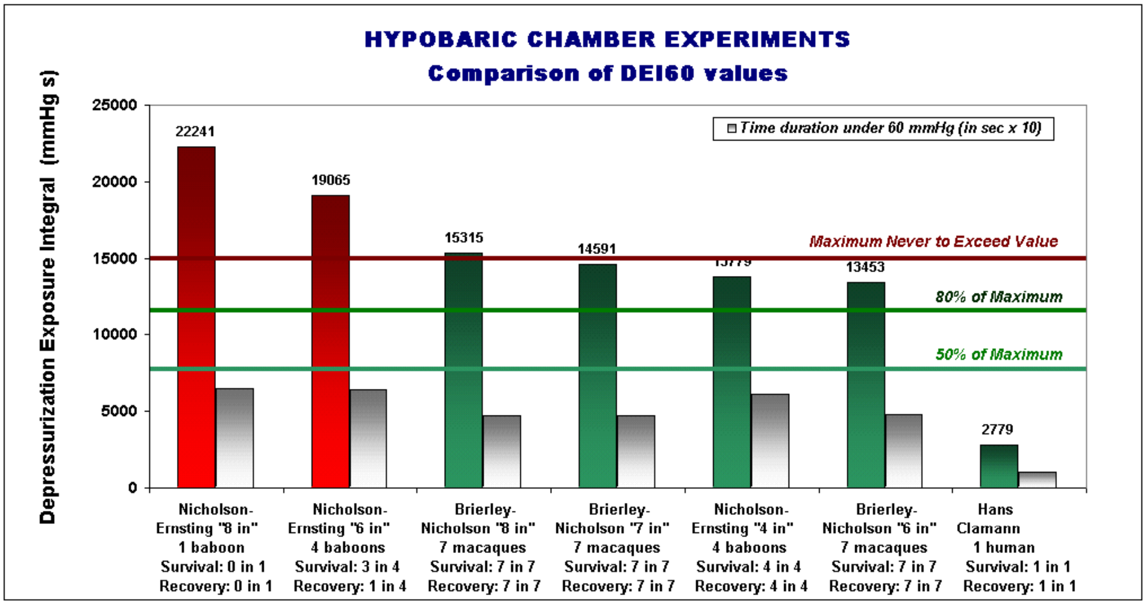


Figure 13-4: Depressurization Exposure Integral Values Referenced to 60 mmHg pressure.

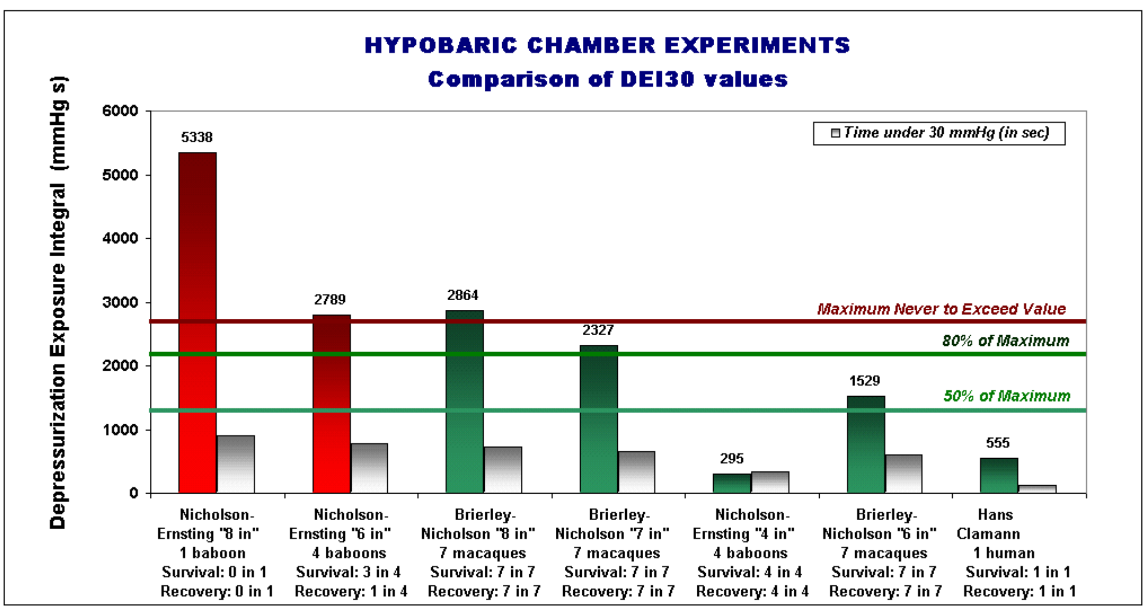


Figure 13-5: Depressurization Exposure Integral values referenced to 30 mmHg pressure.

Due to the observed direct correlation of the DEI to an increasing likelihood of fatalities or permanent physiological harm being sustained by the subjects [Figure 13-4]:

> The "Maximum Never to Exceed Value" of the DEI30 (approximate cabin altitudes > 25,000 ft) is 2,700 mmHg-seconds.
>
> The "Maximum Never to Exceed Value" of the DEI60 (approximate cabin altitudes > 10,000 ft) is 15,000 mmHg-seconds.

Note that the magnitudes of these values are dependent upon the functional relationship used between cabin pressure and DSI as shown in Figure 13-2.

Based upon a review of References 1 through 16 and observations of non-human primate and human studies, and due to the paucity of data and the rarity of an engine induced decompression, means of compliance shall be:

- The maximum allowable value of the DEI values referenced to 30 mmHg pressure for the 30 mmHg reference condition (DEI30) (cabin altitude > 25,000 ft) shall be 2,160 mmHg-sec (this equals 80% of the "Maximum Never to Exceed Value").
- The maximum allowable value of the DEI values referenced to 60 mmHg pressure for the 60 mmHg reference condition (DEI60) (cabin altitude > 10,000 ft) shall be 12,000 mmHg-sec (this equals 80% of the "Maximum Never to Exceed Value").
- The manufacturer must include emergency descent procedures that rely upon swift descent to an altitude of 10,000 feet.
- For no decompression event can the cabin altitude exceed the maximum performance capability of the flight deck crew oxygen system.

The applicant will perform a depressurization analysis based upon the maximum cruise flight conditions. A maximum cumulative hole area will be calculated using airplane and engine historical data, and possibly combined with the use of a geometric analysis describing the impact of engine debris on the pressure vessel, pending PPIHWG recommendation. Analysis and test data shall be provided to successfully demonstrate compliance.

Design solutions, which currently exist or are developed in the future, that reduce the potential for permanent physiological harm (as a result of a depressurization event) or enhance airplane survivability can be incorporated into new airplanes. One design feature that may enhance occupant survivability is an automatic descent system, which, in the event of a rapid loss of cabin pressure (e.g., cabin pressure altitude exceeds 16,000 ft), will command the airplane to commence an emergency descent (Vmo/Mmo) to either 10,000 ft or minimum safe altitude over terrain. Potential design solutions that enhance both airplane and occupant survivability include improved engine fragment shielding or advanced engine blade failure warning devices which may exist in the future. Airplane designs which incorporate such features may significantly impact the testing and analysis necessary to demonstrate compliance.

Section 9 Engines.

The measure of threat from an uncontained engine failure may include the use of an uncontained engine failure debris model validated by existing data or other means as identified by the PPIHWG [FAA to reference PPIHWG recommendation]. A future AC to replace AC 20-128A could provide guidance for addressing the hazards associated with uncontained turbine engine and APU rotor failure. That guidance will focus on the use of a debris model analysis (e.g., Uncontained Engine Debris Damage Assessment Model, which is part of the FAA Catastrophic Airplane Prevention Program) or other means acceptable to the cognizant authority [PPIHWG recommendation pending]. Only airplane survivable events, per FAR/JAR 25.571(e), need be considered for uncontained engine failures discrete source damage.

Section 10 Emergency Descent Following Rapid Decompression.

As mentioned in the preamble to Section 25.841(a)(X)(i), it is recommended that the flight deck crew be trained in initiating emergency descent following rapid decompression. It is recommended that flight deck crew flying aircraft certified to fly above 41,000 feet pressure altitude undergo initial and periodic training in the use of positive pressure breathing masks. In demonstrating compliance with proposed § 25.841, the first priority of the flight deck crew shall be to don oxygen masks. The flight deck crew would then presumably perform an emergency descent in accordance with an approved emergency procedure. In order to maximize occupant survivability following a rapid decompression, the flight deck crew shall descend the airplane at the maximum safe descent speed, which is Vmo/Mmo, assuming structural failure as defined by FAR § 25.571. Any additional training components and flight manual revisions necessary for adoption of the Vmo/Mmo descent criterion shall be required.

The flight deck crew should be thoroughly trained on the use of this procedure in order to avoid an incorrect response (i.e., one that includes a reduced speed descent). They need to be trained so that they understand that structural loads following a decompression are assessed similar to other "Discrete Damage" (pressurized or unpressurized) conditions in which the airplane damage is assessed per FAR 25.571(e) (i.e. structural damage including non-catastrophic rotor failure). Structural load capability of the airplane following a survivable discrete source damage event is considered under unpressurized conditions that results in reduced inertial load factors (See AC 25.571-1C). Therefore, maximum design descent rate (Mmo/Vmo) is not a determining factor in the airplane descent rate following decompression. Thus in all survivable uncontained engine failures the airplane is capable of performing a Vmo/Mmo emergency descent.

a. In demonstrating compliance with § 25.841, it should be assumed that an emergency descent is made in accordance with an approved emergency procedure. Crew recognition time for decompression and oxygen mask donning time should be applied between the cabin altitude warning and the beginning of action for descent. The probable system failure having the most severe effect should be demonstrated by flight test at the maximum airplane altitude. For all failures other than probable failures, the cabin altitude should be established by an analysis that is verified, if necessary, by tests conducted at a lower altitude.

b. A 17-second delay after decompression for crew recognition and oxygen mask donning time should be applied between cabin altitude warning and initiation of action to configure for descent. The 17-second reaction time was originally based on mean values of emergency responses on simulators in terms of aircrew responses in a given emergency situation, where there would actually be pressure loss or some other emergency situation. The 17-seconds is a value that represents the 75th percentile of crew reactions (Reference 17). Reaction times were further studied by Bennett (see Reference 12). Forty-two pilots were exposed to airplane decompression for an overall cabin rate of climb of 30,000 feet per minute to a maximum cabin altitude of 30,000 feet. Eighty-three percent of the pilots donned the oxygen mask in 15 seconds. Emergency descent was initiated in all cases within 5 seconds of the fitting of the mask.

   Furthermore, the 17-sec reaction time cited by Dr Vail is strongly supported by data presented in Reference 3, pg. 121. Figure 27 in Reference 3 depicts a probability graph of data based on Bennett's 1961 study of 42 BOAC pilots reacting to surprise decompressions in realistic conditions. The graph shows that approximately 95% of the pilots were able to react within 17 seconds of onset of the rapid decompression. This correlates well with the 17-sec rule proposed by Vail based on his Wright Development Center simulator studies: "Seventy-five per cent of the response times were 17 seconds or shorter in his experiments, Dr. Vail expressed the view that though one minute would be a desirable allowance for response tome [sic] to decompression, 17 seconds should be sufficient for thoroughly trained crews."

c. The following example of a pressurization failure, other than uncontained engine failures, should make clear the use of delays and environmental limitations.

