U.S. Department of Transportation

Federal Aviation Administration

Advisory Circular

Subject: SYSTEMS AND EQUIPMENT GUIDE FOR CERTIFICATION OF PART 23 AIRPLANES AND AIRSHIPS	**Date:** DRAFT **Initiated By:** ACE-100	**AC No:** 23-17B **Change:**

1. PURPOSE. This Advisory Circular (AC) sets forth an acceptable means, but not the only means, of showing compliance with Title 14 Code of Federal Regulations (14 CFR), part 23, for the certification of systems and equipment in normal, utility, acrobatic, and commuter category airplanes and airships. 'The policy in this AC is considered applicable for airship projects; however, the certifying office should only use specific applicability and requirements if they are determined to be reasonable, applicable and relevant to the airship project. This AC applies to Subpart D from § 23.671 and Subpart F. This AC both consolidates existing policy documents, and certain ACs that cover specific paragraphs of the regulations, into a single document and adds new guidance. This revision has added preamble material, *in italics*, under the applicable rule and amendment level. Material in this AC is neither mandatory nor regulatory in nature and does not constitute a regulation.

2. CANCELLATION or SUPERSEDING. The following AC is canceled and the policy statement is superseded as follows:

a. AC 23-17A, "Systems and Equipment Guide for Certification of Part 23 Airplanes."

b. PS-ACE100-2002-003, "Information Memo: Standardization of Application of 14 CFR Part 23, § 23,1309 Regarding Hazardous Misleading Heading Information for Attitude-Heading Reference Systems."

3. BACKGROUND. In 1968, the Federal Aviation Administration (FAA) instituted an extensive review of the airworthiness standards of part 23. Since then, the regulations have been amended through amendment 23-53. These amendments have changed most of the sections of part 23. This document is intended to provide guidance for the original issue of part 23 and the various amendments. This version of the AC covers policy available through September 30, 2003. Policy that became available after September 30, 2003, will be covered in future revisions to the AC.

4. APPLICABILITY. This AC is applicable only to the original applicant seeking issuance of a Type Certificate (TC), an Amended Type Certificate (ATC), or a Supplemental Type Certificate (STC) for the initial approval of the new type design or a change in the approved type design. This material is not to be construed as having any legal status and should be treated accordingly. This version of the AC covers policy available through September 30, 2003. Policy that became available after that date will be covered in future revisions to the AC.

5. PARAGRAPHS KEYED TO PART 23. Each paragraph has the applicable part 23 amendments shown in the title. As part 23 changes occur, the appropriate revisions will be made to the affected paragraphs of this AC.

6. RELATED PUBLICATIONS. These documents are provided as a quick reference source of documents that are acceptable for use in 14 CFR, part 23 certification programs/projects.

a. Free Policy Memoranda, Orders and ACs. Copies of current publications of the following free Orders and ACs listed below can be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785. The website where these orders and ACs can be found is http://www.faa.gov/certification/aircraft/ACs.

"PS-ACE100-2001-004, "Guidance for Reviewing Certification Plans to Address Human Factors for certification of Part 23 Small Airplanes", August 29, 2002.

PS-ACE100-2002-002, "Installation Approval of Multi-Function Displays Using the AML STC Process; Policy Statement", December 21, 2001.

PS-ACE100-2002-004, "Diesel Engine Installation", May 22, 2003.

FAA Order 8110.4B, "Type Certification", April 24, 2000.

FAA Order 8100.5A, "Aircraft Certification Service Mission, Responsibilities, Relationships, and Programs", September 30, 2003.

FAA Order 8110.42A, "Parts Manufacturer Approval Procedures", March 31, 1999.

AC 20-30B, "Aircraft Position Light and Anticollision Light Installation", July 20, 1981.

AC 20-36S, "Index of Articles (Materials, Parts, Processes and Appliances) Certified Under the Technical Standard Order System", October 1, 1993.

AC 20-41A, "Substitute Technical Standard Order (TSO) Aircraft Equipment", April 5, 1997.

AC 20-42C, "Hand Fire Extinguishers for Use in Aircraft", March 7, 1984.

AC 20-67B, “Airborne VHF Communications Equipment Installations”, January 16, 1986.

AC 20-112, “Airworthiness and Operational Approval of Airborne Systems to be Used in Lieu of a Ground Proximity Warning Systems (GPWS)”, February 19, 1981.

AC 20-115B, “Radio Technical Commission for Aeronautic, Inc., Document RTCA/DO-178B”, January 1, 1993.

AC 20-118A, “Emergency Evacuation Demonstration”, March 9, 1987.

AC 20-121A, “Airworthiness Approval of Loran-C Navigation Systems for use in the U.S. National & Airspace System (NAS) and Alaska”, August 24, 1988.

AC 20-124, “Water Ingestion Testing for Turbine Powered Airplanes”, September 30, 1985.

AC 20-128A, “Design Considerations for Minimizing Hazards caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure”, March 25, 1997.

AC 20-131A, “Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders”, March 29, 1993.

AC 20-136, “Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning”, March 5, 1990.

AC 20-138A, “Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment”, December 22, 2003.

AC 20-146, “Methodology for Dynamic Seat Certification by Analysis for Use in Part 23, 25, 27, and 29 Airplanes and Rotorcraft”, May 19, 2003.

AC 21-16D, “RTCA Document DO-160D”, July 21, 1998.

AC 21-25A, “Approval of Modified Seats and Berths”, June 3, 1997.

AC 21-34, “Shoulder Harness-Safety Belt Installations”, June 4, 1993.

AC 23-2, “Flammability Tests”, August 14, 2003.

AC 23-18, “Installation of Terrain Awareness and Warning System (TAWS) Approved for Part 23 Airplanes”, June 14, 2000.

AC 23-19, “Airframe Guide for Certification of Part 23 Airplanes”, January 27, 2003.

AC 23.143-1, "Ice Contaminated Tailplane (ICTS) Stall", December 20, 2001.

AC 23.562-1, "Dynamic Testing of Part 23 Airplane Seat/Restraint Systems and Occupant Protection", June 22, 1989.

AC 23.1309-1C, "Equipment, Systems, and Installations in Part 23 Airplanes", March 12, 1999.

AC 23.1311-1A, "Installation of Electronic Displays in Part 23 Airplanes", March 13, 1999.

AC 23.1419-2B, "Certification of Part 23 Airplanes for Flight in Icing Conditions", September 26, 2002.

AC 25-11, "Transport Category Airplane Electronic Display Systems", July 16, 1987.

AC 90-79, "Recommended Practices and Procedures for the Use of Electronic Long-Range Navigation", July 14, 1980.

AC 120-31A, "Operational and Airworthiness Approval of Airborne Omega Radio Navigation Systems as a Means of Updating Self-Contained Navigation Systems", April 21, 1977.

AC 120-37, "Operational and Airworthiness Approval of Airborne Omega Radio Navigational Systems as a Sole Means of Long Range Navigation Outside the United States", October 10, 1978.

AC 121-13, and Change 2, "Self-Contained Navigation Systems", December 21, 1970.

Copies of current publications of the following "for sale" ACs may be purchased from the Superintendent of Documents, P. O. Box 371954, Pittsburgh, PA 15250-7954; make check or money order payable to the Superintendent of Documents:

AC 20-88A, "Guidelines on the Marking of Aircraft", September 30, 1985.

AC 20-101C, "Airworthiness Approval of Omega/VLF Navigation Systems for use in the U.S. National Airspace System (NAS) and Alaska", September 12, 1988.

AC 21.303-2H, "Parts Manufacturer Approvals", October 13, 1992 (Microfiche).

AC 23-16A, "Powerplant Guide for Certification of Part 23 Airplanes and Airships", February 23, 2004.

AC 23-8B, "Flight Test Guide for Certification of Part 23 Airplanes", August 14, 2003.

AC 43.13-1B, Change 1, “Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair”, September 27, 2001.

AC 43.13-2A, **“**Acceptable Methods, Techniques, and Practices—Aircraft Alterations”, January 1, 1977.

FAA-P-8110-2, Change 2, “Airship Design Criteria”, February 6, 1995.

NOTE 1: Republishing these documents, as a part of this AC, was not considered to be the best utilization of FAA resources.

b. Industry Documents

(1) To obtain a copy of the TSOs, write to the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785, or from the internet at http://www.faa.gov/certification/aircraft/TSO.

TSO-C9c, “Automatic Pilots”, September 15, 1960.

TSO-C62d**, “**Aircraft Tires”, September 7, 1990.

TSO-C22g, “Safety Belts”, March 5, 1993.

TSO-C26c, “Aircraft Wheels and Wheel-Brake Assemblies, with Addendum I”, May 18, 1984.

TSO-C39b, “Aircraft Seats and Berths”, April 17, 1987.

TSO-C55, “Fuel and Oil Quantity Instruments (Reciprocating Engine Aircraft)”, April 1, 1959.

TSO-C114, “Torso Restraint Systems”, March 27, 1987.

TSO-C151b, “Terrain Awareness and Warning System”, December 17, 2002.

(2) The RTCA documents listed below are available from RTCA, Inc., Suite 1020, 1140 Connecticut Avenue, NW, Washington, DC 20036-4001:

RTCA/DO-160D, “Environmental Test Conditions and Test Procedures for Airborne Equipment”, July 29, 1997.

RTCA/DO-178B, “Software Considerations in Airborne Systems and Equipment Certification”, December 1, 1993.

(3) The documents listed below are available from the Society of Automotive Engineers (SAE), Inc., 400 Commonwealth Drive, Warrendale, PA 15096-0001:

SAE Aerospace Recommended Practice (ARP), ARP 597C, “Wheels and Brakes, Supplementary Criteria for Design Endurance—Civil Transport Aircraft”, April 24, 1991.

SAE ARP 813A, “Maintainability Recommendations for Aircraft Wheel and Brake Design”, February 1, 1995.

SAE ARP 1619, “Replacement and Modified Brakes and Wheels”, March 1, 2001.

SAE Aerospace Information Report (AIR) 1064, “Brake Dynamics”, March 1, 1997.

SAE Aerospace Standard AS1145, “Aircraft Brake Temperature Monitor System (Btms)”, February 1, 1998.

SAE J384, “Motor Vehicle Seat Belt Anchorages-Test Procedure”, June 9, 1994.

SAE Recommended Practice, June 2004 SAE Handbook, Volume 2, pages 33.08-33.09,

SAE ARP 5412, “Aircraft Lightning Environment and Related Test Waveforms”, November 1, 1999.

SAE ARP 5413, “Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning”, (it is being incorporated into an AC), November 1, 1999.

SAE ARP 5414, “Aircraft Lightning Zoning”, December 1, 1999.

SAE ARP 5415, “Users Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning”, May 14, 2002.

SAE ARP 5475, “Abuse Load Testing for In-Seat Deployable Video Systems”, March 1, 2001.

SAE ARP 5577, “Aircraft Lightning Direct Effects Certification”, September 30, 2002.

(4) The Underwriters Laboratories (UL), Inc., document listed below can be obtained from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112:

“UL 1418, Cathode Ray Tubes”, September 6, 1996.

(5) General Aviation Manufacturers Association (GAMA). GAMA publication is available free of charge from the GAMA web site:

GAMA publication No. 10, "Recommended Practices and Guidelines for Part 23 Cockpit/Flight Deck Design", dated September 2000.

c. National Aeronautics and Space Administration (NASA) document

American Society for Testing and Materials (ASTM) Manual 36, "Safe Use of Oxygen and Oxygen Systems, Guidelines for Oxygen System Design, Materials Selection, Operations, Storage, and Transportation", dated 2000, may be obtained from the NASA Technical Standards Program web page at http://standards.nasa.gov/. Copies may be purchased from the ASTM, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959.

d. European Aviation Safety Agency (EASA) Documents

EASA Certification Specifications (CS-23) and guidance materials, Acceptable Means of Compliance, (AMCs), are available from the EASA website at www.ease.eu.int/agenmeas_en.html

7. RELATED 14 CFR, PART 23 REGULATIONS

23.75	Landing distance
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DRAFT

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CONTROL SYSTEMS

23.671 General

No FAA policy is available as of September 30, 2003. EASA AMC 23.671 is acceptable for FAA certification.

This rule was adopted on February 1, 1965 as a recodification of Civil Air Regulations (CAR), CAR 3.335.

23.672 Stability augmentation and automatic and power-operated systems

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-45 and Subsequent

This rule is applicable **only** if the system is required to show compliance with the flight characteristic requirements of part 23.

A proposed revision to NPRM 90-18 explains this amendment as follows: *"This proposal would provide criteria for approval of those stability augmentation, automatic, and power-operated systems whose performance is essential to flight safety. The proposed § 23.672 is similar to § 5.672 and, as part 25, the warning system requirement relating to control system activation is not intended to preclude installing tactile warning devices, such as control system shakers activated independently for other purposes."*

NOTE 2: Section 5.672 in above quote is incorrect. It should be § 25.672.

This requirement would not apply to a simple downspring or a bobweight stability device as affirmed by Final Rule, Docket 26269.

23.673 Primary flight controls

No policy available as of September 30, 2003.

The corresponding rule in CAR 3 is CAR 3.336.

23.675 Stops

No policy available as of September 30, 2003.

The corresponding rule in CAR 3 is CAR 3.340.

23.677 Trim systems

The corresponding rule in CAR 3 is CAR 3.337.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.16.

Original Issue and Subsequent

The trim system should prevent inadvertent, improper or abrupt trim operation. The direction of trim movement and its relation to its range of adjustment should be designed to prevent confusion.

Trim devices should be designed to continue normal operation with one failure of any connecting or transmitting element in the primary flight control system for (1) longitudinal trim in a single-engine airplane, and (2) longitudinal and directional trim in multiengine airplanes.

Amendment 23-7 and Subsequent

The amendment requires there be adequate control for safe flight and landing (rather than to "continue normal operation") using the trim devices following the failure of a connecting/transmitting element in the primary controls. Thus, the control system element failure must not cause a failure of the trim system.

Failures of the trim system must not prevent safe flight and landing.

This amendment is clarified by Final Rule, Docket 8083 as follows: *"The notice proposed to amend § 23.677 to make it clear that operation of the trim system may not be dependent upon the primary control system and that failures of the primary control system may not prevent safe flight and landing. Comments were received objecting to the proposal on the ground that it exceeded the part 25 requirements for transport category airplanes, and that it would improperly and undesirably change trim response and make compliance tests extremely hazardous. The FAA does not agree. The trim requirement is merely one of a number of control system requirements that must be considered as a total requirement. There is, therefore, no comparison between individual provisions in parts 23 and 25. Service experience with existing airplanes does not indicate that the proposal will improperly and undesirably change trim response or that compliance testing will be hazardous. Furthermore, trim response equal to primary flight control response will not necessarily be needed to comply with the proposal. All that is required is that there be adequate control for safe flight and landing."*

Amendment 23-34 and Subsequent

Section 23.677(d) was added by Amendment 23-34 was only applicable to commuter category airplanes.

Probable powered trim runaways should be demonstrated for all part 23 airplanes so equipped. See AC 23-8B, "Flight Test Guide for Certification of part 23 Airplanes," for the procedure.

Even if trim runaways have been determined to be improbable using the guidance in AC 23.1309-1C, "Equipment, Systems, and Installations in Part 23 Airplanes," appropriate trim runaway demonstrations in all axes are required to demonstrate that the airplane has no unsafe features. The FAA has accepted demonstration of control-restrained trim runaways during malfunction testing for systems without a monitor/limiter regardless of the reliability and those with a monitor/limiter whose reliability is less than extremely improbable. However, the FAA has determined this procedure is not acceptable in itself for failure conditions shown to be less than extremely improbable. To allow expansion of the 0 to 2g envelope, as specified in AC 23-8B, the FAA suggests a test procedure that incorporates both control restrained and unrestrained malfunctions. The following test matrix considers the probability of trim runaways, high airframe limit loads, control stick/wheel configuration and absence of an autopilot system. Because rudder trim can be adjusted without the pilot directly in the control loop (i.e., feet on the floor), restrained runaways for rudder trim are not considered acceptable. (See Table 1).

TABLE 1. TRIM SYSTEMS REQUIREMENTS

Axis	Time	Load(g) (unrestrained)	Maximum Attitude Change (unrestrained)	Maximum Force (restrained and unrestrained)	Maximum Rate of Force Change (restrained)
Pitch	recognition +3 seconds	structural limits NTE 3.5g	+/-45 degrees	60 pounds	20 pounds/sec
Roll	recognition +3 seconds	structural limits	+/-90 degrees	30 pounds	10 pounds/sec
Yaw	recognition +3 seconds	structural limits	+/-30 degrees	150 pounds (unrestrained only)	N/A

1. Restrained means the pilot is in the control loop (hands on) and unrestrained means the pilot is not in the control loop (hands off).

2. Trim systems with a monitor/limiter will be tested at a magnitude just below that required for monitor/limiter trip.

3. NTE is Not to Exceed.

Amendment 23-42 and Subsequent

This section was changed by Docket 25811, Amendment 23-42, as follows: *"This proposal would extend the current requirements of Sec. 23.677 for powered trim system runaways to all categories of part 23 airplanes."*

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21, Amendment 23-49, revised § 23.677(a) as follows:

"Proposed revised Sec. 23.677(a) would clarify the need to mark the lateral and directional trim indicators with the neutral trim position. Since trim indicators on most airplanes are currently marked with the neutral position of the trimming device, this proposal would standardize the cockpit markings for all airplanes.

Revised paragraph (a) would also add a requirement for the pitch trim indicator to be marked with the proper pitch trim range for the takeoff of the airplane. Some takeoff accidents, including some involving fatalities, have occurred because the pitch trim was not set to the proper range needed for the airplane takeoff. Because of this accident experience, most of the current airplane manufacturers mark the pitch trim indicator with the pitch trim range for takeoff. Therefore, the proposed marking requirement would not have a significant impact on future airplane designs and would ensure that the markings needed for a safe takeoff are provided for the pilots use."

23.679 Control system locks

The corresponding rule in CAR 3 is CAR 3.341.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.17.

Original Issue and Subsequent

Section 23.679(a) of part 23 and § 3.341(a) of the CAR require that if there is a device to lock the control system, there should be a means to give unmistakable warning to the pilot when the lock is engaged. Several accidents have occurred because the pilot did not remove the control system lock prior to takeoff. Many such accidents relate to internally applied locks, mostly pins installed at the control wheel column. Misuse and alteration of these installed locking devices, together with neglect by the pilot to perform a control freedom check before takeoff, contributed to such accidents.

When evaluating a control lock system, the following factors should be considered in finding compliance with the applicable regulation:

a. The warning should be easily observable during both day and night operations. Color, location, shape, and accessibility of the device, ease of removal with the pilot seated in the flying position, and legibility of any placards, etc., should be considered.

b. The system operation should be obvious. It should be possible to apply the lock only in such a manner that the required warning is provided.

c. When engaged, the lock should, by design, limit the operation of the airplane so that the pilot receives unmistakable warning in the cockpit before or at the start of takeoff by an effective means, such as one of the following:

(1) Preventing the application of sufficient engine power to attempt a takeoff.

(2) Displacement of primary pilot controls, such as the control wheel full forward.

(3) An aural warning device that cannot be disengaged.

For airplanes with separate locks for throttle and control column, where one lock (e.g., throttle) can be removed independently of the other, each lock should independently meet the criteria of paragraph (c) above.

Amendment 23-45 and Subsequent

This amendment, changed by Final Rule, Docket 26269, states as follows*: "The FAA is aware that an automatically released control lock system would be costly. The proposal did not mandate the installation of an automatic system, but would add an optional provision that would show the acceptance of such systems.*

The JAA stated its assumption that the proposed requirement would not be applicable to external locks. Based on the comments received, the FAA has re-examined the proposal. Since the proposal would have eliminated the current Section 23.679(a), external systems that use the red warning ribbons as a means of warning the pilot that the locks are in place would no longer be acceptable. The FAA has determined that there is a need to retain the provision of current Section 23.679(a), so that presently used locks and their warning systems remain acceptable. The added provision of Section 23.679(a)(2) will make it clear that systems that automatically disengage the locks are also acceptable but not mandatory.

The proposal to limit the operation of the airplane when the locks are engaged is being restated since control locks and their warnings can be overlooked and automatic disengage systems will fail. The FAA believes an additional safeguard is required. By requiring a system that will ensure that airplane operation is limited, the pilot will receive a pre-takeoff warning and thus a hazardous takeoff will not be attempted.

In summary, the FAA has considered the comments and has revised the proposed rule language by retaining the current provisions of Section 23.679(a) and Section 23.679(a)(1), and by adding the provision for accepting automatically disengaged locking systems as an option. The language in proposed Section 23.679(a)(2) to require the control surfaces to be locked so the pilot receives an unmistakable warning at the start of the takeoff if the locks have not been removed is retained as Section 23.679(b). The unmistakable warning required by this paragraph may be a tactile warning that the pilot receives by the feel of the controls. Finally, proposed Section 23.679(b) is retained as paragraph (c)."

23.681 Limit load static tests

No policy available as of September 30, 2003.

The corresponding rule in CAR 3 is CAR 3.342.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.18.

23.683 Operation tests

The corresponding rule in CAR 3 is CAR 3.343.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.19.

Original Issue and Subsequent

The 1.25 factor of part 23, § 23.395(a)(1) does not apply to the control system operational test of this section.

Compliance with this section is required whether or not the airplane has a significant flight test history. Proof of structure is accomplished by ground tests because required flight tests may not subject the airplane to limit loads for all possible flight conditions.

Amendment 23-7 and Subsequent

A proposed revision to NPRM 67-14 explains this amendment as follows:

"This proposal would preserve consistency with Sec. 23.397 which provides that the airloads on the surfaces need not exceed those that would result from application of the forces in Sec. 23.397 (b)."

Part 23, § 23.683, and CAR Section 3.343 require showing by operation tests, when the controls are operated from the pilot compartment with the system loaded, that the system is free from jamming, excessive friction, and excessive deflection. This section has not been uniformly applied. Some airplanes were certified using 50 percent of the control surface travel with no load as criteria for meeting the excessive deflection requirements for the operation tests. Other airplanes were not required to meet any specific travel as long as the airplane had adequate flight characteristics.

Requiring a specific large travel while under limit load could result in control system authority that is greater than desired or needed. However, some travel of the control surface should exist when the system is loaded to limit load. No travel could indicate there was a possible fault, such as a jammed system. Secondly, with little or no travel, operation of the controls would have such a limited effect on the maneuverability of the airplane that it could have questionable flight characteristics.

ACCEPTABLE MEANS OF COMPLIANCE

One method, but not the only method, for showing compliance with the control system operation test requirements of § 23.683 and CAR § 3.343 is as follows:

a. This method may be used when clearances around control surfaces are no less than 3/16 inch.

b. Conduct the control system operation tests by operating the controls from the pilots compartment with the entire system loaded so as to correspond to the limit control forces established by the regulations for the control system being tested. The following conditions should be met:

(1) Under limit load, check each control surface for travel and detail parts for deflection. This may be accomplished as follows:

(a) Support the control surface being tested while positioned at the neutral position.

(b) Load the surface using loads corresponding to the limit control forces established in the regulations.

(c) Load the pilots control until the control surface is just off the support.

(d) Determine the available travel, which is the amount of movement of the surface from neutral when the control is moved to the system stop.

(e) The above procedure should be repeated in the opposite direction.

(f) Minimum control surface travel from the neutral position in each direction being measured should be 10 percent of the control surface travel with no load on the surface.

Regardless of the amount of travel of the surface when under limit load, the airplane should have adequate flight characteristics, as specified in § 23.141. Any derivative airplane of a previous type certificated airplane need not exceed the control surface travel of the original airplane; however, the flight characteristics should be flight tested to ensure compliance.

(2) Under limit load, no signs of jamming or of any permanent set of any connection, bracket, attachment, etc., may be present.

(3) Friction should be minimized so that the limit control forces and torques specified by the regulations may be met.

ALTERNATE MEANS OF COMPLIANCE

Applicants and FAA Aircraft Certification Offices (ACOs) involved with certification of small airplanes should generally follow this policy. Applicants should expect that the ACO would consider this information when making findings of compliance.

However, in determining compliance with certification standards, each ACO has the discretion to coordinate deviations from these guidelines with the Small Airplane Directorate when the applicant demonstrates a suitable need. To assure standardization, the ACO should coordinate deviation from this policy with the Small Airplane Directorate. Recently, airplanes have been built with smaller gaps between control surfaces and structure than has been done in the past. In this case, this alternate means of compliance is appropriate. This method also can have the added advantage of demonstrating compliance with several regulations in a single test series.

Regardless of the amount of travel of a control surface when tested as described above, the airplane must have adequate flight characteristics as specified in § 23.141. Any airplane that is a close derivative of a previous type certificated airplane need not exceed the control surface travel of the original airplane; however, the flight characteristics should be tested to assure compliance.

The method of showing compliance with § 23.683 presented in AC 23-17, paragraph 23.683, Operation Tests, discusses only the control system. It does not explicitly specify the consideration of loading on adjacent structures and elements. This is consistent with the wording in § 23.683 of the regulations. Testing, not analysis must be used to show compliance with § 23.683. There are five other regulations, the control system, the control surfaces, and the adjacent fixed aerodynamic surfaces related to both the control system and the control surfaces, which must also be met. These include the following:

1. Section 23.305, paragraph (a), [Subpart C - Structure, General] Strength and Deformation. It requires that "At any load up to limit loads, the deformation may not interfere with safe operation."

2. Section 23.307, [Subpart C - Structure, General] Proof of Structure, states, "Compliance with the strength and deformation requirements of § 23.305 must be shown for each critical load condition. Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made."

3. Section 23.655, paragraph (a), [Subpart D - Design and Construction, Control Surfaces] Installation, requires that "Moveable surfaces must be installed so that there is no interference between surfaces, their bracing, or adjacent fixed structure, when one surface is held in its most critical clearance positions and the others are operated through their full movement."

4. Section 23.681, paragraph (a), [Subpart D - Design and Construction, Control Surfaces] Limit Load Static Tests, requires that "Compliance with the limit load requirements of this part must be shown by tests as follows:

(1) The direction of the test loads produces the most severe loading in the control system; and

(2) Each fitting, pulley, and bracket used in attaching the system to the main structure is included."

5. Section 23.141, [Subpart B--Flight, Flight Characteristics] General, states that "The airplane must meet the requirements of §§ 23.143 through 23.253 at all practical loading conditions and operating altitudes for which certification has been requested, not exceeding the maximum operating altitude established under § 23.1527, and without requiring exceptional piloting skill, alertness, or strength."

To assure that these requirements will be satisfied in the conduct of the control system operation test, inclusion of loads on the adjacent structures or elements in the testing set-up may be required.

While testing is required for demonstration of compliance to § 23.683, in some cases analysis may be acceptable for showing compliance with § 23.305, paragraph (a). Section 23.307, paragraph (a), provides the criterion for when analysis is not acceptable and testing must be performed.

It is not appropriate to define specific quantitative criterion to determine when testing is required to demonstrate compliance with § 23.305, paragraph (a), in accordance with § 23.307, paragraph (a). One specific criterion will not work for all possible airplane designs. It is better that such determinations are made on a case-by-case basis, in which the appropriate details of a particular design can be considered.

However, this policy describes some of the factors that should be considered when determining if tests are required to demonstrate that clearance between controls and adjacent structure (under load) meets § 23.305, paragraph (a). These factors include, but are not limited to, the following:

(1) The clearance between control surfaces and adjacent structure, when at rest.

Suppose an applicant has experience with other airplanes that have a half-inch of clearance between controls and adjacent structure at rest. However, a new design is similar except it now has only a tenth of an inch clearance when at rest. Tests to demonstrate compliance with § 23.305, paragraph (a), may be required because the new structure may not conform to those for which experience has shown this method to be reliable in the past. The accuracy of past methods may not be suitable for the smaller clearances. Critical conditions assessed in past analysis may not have included a condition that is critical for the new smaller clearance.

(2) The amount of deformation (under limit loads) in the control surface or adjacent structure.

If analysis had been shown to be reliable in the past for a wing that had much smaller deflections than a current design, the current structure may not conform to those for which experience has shown this method to be reliable, and testing may be required. Previous analytical methods may no longer be reliable because the new design behaves in a more non-linear manner. It is possible that types of deflection that were neglected in past analysis may now become critical.

(3) New control surface attachment configurations or other local design changes could create new types of deformation that are critical for the new design but were not considered in past analysis.

If the FAA requires (or if an applicant voluntarily chooses) compliance with § 23.305, paragraph (a), to be shown by tests, the following test procedure is one means to simultaneously demonstrate compliance with both § 23.305, paragraph (a), and § 23.683. It also demonstrates compliance with § 23.681, paragraph (a). These tests may be conducted as follows:

Except where otherwise specified, the tests described below in sections (1), (2), and (3) should be conducted within the following parameters (a through h).

PARAMETERS:

a. Conduct the control system operation tests by operating the controls from the pilots' compartment.

b. All the control surfaces must be installed to their adjacent fixed surface on the airframe (according to the type design).

c. The entire control system and adjacent fixed structure should be loaded.

d. The adjacent fixed surfaces (wings, horizontal stabilizers, vertical stabilizers, and so forth) should be loaded to provide deflections equivalent to critical limit load flight conditions.

e. The structural deflections should correspond to the limit flight conditions that represent the worst case conditions for increased cable tension, decreased cable tension, and control/fixed surface proximity for each control system as appropriate.

f. The entire control system must be loaded to either the limit airloads or the limit pilot forces; whichever is less (§ 23.683, paragraph (b)(1)). Per § 23.397, the automatic pilot effort must be used instead of limit pilot forces if it alone can produce higher control surface loads than the human pilot.

g. Minimum clearances around control surfaces and minimum tensions in cable systems should be defined and incorporated in the airplanes instructions for continued airworthiness. The test article should incorporate these minimum clearances and tensions, unless you otherwise account for them.

h. If reductions in the minimum clearances described in paragraph g above are possible due to environmental conditions expected in service, you must account for this. This can be accomplished through analysis or during testing by adjusting the test article clearances to encompass these effects.

SECTION (1):

Consider all airplane maneuver and gust loads, and inertial loads, represented by the airplane flight envelope (V-n diagram); consider unsymmetrical load cases.

(1) The tests described in this section support the demonstration that the control system is free from jamming, excessive friction, and excessive deflection as required by § 23.683, paragraphs (a)(1), (2), and (3). They also support the demonstration that structural deformations not interfere with safe operation as required by § 23.305, paragraph (a). Accomplish the following:

(i) Load the adjacent fixed aerodynamic surface (wing, horizontal tail, or vertical tail) in accordance with one of the conditions of paragraphs d, e, and f above.

(ii) Support the control surface being tested while it is located in the neutral position.

(iii) **Load** the control surfaces to the critical limit loads, as described in paragraph f above, and evaluate their proximity to the fixed adjacent structure for interference (contact).

(iv) Load the pilots control until the control surface is just off the support.

(v) **Determine** the available control surface travel, which is the amount of movement of the surface from neutral when the cockpit control is moved through the limits of its travel.

(vi) The control surface under loads described in paragraph f above must have adequate flight characteristics as specified in § 23.141.

(vii) **To** address the possibility of a critical intermediate control surface loading, gradually remove load from the control surface (while maintaining the load on the adjacent fixed surface) until maximum control surface travel is achieved.

(viii) The above procedure should be repeated in the opposite direction.

(ix) With limit load applied to the adjacent fixed surface and limit or intermediate load applied to the control surface, no signs of jamming, or of any permanent set of any connection, bracket, attachment, and so forth, may be present.

(x) The control system should operate freely without excessive friction. Excessive friction is any increase under limit loads that results in exceeding the limit control forces and torques specified by the regulations.

(xi) Cable systems should be checked with the loads applied to ensure that excessive slack does not develop in the system. Excessive slack is any change in cables or cable hardware that results in reduced airplane control surface movement.

(xii) Repeat this process for each of the critical loading conditions as defined by paragraphs d and f above.

SECTION (2):

(2) **The** tests described in this section support the demonstration that structural deformations not interfere with safe operation as required by § 23.305, paragraph

(a) Accomplish the following:

(i) Load the adjacent fixed aerodynamic surface (wing, horizontal tail, or vertical tail) in accordance with one of the conditions of paragraphs d and e above.

(ii) Operate the unloaded control system from stop to stop.

(iii) No signs of interference (contact) may be present.

(iv) The control system should operate freely without excessive friction.

(v) Repeat this process for each of the critical adjacent fixed surface loading conditions as defined by paragraphs d and e above.

NOTE 3: An alternate procedure may be used to accommodate the testing described in sections (1) and (2) above during structural tests of a partial airplane. This method requires that all control system components that are attached to or enclosed by the loaded test structure be installed per type design. A sufficiently representative mockup of remaining control system components must be used to assure that the full lengths of any cables, which extend from the loaded test structure, are included. This is necessary to make a reasonable assessment that slack that could develop in control cables is not excessive enough to cause an entanglement or jam. The control surface activation may be input at any convenient location between the mockup terminus and the cockpit.

SECTION (3):

(3) The tests described in this section will demonstrate that the control system is free from excessive deflection as required by § 23.683, paragraph (a)(3). These tests complete this means of compliance that the control system is free from jamming and excessive friction as required by § 23.683, paragraphs (a)(1) and (2). They also demonstrate that structural deformations do not interfere with safe operation as required by § 23.305, paragraph (a). These tests meet the limit load static test requirements of § 23.681, paragraph (a). Accomplish the following:

(i) With the adjacent fixed surface (wing, horizontal tail, or vertical tail) unloaded, support the control surface being tested while it is located in the neutral position.

(ii) Load the control surfaces to the critical limit loads, as described in paragraph f above, and evaluate their proximity to the fixed adjacent structure for jamming or contact.

(iii) Load the pilots control until the control surface is just off the support.

(iv) Operate the cockpit control in the direction opposite the load to the extent of its travel.

(v) The above procedure should be repeated in the opposite direction.

(vi) The minimum loaded control surface travel must have adequate flight characteristics as specified in § 23.141.

