DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. 26070, Amendment No. 25–87]

RIN 2120–AB18

Standards for Approval for High Altitude Operation of Subsonic Transport Airplanes

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: This amendment to the Federal Aviation Regulations (FAR) specifies airplane and equipment airworthiness standards for subsonic transport airplanes to be operated up to an altitude of 51,000 feet. This action is prompted by an increase in the number of applications received to raise the maximum certificated operating altitude for transport category airplanes, and is intended to ensure an acceptable level of safety for airplanes operated at high altitudes.

EFFECTIVE DATE: July 5, 1996.

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SUPPLEMENTARY INFORMATION:

Background

This amendment is based on Notice of Proposed Rulemaking (NPRM) No. 89–31, which was published in the Federal Register on November 22, 1989 (54 FR 48538). The notice proposed to upgrade airplane and equipment airworthiness standards for subsonic transport airplanes to be operated up to an altitude of 51,000 feet, and it was based on special conditions that have been used for type certification for many years.

Current policy for FAA rulemaking projects is to endeavor to achieve harmonization with the Joint Airworthiness Authorities (JAA) and other airworthiness authorities through the Aviation Rulemaking Advisory Committee (ARAC) and its harmonization working groups. Although this rulemaking project has not been the subject of a harmonization working group activity, because it was initiated prior to the time harmonization became a high priority with the FAA and JAA, comments received from the JAA members were addressed in this amendment.

As noted in Notice 89–31, the higher operational altitudes made feasible by the advent of turbojet transport airplanes introduced certain risks with respect to crew and passenger breathing that were not experienced with earlier propeller-driven airplanes. Accordingly, certification 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 42,000 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 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 this amendment codify and consolidate the different high-altitude criteria that have been made applicable by special conditions to previously certificated subsonic transport airplanes. In addition, the changes acknowledge a human physiological limit of 34,000 feet (see Glossary), the level above which persons not using supplementary oxygen are in serious peril. To assure compatibility or equivalency with other provisions of part 25, which were amended after many of the special conditions discussed herein were implemented, these changes are written so that terminology relating to the probability of certain failures is consistent with those other provisions. Generally, the intent of those provisions is to recognize that the degree of hazard of any given failure is inversely related to the probability of occurrence of that failure. Failures that are considered to be catastrophic must be shown to be extremely improbable, and hazardous failures must be shown to be improbable (see Glossary). Examples of these terms are found in §§ 25.671, 25.672, and 25.1309.

It must be noted that widespread operation of transport category airplanes at altitudes greater than 51,000 feet is not currently envisioned. A major factor in an approval for operation up to 51,000 feet is an emergency descent during a decompression, which must be shown to result in a maximum cabin altitude of no more than 40,000 feet. Accordingly, the changes adopted in this amendment have been developed to provide adequate standards for safe operation of such airplanes up to 51,000 feet. Should an applicant seek approval to operate a transport category airplane above that altitude, additional standards may be needed for safe operation. If so, appropriate special conditions would be adoptive to require compliance with those standards.

The changes in this amendment involve ventilation, cabin cooling, pressurization and pressure vessel integrity, and oxygen equipment. The following paragraphs describe the changes, and the reasons for the changes, in the regulations incorporated with the adoption of this amendment. The comments received in response to Notice 89–31, the disposition of the comments, and, when applicable, the effect of the comments on the changes, are discussed immediately following this section.

1. Ventilation (Airflow and Contamination)

Prior to this amendment, § 25.831(a) required each passenger and crew compartment to be ventilated and each crew compartment to have enough fresh air to enable crewmembers to perform their duties without undue discomfort or fatigue. For the crew compartment, a minimum of 10 cubic feet of fresh air per minute per crewmember was required. Section 25.1309 (specifically §§ 25.1309(b)(2) and 25.1309(d)(3)) requires that the effects on occupants of any failures of required systems be analyzed, but § 25.1309 is a general rule and does not specifically address minimum airflow requirements.

The executive transport special conditions that have been applied in the past supplemented § 25.831(a) by specifying that the minimum fresh airflow of 10 cubic feet per minute (cfm) per crewmember was to be provided to each occupant during normal operation. The special conditions also required that each occupant be furnished with enough uncontaminated air to provide reasonable comfort during normal operating conditions and also after any probable failure of any system that would adversely affect the cabin ventilation air. This rule amends § 25.831 to include the additional airflow requirements contained in previous special conditions, stipulating that the ventilation system must be designed to provide 10 cfm (converted to pounds of air) for each occupant.

Some airplanes now incorporate ventilation systems in which fresh air is augmented with conditioned and recirculated air. Section 25.831(a) as amended permits a ventilation system that uses a mixture of the minimum amount of fresh air and any desired quantity of recirculated air that is shown to be uncontaminated by odors, particulates, or gases. In this regard, the minimum amount of fresh air is specified by weight rather than by volume in order to provide a parameter independent of altitude. Ten cubic feet of standard air at a typical cabin altitude of 8,000 feet and typical cabin temperature of 75°F. weighs approximately 0.55 pounds. This rule amends § 25.831 to include the additional airflow requirements as noted above. This standard is equivalent to the present requirement for crewmembers.

2. Cabin Cooling

During the Supersonic Transport (SST) review in the 1960s, it was noted that certain pressurization system failures, whether considered by themselves 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 (see Glossary). 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 which 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 are adopted as a new § 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.

3. Pressurization and Pressure Vessel Integrity

Section 25.365(d), increases the fuselage pressure relief valve safety factor of 1.33 by 25 percent to 1.67, codifying the standard that was originally contained in the SST special conditions. This increased structural safety factor was also included in the executive transport special conditions to reduce the likelihood of structural failure and to limit the size of the opening if a failure occurs. It is included in this amendment for this reason.

The FAA had considered proposing both pressurization standards similar to those previously required by the special conditions for executive transport and separate standards similar to those required for large transport airplanes. The separate standards were thought to be necessary because of the inherent differences in pressurized volume of the two types of transports, and the belief that a larger airplane may decompress more slowly than a smaller airplane. Upon further review, this approach was deemed impractical because certain larger transport airplanes have decompression characteristics more analogous to smaller transport airplanes and vice versa. Therefore, this amendment applies the same standard to all transport airplanes.

It should be noted that the special conditions required consideration of specific failures, which are addressed later in this discussion. Subsequent to the issuance of the special conditions, reliability, probability, and damage tolerance concepts addressing other failures and methods of analysis were incorporated into part 25. This amendment allows the use of these additional methods of analysis and failure considerations.

The earlier executive transport special conditions required a pressure demand mask (see Glossary). Later special conditions included, pursuant to the recommendations of the FAA Civil Aeromedical Institute (CAMI), a requirement for a pressure demand mask with a mask-mounted regulator (see Glossary). The requirement for the use of the same type of equipment is adopted by this amendment.

The objective of the amended § 25.841(a) (pressurization) when applied in conjunction with amended § 25.1447(c) (oxygen equipment) is to provide airworthiness standards that allow subsonic airplanes to operate at their maximum achievable altitudes. This is the highest altitude for which an applicant chooses to demonstrate that, after decompression caused by a single failure or combination of failures that are not shown to be extremely improbable: (1) the flightcrew will remain alert and be able to fly the airplane; (2) the cabin occupants will be protected from the effects of hypoxia; and (3) in the event that some occupants do not receive supplemental oxygen, they nevertheless will be protected against permanent physiological damage.

Section 25.841(a)(1) as amended is equivalent to the existing § 25.841(a) with the exception of editorial changes and elimination of the words ‘‘reasonably’’ and ‘‘or malfunctions.’’ The ‘‘probable’’ failure criteria are the same as those contained in § 25.1309. The term ‘‘failure conditions’’ has been added to this section to clarify that failure combinations that lead to a probable depressurization event must also be considered.

Section 25.841(a)(2) as amended limits exposure of the airplane occupants, after decompression, to a cabin altitude no greater than 40,000 feet. This requirement is unchanged from that previously established in part 25 for certification of transport category airplanes using diluter demand (flightcrew) and continuous flow (passenger) oxygen equipment (see Glossary).