Assumption and definitions: H_N = The normal cabin pressure altitude which is less than or equal to 8,000 feet normally.

H_A = Airplane altitude.
Tf = Time of pressurization failure.
T_W = Time of the 10,000 foot cabin pressure altitude warning.
T1 = Time that the airplane descent begins.
T_R = Recognition time for crew response to emergency annunciation (17seconds).
T_S = Time for damage assessment; for example, switching the outflow valve to "manual" to attempt to regain cabin altitude control. Following a rapid decompression, for purposes of showing compliance, a TS=0 seconds can be assumed if an immediate emergency descent is specified.
T_D = Time to configure the airplane for descent; for example, gear extension.
$T1-T_W$ = Delay time from cabin altitude warning to time that the airplane begins to descend = $T_R + T_S + T_D$.

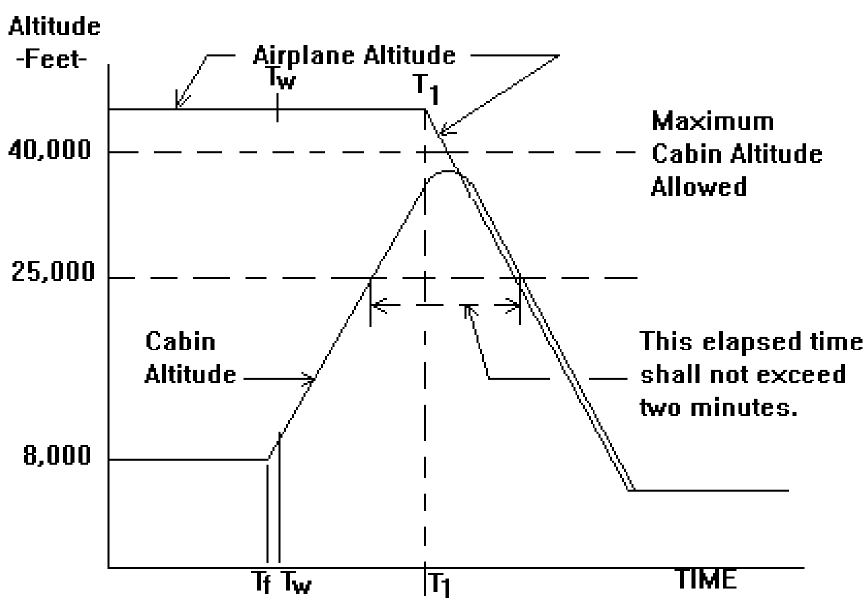


Figure 13-6: Allowable Decompression Profile, Except UEF

d. The limitations specified in § 25.841(a)(x) are not intended to be used in calculating the quantity of oxygen that is needed for emergency descent and sustenance. The flight deck crew may inadvertently, or by intent, delay descent for any number of reasons. However, as noted above, in all failure conditions, including survivable uncontained engine failures, the airplane is capable of performing a Vmo/Mmo emergency descent and this should be clearly stated in any procedure. The operating rules specify the quantity of oxygen that must be carried dependent on route structure.

e. The applicant may use response times less than 17 seconds if they can provide empirical data acceptable to the regulatory authority documenting the time selected. This time may be reduced if, for example, the airplane is equipped with an automatic, or semi-automatic system that initiates the descent based on the 10,000 foot cabin pressure altitude warning, the cabin altitude rate, or other airplane parameters that ensure that there is no delay in beginning the descent.

It is further recommended that the Regulatory Authority develop additional guidance on the following issues and that they be included in the Advisory Circular prepared for this regulation:

The Regulatory Authority should ensure that the operational requirements limit the normal cabin maximum altitude to ensure that the cabin altitude not exceed the design maximum (currently established at 8,000 feet). These requirements may be written into airplane operating manuals (AOM) to mitigate the severity of the post-decompression environment's impact on occupant health. The Regulatory Authority should ensure that the operational requirement for one pilot at the airplane controls is to don a flight deck oxygen mask above 41,000 feet altitude (standard atmospheric conditions).

The Regulatory Authority should recommend that flight deck crew flying aircraft certified to fly above 41,000 feet undergo initial and periodic training in the use of positive pressure breathing systems.

The Regulatory Authority should consider that improved oxygen breathing systems be provided to flight attendants for flight above 41,000 feet.

The Regulatory Authority should accept use of historical data for engine failure analysis.

The Regulatory Authority should accept that a geometric analysis describing the impact of engine debris on the pressure vessel is allowed to determine the cumulative hole area created by uncontained engine failure.

The Regulatory Authority should ensure that any analysis used to determine cumulative pressure vessel hole size due to an uncontained engine failure event includes historical data probability of occurrence and hole size distribution.

The manufacturer will utilize the result of an analysis as recommended by PPIHWG in determining cumulative hole area.

Other design features that should be considered:

- Lower pressure altitudes for nominal operating cabin pressure and cabin pressure warning;
- Actual cabin pressure measurement saved to the flight data recorder (currently, the FAA requires only a discrete record be saved when cabin pressure is exceeded, see FAR Sec. 121.344, Digital flight data recorders for transport category airplanes);
- Better fitting O_2 masks and more reliable deployment systems;
- Thorough maintenance and pre-flight checks of supplemental O_2 systems.

14 - How does the proposed standard compare to the current ICAO standard? [Indicate whether the proposed standard complies with or does not comply with the applicable ICAO standards (if any)]

The proposed standard is in agreement with the intent of International Civil Aviation Organization (ICAO) Annex 8 "Airworthiness of Aircraft" requirements (Reference 18), as there are no specific ICAO requirements defining cabin environmental limits following a failure.

15 - Does the proposed standard affect other HWG's? [Indicate whether the proposed standard should be reviewed by other harmonization working groups and why.]

The means of compliance to the proposed standard will rely in part on the use of an uncontained engine failure debris model that needs to supplied by the PPIHWG group. In addition, the structurally related AC content described in Question 13 should be reviewed by the General Structures Harmonization Working Group (GSHWG). The standard does not need to be reviewed by any other harmonization working groups. It is recommended that the PPIHWG review AC 20-128A, in order to be consistent with the proposed means of compliance identified in the response provided to Question 13.

16 - What is the cost impact of complying with the proposed standard? [Please provide information that will assist in estimating the change in cost (either positive or negative) of the proposed rule. For example, if new tests or designs are required, what is known with respect to the testing or engineering costs? If new equipment is required, what can be reported relative to purchase, installation, and maintenance costs? In

contrast, if the proposed rule relieves industry of testing or other costs, please provide any known estimate of costs.

BACKGROUND

There are now two distinct aviation standards for 25.841(a): the FAR and the Joint Aviation Requirements (JAR). The current FAR 25.841(a), as modified by Amendment 25-87, contains requirements in addition to the current requirement of JAR 25.841(a). The FARs were changed by the FAA via Amendment 25-87 without being harmonized with the Joint Aviation Authorities (JAA). The regulations that we are discussing are not currently harmonized; the JAR reflects these rules, as they existed in the FAR prior to Amendment 25-87. It is noteworthy that the JAA has not adopted the changes in the FAR section as promulgated in Amendment 25-87 and lists it as a significant difference in current FAA/JAA certification/validation programs. The manufacturers must show compliance with both of these standards if they seek both US and JAA type certification, increasing costs of certification.

Further, while it is difficult to quantify, there are other costs associated with FAA and JAA operating under different sets of requirements. For example, airplanes not certificated under the FAR would be able to achieve lower operating costs because they could be designed to higher maximum certified altitude. This may give a competitive advantage to non-FAA certificated airplanes, thus promoting a non-level playing field.

INTRODUCTION

The FAA did not publish documentation that addressed the real cost impact of applying new standards to derivative airplanes, nor whether the new requirement could be met by any practical means for any new or derivative airplane under Amendment 25-87.

The provisions of section 25.841(a)(2) and (3) of Amendment 25-87 of the FAR may limit new or derivative transport airplanes with wing-mounted engines to operating altitudes well below 40,000 feet. This has major cost impacts since new or changed airplane models may not be able to compete with existing certificated airplanes, which did not have to comply with the new requirements. New and derivative airplanes that would be limited to altitudes of 37,000 to 39,000 feet under section 25.841 would no longer be able to compete with currently certificated airplanes that can operate at altitudes above 40,000 feet. The existing airplanes can cruise at the higher altitudes where they are more fuel-efficient. Changes to the regulatory provisions as proposed in this report should allow certification of new and derivative airplane models that are more economical while maintaining the proper safety.

The cost impact of Amendment 25-87 to the aviation industry and the flying public, both here in the United States and in Europe, is predicted to be significant. While it is difficult to place specific dollar impact on these new requirements, it is clear that most new airplane programs are severely impacted. No high altitude (above 39,000 feet maximum altitude) airplane with wing-mounted engines certified today can meet the new altitude limits with the current § 25.841(a)(3).

A primary concern is that new and derivative airplanes with wing-mounted engines designed to meet Part 25 as amended at Amendment 25-87 will have significantly higher design and operating costs than currently certified airplanes. These higher costs will impact the ability of manufacturers to introduce new airplanes that can compete with previously approved airplanes. It is not apparent whether the FAA considered this high cost when assessing the economic impact associated with the amendment.

The current rule is based on previous special conditions for high altitude operation up to 51,000 ft. for small business jets. Current commercial aircraft are designed for operation up to 45,000 ft. Higher altitudes above 45,000 ft. are economically viable not only for small business aircraft but for new proposed commercial aircraft as well. The special conditions applied to small business jets should not be applied in their entirety to commercial aircraft as small jet aircraft have performance comparable to high performance military aircraft. Thus, descending to 25,000 ft. within 2 minutes following an uncontained engine failure is very restrictive for commercial aircraft flying at higher altitudes since their maximum descent speeds are lower. In addition, the limitation of cabin altitude to 40,000 ft. following an uncontained engine failure indirectly limits the aircraft flight altitude to FL400 since worst case failures can decompress the cabin in less time than is required to initiate the descent. This is true for narrow and wide body aircraft.

The economic viability of transport aircraft with wing-mounted engines under development would suffer, because maximum operating altitudes would be limited to around 35,000 to 39,000 ft under the current rule. The proposed harmonized standard in this WG Report should reduce the overall cost and time of the joint certification process and should not increase cost for any present major manufacturer that has a service demonstrated safety record. Any cost change will be negligible compared to the benefits of a clear, concise, and standardized rule that allows new and derivative airplanes to compete economically with the existing fleet. In addition, since the proposed new standard will be harmonized, there will no longer be an additional cost to certify to different FAA and JAA standards.

The following analysis as detailed in Figures 16-1 through 16-5, related to the cost impact of complying to the current Amendment 25-87 for transport aircraft with wing-mounted engines, is provided by The Boeing Company™. This information due to the proprietary nature of its underlying data, has not been evaluated by the MSHWG; it has been provided to assist the FAA in its future economic assessment. Note: In the following figures "current or future generation aircraft" refers to transport aircraft with wing-mounted engines.