(vii) Under limit load, no signs of jamming, or of any permanent set of any connection, bracket, attachment, and so forth, may be present.

(viii) The control system should operate freely without excessive friction.

NOTE 4: The tests described in section (3) above are normally accomplished using a complete airplane. As a minimum, they must be completed using an airframe/control system that completely represents the final product from the cockpit controls to the control surface.

Regardless of the amount of travel of a control surface when tested as described above, the airplane must have adequate flight characteristics as specified in § 23.141. Any airplane that is a close derivative of a previous type certificated airplane need not exceed the control surface travel of the original airplane; however, the flight characteristics should be tested to assure compliance.

EASA AMC 23.683 is acceptable for FAA certification.

23.685 Control system details

No policy available as of September 30, 2003.

The corresponding rule in CAR 3 is CAR 3.344.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.20.

23.687 Spring devices

This rule was adopted on February 1, 1965 as a recodification of CAR 3.347.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.21.

Compliance may be shown by flight tests with the spring disconnected to demonstrate that failure of the spring will not cause flutter or unsafe flight characteristics, or by performing a reliability analysis.

The flight test option is preferred since this approach conclusively addresses the safety issue and is historically a minimal test burden.

An applicant who chooses the reliability analysis option must accept that a failure of the spring could create unsafe flight characteristics and, therefore, meet the corresponding level of reliability. This may involve the use of redundant design such as dual springs and demonstration of flight characteristics with one removed.

A positive determination of spring reliability requires that an applicant show the spring will perform its intended function for a specified interval under operational and environmental conditions appropriate for the proposed airplane. Although not normally used for structural substantiation, the reliability assessment methods for § 23.1309 may contain some concepts that would be helpful in demonstrating the reliability of the spring device. The reliability assessment should consider, but not necessarily be limited to, fatigue failures, failures due to corrosive environments, and any in-service changes in the spring characteristics, particularly the spring constant. The reliability assessment of a spring device used in any airplane flight control system must consider airworthiness standards other than § 23.687. These include, but are not limited to, flutter characteristics and handling qualities.

In addition, § 23.687 is explicit in that the applicant must demonstrate reliability of the spring with tests that simulate service conditions. Tests are the required substantiation method; however, an applicant may show compliance with tests supported by analysis. In addition to the spring device testing requirement, 14 CFR, part 23, § 23.601, General, requires testing for any design detail or part that has an important bearing on safety of flight. An applicant should also show compliance with 14 CFR, part 23, § 23.305 (a) and (b). Finally, when a single spring is required for flutter, handling qualities, or any other regulatory reason, the spring should be considered a single path critical structure and meet the A-Basis requirements of § 23.613(b)(1).

23.689 Cable systems

The corresponding rule in CAR 3 is CAR 3.345.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.22.

Original Issue and Subsequent

If tabs are installed with cable less than 1/8th-inch diameter, the airplane should be safely controllable with the tabs in the most adverse position as if from a failed cable. Using emergency procedures, the pilot should be able to return and land safely. Airplane configurations, such as flaps, landing gear, and power are permissible devices to use in relieving control forces. The temporary control forces of part 23, § 23.143, are applicable until the force reduction procedures are completed.

Smaller diameter cables (no less than 1/16-inch diameter) may be used for rudder pedal interconnections (used for pulling one pedal back when the other is pushed forward, but not used to drive the control surface), if the failure of this interconnection will not affect rudder operation.

This rule was put in the original issue of part 23 from CAR 3.345, and it was intended to apply to airframe control cables not engine controls cables, which are certified under part 23, Subpart E.

A proposed revision to NPRM 67-14 revised this section by Amendment 23-7 as follows*: "Pulley specifications (Sec. 23.689). Section 23.689 (b) was amended by striking out the words "as specified in the pulley specifications" after the words "is used. Explanation. Correspondence of pulley and cable is prescribed in the first sentence of Sec. 23.689 (b). Correspondence may be verified in several ways. The reference to pulley specifications adds nothing."*

23.691 Artificial stall barrier system

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 states as follows: *"This proposed new section would provide standards for stall barrier systems if a stall barrier is necessary to show compliance with Sec. 23.201(c).*

The requirements of Sec. 23.201(c) provide criteria for the in-flight demonstration of wings level stall. The requirements also specify the means of identifying when a stall has occurred. Amendment No. 23-45 (58 FR 42136, August 6, 1993) revised Sec. 23.201(c) by adding the activation of an artificial stall barrier as an acceptable means of identifying when a stall has occurred.

As the technology of airplane designs improved and engines with increased power became available, airplanes were developed that did not meet the older wings level stall requirement of Sec. 23.201. Consequently, these airplanes were equipped with an artificial stall barrier that moved the airplane elevator controls and caused a nose down pitching motion similar to the pitching motion of airplanes that meet the wings level stall requirement of Sec. 23.201. The manufacturer selected the airspeed where this pitching motion occurred and flight testing established compliance with the other flight regulations at airspeeds above the speed selected for the push. These stall barrier systems are commonly called "stick pushers." Such systems have been accepted for compliance with Sec. 23.201 under the equivalent safety provisions of Sec. 21.21(b)(1), since they provide a pitch motion that is equivalent to that experienced during stalls of airplanes that meet the stall requirements of Sec. 23.201. Appropriate compliance with other applicable requirements of part 23 has been established by other design characteristics of the stall barrier system.

The provisions of the proposed new section are based on system design characteristics necessary to ensure the safe operation of previously approved stall barrier systems. The proposed section also requires such systems to include provisions to prevent unwanted activation of the stall barrier systems. This is necessary to ensure that such systems do not cause downward pitching motions at higher airspeeds when such pitching could be unsafe.

The proposed sections would basically codify those provisions that have been found necessary for approving stick pusher systems under the equivalent safety requirements of Sec. 21.21(b)(1). Therefore, in effect, no new requirements would be added by this proposed amendment.

The proposed new section would be applicable only to airplanes with flight characteristics that need an artificial stall barrier system to ensure safe operation of that airplane. Including provision for the installation of an optional stick pusher system would relieve the manufacturer of the financial burden that would be needed to redesign the airplane so that it would meet the wings level stall requirements."

The proposed rule was changed by Final Rule, Docket 27806 as follows: "In the course of the FAAs review, however, the FAA noted that the word "necessary" in the introductory paragraph of Sec. 23.691 should be changed to "used," to make it clear that the equipment requirements of this section are applicable if a stick pusher system is used in the airplane to show compliance with Sec. 23.201(c)."

Section 23.201(b), Amendment 23-45, added the activation of an artificial stall barrier as an acceptable means of identifying when a stall has occurred. A stall barrier is a device that prevents an actual stall (i.e., a stick pusher) while a stall warning is a device that alerts a pilot of an impending stall (i.e., a stick shaker). Of course, the actual stall should not occur before activation of the stall barrier. This amendment provided the standards for an artificial stall barrier system **when** it is used to show compliance with § 23.201(b).

Per § 23.201, a stick shaker is a "stall avoidance" device. Per the NPRM for Amendment 23-45, an applicant may identify a stall as the speed at which a stick shaker activates. This is an acceptable means of compliance to the rules. Stick shaker activation is then identified as a stall for a pilot by Airplane Flight Manual (AFM.) However, from an engineering perspective and considering the "stall avoidance" in § 23.201, this is an acceptable means of compliance not an aerodynamic stall. The difference is important in certification since the aerodynamic stall determines whether a stick shaker is required equipment.

A stick pusher system would be a critical system for an airplane with stall recovery that is undetermined, marginal, or unacceptable. Failure of the system is then required to be extremely improbable. The FAA does not consider the probability of entering a stall environment as a factor in developing system reliability. The exception would be developing specific system component reliability where that component would be active only when the airplane is in a stall environment. The FAA does not give credit toward developing reliability for the use of a "Go/No Go" preflight system check, although the FAA does recommend that preflight procedures for all essential/critical systems be provided for pilot use. (Service experience has shown that some part 23 airplane pilots do not have the discipline to conduct the prescribed preflight checks.) The development of normal/abnormal/emergency procedures is not a factor in determining system reliability; however, such procedures are desirable, as well as required by § 23.1581. These factors may be considered when exercising engineering judgment in approval of the overall system.

Stall can be identified by stick shaker/pusher operation, uncontrollable downward pitching, or the elevator control reaching the stop (see AC 23-8B)—whichever occurs first in any particular flight regime is acceptable. An airplane may be approved if it has stick shaker/pusher operation in one configuration, such as power on, and it has acceptable stall characteristics for the remaining configurations.

Inadvertent stick pusher operation should be investigated and shown not to be hazardous and to be recoverable, or that inadvertent operation is extremely improbable.

23.693 Joints

No policy available as of September 30, 2003.

This rule was adopted on February 1, 1965 as a recodification of CAR 3.346.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.23.

23.697 Wing flap controls

The corresponding rule in CAR 3 is CAR 3.338.

There is no corresponding rule in the Airship Design Criteria.

Amendment 23-49 and Subsequent

A revision to NPRM 94-21 proposed § 23.867(c) as follows: *"This revision is needed to ensure that the flap settings, which establish the safe operation of the airplane, can be positively selected."*

23.699 Wing flap position indicator

No policy available as of September 30, 2003.

This rule was adopted on February 1, 1965 as a recodification of CAR 3.338.

There is no corresponding rule in the Airship Design Criteria.

23.701 Flap interconnection

The corresponding rule in CAR 3 is CAR 3.339.

There is no corresponding rule in the Airship Design Criteria.

Original Issue

The flaps should be synchronized by a mechanical interconnection unless the airplane has safe flight characteristics with the flaps retracted on one side and fully extended on the other side. The safe flight demonstration with asymmetry should be shown throughout the airspeed range permitted for flap extension. The control forces should not exceed those shown for temporary application in the table in § 23.143(c). However, they may not exceed the force that can be demonstrated as safe with one hand on the control wheel/stick (other hand needed to re-trim, pull circuit breaker, operate flap control, etc.). If the forces of asymmetry cannot be alleviated in a reasonable period of time, the remaining forces should not exceed those specified for prolonged application in § 23.143(c).

After demonstrating that the airplane has safe flight characteristics with the flaps in their most adverse position, it is permissible to readjust the remaining flap surfaces after a malfunction occurs.

Amendment 23-42

A proposed revision to NPRM 89-5 explains this amendment as follows: *"This proposal would update the regulations to include provisions for airplanes with a flap configuration other than one flap on each wing. It would also address the failure of any single element in the flap control system and allow for an alternate equivalent means to the mechanical interconnection required by the present rule. Airplanes are currently being manufactured with two flaps on each side of the airplane and are being designed with flaps on canards and tandem wings. On an airplane with four flaps, there is a possibility that only one flap may be asymmetric with respect to the other three and this issue needs to be addressed in the airworthiness standards, as proposed in paragraphs (a) and (b)."*

Amendment 23-42 was not intended to change the requirement that "The main wing flaps and related movable surfaces as a system must be synchronized by mechanical connection." The main purpose of this change was to add the following requirement that would maintain synchronization so that the occurrence of an unsafe condition has been shown to be extremely improbable. This requirement includes provisions for synchronization of the flaps other than by mechanical interconnection of the flap. These reliability requirements by numerical probability analysis for other synchronization methods should not be applied to mechanical interconnection.

It is difficult to assess the reliability of mechanical interconnections by examples of different types of mechanisms. The complete system needs to be analyzed and tested.

Section 23.701, as amended by Amendment 23-42, in part, states the following:

(a) The main wing flaps and related movable surfaces, as a system must:

(1) Be synchronized by mechanical connection; or

(2) Maintain synchronization so the occurrence of an unsafe condition has been shown to be extremely improbable; or

(b) The airplane should be shown to have safe flight characteristics with any combination of extreme positions of individual movable surfaces (mechanically interconnected surfaces are to be considered as a single surface).

During a recent review of this new requirement, it was noted that the new § 23.701(b), particularly the parenthetical portion of that paragraph, could be improperly interpreted and applied. It is possible that this misinterpretation could result in the use of differing terminology (i.e., "mechanical interconnection" and "mechanically interconnected") in paragraphs (a)(1) and (b). These terms mean the same thing; direct positive mechanical interconnection between separate flap surfaces that are isolated from the flap control or actuation system.

Novel and unusual design features, such as an interconnection of the leading and trailing edge flap systems or an interconnection of flaps and ailerons, would require special conditions.

Equivalent Level of Safety (ELOS) Findings

Several findings have been accepted for the mechanical interconnection requirement.

a. Synchronized by a Mechanical Interconnection

These words appeared in 14 CFR, parts 23 and 25, and in CAR 03 and 04b since they were first issued. The synchronization requirement for the motion of the flaps by a mechanical interconnection is applicable to airplanes not having safe flight characteristics under asymmetrical flap operations. For these cases, there would be a hazardous condition when the flaps are retracted on one side and extended on the other side.

b. Mechanical Interconnection Requirement of § 23.70l(a)(l)

This requirement is to assure against hazardous asymmetrical operation of the flaps after any probable single or probable combination of failures of the flap actuating system. A probable combination of failures should be considered when the first failure would not be detected during normal operation of the system, including periodic checks, or when the first failure would inevitably lead to other failures. (Systems where a probable combination of failures may occur include the electrical and hydraulic systems.) The airplane also should be shown to be capable of continued safe flight and landing without requiring exceptional pilot skill or strength following these failures. To demonstrate that the airplane is safe under these conditions, tests should be conducted with the flaps being retracted on one side and extended on the other during takeoffs, approaches, and landing. If there is a probable hazardous condition, a separate positive connection that is not part of the flap actuation system is required.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 revised this section as follows: *"Section 23.701 (a)(1) and (a)(2) would be revised to clarify the requirements for flap systems installed on part 23 airplanes. Following the revision of Sec. 23.701, as adopted by Amendment No. 23-42 (56 FR 353, January 3, 1991), the FAA discovered that the new requirements could be interpreted in a way that was not intended and that this interpretation could result in approval of airplanes with unsafe flight characteristics in the event of flap failure. To clarify the intent of the requirements, the FAA issued on March 14, 1991, a policy letter to all aircraft certification offices that provided guidance for the correct application of the requirements.*

Since then, the FAA has reexamined the requirements and determined that Sec. 23.701(a)(1) and (a)(2) need to be revised to ensure that a failure of the flap system would not create an asymmetric flap configuration that could result in an unsafe flight condition. Therefore, Sec. 23.701 (a)(1) and (a)(2) would be revised to clarify that one of the following would apply:

(1) *The moveable flap surfaces must be synchronized by a mechanical interconnection or by an approved equivalent means that is independent of the flap drive system.*

(2) *The wing flap system must be designed so that any failures of the flap system that would result in an unsafe flight characteristic of the airplane, such as flap asymmetry, are extremely improbable.*

These revisions would ensure that a failure of the flap drive systems will not result in a flap asymmetry configuration."

ACCEPTABLE MEANS OF COMPLIANCE

An acceptable means of compliance with the airworthiness requirements for the flaps mechanical interconnections of § 23.701(a)(1) are described as follows:

a. Reliability

Reliability of the mechanical interconnections is generally shown either by load analysis or load tests, or both, not by numerical probabilistic analysis. The mechanical interconnection should be designed for the loads resulting when interconnected flap surfaces on one side of the plane of symmetry are jammed and immovable, while the surfaces on the other side are free to move and the full power of the surface actuating system is applied. It should also be designed to account for the asymmetrical loads resulting from flight with the engines on one side of the plane of symmetry inoperative and the remaining engines at takeoff power. For single engine airplanes and multiengine airplanes with no slipstream effects on the flaps, it may be assumed that 100 percent of the critical air loads acts on one side and 70 percent on the other. The flight loads from § 23.345 acting on the surfaces should be considered in combination with the actuating system loads (including system inertia loads). Critical air load conditions should consider flap retraction and flap extension, including go-around. These conditions are considered limit loads. If there are no hazardous conditions when the flaps are asymmetrical, the jam or maximum load conditions could be considered an ultimate load.

b. Friction Loads

It may be necessary to consider friction loads in the actuating system that may be reasonably expected to occur in service. Each design should be evaluated to determine its susceptibility to friction in the mechanism and any loads with such resistance.

c. Equivalent Means by Use of the Mechanical Actuation System

The mechanical actuating system for the flaps may be considered the mechanical interconnection, if all elements are mechanically interconnected from the actuator source to the flaps. These mechanical elements may include structures, interconnection linkages, and drive system components. When the mechanical interconnection is through the actuating system, and it is the only means to prevent an unsafe asymmetrical condition, the loads associated with the jam conditions are considered limit loads. A 1.5 factor of safety is required if a failure as a result of the jam condition would cause a hazardous flap asymmetrical operation. A mechanical actuating system having a 1.5 factor of safety may not need to be evaluated for probable failure conditions. Also, if the drive system is designed so that a hazardous flap asymmetrical operation would not occur after a jam condition, the 1.5 factor of safety should not be required.

d. Equivalent Means by Use of a Warning and Prevention System

A second equivalent means is the use of a warning and prevention system. This system monitors the symmetrical condition of the flaps and warns the pilot when an unsymmetrical flap condition occurs, but the asymmetry is still kept within safe limits. It prevents further movement of the flaps from exceeding safe limits. The warning and prevention system should be independent for each functionally related set of surfaces (i.e., a set of flaps on each side of a plane of symmetry that is driven by a common actuator). Again, the airplane should be shown to have safe flight characteristics without requiring exceptional piloting skill or strength at the extreme limits of the asymmetrical condition where the flaps are stopped. Tests should be conducted to simulate flap malfunctioning at the most severe case in the static asymmetrical condition of the flaps during takeoffs, approaches, and landings. The warning and prevention system should provide a pilot with a selectable or automatic test mode that exercises the system to an appropriate depth, so the pilot can determine proper operation of this system.

e. Electrical/Electronic Flap Interconnection System

When Amendment 23-42 was adopted, § 23.701 was amended to include provisions for airplanes with a flap configuration other than a mechanical interconnection. This amendment added the following requirement in § 23.701(a)(2): “Maintain synchronization so that the occurrence of an unsafe condition has been shown to be extremely improbable." This requirement is applicable for electrical/electronic flap interconnection systems, such as airplanes that have additional flaps and tandem wings. Guidelines for performing a design safety assessment by application of § 23.1309(b), as adopted by Amendment 23-41, are given in AC 23.1309-lC. This AC also provides guidance regarding design safety assessments, environmental and atmospheric conditions, and software assessment.

23.703 Takeoff warning system

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-49 and Subsequent

A revision to NPRM 94-21 proposed this rule as follows: *"This proposed new section would require a takeoff warning system on some commuter category airplanes. The requirement would be applicable if the flight evaluation showed that an unsafe takeoff condition would result if lift devices or longitudinal trim devices are set to any position outside the approved takeoff range. If the evaluation shows that no unsafe condition would result at any setting of these devices, a takeoff warning system would not be required. For those airplanes on which a warning system would not be required. For those airplanes on which a warning system must be installed, the proposal would provide requirements for the installation of the system."*

LANDING GEAR

23.721 General

The Small Airplane Directorate has no criteria or policy for taxi over rough surfaces for small airplane landing gear design. Manufacturers are free to develop and substantiate their own criteria.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

23.723 Shock absorption tests

The corresponding rules in CAR 3 are CAR 3.351 and 3.352.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.24.

Original Issue

This regulation **requires** shock absorption tests be performed for certification.

Amendment 23-23 and Subsequent

This amendment permits an analysis rather than a shock absorption test, but to do so the applicant should have a landing gear system with **identical** (similar is not acceptable) energy absorption characteristics. The energy absorption characteristics of the landing gear system (e.g., structure, wheel tire, shock absorber) should be included in determining the dynamic response of the landing gear system. The tests should cover a range of energy absorption characteristics and weights over which the analysis is shown to be valid. If these conditions are not met, drop tests will be required to substantiate maximum takeoff and landing weight increases. It is acceptable to modify individual gear drop test data by adapting the results to the complete aircraft analytically, accounting for the aircraft flexibility.

23.725 Limit drop tests

The corresponding rules in CAR 3 are CAR 3.353 and 3.354.

There is no corresponding rule in the Airship Design Criteria.

Original Issue

This rule gives requirements for limit load drop tests if the applicant uses free drop tests to meet the requirements of § 23.723(a). The applicant should make ten drops from limit height for each basic design condition. The applicant should make one drop from the height (maximum is 2.25 times the limit drop height) needed to develop 1.5 times the limit load using the limit drop weight. It is acceptable to modify individual gear drop test data by adapting the results to the complete aircraft analytically, accounting for the aircraft flexibility.

Amendment 23-7 and Subsequent

This amendment requires that the limit inertial load factor be determined in a rational and conservative manner during the drop test using a landing gear unit attitude and applied drag loads that represent the landing conditions. It is acceptable to modify individual gear drop test data by adapting the results to the complete aircraft analytically, accounting for the aircraft flexibility.

23.726 Ground load dynamic tests

No policy available as of September 30, 2003.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

23.727 Reserve energy absorption drop test

The corresponding rule in CAR 3 is CAR 3.355.

There is no corresponding rule in the Airship Design Criteria.

Amendment 23-7 and Subsequent

Paragraph (b) in § 23.727 requires that the effect of wing lift be provided for in reserve energy drop tests. You should also use the applicable drag loads, as specified in § 23.725(c).

23.729 Landing gear extension and retraction system

The corresponding rules in CAR 3 are CAR 3.356, 3.357, 3.358 and 3.359.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.25.

Original Issue

14 CFR, part 23, does not define landplanes, seaplanes and amphibians. These terms passed unchanged from CARs 3 and 4. As we use them, landplanes can only land on the ground, seaplanes (both boat and float types) can only land on water, and amphibians can land on both water and on the ground.

Therefore, where a rule such as § 23.729(c) states "landplanes" it does not apply to seaplanes or amphibians. When the rule states "airplanes" such as § 23.729(a) it applies to any aircraft that incorporates that equipment. Thus, § 23.729(a) can apply to landplanes and amphibians, but not seaplanes since they don't have retractable land gear.

Amendment 23-7 and Subsequent

A warning device with no manual shutoff is required when the flaps are "to or beyond" the approach flap setting if the landing gear is not down and locked. The "to or beyond" phrase in relation to using a normal landing procedure is intended to provide for differences in design, as follows:

a. For airplanes whose normal procedures only prescribe landings with flaps extended past the approach setting, only the "beyond" aspect of this rule is appropriate. Operating information for these airplanes should convey that landings with approach flaps, or less, are not normal and will not activate the flap/landing gear aural warning.

b. For airplanes whose normal procedures include landings with a flap setting at the approach setting, the "to and beyond" aspect of this rule is appropriate. Designers may choose to include additional logic in the flap/landing gear warning system, such as airspeed, thrust/throttle position, etc. This logic may tend to minimize nuisance warnings and may provide the equivalent safety intended by the rule.

Because part 23 is not specific with regard to flap positions used, we cannot specify the flap position that actuates the warning device. This rule provides a basis for the FAA and the applicant to mutually agree on the set point for the warning device. Although not defined in part 23, most airplanes do have a "normal landing procedure" and an "approach flap position." The flap position will vary among models, but it is this position that should be used to show compliance.

Amendment 23-21, NPRM 75-25, changed this section to require a warning when any throttle is closed. The NPRM explanation states as follows: “The present rule requires that a manual shutoff for the aural landing gear warning device be installed so that reopening the throttle will reset the device. However, when an engine has been shut down in flight, its throttle may not be reopened before landing. The proposal would require the aural warning to be activated when any throttle is subsequently retarded to or beyond the position for a normal landing approach, thus requiring the warning intended by paragraph (e)(2) regardless of the position of any other throttle and the prior deactivation.”

Amendment 23-45, NPRM 90-18, changed this section again. The NPRM states as follows: *“This proposal revises § 23.729(f)(1) and (2) by changing the power and flap settings necessary to activate the device that warns the pilot that the landing gear is not fully extended and locked. The power setting necessary to activate the warning device is changed from when one or more "throttles are closed" to when one or more "throttle are closed beyond the power settings normally used for landing approach." The flap setting necessary to activate the warning device is changed from "flaps are extended to or beyond the approach flap position" to " flaps are extended beyond the approach flap position."*

This information is applicable to the structural substantiation to the loads resulting only from all yawing conditions for the landing gear doors and retraction mechanism of small airplanes per part 23, § 23.729(a)(2).

Section 23.729(a)(2) requires the landing gear doors and retraction mechanism to be substantiated for the loads resulting from all yawing conditions. Attempts have been made to meet these requirements by flight testing to dive speed with some yaw or by flight testing at full yaw at a lower speed. These procedures normally do not result in a test that substantiates a 1.5 factor of safety. If substantiation by flight testing is desired, the landing gear doors and retraction mechanism should be subjected to 1.5 times the limit "q" loading. The limit “q” loading is the “q” at V_{LE} or V_{LO} whichever is greater.

The higher of the above speeds at which V_q is to be computed is designated as V_{LG}.

ACCEPTABLE MEANS OF COMPLIANCE

One method, but not the only method, for showing compliance with the structural requirements of § 23.729(a)(2) for the loads resulting from all yawing conditions for the landing gear doors and retraction mechanism is as follows:

a. Substantiation may be accomplished by flight testing at a speed of V_q and the yaw angle determined in paragraph a (3) below, unless this will exceed the structural limitation as determined by analysis, static test, or a combination of both, where:

(1) V_q = square root of (V_{LG} squared times 1.5).

(2) V_{LG} = The greater of V_{LO} or V_{LE}.

(3) For the yawed condition, the limit "q" load will be at V_{LG} with the airplane at the yaw angle determined by § 23.441. This angle need not exceed 15 degrees. Substantiation should be to 1.5 "q".

(4) If V_q is equal to or less than V_A, substantiation by flight test may be accomplished.

(5) If V_q is greater than V_A, the yaw necessary to produce 1.5 "q" could result in overloading other airplane structures, and the maneuver should not be performed.

(6) V_{LG} may be reduced by imposing limitations on the airplane such that Vq is less than V_A.

(7) The definitions of the terms used above are equivalent airspeeds, as follows:

V_A = Design maneuvering speed

V_D = Design diving speed

V_{LG} = Landing gear speed used in the calculation of V_q

V_{LE} = Maximum landing gear extended speed

V_{LO} = Maximum landing gear operating speed

V_q = Speed which results in 1.5 times limit "q" loading

b. If the condition of Item a (5) above exists, substantiation of the landing gear doors and retraction mechanism may be accomplished by static tests, analyses, or a combination of both.

Amendment 23-49 and Subsequent

This guidance provides clarification of the requirements for tire burst as related to landing gear and 14 CFR, part 23, §§ 23.729(g) and 23.1309 compliance. The intent of the proposed revision to NPRM 94-21 is given as follows: *"This proposal would also add a new Sec. 23.729(g) requiring that if the landing gear bay is used as the location for equipment other than landing gear, the equipment must be designed and installed to minimize damage. On larger airplanes, such as the commuter category, a* *primary cause of damage to such equipment would be tire-burst. In addition, service history has shown that rocks, water, and slush enter the landing gear bay and cause damage. The equipment on any size airplane should be protected from damage by such external sources."*

The requirement in § 23.729(g) states: "If the landing gear bay is used as the location for equipment other than the landing gear . . ." "As used within this requirement, the term landing gear applies to all parts and systems contained in the "LANDING GEAR" section in Subpart D (§§ 23.721 through 23.745) that are specific to the landing gear. For example, wheels, brakes, wheel steering mechanism, and structural portions of the landing gear that are within the gear are all considered part of the "landing gear" for the purposes of § 23.729(g) compliance. Systems that act upon the landing gear, e.g., extension and retraction systems, hydraulic systems, etc., are not considered part of the landing gear itself and should be addressed in § 23.729(g) compliance. Compliance to this section can be by isolation of non-landing gear equipment from the landing gear bay or by protection/shielding of this equipment from the effects of tire burst/loose tread and external forces. Using either of these means of compliance to § 23.729(g) also shows compliance to the § 23.1309 Particular Risk Analysis for non-landing gear equipment.

The effects of tire burst must still be evaluated for § 23.1309 compliance. When showing compliance with § 23.1309 for tire burst, in accordance with § 23.1309(f)(2) and AC 23.1309-1C, only the structural portions of the landing gear are exempt from the § 23.1309 requirements. Addressing external effects as part of the airplane safety analysis is consistent with the FAA advisory material for parts 23, 25, and 29, ARP 4761, and "Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment."

When showing compliance with § 23.1309 for tire burst, it is not appropriate to address compliance by assuming a probability of tire burst occurring, rather tire burst must be assumed to have occurred—(assuming a tire burst probability is inconsistent with the aforementioned advisory material and accepted industry guidelines). Therefore, an acceptable means of compliance with the tire burst requirements § 23.1309 would be to account for all systems and equipment in the tire burst tests and analysis performed under § 23.729(g). These tests and analyses must be conducted on a conformed test article that includes all systems and components as defined in the type design data. Items identified by either analysis or tire burst tests, or both, as capable of causing hazards to the airplane must be protected or relocated. Therefore, we provide answers to the questions raised as follows:

1. "Do hydraulic, mechanical, and electrical components utilized in any way for retraction/extension of the landing gear doors or control of same need to be protected from the tire burst requirements of § 23.729(g)?"

Yes, unless the § 23.1309 safety assessment shows that damage from tire burst cannot cause a hazard(s) to the airplane. The minimization requirements of § 23.729(g) apply.

2. "If the above items are exempt from § 23.729(g), are they exempt from the Particular Risk Analysis required by § 23.1309."

While § 23.729(g) applies to the item 1 equipment, tire burst effects should be considered for all landing gear and non-landing gear systems and equipment, except flight structure, as part of § 23.1309 compliance.

EASA AMC 23.729(g) is acceptable for FAA certification.

23.731 Wheels

See 23.735, Brakes.

The corresponding rule in CAR 3 is CAR 3.361.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.26.

23.733 Tires

The corresponding rule in CAR 3 is CAR 3.362.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.27.

Original Issue and Subsequent

The following is a recommended test procedure for the installation of tires on a part 23 airplane:

1. Inflate an inboard main tire to the minimum allowable inflation pressure for the airplane weight.

2. Inflate the outboard main tire on that same landing gear to the maximum allowable inflation pressure for the airplane weight.

3. Using white shoe polish or equivalent, mark a 2-inch wide stripe on the brake (inboard) side of the outboard tire sidewall adjacent to the wheel rim.

4. Conduct at least two maximum efforts; non-skidding taxi turns into the minimum inflation side of the airplane.

5. Check for evidence of brake wheel housing abrasion contact on the tire sidewall.

NOTE 5: Above applies to a dual tire installation per landing gear. For a single tire per gear, inflate either side to the minimum pressure and the opposite side to maximum, and turn into the minimum pressure side.

A revision to Amendment 23-17, NPRM 75-10, added subparagraph (c) with the following explanation: "*The proposed rule would require that the selection of tires for installation on retractable landing gear mechanisms take into account the tire production tolerance and size increases that would be expected to result from service. The FAA believes compliance with the proposed rule could prevent accidents that might result from jamming of landing gear mechanisms by oversize tires.*"

Tundra Tires

1. **PURPOSE.** This guidance serves several purposes. First, it summarizes the results of flight tests recommended by the National Transportation Safety Board (NTSB) and conducted by the FAA to investigate the effects of tundra tires installed on a Piper PA-18. Second, it provides information concerning possible hazards associated with the type of operations common for tundra tire users and potential adverse effects of untested installations. Third, it provides general information about the certification process for oversized "tundra" tires, as well as

an example "compliance checklist" for the installation of such tires on light airplanes that have CAR, part 3 for a certification basis.

2. RELATED READING MATERIAL

a. Part 23, CAR part 3, and CAR part 03.

b. “National Transportation Safety Board (NTSB) Safety Recommendation A-95-13,” dated February 7, 1995.

c. Technical Standard Order (TSO)-C62d, “Aircraft Tires.”

d. AC 43.13-1B, Change 1, “Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair.”

3. BACKGROUND. In Safety Recommendation A-95-13, dated February 7, 1995, the NTSB shared some of their safety concerns about tundra tires with the FAA and requested that the possibility of problems with tundra tires be investigated.

The NTSB stated the following:

“Since the early 1960s, hundreds of airplanes operating in Alaska have been equipped with tundra tires, and dozens of versions of tundra tires—some exceeding 35 inches in diameter—have been marketed. The Safety Board is concerned that field approvals and STCs have been granted for use of these tires without flight test or other data on the aerodynamic effects of the tires and wheels. The Piper PA-18 is the airplane most frequently equipped with tundra tires. The Safety Board believes that the FAA should conduct a demonstration flight test to determine the effects of tundra tires on the PA-18s flight characteristics—including cruise, climb, takeoff, and landing performance—and, in both straight and turning flight, stall warning and aircraft stability at or near the critical angle of attack. Further, if the tests of the PA-18 indicate the need, the FAA should take corrective action and expand testing to other airplane types equipped with oversized tires.”

4. SUMMARY OF FLIGHT TEST RESULTS FOR PIPER PA-18 EQUIPPED WITH TUNDRA TIRES

The FAAs flight tests of tundra tires and their results are detailed in Appendix 1 following this guidance. As can be seen in the report, the tundra tire installations on the Piper PA-18 “150” caused no observable adverse effects on stall or stall characteristics during the FAA tests. Although there was some degradation of handling qualities associated with increasing the tire size, the effect was not significant with regard to safety. Rate of climb and cruise speed were degraded with the larger tire sizes; however, the aircraft still met certification requirements.

Additional tests conducted by an independent Designated Engineering Representative (DER) flight test pilot showed the same lack of effect on stall characteristics with the main landing gear fabric covering removed. It should be remembered that these results are valid **only** for the Piper PA-18 “150” and for tires no larger than those tested. It should also be noted that, although tundra tires did not cause a safety problem, the stall characteristics of the basic Super Cub (and most other airplanes) make low altitude turning stalls hazardous, especially in uncoordinated flight. Also, although washout was not varied during these flight tests, previous FAA experience has shown that stall characteristics are further aggravated when operators of the PA-18 remove the 2.5 degrees of washout at the wing tip, which is not an approved alteration. This condition will result in a rapid roll when the airplane is stalled during turning flight.