Section 25.841(a)(2) as amended is a combination of the later executive transport high altitude special conditions and § 25.1309, i.e., the degree of the hazard must be inversely related to the probability of the failure condition. The amended § 25.841(a)(2) was developed from the recommendations of CAMI and is based on the concept of ‘‘Time of Safe Unconsciousness’’ documented by James G. Gaume (see Reference 1). The use of continuous-flow oxygen masks by passengers following rapid decompression to cabin altitudes above 34,000 feet may fail to provide protection from hypoxia, as noted in the discussion under Paragraph 4. ‘‘*OXYGEN EQUIPMENT*,’’ below. Additionally, some passengers might be exposed to high cabin altitudes following decompression without the use of oxygen. A few passengers may lose consciousness at 34,000 feet cabin altitude, and more may lose consciousness at greater altitudes even with the use of continuous-flow oxygen equipment. Exposure to cabin altitudes in excess of 25,000 feet for more than 2 minutes without supplemental oxygen may cause permanent physiological (brain) damage. Therefore, in order to demonstrate compliance with this rule, approved emergency descent procedures and a cabin altitude analysis must be prepared to ensure that these altitude limits are not exceeded following a decompression failure that is not shown to be extremely improbable.

Section 25.841(a)(3) as amended describes the failure conditions that must be considered in evaluating cabin decompression. Possible modes of failure to be evaluated include malfunctions and damage from external sources such as tire burst, wheel failure, uncontained engine failure, engine fan, compressor or turbine multi-blade failure, and loss of antennas. Sections 25.1309 and 25.571, and associated advisory material, provide guidance in determining the sources of failure. System failures (both latent and active), combinations of system failures, system failures combined with pressure vessel leaks, system failures causing engine shutdown, uncontained engine failures causing structural and system damage, and structural failures without system failures must all be evaluated. Typical systems include engine bleed air systems, air conditioning systems, power sources, outflow valves and control systems. Failures which expose the occupants to cabin altitudes in excess of either 25,000 feet for more than 2 minutes or 40,000 feet for any amount of time must be shown to be extremely improbable.

The executive transport airplane special conditions required evaluation of uncontained engine failure (including fan, compressor and turbine blades, and rotor disc) and complete loss of thrust from all engines. The FAA policy has been to presume that these failures will occur and permit the use of analytical methods to assess the damage. Multiple engine failures have occurred because of secondary effects from uncontained engine failure and from operational errors. Multiple fan blade, rotor, and other uncontained engine failures have occurred during cruise conditions and have caused cabin decompression. The service history of airplane decompressions resulting from uncontained engine failure has been acceptable. Flight levels for most transport airplanes have been at an altitude where oxygen equipment is capable of providing adequate protection. Uncontained engine failure is most likely to occur during takeoff and climb; however, approximately 20 percent of the known bursts have occurred in cruise mode, not including those caused by bird strikes. The possibility of an uncontained engine failure in cruise mode cannot be ignored, and the damage resulting in depressurization must be assessed.

Structural failures in large transport airplanes which would result in decompression are generally considered to include a loss of a typical skin panel bound by a crack stopper pattern, a door seal, window, or windshield, unless the design is such that loss of the windshield is shown to be extremely improbable when operating at the higher altitudes. Structural failures in executive transport airplanes leading to decompression, discussed in the various special conditions, included the following:

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 in accordance with § 25.841(a).

2. 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.

3. Pressure vessel openings resulting from tire burst, uncontained engine failure, loss of antennas, or stall warning vanes, or any probable equipment failure. The effects of such damage while operating under maximum cabin pressure differential must be evaluated.

Subsequent to the initial development and issuance of high altitude special conditions, § 25.571 was amended by Amendments 25–45 (1978) and 25–52 (1980) to require damage-tolerance and fatigue evaluation of airplane primary structure. Section 25.571 requires showing that a catastrophic failure due to fatigue, corrosion, or accidental damage will not occur throughout the operational life of the airplane (§ 25.571 (a)). The effects that are required to be considered under § 25.571 are not limited to depressurization. Compliance with § 25.571 requires the development of inspection intervals and procedures for the detection of crack lengths associated with the decompression of critical vent areas. Any event that would expose the occupants to cabin pressure altitudes in excess of the limits established under this amendment must be shown to be extremely improbable.

In demonstrating compliance with proposed § 25.841, the crew would presumably perform an emergency descent in accordance with an approval emergency procedure. The time required for the crew to recognize a decompression emergency and don their oxygen masks has been established by tests to be 17 seconds. This 17-second delay is imposed between the cabin altitude warning and the beginning of action for descent. The critical failure case (probable system failure) must be demonstrated by system failure tests at the maximum airplanes altitude. For improbable failure, the cabin altitude can be established by analysis, and verified, if necessary, by tests at a much lower altitude, with the results extrapolated to the higher altitude.

4. Oxygen Equipment

Both diluter demand and pressure demand oxygen equipment have proven satisfactory for cabin pressure altitudes of 40,000 feet or less when the person using the oxygen equipment is exposed gradually to increased altitudes. However, the FAA was concerned that rapid decompression to cabin pressure altitudes that exceed 34,000 feet could temporarily negate the protective qualities of such equipment, unless the mask and oxygen are being used prior to the decompression, leading to moderate to severe decreases in flightcrew performance. To prevent such performance decrements, Notice 89–31 proposed that the use of 100 percent oxygen be required by this amendment for flightcrews operating at airplane altitudes which may expose them to cabin altitudes exceeding 34,000 feet following a pressurization failure. As discussed below, in response to public comment, this requirement has been removed pending further study by the FAA.

Prior to this amendment, § 25,1447(c)(3) required that each washroom be equipped with two oxygen outlets and two units of dispensing equipment. The term washroom has been replaced in other sections of part 25. This reference is deleted for consistency, and the existing provisions of § 25,1447(c)(3) are incorporated into a revised § 25.1447(c)(1). The amended regulation does not specify demand equipment under § 25.1447(c)(2), because § 25.1447(c)(3)(i) as amended allows the option of using either diluter demand or pressure demand equipment for airplanes to be operated above an altitude of 25,000 feet, and § 25,1447(c)(3)(ii) as amended requires pressure demand equipment for airplanes where decompression may expose the flightcrew to cabin altitudes in excess of 34,000 feet.

Discussion of Comments

Comments were received from foreign and domestic airplane manufacturers, foreign government agencies, various trade organizations representing employee groups, and individuals. The majority of the commenters support the proposals but many suggest changes. Many commenters recommend editorial, organizational, and clarifying comments which would result in clearer language.

Several commenters recommend removing the proposed change to § 25.365(d) that would require a safety factor of 1.67 times the structural design pressure differential loads corresponding to the maximum relief valve setting for airplanes to be approved for operation above 45,000 feet. One commenter notes that the pressure vessel structural design is based on fatigue loads and their effect on crack propagation. Another commenter expresses the opinion that, as the justification for the margin increase is concerned with damage tolerance rather than static strength, the FAA should attack the problem through damage tolerance requirements rather than static strength. This commenter also states that the damage tolerance requirements, even at altitudes below 40,000 feet, lead to stress levels sufficiently low so that the 1.67 requirement is ''likely to be complied with.'' A third commenter recommends changing the wording to remove the 1.67 factor, substituting a requirement that thermal effects on structural components and materials must be accounted for. The FAA does not concur that the higher factor is not necessary for airplanes operating at altitudes above 45,000 feet. A rapid decompression at altitudes above 45,000 feet could be catastrophic to the passengers. Therefore, this event must be extremely improbable; i.e., it is not expected to occur during the lifetime of an entire fleet of airplanes. Service history, however, shows that decompressions at higher altitudes are not extremely remote events even for airplanes assessed to the damage tolerance criteria. Loss of cabin pressure at lower altitudes has not been catastrophic to the passengers from environmental effects due to the higher ambient pressures and relatively short time for emergency descent. Although application of damage tolerance techniques will reduce the incidence of pressure vessel failures in service, there is no reason to expect that current methodology will preclude all future failures. To address these concerns, the FAA has determined that requiring the higher safety factor of 1.67 will reduce the probability of structural failures which could result in depressurization. The static factor of 1.67 is not appropriate to account for thermal effects because not all parts are subjected to the same temperature and also materials may not be affected to the same degree. The current § 25.603(c) already requires that the effects of temperature be accounted for in determining material properties. Section 25.365 is, therefore, amended as proposed.

Two commenters note that the probability terminology regarding proposed §§ 25.831 (c), (d), and (g) is not consistent with that found in regulatory and advisory material associated with § 25.1309. The FAA concurs with these comments. The terminology in the amendment is changed to address failure conditions rather than failures or failure combinations as proposed.