Airplane Operation

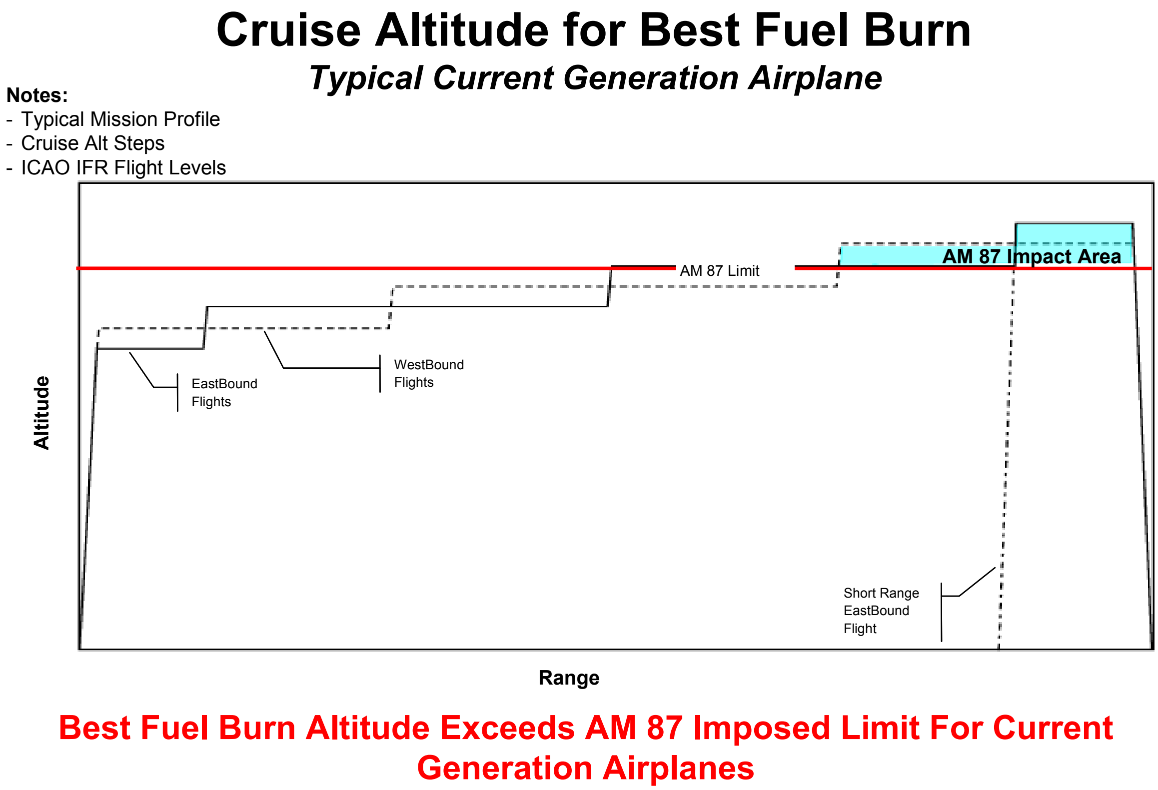


Figure 16-1: Cruise Altitudes for Typical Current Generation Airplanes

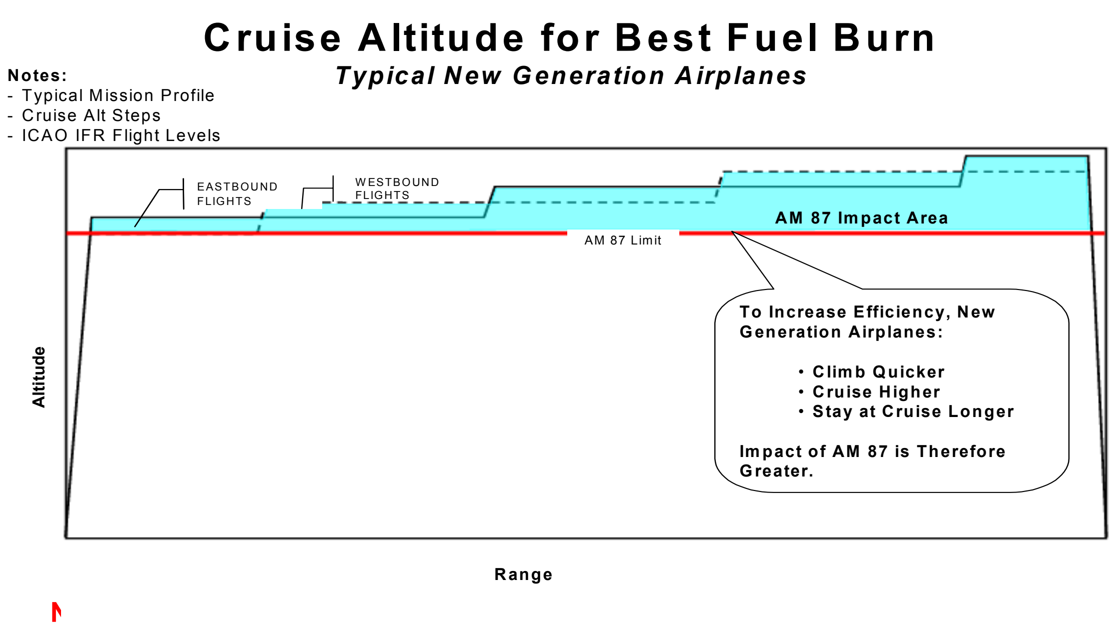


Figure 16-2: Typical Cruise Altitudes for New Generation Airplanes

Figures 16-1 and 16-2 show typical cruise altitudes for current and new generation airplanes. As shown, new generation airplanes flyer higher for longer amounts of time. While current large transport airplanes are certified up to altitudes of 45,000 ft., they must burn off fuel to reach these altitudes. That means that for a large portion of their flight profile they may be below limits imposed by Amendment 25-87, rule 25.841(a). However, newer aircraft are designed to reach higher cruise altitudes quicker and stay there longer. This means they will normally fly above the limits imposed by Amendment 25-87 for most of there flight profile.

Fuel Burn

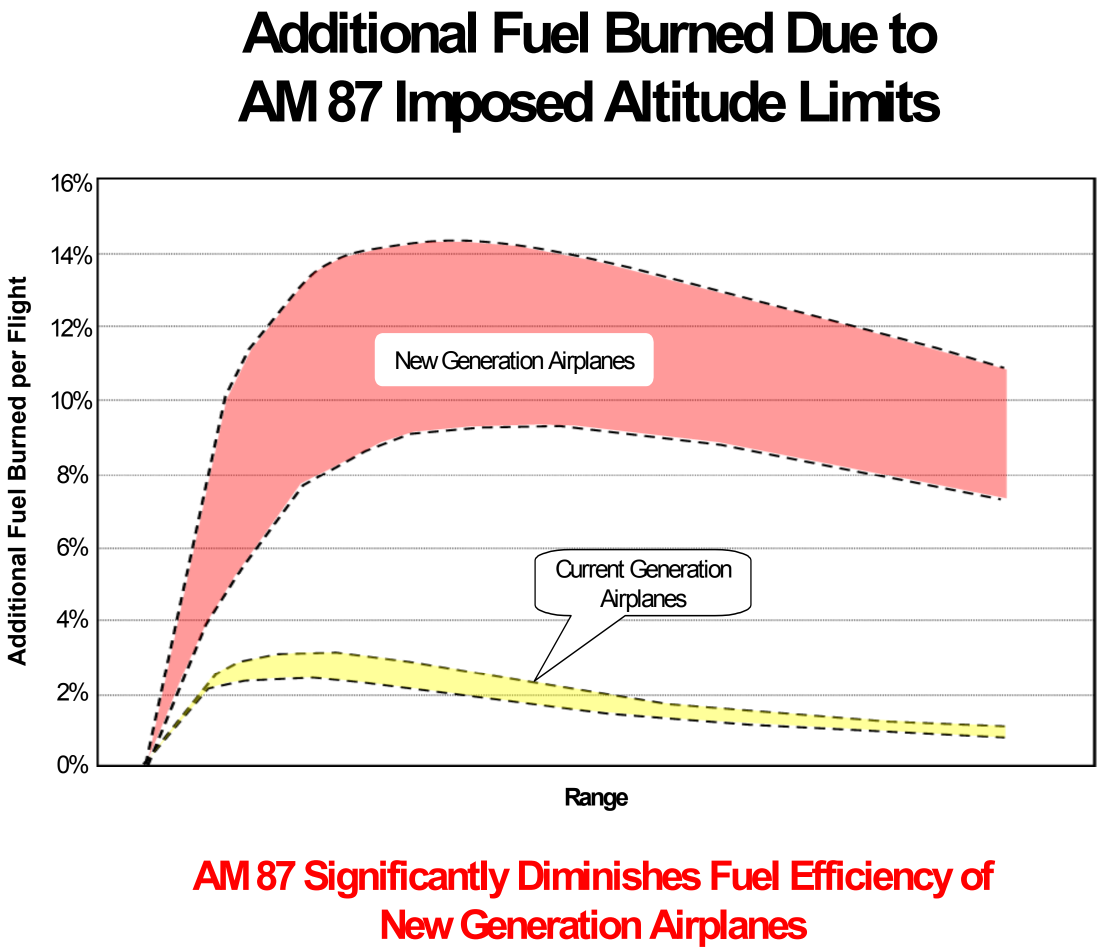


Figure 16-3: Added Fuel Burn due to Amendment 25-87 Imposed Limits

As can be seen from Figure 16-3, the restriction in higher operating altitudes imposed by the current Amendment 25-87, rule 25.841(a) means that if new generation aircraft were built, the fuel penalty would be very significant.

Economics

An economic analysis was based on projected fuel burn increases shown above. The economic penalty was assessed over a 14 year operation for a forecast fleet of airplanes, in terms of 2001 dollars. Fuel cost was assumed to remain constant at $.071 per gallon (Note: fuel costs have ranged in the past from $0.10 in 1970 to $1.045 in 1981).

Results showed a $1billion to $6 billion Net Present Value (NPV)(in 2001 dollars) on a typical fleet of new generation airplanes for the first 14 years of operation. Compliance to FAR 25.841(a), AM 87 would result in economic penalties so severe that new generation airplanes would not be commercially viable. It is estimated that this would result in 41,000 – 75,000 lost U.S. Aerospace jobs for the life of each airplane family.