5. POTENTIAL ADVERSE EFFECTS OF TUNDRA TIRE INSTALLATIONS ON AIRPLANES

a. Performance

Tundra tire installations on airplanes **may** produce one or more of the following effects on performance characteristics:

(1) Increased stall speed.

(2) Reduced stall warning margin.

(3) Reduced rate of climb.

(4) Reduced maximum angle of climb.

(5) Reduced maximum level flight speed.

(6) Reduced cruise speed.

(7) Reduced range.

Tundra tires reduce climb, cruise, and range performance more when installed on relatively “clean,” well streamlined airplanes than they do when installed on less streamlined airplanes.

b. Flight and Ground Handling Characteristics

Tundra tire installations on airplanes **may** produce one or more of the following effects on handling characteristics:

(1) Reduced ability of brakes to hold against takeoff power.

(2) Reduced brake effectiveness during rejected takeoff and braked landing.

(3) Reduced stability and controllability during rejected or balked landing and go around.

(4) Change in either trim range or trim authority, or both.

(5) Reduced directional stability and control during takeoff and landing ground rolls, with consequent increased tendency to ground loop.

(6) Increased tendency to nose over during landing.

(7) Reduced stall warning margin, change in either aerodynamic stall warning characteristics (warning buffet) or reduced effectiveness of stall warning system, or both, in both level and turning flight with power either on or off, or both.

(8) Changes in stalling and stall recovery behavior in both level and turning flight with power either on or off, or both. Stalls may become more abrupt and altitude loss before recovery may increase.

(9) Increased tendency to enter an inadvertent spin and reduced ability to recover from the spin.

(10) Reduced longitudinal**,** lateral, and directional stability.

(11) Increased airframe vibration and buffet.

Tundra tires reduce the airplanes directional stability and controllability during takeoff and landing ground rolls, increase its tendency to ground loop during takeoff and landing ground rolls, and increase its tendency to nose over during landings on paved surfaces more than during landings on gravel, grass, or other surfaces that allow the tires to skid more easily.

c. Potential Propulsion Systems Effects

(1) Fuel flow may be affected by changes in normal flying attitude.

(2) Unusable fuel may be affected by changes in normal flying attitude.

(3) The fuel tank sump may be affected by change in ground attitude.

(4) Fuel drains may be affected by change in ground attitude.

(5) Engine cooling may be affected by performance or flying attitude changes.

(6) Changes in tires may affect the air induction system certification regarding operation on wet runways.

(7) Changes in tires that change ground attitude may affect the induction system icing protection.

6. CERTIFICATION OF TUNDRA TIRES FOR USE ON LIGHT AIRPLANES

The certification process for tundra tires is the same as for any other tire to be used in aviation.

a. A manufacturer may obtain a Technical Standard Order Authorization (TSOA) for the tire using the requirements in TSO-C62d. TSO-C62d contains minimum performance standards for aircraft tires. The TSOA, which covers design and manufacturing of the tire only, is not an installation approval. The tire should be approved for installation on a specific airplane model either by TC or STC. The applicable requirements for installation of a tire on a given airplane should be determined based upon the original certification basis specified in that airplanes Type Certificate Data Sheet (TCDS). The development of a compliance checklist, as described in item 7 below, should be accomplished by the applicant together with the FAA engineer.

b. An alternative certification method exists for a tire that does not have a TSOA. In such a case, the tire design approval may be obtained concurrently with the installation approval for specific airplane models by TC or STC. The requirements of the TSO can be used for a determination of acceptable tire performance in such a project. The applicable requirements for installation of a tire on a given airplane should be determined based upon the original certification basis specified in that airplanes TCDS. The development of a compliance checklist, as described in item 7, should be accomplished by the applicant together with the FAA engineer. Prior to offering tires approved by this method for sale, the tire manufacturer would need a Parts Manufacturing Approval (PMA).

7. COMPLIANCE CHECKLIST

See Appendix 2 for an example of the "Compliance Checklist," to CAR part 3 as amended to November 1, 1949. This checklist is intended to show all aircraft certification requirements that **could** be affected by a tundra tire installation. Many of these requirements may be unaffected by a given installation. The actual compliance checklist for a specific installation should be determined at the start of a project. (See Appendix 2 in this section, which is applicable to § 23.733 Tundra Tires.)

APPENDIX 1

FAA TEST RESULTS/EFFECTS OF TUNDRA TIRES ON THE HANDLING QUALITIES/STALLS/STALL CHARACTERISTICS OF THE PIPER PA-18

1. Tests

Recent accidents in Alaska involving airplanes equipped with tundra tires prompted the NTSB to recommend to the FAA that they conduct flight tests to determine the effects of tundra tires on aircraft performance, stalls, and handling qualities. The following five tires were evaluated at various combinations of Center of Gravity (CG)/weight:

a. Factory installed (8.00-6)

b. McCreary Tundra Tires (8.50-10)

c. McCreary Tundra Tires (29x11.0-10)

d. Schneider Racing Slicks (14.0x32.0x15)

e. Goodyear Airwheels (35x15.0-6).

2. Results

Quantitative/qualitative data obtained from the testing of the four tundra tires were compared to the data obtained from the testing of the factory-installed tire. The following is a summary of the findings:

a. Ground Handling

Forward field of view during taxi is inversely related to tire size. As the tire size increases, the ability to see over the nose decreases requiring that the pilot make “S” turns with the airplane. Ground handling during takeoff from a gravel runway is satisfactory for all configurations. Ground handling during landing on a gravel runway is also satisfactory for all configurations tested, although there is a noticeable nose down pitching moment when the tire(s) contact the ground. This is most evident when making a main wheel only landing. Crosswind landings on runway 13 at Lake Hood Strip, a 2,200 feet x 80 feet gravel runway next to Lake Hood three miles southwest of Anchorage, Alaska, were demonstrated for tire configurations items 1a, 1b, and 1c in winds from 180 degrees (from ahead and to the right of the airplane at an angle of 50 degrees to its flight path) at 14 knots gusting to 16 knots. The wind thus had a crosswind component of approximately 10.7 knots gusting to approximately 12.3 knots and a head wind component of approximately 9.0

knots gusting to approximately 10.3 knots. No crosswinds were available during tests for configurations d and e. No tests for ground handling were accomplished on paved runways. The ground handling characteristics of airplanes equipped with tundra tires are known to be substantially poorer on pavement than on gravel, grass, and other surfaces that allow the tires to skid easily.

b. Performance

Tundra tires adversely affect airplane performance. For example, the uncorrected average rate of climb (tested at 1.05 times maximum gross weight) for the standard tire was 526-feet per minute. The uncorrected average rate of climb for configurations items 1d and 1e (tested at 1.05 times maximum gross weight) was 449 and 464-feet per minute.

3. Stalls/Stall Characteristics

a. The purpose of the stall tests was to determine whether there are any differences between the stalling speed and stall characteristics of a PA-18 "150" airplane equipped with tundra tires and the stalling speed and stall characteristics of the same airplane equipped with standard tires. The data obtained from the stall tests do not validate the theory that tundra tires increase the PA-18 "150" stalling speed.

b. Stall characteristics (all configurations) are normal when the airplane is stalled in balanced flight. In a turning stall, the airplane generally rolls slowly to a near wings level attitude. In maneuvering flight, the tendency is for the nose to drop as the bank angle is increased. If the pilot uses top rudder (right rudder in a left turn) to compensate for this and then stalls the airplane, the airplane may roll rapidly over the top. This could result in a departure or the incipient phase of spin. If the airplane is maneuvering at low altitude when this sequence of events occurs (e.g., while circling to spot moose), the airplane may impact the ground prior to recovery. Also, although washout was not varied during these flight tests, previous FAA experience has shown that stall characteristics are further aggravated when operators of the PA-18 remove the 2.5 degrees of washout at the wing tip, which is not an approved alteration. This condition will result in a rapid roll when the airplane is stalled during turning flight.

4. Handling Qualities

For any given CG/weight, the lateral and directional stability tends to deteriorate as tire size is increased.

5. Stall Warning

Installation of the artificial stall warning system on the PA-18 is optional. Most of the PA-18s in Alaska do not have the system installed. The airplane tested did have the artificial stall warning system, and a number of test points were obtained with the system deactivated. The airplane as tested does not have an aerodynamic stall warning.

APPENDIX 2

A "COMPLIANCE CHECKLIST" TO CAR PART 3, AS AMENDED TO NOVEMBER 1, 1949

Subpart B—Flight Requirements

Weight Range and Center of Gravity

Section	Subject
3.71	Weight and balance
3.72	Use of ballast
3.73	Empty weight
3.74	Maximum weight
3.75	Minimum weight
3.76	CG position

Performance Requirements—General

3.81	Performance*****
3.82	Definition of stalling speeds*****
3.83	Stalling speed*****

Takeoff

3.84	Takeoff*****

Climb

3.85	Climb*****

Landing

3.86	Landing*****

Flight Characteristics

3.105	Requirements***** (exclude § 3.117)

Ground and Water Characteristics

3.143	Requirements*****

Flutter and Vibration

Section	**Subject**
3.159	Flutter and vibration (vibration only)

*** Indicates topics identified by NTSB Safety Recommendation A-95-13**

Subpart C—Strength Requirements

Symmetrical Flight Conditions (Flaps Retracted)

3.189	Airplane equilibrium

Flaps Extended Flight Conditions

3.190	Flaps extended flight conditions

Unsymmetrical Flight Conditions

3.191	Unsymmetrical flight conditions

Control Surface Loads

3.211	General
3.212	Pilot effort
3.213	Trim tab effects

Horizontal Tail Surfaces

3.214	Horizontal tail surfaces

Vertical Tail Surfaces

3.219	Maneuvering loads

Control System Loads

3.231	Primary flight controls and systems

Ground Loads

3.241	Ground loads
3.242	Design weight
3.243	Load factor for landing conditions

Landing Cases and Attitudes

Section	Subject
3.244	Landing cases and attitudes

Ground Roll Conditions

3.248	Braked roll
3.249	Side load

Subpart D—Design and Construction
Control Systems

3.342	Proof of strength

Landing Gear

3.351	Tests
3.352	Shock absorption tests
3.353	Limit drop tests
3.354	Limit load factor determination
3.355	Reserve energy absorption drop tests

Wheels and Tires

3.361	Wheels
3.362	Tires

Brakes

3.363	Brakes

Subpart E- Propulsion Systems

3.429	Fuel System General
3.437	Unusable Fuel
3.444	Fuel Tank Sump
3.553	Fuel Tank Drains
3.583	Cooling Tests
3.605	Induction System General
3.606	Induction Systems de-icing and anti-icing provisions

Subpart F—EQUIPMENT
Landing Lights

3.699 Landing light installation

Subpart G—OPERATING LIMITATIONS AND INFORMATION

3.735 General

Limitations

3.737 Limitations

23.735 Brakes

The corresponding rule in CAR 3 is CAR 3.363.

There is no corresponding rule in the Airship Design Criteria.

Original Issue and Subsequent

Brake Replacement and Modified Parts

1. Related regulations and documents are:

a. Regulations

Acceptable means of compliance are found in 14 CFR, part 23. Additional specific information is listed below, including other regulatory material and advisory information. Part 23 sections may be used in showing compliance with the corresponding sections of the former CAR for airplanes where the CAR regulations are applicable. For convenience, the former CAR section reference is also shown in parenthesis following the part 23 section reference:

Part 21, § 21.15	Application for type certificate
Part 21, § 21.93	Classification of changes in type design (TC)
Part 21, § 21.113	Requirement of supplemental type certificate
Part 21, § 21.303	Replacement and modification parts
Part 21, § 21.611	Design changes (TSO)
Part 23, § 23.55	Accelerate-stop distance
Part 23, § 23.75 (3.86)	Landing
Part 23, § 23.143 (3.106)	Controllability and maneuverability: General
Part 23, § 23.231 (3.144)	Longitudinal stability and control
Part 23, § 23.233 (3.145)	Directional stability and control
Part 23, § 23.493 (3.248)	Braked roll conditions

Part 23, § 23.731 (3.361)	Wheels
Part 23, § 23.735 (3.363)	Brakes
Part 23, § 23.1301 (3.652)	Function and installations
Part 23, § 23.1309	Equipment, systems, and installations
Part 23, Appendix D	Wheel spin-up and spring back loads
Part 23, § 23.1529 and	Instructions for Continued Airworthiness Appendix G to Part 23
Part 135, Appendix A	Additional airworthiness standards for 10 or more passenger airplanes
Part 45, § 45.14	Identification of critical components
Part 45, § 45.15	Replacement and modification parts.

b. Advisory Circulars (AC's)

AC 21.303-2H	"Parts Manufacturer Approvals"—October 13, 1992 (Microfiche).
AC 23-8B	"Flight Test Guide for Certification of Part 23 Airplanes", August 14, 2003.

c. Technical Standard Order (TSO)

TSO-C26c	"Aircraft Wheels and Wheel-Brake Assemblies, with Addendum I", May 18, 1984.

d. Industry Documents

SAE ARP 597	"Wheels and Brakes, Supplementary Criteria Design for Endurance-Civil Transport Aircraft", April 24, 1991.
SAE ARP 813	"Maintainability Recommendations for Aircraft Wheels and Brake Design", February 1, 1995.
SAE AIR 1064	"Brake Dynamics", January 1, 1997.
SAE AS 1145	"Aircraft Brake Temperature Monitor System (Btms)", February 1, 1998.

SAE ARP 1619	“Replacement and Modified Brakes and Wheels”, March 1, 2001.

2. BACKGROUND

A review of recent replacement and modification wheel/brake system and installation approvals on part 23 airplanes has resulted in the need to provide FAA guidelines that clearly describe the changes and associated substantiation procedures involved. As contained herein, these guidelines will reflect upon issues that have been identified by industry under ARP 1619, which, in part, concerns the variance in compliance provisions associated with original equipment manufacturers (OEM) and non-OEM applicants. The guidelines will include a description of replacement or modified wheel, wheel/brake parts or assembly changes, a description and examples of associated "major" and "minor" changes, and a description of corresponding laboratory and airplane flight tests needed to ensure that requested changes will result in a continued level of airplane safety and performance.

3. CLASSIFICATION OF REPLACEMENT AND MODIFIED WHEEL/BRAKE CHANGES

a. Replacement of Wheel, Wheel/Brake Parts, or Assembly Changes

A replacement wheel, wheel/brake part, or an assembly change is classified as one in which either the included parts or assemblies that are being changed are of **equivalent** design that will result in an **equivalent** level of certified type performance and safety to that exhibited by either the originally approved parts or assemblies. The change may be approved under a PMA by the provisions of part 21. Under part 21, § 21.303, an applicant may be eligible for approval of either PMA replacement parts or assemblies, or both, by demonstrating compliance in accordance with the following methods, as applicable**:**

(1) Licensing Agreement

Applicant should provide evidence of a licensing agreement or equivalent with the holder of a TSOA, TC, or an STC together with the submission of any design data covered by the licensing agreement, as determined by the FAA.

(2) Identicalness

Applicant should provide evidence that the parts he produces will be identical in all respects to the corresponding parts of an approved 14 CFR type design, TSO, or PMA. Data submitted should include all applicable design, material, and process specifications that is, technical data that would specify all dimensions, tolerances, materials, processes, and specifications to the design of the corresponding part of an approved design.

(3) Airworthiness Requirements (Tests and Analyses)

Applicant should provide evidence—in the form of drawings, test reports, computations, and other substantiating data—showing that the part meets either the applicable part 23 airworthiness requirements or the certification basis under which the airplane was approved. Compliance to applicable part 23 airworthiness requirements may include the following:

(a)	Part 23, § 23.55 and Part 135, Appendix A	Accelerate-stop distance for commuter category airplanes and other airplanes that have accelerate-stop distance requirements, including airplanes that have published data such as stopping distances and brake energy/cooling charts in the AFM.
(b)	Part 23, § 23.75	Landing.
(c)	Part 23, § 23.143	Controllability and maneuverability: General.
(d)	Part 23, § 23.231	Longitudinal stability and control.
(e)	Part 23, § 23.233	Directional stability and control.
(f)	Part 23, § 23.493	Braked roll conditions.
(g)	Part 23, § 23.731	Wheels.
(h)	Part 23, § 23.735	Brakes.
(i)	Part 23, § 23.1301	Function and installation.
(j)	Part 23, § 23.1309	Equipment, systems, and installations.
(k)	Part 23, § 23.1529 and	Instructions for Continued Appendix G to Part 23 Airworthiness.
(l)	TSO-C26c	"Aircraft Wheels and Wheel-Brake Assemblies, with Addendum 1"

NOTE 6: A description of the certification basis in which an airplane was approved can be obtained from the FAA.

b. Identical Wheel, Wheel/Brake Parts, or Assembly

An identical wheel, wheel/brake part, or assembly is classified as a replacement in which either the included parts or assemblies being changed are of an identical design and will result in an equivalent level of demonstrated performance to that exhibited by either the originally approved parts or assemblies.

c. Modified Wheel, Wheel/Brake Parts, or Assemblies May Be Approved Under a Provision of Part 21

Under part 21, § 21.303, an applicant may be eligible for approval of modified wheel, wheel/brake parts, or assemblies by demonstrating compliance to methods identified under the above paragraph 3(a)(3) "Airworthiness Requirements (Tests and Analysis)".

d. Major and Minor Wheel, Wheel/Brake Parts, or Assembly Changes

Since design changes appropriate to replacement and modified wheels, wheel/brake parts, or assemblies may involve changes to the original TSO wheel or wheel/brake assembly approval basis under an STC or TC in which the wheel or wheel/brake was installed, compliance to applicable provisions for "major" and "minor" design changes under part 21, § 21.93 or § 21.611, or both, should also be complied with per the following:

(1) Major Design Changes

A major design change to an existing TSO approved assembly is one that would require a substantially complete investigation of change for compliance to requirements under the TSO, and would result in a new type or model designation. A major design change to an airplane's type design or certification basis is one that could appreciably affect the weight, balance, structural strength, reliability, operational characteristics or other characteristics affecting the airworthiness of the airplane. Examples of such major design changes involving the wheel, wheel/brake parts, or assemblies include, but are not limited to, the following:

(a) Structural material changes and friction material composition changes of heat sink elements that result in changes to FAA-approved performance data.

(b) Reduction of original heat sink mass.

(c) Change in the total brake actuation load or area.

(d) Changes in the friction radius, the total number, or the area of friction faces or elements.

(e) Fuse plug relocation in the wheels, change in release temperature, or a fuse plug redesign where a minor change has not been substantiated.

(f) Changes that would adversely affect the temperature-time profile of either a wheel or fuse plug, or both.

(g) Relocation of "overpressure release" or "inflation valve."

(h) Redesign of the wheel in a wheel/brake assembly, including a reduction in the wheel or brake structure that could adversely affect wheel strength or fatigue life.

(i) Reduction in the wheel tie-bolt diameter or material strength of bolt and nut.

(j) Change in the wheel bearing size that could or would adversely affect the wheel or bearing load capacity.

(k) Changes in the wheel structural strength, deflection, fatigue life, or weight.

(2) Minor Design Changes

A minor design change to the TSO assembly (or airplane once the assembly is installed) is one that would have no appreciable affect on either the performance of the original TSO assembly or the certification basis (as identified above for major change) of the airplane in which the assembly is to be installed. Investigation into further compliance and FAA approval would normally be limited to minimal functional and compatibility tests. Original model numbers would be retained while part numbers could be used to identify minor changes for TSOA. See paragraph 6.b. “Part Numbering.” of this AC in § 23.735 Brakes, for PMA part numbering requirements. Examples of potential minor design changes involving wheel, wheel/brake parts or assemblies might include but are not limited to the following:

(a) Brake friction material changes or heavier heat sink elements that do not result in a change of FAA-approved performance data.

(b) Structural improvements to improve fatigue life.

(c) Paint/corrosion protection changes.

(d) Changes to bleed ports or tube and service fittings.

(e) Revised over-inflation devices.

4. SUBSTANTIATION PROCEDURES

Replacement and modified wheels, wheel/brake parts or assembly changes should be substantiated by conducting the necessary analytical investigations, laboratory testing, or airplane testing, or all of these, to ensure that the change can be made without adversely affecting aircraft safety and associated braking and rolling performance. A substantiation plan should first be proposed by the applicant for FAA approval followed by the applicant's implementation of the plan.

a. Substantiation Plan

A proposed substantiation plan may be presented to the FAA for approval that identifies the applicants requested change and intended approach in substantiating the change in accordance with the methods addressed under this section. The plan should include the following:

(1) A description of the replacement or modified part or assembly, or both.

(2) An assessment covering the applicable airworthiness requirements involved.

(3) A statement of change that is determined to be either "major" or "minor" along with the basis for the classification relative to the applicable requirements of part 21.

(4) An assembly drawing reflecting the replacement or modified part or assembly, or both.

(5) Aircraft installation drawings/instructions.

(6) The substantiation method, which includes an analysis/test protocol.

(7) The method of identification and maintenance procedures that will be utilized.

(8) The quality management and quality assurance system under which either the part or assembly, or both, will be produced.

b. Substantiation Requirements

The recommended substantiation requirements for replacement and modified wheels, wheel/brake parts or assemblies are based upon changes for which approval is requested, and the impact a new part or assembly will have on prior certification. If the replacement and modified wheel, wheel/brake part or assembly meets the minimum applicable airworthiness requirements to the product (airplane) on which either the part or assembly, or both, is to be installed, but not the AFM performance data, then the applicant should provide the applicable performance data in an FAA approved AFM or Airplane Flight Manual Supplement (AFMS). Depending upon the type and extent of change (as defined under “Section 3, CLASSIFICATION OF REPLACEMENT AND MODIFIED WHEEL/BRAKE CHANGES”) and either engineering or pilot judgment, or both, FAA approval will be determined on the basis of compliance with the following substantiation requirements:

(1) Replacement Wheel, Wheel/Brake Parts or Assemblies

(a) Brake-Anti-skid Compatibility

Replacement part or assembly changes, or both, defined under paragraph 3(d)(2) titled "Minor Design Changes," are considered to be minor whether they are proposed by the original wheel and brake manufacturer who holds the TSO authorization or by another manufacturer seeking to produce a replacement part or assembly. While such changes are not expected to affect braking performance, functional landings may be required as a minimum to verify airplane/pilot/brake/anti-skid combination compatibility (reference part 23, § 23.735(d)). Normally five non-instrument, functional landings are necessary to verify this compatibility.

(b) Brake Rotors/Stators

In general, changes to the friction surfaces of the aircraft brake, including the stator and rotor, are considered to represent a major change per 3(d)(1), titled "Major Design Changes," unless it can be shown that the change cannot affect the airplane stopping performance, brake energy absorption characteristics, or continued airworthiness (reference part 23, § 23.735(a)/(e)). In addition, if changes in heat sink friction components are proposed, certain provisions of 4(b)(2), titled "Modified Wheel, Wheel/Brake Parts, or Assemblies," may also be applicable. Changes to continuing airworthiness, such as thermal control, vibration control, etc., should also be considered for the major/minor determination. In this regard, the original manufacturer of the wheel or wheel/brake assembly who holds the TSO authorization may possess data sufficient to show that such changes could be considered minor (e.g., airplane performance would not be affected). On the other hand, a manufacturer other than the original manufacturer who may wish to produce replacement rotors and stators may not have data sufficient to show that performance would not be affected. In this case, the major/minor status would be determined by applicable dynamometer tests per TSO-C26c and some functional airplane tests as a minimum.

(c) Brake Performance Equivalency

It may be difficult to determine identicalness but a finding of equivalency can be shown by additional design, analysis, and dynamometer tests as applicable. A change to an approved part that is determined to be minor can be validated on the dynamometer by a controlled test at the maximum certified kinetic energy capacity of the original brake assemblies from TSOA, or the dynamometer testing may be done to the design landing and accelerate-stop kinetic energy levels appropriate to the aircraft [Reference part 23, § 23.735 (a) through (e)]. The following dynamometer test protocol is acceptable to validate replacement rotors/stators proposed by an applicant other than the original TSO holder:

1. Use of new stator or rotor parts in the replacement manufacturers brakes for each dynamometer test will be required in order to minimize test configuration variables. If rebuilt or in-service components other than these fail during testing, it should be realized that the results may be questionable. Suspect tests would be carefully scrutinized by the FAA, and retesting may then be necessary. Test methods, test hardware (including the tire size, ply and condition), and test procedures should be the same to ensure proper comparative evaluations. If brake friction materials are being compared, the heat sinks to be used for maximum certified Kinetic Energy (KE) testing should not have been subjected to test energies higher than design landing energy.

2. The maximum certified KEs approved under TSOA for the original manufacturer are proprietary data. Therefore, a PMA applicant that desires to maintain the TSOA status of a modified assembly will have to do the testing in this paragraph without knowing the kinetic energy levels the OEM tested for the TSOA. A series of tests may be necessary for a replacement manufacturer to reach the maximum certified level of the original manufacturers brake. For each succeeding run, the KE will be increased by at least five percent over the previous run until the maximum certified KE level is reached. The initial KE level for this series of tests will be at the discretion of the applicant. If maintaining the TSOA is not desired, the PMA applicant may perform dynamometer tests at the airplane derived kinetic energy levels.

3. Maximum braking force pressure, derived from the airplane maximum brake pressure capability, is to be applied during the tests.

4. Fuse plugs may be released or the tire deflated after each test run to reduce the risk to test personnel.

5. A minimum of five functional landings for anti-skid equipped airplanes and a minimum of three functional landings for non-anti-skid equipped airplanes, as described above, are needed.

(d) Worn Brakes [optional]

While there are no provisions under part 23 to require the evaluation of brake performance using worn brakes, there have been rejected takeoff accidents in which the brakes on subject airplanes were at or very near their completely worn state of energy absorption capability and stopping capability. Therefore, as an **optional** test to a replacement brake performance evaluation (when there is question concerning variances in worn brake performance), it is recommended that such an assessment on the dynamometer be undertaken to support compliance with maximum Rejected Takeoff (RTO) performance in the AFM. Dynamometer tests simulating a maximum energy RTO should be performed on the replacement brake assemblies with individual brakes within 10 percent of their wear limit (e.g., at least 90 percent worn). The tests, used to verify the safety of a replacement brake system and to determine the maximum energy absorption capability of brakes in their fully worn state, should be substantiated as being representative of actual airplane and runway conditions.

(2) Modified Wheel, Wheel/Brake Parts, or Assemblies

(a) Modified Brake Design

This laboratory and airplane test requirement applies to the addition of a major change brake design to an existing airplane for which FAA approved braking performance test data exists. Testing may be performed either for performance credit or to the existing performance level of the aircraft. As provided under examples of 3(d)(1), a modified brake is one that contains new or modified parts that may cause a significant variance in the kinetic energy absorption characteristics, AFM stopping distances and continuing airworthiness of the brake [reference 14 CFR, § 23.735 (a) through (e)]. Substantiating laboratory and airplane flight testing required for approval of a major changed brake will include the following:

1. For improved performance

(aa) Applicable dynamometer tests under TSO-C26c.

(bb) Instrument flight tests to include six takeoffs and six landings. The six landings are to be conducted on the same wheels, tires, and brakes. All tests should be conducted with engines trimmed to the high side of the normal idle range, if applicable. The engine idle schedule may include a flight-idle schedule that may be applicable to the test.

(cc) Additional tests may be necessary for each airplane configuration change (e.g., takeoff flaps, landing flaps, nose wheel brakes, anti-skid devices inoperative, deactivation of wheel/brakes, etc.).

(dd) Brake system response evaluation.

(ee) Parking brake adequacy. Tires are allowed to skid during maximum power engine checks.

(ff) Alternate braking system stops.

(gg) Fuse plug evaluation.

(hh) Anti-skid compatibility on wet runway.

(ii) Taxi tests, to ensure that ground handling, maneuvering, and brake sensitivity are satisfactory, should be conducted.

(jj) At least two braking stops, one at maximum takeoff weight and one at minimum landing weight, should be conducted on a wet runway to verify brake and anti-skid compatibility.

NOTE 7: Improved performance implies an increase in the friction coefficient (mu) versus energy level for the desired operation(s) and may be requested for landing, RTOs, or a specific configuration such as anti-skid "on" only.

2. For equivalent performance

(aa) Applicable dynamometer tests under TSO-C26c.

(bb) A sufficient number of conditions to verify the existing approved performance levels (RTO and landing for either TSOA levels or AFM levels). Consideration should be given to verification of fuse plugs, performance verification at appropriate energy levels, and configuration differences, including anti-skid on and off.

(cc) Taxi tests, to ensure that ground handling, maneuvering, and brake sensitivity are satisfactory, should be conducted.

(dd) At least two braking stops, one at maximum takeoff weight and one at minimum landing weight, should be conducted on a wet runway to verify brake and anti-skid compatibility.

NOTE 8: Equivalent performance implies that sufficient data will be obtained to verify that the performance level for the change is equal to or better than the existing performance levels. The change may be for the purpose of changing the CG envelope, or for airplane configuration changes (such as flap angles), and may apply to specific operations (such as landings.

3. For extended performance

(aa) Applicable dynamometer tests under TSO-C26c. Consideration should be given to the items in section 4b(2)(a)(2).

(bb) A sufficient number of conditions to define the extended life and determine equivalency to the existing performance levels. Consideration should be given to the items in section 4b(2)(a)(2).

NOTE 9: Extended performance implies that the existing certification μ versus energy line will extend to establish the braking force level for a proposed change, such as gross weight or the desired maximum energy level, and may be applied to a specific operation (such as landing only).

(b) Modified Anti-skid System

This airplane test requirement applies to the addition of a new anti-skid system or changes to an existing anti-skid system that may affect airplane performance (e.g., new anti-skid system, or a change from couple to individual wheel control). A sufficient number of either airplane performance tests or functional tests, or both, should be conducted to verify existing approved performance anti-skid "on" levels. In the event an increase of braking performance is desired, full airplane performance testing will be required [reference part 23, § 23.735 (d)].

(c) Modified Fuse Plugs/Wheels

This item covers the addition of a significant modification to any portion of the existing wheel design on an airplane (change of wheel design, redesign, or relocation of fuse plugs). The following airplane tests can be performed when such changes are made:

1. One airplane-braking test should be conducted to show that the fuse plugs would release when excessive energies are absorbed.

2. One airplane-braking test should be conducted to verify the maximum kinetic energy at which fuse plugs will not release (fuse plug substantiation). Dynamometer tests are not adequate for this test.

NOTE 10: Wheel fuse plug integrity should be substantiated during braking tests where the energy level simulates the maximum landing energy. It should be demonstrated that the wheel fuse plugs will remain intact and that unwanted releases do not occur. One acceptable method to determine this is as follows:

(aa) Set engine idle thrust at the maximum value specified (if applicable). The engine idle schedule may include a flight-idle schedule that may be applicable to the test.

(bb) Set tire pressures to the minimum value appropriate for the airplane test weight.

(cc) Taxi at least three miles (normal braking, at least three intermediate stops, and all engines operating).

(dd) Conduct accelerate-stop test at maximum landing energy, maintaining the deceleration rate consistent with the values used to determine performance distance.

(ee) Taxi at least three miles (normal braking, at least three intermediate stops, and all engines operating).

(ff) Park in an area to minimize wind effects until it is assured that fuse plug temperatures have peaked and that no plugs have released.

Instead of simulating the maximum kinetic energy landing during an accelerate-stop test, an actual landing and quick turnaround may be performed; however, caution should be exercised in order to prevent jeopardizing the safety of the flight crew and airplane if the wheel plugs release right after liftoff, requiring a landing to be made with some flat tires. The following elements should be included in the tests:

(aa) Set engine idle thrust at maximum value specified (if applicable).

(bb) Set tire pressures to the minimum value appropriate to the airplane test weight.

(cc) Conduct a landing stop at maximum landing energy, maintaining the acceleration rate consistent with the values used to determine performance distance.

(dd) Taxi to ramp (three miles minimum with normal braking, at least three intermediate stops, and all engines operating).

(ee) Stop at the ramp. Proceed immediately to taxi for takeoff.

(ff) Taxi for takeoff (three miles minimum with normal braking, at least three intermediate stops, and all engines operating).

(gg) Park in an area to minimize wind effects until it is assured that fuse plug temperatures have peaked and that no plugs have released. Fuse plug protection of wheels and tires should be demonstrated to show that the fuse plugs would release when excessive energies are absorbed. Normally, this will occur during RTO performance tests.

(d) Accelerate Stop Tests

Accelerate-stop tests for commuter category airplanes and other airplanes are defined under part 23, §§ 23.55 and 23.735 (e). Accelerate-stop tests should be conducted for all modified wheel, wheel/brake parts or assemblies involving a major design change when this testing was performed for the certification of the original brake assembly. Such tests should include substantiation of the critical maximum brake energy stop (highest ground speed based on the V_1 speed applicable to the maximum altitude and temperature the airplane is certified for according to the FAA approved AFM). On airplanes with wheel fuse plugs, a satisfactory demonstration of fuse plug compatibility should be conducted as stated under item (2)(c) titled, "Modified Fuse Plugs/Wheels."

(e) Other Substantial Airplane Tests

Depending upon the extent of wheel, wheel/brake part, or assembly modifications that may be involved, there will be a number of airplane tests that should be considered in addition to those above. As applicable to specific changes and to the type of part 23 airplane involved, the following are tests that may be appropriate and required by the FAA for approval:

1. Brake Kinetic Energy (KE) Absorption Tests

Verify that the brake KE absorption test determined by the laboratory test meets the TSO requirements and the airplane manufacturers requirements (to be identified by the FAA) [reference part 23, § 23.735(a) through (e)]. The engine idle schedule may include a flight-idle schedule that may be applicable to the test.