One commenter recommends allowing the fresh air requirements proposed to be required under § 25.831(a) to remain a crewmember requirement only. The FAA does not concur with this recommendation. It has been determined that this level of airflow is required for several reasons. Members of the flightcrew performing their functions in the passenger cabin are not sedentary and must perform their duties without undue discomfort or fatigue. In addition, fresh airflow has been determined to be necessary to provide adequate smoke clearance in the event of smoke accumulation due to a system failure or fire. However, it is clear that the additional airflow is not required at all times and under all operating conditions. Therefore, the wording in the final rule has been changed to state that the ventilation system must be *designed* to provide the fresh airflow. This also addresses concerns regarding the low fresh airflow capability that occurs during descent at low power levels.

Two commenters note that the fresh air requirement should be 0.55 pounds of fresh air per minute per occupant rather than the 0.6 pounds proposed in the notice. The FAA ''rounded off'' the value for mass flow from 0.55 to 0.6 pounds of fresh air per second when proposing the rule. Recognizing that this constitutes an increase in the level of safety not originally intended by the FAA, and noting that the added fresh air must be supplied at some specific cost, the final rule is changed to require that the airplane ventilation system be designed to provide 0.55 pounds of fresh air per minute per occupant. Another commenter recommends that the FAA use 0.5 pounds per minute per occupant rather than 0.6, noting that the Civil Aviation Authorities (CAA) and other airworthiness authorities use 0.5 pounds per minute. The FAA has determined that the 10 cubic feet per minute, converted to 0.55 pounds per minute as noted above, provides an acceptable minimum airflow. The commenter provides no data to support the recommendation. The rule is issued with the change noted above.

The same commenter notes that the notice does not contain clear requirements for airflow following failures. The commenter further notes that the JAA provides guidance in ACJ 25.831(e) regarding this matter. The FAA has not determined that a need exists to define the ventilation requirements following failures. The ventilation rates following various failures conditions were not addressed either in previously issued special conditions or Notice 89–31. In addition, the commenter did not provide any data in support of his proposal other than that it exists in advisory material in other airworthiness standards.

One commenter states that 0.6 pounds of fresh air per occupant is impractical and unjustified for commuter airplanes because available engines do not provide sufficient bleed flow to meet the new requirement. The FAA does not concur that this proposal is impractical or unjustified. This rule will not apply to existing airplanes. When new airplanes are designed and certificated, propulsion systems are available that can provide adequate bleed air to meet these requirements. The FAA has determined that health and safety considerations justify the new requirements for airplanes operating at all altitudes.

Further, the commenter states that the changes proposed for §§ 25.831 (c) and (d) will require an increase in reliability requirements that is not justifiable for airplanes certificated for altitudes below 40,000 feet. This commenter believes that the existing wording, ''reasonably probable,'' is not equivalent to the proposed wording, ''not extremely improbable.'' The FAA concurs with the commenter, and has determined that these changes are not needed. Therefore, because these were the only proposed changes to §§ 25.831 (c) and (d), the final rule has been revised to remove the changes to these sections.

Two commenters recommend either removing or defining the word ''uncontaminated'' as used in the proposed § 25.831(a), noting that the term is too vague, and might well be impossible to meet in, for instance, the case where the airplane is operating in an environment which itself contains contaminants, as might be the case near some airports in congested areas, the FAA does not concur with the comment. Descriptive wording is often used when the desire is to present objective design standards. The intent in this case is to ensure that the system designer will consider the need to provide an environment conducive to crew and passenger comfort. The FAA has prepared and plans to release advisory material to provide more detailed guidance for use in finding compliance with this rule.

One commenter recommends removing both the proposed and the existing §§ 25.831 (c) and (d), stating that the sections are ambiguous and that the requirement that the systems perform their intended functions under all foreseeable (normal and failure) conditions is addressed in § 25.1309. The FAA does not concur. As noted above, descriptive terminology is used to present design standards when specific requirements would be too inflexible and restrictive. Further, § 25.1309 is not intended to be the sole regulation for use in determining acceptability of system design when failure conditions exist. The FAA has found that individual rules are desirable when addressing specific functions, such as those governing ventilation requirements, in order to ensure adequate consideration of the specific issues identified.

One commenter suggest changing the wording of the proposed § 25.831(d) from ''If the accumulation of hazardous quantities of smoke * * *,'' noting that in-service experience has shown that accumulation of smoke is reasonably likely. The FAA concurs that the accumulation of smoke in cockpits has occurred on numerous occasions, and is not an extremely improbable event. However, future designs may embody features that render smoke accumulation extremely improbable. Should a manufacturer be able to show such reliability, smoke evacuation should not be required to be demonstrated.

Two commenters note that protection from smoke in the cockpit cannot be ensured, even while wearing and using the crewmember oxygen equipment stipulated in the proposed § 25.1447(c)(3), unless an ''emergency pressure (1 to 3 inches of water) is provided to ensure positive mask pressure and flow into goggles.'' The FAA recognized that a positive pressure differential between the inside of the mask and ambient is desirable. Many existing regulators have a ''test'' or ''emergency'' position to provide the pressure differential noted above. However, the FAA does not concur that this approach needs to be required by regulation, and has not proposed such a change. For the purposes of this rulemaking, the preamble of Notice 89–31 merely notes that one of the advantages of the pressure demand mask is that, if either the 100 percent or the full positive pressure (sometimes called ''test'') setting is selected, protection from smoke within the cockpit would be provided. While the degree of protection is not identified, selection of either of these settings does eliminate the ambient air which is inspired with diluter demand masks, thus reducing the risk of smoke or fumes being inhaled by the wearer.

Three parties offer comments on the proposed new § 25.831(g). One commenter recommends continuing the time/temperature curve proposed for this section beyond 90 minutes, and recommends referring to the curve in the FAA SST ''white book,'' TENTATIVE AIRWORTHINESS STANDARDS FOR SUPERSONIC TRANSPORTS. Copies of the appropriate pages from that document have been added to the docket for this rulemaking action. The FAA infers that the commenter believes the curve should be extended to 200 plus minutes because that is the extent of the graph in the white book. The FAA does not concur with this comment. The curve in the white book actually ends at 90 minutes for a temperature of 90 degrees Fahrenheit (90 °F), although the actual graph grid extends to over 200 minutes. The FAA, in responding to comments on previously issued special conditions for high altitude operations, modified the SST time/temperature curve by increasing the allowable maximum temperature from 90 degrees to 100 degrees Fahrenheit to accommodate aircraft while operating in high ambient temperature conditions. It was noted that it would be difficult to meet the temperature maximums while operating on the ground with outside temperatures above 100 degrees. The end point on the proposed curve indicates that the exposure time to a temperature of 100 degrees Fahrenheit (100 °F) shall not exceed 90 minutes. The FAA has determined that the limits established by this curve are appropriate for improbable failure conditions. In addition, there were no other comments addressing the proposed time/temperature limits. Considering the above, the curve in the final rule is retained as proposed.

A second commenter states that this amendment is not justified for airplanes operating below 40,000 feet. The FAA infers that the commenter is recommending removing this proposal. The FAA does not concur that this change is unjustified. Excessive temperatures in the crew and passenger compartments can present a hazard to continued safe flight and landing for any airplane. Therefore, although this hazard is not regarded as sufficient to warrant retroactive application of these requirements to existing designs, these improvements in design standards are appropriate and cost effective for future designs. While this change was proposed primarily to codify existing special conditions for high altitude operation, it is also appropriate for airplanes certificated for operation at lower maximum altitudes. A third commenter recommends changing the proposed rule to clarify that the amended rule is directed at airplanes which utilize high temperature air to maintain pressurization following failure conditions. While the FAA concurs that the requirement, which originated in existing special conditions, was directed primarily at such airplanes, the amended rule is intended to apply to any failure condition that can result in excessively high temperatures. For the above reasons, § 25.831(g) is added as proposed.

One commenter recommends leaving the phrase ''Pressurized cabins and compartments to be occupied * * *'' in § 25.841(a) rather than changing it to ''Pressurized cabins and any other occupied compartments * * *'' as proposed. The commenter notes that this change is not addressed in the preamble to the proposal, and expresses concern that the change in wording might result in a change in interpretation. The FAA does not concur with this comment. This change in wording does not change the meaning of the Section, and, in the opinion of the FAA, is clearer.

One commenter recommends adding a section to the proposed § 25.841(a)(3) to note that ''Turbine engine installations failures must be assessed according to the specific requirements of § 25.903(d) * * *'' The FAA does not concur with this recommendation. It is not clear how adding this detail would clarify the requirements for assessing the damage resulting from an contained engine failure. Further clarification is considered to be appropriate for advisory material, and the FAA addresses uncontained engine failure in the advisory circular which was proposed concurrent with Notice 89–31.