Environmental Effects

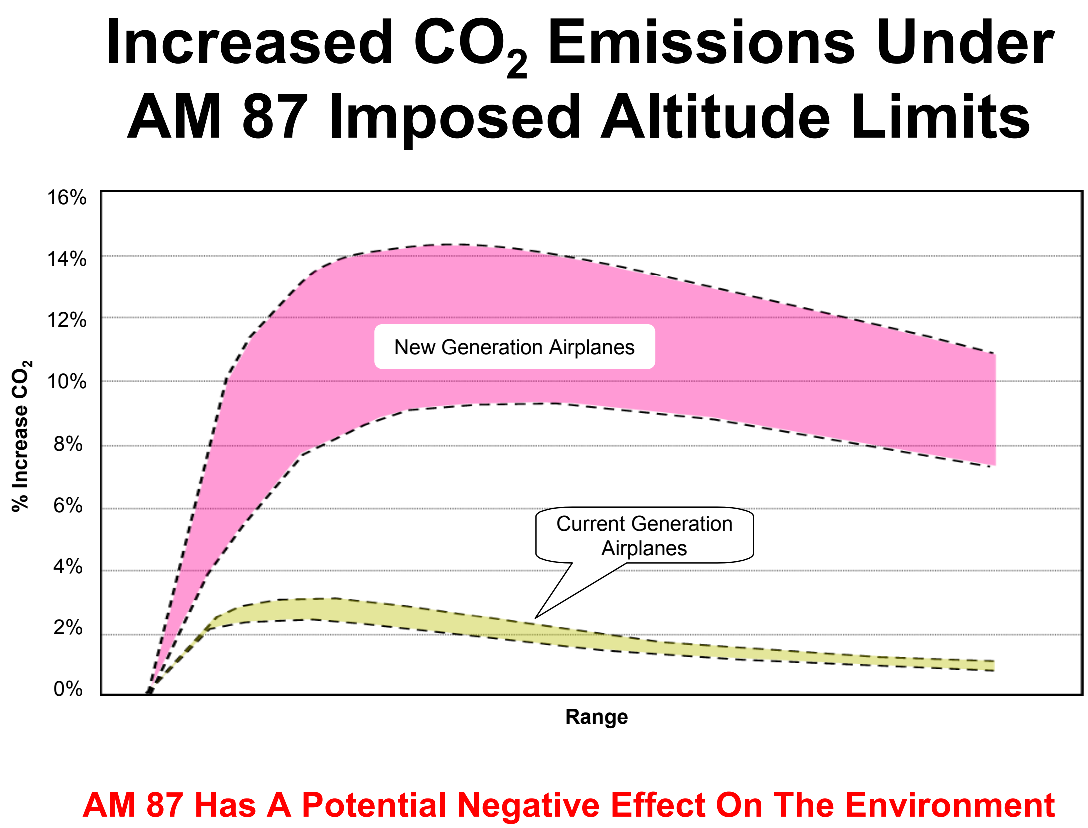
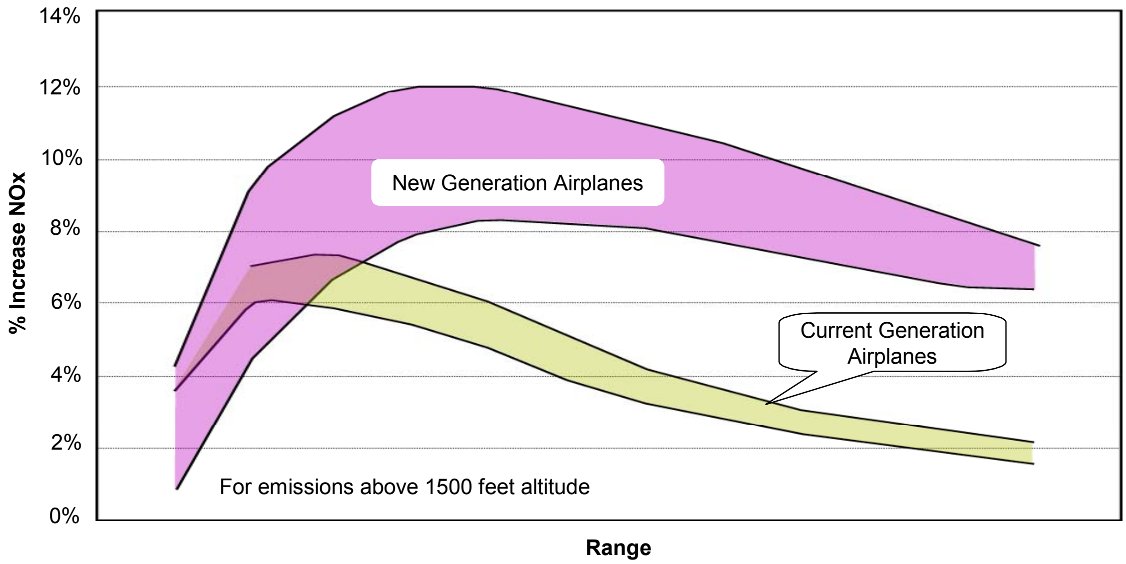


Figure 16-4: Projected Increased CO2 emissions due to Amendment 25-87

Increased NOx Emissions Under AM 87 Imposed Altitude Limits



AM 87 Has A Potential Negative Effect On The Environment

Figure 16-5: Projected increased NOx emissions due to Amendment 25-87

Figure 16-4 and 16-5 project the potential increase in CO_2 and NOx emissions that could result from compliance to Amendment 25-87, for both the current generation aircraft and new generation aircraft due to the imposed altitude limits. Note that the increase in both pollutants is very significant.

Air Traffic

The following air traffic data is provided to support economic analyses by the regulatory authorities. Three separate studies were conducted; Air Transport Association, FAA, and The Boeing Company™.

1. Air Transportation Association study.

Information from the ATA Air Traffic Department on number of aircraft flying at or above FL410:

DATE	Air Carrier >FL410	All Alts.	Total Operations >FL410	All Alts.
8/15/01	871	37,151	1,901	65,162
8/16/01	773	37,783	1,792	65,039
	(2.2%)		(2.8%)	
10/31/01	1,387	31,869	2,303	57,263
11/1/01	1,048	32,163	1,962	58,967
	(3.8%)		(3.7%)	

ATA assessment of the above data: considering the fact that these altitudes are at or above the max altitude limitation for most air carrier aircraft, the percentages shown represent a high utilization of the available altitude capability. Additionally, the capability to operate at these altitudes is critical to the design payload-range capability of the aircraft. These altitudes are frequently required on range-critical missions in order to avoid excessive payload penalties or unscheduled intermediate stops. Furthermore, in order to improve efficiency and flexibility as well as relieve airspace congestion, it is anticipated that future aircraft design will place a greater demand on high altitude operation.

2. FAA Study

FAA Air Traffic Control (ATC) scans also provided information on the number of airplanes flying above 40,000 feet. These scans revealed 0.6% of all active airplanes within the ATC system [Eastern Pacific, Continental US and Western Atlantic] were operating above 40,000 feet. However these scans represent a "snap-shot" of the airplanes flying at the specific time of day and may not be representative of the total airplanes flying at these altitudes on an annual basis. A more exhaustive survey would need to be completed to provide an annual usage rate.

3. Boeing Study of Flight frequency above 37,000 ft.

Vertical Distribution of Traffic

- **US Domestic**
  - **Approximately 16% of traffic currently operates above FL 370**
- **North Atlantic**
  - **Approximately 21% above FL370**
- **North and Central Pacific**
  - **Approximately 12% of traffic above FL370 in all Oakland's oceanic airspace**
  - **Approximately 9% of traffic above FL370 in Anchorage's oceanic airspace**

Note: Data are not long-term statistics; simply a quick look at representative numbers and are based on ATM Center reports for one day in Aug. 2002. Above data shows that 10% to 20% of Today's Fleet Operates Above FL 370.

Effect on Air Traffic System

Far 25.841(a), Amendment 25-87 may also have an unintended negative effect on today's air traffic system. Consider the following:

Limiting operation of new generation airplanes to lower altitudes may result in higher traffic density, which could lead to greater collision risk if not otherwise mitigated. In anticipation of this increased level of risk, additional costs may be imposed on the aviation system, in order to maintain an acceptable level of safety.

According to Boeing Air Traffic Control experts, the following may be collateral impacts of preserving an equivalent level of safety while limiting maximum flight altitudes.

- Larger separation minima may be required, resulting in lower capacity, more delay, and less growth potential. Simply stated, the rationale is that, if more aircraft are forced by altitude restrictions to share the same block of airspace, the potential for loss of separation increases and the achieved level of safety suffers. Just about the only parameter that the system has to deal with this and achieve the target level of safety is increased separation standards. Controllers already do this informally by building in separation buffers to help them handle the excess workload while avoiding losses of separation.

- **Use of even lower, less economical altitudes required.**
- **More sectors, controllers and communications frequencies required.**
- **More automation tools required.**
- **Improvements in Flow Management required.**
- **Earlier implementation of ground system enhancements required.**

The above changes to the air traffic system may be costly to implement.

17 – If advisory or interpretive material is to be submitted, document the advisory interpretive guidelines. If disagreement exists, document the disagreement.

The proposed advisory material (i.e., Advisory Circular) and issues that should be included in the AC appear in the response to Question 13.

Below are the initial ground rules (cabin decompression, probability, damage assessment) that were used by the MSHWG for developing the interpretative material for the proposed rule and Advisory Circular.

GROUND RULES

Ground rules for cabin decompression

3. Airworthiness Standards

The pertinent sections from FAA 14 CFR 25, 2001, and JAA JAR-25, 2000 related to the certification of today's aircraft are as follows:

A. Airworthiness Standards, Transport Category Airplanes

FAR 25.841	Pressurized cabins
FAR 25.1443(d)	First aid oxygen
FAR 25.1447(c)(2) & (4)	Oxygen for flight deck crew and flight attendants
FAR 25.1441	Oxygen equipment and supply
FAR 25.1445	Equipment standards for the oxygen distributing system
FAR 25.1449	Means for determining use of oxygen
JAR 25.841	Pressurized cabins
JAR 25.1439	Protective breathing equipment
JAR 25.1441	Oxygen equipment and supply
JAR 25.1443	Minimum mass flow of supplemental oxygen
JAR 25.1445	Equipment standards for the oxygen distributing system
JAR 25.1447	Oxygen for flight deck crew and flight attendants
JAR 25.1449	Means for determining use of oxygen

4. Operating Requirements: Domestic, Flag, and Supplemental Operations

U.S. operators

121.329	Supplemental oxygen for sustenance; turbine engine powered airplanes
121.333.1	Supplemental oxygen for emergency descent and for first aid; turbine engine powered airplanes with pressurized cabins
121.335	Equipment standards
121.337	Protective Breathing Equipment
121.574	Oxygen for medical use by passengers http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-574.rtf

AC 120-43:	Influence of Beards on Oxygen Mask Efficiency http://www1.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/1ab39b4ed563b08985256a35006d56af/f9789ad5efc61df6862569ba00752817/$FILE/AC120-43.pdf
TSO-C78:	Crewmember Demand Oxygen Masks http://av-info.faa.gov/tso/Tsocur/C78.doc
TSO-C89:	Oxygen Regulators, Demand http://av-info.faa.gov/tso/Tsocur/C89.doc

Canadian operators,

Operational Standards-Airline Operations

705.71.1.1	Protective Breathing Equipment
705.71.1.2	First Aid Oxygen
705.94.1.1	Portable Oxygen
605.31(2)	Oxygen Equipment and Supply
605.32.1.1	Use of Oxygen

Operational Standards-Private Operator Passenger Transportation

604.40	Protective Equipment

European operators

JAR-OPS 1.760 First aid oxygen
JAR-OPS 1.770 Supplemental Oxygen -pressurized aeroplanes
JAR-OPS 1.770 Appendix 1 Oxygen – Minimum requirements for supplemental oxygen for pressurized aeroplanes
JAR-OPS 1.780 Protective Breathing Equipment

From JAR-OPS,

a) 'First aid oxygen' means the additional oxygen provided for the use of passengers, who do not satisfactorily recover following subjection to excessive cabin altitudes, during which they had been provided with supplemental oxygen.

b) 'Supplemental oxygen' means the additional oxygen required to protect each occupant against the adverse effects of excessive cabin altitude and to maintain acceptable physiological conditions.