2. Brake Pressure Test

Verify brake pressure tests conducted under the TSO are adequate for the brake system pressure on the airplane, as determined by the manufacturer's brake system pressure data. Conduct a brake pressure test on the airplane if manufacturers brake system data is not available to verify the adequacy of the TSO test [reference part 23, § 23.735(c)].

3. Taxi Ground Handling Tests

Perform taxi tests to assure that ground handling, controllability, maneuverability, and brake sensitivity are satisfactory. Use normal braking, intermediate stops, with all engines operative [see 4b(2)(a), Modified Brake Design].

4. Wet Running Tests

Perform brake stops on a wet runway to verify brake and, if applicable, anti-skid system compatibility [see 4b(2)(a), Modified Brake Design].

5. Function Reliability Tests

Perform function reliability landing stops. Normally six maximum brake landings should be satisfactorily conducted on the same set of wheels, tires, and brakes [see 4b(2)(a), Modified Brake Design].

6. Landing Performance Tests

Determine that the landing performance is adequate to the previously approved performance data shown in the AFM. If the AFM performance data is not available because that it is not required by the airplane certification basis, the manufacturers data (if available) provided to the pilot should be used as a basis for comparison [see 4b (2)(a) Modified Brake Design].

7. Static Torque Tests

Determine whether there is adequate static torque when parked and during appropriate engine run up conditions [reference part 23, § 23.735(b)].

8. Brake Response Tests

During the aforementioned tests, brake response characteristics should be monitored for unacceptable vibrations, squeal, fade, grabbing, and chatter. These characteristics may have a destructive effect on the brake assembly components and may be pertinent to endurance of landing gear system components.

5. INSTRUCTIONS FOR CONTINUED AIRWORTHINESS

A PMA applicant may be required to furnish instructions for continued airworthiness if the article on which the part is eligible for installation has an existing set of instructions for continued airworthiness that are not considered adequate for the applicants PMA part (reference part 23, § 23.1529).

6. IDENTIFICATION OF PMA PARTS

a. General

Under part 45, § 45.15, parts produced under a PMA should be permanently and legibly marked in a manner that will enable persons to identify the following:

- It is a PMA part.
- The manufacturer.
- The part number.
- The type certificated product(s) or TSOA article(s) on which it may be installed.

For a part based on an STC, the identification of installation eligible type certified products should include reference to the STC. In accordance with part 45, § 45.14, parts that have been identified as critical components should be marked with a part number, or equivalent, and serial number or equivalent. If the TC or TSOA holder applies serial numbers to a critical part, the PMA holder should also "permanently mark" their parts with serial numbers.

NOTE 11: Due to the harsh environments that wheels and brakes experience, decals or adhesive backed "metalcals" are not considered permanent forms of marking. Metal stamping, etching or permanently affixing a data plate with rivets or drive screws in a non-critical area is satisfactory. Laser marking is also acceptable if it can be read under 2X magnification. Ink stamping is allowed only if more permanent means are not possible.

b. Part Numbering

The PMA holders' part should be numbered such that it is sufficiently different from the OEM holders' part number to be distinguishable. The OEM holders' part number with a prefix/suffix is sufficient for this purpose. The requirements of part 45, § 45.15(a)(2), to mark with name, trademark, or symbol of the PMA holder may be satisfied by the prefix/suffix if the prefix/suffix is done consistently across the PMA holders product line. The FAA-PMA letter should show the type approved part number with which the PMA holders' part is interchangeable.

c. Parts Manufactured Under License

When the PMA is issued by showing evidence of a license agreement or equivalent, the PMA part number may be identical to that on the type certificated part providing the PMA holder also meets the requirements of part 45, § 45.15(a)(1) and (2) to **permanently mark the part** with the letters "FAA-PMA" and the name, trademark, or symbol of the PMA holder.

d. Parts that are Impractical to Mark

In all cases where the part is found by the FAA to be too small (or to have other characteristics that make it impractical) to mark all (or any) of the information on the part, the information not marked on the part should be put on the tag that is attached to the part or marked on the container for the part. If the number of certificated products or TSOA articles on which the part is eligible for installation is too long to be practicable to include with the part, the tag or container may refer to a readily available manual or catalog made available by the PMA holder for part eligibility information.

Amendment 23-7 and Subsequent

Amendment 7 was a major change in the standard. The following explanation in NPRM 67-14 is stated as follows: *"Part 23 does not provide for the determination of the energy absorption requirements of brakes. The present requirement in Sec. 23.735 (b) may not ensure the design of wheel brake combinations adequate for safe operation of the airplane. Proposed Sec. 23.735 (a) would therefore provide standards similar to the energy absorption determination requirements for transport category airplanes (Sec. 25.735 (f)). Proposed Sec. 23.735(b) would reflect the fact that, for aircraft with high power-to-weight ratios, it may be impossible to prevent motion, with locked wheels, when takeoff power is applied to the critical engine. Some question has arisen as to whether such motion constitutes "rolling" of the airplane within the meaning of present (a). It is not the intent of present (a) to prevent this motion, but only to ensure that the brakes can prevent the wheels themselves from rolling. The proposed energy absorption requirements reflect current industry practice in the design of small airplanes."*

Amendment 23-42 and Subsequent

<u>Policy for 14 CFR part 23, § 23.735, Brakes, and Specific Sections versus § 23.1309; Equipment, Systems and Installations</u>

Brake systems are approved based on compliance to the specific standard, § 23.735, not the general standard, § 23.1309. This is true for any installations where there are specific standards in 14 CFR, part 23 (i.e., brakes, autopilots, ice protection systems, etc.).

In the past, the Small Airplane Directorate has not considered brake failures catastrophic or severe-major due to mitigating factors, which include the following: low stall speeds, minimum field lengths for landing, and propeller feathering or reverse thrust. For commuter category airplanes where loss of the brakes is catastrophic or severe-major, we will accept an emergency brake system or a single failure in the primary system that meets the following requirements (based on § 25.735(b)):

In the following circumstances, the brake system and associated systems must be designed and constructed so that the airplane may be brought to rest under conditions specified in § 23.75:

> If any electrical, pneumatic, hydraulic, or mechanical connecting or transmitting element (excluding the operating pedal or handle) fails, or
>
> If any single source of hydraulic or other brake operating energy supply is lost.

The airplane can be brought to rest with a mean deceleration during the landing roll of at least 50 percent of that obtained in determining the landing distance as prescribed in that section. Subcomponents in a brake assembly such as brake drums, shoes and actuators (or their equivalents), shall be considered as connecting or transmitting elements unless it is shown that leakage of hydraulic fluid from a failure of sealing elements in these subcomponents would not reduce the braking effectiveness below that specified in this paragraph.

We agree that requiring an emergency brake system is not desirable for small single-engine airplanes. We cannot agree that brake system failure for commuter category and turbojet powered airplanes can automatically be classified as severe-major. Mitigating factors must always be considered for any part 23 airplanes.

Amendment 23-49 and Subsequent

The intent of the proposed revision to NPRM 94-21 is given as follows: *"Section 23.735(a) would be revised to state plainly that wheel brakes must be provided. A proposed new Sec. 23.735(c) would require the brake system to be designed so that the brake manufacturer's specified brake pressures are not exceeded during the landing distance determination required by Sec. 23.75. Proposed new Sec. 23.735(e), applicable to commuter category airplanes, would require establishing the minimum rejected takeoff brake kinetic energy capacity rating of each main wheel brake assembly. Section 23.45 provides that the determination of the accelerate-stop distance for commuter category airplanes be made in accordance with the applicant's procedures for operation in service. The proposed requirement is needed to ensure that the brakes will perform safely under accelerate-stop conditions."*

EASA AMC 23.735(c) is acceptable for FAA certification.

23.737 Skis

The corresponding rule in CAR 3 is CAR 3.364.

There is no corresponding rule in the Airship Design Criteria.

Amendment 23-45 and Subsequent

See § 23.505, Supplementary conditions for ski-planes, for additional guidance about aircraft skis.

23.745 Nose/tail wheel steering

No policy available as of September 30, 2003.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

FLOATS AND HULLS

23.751 Main float buoyancy

The corresponding rule in CAR 3 is CAR 3.371.

There is no corresponding rule in the Airship Design Criteria.

Original Issue and Subsequent

For a twin float seaplane or amphibian aircraft, the 80 percent excess buoyancy requirement should be applied to both rather than each float.

The rules for twin float aircraft do not address water stability or capsizing. They only require that the aircraft remain afloat with any two compartments of the main floats flooded. The history does not support the position that the aircraft will remain afloat indefinitely without capsizing with two compartments flooded. However, if an unsafe condition exists, certification should be denied under the provisions of part 21, § 21.21(b)(2). An example of an unsafe condition could be capsizing so rapidly that the occupants could not safely exit. Capsizing that is delayed long enough to permit taxi to the shore or dock is not an unsafe condition. The time to capsize should be listed in the Emergency Procedures Section of the AFM.

Amendment 23-45 and Subsequent

A revision to NPRM 90-18 explains this amendment as follows: *"This proposal revises Section 23.751 to clarify the buoyancy requirements for main floats in paragraph (a)(1) by specifying an 80 percent excess in buoyancy for each main float above the buoyancy required by that float to support the maximum weight of the seaplane. Additionally, the words "without capsizing" are added to paragraph (a)(2) to clarify the extent of flotation necessary after main float compartment flooding.*

A strict interpretation of existing Section 23.751(a)(1) results in a buoyancy excess of 80 percent of the maximum weight of the seaplane when the design consists of only one main float, or a total of 180 percent of the maximum weight. However, on seaplanes having two main floats, each float would be required to have buoyancy of 80 percent in excess of that necessary to support the seaplane, or 180 percent of the maximum weight of the seaplane; for a total of 360 percent of the maximum weight. For designs having three floats, each float would be required to support 180 percent of the maximum weight for a total of 440 percent. This is neither the intent of the rule nor the practice of industry.

The change to paragraph (a)(2) is intended to clarify the fact that the seaplane be afloat in the upright condition."

23.753 Main float design

No policy available as of September 30, 2003.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

23.755 Hulls

The corresponding rule in CAR 3 is CAR 3.372.

There is no corresponding rule in the Airship Design Criteria.

Original Issue

The discussion on capsizing and unsafe conditions in § 23.751 applies to this rule also.

Amendment 23-45 and Subsequent

This amendment changed the rule to **prohibit capsizing** in fresh water for planes over 5,000 pounds with two adjacent compartments flooded, and those between 1,500 and 5,000 pounds with any single compartment flooded.

23.757 Auxiliary floats

No policy available as of September 30, 2003.

This rule was adopted on February 1, 1965 as a recodification of CAR 3.373.

There is no corresponding rule in the Airship Design Criteria.

PERSONNEL AND CARGO ACCOMMODATIONS

23.771 Pilot compartment

No policy available as of September 30, 2003.

The corresponding rule in CAR 3 is CAR 3.381.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.28.

23.773 Pilot compartment view

The corresponding rule in CAR 3 is CAR 3.382.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section .29.

Amendment 23-14 and Subsequent

See AC 23-8B, "Flight Test Guide for Certification of Part 23 Airplanes," for guidance on this regulation. EASA AMC 23.773 references the CS-23 Flight Test Guide.

Amendment 23-45 and Subsequent

A proposed revision to NPRM 90-18 explains the rewrite of this section as follows: *"This proposal is based in part on conference recommendation 272, on conference comments, and on a post conference review of the adequacy of previous certifications, which establishes a precedent for compliance with existing Section 23.773. It is not the intent of this proposal to require windshield heat on all small airplanes, to preclude open cockpit designs or to prohibit the pilot from using a cloth to wipe the windows. It does, however, define requirements to assure that a means exists to remove or prevent the formation of fog or frost on the inside of the windshield, specifies the extent of credit to be given to pilot actions and defines the area of windshield and windows to be kept clear.*

Paragraph (a)(1) of this proposal requires an extensive, clear, and undistorted view sufficient to enable the pilot to perform any maneuvers within the operating limitations of the airplane, and specifies particular operations, such as taxi, takeoff, approach and landing to clarify the extent of view necessary for safe operation.

Paragraph (b) of this proposal is included to address the condition where an airplane is operated at high altitudes, becomes cold-soaked, and is then descended into warm, moist air. Such conditions have resulted in the formation of frost on the inside surface of the windshield and crew compartment windows, which resulted in a limited or completely obscured view. Since, in such cases, compliance has been shown for the current Section 23.773(a)(3), a rule change is appropriate to address this condition. The FAA proposes to revise Section 23.773 to identify this condition and to clarify the extent of actions taken by the pilot to remove such moisture."

The Final Rule 26269 for Amendment 23-45 states as follows: *"The FAA proposed to revise the 23.773 requirements for the pilot compartment view to address the environment expected in all the operations requested for certification. The JAA states that it will consider this change for JAR 23 but that it proposes to retain present paragraph (b) relating to night flight tests. The GAMA contends that the words* *"must be shown in all operations for which certification is requested," could be interpreted to mean that the same view must be provided for all operations.*

The FAA does not agree with the GAMA interpretation. Section 23.773(a) and (a)(1) require the pilot compartment view to be sufficiently extensive, clear, and undistorted to allow the pilot to perform the various functions identified in this proposal. The word "sufficiently" is included because the FAA recognizes that the view needed for one operation may differ from the view needed for another. The intent is also shown by the words "sufficiently large" used in Section 23.773(b). The FAA adopts Section 23.773 as proposed."

23.775 Windshields and windows

The corresponding rule in CAR 3 is CAR 3.383.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.30.

Original Issue and Subsequent

The rule requires the Luminous Transmittance (LT) be no less than 70 percent when the pilot is seated in a normal flight position. This rule does not specify how the LT is to be measured. Industry, federal practices, standards and airframe manufacturer specifications have specified a minimum LT measurement per Federal Standard 406, Method 3022 or equivalent.

On the basis of available data, we cannot determine that an LT of 70 percent is in itself an unsafe condition. There are other factors such as windshield/window inclination from vertical. The criterion to determine an unsafe condition is a qualitative pilot evaluation.

Nonsplintering material in this section refers to materials such as safety glass, which shatter into small fragments that can cause superficial injuries. Splintering materials are those that shatter into slivers, which can result in serious injuries.

Policy for 14 CFR, part 23, § 23.775, Temperature and Temperature Gradient Requirement Certification:

Section 23.775 requires the following:

- "The design of windshields, windows, and canopies in pressurized airplanes must be based on factors peculiar to high altitude operation, including – The effects of temperatures and temperature gradients;" and

- "If certification for operation above 25,000 feet is requested, the windshield, window panels, and canopies must be strong enough to withstand the maximum cabin differential loads combined with critical aerodynamic pressure and temperature effects, after failure of any load-carrying element of the windshield, window panel, or canopy."

On-airplane testing is one acceptable Means of Compliance (MOC) to these requirements. Other acceptable MOCs are component level testing, a combination of tests and analyses, or an analysis based on known temperature and temperature gradient effects for a specific material and installation. Qualification by similarity is also acceptable.

NOTE 12: At this time, we are not aware of any case where an applicant has used an analysis without testing, but we should consider this if an applicant proposes it.

The testing or analysis would have to consider pressurization loads or fail-safe loads with the temperature and temperature gradient effects. These would be in addition to the cyclic or fail-safe testing of the complete pressure cabin at ambient temperature.

Current practice is to superimpose the pressure loading and the thermal gradients in a test. The testing and conditions vary from full-scale test articles with environmental chambers around the windows and windshields to component tests. For fail-safe requirements, most manufacturers are using a “failed” article (cut before test) while running a test to fail-safe loads or better.

If the bird strike requirements in § 23.775(h)(1) are applicable (Amendment 23-49), the applicant should consider the effects of temperature and temperature gradients when showing compliance to the two-pound bird strike.

Amendment 23-7 and Subsequent

A proposed revision to NPRM 67-14 explains this amendment as follows*: “Sudden decompression of small cabins due to transparency failure is potentially catastrophic. Experience with transport category airplanes has shown that decompression has been averted in several cases because of the dual element design of transparencies. The value 25,000 feet is believed to represent a reasonable point of demarcation between the altitudes at which sudden decompression is and is not potentially catastrophic, considering the expected cabin sizes and operating altitudes of small airplanes.”*

The preamble material for Final Rule, Docket 8083 is explained as follows: “The notice proposed to add a new Sec. 23.775(e) imposing a fail-safe requirement for windshields, window panels, and canopies of airplanes certificated for operation above 25,000 feet. One comment objected, stating that the proposed requirement is unnecessary and an arbitrary dictation of design; that windshields should not be singled out over control systems or other components, and that transport category airplane decompression experience does not apply to Part 23 airplanes because the differential pressures are not the same. Commentator also suggested that if the proposal is adopted, the prescribed load should be the ultimate load. The FAA does not agree. Windshield strength cannot be controlled to the same degree of precision as is achieved with other materials, consequently redundancy is particularly important. Part 23 airplanes operate at the same altitudes as transport airplanes, where windshields have been lost and where windshield failure can be extremely hazardous. There is no justification for Part 23 design standards for windshields to be lower than those required in Part 25. The prescribed loading cannot be considered the ultimate load because a partially failed windshield would have essentially no factor of safety. Another comment objected to the proposal because paragraph (e) would require a fail-safe determination for all canopies of pressurized *airplanes operated above 25,000 feet in addition to the testing already required under present paragraph (c). The intent of the proposal is to require airplanes certificated for operations above 25,000 feet to comply with the requirements of proposed paragraph (e) instead of the requirements of current paragraph (c), and paragraph (c) is amended to limit its applicability to pressurized airplanes that do not comply with the fail-safe requirements of paragraph (e). Except for this change the amendment is adopted as proposed."*

Amendment 23-45 and Subsequent

A proposed revision to NPRM 90-18 explains a change to this amendment as follows: *"This proposal is intended to clarify the criteria for determining the cleared windshield area the FAA deems necessary to assure safe operation for icing certification. By specifically identifying the operational phases of takeoff, approach, landing, and taxi, this proposal is intended to prevent the past practice of certifying airplanes for operation in known icing conditions, with panels too small and too far in front of the pilot (in some cases, a single small panel centered on the windshield to be used from either pilot seat) to allow full operation of the airplane. In such cases, the runway is not always visible during approach when crosswinds result in large crab angles. Additionally, upon landing, the ability to locate and safely use taxiways is hampered because of the restricted view available to the pilot through the small panel. This proposal is not intended to preclude the use of such panels, but does identify the criteria for determining the size, location, and, if necessary, the number of panels.*

In addition, a proposal is made to require that the probable single failure of transparency heating systems not adversely affect the integrity of the airplane cabin. Such failures do occur and consideration of such occurrences is necessary as a minimum requirement for the type certification of new airplane designs."

EASA AMCs 23.775(f) and 23.775(g), which apply to § 23.775(g) and (h) in 14 CFR, part 23, are acceptable for FAA certification.

23.777 Cockpit controls

The corresponding rule in CAR 3 is CAR 3.384.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.31.

Original Issue and Subsequent

The FAA has no rule preventing placement of non-flight controls on control wheels, but we consider such installations to be marginal since a switch could easily be confused with microphone or autopilot switches. Approval would require special crew training and AFM guidance to ensure it was used properly.

We strongly recommend that all redundant cockpit controls be symmetrical from one side of the cockpit to the other.

A proposed revision to NPRM 67-14 added a requirement under Amendment 23-7 about fuel selectors. The explanation in the NPRM reads as follows*: "Proper fuel management requires that the pilot be able to reach the fuel selector, at any time, without being forced to move the seat or the primary controls (which may be hazardous at low altitudes). Ability to reach the fuel selector under any condition requires that each selector be visible to the pilot with the seat in any normal inflight position."*

Amendment 23-33 and Subsequent

This amendment added § 23.777(c)(4). It requires that airplanes with side-by-side pilot seats **<u>and</u>** two sets of powerplant controls, have one set on the left console and one set on the right console. We will consider an ELOS finding for airplanes with one set on the left hand side and one on or near the cockpit centerline.

The preamble to Amendment 23-33 shows that floor mounted, mechanical flap controls are acceptable.

<u>14 CFR part 23/CAR 3 Airplanes; Clarification of Type Certification Process of Single Lever Power Controls (SLPCs)</u>

The purpose of this guidance is to provide recommendations for certification of SLPC installed in part 23/CAR 3 airplanes.

There are airplanes certificated or currently undergoing certification that have combined the features of two or more of the cockpit powerplant controls for power (thrust), propeller (Revolutions Per Minute (RPM) control), and mixture control (condition lever and fuel cutoff for turbine powered airplanes) into a single power lever. The design feature of an SLPC was not envisioned by part 23/CAR 3. Further, an SLPC cannot meet the standards imposed by §§ 23.777(d) and 23.781(b) as amended by Amendment 23-33. The current amendment level of part 23 (Amendment 23-53) contains regulations that allow evaluation of an SLPC without the need for Special Conditions (e.g., §§ 23.777(a)(b), 23.779(b)(1), 23.1309). However, since an SLPC was not envisioned at the time Amendment 23-33 was adopted, the question of compliance with §§ 23.777(d) and 23.781(b) as amended by Amendment 23-33 still exists.

Due to recommendations made by the NTSB, Amendment 23-33 provides specific location, height, and shape requirements for a number of cockpit controls, including power, propeller, and mixture controls. With the design feature of an SLPC integrating the functions of multiple controls into a single cockpit control, a nonstandardized design approach for the affected powerplant cockpit controls is used. Additionally, § 23.1141(a) states as follows: "Powerplant controls must be located and arranged under § 23.777. "However, an SLPC, as described earlier, cannot be arranged in accordance with § 23.777; therefore, compliance with § 23.1141(a) is not possible."

Notice No. 84-12, the basis for Amendment 23-33, describes the intent of §§ 23.777 (d) and 23.781 (b). As stated in the notice:

> "An effective means of enhancing pilot experience and training would be to require complete standardization in cockpit design. While such action may initially improve the level of safety, it might ultimately inhibit design advancement and result in lower levels of safety than would have evolved without such a total standardization.
>
> An effective and practical means of enhancing the effectiveness of pilot training and enhancing safety would be to require standardization of location, shape, color, and direction of movement of those cockpit controls. This would have minimal adverse effect on design advancement."

From the preceding, it is obvious that the FAA and industry did not envision or address the future use of an SLPC when drafting this rulemaking, but it was intended to allow design advancements that would enhance safety. An SLPC is a design advancement in the public interest and does not adversely affect safety. Therefore, an SLPC will meet the intent, but not literal compliance, of §§ 23.777(d) and 23.781(b) as amended by Amendment 23-33.

We, therefore, recommend use of an ELOS finding for airplanes with a certification basis of Amendment 23-33 or later when making compliance determinations for §§ 23.777(d) and 23.781(b). For these airplanes, Special Conditions are usually unnecessary. In some cases, however, the applicable airworthiness standards may not be adequate due to other novel or unusual features of the aircraft, and Special Conditions may be warranted.

For airplanes with a certification basis prior to Amendment 23-33, no special considerations will be needed unless they involve other novel or unusual design features not covered by the applicable regulations.

We have initiated regulatory action to revise part 23 to allow incorporation of an SLPC without special considerations. However, until these actions have been completed, the recommendations in this AC may be used for certification of an SLPC on part 23/CAR 3 airplanes.

23.779 Motion and effect of cockpit controls

The corresponding rule in CAR 3 is CAR 3.384.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.32.

Original Issue—Reserved

The original rule only specified primary aerodynamic and throttle motion.

Amendment 23-33 and Subsequent

This amendment requires that the propeller control should move forward to increase RPM. Therefore, a propeller pitch control on the vertical instrument panel does not comply. A switch located in a horizontal position with forward motion to increase RPM does comply. Other designs would have to be considered by an ELOS finding. We would consider a propeller pitch control switch that would increase propeller RPM when moved to the "UP" position with a placard to denote RPM change to be eligible as an equivalent.

We have no objection to the propeller pitch control switch being spring loaded against the fine and coarse propeller blade angles. The airplane should be evaluated to ensure no unsafe operating condition occurs with a propeller switch in each critical blade position.

See § 23.777 for guidance applicable to single power lever controls.

23.781 Cockpit control knob shape

The corresponding rule in CAR 3 is CAR 3.384.

There is no corresponding rule in the Airship Design Criteria.

Amendment 23-33 and Subsequent

This rule did not envision a single power lever installation. See § 23.777 for guidance applicable to single power lever controls.

23.783 Doors

The corresponding rule in CAR 3 is CAR 3.389.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.33.

Original Issue and Subsequent

An ELOS finding process for part 23, § 23.783(b), should include the following:

a. Pilot operated locks when the propeller stops turning.

b. A special operating procedure to assure the door is opened only after the propeller has stopped turning should be provided in the flight manual and on the inside of the door.

c. If an electric lock is used, complete loss of electric power should not affect opening the door.

d. The door should be designed and placarded so it can be opened from the inside by passengers and from outside by ground personnel.

e. A railing or guard that would deploy to guide passengers away from the propeller plane should be provided as an integral part of the door.

f. If engagement of the engine starter would be an immediate hazard to a person near the propeller, an interconnection between the door and the engine starting circuit should be included in the design.

Amendment 23-34 and Subsequent

The direct visual inspection of the locking mechanism by crewmembers to determine whether external doors, for which the initial opening movement is outward, are fully closed and locked may be conducted from outside the airplane. It will be necessary to provide a means to visually inspect each individual lock of the locking mechanism. Means that do not permit direct visual inspection of each lock are unacceptable unless there is no failure mode of the locking mechanism that would allow a false visual indication that each latch is properly positioned and locked. If optical devices are used from either inside or outside, it should be determined that they are not subject to fogging, to obstruction by foreign objects, or to a false indication of a locked condition.

The locking mechanism should incorporate features that provide a positive means to prevent the door from vibrating open throughout the approved operating envelope. Over center features of the mechanism are not acceptable as a locking means. Also, it should not be possible to position the locks in a locked position if any of the latches are not in the fully latched position.

Amendment 23-36 and Subsequent

Section 23.783(c) was adopted to provide standards that would assure the opening means of passenger and crew doors were simple, easy to locate, and could be operated in darkness. It also assured the doors met particular marking requirements. Overly complex opening means had been identified as a major contributor in accident investigations. The particular marking means are those of § 23.811. Paragraph 23.783(c)(3) was adopted mainly as a measure to ensure that the opening means of passenger and crew doors were kept as simple as possible, and that these doors could be located and opened in a timely manner. Paragraph 23.783(c)(4) was adopted in order to make the location of cabin doors more conspicuous and to facilitate emergency evacuation.

These requirements do not mandate the use of self-illuminated or electrically illuminated external markings. A reasonable and acceptable method of compliance can be found in § 23.807 by substituting “passenger or crew door” where reference is made to “emergency exit.”

This amendment added a requirement that doors be reasonably free of jamming from fuselage deformation from the ultimate load factors found in the General Requirements for Emergency Landing Conditions (§ 23.561) and the limit Proof of Structure (§ 23.307(a)). Some applicants choose ultimate Proof of Structure loads as a higher level of safety than proposed here. Methods used to demonstrate compliance with these requirements should include:

A determination from tests that each emergency door can be opened from inside and outside the airplane after imposing each critical static test load condition from the following limit flight and ground design load requirements (provided they equal or exceed the Emergency landing Conditions).

<u>FLIGHT LOADS</u>

General (§ 23.321)
Symmetrical flight conditions (§ 23.331)
Flight envelope (§ 23.333)
Design airspeeds (§ 23.335)
Limit maneuvering load factors (§ 23.337)
Gust load factors (§ 23.341)

Pressurized cabin loads (for flight, § 23.365(a) and (b); and for landing, § 23.365(a) and (c))

GROUND LOADS

General (§ 23.471)
Ground load conditions and assumptions (§ 23.473)
Landing gear arrangement (§ 23.477)
Level landing conditions (§ 23.479)
Tail down landing conditions (§ 23.481)
One-wheel landing conditions (§ 23.483)
Side load conditions (§ 23.485).

Amendment 23-49 and Subsequent

This amendment adds a requirement that passenger doors not be located with respect to any other potential hazard as well as the propeller disk. These hazards could include hot anti-ice, hot de-ice surfaces, and sharp objects on the airplane structure.

EASA AMC 23.783(b) is acceptable for FAA certification.

23.785 Seats, berths, litters, safety belts, and shoulder harnesses

The corresponding rule in CAR 3 is CAR 3.390.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.34.

Original Issue and Subsequent

Methods of Approval of Retrofit Shoulder Harness Installations in Small Airplanes

A retrofit shoulder harness installation in a small airplane may receive approval wither by an STC, field approval, or as a minor change. An STC is the most rigorous means of approval and offers the highest assurance the installation meets all the airworthiness regulations. A field approval is a suitable method of approval for a shoulder harness installation that needs little or no engineering. Shoulder harness installations may receive approval as a minor change in certain cases. In such cases, the FAA certificated mechanic who installs the shoulder harness records it as a minor change by making an entry in the maintenance log of the airplane.

The FAA does not encourage the approval of retrofit shoulder harness installations as minor changes. The preferred methods of approval are STC or field approval. However, the FAA should not forbid the approval of a retrofit shoulder harness installation as a minor change in: the **front seats** of those **small airplanes manufactured before July 19, 1978**, and in **other seats** of those **small airplanes manufactured before December 13, 1986.**

A retrofit shoulder harness installation may receive approval as a minor change in these small airplanes if:

The installation requires no change of the structure (such as welding or drilling holes).

The certification basis of the airplane is either 14 CFR, part 23 before Amendment 23-20, part 3 of the CAR, or a predecessor regulation.

In addition, a minor change installation should follow the guidance for hardware, restraint angles, and attachment locations provided in the following:

AC 43.13-2A, “Acceptable Methods, Techniques, and Practices Aircraft Alterations.”

AC 21-34, “Shoulder Harness-Safety Belt Installations.”

AC 23-4, “Static Strength Substantiation of Attachment Points for Occupant Restraint System Installations.”

Installations approved as a minor change may not provide the occupant with the protection required either by regulation (CAR 3.386) or 14 CFR, part 23, § 23.561). However, a properly installed retrofit shoulder harness installation is a safety improvement over occupant restraint by seat belt alone.

References

AC 21-34, "Shoulder Harness-Safety Belt Installations," June 4, 1993.

AC 23-4, "Static Strength Substantiation of Attachment Points for Occupant Restraint System Installations," June 20, 1986.

AC 43.13-2A, "Acceptable Methods, Techniques, and Practices—Aircraft Alterations," Revised 1977.

Order 8300.10, "Airworthiness Inspectors Handbook," Change 12, December 14, 1999, Volume II.

Technical Standard Order (TSO)-C114, "Torso Restraint Systems," March 27, 1987.

Technical Standard Order C-22g, "Safety Belts," March 5, 1993.

What are the Requirements?

1. Front seat shoulder harnesses required. Section 23.785 of 14 CFR, part 23, as amended by Amendment 23-19 effective July 18, 1977, required all normal, utility, and acrobatic category airplanes for which **application for TC was made on or after July 18, 1977,** to have an approved shoulder harness for each front seat. Section 91.205(b)(14) requires all small civil airplanes **manufactured after July 18, 1978**, to have an approved shoulder harness for each front seat. The shoulder harness must be designed to protect the occupant from serious head injury when the occupant experiences the ultimate inertia forces specified in § 23.561(b)(2). The inertia force requirements are discussed in paragraph 3 below.

2. Shoulder harnesses required at all seats. Section 91.205(b)(16) requires all normal, utility, and acrobatic category airplanes with a seating configuration of 9 or fewer seats, excluding pilot seats, **manufactured after December 12, 1986**, to have a shoulder harness, for forward-facing and aft-facing seats, that meets the requirements of § 23.785(g) [which requires that the occupant be protected from the ultimate inertia forces specified in § 23.561(b)(2)]. Section 23.785(g) also provides the following: "For other seat orientations, the seat and restraint means must be designed to provide a level of occupant protection equivalent to that provided for forward and aft-facing seats with safety belts and shoulder harnesses installed." The above part 91 operating rule stems from § 23.2, Special retroactive requirements, Amendment 23-32, effective December 12, 1985.

3. Belts or harnesses provided for in the design. CAR 3.386 and part 23, § 23.561, Amendments 23-0 through 23-34, effective February 17, 1987, require occupant protection from serious injury during a minor crash landing when "proper use is made of belts or harnesses provided for in the design," when the occupants are subjected to the following ultimate inertia forces:

	Normal and Utility Category	Acrobatic Category
Forward	9.0g	9.0g
Sideward	1.5g	1.5g
Upward	3.0g	4.5g

With Amendment 23-36, effective September 14, 1988, the text of § 23.561 quoted above was changed to read: "proper use is made of seats, safety belts, and shoulder harnesses provided for in the design." Section 23.785(b) was also changed to read:

"Each forward-facing or aft-facing seat/restraint system in normal, utility, or acrobatic category airplanes must consist of a seat, safety belt, and shoulder harness that are designed to provide the occupant protection provisions required in § 23.562 of this part. Other seat orientations must provide the same level of occupant protection as a forward-facing or aft-facing seat with a safety belt and shoulder harness, and provide the protection provisions of § 23.562 of this part."

The emergency landing ultimate inertia load factors have remained unchanged from Amendment 23-36 through Amendment 23-54, effective December 20, 2000. Amendment 23-54 is the latest amendment level to part 23.

For inertia force requirements for occupant protection preceding CAR 3, refer to Table 1 in AC 21-34, which lists the requirements for the regulations dating from Bulletin 7-A to the original part 23.

What are the methods of approval for retrofit shoulder harness installations?

1. Supplemental Type Certificate (STC). An STC is the most desirable and most rigorous approval. The STC offers the highest assurance that all of the airworthiness regulations have been met. The STC approvals are issued by the FAA ACOs. STC approvals are usually obtained by a shoulder harness installation kit supplier for multiple airplane installations in an airplane model or model series.

ACs 21-34 and 23-4 (references 1 and 2) provide guidance and acceptable means of compliance for shoulder harness and seat belt installations. AC 23-4 specifically addresses part 23 installations. These ACs are also applicable to installations in airplanes having a certification basis of predecessor regulations (for example, CAR 3).