One commenter states that the proposed § 25.841(a)(1) calls for ''an unjustified reliability increase relating to the pressurization system.'' The FAA infers that the commenter is requesting that the rule continue to address only those failures which are ''reasonably probable.'' The FAA does not concur. As noted earlier, reasonably probable has been interpreted by the FAA to include both the probable and improbable categories. For this reason, the new wording does not constitute an increase in the required reliability.

The same commenter states that the proposed § 25.841(a)(2) will be in conflict with the proposed § 25.841(a)(1). The FAA does not agree. Section 25.841(a)(1) addresses acceptable cabin pressure altitudes following probable failure conditions, while § 25.841(a)(2) addresses cabin altitudes following failure conditions not shown to be extremely improbable, i.e., probable and improbable failure conditions.

One commeter expresses the concern that the adoption of the proposed § 25.841(a)(2)(i), which limits exposure to cabin pressure altitudes exceeding 25,000 feet to a maximum of 2 minutes for failure conditions not shown to be extremely improbable, will result in ''severe restrictions on flight routes as well as maximum certification altitude.'' The commeter states that the proposed §§ 25.841(a)(2) and (a)(3) are proposed to address concerns regarding ''extremely rapid decompressions which may occur with small volume, high altitude (to 51,000 feet) executive transport airplanes,'' and recommends that the FAA remove these sections from the final rule. The FAA does not concur. While it is true that one of the reasons for formulating this rule change was to codify the certification requirements previously issued as special conditions for small volume transport category airplanes requesting approval for high altitude operation, the FAA has reviewed the service history of rapid depressurizations on all transport category airplanes including those with large pressurized volumes. Such events, while rare, do occur in service. The effects of exposure to altitudes above 25,000 feet for more than 2 minutes, or to an altitude above 40,000 feet for any period of time, are discussed in the preamble of the notice. If an applicant can show that failure conditions leading to excellence of these cabin altitudes are extremely improbable, there is no impact on operating altitude. As to having a significant effect on operating altitudes, this requirement does not affect airplanes already certificated, so there would be no ''more extensive requirements on the current commercial fleet.'' This commenter also recommends changing ''any probable failure or failure combinations'' to ''any probable failure or probable failure combination.'' As noted earlier, the FAA is changing the wording for both §§ 25.831 and 25.841 to ''failure conditions,'' which covers failures and combinations of failures, and more closely parallels § 25.1309 terminology.

One commenter recommends revising § 25.841(a)(1) to show that ''In case of dispatch with equipment inoperative per an approved Minimum Equipment List (MEL), only reasonably probable failures or reasonably probable failure malfunctions need be considered,'' when addressing the 15,000 feet maximum cabin altitude requirement of this section. The commenter notes that dispatch under an approved MEL with one of two air conditioning packs inoperative has been a safe practice. The FAA does not concur with this recommendation. The certification rules in part 25 do not address MEL dispatch. In the case of dispatch with one pack inoperative, the practice followed in recent certification projects has been to limit the operating altitude of an airplane dispatching under these conditions to that which has been demonstrated in that configuration considering the effect of potential failures. The FAA intends that this practice be continued under this rule.

One commenter suggests adding a new § 25.841(a)(2)(iii) reading ''Compliance with paragraph (i) is not required for cabin altitude versus time profiles where exposure above ten thousand feet does not exceed 10 minutes.'' The commenter notes that operating rules (§ 121.333(a)) assume that the airplane descends from the maximum altitude to 10,000 feet in ten minutes, and that permanent ill effects from hypoxia under present operating rules have been rare. Further, recent special conditions for the Beech Model 400A and British Aerospace Model BAe Model 125–1000A airplane contains cabin altitude versus time curves which support the ''ten minutes above 10,000 feet'' criteria. The FAA does not concur with the commenter's suggestion. The cabin altitude limitations stipulated in the special conditions were interim standards applicable to those airplanes only. Physiological data from CAMI have resulted in the FAA establishing the requirements for cabin altitudes as they are stated in the proposal. Adopting the commenter's proposal could result in an applicant being allowed to demonstrate compliance while showing exposures to cabin altitudes up to 40,000 feet for extended periods while still meeting the standards, which would be unacceptable. The FAA has determined that preventing the occupants from being exposed to cabin altitudes greater than 25,000 feet for more than 2 minutes or 40,000 feet for any duration will provide an acceptable level of safety at an acceptable cost.

This commenter also suggests adding a new § 25.841(a)(2)(iv) to allow the occupants to be exposed to cabin altitudes greater than 25,000 feet or 10,000 feet (if (iii) were adopted) when minimum flight altitudes make literal compliance with these sections impractical. The commenter is concerned that literal compliance with § 25.841(b) would result in prohibition of flight over the Himalayas or Andes, or in certain areas where minimum altitudes are stipulated. The FAA does not share this concern. The proposed rule requires design features to prevent the exposure of occupants to the high cabin altitudes in the presence of failure conditions. The ability to operate in areas where operational constraints dictate minimum flight altitudes is a function of operating rules and appropriate flight planning in terms of supplemental oxygen, etc. The certification rules do not address these considerations.

The same commenter recommends changing § 25.841(a)(3) to more precisely define the manner in which various causes of a decompression are treated, and suggests subparagraphs treating uncontained engine failure, fuselage structural failure, discrete source failure, and system failure separately. The FAA does not agree that these details are appropriate for inclusion in the certification rule. The FAA plans to provide guidance material regarding the manner in which the various failure cases may be addressed.

One commenter supports the rulemaking but states that ''Existing crew and passenger emergency oxygen systems in civil aircraft do not have sufficient pressure breathing capability to protect the individual for the required length of time for controlled descent to below 33,000 feet where, I believe, existing oxygen systems may function adequately for life support.'' The FAA infers from this comment that the commenter desires that this proposal contain new requirements for oxygen systems. The FAA does not agree with this commenter concerning equipment used by the flightcrew. The FAA has determined that the oxygen dispensing equipment required by this rule will provide adequate protection when the exposure envelopes are observed. The FAA shares the commenter's concern with respect to the passenger oxygen equipment. While the passenger equipment is certificated to operate to a pressure altitude of 40,000 feet, the physiological effects of decompression on the passengers may prevent the equipment from being effective in all cases. The alternatives would be to require the passengers to breathe 100 percent oxygen at the altitudes of concern or to prohibit operation at the higher altitudes. Breathing 100 percent oxygen by all passengers is considered to be an unacceptable solution from an operational standpoint, and the exposure envelopes adopted for this rule have been selected to mitigate the limitations of the passenger oxygen system. It is considered that developing new oxygen equipment standards to be included with this rule is unwarranted. The FAA has determined that operation at the altitudes addressed in this rule can be accomplished with an acceptable level of safety, and this rule has established cost effective means of attaining that goal.

One commenter suggests that the requirement in § 25.1447(c)(1) for automatic presentation of oxygen dispensing units if certification for operation above 30,000 feet is requested refer to 31,000 feet, as 30,000 feet (FL300) is not an authorized cruising altitude. The FAA agrees that this is not a cruising altitude. However, the FAA does not concur that it is inappropriate to stipulate a requirement for operation *above* 30,000 feet. Further, this requirement is unchanged from the existing rule.

A second commenter recommends amending § 25.1447(c)(1) by removing the requirement for supplemental oxygen for passengers if the cabin altitude limits in Notice 89–31 are adopted. The commenter states that it is not realistic to expect all passengers to utilize the oxygen system, and infers that if the limits proposed are adopted, the risk to healthy passengers is minimal. The FAA does not concur with this comment. If the FAA were to follow the commenter's logic, i.e., not to require passenger oxygen systems, the exposure envelope would limit the cabin altitude to 15,000 feet. Historical events and decompression tests indicate that supplemental oxygen is needed even when the cabin pressure altitudes required by this rule are observed. Further, this requirement is unchanged from the existing rule. No other comments were received on the proposed §§ 25.1447 (c)(1) and (c)(2) and they are adopted as proposed.

One commenter states that § 25.1447(c)(3) requires pressure demand masks for operation above 25,000 feet but the justification in the preamble of the notice states that diluter demand masks are acceptable up to 34,000 feet. The FAA does not agree with this comment. Section 25.1447(c)(3)(i) requires a diluter demand *or* pressure demand (pressure demand mask with a diluter demand pressure breathing regulator) type mask for airplanes to be operated above 25,000 feet. The pressure demand (pressure demand mask with a diluter demand pressure breathing regulator) type with a mask-mounted regulator is required for airplanes operated at altitudes where decompressions that are not extremely improbable may expose the flightcrew to cabin pressure altitudes above 34,000 feet.