From FAA,

Supplemental oxygen means the additional oxygen required to protect occupants against the adverse effects of excessive cabin altitude and to maintain acceptable physiological conditions during and after decompression.

Suggestions for modifications to the above present FAA airworthiness and operational standards that have evolved over decades of research and flight experience would be better amenable to evaluation and group interchange if each suggestion were tied up front to one of the above regulatory categories.

5. Crew Inflight Post-Decompression Performance

3.1 Flight Deck Crew Performance

a. Need to evaluate the effects that immediate exposure to various cabin altitudes will have on flight deck crew cognitive function if not wearing mask and if at least one crewmember will always be wearing oxygen higher than 41,000 ft. as required by FAA regulation (Note: FAA and Transport Canada requirement only. There is no European operational requirement for a crewmember to wear an oxygen mask at flight levels above 41,000 ft.)

   The flight deck crew criterion is based on an individual performing useful flying duties in an environment of inadequate oxygen pressure (Reference 13, pg. 25).

   Depending on the size of the hole and the net volume of the aircraft, depressurization may not occur within a few seconds. Therefore, the time to depressurize the aircraft after the hole is created should be considered.

b. Increased workload following a rapid decompression.

3.2 Cabin Crew Performance

a. The cabin crew criterion is based on assuming the cabin crew is not at rest. Some useful information is contained in Reference 14.
b. F/As are to put on mask, sit or hold on, and await flight crew instructions before attempting to help passenger. It is assumed for the purposes of showing compliance to design rule that F/A's are able to don masks and achieve a minimal level of protection within some reasonable number of seconds following mask drop. Following flight crew instructions, flight attendants will move about the cabin performing emergency procedures.

4. Maximum Operating Altitudes, Cabin and Airplane

a. Recommendation from the team will cover subsonic airplanes at flight altitudes at and below 51,000-ft alt. (contained in Amendment 25-87 preamble).

b. Design cabin altitude, per regulations should be considered up to a maximum of 8,000 ft.

5. Passenger Criteria

a. There is the potential that not all passengers will obtain sufficient protection from the cabin supplemental oxygen system. Therefore, for purposes of this study, it will be assumed that not all passengers are able to effectively don masks.

b. Throughout emergency descent, landing and aircraft egress following a rapid decompression event, all passengers are at some level of risk for permanent physiological harm. Due to numerous factors, including age, pre-existing medical condition, etc., some passengers will face greater levels of risk than others. The current FAR/JAR 25.1309 categorizes this failure condition as hazardous and acknowledges the potential for incurring injuries and/or fatalities to the airplane occupants following this failure event as follows:

   Harmonized 25.1309 (Proposed)
   Serious or fatal injury to a relatively small number of the occupants other than the flight crew.

With the type of failure condition defined above, there exists uncertainty with respect to the level of risk to each passenger's survival associated with exposure to the cabin environment following a decompression. To satisfy the harmonized FAR/JAR 25.1309 it is necessary to assess the degree of risk in order to minimize the potential for permanent physiological harm to the airplane's occupants. An analysis that defines the envelope of vulnerability of passengers for permanent physiological harm in a decompression and identifies the continuously available design features of the airplane (i.e., aircraft systems) and the operational features (e.g., crew training, AFM limitations, etc.) to enhance the survivability of those passengers at increased levels of risk, would be an acceptable approach towards determining compliance with the harmonized FAR/JAR 25.1309. Note that the measure of adequacy is the presence of aircraft features (e.g., design and operational) that are commensurate with the level of risk associated with the cruise flight altitude.

c. Healthy passengers will self resuscitate, i.e., regain consciousness without any direct action of the crew and/or other occupants. Passengers must recover sufficient cognitive function to exit the aircraft following emergency descent, safe flight and landing. Some assistance may be required for passengers with pre-existing impairments.

6. Environment

a. Flight Deck Environment: Possibility of fog, air movement, vibration, noise, and decreased temperature.

b. Cabin Environment: Possibility of chaos or panic, fog, air movement, vibration, noise, flying objects, and decreased temperature.

c. It must be assumed that the occupied areas of the airplane may experience a sudden decompression (i.e., one occurring within the time allotted the crew to don their mask, isolate the source, reconfigure the airplane for descent and initiate the descent) to ambient pressure. Additional factors that can influence the resulting environment of the occupied areas (e.g., aerodynamic suction) need to be considered.

7. Regarding Choices

Time vs. Altitude

a. There is a physiological basis for determining emergency descent procedures.

b. Relevant, existing data must be available to support claims for physiological limits.

c. These data should provide recommendations for allowable time exposures following cabin decompression for the occupants (i.e. where permanent physiological damage is avoided) at varying cabin altitudes.

d. Requirements should consider different standards for flight crew, cabin crew, and passengers based on their role in supporting continued safe flight and landing (i.e., training, protection, etc.).

8. Crew Duties and Training in the Event of Emergencies

FAR 121.391 Flight attendants (duties)
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-391.rtf

FAR 121.397 Emergency and emergency evacuation duties http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-397.rtf

FAR 121.417 Crewmember emergency training
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-417.rtf

FAR 121.427 Recurrent training
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-427.rtf

FAR 121.557 Emergencies: Domestic and flag operations
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-557.rtf

121.559 Emergencies: Supplemental operations
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-559.rtf

FAR 121.587 Closing and locking of flight crew compartment door
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-587.rtf

AC 120-48 COMMUNICATION AND COORDINATION BETWEEN FLIGHT CREWMEMBERS AND FLIGHT ATTENDANTS
http://www1.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/1ab39b4ed563b08985256a35006d56af/ffeb9277f3866c5b862569f1005f7eb6/$FILE/AC120-48.pdf

ACOB 205 DUTY ASSIGNMENT OF REQUIRED AND NON-REQUIRED FLIGHT ATTENDANTS
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB205.rtf

ACOB 207 PREDEPARTURE CABIN EQUIPMENT CHECKS BY FLIGHT ATTENDANTS
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB207.rtf

ACOB 223 FLIGHT ATTENDANT TRAINING ON CONDITIONS OF AIRCRAFT FOLLOWING AN ACCIDENT
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB223.rtf

ACOB 225 Training of Cockpit and Cabin Crewmembers on the Operational Characteristics of Chemically Generated Supplemental Oxygen System and Updating of Passenger Briefing Information
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB225.rtf

ACOB 226 PREPARATION OF CABIN FOR IMPENDING EMERGENCY LANDING
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB226.rtf

ACOB 227 FLIGHT ATTENDANT RESTRAINT DURING A CRASH AND EMERGENCY EVACUATION SECOND CHOICE EXIT DETERMINATION
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB227.rtf

ACOB 229 FLIGHT ATTENDANT TRAINING ON THE USE OF COCKPIT EMERGENCY EQUIPMENT
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB229.rtf

ACOB 231 CREWMEMBER CABIN SAFETY TRAINING
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB231.rtf

ACOB 928 Crewmembers Procedures for Assessing Damage to Aircraft In flight (F/A reporting hazardous conditions)
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB928.rtf

ACOB 979 Require any Crewmember who Observes a Potential or Actual Emergency Situation to Verbally Call it to the Captain's Attention
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB979.rtf

HBAT 98-18 Air Carrier Manual Instructions Concerning Minimum Equipment List Conditions and Limitations
http://www.faa.gov/avr/afs/hbat/hbat9818.txt

HBAT 98-26 Flight Attendants Operating Experience
http://www.faa.gov/avr/afs/hbat/hbat9826.doc

FSAT 95-27 Use of Oxygen Mask by Cabin Crew During Decompression
http://www.faa.gov/avr/afs/fsat/fsat9527.txt

FSAT 97-02: Approval of Flight Attendant Training Programs and Acceptance of Flight Attendant Manuals(inspector approval).
(especially pages 3-2127 Use of Oxygen and 3-2132 f/a actions)
http://www.faa.gov/avr/afs/faa/8400/8400_vol3/3_015_06.pdf

Ground rules for probability

Airworthiness Standards and References

The pertinent FAA major categories, Title 14, 2001, constituting the certification of today's aircraft are as follows:

FAR 25.365 (e), (f)	
FAR 25.571 & ACs	Damage-tolerance and fatigue evaluation of structure
FAR 25.1309 & ACs	Equipment, systems, and installations

Ground Rules

1. If probability is used in showing compliance then it must be applied only to conditions, which are predictable, and the probability of the event is supported by data.

2. The consequences of an event in terms of severity and the probability of that event occurring should be inversely related such that potentially catastrophic conditions will not occur. See table below, FAR Category "Major, Catastrophic":

Table 1 FAR/JAR Failure/Probability/Criticality Definitions

<table>
<tr><td rowspan="2">Effects on aircraft and occupants of the identified failure condition.</td><td>FAR -AC 25.1309-1A definitions.</td><td colspan="2">No significant degradation of aircraft capability. Crew actions well within their capabilities.</td><td colspan="2">Reduction of the aircraft capability or of the crew ability to cope with adverse operating conditions.</td><td>Prevention of continued safe flight and landing of the airplane.</td></tr>
<tr><td>ACJ No. 1 of JAR 25.1309 definitions</td><td colspan="2">Slight reduction of safety margins,

slight increase in work load, (e.g. routine changes in flight plan), or

physical effects but no injury to occupants.</td><td>Significant reduction in safety margins,

reduction in the ability of the flight crew to cope with adverse operating conditions impairing efficiency, or

injury to occupants.</td><td>Large reduction in safety margins,

physical distress or workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely, or

serious injury to or death of a relatively small portion of the occupants.</td><td>Loss of the airplane and/or fatalities.</td></tr>
<tr><td colspan="2">FAR effect category AC 25.1309-1A.</td><td colspan="2">Minor</td><td colspan="2">Major</td><td>Catastrophic</td></tr>
<tr><td colspan="2">FAR qualitative probability terms.</td><td colspan="2">Probable</td><td colspan="2">Improbable</td><td>Extremely improbable</td></tr>
<tr><td colspan="2">JAR qualitative probability terms.</td><td>Frequent</td><td>Reason-ably Probable</td><td>Remote</td><td>Extremely Remote</td><td>Extremely Improbable</td></tr>
<tr><td colspan="2">FAR and JAR qualitative probability ranges.</td><td colspan="5">10^{-3} 10^{-5} 10^{-7} 10^{-9}
Probability of Failure Condition (for one flight hour or flight if less than one hour).</td></tr>
</table>

Table 2 Relationship Between Probability and Severity of Failure Condition.

Effect on Airplane	No effect on operational capabilities or safety	Slight reduction in functional capabilities or safety margins	Significant reduction in functional capabilities or safety margins	Large reduction in functional capabilities or safety margins	Normally with hull loss
Effect on Occupants excluding Flight Crew	Inconvenience	Physical discomfort	Physical distress, possibly including injuries	Serious or fatal injury to a small number of passengers or cabin crew	Multiple fatalities
Effect on Flight Crew	No effect on flight crew	Slight increase in workload	Physical discomfort or a significant increase in workload	Physical distress or excessive workload impairs ability to perform tasks	Fatalities or incapacitation
Allowable Qualitative Probability	No Probability Requirement	<---Probable---->	<----Remote----->	Extremely <------------------> Remote	Extremely Improbable
Allowable Quantitative Probability: Average Probability per Flight Hour on the Order of:	No Probability Requirement	<------------------> $<10^{-3}$ Note 1	<------------------> $<10^{-5}$	<------------------> $<10^{-7}$	$<10^{-9}$
Classification of Failure Conditions	No Safety Effect	<-----Minor------>	<-----Major------>	<--Hazardous--->	Catastrophic

Note 1: A numerical probability range is provided here as a reference. The applicant is not required to perform a quantitative analysis, nor substantiate by such an analysis, that this numerical criteria has been met for Minor Failure Conditions. Current transport category airplane products are regarded as meeting this standard simply by using current commonly-accepted industry practice.