An applicant for an STC may use a salvaged airplane fuselage to substantiate the strength of the fuselage and the shoulder harness attachment fittings by structural tests, since the shoulder harness attachment structural test may damage an airworthy fuselage. It may be a problem that the available test airframe may be stronger than the lowest strength production airframe. This may be a problem in steel tube airframes.

During many years of producing such airframes, various specification materials may have been used. For example, many CAR 3 (and predecessor regulations) airplanes were originally produced from 1025 steel tubing and later constructed from higher strength 4130 steel. In one case studied, two different specification 1025 steel tubes were used which may have an Ultimate Tensile Strength (UTS) ranging from 55,000 to 79,000 Pounds Per Square Inch (PSI). The UTS of 4130 steel is 90,000 to 95,000 PSI.

The test article should be representative of the lowest strength production airframe. This may be accomplished by a conformity inspection using the production drawings. The strength of materials of parts affected by the modification needs to be verified by the airframe manufacturers process and production records. The serial number of the test article needs to be verified.

An alternative course of action would be to determine, by appropriate tests (for example, chemical analysis, hardness tests, strength tests), the strength of the parts of the test article affected by the modification. Follow with testing to a conservatively higher load that accounts for the difference in strengths of the test article and the lowest strength production article. Determination of the higher applied test load should take into account any uncertainty in the test(s) used to determine the strength of the material.

Another alternate course of action may be to conduct the harness pull test on the available test airframe. The applicant may then substantiate the strength of other tubing specifications by a combination of test results and analysis.

AC 23-4 provides an acceptable means of compliance for static strength substantiation of attachment points for occupant restraint system installations. A test block is described to apply the 9.0-g forward inertia load. The safety belt installation alone is tested to 100 percent of the load. The shoulder and safety belt combined load is distributed 40 percent to the shoulder harness and 60 percent to the seat belt.

In airplanes having side-by-side seats, the pull test may need to be applied simultaneously to the harness fittings for both seats. However, this depends on the type of harness and where the upper ends are anchored. Normally, this would not be necessary for a single diagonal belt shoulder harness attached to the outboard fuselage side or wing spar root end.

In the case of a pull test for a retrofit shoulder harness installation in a tandem seated tubular steel fuselage, the forward inertia load was applied simultaneously for both harnesses. This was done for convenience in applying and reacting the loads. It was found, that due to the tube geometry, the load at the aft harness attachment caused a tension in the rear spar carry through tube. The front seat shoulder harness upper end was attached to the rear spar carry through tube. This enabled the front seat harness attachment to test to a higher load than if the pull test was done to each harness individually. In such a case, the test loads for each harness should be done individually.

Part 21, § 21.50(b) requires the holder of an STC to furnish instructions for continued airworthiness, prepared in accordance with § 23.1529.

An STC cannot be used to modify an aircraft without the permission of the STC holder. FAA Notice 8110.69, dated June 30, 1997, requires the STC holder to provide the customer (installer or airplane owner) with a signed permission statement that includes the following:

- product (aircraft, engine, propeller, or appliance) to be altered, including serial number of the product;

- the STC number; and

- the person(s) who is being given consent to use the STC.

The permission statement needs to be kept as part of the aircraft records. The requirement for this permission statement originated in the Federal Aviation Authorization Act of 1996 (Public Law 104-264). This provision was put into law to try to stop the pirating of STCs.

2. Field Approval. A shoulder harness installation in a small airplane may receive a field approval (FAA Form 337) granted by a Flight Standards Aviation Safety Inspector (ASI). Field approvals are appropriate for alterations that involve little or no engineering. If the installation requires structural modifications, an ACO will need to assist in the field approval process by approving the structural aspects of the installation. A field approval constitutes a change to type design and must meet the same regulatory requirements as an STC.

AC 43.13-2A (reference 3) contains methods, techniques, and practices acceptable to the Administrator for use in altering civil aircraft. Chapter 9 covers shoulder harness installations. Section 3 covers attachment methods. Shoulder harnesses installed under field approval must meet the same regulatory requirements as an STC; therefore, the applicant should demonstrate by test 9.0-g forward load capability. The test load should be 814 pounds for normal category or 910 pounds for utility or acrobatic category, in accordance with AC 23-4.

Reference 4, Chapter 1, Perform Field Approval of Major Repairs and Major Alterations, Section 1, paragraph 5D(2) states: “Acceptable data that may be used on an individual basis to obtain approval are:

- ACs 43.13-1A and 43.13-2A, as amended*

- Manufacturers technical information (for example, manuals, bulletins, and kits)

- FAA Field Approvals”

***NOTE 13:** AC 43.13-1B, Change 1, dated September 27, 2001 superseded AC 43.13-1A.

When using a previous field approval as acceptable data, the pull test need not be done if it can be determined that a previous pull test applied 814 pounds for normal category or 910 pounds for utility or acrobatic category. Field approvals for shoulder harness installations should not be done by referencing a previous field approval and deleting the pull test, unless the attachment parts either have a PMA, or other FAA approval. If the attachment parts have no FAA approval, the strength is not known or assured, since they have not been manufactured to an FAA approved quality control system.

Shoulder harness installations attaching to the center of an unsupported wing carry through tube, or other unsupported member, should not receive a field approval without a design approval from an ACO. Applying the test load in such cases may cause damage or permanent set to the affected structure.

Existing FAA guidance, including AC 43.13-2A and AC 21-34, recommend against attachment to the center of unsupported members. Figure 9-16 in AC 43.13-2A shows typical shoulder harness attachments to tubular members. These are all at tube intersections and not at the center of unsupported tubes.

Figure 9-12 shows a typical wing carry through member installation. This appears to be in the center of the carry through member that is a hat section as found in metal skinned airplanes. Part of the figure shows that the hat section is riveted to sheet metal skin (which would provide longitudinal support

Personnel performing the field approval must assure that both the harness and belt are compatible and have a TSO approval.

3. Minor change. Part 21, § 21.93(a), Classification of changes in type design, states as follows: “A minor change is one that has no appreciable effect on the weight, balance, structural strength, reliability, operational characteristics, or other characteristics affecting the airworthiness of the product.”

Information provided to us by the Anchorage ACO indicates that some shoulder harness installations that provide known safety improvements have been approved as a minor change. In these situations, the FAA certificated mechanic who installs it makes an entry in the maintenance log of the airplane.

One shoulder harness installation kit supplier uses this process (no FAA approvals) to install shoulder harnesses in PA-18 airplanes. The installation does not require modification of the airframe. The front seat harness attaches to the center of the rear wing spar carry through tube. However, it may not meet the 9.0-g forward inertia load required by CAR 3.386. The kit supplier stated that some airplane owners who had accidents reported that the harness installation had saved their lives.

In general, shoulder harness installations should not use the center of an unsupported wing carry through tube or other unsupported member as an attachment point. This type of attachment may pose a risk to the structural integrity of the airplane. Although the attachment may be a clamp-on fitting that does not alter the existing airframe, the installation may result in a major change in the type design. This is because the shoulder harness attachment may introduce new loading conditions into the carry through tube.

It is acceptable for the carry through structure to be damaged in an emergency landing. However, it is unacceptable for the tube to fail in-flight. Carry through tubes, highly loaded in compression, may experience a beam-column buckling failure if the occupant applies a load to the shoulder harness attachment. In some cases, very small loads on the shoulder harness attachment may cause beam-column buckling failures.

Some shoulder harnesses that have been installed by minor change do not have a TSO approval. TSO-C114, Torso Restraint Systems, was issued March 27, 1987. Torso restraint systems manufactured before that date did not have to meet the prescribed SAE standard, Aerospace Standard 8043, “Aircraft Torso Restraint System,” dated March 1986. AC 43.13-2A and AC 21-34 provide guidance for acceptable harnesses. Acceptable harnesses for minor change installations include the following:

- harnesses that meet TSO-C114 or Military Specification (MIL-SPEC) requirements,

- harnesses that have been produced under a PMA, or

- other harnesses appropriate to the certification basis of the aircraft.

We have studied the circumstances and legality of shoulder harness installations done by minor change. An airplane owner may wish to install shoulder harnesses, but an STC or prior field approval is not available for his airplane. In this case, it is not likely that an individual airplane owner would apply for an STC or a field approval since the owner would need to hire an engineering consultant to perform the structural test and any associated structural analysis. Also, there is a possibility that the airframe may be damaged during the pull test. In such installations, a pull test would not be done and there is no assurance that the installation will provide occupant protection to the ultimate inertia force requirements (particularly the 9.0-g forward force) of § 23.561 or CAR 3.386.

Concerning the legality of shoulder harness installation by minor change, we conclude the following: Since CAR 3.386 and § 23.561(b)(1) before Amendment 23-36 (which became effective September 14, 1988) state that “proper use is made of belts <u>or</u> harnesses provided in the design,” the previously approved seat belt installation <u>alone</u> must meet the prescribed ultimate inertia forces.

CAR 3.652, Functional and installation requirements, states as follows: “Each item of equipment which is **essential to the safe operation of the airplane** shall be found by the Administrator to perform adequately the functions for which it is to be used, shall function properly when installed, and shall be adequately labeled either for identification, function, operational limitations, or any combination of these, whichever is applicable.”

Before Amendment 23-20 (which became effective September 1, 1977), § 23.1301 contained essentially the same requirement as CAR 3.652. Amendment 23-20 deleted the words “essential to safe operation” and made the provisions of § 23.1301 applicable to “each item of installed equipment.”

We conclude from these rules that if a shoulder harness is not required equipment, it is not essential to the safe operation of the airplane; therefore, CAR 3.652 and § 23.1301, before Amendment 23-20, should not be used as a basis to prohibit shoulder harness installation by minor change. These rules should be applied to shoulder harness installations made by STC and field approval.

The mechanic making such installations should consult AC 43.13-2A, Chapter 9, for information on restraint systems, effective restraint angles, attachment methods, and other details of installation.

See AC 21-34, “Shoulder Harness-Safety Belt Installations,” AC 21-25A, “Approval of Modified Seats and Berths,” and AC 43.13-2A, “Acceptable Methods, Techniques, and Practices—Aircraft Alterations.”

Aft-facing and side-facing seats

For aft-facing seats, seat obliqueness should be limited to 15 degrees unless additional occupant protection for side-facing seats is installed.

Part 23 permits side-facing seats, but it does not address the crashworthiness problems of these installations. We recommend that side-facing seat installations be discouraged. If such an installation is made, the following should be applied in addition to any applicable rules from the original certification basis:

a. A sideward facing seat is defined as one in which the plane of symmetry of the occupant makes more than an 18 degrees angle with the vertical plane containing the airplane centerline when viewed from above.

b. Each occupant of a sideward facing seat should be protected from serious head injury when experiencing the inertia forces of § 23.561(b)(2) by both a safety belt and energy absorbing rest that will support the head and torso or by a safety belt and shoulder harness that will prevent the head from contacting any injurious object. There should be adequate padding on any restraining bulkhead. Riding up of diagonal shoulder straps on the neck, which could cause neck injury, and location of attachments and rigidity of the seat support that could cause twisting and compression of the spine should be considered. For a multiple side-facing seat, a passenger seated immediately forward of another passenger cannot be considered an energy absorbing rest (human cushion).

c. Sideward facing seat installations that do not comply with paragraph “b” above should be placarded to prohibit occupancy during takeoff and landing. In any case, the side-facing seats still require one seat belt for each passenger to protect against in-flight turbulence, and the berth should be considered an item of mass for emergency landing conditions of § 23.561.

d. Special conditions will be required for sideward facing seats that are to be occupied during takeoff and landing when the certification basis requires compliance with § 23.562, Emergency landing dynamic conditions.

Seat Removal for Parachute Operations

This guidance is intended for engineering assistance in the field approval process, TC approval or STC approval of sport parachute modifications to small airplanes. The Small Airplane Directorate has received NTSB recommendations regarding the safety record of small airplanes that have been modified for use in sport parachute operations. Most of these modifications have been approved by FAA Form 337 field approvals without engineering assistance. These modifications should either be approved by the TC process, STC process or by a field approval with engineering assistance. ACOs should not provide engineering assistance for sport parachute modifications that change the limitations of an airplane or affect primary structure, required systems and equipment, handling, crashworthiness or performance. They should be completed using an STC or TC.

The acceptability of sport parachute operations is given in operational regulations. 14 CFR, part 91, allows the use of the cabin floor for sport parachute operations and requires the operations be conducted per 14 CFR, part 105. Part 105 requires radio equipment for operations in controlled airspace, but there are no other equipment requirements other than the parachutes. AC 105-2C, “Sport Parachute Jumping,” gives information on complying with the regulations and provides a list of airplanes that may be operated with one cabin door removed. The part 91 regulation means floor seating is acceptable only for sport parachute operations, but this does not mean that the crashworthiness of the airplane can be unacceptable or that an unsafe condition can be created by a modification.

The small airplane certification basis is mostly CAR 3 or early part 23. The modifications include the following: seating capacity increases, seat and restraint removal and replacement belt installation, door removal for airplanes not listed in AC 105-2C, step and hand holds on airplane exteriors, gross weight increases and CG changes.

Seating capacity increases can be acceptable if all persons are protected in emergency landing loads per § 23.561 (3.386), all persons are secured against sliding backwards in climbs to maintain an acceptable CG position, and any changes in allowable CG range and increased gross weight are found acceptable. The applicant should also supply data to show that emergency exits are not crowded in a ground evacuation with the increased seating capacity per § 23.807 (3.387). This test/analysis must be done with all occupants except one representing a pilot in a parachute, and all parachutists initially restrained in place by the replacement belts/restraints.

Removal of certified seats, seat belts and shoulder harnesses, if any, is allowable per part 91, § 91.207(a)(3)(ii). This does not remove the requirement to prevent an unsafe condition in an emergency landing or normal operations. The replacement belts/restraints should, therefore, meet the requirements for emergency landing upward, forward and sideward loads, per § 23.561 (3.386), and secure all persons against sliding backwards in climbs to maintain an acceptable CG position. Per § 23.785 (3.390), the attachment of the replacement belts/restraints to structure must have a factor of 1.33 times the emergency landing loads in § 23.561 (3.386). A simple belt that fastens across the lap of a person sitting on the cabin floor is not acceptable. This prevents movement only in the direction the person is facing. For instance, facing to the rear (as has been reported) prevents movement toward the tail in a climb, but it does not secure a person against uncontrolled movement toward the front in an emergency landing. The FAA and the United States Parachute Association (USPA) have tested a pair of adjustable belts attached to the parachute harness and found that they are more effective in providing restraint while the emergency-landing forces dissipate. We find it acceptable, therefore, for a parachutist to use adjustable belts instead of the seat belt. Acceptable restraint systems for floor seating of sport parachutists are given by the Civil Aeromedical Institute (CAMI) of the FAA in Report DOT/FAA/AM-98/11, “Evaluation of Improved Restraint Systems for Sport Parachutists,” dated March 1998. The dual-strap restraints (5D, 6D and 7D) provided the least flailing and bending of body segments and the least forward translation of the pelvis. ACOs should require one of these restraint systems for any TC, STC or engineering assistance to a field approval. Limitations should be imposed to call out the three operational procedures on page 21 of the CAMI Report.

The dual strap restraints have been tested with floor attachments. To date, there has not been any acceptable testing of a sidewall attachment. An applicant who wants to attach a restraint system to a sidewall will need to perform sled testing per an approved procedure to verify its suitability in the emergency landing loads.

An acceptable procedure for use of the dual-strap restraints (5D, 6D and 7D) is as follows:

a. Sit on the aircraft floor between two seat rails facing aft.

b. Attach two adjustable belts to your parachute harness for the 5D, 6D, or 7D configuration. You may loop the adjustable belt through your parachute harness webbing or you may attach a quick-release clip through the ring on your harness.

c. Attach the other end of each harness to the seat rail in the aircraft floor. Make the attachment to the floor rail on the same side as the attachment to your harness.

d. Adjust the belt as snugly as possible without causing discomfort.

NOTE 14: If possible, place a lap belt attached to the floor rails around your upper legs to prevent flailing during the emergency landing.

Door removal raises issues in Subpart B of 14 CFR part 23. Performance, stability, and control must be found acceptable with the door removed in flight. If the AFM gives performance numbers such as takeoff and takeoff over a 50-foot obstacle, the applicant should verify that performance or issue a Flight Manual Supplement (FMS) with the revised numbers. Of course, the applicant does not have to present any data or do any tests for airplanes that are listed in AC 105-2C.

Steps and handholds to be installed on the exterior of a small airplane should be shown to meet the structural strength and fatigue requirements in part 23 (CAR 3). Carriage of parachutists outside the aircraft must be shown to not be hazardous in a power loss failure in takeoff and climb flight phases.

Increases in gross weight and allowable CG range should be shown to comply with the requirements in part 23 (CAR 3) as would any other modification that affected these numbers.

Aircraft modified for sport parachute operation must include a placard or flight manual limitation that prohibits flight with doors or seats removed except in sport parachute operation.

Amendment 23-7 and Subsequent

A revision to NPRM 67-14 explains this amendment as follows: *"Experience indicates that a significant reduction in injuries and fatalities in small airplane accidents may be obtained by the installation and use of effective upper body restraints or by designing airplane interiors to either eliminate injurious objects within striking radius of the head or provide energy absorbing support for the upper torso. This proposal would therefore apply, to small airplanes, standards identical with those long administered for large airplanes under Sec. 25.785(c)."*

AC 23-28, when issued, will provide information and guidance applicable to the static strength substantiation of the attachment points for occupant restraint system installations, which have both a safety belt and shoulder harness.

Amendment 23-36 and Subsequent

A revision to NPRM 86-19 explains this amendment as follows: *"The FAA is proposing a substantial revision of the current and new requirements for seats, berths, litters, safety belts, and shoulder harnesses. The revision is considered necessary to present the proposed requirements in a more logical sequence as a result of the new requirements being proposed by this rulemaking action. The new requirements are based to a large extent on the proposals submitted by the GASP to the Part 23 Airworthiness Review Program. The GASP proposals were based in large measure on FAA, NASA, and NTSB research studies and impact/accident analyses."*

See guidance for § 23.562, Emergency landing dynamic conditions.

See guidance for dynamic seat certification in AC 20-146, "Methodology for Dynamic Seat Certification by Analysis for Use in Part 23, 25, 27, and 29 Airplanes and Rotorcraft."

Part 23 did not envision more than two seats on the flight deck, although the part does not prohibit such an installation. The airworthiness standards do not contain adequate standards for an "observer" seat (occupied by an FAA Flight Standards inspector on commuter flights). Therefore, we would expect to apply special conditions to such an installation that would address occupant restraint, emergency egress, and appropriate placarding to prohibit use by a passenger under any circumstances. The special conditions should establish a level of safety equivalent to that established in the certification basis of the airplane, not only for the observer seat occupant but also the crewmember seated in front of the occupant.

The weight of a parachute is included in the 215-pound occupant weight if a parachute is required. The weight remains at 215 pounds when a parachute is not required.

23.787 Baggage and cargo compartments

The corresponding rule in CAR 3 is CAR 3.392.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.35.

Original Issue and Subsequent

Questions have been raised regarding § 23.787(c), which requires an ultimate inertia forward force of 4.5g for the protection of passengers from any cargo compartment. This regulation is related to the CAR, which envisioned a crew compartment forward, a passenger compartment in the middle followed by a bulkhead and a small cargo/baggage compartment aft. In this concept, the 4.5g was considered adequate based on NASA data that showed g forces become less as distance from the nose increases in a typical crash. Our review of all cargo configurations has led to the conclusion that under § 23.561(b) and (e), the restraining devices should meet the 9g requirements. The up and side load inertia forces are not considered to be applicable in this case where the crew would not be subject to injury from upward or sideward cargo movement.

To modify a passenger plane to an all-cargo configuration, the following items should be considered:

a. The cargo compartment should meet the requirements of § 23.787. Special attention should be given to cargo loading placards and the cargo restraint system.

b. The cargo restraint system, including tie downs and the supporting structure to which they are attached, should be substantiated to the emergency landing ultimate inertia forces in § 23.561(b)(2).

c. The floor loading should be re-substantiated to assure the floor structure is not overloaded.

d. Emergency egress from an emergency exit or the entrance door should be verified accessible for the crew.

e. A supplement to the AFM weight and balance section that shows the various permissible cargo loading arrangements and cargo restraints should be furnished.

Guidance on Carriage of Hazardous Cargo for Operators of part 23 Certificated Aircraft

There are no 14 CFR, part 23, airworthiness standards that directly address the design of an aircraft to allow for the carriage of hazardous cargo and passengers simultaneously. We cannot, therefore, provide guidance on the issuance of ATCs or STCs specific to this kind of operation.

However, for the carriage of cargo and baggage in general, 14 CFR, part 23, does provide certification requirements for baggage and cargo compartments. Specifically, § 23.787 "Baggage and cargo compartments," which focuses on the design requirements of the baggage or cargo compartment and its integration with the airframe.

§ 23.855 "Cargo and baggage compartment fire protection" focuses on the shielding, insulation, and flammability requirements of cargo or baggage containers. In addition, this regulation adds additional requirements and tests on cargo and baggage compartments for use in commuter category aircraft.

Title 49, § 175.85, states that hazardous materials may be carried in a main deck cargo compartment of a passenger aircraft provided the compartment meets all certification requirements for a Class B aircraft cargo compartment as defined in 14 CFR, part 25, § 25.857.

The certification requirements for Class B cargo compartments exceed the requirements identified in §§ 23.787 and 23.855. Normally, a Class B cargo compartment is not a certification requirement for a part 23 certificated airplane. However, a cargo compartment may be certificated, using either an ATC or STC process possibly involving special conditions, if it meets the appropriate airworthiness design standards for a Class B aircraft cargo compartment. Any ATC/STC effort must be coordinated with the responsible ACO.

Once approved, a Class B cargo container installation in a part 23 certificated aircraft does not necessarily entitle the operator to carry hazardous cargo. The operator must also demonstrate compliance with the appropriate operational rules and requirements of 14 CFR, part 135, and Title 49 governing the carriage of hazardous cargo. For additional information on part 135 requirements, we recommend the operator contact their local FSDO.

Amendment 23-14 and Subsequent

See AC 23-2, "Flammability Tests."

A proposed revision to NPRM 71-13 explains this amendment as follows: "*This proposal would make it clear that it is not only the cargo shifting that would affect the CG of the airplane that is covered by the rule but it is also cargo shifting which could damage essential controls, equipment etc. In addition, for airplanes in which cargo is carried in the passenger compartment the proposal would make the higher* *inertia forces of Sec. 23.561(b)(2) applicable to the protection of the passengers."*

Amendment 23-36 and Subsequent

A proposed revision to NPRM 94-21 explains the amendment as follows*: "Section 23.787(c) is proposed to be revised because, as presently stated, the required ultimate forward inertia force for cargo restraint is not adequate considering the current requirements of Section 23.561. It was the consensus at the conference that cargo restraint should be at least to the ultimate inertia forces of Section 23.561 to adequately protect occupants forward of the cargo. In addition, when designs provide for cargo to be carried in the same compartment with occupants, it is proposed that means be provided to restrain the cargo, at least to the loads resulting from the emergency landing dynamic conditions being proposed in Section 23.562(b)(2). It is considered necessary to protect occupants from cargo being forced into their occupied area as a result of an emergency landing when they are otherwise being adequately protected from serious injury. The increased ultimate static load factors will achieve this objective."*

The rigid moveable/removable cargo restraint bulkhead attached to seat rails and to points along the cabin sidewalls and roof is considered a structure per § 23.787(c). Prior to this amendment, the loads to design this structure were not defined, but the loads for a cargo restraint system and tie downs in a cargo compartment had to withstand an ultimate inertia force of 4.5g. Even though not defined, some certification programs applied a 4.5g ultimate load factor to design a rigid moveable/removable cargo restraint bulkhead in the cabin. The rationale was to bring the sum of occupant protection to a 9g forward load. In this amendment, the ultimate forward load factor for any cargo restraint system and tie downs has been increased to 9g. In this case, the structure can be designed to no load since the occupant protection of 9g has been met by the cargo restraint system and tie downs.

If this structure separates the occupant compartment from the cargo compartment, only § 23.787(c) applies. Section 23.787(b) is applicable if cargo is carried aft of the occupants in the same occupant compartment. The ultimate load factor in § 23.561 has been increased to 18g by Amendment 23-36.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this amendment as follows: *"Section 23.787 would be revised by extending the present requirements for cargo compartments to baggage compartments. As proposed, future baggage compartments on all airplane categories would be required to be placarded for their maximum weight capacity; have a means to prevent the baggage from shifting; and have a means to protect controls, wiring, lines, and equipment or accessories that are located in the compartment and whose damage or failure would affect safe operation of the airplane. These standards have been applicable to cargo compartment design* *for same time and should be applied to baggage compartments since the same safety factors are involved. Because manufacturers recognize the need for these standards, many of these provisions have been included in the current design of baggage compartments and, therefore, the proposed requirements are not expected to create a significant burden. With this revision the commuter category requirements of Sec. 23.787(g) would be redundant and that requirement is being removed.*

Proposed revisions to this section would also move the substance of paragraphs (d) and (f) to a proposed new Sec. 23.855, which will address cargo and baggage compartment fire protection.

Proposed new paragraph (c) of this section would require flight crew emergency exits on all cargo-configured airplanes to meet the requirements of Sec. 23.807. This requirement would provide increased assurance that flight crews of all cargo airplanes will have ready access to an emergency exit."

23.791 Passenger information signs

No policy available as of September 30, 2003.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

23.803 Emergency evacuation

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-34 and Subsequent

See AC 20-118A, "Emergency Evacuation Demonstration," for information on how to conduct an emergency evacuation demonstration of a commuter category airplane.

If there is a project for a litter installation for non-ambulatory passengers, then the airplane should be evaluated for compliance with the applicable egress requirements for those passengers who can exit the airplane under their own power per § 23.803. This evaluation can be a simple engineering judgment if it is clear the litter installation will not prevent the safe egress of all non-litter passengers within the allotted time. If there is doubt, a new demonstration should be run that evaluates the ability of non-litter passengers to exit the airplane with special attention to the litter installation and possible obstructions to safe exit.

Amendment 23-46 and Subsequent

This amendment adds a requirement for emergency lighting per § 23.812 to be the only lighting used in an emergency evacuation demonstration when certification of emergency exits is done per § 23.807(d)(4). AC 20-118A is still applicable with the exception of paragraph 5a(3)(vi).

23.805 Flight crew emergency exits

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.36.

Amendment 23-46 and Subsequent

Section 23.805 requires two crew compartment exits or a singular hatch if the passenger exits are not convenient and readily accessible to the crew, while § 23.807(a)(3) requires a single crew compartment exit if there is a door that is likely to block the crew's access to the passenger exits. If a crew compartment exit is necessary under § 23.807(a)(3), the more stringent requirements of § 23.805 are also applicable. In other cases, the crew compartment exits may be required by § 23.805 independent of § 23.807(a)(3). Crew compartment exits that comply with the requirements of § 23.805 would also comply with § 23.807(a)(3) without further showing.

Amendment 23-49 and Subsequent

Crew compartment exits that comply with the requirements of § 23.805 would provide an equivalent level of safety to § 23.787(c). According to the preamble to Amendment 23-49, which added § 23.787(c), “this requirement would provide increased assurance that flight crews of all cargo airplanes will have ready access to an emergency exit.”

23.807 Emergency exits

The corresponding rule in CAR 3 is CAR 3.387.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.36.

Original Issue and Subsequent

"Seating Capacity" as used in this regulation is defined as the number of occupants, both crew and passengers, for which the airplane is certificated. Consequently, removal of installed seats is not justification for removal of certificated emergency exits.

The regulation requires a clear and unobstructed opening. An exemption per 14 CFR, part 11 to § 23.807(b), is acceptable for a seatback that protrudes into the opening if it can be easily pushed forward to clear the exit without requiring an action to unlock/unlatch the seat. If a seatback clears the exit when upright but not when reclined, it is acceptable to placard the seat to be upright during takeoff and landing.

Emergency exits should be located to allow escape without crowding in any probable crash attitude. The inverted position is considered probable for both tail wheel and tricycle gear airplanes. This applies to airplanes with doors, forward sliding canopies, rearward sliding canopies and jettisonable canopies. If escape in an inverted attitude is not obvious or is questionable, then compliance should be demonstrated.

It is not acceptable for certification purposes, except for acrobatic airplanes (§ 23.807(b)(5)), to rely on an emergency procedure requiring canopy jettisoning before an accident occurs. Regarding the acrobatic category, if the canopy is not jettisonable, it should be shown that the canopy could be opened far enough in flight between V_{SO} and V_D to enable the occupants to safely exit the airplane. If jettisonable, it should be shown that the canopy trajectory would not cause injury to the occupants while separating from the airplane between V_{SO} and V_D. Also, if the canopy is jettisonable, it should be demonstrated that the airplane can be safely flown without the canopy, or that an inadvertent jettisoning is shown to be improbable.

Regarding doors between the pilots' compartment and the passenger compartment that are likely to block the pilots' egress in a minor crash landing, there should be an exit in the pilots' compartment. This does not apply to curtains suspended from a rod at the top and made of flexible material without slats on any side.

Doors or folding doors with rigid-frangible materials may jam in a minor crash. Acceptance of frangible doors can be shown by the evacuation procedure in section 23.807(a) below or by the conditions for acceptance of rigid doors in section 23.807(b) below. Rigid doors are only acceptable by placarding the doors to be latched in the open position for takeoff and landing, providing the conditions in section 23.807(b) below are in compliance.

a. The purpose of the test is to demonstrate that the door between the pilots' compartment and the passenger compartment will not block the pilots' escape in the event the door is jammed. Acceptable means of compliance is by demonstrating the door is frangible and the flight crew can egress the airplane without assistance within the 90-second time limit.

(1) The test should be conducted in an airplane or a mockup that conforms to the production airplane interior configuration that contains a bulkhead and door to be tested. The door should be closed to simulate jamming. If fragments from the broken door could obstruct the escape route of passengers and an emergency evacuation demonstration is required by either airworthiness or operating rules, then consideration should be given to including passenger participants in the test. In this case, refer to § 23.803 for guidance.

(2) Two participants representing a pilot and a copilot will be used in the test. They should be persons with no particular escape abilities. The approximate stature and weights for the participants should be a female 60-inches tall weighing 102 pounds and a male 74-inches tall weighing 210 pounds (fifth to 95th percentile). The female participant will break the door and be the first person through the exit without assistance from the male participant. Instructions for enhancing the egress should be limited to those instructions that are provided in either the FAA approved AFM or on related placards, or both.

(3) Determine that the lighting simulates night lighting with no moonlight or starlight. Lighting may be allowed at ground level to aid in leaving the area near the airplane providing the lighting is kept low and is shielded so it does not aid in evacuating the airplane.

(4) Participating personnel should be informed of the purpose of the demonstration and of the safety precautions. Safety of participants is the responsibility of the applicant and safety procedures should protect the applicants without impacting the test results. Participants may wear protective gear such as helmets, but such gear, tools, or any other device should not be used to break through the door.

(5) The time limit is 90 seconds whether or not passenger participants are used in this demonstration.

(6) Information advising the flight crew that the door is frangible should be placarded on the door(s) and should be noted in the limitations section of the AFM.

b. Rigid doors (those with stiff members that may jam in a minor crash) may be approved providing they are placarded to be latched open during takeoff and landing and under the following conditions:

(1) The opening and latching should be included in the Normal Procedures Section under the Before Takeoff and Before Landing Checklists of the AFM.

(2) With the door latch in the fully open position, the latch should be able to withstand the loads from the ultimate forces relative to the surrounding structure, per § 23.561.

(3) Flight crew members should be able to open and latch the door with their safety belts/shoulder harnesses fastened, if required by either airworthiness or operating rules.

(4) If certification for night operation is requested, the pilots compartment—with the doors open—should be free from glare and reflections that could interfere with a pilots vision, per § 23.733.

(5) The doors should be placarded in accordance with § 23.1557. The placards should state that the doors are to be latched in an open position before takeoff and landing. Placard information should be in the imitations section of the AFM.

The following should be considered when approving STCs for cargo conversions (no passenger seating) on airplanes with a certification basis of 14 CFR, part 23, including commuter category airplanes:

- Unless otherwise specified, the airplane "seating capacity" is defined as the number of occupants, both crew and passenger, for which the airplane is certificated. Simply removing seats from the seat rails does not change the seating capacity.

- The § 23.807(a)(3) conditional requirement for one crew compartment exit is applicable to all airplanes with a part 23 certification basis, including commuter category.

- Airplanes with a crew compartment door that may block the pilots exit must have an exit in the crew compartment. In this circumstance, a normal, utility, or aerobatic category airplane with a certificated passenger seating capacity of zero (cargo only), a minimum of a single accessible exit in the cargo compartment in addition to the crew compartment exit is necessary (reference § 23.807(a)(3).

- It is not acceptable to eliminate emergency exits by modifying an existing exit so it no longer complies with 14 CFR, part 23 airworthiness requirements. However, under certain circumstances, such as in an airplane with more than two exits, it may be permissible to block exits with cargo provided one or more exits remain accessible on each side of the airplane. Implicit within the definition of "readily accessible" is a requirement that the unblocked emergency exits have no obstacles such as cargo nets or cargo. Obstacles pose an impediment to the emergency evacuation process that cannot be quantified, particularly when consideration is given to the effect of a post-crash environment. An emergency evacuation demonstration, therefore, is not acceptable as an ELOS since it is not meant to allow alleviation or deviation of specific requirements.

If the airplane is configured for passenger and cargo (Combi), the requirements of this section should be met for the passenger compartment. In addition, cargo should be located so that it does not obstruct either access to or use of any required emergency or regular exit; so that it does not obstruct the use of the aisle between the crew and passenger compartment; and so that it meets the additional requirements of § 135.87.