One commenter recommends that the pressure breathing requirements of §§ 25.1447(c)(3)(i) and (ii) be detailed in the form of mask pressure versus cabin altitude curves. The commenter suggests that the current pressure breathing equipment specified under Technical Standard Order TSO–C89 may not be acceptable for cabin altitudes up to 45,000 feet. The commenter provides no rationale in support of his recommendation. The FAA does not concur. The type of data recommended by the commenter is appropriate to TSO requirements, and the revision to those documents is beyond the scope of this notice. Further, one of the purposes of this rulemaking is to provide protection by preventing exposure of the occupants to cabin altitudes above 40,000 feet. Masks and regulators are currently in use that meet the requirements in the curves submitted by the commenter for conditions up to that altitude.

One commenter notes that a pressure demand mask with a mask-mounted regulator may have different oxygen delivery percentage requirements under TSO–C89 depending on the altitude for which it is certificated. The commenter suggests that the rule clarify the mask and regulator requirements by stipulating the altitude to which the mask and regulator are approved under the TSO. The FAA does not concur with this suggestion. By specifying the type of oxygen equipment for the crew, and the manner of its use, the FAA has determined that the flightcrew will retain the ability to safely operate the airplane during a decompression.

One commenter suggests withdrawing the proposed § 25.1447(c)(3)(ii) because the equipment standards defined in TSO–C89 ''provide the necessary oxygen up to 40,000 feet, and are considered safe.'' The FAA does not concur. There is no requirement that the equipment used in transport category airplanes be approved under a TSO. As discussed in the notice, operation at altitudes which can, in the event of a rapid decompression, result in incapacitation or a physiological hazard to the occupants requires oxygen equipment to meet the specific environments that may be encountered. It is recognized that equipment with TSO authorization is available that will provide the required protection at a reasonable cost. The intent of this rulemaking is to identify a minimum equipment standard that is known to provide this protection, and that equipment is called out in the amended sections.

Another commenter suggests amending § 25.1443 by addition of a curve of ''cabin pressure altitude versus minimum required oxygen mass flow'' for cabin altitudes from 0 to 51,000 feet which would replace the generic mass flow requirement which appears in § 25.1441. The FAA does not concur with this comment. A revision to § 25.1443 as suggested by the commenter would not increase the level of safety. Existing rules related to oxygen mass flow provide an adequate level of safety. If such material were to be added, this level of detail would be more appropriate in a Technical Standard Order or the advisory material that has been proposed to accompany this rulemaking action.

One commenter recommends deleting § 25.1447(c)(3)(ii) both as it now exists and as proposed. The existing section is deleted for the reasons noted in the preamble to Notice 89–31. The commenter believes that the section as proposed, which stipulates the use of ''a pressure demand (pressure demand mask with a diluter demand pressure breathing regulator) type with a mask-mounted regulator,'' is unduly restrictive by requiring a mask-mounted regulator, and dictates a design solution. Additionally, the commenter states that §§ 25.1441(d) and 25.1443(b) and Technical Standard Order TSO–C89 address oxygen equipment, thereby obviating the need for the proposed section. Another commenter recommends that the FAA define the required oxygen equipment (diluter demand and pressure demand masks) in terms of performance rather than by stipulating a specific equipment type. The FAA does not concur with these comments. The specific descriptions for the oxygen equipment that is proposed in these amendments has been determined by the FAA to be necessary to provide protection for the flightcrew in cases where the cabin altitude will exceed the specified levels. Neither of the FAR sections nor the TSO data provide adequate assurance of that protection. The FAA believes that this detailed stipulation is necessary to ensure the protection and to provide standardization in interpretation of the new requirements. However, the FAA intends to allow sufficient latitude for system designers to develop safer and/or less expensive approaches to specific requirements. For this reason, § 25.1447(c)(3)(ii) is changed to allow other means of protection for flight crewmembers if the proposed equipment affords the same protection.

One commenter states that existing panel-mounted diluter-demand regulators have proven satisfactory. This party suggests that the pressure-demand mask with a mask-mounted regulator be mandatory for newly certificated airplanes only. The FAA agrees that panel mounted regulators have proven satisfactory, but the FAA has determined that in a high altitude rapid decompression, the protection afforded by a mask mounted regulator is superior to that found in panel mounted regulators. As noted in the preamble of the notice, the time delay in providing 100 percent oxygen to the flight crewmember, which results from the air in the hoses of the oxygen equipment, can significantly negate the hypoxic protection of such equipment. Further, this amendment constitutes a revision to part 25, and is not applicable to the existing fleet. It is, however, the FAA's position that every effort be made to provide a level of safety equal to the latest certification standards for existing airplanes that are updated by amended or supplemental type certification. The FAA's policy regarding establishment of the type certification basis for derivative airplanes is described in Action Notice A 8110.23, dated September 26, 1990. A copy of this document has been placed in the Rules Docket. Following issuance of these amendments, the concepts contained herein would be applicable to airplanes which incorporate changes in the oxygen systems or increases in approved operating altitudes, in accordance with § 21.101. For high altitude approvals, this has been accomplished in the past through special conditions which contain provisions essentially the same as those embodied in these amendments.

Several comments express concerns regarding long term use of 100 percent oxygen by fightcrews. One of these parties suggests that the crew member use normally diluted oxygen with the regulator set at the ''normal'' position. Another states that 100 percent oxygen should not be permitted unless adequate safeguards have been established. A third party states that 100 percent oxygen should be used only for short periods as an emergency measure due to a health hazard. One commenter recommends deleting the proposed § 25.1447(c)(4) and retaining § 121.333(c)(2), which requires at least one pilot to wear and use an oxygen mask at altitudes of 41,000 feet and greater. Another commenter believes that wearing an oxygen mask at lower altitudes ''is not necessary nor is it useful.'' One commenter notes that breathing 100 percent oxygen will dry out the lungs, can lead to narcosis, and states that the long term effects are not clearly understood. Another commenter recommends deleting the proposal to require the wearing of masks and revert to the requirements in the operating rules. Another commenter states that large volume transports decompress slowly giving crews more time to don oxygen masks, and current large transports are certificated to 45,000 feet without requiring the flightcrew to be using oxygen. The FAA infers that the commenter believes that this proposal should not apply to ''large'' transport airplanes. The FAA does not concur with this viewpoint. The physical size of the airplane is not germane; the important parameter is the post-decompression cabin altitude and its effect on occupants. One commenter notes that the requirement for prebreathing 100 percent oxygen would necessitate additional oxygen supplies at added cost. Finally, one commenter questions whether breathing 100 percent rather than 40 percent oxygen provides better protection in terms of blood oxygen saturation level. This commenter provides data showing that prebreathing 30 to 40 percent oxygen provides adequate protection against the effects of hypoxia following rapid decompression. The data show that the blood oxygen saturation level following the decompression is not significantly depressed even if the crew member is breathing 30 percent oxygen, as long as the oxygen supplied to the crew member goes to 100% immediately. After considering all the negative comments received and reviewing existing data regarding high altitude decompressions, the FAA has determined that it is appropriate to withdraw this proposal. The proposed § 25.1447(c)(4), requiring that one flight crewmember be wearing an oxygen mask and breathing 100 percent oxygen when operating at altitudes where the cabin altitude can reach 34,000 feet in the event of a decompression, has been withdrawn.

One commenter states that, regarding the proposed § 25.1447(c)(5), portable oxygen equipment would only be ''at hand'' if the crew members were sitting by the oxygen equipment or were actually using it, and recommends striking the work ''immediately'' from the proposal. The FAA does not believe this change is necessary or warranted. This requirement is retained from the existing § 25.1447(c)(4), and is considered met in existing airplanes by having portable oxygen equipment located adjacent to the crew member seat with additional units located at specific locations in the passenger cabin. The FAA anticipates that industry will continue to provide this protection in the same manner as it has done in existing airplanes, with no change in the rule or in FAA policy regarding showing compliance.

Two commenters point out that the nomenclature used in the glossary of the notice misidentified the type of passenger oxygen equipment used in airplanes with altitudes above 35,000 feet. One commenter recommends changing the definition in the Glossary for ''Continuous Flow Oxygen Systems'' to note that the type of equipment used is a mask with a ''reservoir'' bag rather than a ''rebreather'' bag. The FAA concurs with these comments, and the glossary is changed to reflect the terminology used in current descriptive literature.