3. Failure Modes & Effects Analysis (FMEA) and Fault tree methodology for system failures are a means to show compliance to FAR/JAR 25.1309.

4. Damage tolerance and fail-safe design principles are an equivalent methodology to show compliance FAR/JAR 25.571(e).

5. Base recommendation on assumption other FAR/JARs are in their current approved state, except FAR/JAR table 2, “Relationship Between Probability and Severity of Failure Condition”, above.

6. The application of probability of structural failure is contrary to the basic structural design approach, and therefore probability of structural failure should not be considered in establishing compliance to the subject rule. The regulations governing structures are intended to render structural failures extremely improbable by virtue of choice of design loads, margins of safety,

testing, and required maintenance programs, even though a numerical value for extremely improbable is not always computed.

7. Engine rotor burst related events are not considered as part of this subteam's assessment; however, engine system failures will be considered, (for example loss of engine bleed air).

Ground rules for damage assessment

1. During rapid and/or explosive decompression at cruise altitudes, flight crew would be in a highly chaotic environment with various warning sounds and vision may be severely limited due to fog, etc., in the flight deck air. Similarly, cabin flight attendants would not be able to reliably assess damage and report to flight crew. In fact, damage may be hidden from view.
2. In order to best ensure airplane survivability following a rapid or explosive decompression, flight crew would descend airplane to not exceed Vmo/Mmo. Adoption of the Vmo/Mmo descent criterion may require additional training components and flight manual revisions. Flight crew first priority would be to don oxygen masks.
3. Embedded sensor technology may be utilized to determine extent of structural failures when proven technology is available. Such technology may enhance the flight crew's ability to assess the extent and nature of the structural failure and to respond with appropriate emergency measures.
4. Instruments for measuring and deciphering rapid cabin pressure changes may be utilized to determine extent of structural failures when proven technology is available. Such technology may enhance the flight crew's ability to assess the extent and nature of the structural failure and to respond with appropriate emergency measures.
5. Video cameras or similar devices to monitor the structure, either internally or externally, may be utilized to determine extent of structural failures when proven technology is available. Such technology may enhance the flight crew's ability to assess the extent and nature of the structural failure and to respond with appropriate emergency measures.
6. Current FAA interpretation is that no other damage is assumed to occur (i.e., airplane has sustained loss of one engine – pressurized vessel punctured – decompression occurs – no loss to control surfaces or controllability of airplane). However, manufacturers shall account for loss of system capability, based on the specific systems architecture of the aircraft (only the systems that may be lost following an engine failure, as would be done in a hazard analysis, etc.), following loss of an engine.

Uncontained Engine Failure as Specific Risk

One major area of continuing disagreement where no majority position was achieved by the MSHWG is that of engine failure being considered a specific risk (i.e. probability of occurrence is one).

Background

The current probability of an engine uncontained failure, which is considered a random, unpredictable event, based on historical data is on the order of 10^{-7}(Reference 10). When combined with a simple geometrical analysis that shows the probability of fragments hitting the fuselage, and subtracting airplane non-survival events, it is possible that the probability of an engine uncontained failure causing a airplane survivable rapid decompression is of the order of 10^{-9} (extremely improbable). The MSHWG achieved agreement on an acceptable means of compliance with the use of DEI methodology for uncontained engine failure. However, there is still a disagreement as to whether a combined probability assessment is also an acceptable means of compliance, vs. consideration of an uncontained engine failure as a specific risk.

The MSHWG notes that the System Design and Analysis Harmonization Working Group, SDAHWG, is currently reviewing the issue of specific risk and its impact on FAR/JAR 25.1309.

The FAA position on Specific Risk is as follows:

The current FAA thinking/policy on this subject is that where there is a significant potential for flight to flight variation in risk and/or significant variability and uncertainty within the computation of average risk; the concept of "specific risk" must be taken into account in order to effectively find compliance with even §25.1309(b). FAA believes that it isn't enough to conclude that an event is not expected to occur during a series of typical flights of mean duration, we must conclude that the event is not anticipated to occur during any one flight.

This is particularly true for the accepted means of compliance for rules like: §25.901(c) where such considerations have traditionally been part of the means of compliance; §25.981 where consideration of the "latent plus one" criteria is specifically called out in the rule; §25.671 where even the ARAC Recommendations include some "specific risk" considerations; §25.841 where FAA historically has called out that structural, system and engine failures must be considered. {With regard to UEF, this has been done in part because of the variability and uncertainty in the likelihood of an UEF worst-case decompression.}

To summarize, the FAA is not currently applying the formal "specific risk" assessment and acceptance policies that it proposed as part of AC 25.1309-1B to "all FAR's". FAA may elect in the future (pending the supplemental tasking mentioned above) to apply the concept to some FAR's that meet guidance requirements within the AC 25.1309-1B. However, the FAA has not found any "grand strategy" or "guidance" provided at this time that would indicate that FAA would preclude a "specific risk" from being a required part of the demonstration of compliance for any FAR's that have historically required that particular "specific risk" be considered in a finding of compliance.

The Aircraft industry position on Specific Risk is as follows:

The SDAHWG reviewed all the compelling data the FAA and industry had assembled and determined that there was no evidence of a "compelling public need" which would justify specific risk inclusion within 1309, (as required by executive order 12866). The committee did however conclude that there is a need to better understand and execute our current design and safety assessment methodology, particularly when it comes to identifying failure modes, validating requirements, modeling failure conditions and the use of proper assumptions and accurate failure rates. The data that the MSHWG has compiled shows that no deaths have ever occurred in commercial airplanes due to a high altitude rapid decompression. There is no compelling public need or justification for specific risk within 25.841(a), and to do so may be in violation of executive order 12866.

The FAA mentioned above that within 25.841(a), UEF is a specific risk due in part to the variability and uncertainty in the likelihood of an UEF worst-case decompression. Yet work in SDAHWG has shown that we do a good job of managing risk by design and analysis using average risk techniques. The deviation from average risk is not significant, certainly not enough to warrant a specific risk approach.

Also in the above argument, it was noted that a grand strategy or guidance to indicate that the FAA would preclude a specific risk from being a requirement was not found. Certainly the opposite is true also. There is no regulatory guidance we are aware of that makes specific risk a grand strategy either in the finding of compliance. In fact the SDHWG draft 1309 product purposefully did not include any mention of specific risk in the preamble, rule body, or advisory material for exactly this reason.

Depressurization Exposure Integral (DEI) Method

In addition, another area that achieved a majority position, but continues to be an area of controversy, is the DEI method.

As noted in Question 6, some members of the medical community have expressed concern over the fact that the human response to the rarified atmosphere following decompression is a dynamic multi-factorial response to changes in, among other things, the tracheal, alveolar, arterial and end-tidal partial pressure of oxygen, carbon dioxide, water vapor, pH of the blood, arterial blood pressure, cerebral vascular resistance and the local cerebral blood flow. While we acknowledge these concerns, the majority of the group believes that through the selection of sufficiently conservative acceptance criteria validated by additional experimental data obtained through an appropriate research program, this approach will permit a realistic numerical appraisal of the severity of the hypoxic environment due to an uncontained engine failure event.

18.- Does the HWG wish to answer any supplementary questions specific to this project? [If the HWG can think of customized questions or concerns relevant to this project, please present the questions and the HWG answers and comments here.]

The MSHWG does not have any supplementary issues to address related to FAR 25.841(a)(2) and (3).

19 - Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

A Notice is required for the proposed FAR change and current members of the Mechanical Systems Harmonization Working Group should review any draft Notice of Proposed Rulemaking prior to publication in the Federal Register.

No Notice is required for the advisory material. However, it has been the policy of the Transport Airplane Directorate to provide a Notice of Availability of Proposed Advisory Circular (AC) and request for comments prior to issuing advisory material. Therefore, the current members of the MSHWG would like to review any draft notice prior to publication in the Federal Register**.**

20 – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process. Explain. [A negative answer to this question will prompt the FAA to pull the project out of the Fast Track process and forward the issues to the FAA's Rulemaking Management Council for consideration as a "significant" project.]

Harmonization of these regulatory issues is beyond the "Better Plan" for Harmonization tasks that are being handled under the Fast Track ARAC process. Therefore, this should not be a "fast track" process, but instead a normal NPRM process. This issue should be forwarded to the FAA's Rulemaking Management Council for establishment as a "significant" project. It should then be given highest priority to complete as quickly as possible. Failure to do will severely impede the design and manufacturer of new commercial airplane designs.

Attachment A - Reference List

1. "Aircraft Standards for Subsonic Transport Aeroplanes to be Operated above an Altitude of 41 000 ft", Generic Special Condition, developed by Panel 08 CSP, JAA/ System D&F Steering group, October 15, 2002.

2. "Draft AC/AMJ 25.1309", Initiated by System Design and Analysis HWG, Arsenal Version, 6/10/2002.

3. An Analysis of the Oxygen Protection Problem at Flight Altitudes Between 40,000 and 50,000 Feet, Final Report, prepared for the Federal Aviation Agency, Contract FA-955, by Blockley and Hanifan, February 20, 1961.

6. Neurological Sequelae of Prolonged Decompression, Aerospace Medicine, A.N. Nicholson and J.R. Ernsting, April 1967

7. Neurological Study of Simulated Decompression in Supersonic Transport Aircraft, Aerospace Medicine, J.B. Brierley and A. N. Nicholson, August 1969.

8. Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations, 1959-2002, Published by Boeing Commercial Airplane, May, 2003

9. Uncontained Engine Failure Fuselage Hole Analysis, Draft Technical Note, October 2001.

10. Uncontained Engine Damage Database, ACCESS 2000 Database, FAA UED v001, June 10, 2002.

11. “Factors Influencing the Time of Safe Unconsciousness (TSU) for Commercial Jet Passengers Following Cabin Decompression”, James G. Gaume, Aerospace Medicine, April 1970.

12. Society of Automotive Engineers (SAE) studies and their associated Aerospace Information Reports (AIRs) AIR1537, AIR4003, and AIR4770 (Draft).

13. "High Altitude air transport system symposium, May 23, 24, 1956, at the Institute of Aeronautical Sciences," OCLC: 1134264, Dr. E. G. Vail

14. "Reactions and Performance of Pilots Following Decompression by G. Bennett, Aerospace Medicine, February 1964.

15. Human Performance and Limitations in Aviation, Third Edition, R. D. Campbell and M. Bagshaw, Blackwell Sciences Ltd., pg. 25.

16. Effect of Physical Activity of Airline Flight Attendants on Their Time of Useful Consciousness in a Rapid Decompression, Douglas E. Busby, Arnold Higgins, and Gordon E. Funkhouser, FAA/CAMI, Aviation, Space, and Environmental Medicine, February 1976.