Amendment 23-7 and Subsequent

A proposed revision to NPRM 67-14 explains this amendment as follows: *"Section 23.807 (a) (1) exempts all airplanes with five-or-less occupants from the requirement to have an emergency exit opposite the main door. For airplanes with engines mounted on the wings or on the side of the fuselage, the main door may be blocked by engine fire regardless of the number of occupants. Therefore the five-or-less exemption would be discontinued for these aircraft but would be continued for single engine airplanes and centerline thrust twins."*

Amendment 23-10 and Subsequent

Multiseat airplanes must have a second exit on the opposite side from the main door, per § 23.807(a)(1). Both exits must be accessible and must not be blocked with cargo.

Amendment 23-34 and Subsequent

A proposed revision to NPRM 83-17 added Amendment 23-34. *"The source for this revision is part 135, Appendix A., sections 32(a) and (b); SFAR 41, section 5(e), Doors and Exits, paragraphs (g), (i), and (j)"*. This amendment added emergency exit requirements for commuter airplanes. Included are emergency exit marking requirements as well as those in §§ 23.783 and 23.1557. The additional emergency exit marking requirements in § 23.1557(d) regarding the red operating handle and placard that provides door opening instructions are not mandatory for the passenger entrance door. However, § 23.807(b)(3) requires markings for easy location and operation of the exit even in darkness, and § 23.811(b) requires the illumination of the exit sign. As an added safety feature, it is recommended that the operating handle be self-illuminated and marked with a red arrow and the word "OPEN" in red letters placed near the head of the arrow. If necessary, other pertinent instructions for opening the door should also be in red.

This amendment requires three emergency exits as well as the entrance door for commuter airplanes with passenger seating from 16 to 19. Part 25, § 25.807, requires two Type III emergency exits on opposite sides of the cabin. It is possible for an applicant to use part 25 for emergency exits. To do so requires a petition for exemption per part 11, and compliance to part 25, §§ 25.807, 25.561(b)(3)(iv), 25.783, 25.809, 25.811, 25.812, 25.813, 25.815, and 25.817.

An integral stair, if installed at an entrance door, should be designed so it does not reduce the effectiveness of the door as an emergency exit under the inertia forces of § 23.561 and following the collapse of one or more legs of the landing gear. An actual demonstration of this failure mode is beyond the intent of this rule. It should be shown by orthographic drafting techniques or test (i.e., ground plane under an airplane to simulate various attitudes) that with the various combinations of collapsed landing gears and resulting airplane attitudes, the exit effectiveness is not reduced. This is done with no fuselage deformation.

There are no standards for ejection seats in part 23. If an applicant needs an ejection seat to meet the emergency exit requirement in § 23.807, an ELOS will have to be justified.

Emergency Exit Size and Shape

Background

For a commuter category airplane with a certificated passenger seating capacity of zero (cargo only), two emergency exits (one on each side) are required in addition to the main door (reference § 23.807(d)(1)(i)) regardless of the crew compartment door configuration.

CAR 3.387 and 14 CFR, part 23, § 23.807, have required that all emergency exits have sufficient size and shape to admit a 19 x 26 inch ellipse. Time to egress through an exit is related to the total open area and the most critical dimension of the exit. The area of a 19 x 26 inch ellipse is 388 square inches. Studies for emergency evacuation demonstrations with the standard ellipse have shown that the duration to egress was equal or less with other exits having a total open area equal to or greater than 388 square inches and the most critical dimension, width or height, greater than 19 inches, but lacking the shape to admit a 19 x 26 inch ellipse.

Acceptable Means of Compliance

Alternatives for compliance to the airworthiness standards are permitted by an ELOS. One method for determining compliance by an ELOS is by the test procedure below. Demonstrations have shown that the emergency exit size and shape greatly affect the time and ease of an emergency evacuation. An ELOS should only be considered if the exit meets the logical limits that correspond to the standard exit; that is, the total open area is equal or greater than 388 square inches and the most critical dimension, width or height, is not less than 19 inches. These limits for area, width, and height were established after considering human factors, evacuation demonstrations, and existing airworthiness standards.

Test Procedure

Area of opening. The following factors should be considered when measuring or computing the area of opening:

a. Firm protrusions that would hamper egress should be eliminated from the minimum required exit opening. Examples are seals or escape latches that will not easily compress, move, or fold out of the opening with the motion of a person moving through the opening.

b. When a compressible seal protrudes into an opening, the seal may be in the compressed condition when measuring or computing the opening area.

c. During the comparison test, the emergency exit opening used as a standard is an opening that will allow passage of a 19 x 26 inch ellipse with a major axis being in a vertical position, a horizontal position, or any other position.

d. The area leading to the opening should be clear and unobstructed. Minor obstructions could be acceptable if there are compensating factors to maintain the effectiveness of the exit; that is, a total effective open area of 388 square inches and the most critical dimension, width or height, not less than 19 inches. For example, soft seatback cushions may constitute minor obstructions if the cushion can be readily moved away from the exit and the exit can be easily opened, and if the cushion in its normal position does not prevent identification of the exit or obscure the exit marking.

Comparison Test Conditions. The comparison test will determine the difference in mean escape time between either the proposed and standard exit or exits.

a. A mockup of a section of the fuselage may be used. The arrangement of exits, passenger seats, and the step-up and step-down distances from the sill to the wing or step may be simulated. Ramps or stands are permitted to assist participants in descending from a wing when over-wing exits are used if the acceptance rate of the ramp or stand is no greater than that of the assist means of the airplane in an actual crash landing situation. Mats may be used on the floor or ground to protect participants. No other equipment that is not part of the airplanes emergency evacuation equipment may be used to aid the participants in reaching the ground.

b. At the start of each trial, participants should be seated as called out in AC 20-118A, “Emergency Evacuation Demonstration.”

c. Participants should not be permitted any “practice” runs, but they may be briefed on the purpose of the test to demonstrate a rapid emergency evacuation of the airplane. They should not be briefed that the test is to compare exits. An example of an acceptable instruction would be to pass through one foot first, followed by the head and the other foot. The briefing should be the same for each trial.

d. The test should be conducted under dark or simulated dark conditions for both standard and proposed exit configurations per the compliance inspection requirements of AC 20-118A.

e. The participant composition should be as specified in AC 20-118A.

Statistical Design. An acceptable statistical design is as follows:

a. There should be 15 or more participants for each exit configuration to be tested, including the standard configuration.

b. The participants should be assigned to the number of subgroups corresponding to the number of exit configurations to be tested. As noted in paragraph a, each subgroup should have at least 15 people unless the seating configuration is less than 15. In this case the following procedures should be used:

(1) The subgroups should be divided into sub-subgroups of approximately equivalent size where the sub-subgroup size is equal to or less than the seating capacity of the airplane. The egress time of the sub-subgroups is totaled to constitute the subgroup time.

(2) When a mockup for an airplane is used, even if the number of passenger seats is less than 15, the total subgroup of 15 participants may participate at the same time providing the increase of space from the standard mockup for the additional subjects does not degrade the comparison tests. Under these conditions, the participants with the least physical agility should be in the most critical positions.

c. The subgroups should be as neatly alike as possible with respect to physical agility, age, sex, and weight. This can be achieved by first dividing the group by age and sex then subdividing each age/sex group at random into the required number of subgroups.

d. Each subgroup should test each configuration, but the order of trials should be different for each subgroup as well as chosen in accordance with the Latin Square Principle. This principle is that each configuration be tried once by each subgroup and appear once in each possible order. Thus if there are two configurations to be tested and, therefore, two subgroups A and B, then Subgroup A should first try the standard configuration followed by the proposed configuration; Subgroup B should perform the trials in the reverse order. This arrangement eliminates the effects of an individuals learning, fatigue, and agility.

Recording of Trials. Recording should be done as follows:

a. Motion pictures or video recordings, sound or silent, should be made to analyze the trials for difficulties with an exit, individual escape times, and other performance factors.

b. A large clock with a second hand should be placed in the camera field so that time can be recorded or synchronized electric cameras may be used with the time superimposed in the film processing. A signal light to indicate the beginning and end of each trial should also be arranged in the field of view of the camera.

c. Evacuation time should be rounded to the nearest second. The timed demonstration is performed per the Evacuation section of AC 20-118A.

Evaluation of Results. The evaluation should be performed as follows:

a. The effectiveness of the proposed exit or exits compared with the standard exit or exits is determined by comparison of the average time of the subgroups to pass through each exit tested. The effect of subgroup learning is canceled by the Latin Square Principle.

b. It is possible that one group may contain one or two persons who find it difficult to go through the exits. The Latin Square Principle will cancel such unbalance between subgroups.

c. It may happen that an individual may, through chance, have considerable difficulty with an exit, but their performance may compare with average performance of other individuals. A study of the individual escape times will enable such occurrences to be evaluated and will assist in the final determination of the acceptability of the proposed exit or exits.

d. A proposed exit configuration is acceptable when its egress time is equal to or less than the time required to pass through the standard exit.

Type Certificate Data Sheet (TCDS). An equivalent level of safety should be part of the type certification basis and noted on the TCDS. Suggested wording is, "Equivalent Safety Findings: Section 3.387 of the CAR and Section 23.807 of 14 CFR part 23, emergency (particular) exit in accordance with AC 23-17, Systems and Equipment Guide for Certification of Part 23 Airplanes."

Amendment 23-36 and Subsequent

This amendment is explained by Notice 86-19 as follows: *"The issue of number and location was addressed by one proposal to require that for all airplanes with a seating capacity of two or more, excluding airplanes with canopies, have at least one emergency exit on the opposite side of the cabin from the main door specified in Section 23.783. There have been egress difficulties experienced with center line engine airplanes with a seating capacity of two or more, excluding those airplanes with canopies, and no emergency exit or door opposite the main cabin door. In some cases, occupants have had to kick out windows to egress the airplanes after survivable accidents."*

Amendment 23-46 and Subsequent

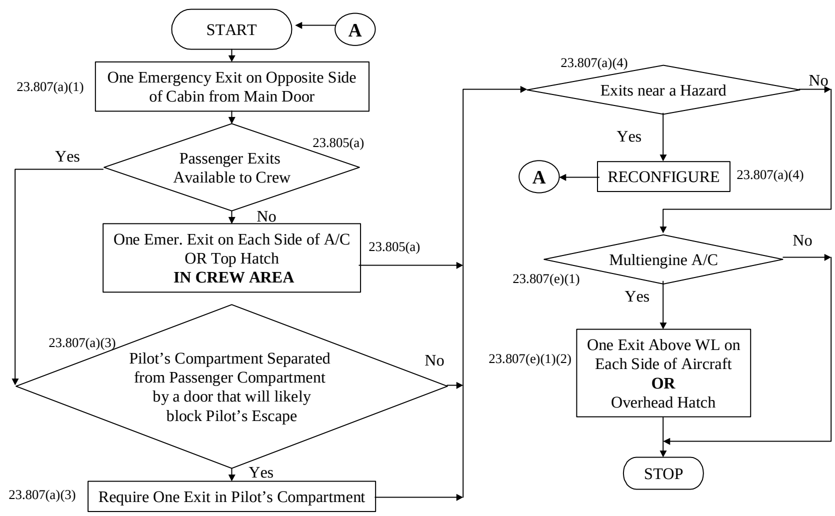
A proposed revision to NPRM 90-20 explains this amendment as follows: *"For standardization between the airworthiness requirements for commuter category and transport category airplanes, and to simplify the alternate emergency exit standards proposed in this notice, the FAA proposes to move certain requirements of Sec. 23.807(d)(1) to a new paragraph (f) in Sec. 23.783 and proposes a new paragraph (d)(3) in Sec. 23.807. The standards in proposed Sec. 23.783(f) require that each passenger entry door qualify as a floor level emergency exit and provide requirements for integral stairs when installed at a passenger entry door. The standards in proposed 23.807(d)(3) require that each emergency exit that is not a floor level exit either be located over the wing or, if not less than six feet from the ground, have an acceptable means to assist the occupants in descending to the ground. There are no substantive differences between the requirements in proposed Sec. 23.783(f) or in proposed Sec. 23.807(d)(3) and those requirements proposed to be removed from Sec. 23.807(d)(1)."*

A proposed revision to the NPRM explains the following: *"This notice proposes new requirements for emergency exit ditching provisions for multiengine airplanes that are type certificated to the airworthiness standards of part 23. The FAA anticipates an increase in the use of commuter category airplanes and multiengine normal category airplanes in over water operation. Airports developed near large bodies of water increase the number of departures and approaches that are conducted over water. Since ditching provisions may be critical for occupant egress following an emergency landing in water, the standards in proposed Sec. 23.807(e) ensure the availability of exits for emergency egress following an emergency landing in water."*

Amendment 23-49 and Subsequent

The following flow chart is valid for emergency exit in normal, utility, and acrobatic category airplanes.

Non-Commuter Emergency Exit Flowchart



23.811 Emergency exit marking

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.36.

Amendment 23-36 and Subsequent

For small airplanes with emergency exits that open from the outside, the FAA recommends that markings be added to the outside of all exits as follows:

a. Outline the exit with a band of a contrasting color from the surrounding fuselage surface.

b. Mark the corners of the exit in a conspicuous manner.

c. Outline the exit handle with a band of a contrasting color.

d. Mark the exit with any other conspicuous visual identification scheme.

e. Install a decal on the outside surface of the exit or the surrounding surface adjacent to the exit that shows the means of opening the exit, including any special instructions if applicable.

Section 23.811(a) is specifically intended to be applicable to exterior emergency exit markings and placards. It does not stipulate the color of these markings and placards, with the exception that they must be conspicuously identifiable from outside the airplane. Section 23.1557(d) specifically requires that each placard and operating control for each exit must be red. Furthermore, a placard must be near each emergency exit control and must clearly indicate the location of that exit and its method of operation.

Since the emergency exit exterior markings are conspicuously identifiable from the outside of the airplane, to further require red placards that indicate the location of these exits does not make sense. There might be instances where the red placard may not be conspicuously identifiable due to the exterior color of the fuselage. Section 23.807 gives further guidance regarding adding external markings to emergency exits. Not one of the recommendations specifies the use of red placards. Other subparagraphs of § 23.811 require the use of red markings when the subject involves the interior of the airplane. Being consistent with these facts, therefore, we interpret the intent of § 23.1557(d) to be applicable to the interior of the airplane.
Passenger exit signs should have an initial luminescence of at least 160 microlamberts, and should be replaced when its luminescence decreases below 100 microlamberts.

Amendment 23-46 and Subsequent

The explanation for this amendment in NPRM 90-20 states as follows *"The emergency exit marking standards for transport category airplanes, as stated in Sec. 25.811, have specific requirements that go beyond the current commuter category airplane emergency exit marking standards. Therefore, this notice proposes to add a new Sec. 23.811(c) providing additional airworthiness requirements for emergency exit marking that would be applicable when certification to the emergency exit provisions of Sec. 23.807(d)(4) is requested. The standards in proposed Sec. 23.811(c)(1), which are similar to the requirements of Sec. 25.811(a), ensure conspicuous marking for each emergency exit, its means of access and its means of opening for rapid identification and operation of the exits in an emergency condition. The standards in proposed Sec. 23.811(c)(2), which are similar to the requirements of Sec. 25.811(b), ensure that the airplane occupants can readily identify and locate the emergency exits on the opposite side of the cabin from where they are seated. The standards in proposed Sec. 23.811(c)(3), which are similar to the requirements of Sec. 25.811(c) that ensure that the airplane occupants can locate the emergency exits when the cabin is filled with dense smoke. The standards in proposed Sec.23.811(c)(4), which are similar to the requirements of Sec. 25.811(e)(1), ensure that the operating handle and the instructions for opening the emergency exits are shown by a marking that is readable from a distance of 30 inches. The standards in proposed Sec. 23.811(c)(5), which are similar to the requirements of Sec. 25.811(e)(2), ensure that there is sufficient lighting to allow identification of the passenger entry door operating handle. The standards in proposed Sec. 23.811(c)(6), which are similar to the requirements of Sec. 25.811(e)(4), ensure the ease of access and operation of a passenger entry door with a locking mechanism that is released by a rotary motion of the handle. The standards in proposed Sec. 23.811(c)(7), which are similar to paragraphs (1) and (2) or Sec. 25.811(f), ensure that the emergency exits are externally marked so that they can be readily identified in conditions of low lighting or poor visibility. These proposed requirements would result in emergency exits that are easier to locate and open in adverse conditions."*

23.812 Emergency lighting

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-46 and Subsequent

The explanation for this rule adopted in Amendment 23-46 states as follows: *"This proposal adds requirements for an emergency lighting system, to be applicable when an applicant for type certification chooses to comply with the alternate emergency exit provisions of proposed Sec. 23.807(d)(4) of this part. The proposal defines specific minimum requirements for supplying power, arming, and activating the emergency lighting system. The impact-activation requirement is consistent with that for emergency locator transmitters. The proposal also includes illumination, function, and survivability requirements for the emergency lighting system. An emergency lighting system complying with these proposed requirements would aid occupants in locating the emergency exits and getting to those exits after an emergency landing."*

23.813 Emergency exit access

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-36 and Subsequent

A change to this amendment was added by Final Rule docket 25147 as follows*:* "In addition, the requirements of Section 23.807(d)(4) are moved to a new Section 23.813, titled Emergency exit access", in this final rule."

See § 23.807 Means of Compliance for policy on acceptance of seatbacks obstructing emergency exits that can be easily moved.

Amendment 23-46 and Subsequent

The explanation in NPRM 90-20 for this amendment states as follows*: "This proposal adds requirements to ensure emergency exit accessibility, to be applicable when an applicant for type certification choose to comply with the alternate emergency exit provisions of proposed Sec. 23.807(d)(4) of this part. Structural failures or yielding of the airframe can occur during an emergency landing or minor crash event that may result in one or more emergency exits or the passenger door becoming unopenable. Since the total number of exits available for emergency egress can be fewer with the alternate emergency exit requirements, this proposal defines minimum unobstructed aisle width at the passenger entry door and adds other requirements to ensure that any partitions or doorways within the passenger compartment will not hinder occupant access to the exits during an emergency situation."*

23.815 Width of aisle

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-34 and Subsequent

This rule, adopted "*from SFAR 41, Sec. 5(e), Doors and Exits, paragraph (k), applies to commuter category airplanes*". The main passenger aisle width is the minimum distance between seats measured without occupants. This distance is measured without compressing the seat fabric or cushions, and with the seats and other aisle constraints in their most adverse position. If the seats can swivel and the distances can be less than the rule requires, the most adverse position may be defined with placards or flight manual limitations to require locking them in either a forward or aft facing position for taxi, takeoff, and landing. This is acceptable only when those positions give an aisle distance that meets or exceeds the requirement.

Amendment 23-46 and Subsequent

A proposed revision to NPRM 90-20 explains this amendment as follows: "*This proposal requires increased aisle widths to be applicable when an applicant for type certification chooses to comply with the alternate emergency exit provisions of proposed Sec. 23.807(d)(4) of this part. The proposed increased aisle width requirements are intended to ensure that the airplane passengers can reach an exit in an emergency situation even though the floor structure has been warped or there are seats or other items protruding into the normal aisle space.*"

23.831 Ventilation

The corresponding rule in CAR 3 is CAR 3.393.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.38.

Original Issue and Subsequent

The use of an alternate air supply, either automatic or manual, that picks up air from within the engine compartment is unacceptable for cabin ventilation because of possible contamination from either fuel, oil, or exhaust leaks.

Halon 1301 may be safely used in concentrations up to 10 percent in airplane cabins. Ventilation in airplane cabins is sufficient for the agent to disburse in less than five minutes, so the time limit need not be considered if the concentration is held below the 10 percent limit. Halon 1211, however, should not be used in airplane cabins.

The regulation regarding allowable carbon monoxide (CO) concentration is given in part 23, § 23.831(a): carbon monoxide concentration may not exceed one part in 20,000 parts of air.

Tests to verify compliance with part 23, § 23.831(a) are done as part of the original type certification of an aircraft when a modification that has a possible effect on the compliance to part 23, § 23.831(a) is made and when Co is verified or suspected in operation.

Two acceptable methods of detecting carbon monoxide are given in AC 20-32B. These are acceptable either for a TC applicant, an STC applicant, a parts manufacturer approval applicant, an FAA field approval applicant, or an owner/operator. Other methods of verifying compliance to part 23, § 23.831(a) can be used if they are shown to provide acceptable results.

Amendment 23-34 and Subsequent

The source for this revision is shown by NPRM 83-17 as "*Part 135, Appendix A, section 60, and SFAR No. 41, section 4(c)(3), which incorporates § 25.831(d) by reference*". For pressurized commuter category airplanes, if hazardous accumulations of smoke are found to be reasonably probable in the cockpit area, smoke evacuation to a non-hazardous level should be readily accomplished from full pressurization to minimum safe levels (per 14 CFR, part 91, § 91.211). Smoke evacuation procedures should be included in the AFM, Emergency or Non-Normal (Abnormal) Procedures Section, or on approved placards.

1. What is the acceptable level of smoke, in the cockpit, as a result from this type of test?

The test to show compliance to § 23.831(b) is for "all" fires that are possible not just engine fires. Conservatism requires that the test begin with smoke sufficient to obscure the instrument panel. The plane must remove this smoke without depressurizing the plane below safe limits per § 23.831(b).

2. What is the acceptable level of toxicity of the smoke?

FAA has a requirement for carbon monoxide in § 23.831(a), but no other material. The applicant must determine what combustion by-products will be generated from the reasonably probable failure of an engine fire in a reciprocating engine.

3. Three minutes or five minutes for clearing smoke from the cockpit?

The three-minute period is acceptable not to completely remove all smoke but to permit the pilot to safely fly the plane (see the flight instruments).

4. What does "readily accomplished" mean?

This rule came from part 135, Appendix A, which was based on § 25.831(d). It means that the flight crew can easily activate the depressurization system while seated and belted in the cockpit. In a single pilot airplane, this means from the left seat.

5 What does "without depressurizing beyond safe limits," mean?

The source for this rule was the same as question 4. Part 91 specifies that a flight crew can operate at 14,000 feet cabin pressure for 30 minutes. This is the maximum level that the plane can be depressurized without supplemental oxygen for operation above 14,000 feet for more than 30 minutes. However, applicants can use Time of Useful Consciousness for an emergency descent as in a pressurization failure, but they must allow time for the cockpit to clear of smoke sufficiently for the flight crew to safely begin the descent to 14,000 feet or below.

6. Can the smoke evacuation test be done on the ground?

Yes, a ground test is acceptable IF the applicant can clearly demonstrate that all relevant test boundary conditions match the respective flight conditions (such as airflows, and pressure fields, etc.). If an applicant elects to have a cabin altitude limiter, the ground test must be conducted at or above the setting of the limiter (example: test site above 14,000 feet Mean Seal Level (MSL), if the limiter is set at 14,000), otherwise no.

7. Can the applicant assume an emergency descent?

Per answer 1, the smoke must obscure the panel. An emergency descent cannot be started until the smoke evacuation takes effect.

Amendment 23-42 and Subsequent

This amendment makes paragraph (b) and the policy under Amendments 23-34 and subsequent applicable to all part 23 pressurized airplanes, not just commuter category.

AC 25-9A, “Smoke Detection, Penetration, and Evacuation Tests and Related Flight Manual Emergency Procedures,” dated January 6, 1994, provides an acceptable means of compliance for the smoke evacuation requirements of this section.

PRESSURIZATION

23.841 Pressurized cabins

The corresponding rules in CAR 3 are CAR 3.394 and 3.395.

There is no corresponding rule in the Airship Design Criteria.

Original Issue and Subsequent

Paragraph (c) in § 23.841 requires there be a means to rapidly equalize the pressure differential. Assuming isothermal conditions, the time for the pressures to equalize depends on the cabin volume, the effective area of the safety-dump valves, the cabin inflow, and the pressures inside and outside the cabin. If the size of the effective area of the valve is small in comparison to the cabin volume, the rate of pressure change may be too slow to equalize the pressures before an adverse event could occur. The time period to rapidly equalize the pressures should consider maximum certificated cabin pressure differential, operation of the pressurization system, and either operation of the emergency exits or the cabin entrance doors, or both. When landing the airplane under emergency conditions, the safety-dump valve should have sufficient flow capacity to rapidly equalize the cabin pressure within a time period so that the cabin doors and emergency exits can be opened and evacuation is not impaired. Time to equalize the ambient and cabin pressures should be demonstrated. Inflatable door seals, if installed, are subject to the requirements of this rule.

Paragraph (f) of § 23.841 requires a warning device for safe or preset pressure differential and absolute cabin pressure. A warning is interpreted to convey the need for an immediate corrective action, so it may not operate unless there is a failure, and the visual indication should be red per § 23.1322. Red lines on altimeters or pressure indicators are used to indicate operating limits, but they are not acceptable warning means.

Amendment 23-7 and Subsequent

This amendment changed the warning requirements in paragraph (f). The explanation in NPRM 67-14 states as follows: *"Present Sec. 23.841 (f) does not describe what pressure warning devices are acceptable. This proposal would follow the approach of Sec. 25.841 (b) (6), that is, that instrument markings are sufficient for safe warning of pressure differential limits, whereas aural or visual means are necessary for safe warning of absolute pressure limits." The Final Rule, Docket 8083, added the following: "The proposed requirement permits the use of markings on the presently required pressure differential indicator as the warning indicator."*

Amendment 23-14 and Subsequent

This amendment requires that cabin pressure altitude not exceed 15,000 feet in any probable failure for airplanes certificated to operate over 31,000 feet. It is not appropriate to use an emergency descent procedure to demonstrate compliance to this rule when compliance can be achieved through design. The Emergency Operations Section of the AFM should include an emergency descent procedure for use in a rapid decompression from any failure not withstanding the probability of its occurrence.

Amendment 23-17 and Subsequent

A proposed revision to NPRM 75-10 explains Amendment 23-17 as follows: *"This proposal would make clear that the rule applies to cabin pressure and the rate of change of cabin pressure. The proposal would also conform the rule to current practice, which is to provide a warning when the cabin pressure altitude exceeds 10,000 feet. This amendment established 10,000 feet as the maximum absolute cabin pressure for operation of the pressure altitude warning. Therefore, the pressure sensors used in the warning system cannot have an operating set point and tolerance that would prevent the warning from being given at or before 10,000 feet. A feature that automatically changes the warning altitude to 15,000 feet for operations at field elevations above 10,000 feet is acceptable to prevent nuisance warnings."*

The following material is a means of compliance to § 23.841(b)(3) that requires a means by which the pressure differential can be rapidly equalized. Section 23.841(b)(6) offers a provision for a warning indication at the pilot station to indicate when a cabin pressure altitude of 10,000 feet is exceeded.

1. RELATED 14 CFR PART 23 SECTIONS. These acceptable means of compliance refer to certain provisions of part 23 and the corresponding provisions of part 3 of the CAR in the case of airplanes for which those regulations are applicable. Listed below are the applicable and the related part 23 sections with the corresponding CAR sections shown in parenthesis:

a. § 23.365 (3.197)

b. § 23.775(c) (3.383)

c. § 23.841 (3.395)

d. § 23.843 (3.396)

2. DISCUSSION OF REQUIREMENTS. In discussing these requirements, a brief history on the development of the applicable airworthiness regulations is first presented. The purpose of the airworthiness requirements for small airplanes is then explained.

a. Rapidly Equalizing the Pressure

(1) History. The requirement for a means by which the pressure differential can be rapidly equalized was introduced in the airworthiness regulations for pressurized cabins for transport category airplanes when part 04 of the CAR became effective on November 9, 1945. Due to the trend to develop pressurized cabins for small airplanes, the 1956 Annual Airworthiness Review established similar requirements for pressurized cabins for small airplanes. The criteria were developed by using the principles that were applicable to pressurized cabins on transport category airplanes since most of the cabin pressure control system design for small airplanes drew heavily upon the equipment designed and developed for transport category airplanes. As a result, many of the provisions added to part 3 of the CAR by Amendment 3-2, effective August 12, 1957, were substantially the same as those which applied to transport category airplanes. Under the recodification program in 1965, part 23 replaced part 3 of the CAR and these requirements are now in § 23.841(b)(3).

(2) The purpose of this requirement is to provide the crew with a means to rapidly equalize the differential pressure to permit quick opening of the emergency exits and entry door(s) in the event of a gear up landing under emergency conditions. This means may be used for other events such as over pressurization and reducing cabin contamination. These functions are described in further detail as follows:

(i) Due to a malfunction in the pressurization system or abnormal operational conditions, the cabin pressure is above normal conditions during the airplane-landing phase. In this case, the cabin pressure may be vented by the safety-dump valve operated through a manual controller or triggered by the landing gear safety switch so the emergency exits and the cabin entrance doors could be opened.

(ii) If a failure such as a cracked window or windshield occurs, the cabin pressure should be capable of being rapidly reduced so the loads due to cabin pressure differential can be reduced accordingly.

(iii) When a threatening cabin overpressure condition exists due to cabin pressurization system malfunction, the cabin pressure can be reduced by the safety-dump valve to prevent a structural failure of the pressure vessel.

(iv) When the cabin air becomes contaminated by smoke, fumes, etc., the cabin safety-dump valve may be used, depending on the conditions, to assist the pressurization or ventilation system, or both, in evacuation of the cabin air to reduce the contaminants.

b. Cabin Pressure Altitude Warning

(1) History

(i) The cabin altitude warning and many of the provisions for pressurized cabins for small airplanes were added to part 3 of the CAR by Amendment 3-2, effective August 12, 1957. Section 3.395(f) of part 3 of the CAR required, in pertinent part, that the pilot be provided a warning when safe or preset limits on pressure differential and on absolute cabin pressure were exceeded.

(ii) In May 1958, a quantitative requirement was introduced in the airworthiness regulations when FAA established policy for altitude warning on the sport category airplanes. This policy, which was set forth in § 4b.375-l of CAR part 3, required that the warning for cabin pressure would meet the applicable requirements if it occurred when cabin absolute pressure was reduced below that equivalent to 10,000 feet. Under the recodification program in 1965, part 25 replaced part 4b of the CAR and the 10,000 feet warning policy was carried over as an appropriate means of meeting the warning requirements in § 25.841.

(iii) As part of the First Biennial Airworthiness Review Program in 1975, Amendments 23-17 and 25-28, which changed parts 23 and 25 respectively, were issued and became effective February 1, 1977. Amendment 25-28 transmitted a minor change to § 25.841 as follows: It changed "cabin absolute pressure is below that equivalent to 10,000 feet" to "cabin pressure altitude exceeds 10,000 feet." Amendment 23-17 brought into § 23.841 of part 23 a warning indication when the cabin pressure altitude of 10,000 feet MSL is exceeded. The preamble for this change indicated this proposal was adopted because a large number of small airplanes had such a warning and many pilots had begun to rely on this warning.

(2) The purpose of the cabin pressure altitude-warning requirement is to indicate a warning at the pilot station when the cabin pressure altitude is greater than 10,000 feet MSL. A possible hazardous condition could be when the airplane reaches the operating altitude, which is greater than 10,000 feet MSL, and a malfunction in the cabin pressurization system occurs. If there was no warning for cabin pressure altitude, the cabin pressure altitude could slowly increase undetected to the airplane altitude, and the crew and passengers could become unconscious due to hypoxia. The effects of hypoxia are usually encountered when the flight crew is exposed to altitudes above 10,000 feet during extended flights.

3. ACCEPTABLE MEANS OF COMPLIANCE

Warnings and Cautions. Section 23.1322 provides specific requirements for the assignment of red and amber for visual indications. Specifically, for abnormal operational or airplane systems conditions, a "caution" should be generated for crew awareness and subsequent crew action may be required; the associated color is amber. Under emergency operational or airplane systems conditions, a “warning” should be generated for immediate crew recognition and when corrective or compensatory action may be required; the associated color is red. If the cabin pressure altitude warning is a visual indicator, it should be red to indicate a hazard.

<u>Air Conditioning System R12 to R134 conversion</u>
Direct conversion without certification is not possible, due to the characteristics of the refrigerants. Incompatibilities can include o-rings, gaskets, washers, receiver-dryers, expansion valves, and hoses. The system oil must also be changed, so a complete flush is required.

Amendment 23-49 and Subsequent

This amendment changed the 33,000 feet in paragraph (a) to 25,000 feet based on European Joint Aviation Requirements Proposals.

23.843 Pressurization tests

Original Issue and Subsequent

The corresponding rule in CAR 3 is CAR 3.396.

There is no corresponding rule in the Airship Design Criteria.

This rule applies to all doors. This includes doors that open outward, doors that open inward, and emergency exits.

The 1.5 safety factor in § 23.303 does not apply when executing the pressurization tests in this section. Paragraph (a) of the rule specifies the pressure differential of § 23.365(d), which is 1.33 times the maximum relief valve setting. Paragraph (b) requires functional testing to verify operation so there cannot be any gross plastic deformation from the 1.33 factor.

FIRE PROTECTION

23.851 Fire extinguishers

The corresponding rule in CAR 3 is CAR 3.388.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.39.

Amendment 23-34 and Subsequent

A proposed revision to NPRM 83-17 lists the source for Amendment 23-34 as SFAR 41, sections 7(d) and (e).

See AC 20-42C, "Hand Fire Extinguishers for Use in Aircraft," for guidance. European Aviation Safety Agency (EASA) AMC 23.851(c) accepts the above AC as an AMC pending research into Halon replacement.

Amendment 23-45 and Subsequent

A proposed revision to NPRM 90-18 explains this amendment as follows*: "This proposal extends the commuter category requirement for a hand fire extinguisher in the pilot compartment to all small airplane categories. Additionally, this proposal provides minimum acceptable standards for on-board hand fire extinguishers." "Besides this specific rule for fire extinguishers, there are other rules including § 23.561, Emergency Landing Conditions (extinguishers cannot be a missile in an emergency landing); § 23.303, Factor of safety; § 23.601, Design and Construction, General; § 23.603, Materials and workmanship; and § 23.613, Material strength properties and design values. You will need to contact an Aircraft Certification Office for an installation in a small airplane."*

23.853 Passenger and crew compartment interiors

The corresponding rule in CAR 3 is CAR 3.388.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.39.