One commenter notes that, while special conditions have been issued covering various airplanes requesting approval for high altitude operations, this proposal impacts all airplanes seeking certification under part 25 of the FAR, including those with maximum flight altitudes less than 41,000 feet. These proposals constitute increased standards for those airplanes. The FAA concurs with this statement. This rulemaking addresses the physiological limitations of occupants of transport category airplanes which can experience depressurization to cabin altitudes greater than 34,000 feet. However, the commenter does not recommend any specific changes in the proposals.

The JAA notes that future rulemaking relative to the Joint Airworthiness Regulations (JAR) will require retroactive application for each new amendment, and asks if the FAA is considering similar action. As noted earlier, application of new amendments to the FAR are made applicable to type certification programs in accordance with § 21.101 of the FAR. There are no plans to require retroactive application of new amendments to the existing fleet, as suggested by the JAA. The JAA also suggests considering a number of added concerns regarding operations at high altitudes, such as the effects of icing on airspeed and pressure probes, changes in static stability criteria for high mach/high altitude operation, and health hazards related to cosmic radiation during high altitude cruise. A second commenter recommends that the proposal be revised to address standards related to the exposure of crewmembers to cosmic radiation when operating at altitudes up to 51,000 feet. The effects of icing (ice crystals) on airspeed and pressure probes and stability criteria were not considered in the special conditions issued prior to this rulemaking, and no data was submitted by the commenter to support its position. No action is contemplated by the FAA regarding these comments. The effects of cosmic radiation are not addressed in this proposal, and no data were submitted by either commenter in support of their suggestions. The FAA is aware of the concerns expressed by the commenters and may consider further rulemaking to address those concerns.

One commenter suggests requiring initial and periodic training including altitude chamber and pressure breathing instruction for pilots of airplanes affected by this rulemaking. As the certification rules in part 25 do not address specific training requirements, this proposal is outside the scope of this rulemaking. However, this proposal will be discussed with the FAA organization responsible for crew training.

One commenter notes that the FAA should require improvements in pressure demand masks to improve comfort, and suggests that research and development in comfort and human factors is needed. The FAA believes that there is oxygen equipment available that meets the requirements of this rule and also provides an acceptable level of comfort. The small executive jet airplanes approved under existing special conditions are so equipped. If further improvements are needed, the marketplace will drive the development and availability of these products.

One commenter suggests that the FAA has failed to consider the relatively small transport category airplanes intended for commuter airline operation. The example noted is a 16,000 pound airplane intended to carry 25 passengers, operating at altitudes of 25,000 to 30,000 feet. The commenter states that the manufacturer will apply for certification to the highest expected operating altitude and the amendments of this proposal will apply. The specific comments related to these concerns are addressed elsewhere in this document, but the commenter apparently believes that these applicants should not have these requirements imposed on their airplanes. The position adopted by the FAA with this rulemaking action is that any airplane operating at flight altitudes where decompression can result in a hazard to the occupants must be designed to provide protection.

One commenter recommends leaving the regulations as they now exist for large airplanes operating up to 45,000 feet and directing the proposed rules to the smaller airplanes operating at higher altitudes. This party states that large airplanes certified under the existing rules provide an acceptable level of safety, and the proposed rules will result in ‘‘undue restrictions or unvalidated costly additional effort.’’ Another commenter expresses a similar opinion, and comments that adoption of these standards will have a significant economic impact due to requiring retrofit of many existing airplanes. The FAA does not share these views. The protection afforded the occupants should be the same for any transport category airplane, regardless of volume. Larger airplanes have shown decompression characteristics similar to the small airplanes. If the applicant can demonstrate that the cabin altitude does not exceed prescribed limits, many of the provisions of this amendment do not apply. In any case, these rules are not retroactive to existing airplanes as a result of this rulemaking, and only new or modified airplanes are required to meet the new requirements. Another commenter makes the point that there have been recent decompression events involving large airplanes wherein the decompression ‘‘is surely as explosive as any to be realized on a smaller Lear Jet . . .,’’ and agrees with the proposals.

Another commenter believes that existing supplemental oxygen systems are acceptable, and if the requirements in Notice 89–31 are adopted, there are strong arguments for elimination of the passenger oxygen system. The FAA does not concur with these statements. While it is recognized that not all passengers will be able to don their oxygen equipment, the protection afforded by the systems currently installed provides acceptable protection from the effects of hypoxia at an acceptable cost for the majority of the occupants from the effects of hypoxia. Even when the decompression event is slower or the cabin altitude is limited, and the oxygen masks are not absolutely essential for survival, some protection is afforded to all the passengers when the cabin altitude exceeds safe limits. The operating rules also require the installation of this equipment.

One commenter states that the economic analysis reflects an operating cost increase of $19 million per year, implying that the rule would have to save 19 lives per year to be reasonable. The same commenter recommends revising the Regulatory Flexibility Determination because small entities may operate affected airplanes and may incur increased operating costs. In each case, the commenter appears to be referring to FAA's economic analysis of proposed § 25.1447(c)(4). As noted earlier, Notice 89–31 proposed that § 25.1447(c)(4) require that one flight crewmember wear an oxygen mask and breathe 100 percent oxygen when operating at altitudes where the cabin altitude can reach 34,000 feet in the event of a decompression. In response to public comments and cost considerations, the FAA has withdrawn this proposal and will subject it to further study. In regard to the commenter's recommendation regarding small entities, the magnitude of the costs and the number of affected small entities, rather than simply the incidence of costs, are the criteria by which a rule is judged to have a significant economic impact on small entities. A regulatory flexibility determination of the final rule is presented in the next section of this document.

The same commenter also states that the Regulatory Evaluation does not take into consideration evolving FAA policy of applying the latest FAR amendments when determining the certification basis for amended type certifications. The FAA agrees and has added this policy to this final regulatory evaluation, without affecting the justification of the rule. It is FAA's policy that every effort be made to provide a level of safety equal to the latest certification standards for existing airplanes that are updated by amended or supplemental type certificates. Amendments to the FAR may be made applicable to derivative airplanes in accordance with § 21.101 if it is determined that the new or redesigned system is not adequately addressed in the regulations incorporated by reference to the type design.

The commenter also identifies a statement in the NPRM Regulatory Evaluation that incorrectly assumes that new airplanes will not have engines mounted in positions which could damage the fuselage. The commenter appears to be misinterpreting FAA's language. The statement being referred to by the commenter is one pertaining only to small volume transport airplanes. The FAA agrees that most other transport category airplanes will have wing-mounted engines located such that fragments from an engine burst could affect the fuselage and pressure vessel.

References

Reference 1. ‘‘Factors Influencing the Time of Safe Unconsciousness (TSU) for Commercial Jet Passengers Following Cabin Decompression’’ by James G. Gaume, *Aerospace Medicine,* April 1970.

Reference 2. Aerospace Information Report (AIR) No. 822 and 825B (Physiology Section); SAE Committee A–10.

Copies of pertinent portions of these documents have been placed in the

Rules Docket and are available for public inspection.

Glossary

Physiology Altitude Limits. The response of human beings to increased altitude varies with the individual. People that smoke or are in poor health will be affected at a much lower altitude than people who are young and in good physical condition. Without supplementary oxygen, most people will begin to experience a reduction in night vision or general visual acuity at approximately 5,000 feet altitude. At an altitude of approximately 10,000 feet, a person will begin to display measurable deterioration in mental abilities and physical dexterity after a period of several hours. At 18,000 feet, the mental deterioration may result in unconsciousness, and the time of useful consciousness (TUC) is generally about 15 minutes. At 25,000 feet, the TUC for most people is about 3–10 minutes. At altitudes above 25,000 feet, the TUC decreases very rapidly, becoming only a few seconds at 40,000 feet. If a person is breathing 100 percent oxygen, however, the partial pressure of oxygen in the lungs at 34,000 feet altitude is the same as that for a person breathing air at sea level. At 40,000 feet, a person breathing 100 percent oxygen will have the same partial pressure of oxygen in the lungs as a person breathing air at 10,000 feet. Therefore, 34,000 feet is the highest altitude at which a person would be provided complete protection from the effects of hypoxia, and 40,000 feet is the highest altitude at which 100 percent oxygen will provide reasonable protection for the time period needed to descend to a safe altitude.

Hypoxia. Hypoxia is a condition caused by insufficient oxygen. It results from the reduced oxygen partial pressure in the inspired air caused by the decrease in barometric pressure with increasing altitude.