17. Fundamentals of Aerospace Medicine, 2nd edition, Roy L. Dehart, Williams and Wilkens Publishers, 1996, Table 5.12, pg.91.

18. "Hypoxia and Performance Decrement", William F. O'Connor, Ph. D., Jim Scow, M.D., George Pendergrass, Capt., USAF, DOT/FAA/AM 66-15, May, 1966.

19. Physiological Requirements by Dr. E.G. Vail, WADC, United States Air Force (USAF) - Presented at a USAF symposium on high altitude oxygen requirements in May 1956

20. International Civil Aviation Organization, Ninth Edition, July 2001.

Attachment B - Bibliography

1. "Prevention of Hypoxia – Acceptable Compromises", Aviation, Space, and Environmental Medicine, J. Ernsting, March 1978.

2. "Quick Response by Pilots Remains Key to Surviving Cabin Decompression", Stanley R. Mohler, M.D., Human Factors & Aviation Medicine, Vol. 47, No. 1, Jan.-Feb., 2000

3. "Concepts Providing for Physiological Protection After Aircraft Cabin Decompression in The Altitude Range of 60,000 to 80,000 Feet above Sea Level", Robert P. Garner, DOT/FAA/AM-99/4, Office of Aviation Medicine, February, 1999.

4. "Performance of a Continuous Flow Passenger Oxygen Mask at an Altitude of 40,000 Feet", Robert P. Garner, DOT/FAA/AM-96/4, February 1996.

5. "Rapid Decompression of a Transport Aircraft Cabin: Protection Against Hypoxia", H. Marotte, C.Toure, J.M. Clere, and H. Vieillefond, Aviation, Space and Env. Medicine, Jan., 1990.

6. "Effects of Decompression on Operator Performance", William F. O'Connor, Ph. D., George E. Pendergrass, DOT/FAA/AM 66-10, April, 1966.

7. "Behaviour of Naïve Subjects During Decompression: An Evaluation of Automatically Presented Passenger Oxygen Equipment", Chisholm DM, Billings CE, Bason R, Aerospace Medicine, February 1, 1974.

8. "Physiologically Tolerable Decompression Profiles for Supersonic Transport Type Certification", Stanley R. Mohler M.D. and P.V. Siegel M.D., DOT/FAA/AM 70-12, July 1970.

9. "Military Standard Climatic Extremes for Military Equipment, MIL-STD-21 OB."

10. Aerospace Information Report (AIR) No. 822 and 825A (Physiology Section); SAE Committee A-10.

11. AC 20-32B, Carbon Monoxide (CO) Contamination in Aircraft - Detection and Prevention.

12. AC 91-8B, Use of Oxygen by Aviation Pilots/Passengers. {Note: AC 91-8B, dated 4/7/82, was canceled by AC 61-107, dated 1/23/91 - Ed.}

13. {Sic} Bioastronautics Data Book, NASA SP-3006, National Aeronautics and Space Administration.

14. Reactions and Performance of Pilots Following Decompression, G. Bennett, Aerospace Medicine, 32:134, February 1961.

Attachment C - Associated Regulatory and Advisory Material

The pertinent sections from FAA 14 CFR 25, 2001, and JAA JAR-25, 2000 related to the certification of today's aircraft are as follows:

A. Airworthiness Standards, Transport Category Airplanes

FAR 25.841	Pressurized cabins
FAR 25.1443(d)	First aid oxygen
FAR 25.1447(c)(2) & (4)	Oxygen for flight deck crew and flight attendants
FAR 25.1441	Oxygen equipment and supply
FAR 25.1445	Equipment standards for the oxygen distributing system
FAR 25.1449	Means for determining use of oxygen
JAR 25.841	Pressurized cabins
JAR 25.1439	Protective breathing equipment
JAR 25.1441	Oxygen equipment and supply
JAR 25.1443	Minimum mass flow of supplemental oxygen
JAR 25.1445	Equipment standards for the oxygen distributing system
JAR 25.1447	Oxygen for flight deck crew and flight attendants
JAR 25.1449	Means for determining use of oxygen

Operating Requirements: Domestic, Flag, and Supplemental Operations

U.S. operators

121.329	Supplemental oxygen for sustenance; turbine engine powered airplanes
121.333.1	Supplemental oxygen for emergency descent and for first aid; turbine engine powered airplanes with pressurized cabins
121.336	Equipment standards
121.337	Protective Breathing Equipment
121.574	Oxygen for medical use by passengers http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-574.rtf
AC 120-43:	Influence of Beards on Oxygen Mask Efficiency http://www1.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/1ab39b4ed563b08985256a35006d56af/f9789ad5efc61df6862569ba00752817/$FILE/AC120-43.pdf
TSO-C78:	Crewmember Demand Oxygen Masks

	http://av-info.faa.gov/tso/Tsocur/C78.doc
TSO-C89:	Oxygen Regulators, Demand http://av-info.faa.gov/tso/Tsocur/C89.doc

Canadian operators,

Operational Standards-Airline Operations

705.71.1.1	Protective Breathing Equipment
705.71.1.2	First Aid Oxygen
705.94.1.1	Portable Oxygen
605.31(2)	Oxygen Equipment and Supply
605.32.1.1	Use of Oxygen

Operational Standards-Private Operator Passenger Transportation

604.40	Protective Equipment

European operators

JAR-OPS 1.760	First aid oxygen
JAR-OPS 1.770	Supplemental Oxygen -pressurized aeroplanes
JAR-OPS 1.770	Appendix 1 Oxygen – Minimum requirements for supplemental oxygen for pressurized aeroplanes
JAR-OPS 1.780	Protective Breathing Equipment

Airworthiness Standards and References

The pertinent FAA major category, Title 14, 2001, constituting the certification of today's aircraft are as follows:

FAR 25.365 (e), (f)	
FAR 25.571 & ACs	Damage-tolerance and fatigue evaluation of structure
FAR 25.1309 & ACs	Equipment, systems, and installations

Crew Duties and Training in the Event of Emergencies

FAR 121.391 Flight attendants (duties)
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-391.rtf

FAR 121.397 Emergency and emergency evacuation duties
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-397.rtf

FAR 121.417 Crewmember emergency training
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-417.rtf

FAR 121.427 Recurrent training
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-427.rtf

FAR 121.557 Emergencies: Domestic and flag operations
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-557.rtf

121.559 Emergencies: Supplemental operations
http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-559.rtf

FAR 121.587 Closing and locking of flight crew compartment door

http://www.faa.gov/avr/afs/cabinsafety/FAR's/121-587.rtf

AC 120-48 COMMUNICATION AND COORDINATION BETWEEN FLIGHT CREWMEMBERS AND FLIGHT ATTENDANTS
http://www1.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/1ab39b4ed563b08985256a35006d56af/ffeb9277f3866c5b862569f1005f7eb6/$FILE/AC120-48.pdf

ACOB 205 DUTY ASSIGNMENT OF REQUIRED AND NON-REQUIRED FLIGHT ATTENDANTS
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB205.rtf

ACOB 207 PREDEPARTURE CABIN EQUIPMENT CHECKS BY FLIGHT ATTENDANTS
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB207.rtf

ACOB 223 FLIGHT ATTENDANT TRAINING ON CONDITIONS OF AIRCRAFT FOLLOWING AN ACCIDENT
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB223.rtf

ACOB 225 Training of Cockpit and Cabin Crewmembers on the Operational Characteristics of Chemically Generated Supplemental Oxygen System and Updating of Passenger Briefing Information
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB225.rtf

ACOB 226 PREPARATION OF CABIN FOR IMPENDING EMERGENCY LANDING
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB226.rtf

ACOB 227 FLIGHT ATTENDANT RESTRAINT DURING A CRASH AND EMERGENCY EVACUATION SECOND CHOICE EXIT DETERMINATION
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB227.rtf

ACOB 229 FLIGHT ATTENDANT TRAINING ON THE USE OF COCKPIT EMERGENCY EQUIPMENT
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB229.rtf

ACOB 231 CREWMEMBER CABIN SAFETY TRAINING
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB231.rtf

ACOB 928 Crewmembers Procedures for Assessing Damage to Aircraft In flight (flight attendant reporting hazardous conditions)
http://www.faa.gov/avr/afs/cabinsafety/ACOB's/ACOB928.rtf

ACOB 979 Require any Crewmember who Observes a Potential or Actual Emergency Situation to Verbally Call it to the Captain's Attention
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HBAT 98-18 Air Carrier Manual Instructions Concerning Minimum Equipment List Conditions and Limitations
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HBAT 98-26 Flight Attendants Operating Experience
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FSAT 95-27 Use of Oxygen Mask by Cabin Crew During Decompression
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FSAT 97-02: Approval of Flight Attendant Training Programs and Acceptance of Flight Attendant Manuals (inspector approval).
(Especially pages 3-2127 Use of Oxygen and 3-2132 f/a actions)
http://www.faa.gov/avr/afs/faa/8400/8400_vol3/3_015_06.pdf

Attachment D - Definitions List

Continuous Flow Oxygen System. The oxygen system usually provided for passengers. The passenger mask typically has a reservoir bag, which collects oxygen from the continuous flow oxygen system during the time when the mask user is exhaling. The oxygen collected in the reservoir bag allows a higher inhalation flow rate during the inhalation cycle, which reduces the amount of air dilution. Ambient air is added to the supplied oxygen during inhalation after the reservoir bag oxygen supply is depleted. The exhaled air is released to the cabin.

Decompression event – An event consistent with the complete loss of cabin pressure in 20 to 60 seconds**.**

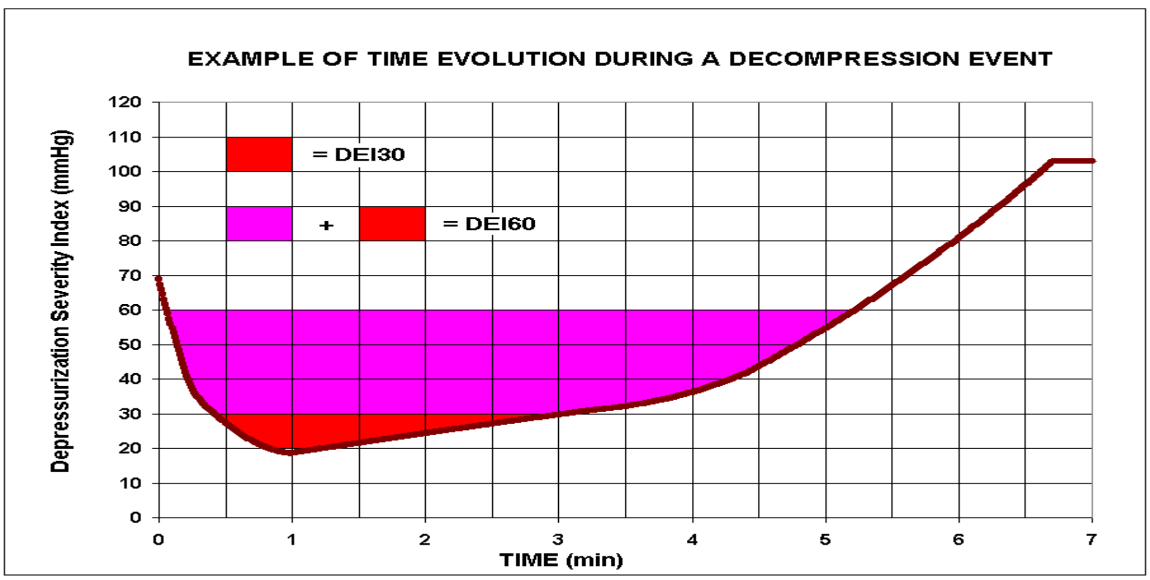
Depressurization Severity Indicator (DSI) **-** A pressure parameter indicative of the severity to the occupants due to an aircraft depressurization event. It is defined as a function of aircraft cabin pressure, see (reference for set of equation 4). This definition has been chosen to be an estimate of the partial pressure of alveolar oxygen below 25 000 ft, see (DeHart reference).