Original Issue and Subsequent

See AC 23-2, “Flammability Tests.”

The purpose of this policy is for standardization in the approval of flammability testing of materials used in small airplanes per 14 CFR part 23, §§ 23.853, 23.855, and 23.1359.

The Small Airplane Directorate policy for all certification projects, including engineering assistance for major alterations on FAA Form 337, Field Approvals, is as follows:

a. The only materials for which flammability testing is not required are those that would not contribute significantly to the propagation of a fire per 14 CFR, part 23, § 23.853. These materials/parts are typically small parts. Material certification by an applicant or their supplier can be used in the determination that the material will not significantly contribute to the propagation of the fire. Company/supplier material certifications cannot be used in lieu of official FAA flammability testing.

b. All other proposed materials must be tested to the flammability level required by the certification basis and category of airplane. AC 23-2, “Flammability Tests,” gives guidance on conducting flash-resistant, flame-resistant, fire-resistant, fireproof, and self-extinguishing tests. The AC specifies that Appendix F of part 23 be used for proposed self-extinguishing materials. These are official FAA certification tests, which require witnessing by either an FAA certification engineer or an FAA Flammability DER who has authorization to witness a test. We will also accept from a DER submittal of an FAA Form 8110-3 that attests to the validity of the data being approved. This can occur when the people running the test are well known to the DER and judged by the DER to be technically competent and reliable. Test data may only be approved by the FAA or by a DER with that approval authority.

NOTE 15: DOT/FAA/CT-89/15” Aircraft Material Fire Test Handbook” is good reference material.

c. A DER should not use FAA Form 8110-3 for flammability test results for a material when the testing is for quality assurance purposes for either a manufacturer or a repair station. Testing done for these purposes should be documented in a quality assurance report. When the material supports a certification project or an alteration or repair, FAA Form 8110-3 is the DERs only means of approving the technical data. The DER should determine if the testing documented in the test report adequately addresses the applicable airworthiness standards for the intended use of the material. If found acceptable, the DER may generate an FAA Form 8110-3 that references the test report. For the purposes of flammability testing, this technical data includes records of preconditioning of the test specimen. The flammability testing required by the certification basis is as follows:

Passenger and Crew Compartment Interiors, § 23.853

Certification Basis	Category	Material Flammability Testing
CAR 3 (1945-1946) Effective November 13, 1945	Normal Restricted Experimental	Flame resistant if smoking allowed
CAR 3 (1946-1949) Effective December 15, 1946	Normal, Utility and Acrobatic	Flash resistant
CAR 3 (1949-1965) Effective November 1, 1949	Normal, Utility and Acrobatic	Flash resistant or flame resistant if smoking is allowed in a specific compartment
Part 23 Through Amendment 23-22 (1965-1978) Effective December 5, 1978	Normal, Utility and Acrobatic	Flame resistant
Part 23 (78-present) extinguishing Amendment 23-23 Subs located and Subsequent (1978-present) Effective December 1, 1978	Normal, Utility and Acrobatic	Flame resistant or self- per Appendix F for materials and on the cabin side of the firewall

Part 23 Amendment 23-34 and Subsequent (1987-present) Effective February 17, 1987	Commuter	Self-extinguishing per Appendix F except for small parts in § 23.853(d)(3)(v)

Cargo and Baggage Compartment Fire Protection, § 23.855

Part 23 Amendment 23-49 (1996-present) Effective March 11, 1996	Normal, Utility and Acrobatic	Meet provisions of § 23.853(d)(3)
Part 23 Amendment 23-49 (1996-present) Effective March 11, 1996	Commuter	Meet provisions of § 23.853(d)(3)

Electrical System Fire Protection, § 23.1359

Part 23 (96-present) Amendment 23-49 Effective March 11, 1996	Normal, Utility, Acrobatic and Commuter	Meet provisions of § 23.863 and § 23.1182 and wire insulation self extinguishing per Appendix F, 60-degree angle test

1. Per AC 23-2, cloth, wire and sheet specimens may be taken from a sample segment (batch/roll/sheet). In this case, FAA conformed test specimens/parts per 14 CFR, part 21, § 21.33, are not required. Instead, conformity can be established for these types of materials on the basis of bill of materials, roll identification, etc. The FAA Form 8110-3 should state it applies to the specific batch/roll/sheet for which the test was conducted.

NOTE 16: Wire specified in AC 43-13-1B, section 7, has been determined to be acceptable for use in certified airplanes and may be used without flammability testing.

2. In other cases, test specimens must be fabricated to accurately represent the production assembly or must be cut from actual parts. These parts should be conformed per 14 CFR, part 21, § 21.33, prior to testing.

3. In both 1 and 2 above, a DER must comply with Order 8110.37C, “Designated Engineering Representative Guidance Handbook.” While we understand that in the past some DERs have not always submitted FAA Forms 8110-3 with make and model information, FAA Forms 8110-3 must always be complete, including the make and model information.

d. Flammability requirements have not been applied to conventional aircraft structure. However, the use of composite structure can result in a need to test a representative build-up panel with an interior material, adhesive and composite structure, unless it is demonstrated the interior material does not permit an ignition source to penetrate it.

e. Interior flammability tests may be required with build-up samples. Experience has shown that the thin exposed layer can burn away and expose the adhesive layer, which in many cases is extremely flammable and would contribute significantly to the propagation of a fire. Testing only the exposed layer without the adhesive backing would not be representative. Adhesives with a flame-retardant additive should be encouraged and listed; known flammable adhesives should not be used.

f. We have reviewed the test criteria of part 25, Appendix F, part I, and have determined that parts/materials tested to the part 25 test criteria are acceptable data to show compliance with the flame-resistant material requirement of § 23.853(a).

Amendment 23-14 and Subsequent

Notice 71-13 explains this amendment level as follows: *"The proposal makes provision for illuminated signs in airplanes having separate compartments. Because of increased complexity of systems carrying flammable fluids, the regulations must provide protection."*

Amendment 23-23 and Subsequent

Requirements for materials on the cabin side of the firewall were added as a result of this amendment. The following explanation in NPRM 75-26 states: *"There have been instances where cabin upholstery has been ignited by engine fires even though the flame did not penetrate the firewall. This proposal would broaden Sec. 23.853 to require materials located on or adjacent to the cabin side of the firewall to be self-extinguishing or otherwise protected to prevent fire within the cabin due to engine fire."*

Amendment 23-25 and Subsequent

The proposed revision to NPRM 75-10 changed the "No Smoking" rules. The following explanation states: *"The purpose of this proposal and the similar proposals to Secs. 25.853(c), 27.853(c) and 29.853(c) is to update and make consistent the certification requirements necessary to permit smoking in aircraft."*

Amendment 23-34 and Subsequent

This change added requirements for commuter category airplanes. The explanation in NPRM 83-17 states the following: *"SFAR 41, Sec. 7(b) and (c), and Secs. 91.56 and 135.170 of the FAR."*

23.855 Cargo and baggage compartment fire protection

The corresponding rule in CAR 3 is CAR 3.392.

There is no corresponding rule in the Airship Design Criteria.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this rule as follows:

"Proposed paragraph (a) would require all sources of heat within each cargo and baggage compartment that are capable of igniting the compartment contents to be shielded and insulated to prevent such ignition.

Proposed paragraph (b) would require cargo and baggage compartments to be constructed of materials that meet the appropriate provisions of Sec. 23.853(d)(3). Currently these requirements apply to commuter category airplanes and to the materials used in the compartments of these airplanes. The proposed new requirement would expand this applicability to the cargo and baggage compartments of all part 23 airplanes. In effect, the proposed new requirement would require materials that are self-extinguishing rather than flame resistant as currently required under Sec. 23.787(d).

Proposed new paragraph (c) would add new fire protection requirements for cargo and baggage compartments for commuter category airplanes. The proposed rule would require on of the following alternatives: (1) Either the compartment must be located where pilots seated at their duty station would easily discover the fire or the compartment must be equipped with a smoke or fire detector system to warn the pilot's station. The compartment must also provide access to the compartment with a fire extinguisher. (2) The compartment may be inaccessible, but must be equipped with a fire detector system that warns the pilot station, and the compartment must have ceiling and sidewall floor panels constructed of materials that have been subjected to and meet the vertical self-extinguishing tests of Appendix F of this part. (3) The compartment must be constructed and sealed to contain any fire.

The proposed new section is necessary for several reasons. The proposals for additional requirements for commuter category airplane cargo and baggage compartments were developed after an examination of reported incidents of inflight fires and their causes. Although most of these incidents of inflight fires occurred on transport category airplanes, the reported sources of the fires showed that the fires originate from sources, such as matches in the pockets of clothing, that are as likely to be found on part 23 airplanes as on transport category airplanes. The same potential for inflight fires exists on commuter category airplanes and adequate protection should be provided."

See guidance for § 23.853.

All-Cargo or Combination Passenger/Cargo Operations

Special conditions will be required for airplanes approved for all-cargo or combination passenger/cargo operations because 14 CFR, part 23, does not have applicable airworthiness standards for these operations.

23.859 Combustion heater fire protection

The corresponding rule in CAR 3 is CAR 3.388.

There is no corresponding rule in the Airship Design Criteria.

Amendment 23-5 and Subsequent

A proposed revision to NPRM 65-43 explains this amendment as follows: *"Secs. 23.859, 25.859, 27,859, and 29,859 would be amended to clarify, without changing, the conditions under which the "means independent of the components provided for the normal continuous control of combustion heater air temperature, airflow, and fuel flow" must be provided. The intent of this requirement is to require independent means of control when any one of the listed conditions exists."*

Amendment 23-27 and Subsequent

This rule was changed with the following explanation in Docket 20052: *"The design complexity and operational altitude and weather capability of current Part 23 piston-powered airplanes may necessitate installation of combustion heaters for occupant survival and airplane heating to counteract windshield icing conditions. Part 25 presently contains updated type certification requirements for combustion heater fire protection that are applicable regardless of the size of airplane in which the heater is installed. Among these requirements are those for fireproof air ducts and protection of the ventilating airstream from backfire and reverse burning, as recommended by the NTSB for inclusion in Part 23. In addition, Part 25 designates fire zones, requires fire detection means, contains heater control requirements, sets forth air intake location standards, gives heater exhaust requirements, and provides for fuel system protection and drainage. These requirements constitute the necessary minimum safety standards for combustion heater fire protection for any high-performance airplane.*

Because of the increasing sophistication of normal category small airplanes and the expanded operating environment for which they are designed and used, the FAA has determined that more stringent type certification fire protection and detection standards are needed for combustion heaters when such heaters are installed in these airplanes. In view of the technical similarities between these airplanes and airplanes designed to Part 25 standards, the Part 25 standards for combustion heater fire protection are substantially adopted as type certification requirements for Part 23."

23.863 Flammable fluid fire protection

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.40.

Amendment 23-23 and Subsequent

Those areas where ignition sources and flammable fluids are present must be designated as flammable fluid zones, and measures must be taken to minimize the probability of ignition sources and leakage being present. This is followed by a means to minimize the effects once a fire has occurred by extinguishing, ventilation, isolation, drainage, etc. The rule does not go so far as to make the entire airplane a "designated fire zone."

Fire detection and extinguishing is believed to be impractical for many part 23 airplanes. Where fire detection and extinguishing means might be impractical, the back up provisions could, for example, consist of a means to limit fluid leakage and fireproofing or isolation of critical parts. Therefore, compliance with § 23.863 could be accomplished with a means to limit fluid leakage, minimizing the probability of ignition, fireproofing or isolating critical parts. Minimization of ignition requires that equipment where a single failure can cause flammable fluid leakage, be tested to the explosion proof standards in RTCA/DO-160.

If a finding is made that either flammable fluids or vapors cannot escape into an area containing a potential ignition source or if the fluids are nonflammable, this rule would not apply to that area. Design measures could support the finding such as: either (1) shrouding (sealing off) of all potential ignition sources, or (2) shrouding or sealing off of all flammable fluid/vapor sources. In either case, it should be ascertained that the means would continue to serve its function following any single failure of the system or component it is isolating from the area.

23.865 Fire protection of flight controls, engine mounts, and other flight structure

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.41.

Amendment 23-14 and Subsequent

A proposed revision to NPRM 71-13 explains this rule as follows: *"Experience has indicated the need to ensure that flight controls and flight structure in powerplant fire zones remains operable in the event of a fire. The proposal requires this."*

Amendment 23-45 and Subsequent

A proposed revision to NPRM 90-18 added "engine mounts" to the rule with the following explanation: *"This proposal clarifies existing Section 23.865 by excluding those portions of the engine mount certificated with the engine from this section. Additionally, a clarification is provided to address the allowable damage expected on engine isolators."*

The engine mounts refer to the aircraft structure for mounting the engine and not the mount pads or attachment points, which are integral parts of the engine.

The intent of the regulations regarding engine mounts is that the engine remains in place with a fire heating an engine mount. We do not intend to cover the case of a general conflagration where the entire engine compartment is burning. Therefore, an applicant should design sufficient load paths for the engine to remain in place with a localized fire.

For purposes of this rule, landing gears are not considered to be flight structures, so fireproofing or shielding landing gears are at the option of the manufacturer.

Shielding made from fireproof materials in part 23, § 23.1191(h), may be used without flame testing. While the shielding may be made of fireproof materials that do not require testing, means of installing the shielding such as sealers, adhesives, etc. should be shown not to reduce the efficacy of the shielding. Shielding materials subject to corrosion should be appropriately protected. Shielding need not be fireproof if it protects the enclosed structure to an extent equivalent to the enclosed structure being fireproof by itself.

The effectiveness of such shielding or fireproof materials should be determined by subjecting the shielded or fireproof structure, or control, to flammability testing as defined in AC 23-2, "Flammability Tests." Before removal of the flame at the end of the test, loads should be applied to the shielded structure or control to demonstrate that it can withstand the loads expected to occur during completion of the flight. These loads can be treated as ultimate loads. In the absence of a more rationale determination of the expected flight loads, a load factor of 70 percent of maneuver load or 40 percent of gust load superposed with the loads from the engine thrust and torque for maximum continuous power. After five minutes and until the end of 15 minutes the engine may be assumed to be shutdown.

Amendment 23-48 and Subsequent

Policy on compliance of 14 CFR, part 23, § 23.865 at Amendment 23-48 for Structures in Adjacent Areas Subjected to Effects of Fire in Designated Fire Zones

The revision of 14 CFR, part 23, § 23.865 at Amendment 23-48 includes:

- changing the words “engine compartment” to “designated fire zones” for consistency with §§ 23.1181 and 23.1203; and

- adding the phrases “adjacent areas that would be subjected to the effects of fire in the designated fire zones.”

The intent of this section in the rules is to require that the materials and components, in the designated fire zone, that are essential to flight safety be fabricated either from a material meeting the definition of fireproof under Title 14, part 1.1, or be shown to be capable of maintaining their integrity or performing their function under the conditions of fire at least as well as steel. The intent of this section is also to require that materials and components, in adjacent areas to a designated fire zone, that are essential to flight safety, be capable of maintaining their integrity or performing their function under the conditions of fire in the designated fire zone.

The fire condition characterized by a 2000-degree Fahrenheit (F) flame can be treated as a failure condition that should not prevent continued safe flight and landing for at least 15 minutes. The rule requires the structures (composite and metallic) behind the firewall and subjected to the heat effects of the fire be able to withstand the flight loads expected to occur during completion of the flight. It also requires these flight loads to not be less than the gust loads expected to be encountered during the completion of the flight. These loads can be treated as ultimate loads. Design features, including multiple load path arrangement, can be taken into account when establishing the remaining structural capacity. Freedom from flutter and whirl mode should also be demonstrated.

Compliance with the above requirement must be demonstrated by tests, or by analysis supported by tests. The assessment of heat effects needs to include all heat transfer mechanisms that may occur in the area of concern. For composite structure, the long-term environmental effects that may degrade the mechanical properties of the structures also need to be considered. These may include the effects due to moisture and steam pressure.

EASA AMC 23.865 is acceptable for FAA certification.

ELECTRICAL BONDING AND LIGHTNING PROTECTION

23.867 Electrical bonding and protection against lightning and static electricity

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.42.

Amendment 23-7 and Subsequent

A proposed revision to NPRM 67-14 explains this rule as follows: "*Small airplane operations involving potential exposure to lightning strikes are increasing. The hazardous effects of lightning on aircraft are well known. Economically practical means of protecting aircraft from such effects have been under study for several years. In order to prevent undue dictation of design, and yet, on the other hand, avoid an unnecessarily vague standard, this proposal summarizes the design objectives derived from the studies and experience obtained in the field of lightning protection of aircraft structures.*"

Lightning protection of Visual Flight Rules (VFR) airplanes was considered because there is a possibility that a lightning strike on a VFR airplane could occur. However, the probability and consequences of a VFR lightning strike are more pertinent than the possibility. The hundreds of millions of hours of service history on metallic airplanes illustrate neither a probability nor a consequence worthy of requiring the customer's assets be expended on lightning certification of this class of airplane. Therefore, this section is not applicable to VFR-only airplanes that have electrical-bonding characteristics commensurate with metallic construction.

<u>Protection of Composite Structure and Installed Equipment from the Direct and Indirect Effects of Lightning</u>

Unless VFR-only airplanes, per the preceding paragraph, an applicant should submit a certification test plan describing the analyses/testing to be used to demonstrate lightning protection effectiveness. At a minimum, the test plan should describe the sub-components, components, and systems to be tested and include the following:

a. Zone definition of the entire aircraft (show how this will be accomplished—strike attachment model tests, similar design, etc.).

b. Full scale or other acceptable means of simulated lightning qualification test on all flight critical portions of the airframe, flight controls, fuel, propulsion, electrical and avionics systems, including damage assessment procedures.

c. The indirect effect on the airplane and its systems after a direct lightning strike must also be evaluated. This will include both upset and damage assessment to the electrical and avionics systems.

d. Values for each phase of the protection should be delineated. This includes test procedures, test parameters, methodology, and simulation techniques to be used during the validation phase.

e. Grounding and bonding concerns are paramount in any aircraft but are more critical in composite structures. The test plan must address these areas and include life cycle environmental tests.

f. Lightning simulation methods including test voltages and current waveforms must be defined.

g. The test plan should address maintenance practices and repairs to the structure that ensure the continued lightning protection effectiveness.

<u>The following SAE documents are applicable:</u>

SAE ARP 5412, “Aircraft Lightning Environment and Related Test Waveforms”, November 1, 1999.

SAE ARP 5413, “Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning,” (being incorporated into an AC), May 14, 2002.

SAE ARP 5414, “Aircraft Lightning Zoning”, December 1, 1999.

SAE ARP 5415, “Users Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning”, May 14, 2002.

SAE ARP 5577, "Aircraft Lightning Direct Effects Certification”, September 30, 2002.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains the change in the title of § 23.867 as follows: *“This proposed revision would change the heading that precedes the section from "Lightning Evaluation" to "Electrical Bonding and Lightning Protection." It would also revise the section heading form "Lightning protection of structures" to "Electrical bonding and protection against lightning and static electricity." The proposed revisions more accurately clarify the content of the section.”*

MISCELLANEOUS

23.871 Leveling means

The corresponding rule in CAR 3 is CAR 3.401.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 4.50.

Amendment 23-7 and Subsequent

The original rule required “reference marks.”

This amendment has the following explanation in NPRM 67-14: *“any means, not just reference marks, are acceptable for leveling the airplane on the ground.”*

Subpart F—Equipment

GENERAL

23.1301 Function and installation

The corresponding rules in CAR 3 are CAR 3.651 and 3.652.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.1.

Original Issue and Subsequent

When performing TSO testing to RTCA/DO-160, sections 16 and 17, the sentence "After exposure, **DETERMINE COMPLIANCE WITH APPLICABLE EQUIPMENT PERFORMANCE STANDARDS"** is considered to refer to the appropriate section of the RTCA Minimum Operational Performance Standards (MOPS) that references DO-160.

For a test section of a MOPS that is titled "Normal Operating Conditions," the applicable equipment standards should be met while the test is being conducted. If the equipment experiences an interruption of operation as a result of the test, then the acceptability of the duration of the interruption will depend on the intended function of the equipment and must be justified.

Manual resets or pilot actions required to restore normal operation following any test must be explicitly permitted by the applicable TSO or MOPS. If the TSO or referenced MOPS does not specifically allow for a reset, then the equipment must continue to operate or resume normal operation without any pilot action.

Instruments and equipment installed to meet the requirements of 14 CFR, part 23, § 23.1303 and part 91, § 91.205 should meet the TSO requirements that are applicable for that instrument or equipment or equivalent requirements.

Amendment 23-7

A proposed revision to NPRM 67-14 explains this change as follows: *"This proposal would remove the unnecessary distinction between radio and other equipment that now exists in Sec. 23.1301 (a) (2) and (3), and extend the provisions of Sec. 23.1431 to all equipment, not only radio equipment. There is no basis for distinguishing between radio and other equipment so far as general functioning requirements are concerned. The other changes are intended to bring the sections in closer conformity with the corresponding sections in Part 25 through 29, without substantive change."*

Original Issue through Amendment 23-19

A system/equipment that is **neither** essential for safe operation **nor** required by airworthiness or operating rules may be approved if it is not a hazard in normal operation or when it malfunctions/fails. It does not have to perform its intended function.

Section 23.1301 requires that instruments be installed in accordance with prescribed limitations. Therefore, if an instrument manufacturer specifies any allowable installation requirements (i.e., panel slope for gyroscopic instruments), the installer should stay within the limitation(s).

Each piece of installed equipment must be either labeled as to its identification, function, operating limitations, or any combination. This applies to the manufacturer of the equipment not the installer. The installer is required to verify the intended function and make any placards or flight manual limitations per Subpart G that the installed equipment makes necessary.

See ACs 23-8B, "Flight Test Guide for Certification of Part 23 Airplanes; 20-67B, Airborne VHF Communications Equipment Installations;" and 20-41A, "Substitute Technical Standard Order (TSO) Aircraft Equipment."

Amendment 23-20 and Subsequent

All installed systems/equipment should perform their intended functions. For systems/equipment neither essential for safe operation nor required by airworthiness or operating rules, the manufacturer should define the intended functions that the FAA will verify as part of the certification project.

Section 23.1301 requires that instruments be installed in accordance with prescribed limitations. Therefore, if an instrument manufacturer specifies any allowable installation requirements (i.e., panel slope for gyroscopic instruments), the installer should stay within the limitation. We recommend that the slope be no more than 15 degrees. If applicants want a slope greater than 15 degrees, they should show conclusively by tests or analyses that the instrument will function properly when subjected to all expected airplane maneuvers.

Each piece of installed equipment must be either labeled as to its identification, function, operating limitations, or any combination. This applies to the manufacturer of the equipment not the installer. The installer is required to verify the intended function and make any placards or flight manual limitations per Subpart G that the installed equipment makes necessary.

There has been a trend to install equipment mainly navigation related such as moving maps, as non-required, “Not approved for primary navigation” or “Situation Awareness Only (SA-Only).” The basis for certification has been to perform its intended function and not present a hazard per this section. Instruments that aid situational awareness should be certified per the requirements in § 23.1309, functional hazard assessment. It is not acceptable to label an instrument as “SA-Only” and assume its failure in normal operation is acceptable. It is also unacceptable to place such an instrument in the primary field of view of the pilot. Based on history where pilots have tended to fly to known failed gyroscopic instruments, they cannot be expected to ignore an instrument in this position. Last, it is not acceptable to install an instrument as non-required and use its outputs as input data to required instruments.

Guidance for Required Instruments

The purpose of this guidance is to provide clarification on instrument and equipment requirements that are required by 14 CFR part 91, § 91.205 for part 23 airplanes.

Instruments and equipment installed to meet the requirements of § 91.205 should meet the TSO or equivalent requirements. TSO or equivalent requirements are an acceptable means of compliance for the instrument or equipment standards for installation in part 23 airplanes. The pertinent requirements in 14 CFR, part 23, for the basis of the above statement is as follows:

(1) Section 23.1301 Function and installation.

Each item of installed equipment must--

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

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

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

(d) Function properly when installed.

and

(2) Section 23.1525 Kinds of operation.

The kinds of operation authorized (e.g., VFR, Instrument Flight Rules (IFR), day or night) and the meteorological conditions (e.g., icing) to which the operation of the airplane is limited, or from which it is prohibited, must be established appropriate to the installed equipment.

Accuracy of the Magnetic Gyroscopically Stabilized Heading System

PURPOSE.

The purpose of this guidance is to provide information on accuracy of the magnetic gyroscopically stabilized heading system that can be displayed on a Horizontal Situation Indicator (HSI) installed in part 23 airplanes.

The operating rules such as 14 CFR, part 91, and 14 CFR, part 135, specify the minimum required equipment that must be installed based in part 23 airplanes for the type of operation, such as VFR or IFR. 14 CFR, part 91, § 91.205 requires for heading information; under VFR operation, a magnetic non-stabilized direction indicator (i.e. compass) is required and; in addition under IFR operation, a gyroscopically stabilized heading system is required.

The general airworthiness requirements in 14 CFR, part 23, § 23.1301 and § 23.1525, determine the flight instrument and equipment accuracy requirements for part 23 airplanes. Part 23 does not prescribe specific accuracy requirements for magnetic gyroscopically stabilized heading systems. Specific accuracy requirements for avionics may be found in TSOs and as acceptable means of compliance to § 23.1301 in ACs, notices, or policy statements/letters.

ACCURACY REQUIREMENTS:

Magnetic Non-Stabilized Direction Indicator. A magnetic non-stabilized direction indicator (compass) is required (reference § 23.1327) to have an accuracy of ±10 degrees or have a correction card, placard, or a back-up gyroscopic direction indication provided that indicator has an accuracy better than ±10 degrees. If the sole purpose of the gyroscopic direction indication is for backing up the magnetic non-stabilized direction indicator, then the accuracy of displayed headings can also be to ±10 degrees. However, if a gyroscopic direction indicator is installed to meet the IFR operating rules, then the installation requirements are defined by § 23.1301.

Magnetic Stabilized Gyroscopically Stabilized Direction Indicator. An installed final accuracy for a magnetic stabilized gyroscopically direction indicator of ±4 degrees on the ground or ±6 degrees in normal level flight on any heading would meet the requirements of 14 CFR, part 23, § 23.1301. This accuracy applies after compensation and should include cumulative errors in all combinations due to:

- the equipment itself,
- the current flow in any item of electrical equipment and its associated wiring,
- the movement of any component, (e.g. controls or undercarriage), and

- the proximity of any item of equipment containing magnetic material direction indicators.

COMPARATOR MONITOR

For systems installations that include two magnetic gyroscopically stabilized heading systems and a comparator that monitors the differences between the headings of the two systems, the comparator trip point set as follows would meet the requirements of 14 CFR, part 23, § 23.1301:

- six degrees in stabilized level flight.
- six degrees plus ½ of the bank angle; or
- 12 degrees with a bank angle greater than six degrees;
- The alert function can be disabled at a bank angle greater than 20 degrees.
- An alert is provided if the condition exceeds 60 seconds, but allow two minutes for a turn error as stated in the TSO.

It should be noted that the 6 degrees trip point during level flight actually permits a heading error of as much as 12 degrees. This would be comprised of one system at the six degrees in-flight tolerance limit while the other system, presumably with some sort of malfunction, could have an error of 12 degrees in the same direction before the comparator monitor alert is tripped.

BACKGROUND INFORMATION. ***The following background information is provided for additional information.***

EQUIPMENT REQUIREMENTS.

Instruments and equipment installed to meet the requirements of § 91.205 should meet either the TSO or equivalent requirements. Either the TSO or equivalent requirements are an acceptable means of compliance for either the instrument or equipment standards for installation in small airplanes. The pertinent requirements in 14 CFR, part 23, for the basis of the above statement is as follows:

Section 23.1301, Function and installation.
Each item of installed equipment must--
(a) Be of a kind and design appropriate to its intended function.
(b) Be labeled as to its identification, function, or operating limitations, or any applicable combination of these factors;
(c) Be installed according to limitations specified for that equipment; and
(d) Function properly when installed.

Section 23.1525, Kinds of operation.
The kinds of operation authorized (e.g., VFR, IFR, day or night) and the meteorological conditions (e.g., icing) to which the operation of the airplane is limited, or from which it is prohibited, must be established appropriate to the installed equipment.

VFR REQUIREMENTS.

A magnetic non-stabilized direction indicator is required equipment by § 23.1303 and also for VFR operation by § 91.205. The required accuracy for magnetic non-stabilized direction indicator is prescribed in § 23.1327 as ±10 degrees unless a correction card, placard, or gyroscopic direction indicator is used. If the sole purpose of the gyroscopic direction indication is for backing up the magnetic non-stabilized direction indicator, then the accuracy of displayed headings can also be to ±10 degrees. This should not be interpreted as the required accuracy for the gyroscopic direction indicator in general.

IFR REQUIREMENTS.

For IFR, a gyroscopic direction indication is required by § 91.205. The gyroscopic direction indicator should meet either the TSO-C5d or TSO-C6c, or equivalent. A direction instrument, magnetic (gyroscopically stabilized) should meet the minimum performance standard of TSO-C6d. As with most TSOs, TSO-C6d refers to SAE documents AS 8013 for the minimum performance standards. In this document, the standard in paragraph 4.4, Turn Error, is “Two minutes after resumption of straight and level flight the scale error resulting from coordinated turn of 180 degrees in one minute at a true airspeed of 180 Miles Per Hour (MPH) (289 km/h) shall be within two degrees.” During stabilized and under environmental conditions, the test requirement for the error tolerance is two degrees.

The TSO is an equipment minimum performance standard and not an installation standard. For the TSO qualification, the equipment is tested under extreme environmental conditions and they should be compatible for this airplane installation.

See AC 23-8B, “Flight Test Guide for Certification of Part 23 Airplanes," for additional guidance.

23.1303 Flight and navigation instruments

The corresponding rule in CAR 3 is CAR 3.655.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.2.

Original Issue and Subsequent

Altimeters

A servo-corrected altimeter may be installed as the required altimeter provided an electrical failure is apparent to the pilot and the altimeter meets the accuracy requirements of the standard pneumatic altimeter without electrical power. Or, a servo-driven or servo-corrected altimeter with insufficient accuracy may be installed with at least one pneumatic altimeter installed for use by the pilot. On aircraft requiring two pilots, instruments should be located in front of each pilot. Therefore, either the pneumatic or the electrical altimeter can be installed in either location. The desired level of safety could be achieved without a pneumatic altimeter if the electrical supply is ensured. The provision of a pneumatic altimeter is usually more practical than the design and installation of a suitably reliable electrical supply system.

Altimeters that employ a “Smiths Law” correction are acceptable provided they are identified by an appropriate part number, marked clearly for use only on the airplane on which they are calibrated, and information is available to the pilot to enable manual correction computations at airspeeds other than those used in designing the instrument correction.

Amendment 23-17 and Subsequent

A proposed revision to NPRM 75-10 explains this amendment as follows: *“The proposal would update Sec. 23.1303 to require a free air temperature indicator for turbine engine powered airplanes. The proposal would also update the section to provide for a speed warning device for turbine engine powered airplanes and certain other airplanes for which V_{MO}/M_{MO} and V_D/M_D have been established. The speed warning device proposal is similar to the requirement contained in Part 25 to the extent practicable for Part 23 airplanes. It should be noted that under the proposal turbopropeller powered airplanes would be required to have installed both a free air temperature indicator and speed warning device since service experience does not indicate any need to differentiate those airplanes from other turbine engine powered airplanes with respect to the need for such equipment.”*

See AC 23-8B, "Flight Test Guide for Certification of Part 23 Airplanes," for information on free air temperature instruments and speed warning devices required for turbine engine powered airplanes.

Altimeters

For installation of electronically powered altimeters, when the regulations were promulgated for the requirements of altimeter systems, only pneumatic altimeters were envisioned. The minimum level of safety established by the regulation was based on the reliability and failure modes of pneumatic altimeters.

a. Service history has shown numerous occurrences of complete loss of primary electrical power for both single-engine and multiengine airplanes. The complete loss of altimeter information from a failure of primary power could adversely affect the safe operation of the airplane and is considered an unsafe feature. An electrically powered altimeter installation should have a level of safety equivalent to a pneumatic altimeter installation, and it may be found acceptable if there is no unsafe feature or characteristic.

b. In assessing an electrically powered altimeter with pneumatic reversion capability, the means of providing continuous and usable altitude information should be considered upon a failure of the primary electrical power. An electrical powered altimeter may be acceptable under one of the following types of installation:

(1) An electrical powered altimeter with pneumatic reversion that provides a power failure warning as an integral part of the instruments display, and appropriate correction information is provided for the reversionary pneumatic mode.

(2) An electrical powered altimeter that is provided with an alternate power source independent of the electrical generating system. Adequate information should be provided to the pilot on the operating limitations and procedures when operating on the alternate power source.

(3) An electrical powered altimeter without a pneumatic reversionary mode may be installed at any pilots position provided a pneumatic altimeter is located on the instrument panel so that it is found to be usable from any pilots' flight position.

Radar Altimeters

Radar altitude is not required for part 23, so it could be installed as no-hazard if it is a stand-alone installation of a TSO-C67, "Radar Altimeter," with structural implications of the antenna considered, on a nonessential bus, with circuit protection, and separate annunciation from other aircraft warning systems. In this case, a field approval could be acceptable.

If it is tied in to an approved warning system, or if it is part of a required TAWS, or if it is part of a precision landing system (Cat II or Cat III), then a STC is required.

For TAWS, use AC 23-18 and TSO-C151.

For precision landing, use 14 CFR, part 91, Appendix A.

Guidance Regarding Latent Failures of Altimeters

Though “pilot error” seems likely as a primary cause in a Controlled Flight Into Terrain (CFIT) accident, we recognize that CFIT accidents are unfortunately common and a misleading, latent failure of an altimeter could impact other airplanes. Rulemaking to require monitoring of an encoding altimeter to activate a warning means for a failure is possible. Whether this is economically justified will have to be determined.