Diluter Demand Oxygen System. A flightcrew oxygen system consisting of a close-fitting mask with a regulator that supplies a flow of oxygen proportional to cabin altitude. Regulators are usually designed to provide zero percent 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. Oxygen is supplied only when the user inhales, reducing, the amount of oxygen that is required.

Pressure Demand Oxygen System. Similar to diluter demand equipment, except that oxygen is automatically supplied to the mask under pressure at cabin altitudes above approxmately 34,000 feet. This pressurized supply of oxygen provides some additional protection against hypoxia at altitudes up to 39,000 feet.

Pressure Demand Mask With Mask-Mounted Regulator. A pressure demand mask with the regulator attached directly to the mask, rather than mounted on the instrument panel or other area within the flight deck. The mask-mounted regulator eliminates the problem of a long hose which must be purged of air before oxygen is delivered to the mask.

Continuous Flow Oxygen System. The oxygen system typically provided to passengers. The passenger mask most commonly used in transport category airplanes is equipped with a reservoir bag, which is replenished by a continuous flow of oxygen. This design incorporates a check valve between the reservoir bag and the face mask to prevent introduction of exhaled gasses into the bag and assure 100% oxygen in the reservoir. Dilution is accomplished at the later phases in inspiration by a loaded ambient air valve which introduces ambient air following depletion of the oxygen in the reservoir bag.

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 1×10^{-5} or greater (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. Systems that operate within this category are referred to as nonessential systems.

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 1×10^{-5} or less. The consequences of the failure or the required corrective action must not prevent the continued safe flight and landing of the airplane. Systems that operate within this category are referred to as essential systems.

Extremely Improbable Failures. Extremely improbable failures are so unlikely that they need not be considered to ever occur, unless engineering judgement 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. Systems that operate within this category are referred to as critical systems.

Regulatory Evaluation Summary

Proposed changes to Federal regulations must undergo economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Section, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) will generate benefits that justify its costs; (2) is not a ‘‘significant regulatory action’’ as defined in the Executive Order and is not ‘‘significant’’ as defined in DOT’s Regulatory Policies and Procedures; (3) will not have a significant economic impact on a substantial number of small entities; and (4) will not constitute a barrier to international trade. These analyses, available in the docket, are summarized below.

Regulatory Evaluation Summary

The rule may impose relatively incremental costs in that applicant manufacturers will be required to demonstrate compliance and operators may experience increased operating costs. The FAA has determined that these potential incremental costs will be exceeded by the safety and efficiency benefits of the rule.

A. Ventilation and Cabin Cooling—§ 25.831 (a), (c), (d), and (g)

The FAA has determined that health and safety considerations justify the airflow design requirements of § 28.831(a) for all transport category airplanes. First, cabin crewmembers must be able to perform their duties without undue discomfort or fatigue. Secondly, benefits may be realized from the assured availability of the additional airflow when it is required. Third, fresh airflow is necessary to provide adequate smoke clearance in the event of smoke accumulation in the passenger cabin, an event which has occurred on several occasions. Fourth, administrative benefits will be realized because codified regulations are more efficient than special conditions. Finally, it is noted that other airworthiness authorities have comparable ventilation standards.

The airflow design requirements in revised § 25.831(a) are not expected to result in significant cost changes. Incremental design and manufacturing costs will be negligible because most current airplane models were designed with the additional airflow capability and, even in the absence of this rule, future airplane models would likely continue to be so designed. Incremental operating costs are expected to be nominal because the rule isn't an operating requirement and because the additional airflow is not required at all times and under all operating conditions. Furthermore, to the extent that the amendment codifies special conditions that would have continued to be applied to future high altitude airplane certifications, it will not cause changes in costs.

The new § 25.831(g) supplements the requirements found in § 25.1309 by limiting exposure times to excessive temperatures in the crew and passenger compartments which can present a hazard to continued safe flight and landing, and the limits are appropriate for all transport category airplanes, regardless of certificated maximum flight altitude.

B. Pressurization and Pressure Vessel Integrity—§§ 25.365(d) and 25.841(a)

The higher structural safety factor in revised § 25.365(d) is necessary for airplanes operating above 45,000 feet because a rapid decompression could be catastrophic to occupants. Therefore, the FAA finds that this event should be extremely improbable; i.e., not expected to occur during the lifetime of an entire fleet of airplanes. Service history shows that decompressions at high altitudes are not extremely remote events even for airplanes assessed to damage tolerance criteria. Loss of cabin pressure at lower altitudes has not been catastrophic due to higher ambient pressures and relatively short emergency descent time. The higher structural safety factor was included in the SST and executive transport category airplane special conditions to reduce the likelihood of structural failure and to limit the size of the opening if a failure occurs. The amendment will have a negligible cost.

Revised § 25.841(a) will provide airworthiness standards that allow subsonic airplanes to operate at the highest altitude for which the applicant manufacturer chooses to demonstrate that, after decompression caused by a single failure or combination of failures that are not shown to be extremely improbable: (1) the flightcrew will remain alert and be able to fly the airplane; (2) the cabin occupants will be protected from the effects of hypoxia; and (3) in the event that some occupants do not receive supplemental oxygen, they nevertheless will be protected against physiological injury.

Revised § 25.841(a)(1) is equivalent to existing § 25.841(a) except for editorial changes, elimination of the words ''reasonably'' and ''or malfunctions,'' and addition of the term ''failure conditions.'' Revised § 25.841(a)(2), which limits exposure of occupants after decompression to a cabin altitude not greater than 40,000, is unchanged from previously established standards for airplanes using diluter demand (flightcrew) and continuous flow (passenger) oxygen equipment. It combines the executive transport category high altitude special conditions and § 25.1309, i.e., the degree of the hazard must be inversely related to the probability of the failure condition.

The FAA has determined that the amendment will provide an acceptable level of safety at an acceptable cost. To demonstrate compliance with revised § 25.841, an approved emergency descent procedure and a cabin altitude analysis must be prepared and the crew would perform an emergency descent in accordance with the approved procedure. For probable system failures, the critical failure case (probable system failure) system failure tests must be conducted at the maximum airplane altitude. For improbable failures, the cabin altitude could be established by analysis and verified by tests at a lower altitude with the results extrapolated to the higher altitude. To the extent that the rule codifies special conditions that would have continued to be applied to future high altitude airplane type certifications, it will have no incremental economic effects. There will also be administrative benefits in that codified regulations are more efficient than special conditions.

C. Oxygen Equipment—§ 25.1447(c)

The FAA has determined that operation in accordance with the revised oxygen equipment standards will provide an acceptable level of safety. By specifying the type of oxygen equipment for the crew and the manner of its use, there will be assurance that the flightcrew will retain its ability to safely operate the airplane during a decompression. Panel-mounted regulators have proven satisfactory, but the FAA has determined that in a high altitude rapid decompression, the protection afforded by a mask-mounted regulator is superior to that of panel-mounted regulators. The FAA intends to allow sufficient latitude for system designers to develop safer and/or less expensive approaches to specific requirements. For this reason, § 25.1447(c)(3)(ii) will allow other means of protection for flight crewmembers if they afford the same protection.

To the extent that the changes codify special conditions that would have continued to be applied to future high altitude airplane type certifications, the amendments will have no incremental economic effect other than the administrative benefits of codified regulations relative to special conditions.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily or disproportionately burdened by Government regulations. The RFA requires a Regulatory Flexibility Analysis, in which alternatives are considered and evaluated if a rule is expected to have ''a significant economic impact on a substantial number of small entities.'' FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, prescribes standards for complying with RFA review requirements in FAA rulemaking actions. The Order defines ''small entities'' in terms of size thresholds, ''significant economic impact'' in terms of annualized cost thresholds, and ''substantial number'' as a number which is not less than eleven and which is more than one-third of the small subject to the proposed or final rule.

The rule will affect manufacturers and operators of transport category airplanes produced under future new, and some amended and supplemental, airplane type certifications. For manufacturers, Order 2100.14A specifies a size threshold for classification as a small entity as 75 or fewer employees. Since no part 25 airplane manufacturer has 75 or fewer employees, the rule will not have a significant economic impact on a substantial number of small airplane manufacturers. The size threshold for classification as a small operator is the ownership (but not necessarily the operation) of nine or fewer aircraft. The annualized cost thresholds constituting ''significant economic impact'' for operators of aircraft-for-hire, when expressed in 1994 dollars, are $120,000 for scheduled operators whose fleets consist entirely of aircraft with seating capacities of over 60, $69,000 for other scheduled operators, and $4,900 for unscheduled operators. The annualized incremental costs of this rule amortized over a maximum nine-airplane fleet are expected to be less than these annualized cost thresholds. The FAA has therefore determined that the rule will not have a significant economic impact on a substantial number of small operators.