Depressurization Exposure Integral (DEI) - The time integral of the DSI over a selected period of the depressurization event

DEI30 - DEI for the selected period corresponding to a DSI value below 30 mmHg

DEI60 - DEI for the selected period corresponding to a DSI value below 60 mmHg

The Figure below graphically depicts the DEI for an event where the cabin pressure reaches 51,000 feet pressure altitude. Note that the integral is calculated based upon the difference in DSI and the given reference condition (i.e., 30 mmHg).



Diluter Demand Oxygen System. A flight deck crew oxygen system consisting of a close-fitting mask with a regulator that supplies a flow of oxygen dependent upon cabin altitude. Regulators approved for use up to 40,000 feet are designed to provide zero percent cylinder oxygen and 100 percent cabin air at cabin altitudes of 8,000 feet or less, with the ratio changing to 100 percent oxygen and zero percent cabin air at approximately 34,000 feet cabin altitude. Regulators approved up to 45,000 feet are designed to provide forty percent cylinder oxygen and 60 percent cabin air at lower altitudes, with the ratio changing to 100 percent at the higher altitude. Oxygen is supplied only when the user inhales, reducing the amount of oxygen that is required.

Explosive decompression – complete loss of cabin pressure in 1 to 3 seconds.
The above definition is according to DOT/FAA Report DOT/FAA/AM-99/4, "Concepts Providing for Physiological Protection After Aircraft Cabin Decompression in the Altitude Range of 60,000 to 80,000 Feet above Sea Level", Robert Garner, February 1999:

Extremely Improbable Failures. - Extremely improbable failures are so unlikely that they need not be considered to ever occur, unless engineering judgment would require their consideration. The probability of occurrence is on the order of 1×10^{-9} or less. This category includes failures or combinations of failures that would prevent the continued safe flight and landing of the airplane.

First aid oxygen - The additional oxygen provided for the use of passengers, who do not satisfactorily recover following subjection to excessive cabin altitudes, during which they had been provided with supplemental oxygen.

Flight Level (FL) – Because of continuously changing atmospheric pressure, and because at any one time the pressure varies at different points of the earth's surface, the standard atmospheric pressure (1013.2 mb or 29.92 in Hg) is used as the datum pressure for en-route flying above a certain altitude. This altitude is referred to as the *transitional altitude*, above which vertical distance is referred to as a *flight level* (FL.). The flight level is stated in 3 digits, representing hundreds of feet. E.g. FL 290 means that the aircraft altimeter indicates 29,000 ft above standard pressure datum of 1013.2 mb. Reference: Human Performance & Operating Limitations in Aviation, by M. Bagshaw, Chapter 2, p. 12.

Hypoxia. - Hypoxia is an insufficient supply of oxygen. Hypoxia results from the reduced oxygen partial pressure in the inspired air caused by the decrease in barometric pressure with increasing altitude.

Improbable Failures. - Improbable failures are not expected to occur during the total operational life of a random single airplane of a particular type, but may occur during the total operational life of all airplanes of a particular type. The probability of occurrence is on the order of 1 x 10-5 or less, but greater than 1 x 10-9. The consequences of the failure or the required corrective action must not prevent the continued safe flight and landing of the airplane.
Pressure Demand Oxygen System – Similar to diluter demand equipment, except that oxygen is supplied to the mask under pressure at cabin altitudes above approximately 34,000 feet. This pressurized supply of oxygen provides some additional protection against hypoxia at altitudes up to 40,000 feet.

Permanent physiological harm – Physical or mental damage (death, injury, or illness) to an organism's healthy or normal functioning that continues or endures without fundamental or marked change.

Probable Failures. – Probable failures may be expected to occur several times during the operational life of each airplane. The probability of occurrence is on the order of 1 x 10-5 or greater (see Advisory Circular

25.1309-1A). The consequences of the failure or the required corrective action may not significantly impact the safety of the airplane or the ability of the crew to cope with adverse operating conditions.

Rapid decompression – complete loss of cabin pressure in 30 to 60 seconds.
The above definition is according to DOT/FAA Report DOT/FAA/AM-99/4, "Concepts Providing for Physiological Protection After Aircraft Cabin Decompression in the Altitude Range of 60,000 to 80,000 Feet above Sea Level", Robert Garner, February 1999:

Response time – The crew recognition and reaction time that is applied between the cabin altitude warning and the initiation of the emergency descent procedure, that includes the donning of O2 masks by the pilots, isolation of failure, configuration of the airplane for descent and initiation of the emergency descent.

Supplemental oxygen – The additional oxygen required to protect each occupant against the adverse effects of excessive cabin altitude and to maintain acceptable physiological conditions during and after decompression.

Time of Safe Unconsciousness (TSU) – The period of time that a person may be rendered unconscious from oxygen deficiency without production of permanent neurological damage or other health problems. (Reference: Concept Providing for Physiological Protection After Aircraft Cabin Decompression in the Altitude Range of 60,000 to 80,000 Feet above Sea Level, Robert P. Garner, Feb., 1999.)

Time of Useful Consciousness (TUC) – The maximum length of time during which an individual can carry out some purposeful activity following a loss of oxygen supply. It is also referred to as the effective performance time (EPT), which is defined as the length of time an individual is able to perform useful flying duties in an environment of inadequate oxygen. (Reference: Human Performance and Limitations in Aviation, R.D. Campbell & M. Bagshaw, 2002)

Uncontained Engine Rotor Failure. – The failure of any rotating part(s) of an engine, including blades, impellers, rim and spacer pieces, seals and spacers, drums, and disc segments, that is subsequently released outside of the main engine compartment (nacelle).

Unhealthy passenger – An airplane occupant other than a crew member who is at elevated risk of permanent physiological harm, the result of exposure to hypoxic conditions following a rapid decompression event, due to one or more pre-existing respiratory (e.g., restrictive or obstructive airway diseases) or circulatory (e.g., peripheral vascular disease, anemia) impairments.

Center'' and adding, in their place, the words ''Natural Sounds Program Office.''

Sec. 6. Organization and Administration [Amended]

3. Section 6.a is amended by removing the words ''The general membership of the NPOAG will be composed of a representative of general aviation (two members), commercial air tour operators (two members),'' and adding, in their place, the words ''The general membership of the NPOAG will be composed of a representative of general aviation (one member), commercial air tour operators (three members).''

4. Section 6.b is amended by removing the words '' The term of office will be staggered as follows: One general aviation representative, one commercial air tour operator representative, two environmental representatives and one Native American representative will serve for a period of two years from the date of this charter. The remaining representatives will serve a three-year term from the date of this charter. Thereafter, the term of each office for each member will be three years. Those individuals chosen for the initial two-year term will be selected either by volunteering for a two-year term, or by blind draw,'' and adding, in their place, the words ''Membership will continue with individuals already serving on the NPOAG, at the request of the Administrator and the Director. The term of office for each member will be three years. The three year membership begins on the original date of appointment.''

5. Section 6.c is amended by removing the words ''The first members of the NPOAG are listed in Attachment A to this order.''

Sec. 8. Meetings [Amended]

6. Section 8 is amended by removing the words ''The schedule for regular meetings will be set by the Chairperson after consideration of recommendations from the group'' and adding, in their place, the words ''The Chairperson will set the schedule for regular meetings, after consideration of recommendations from the group.''

7. Section 8 is also amended by removing the words ''The meeting location will be set by the Chairperson after considering recommendations from the group'' and adding, in their place, the words ''The Chairperson will set the meeting location after considering recommendations from the group.''

Sec. Addendum to: The National Parks Overflights Advisory Group Aviation Rulemaking Advisory Committee Order

1110.38 [Removed]

General Aviation Representatives

David Kennedy—National Air Transportation Association.
Heidi Williams—Aircraft Owners and Pilots Association.

Commercial Air Tour Operators Representatives

Lash Larew—ERA Helicopter, USATA, HAI.
Alan Stephen—Grand Canyon Airlines.

Environmental Concerns Representatives

Steven Bosak—National Parks Conservation Association.
Chip Dennerlein—State of Alaska Fish and Game.
Susan Gunn—The Wilderness Society.
Charles Maynard—Friends of the Smokies.

Native American Tribes Representatives

Richard Deertrack—Native American Tribes.
Germaine White—CS and KT Tribes.

Issued in Washington, DC, on March 23, 2005.

Barry Brayer,

Manager, Executive Resource Staff, Western-Pacific Region.

[FR Doc. E6–4793 Filed 3–31–06; 8:45 am]

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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[Policy Statement No. ANM–03–112–16]

High Altitude Cabin Decompression Interim Policy (Reference Amendment 25–87)

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of final policy.

SUMMARY: The Federal Aviation Administration (FAA) announces the availability of final policy that provides FAA certification policy on the compliance issues associated with high altitude flight.

DATES: The final policy was issued by the Transport Airplane Directorate on March 24, 2006.

FOR FURTHER INFORMATION CONTACT: Stephen Happenny, Propulsion and Mechanical Systems Branch, ANM–112, Federal Aviation Administration, Transport Airplane Directorate, Transport Standards Staff, 1601 Lind Avenue, SW., Renton, WA 98055–4056; telephone (425) 227–2147; fax (425) 227–1232; e-mail: *stephen.happenny@faa.gov*

SUPPLEMENTARY INFORMATION:

Discussion of Comments

A notice of proposed policy was published in the **Federal Register** on May 30, 2003 (68 FR 32570). Five (5) commenters responded to the request for comments.

Background

The policy provides applicants with information on how the FAA will evaluate petitions for exemption from § 25.841(a), as amended by Amendment 25–87. For airplanes with wing-mounted engines, this regulation in effect limits the maximum operating altitude of airplanes approved to this standard to 40,000 feet. An Aviation Rulemaking Advisory Committee (ARAC) recommended that the FAA to develop a new safety standard, which is being addressed in rulemaking activities. That committee also asked for interim policy to be used during the rulemaking process, to provide relief because high altitude operations offer benefits in terms of reduced fuel consumption and better airspace utilization. This policy applies to the regulatory provisions regarding cabin pressure failures caused by uncontained engine failures. This policy does not provide relief from the regulatory cabin pressure limits for the more common types of failures (*i.e.*, environmental systems and structural failures).

The final policy as well as the disposition of public comments is available on the Internet at the following address: *http://www.airweb.faa.gov/rgl.* If you do not have access to the Internet, you can obtain a copy of the policy by contacting the person listed under **FOR FURTHER INFORMATION CONTACT.**

Issued in Renton, Washington, on March 24, 2006.

Ali Bahrami,

Manager, Transport Airplane Directorate, Aircraft Certification Service.

[FR Doc. 06–3174 Filed 3–31–06; 8:45am]

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