International Trade Impact Assessment

The rule will have little or no effect on the sale of U.S. airplanes in foreign markets and the sale of foreign airplanes into the U.S.

Federalism Implications

The regulations adopted herein will not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this final rule will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

International Compatibility

The FAA has reviewed corresponding International Civil Aviation Organization regulations and Joint Airworthiness Authorities regulations, where they exist, and has identified no differences in these amendments and the foreign regulations.

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act of 1980 (Pub. L. 96–511), there are no requirements for information collection associated with this rule.

Conclusion

Because amending the airplane and equipment airworthiness standards for subsonic transport airplanes for operation to an altitude of 51,000 feet is not expected to result in substantial costs, the FAA has determined that this final rule is not major as defined in Executive Order 12866. For the same reason and because this is an issue which has not prompted a great deal of public concern, this final rule is not considered to be significant as defined in Department of Transportation Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). In addition, since there are no small entities affected by this rulemaking, it is certified, under the criteria of the Regulatory Flexibility Act, that this final rule, a promulgation, will not have a significant economic impact, positive or negative, on a substantial number of small entities. A copy of the final regulatory evaluation prepared for this project may be examined in the public docket or obtained from the person identified under the caption **FOR FURTHER INFORMATION CONTACT.**

List of Subjects in 14 CFR Part 25

Air transportation, Aircraft, Aviation safety, Safety.

The Amendment

Accordingly, the FAA amends part 25 of the Federal Aviation Regulations (FAR) (14 CFR part 25) as follows:

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for part 25 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701–44702, 44704.

2. By amending § 25.365, by revising paragraph (d), to read as follows:

§ 25.365 Pressurized compartment loads.

* * * * *

(d) The airplane structure must be designed to be able to withstand the pressure differential loads corresponding to the maximum relief valve setting multiplied by a factor of 1.33 for airplanes to be approved for operation to 45,000 feet or by a factor of 1.67 for airplanes to be approved for operation above 45,000 feet, omitting other loads.

* * * * *

3. By amending § 25.831 by revising paragraph (a) and by adding a new paragraph (g) to read as follows:

§ 25.831 Ventilation.

(a) Under normal operating conditions and in the event of any probable failure conditions of any system which would adversely affect the ventilating air, the ventilation system must be designed to provide a sufficient amount of uncontaminated air to enable the crewmembers to perform their duties without undue discomfort or fatigue and to provide reasonable passenger comfort. For normal operating conditions, the ventilation system must be designed to provide each occupant with an airflow containing at least 0.55 pounds of fresh air per minute.

* * * * *

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

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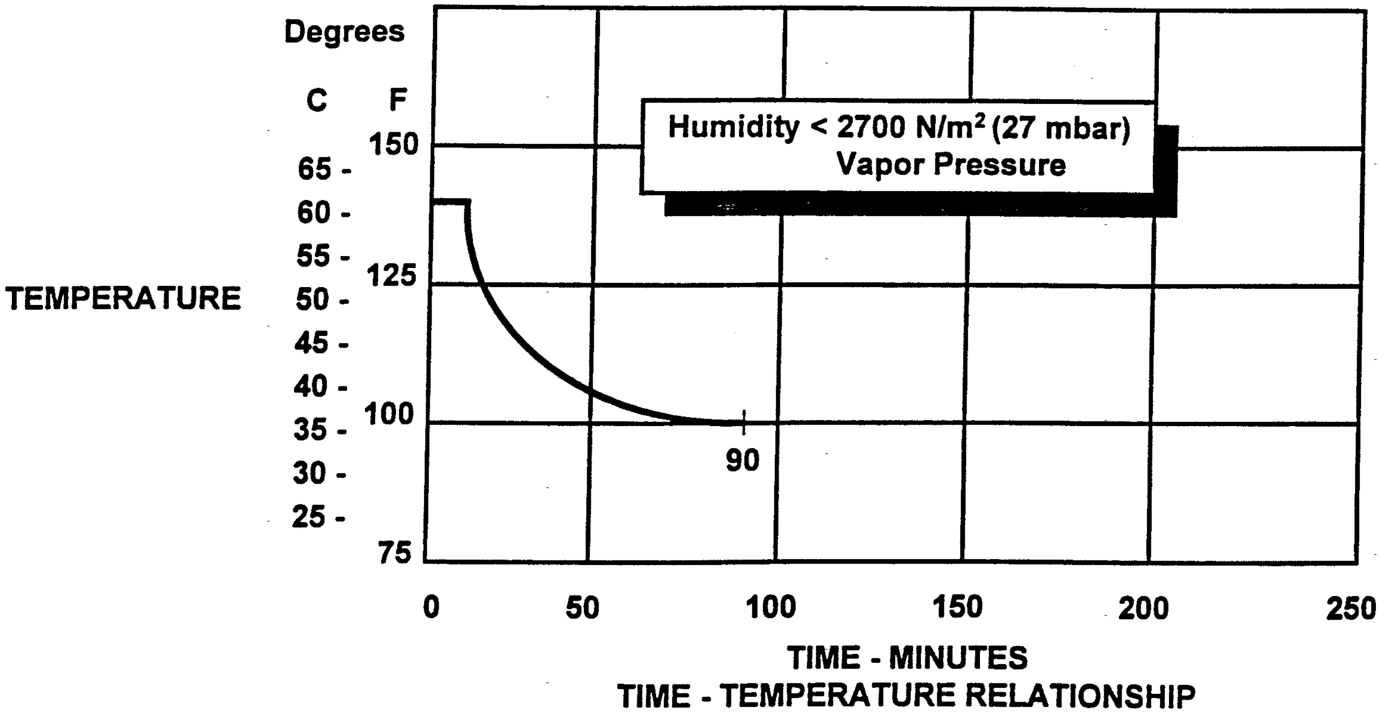

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4. By amending § 25.841 by revising paragraph (a) to read as follows:

§ 25.841 Pressurized cabins.

(a) Pressurized cabins and compartments to be occupied must be equipped to provide a cabin pressure altitude of not more than 8,000 feet at the maximum operating altitude of the airplane under normal operating conditions.

(1) If certification for operation above 25,000 feet is requested, the airplane must be designed so that occupants will not be exposed to cabin pressure altitudes in excess of 15,000 feet after any probable failure condition in the pressurization system.

(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.

* * * * *

5. By amending § 25.1447, by revising paragraphs (c) (1) through (4), to read as follows:

§ 25.1447 Equipment standards for oxygen dispensing units.

* * * * *

(c) * * *

(1) There must be an oxygen dispensing unit connected to oxygen supply terminals immediately available to each occupant, wherever seated, and at least two oxygen dispensing units connected to oxygen terminals in each lavatory. The total number of dispensing units and outlets in the cabin must exceed the number of seats by at least 10 percent. The extra units must be as uniformly distributed throughout the cabin as practicable. If certification for operation above 30,000 feet is requested, the dispensing units providing the required oxygen flow must be automatically presented to the occupants before the cabin pressure altitude exceeds 15,000 feet. The crew must be provided with a manual means of making the dispensing units immediately available in the event of failure of the automatic system.

(2) Each flight crewmember on flight deck duty must be provided with a quick-donning type oxygen dispensing unit connected to an oxygen supply terminal. This dispensing unit must be immediately available to the flight crewmember when seated at his station, and installed so that it:

(i) Can be placed on the face from its ready position, properly secured, sealed, and supplying oxygen upon demand, with one hand, within five seconds and without disturbing eyeglasses or causing delay in proceeding with emergency duties; and

(ii) Allows, while in place, the performance of normal communication functions.

(3) The oxygen dispensing equipment for the flight crewmembers must be:

(i) The diluter demand or pressure demand (pressure demand mask with a diluter demand pressure breathing regulator) type, or other approved oxygen equipment shown to provide the same degree of protection, for airplanes to be operated above 25,000 feet.

(ii) The pressure demand (pressure demand mask with a diluter demand pressure breathing regulator) type with mask-mounted regulator, or other approved oxygen equipment shown to provide the same degree of protection, for airplanes operated at altitudes where decompressions that are not extremely improbable may expose the flightcrew to cabin pressure altitudes in excess of 34,000 feet.

(4) Portable oxygen equipment must be immediately available for each cabin attendant.

Issued in Washington, DC, on May 29, 1996.

David R. Hinson,

Administrator.

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