The following options would be useful in a single pilot, high workload situation such as a descent in instrument meteorological conditions. The Small Airplane Directorate <u>recommends</u> that applicants do one of the following when installing an altitude-encoding altimeter:

1. Install a monitor between another altitude source and the primary, encoded altimeter. If installed, a GPS source would be best. Another altimeter would also be acceptable. A warning would indicate a discrepancy and permit troubleshooting to determine which altitude source is failed, or

2. Install a non-encoding altimeter as primary with the encoding altimeter as secondary. This would allow for warnings from air traffic controllers about terrain clearance when primary system failures were undetected by cross checks, or

3. Install a TAWS.

TAWS Class A and B are required for turbine-powered airplanes configured with six or more passenger seats operating under parts 91 and 135 and all turbine-powered airplanes operating under part 121. (See AC 23-18 for more details). We plan to initiate a rulemaking project for item 1.

Long-Range Navigation-C System (LORAN-C)

See AC 20-121A, "Airworthiness Approval of Loran-C Navigation Systems for use in the U.S. National & Airspace System (NAS) and Alaska," for information on LORAN-C installations.

Global Positioning System (GPS)

See AC 20-138A, "Airworthiness Approval of Global Navigation Satellite System (GNSS) Equipment", December 22, 2003.

For GPS based navigation systems, the maximum allowable time to reestablish a valid navigation position is five seconds. This reacquisition period is considered normal operation; the navigation failure flag(s) or annunciation(s), therefore, should not be displayed and the equipment must not present misleading information to the flight crew.

Questions have arisen regarding the intent of paragraph (a)(3)(x) of TSO-C129 as it applies to approach qualified (Class A1) GPS receivers. The paragraph states in part that the databases would contain all Standard Instrument Departures (SIDs) and all Standard Terminal Arrival Routes (STARs). The initial intent was that these procedures be selectable by name and not require manual selection of all waypoints. The workload associated with manual selection of individual waypoints has been determined to be unacceptable for single pilot operation. There are two potential deviations to the original intent of the TSO that must be requested formally by the TSOA holder:

- If the SIDs are not stored and selectable by name, then a limitation must be placed in the AFMS stating that SIDs must be entered prior to departure.

- If all named waypoints of the STARs are stored individually in the database (not selectable as a procedure), then a limitation must be placed in the AFMS stating that GPS equipment is not approved for conducting STARs. This limitation may be removed as part of an installation approval for aircraft requiring more that one pilot crewmember.

Terrain Awareness Warning System (TAWS)

This guidance is in response to a request for clarification on follow-on installation field approval by the FSDO) for the TAWS, Class B, for part 23 airplanes. The questions regarded field approvals by the Airworthiness ASI approving an AFMS, or supplemental AFM. We have coordinated this guidance with the Continuous Airworthiness Maintenance Division, Flight Standards Service (AFS-300).

Flight Standards Information Bulletin for Airworthiness (FSAW) 02-03A, "Follow-On Approval of Class B Terrain Awareness and Warning Systems (TAWS)

(Amended)" was issued April 16, 2002. This bulletin explains the standards a Class B Terrain Awareness and Warning System (TAWS), also called an Enhanced Ground Proximity Warning System (EGPWS), and must meet to qualify for a follow-on field approval.

Policy for TAWS B Displays of Geometric Altitude Labeled Mean Sea Level (MSL)

The Small Airplane Directorate was recently informed that some ACOs have stopped certification projects of TAWS with electronic displays. The Small Airplane Directorate did not issue any policy, etc., to stop any installations of TAWS B in part 23 airplanes. This policy is intended to permit current and future installations of TAWS equipment, which is not only required for some part 23 airplanes, but also proven to enhance safety.

The Small Airplane Directorates position is that the TAWS B system with a display is a safety improvement over a warning only system in reducing CFIT accidents/incidents. The display provides two significant enhancements: 1) improved situational awareness, and 2) fewer altimeter errors (e.g., due to ground-pilot communication/interpretation errors, pilot setting errors, static source errors, static system failures, icing effects, pressure and temperature changes, non-standard pressure gradients, etc.) However, as the current universal standard, pilots must use their primary barometric based altimeter instrument for navigation within the NAS. Thus, the MSL label on the TAWS altitude display, without clarification of its geometrically calculated multi-sensor source, could be misleading due to customary pilot expectations of a barometric based altimeter source. Nonetheless, at this time there is no history of accidents or incidents from use of the MSL label on this geometric altitude.

Because this label has not been shown to be a safety hazard, the FAA cannot mandate a corrective Airworthiness Directive (AD) for previous installations. Therefore, because the need or nature of a future labeling change is still being debated within the FAA, and until such time that a change may be required, current and future installations in part 23 aircraft may continue to be approved. These installations will require agreed-to additions to airplane flight manuals and TAWS user guides as per the following paragraphs.

1. The AFM or AFMS will describe the following limitations of the TAWS altitude displayed:

The indication of MSL altitude on the upper left-hand corner of the terrain awareness display must not be used for navigation, especially for maintaining an ATC assigned altitude.

Navigation must not be predicated upon the use of the terrain awareness display. The terrain awareness display is intended to serve as a situational awareness tool only and may not provide the accuracy and/or fidelity on which to solely base terrain or obstacle avoidance maneuvering decisions.

2. The AFM or AFMS will describe the following normal procedures of the TAWS altitude displayed.

"The indication of MSL altitude is shown on the upper left hand comer of the Terrain Display. This altitude is the reference altitude for the display and the terrain awareness algorithm. This reference altitude is based on internally calculated Geometric Altitude and NOT corrected barometric altitude that must be used when navigating within the National Airspace System. Geometric Altitude is the height above mean sea level (MSL) derived from the GPS receiver, filtered by the vertical figure of merits from the same GPS and complemented by short-term variations in barometric altitude. It represents the aircraft's calculated true height above MSL and serves as the reference altitude for color-coding of the terrain display and the altitude input to the look-ahead algorithm. Because it is primarily comprised of GPS altitude, this reference altitude will often differ from cockpit displayed corrected barometric altitude. The geometric altitude is not to be used for navigation. It is presented to provide the crew with additional situational awareness of true height above sea level upon which terrain alerting and display is based. GPS altitude is an altitude above mean-sea-level and it is the geodetic height above the WGS-84 ellipsoid corrected by the geoid height in the GPS receiver itself. With Selective Availability turned off as currently, the accuracy is usually better than 75 feet and with Selective Availability turned on, short term accuracy is in the order of 400 feet, but the geometric altitude should be within 100 feet."

3. The TAWS manufacturers will provide the above information to all installations until or unless they develop a software change that will re-label geometric altitude something else such as "GPSA."

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 requires that the direction indicator be a non-stabilized magnetic compass based on the following explanation: "*This proposal would clarify the intent of the regulations for a magnetic nonstabilized direction indicator. The nonstablized magnetic direction indicator, which does not require power from the airplane's electrical systems, provides directional information to the pilot when all other directional navigation systems have failed due to loss of power. There have been contentions that a magnetic direction indicator with a remote magnetic sensor should be acceptable because only one magnetic direction indicator is required and it is more accurate for navigation.*

When the requirement for a magnetic direction indicator was promulgated, only a nonstabilized magnetic direction indicator (magnetic compass) was envisioned. Requirements in the operating rules for various kinds of operations are in addition to *these basic requirements for type certification. The minimum level of safety established by these regulations was based on the reliability and failure modes of the nonstabilized magnetic compass and its ability to provide continuous heading information due to its functional independency."*

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this amendment as follows: *"The lead in for Sec. 23.1303(a) would be revised to clarify that the instruments required by this section are the minimum ones required. Also, Sec. 23.1303(d) would add a requirement for those airplanes whose performance must be based on weight, altitude, and temperature to be equipped with a free air temperature indicator. A new sentence added to Sec. 23.1303(e)(2) would state that nuisance overspeed warnings should not occur at lower speeds where pilots might ignore the warning. A new paragraph (f) would propose requirements for attitude instruments that include a means for flightcrew members to adjust the reference symbol. Finally, it would add a new paragraph (g) to define certain specific instruments required for a commuter category airplane.*

The proposal for Sec. 23.1303(e)(2) was developed following a Joint Aviation Authority recommendation that the warning should not occur below the maximum operating limit speed (V_{MO}/M_{MO})/. To determine the effect that this recommended V_{MO}/M_{MO} limit would have on the design of overspeed warning devices, the FAA contacted several equipment manufactures. These manufacturers responded that it would be possible to establish a lower limit at V_{MO}/M_{MO}, but that the design changes needed to ensure that the warning occurred between the presently required upper limit and the recommended lower limit would be very expensive.

The FAA notes that no known safety problem justifies that cost of these design changes. However, the FAA is also aware that if warnings of any type occur when the pilots know that no particular problem exists, such warnings may become a nuisance. If warnings become a nuisance, a pilot may disregard a warning when the airplane is approaching a flight speed where an unsafe flight condition may occur. Regulatory action is therefore needed to ensure that the warning will occur within appropriate speed limits. Proposed Sec. 23.1303(e)(2) would require manufacturers to establish a lower speed limit so that nuisance overspeed warnings will not occur. The manufacturer would be required to show that this limit is appropriate for the airplane design but would not be required to set this lower limit at one specific speed, such as V_{MO}/M_{MO}, which would be costly to achieve.

A new Sec. 23.1303(f) is proposed because attitude instruments are available that provide a means accessible to the flightcrew members, for adjusting the reference symbol through ranges that could result in unsafe pitch angles in small airplanes. These instruments were developed for airplanes that use high pitch angles for *approved climb or descent gradients. By permitting these airplanes to use instruments that can be adjusted for these higher pitch angles, pilots are able to maintain the design gradients using an instrument that provides a normal indication at that pitch.*

If each attitude instruments are installed in small airplanes, pilots could adjust the reference symbol to ranges that could result in unsafe pitch angles. The recommendation showed that some instruments can be adjusted to result in pitch angles that are nearly the same as the pitch angle that many small airplanes achieve before stalling. To preclude potential cases of unwanted pitch adjustments of attitude instruments installed in small airplanes, Sec. 23.1303(f) proposes to limit the adjustment range to that limit that is needed for parallax correction.

Proposed new Sec. 23.1303(g) would identify specific instruments, and limits of those instruments, required for commuter category airplanes. When the JAA initiated their consideration of commuter category airplanes, one of the proposals they received recommended adding the instrument requirements of Sec. 25.1303 to part 23 for commuter category airplanes. In considering this recommendation, a review of the requirements showed that many instruments required under Sec. 25.1303 are presently required by the operating rules. In addition, Sec. 23.1583(h) requires a list of the equipment that must be installed for the kinds of operation for which the airplane is approved. Based on the review, it was determined that many of the requirements in Sec. 25.1303 would be redundant, and the recommendation was not accepted.

In considering a portion of the recommendation to require a third attitude instrument, the FAA noted that Sec. 91.531(a)(3) requires a commuter category airplane of ten or more passengers to be operated with a second-in-command and that Sec. 23.1321 requires flight and navigation instruments for such required pilot. Accordingly, two attitude instruments are required for a ten passenger, IFR approved commuter category airplane. Service experience has shown that failures of an attitude instrument system can occur where there will be a time period in which the indicator appears to be working but is providing incorrect information. During such a failure of one instrument in an airplane equipped with only two instruments, the pilots may have difficulty determining which instrument to follow, and hazardous flight attitudes may result. A third attitude instrument would allow the crew to retain reliable attitude information at all times, and thus the proposed rule would require a third attitude instrument for commuter airplanes operated by two pilots."

23.1305 Powerplant instruments

The corresponding rules in CAR 3 are CAR 3.655 and 3.675.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.3.

Original Issue and Subsequent

a. Fuel Pressure Indication

Paragraph (b)(4)(ii) of § 23.1305 requires fuel pressure indicators for pump-fed engines. An ELOS finding can be made for a warning (red per § 23.1322) light set to operate when the primary pump fails and the emergency pump must be manually activated. A caution (amber per § 23.1322) light is acceptable for an automatic switchover to the emergency fuel pressure pump. Also, a fuel flow indicator can be used to indicate the primary pump is operating normally if there is either a placard or AFM to advise the pilot on how to determine primary pump condition from fuel flow information.

b. Powerplant Instrument Marking

See AC 20-88A, "Guidelines on the Marking of Aircraft." In consideration of the policy in item 6d of AC 20-88A, where the rate of change is small or nearly steady state (i.e., cylinder head temperature, exhaust gas temperature, or turbocharger inlet temperature), reciprocating engine parameter instruments may use direct reading digital (alphanumeric) instrument displays with ancillary displays such as warning lights. These ancillary light displays should include amber lights for takeoff/cautionary ranges and red lights for appropriate limits. Placards containing operating range and limitation information should also be included.

c. Fuel Flowmeters

This guidance is applicable to the installation of fuel flowmeters in small airplanes with continuous-flow, fuel injection, and reciprocating engines.

1. RELATED REGULATIONS

These acceptable means of compliance refer to certain provisions of part 23 and the corresponding provisions of the former part 3 of the CAR in the case of airplanes for which those regulations are applicable. Listed below are the applicable part 23 sections with the related CAR sections shown in parentheses:

Part 23 Sections

§ 23.773	(3.382)
§ 23.955	(3.433)
§ 23.961	(3.438)
§ 23.991	(3.449)
§ 23.993	(3.550)
§ 23.1183	(3.638)
§ 23.1191	(3.624)
§ 23.1305	(3.655)
§ 23.1337	(3.673)
§ 23.1529	
§ 23.1541	(3.755)
§ 23.1543	(3.756)
§ 23.1549	(3.759)

2. BACKGROUND

a. Recently there has been a trend toward replacing fuel pressure indicators and analog reading fuel flowmeters with digital fuel flowmeters/fuel totalizers. New developments in microprocessor technology have resulted in digital fuel flow computer systems that are economical, accurate, and that provide data for improved fuel management. These digital fuel flow computer systems also have features for displaying total fuel consumed, total fuel remaining, and time remaining; however, the accuracy of these readings is dependent upon the initial fuel supply entered into the fuel computer. The precise digital readings that are displayed to the nearest tenth of a gallon could give a pilot a false sense of accuracy and security, especially the readings for total fuel remaining and time remaining.

b. Digital fuel flowmeters are not a required powerplant instrument except for turbine engine airplanes with an Amendment 23-43 certification basis. They are optional equipment and should not be considered replacements for fuel quantity or fuel pressure indicators. Different interpretations of the regulations have caused conflict and lack of national standardization on installation of fuel pressure indicators and fuel flowmeters/fuel totalizers in small airplanes that have continuous-flow, fuel-injection systems in reciprocating engines. Inquiries from members of the aviation community and manufacturers have indicated a need for information concerning approval and installation of digital fuel flowmeters/fuel totalizers. The location of the fuel flow transducer in the fuel system is critical for measuring the total fuel flow consumed by the engine and maintaining engine performance. Each type of installation has an impact on the operation of the fuel system and needs to be evaluated and approved.

3. DISCUSSION

a. Fuel Pressure and Fuel Quantity Indicator

(1) A fuel pressure indicator is required for pump-fed engines in accordance with § 23.1305(g). It is intended to monitor metered fuel pressure at the inlet to the injector and to advise the pilot of a fuel pressure deficiency. Many small airplanes with reciprocating, continuous-flow, fuel-injection engines are equipped with fuel pressure indicators that actually measure metered fuel pressure. Metered fuel pressure in a fuel-injection system also relates to fuel flow, and can provide a satisfactory method for displaying fuel flow. However, replacing the metered fuel pressure indicators with fuel flowmeters could cause an unsafe condition by failing to provide critical fuel pressure information to the pilot that is especially important during the takeoff phase of flight. Fuel flowmeters are not required powerplant instruments for reciprocating engines to meet airworthiness standards of part 3 of the CAR or part 23.

(2) Digital fuel flow computer systems have a fuel flow transducer that directly measures the amount of fuel being fed to the engine. The fuel flow transducer may be a small paddle wheel, an impeller, or spring-loaded movable vanes. Digital displays with a fuel computer also permit these instruments to display total fuel consumed, total fuel remaining, and time remaining at the present fuel flow rate for fuel management. Overall accuracy for fuel remaining and time remaining readings depends on the transducer processing unit and display. The largest possible error is the initial fuel supply, which is entered by the pilot at the start of each flight. Errors in the initial fuel supply may be caused by an uneven ramp, unusual loading, volume changes of the fuel due to temperature variations, malfunctions in the fuel system such as leaks, siphoning actions, collapsed bladders, and other factors. Consequently, total fuel remaining should be verified with the fuel quantity indicator. In accordance with § 23.1337(b)(1), fuel quantity indicators are required to be calibrated to read "zero" during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply. For this reason, fuel quantity indicators should be used as the primary fuel-remaining instruments. Fuel quantity indicators that are inaccurate should be periodically calibrated, repaired, or replaced, as necessary, to ensure reliable readings.

b. Fuel-Injection Systems

Fuel-injection systems have been designed for many types of reciprocating engines, and they vary in details of construction, arrangement, and operation. Only continuous-flow, fuel injection systems for reciprocating engines will be discussed in either the speed-sensing pressure pump or constant-pressure pump categories.

(1) Fuel Injection System with Integral Speed-Sensing Pressure Pump

(a) A fuel injection system with an integral speed-sensing pressure pump delivers fuel at a pressure proportional to engine speed, and the pump is approved as part of the engine type design during the engine certification process. The fuel-injection system has fuel lift capability that enables the system to function with a negative inlet pressure within specific limits as indicated by the engine type data sheet. An emergency fuel pump is not required when the fuel injection pump is approved as part of the engine in accordance with § 23.991(b). The airframe manufacturers may provide an auxiliary fuel pump located upstream of the fuel-injector pump for priming the engine and suppressing fuel vapors. This auxiliary fuel pump can provide some fuel during emergency operations but may not sustain engine operation at full power in the event the engine-driven, fuel-injector pump fails; therefore, it is not considered an emergency fuel pump.

(b) If the fuel system in the airplane can meet the fuel flow requirements of § 23.955(c) at the minimum allowable inlet pressure limits without the need of an external pump, a fuel pressure indicator is not required. Nonetheless, some manufacturers have installed a fuel pressure indicator that senses metered fuel pressure at the fuel distribution valve. Since metered fuel pressure is related to fuel flow, it can provide a means for displaying fuel flow. A pressure indicator that is measuring metered fuel pressure may have the scale marked in terms of fuel pressure, fuel flow, or percentage of engine power. With these fuel flow markings, the indicator sometimes is referred to as an analog pressure-type flowmeter. If an analog pressure-type flowmeter is installed as part of the airplane manufacturer's TC, a replacement digital or analog fuel flowmeter/fuel totalizer is acceptable, provided the installation meets the applicable airworthiness requirements mentioned in the acceptable means of compliance.

(2) Fuel Injection System with Constant Pressure Pump

(a) A fuel injection system with constant discharge pressure during normal flight-engine-revolutions usually requires that fuel be supplied at a positive pressure within specified limits to the fuel-injector inlet. To provide this inlet pressure, the engine-driven fuel pump and the emergency pump are usually installed by the airplane manufacturer. An emergency fuel pump is required by § 23.991(b), and this pump should meet the fuel flow rate of

§ 23.955; therefore, it will sustain engine operation if the engine-driven fuel pump fails.

(b) A fuel pressure indicator is required for pump-fed engines in accordance with § 23.1305(g) and is intended for monitoring unmetered fuel pressure at the inlet to the injector. The fuel pressure indicator provides a means for the pilot to determine if the fuel pressure is within safe limits for proper operation.

(c) Several airplanes have been approved with a fuel pressure indicator connected to the fuel distribution valve where the fuel flow is a function of metered fuel pressure to the discharge nozzle. Metered fuel pressure is related to fuel flow and also relates to engine power output. In some applications, metered fuel pressure has been found acceptable for monitoring fuel pressure and controlling engine performance. The scale on the pressure indicator is to be marked in fuel pressure; in addition, it may be marked in either fuel flow or percentage of engine power output. A fuel pressure indicator at the inlet to the injector provides a more positive means of monitoring the operation of the engine-driven fuel pump and the emergency fuel pump.

(d) An airplane that has both a separate unmetered fuel pressure indicator and an analog pressure-type flowmeter may have the analog pressure-type fuel flowmeter replaced with a digital fuel flowmeter/fuel totalizer. If only an analog pressure-type fuel flowmeter is installed that actually operates from metered fuel pressure, the analog pressure-type fuel flowmeter may not be replaced with a digital fuel flowmeter/fuel totalizer unless another fuel pressure indicator is installed to sense the fuel pressure at the fuel-injector inlet. Or, the analog pressure-type fuel flowmeter may be replaced with a digital fuel flowmeter/fuel totalizer if an ELOS for the airplane shows that replacing the fuel pressure indicator with a flowmeter will still meet the applicable airworthiness requirement. A finding of ELOS should substantiate that the instrumentation provided by the fuel flowmeter is satisfactory, reliable, and safe under all reasonably foreseeable operating conditions.

4. ACCEPTABLE MEANS OF COMPLIANCE

An acceptable method of compliance with the airworthiness standards for installation of fuel flowmeters in small airplanes with continuous-flow, fuel-injection system, reciprocating engine is described below.

a. **FAA Approval of Technical Data/Installation**. Installation of the fuel flowmeter/fuel totalizer may be approved through TC or STC for either the airframe or the engine. FAA approval is obtained after the applicant shows that the fuel flowmeter/fuel totalizer will perform its intended functions and ensures that no unsafe features are incorporated. The need for certification approval for the engine will be determined for each particular installation. Certification approval for the engine is not required when the applicant provides FAA approved data that shows an alternate configuration that permits a digital flowmeter with specific instructions. An improper installation not only will jeopardize the safety of the present designs, but could also increase the probability of system failure. Installations should comply with the airworthiness regulations and with the manufacturers installation criteria.

b. Airworthiness Considerations

(1) Fuel Injection System with Integral Speed Sensing Pressure Pump

Installation of a digital or analog fuel flowmeter may replace the analog pressure-type flowmeter.

(2) Fuel Injection System with a Constant Pressure Pump

Installation of a digital or analog fuel flowmeter may replace the analog pressure-type flowmeter, provided an unmetered fuel pressure indicator is installed or it has been determined that replacing the fuel pressure indicator with a fuel flowmeter constitutes an ELOS.

(3) General Considerations

Changes to the fuel systems should be evaluated for fuel flow rates, maximum allowable pressure drop, hot weather operations, vibration and loads on lines and fittings, fire protection, and powerplant instruments, including effects of glare and reflections on instruments in the pilot compartment. An engineering analysis should be made to assure good engineering practices are incorporated in the design and that the installation is in accordance with airworthiness standards of the following §§ 23.773, 23.955, 23.961, 23.993, 23.1183, 23.1191, 23.1301, 23.1309, 23.1337, and 23.1529 of part 23. The fire-resistant capability of fuel system components in the engine compartment should be evaluated. The extent and nature of ground and flight evaluations depend upon each particular installation.

c. Evaluation

Modification of the approved fuel system may have major effects; therefore, an evaluation should be conducted to substantiate continued compliance of the fuel system with airworthiness requirements. FAA approval is issued when all airworthiness requirements are met. The following items should be considered:

(1) Fuel flow transducer should measure the total fuel flow under all operating conditions with either the engine-driven or the emergency fuel pumps. Some fuel systems provide an alternate fuel flow path under different operating conditions; for this reason, the fuel flow transducer should be installed upstream of the alternate fuel flow path.

(2) Fuel flow transducer should be installed downstream of any bypasses or vent returns to the fuel system.

(3) Maximum fuel pressure drop across the fuel flow transducer (normal and blocked conditions) should be within manufacturer's specifications and airworthiness requirements. Fuel pressure drop may affect the minimum fuel injector inlet pressure. The minimum fuel injector fuel inlet pressure may require redefinition, and the instrument range markings on the fuel pressure indicator may need to be revised. An engine-driven pump and emergency or boost pump may require adjustment to a higher pressure to account for the added restriction of the transducer. The pumps should be tested to ascertain their capability to supply the required fuel flow rate at the higher pressure. Flight tests for turbocharged engines may be required to determine that the minimum fuel injector inlet pressure meets the engine TCDS at the maximum approved altitude.

d. Markings and Placards for Powerplant Instruments

AC 20-88A provides guidelines on markings of airplane powerplant instruments. Sections 23.1541, 23.1543 and 23.1549 of part 23 provide the airworthiness requirements for instrument markings and placards. Either the required range marking or placards, or both, should be furnished with the safe operating limits. A placard should be located near the fuel flowmeter/fuel totalizer display with the following statement: “Original equipment fuel quantity indicator is the primary reading of fuel on board the airplane.”

e. Airplane Flight Manual (AFM)

Either a FMS or AFMS, or placards, if appropriate, should be prepared by the applicant. The information should be presented for FAA approval in the following sections:

(1) Limitation section should include placard information and instrument markings.

(2) Normal procedure section should include information on the operation and function of the equipment. Included in this section should be information that the fuel totalizer does not sense the quantity of fuel in the tank and it should not be used as a fuel quantity indicator. The accuracy of total fuel remaining displayed on the fuel flowmeter/fuel totalizer is dependent upon the initial fuel supply programmed into the computer before the start of each flight. Uncertainties about initial fuel supply and total fuel remaining can be due to an uneven ramp, unusual loading, volume changes of the fuel due to temperature variations, malfunctions such as leaks, siphoning action, collapsed bladder, and other factors; therefore, the total fuel remaining should be verified with the fuel quantity indicator. Before flight, it is essential that the pilot determine that the fuel programmed into the computer is the same as the usable fuel on board the airplane.

(3) The emergency procedure section should include any system malfunction that may occur due to electrical power failure and the procedures for verifying proper operation after power outages.

(4) If the certification basis does not require an AFM with the airplane, the applicant may provide a supplemental AFM or provide the necessary information to the pilot by means of placards.

Amendment 23-7 and Subsequent

A proposed revision to NPRM 67-14 explains this amendment that added turbine engine requirements as follows: *"The powerplant instruments in present Sec. 23.1305 are not appropriate for turbine engine powered airplanes. The instruments in this proposal are those that experience has shown to be necessary for the safe operation of those airplanes."*

Changes to the NPRM explain Final Rule, Docket 8083 as follows: *"The notice proposed to amend Sec. 23.1305 to require specified powerplant instruments for turbine engine powered aircraft. One comment objected to the requirement for a propeller blade angle sensor. However, the FAA considers that the reliability of direct sensing is essential, considering the critical nature of an unwanted travel of the blade below the flight low pitch position. In response to another comment, the FAA has withdrawn the proposed requirement for a reverse-blade angle sensor. The FAA is aware that such a sensor is not currently practical. The proposed requirement for firewarning indicator is also withdrawn consistent with the withdrawal of proposed new Sec. 23.1203. The notice also proposed to add a new Sec. 23.1307(c) to require, for turbosupercharger installations, specific instruments to allow monitoring of these installations. In response to a comment received, the proposed amendment has been* *changed to require these instruments only if limitations are established for either carburetor air inlet temperature or exhaust gas temperature and those limitations can be exceeded in operation, and the amendment has been adopted as Sec. 23.1305(p). In addition, the cylinder head temperature indicator requirements of present Sec. 23.1337(e) are transferred to new Sec. 23.1305(f) inasmuch as it is a required instrument and should properly be included with the other required powerplant instruments. No substantive change is intended. In addition, the proposal concerning thrust indicators has been changed to specify the equivalent means, and the reference to an equivalent to a torque indicator has been deleted since there is no equivalent, and the purpose of the tachometer for turbine engines has been specified. Finally, the format of present Sec. 23.1305 has been changed to simply list the required instruments inasmuch as the requirement for each instrument is now set forth as to each instrument."*

1. Digital (Alphanumeric) Instruments

See AC 23.1311-1A for guidance on this topic.

2. Torque Meter Markings

Markings on torque meters should be as follows:

a. The maximum safe operating torque should be indicated by a red radial.

b. The green arc should extend across the complete normal operating range.

c. Takeoff torque can be indicated by the word "Takeoff" or the letters "T.O." arranged as a radial with an explanation of their significance in the AFM.

3. Warning Means Instead of Indicators

Warning means for § 23.1305: oil quantity measuring device, powerplant ice protection indicating means, fuel system anti-ice indicating means, thrust reverser indicating means, and propeller blade angle indicating means, can be acceptable as an ELOS.

4. Fuel Strainer or Filter Indicators

Acceptable means of compliance for fuel strainers or filter indicators for turbine-engine airplanes are as follows:

a. A fuel filter approved under 14 CFR, part 33, § 33.67, Amendment 33-6, installed within the engine upstream of the high-pressure engine-driven positive displacement pump or the fuel metering device will comply with the provisions of § 23.997 without an airframe supplied filter. The fuel filter should be capable of sustained operation while operating with water in the fuel as specified in §§ 23.991(c) or 33.67(b)(4). An engine-driven, low-pressure fuel pump may be installed upstream of the fuel filter. If an airframe-mounted filter is not installed, care should be taken to assure there are no undrainable low spots between the fuel tank outlet and the inlet to the engine.

b. A fuel strainer approved under § 33.67, Amendment 33-6, would not require an indicator in the cockpit to indicate the occurrence of contamination before it reaches the capacity of the fuel strainer, as required by § 23.1305(c)(8). However, an indicator on the engine should be installed such that it can be readily inspected for operation prior to flight. Instructions for this inspection should be included in the preflight check procedures in the AFM.

c. Turbine engine installations that do not have a fuel filter per § 33.67 should have an airframe mounted fuel strainer to comply with § 23.997. Also, an indicator for contamination before it reaches the capacity of the fuel strainer, as required by § 23.1305(c)(8), should be provided. A pop-out button on the filter is not acceptable for compliance to § 23.1305(c)(8), because the rule requires an indicator, which is a cockpit-mounted indication.

For reciprocating engines, the fuel strainer should comply with all the requirements of § 23.997.

See AC 23.1311-1A for guidance on electronic displays of propulsion parameters.

Diesel engines were not considered when this rule was written. For policy regarding diesel engine installations in small airplanes, see PS-ACE100-2002-004, Final Policy Statement; "Diesel Engine Installation."

Amendment 23-14 and Subsequent

A proposed revision to NPRM 71-13 added requirements for an oil pressure warning means for each turbine engine and an induction system air temperature indicator for each engine equipped with a preheater and having induction air temperature limitations which can be exceeded with preheat. No explanation was given. Amendment 23-14 is explained by Final Rule, Docket 11011, as follows: *"Proposed Sec. 23.1305 (a), now Sec. 23.1305(q), has been revised to clarify that the only oil pressure warning means required is for low oil pressure."*

Amendment 23-15 and Subsequent

This amendment added these instruments:

(q) For each turbine engine, an indicator to indicate the functioning of the powerplant ice protection system.

(r) For each turbine engine, an indicator for each fuel strainer or filter to indicate the degree of contamination of the strainer or filter to the degree established as an operating limitation for the engine.

(s) For each turbine engine, a warning means for each oil strainer or filter that has no bypass, to warn the pilot of the occurrence of contamination of the strainer or filter before attainment of contamination of the degree established as an operating limitation for the engine.

(t) An indicator to indicate the functioning of any heater used to prevent ice clogging of fuel system components.

A proposed revision to NPRM 71-12 explains Amendment 23-15 as follows: *"The provisions of paragraph (q) would be transferred from present Sec. 23.1093. The indicator and the means proposed in paragraphs (r) and (s) are necessary to implement the requirements of proposed Secs. 23.997 and 23.1019, respectively. The indicator proposed in paragraph (t) is necessary in the event that a mechanical means, such as a fuel heater, is used in the airplane to heat the fuel as it passes through a filter or screen in the fuel system. Such an indicator could be used in meeting the requirements of proposed Sec. 23.951."*

Amendment 23-15 is further explained by Final Rule, Docket 11010 as follows: *"As a result of the issuance of Amendment 23-14 (38 FR 31816), which contains new paragraphs, Sec. 23.1305(q) and (r), the proposed paragraphs (q), (r), (s), and (t) are redesignated (s), (t), (u), and (v), respectively. The following discussion is keyed to the new designations.*

One commentator questioned whether the fuel strainer or filter indicator referred to in Sec. 23.1305(t) were required on all filters, even "last chance" filters. Consistent with the requirements applicable to the strainers or filters themselves, Sec. 23.1305(t) has been revised to make clear that the indicator required is for a fuel strainer or filter required under Sec. 23.997. Similarly, Sec. 23.1305(t) and (u) have been reworded in order to be consistent with Secs. 23.997 and 23.1019, respectively, in regard to the degree of contamination that must be indicated. In response to a further comment, Sec. 23.1305(t) has been reworded to clarify that the desired indication is of the occurrence of contamination rather than the more stringent requirements of the degree of contamination as suggested in the notice. This change achieves consistency between paragraphs (t) and (u).

One commentator questioned whether other presently installed gauges for other functions could be used as "indicators" to indicate the functioning of a heater as required in paragraph (v). As discussed above, in connection with the indicators required for oil strainers or filters, the FAA anticipates that the requirement will be met by installation of gauges to indicate the functioning of heaters. However, if a clear and positive indication can be obtained from other gauges used to portray *functions different than direct heater functioning, the requirements of the section are met."*

Amendment 23-18

A proposed revision to this amendment added a requirement for a fire-warning indicator for those airplanes required to comply with § 23.1203.

Amendment 23-26

A proposed revision to NPRM 75-31explains this amendment as follows*: "The proposal would permit up to an eight-degree movement of the propeller blade below the flight low pitch position before an indication of the movement is required for the flight crew. This would be consistent with the corresponding requirements in Part 25 and with the proposal to revise Sec. 35.23. The FAA does not believe it necessary to require immediate indication when the propeller blade moves past the flight low pitch stop."*

Amendment 23-34

A proposed revision to NPRM 83-17 added the following instruments:

(f) A cylinder head temperature indicator for -
(1) Each air-cooled engine with cowl flaps, and for each airplane for which compliance with Sec. 23.1041 is shown at a speed higher than V_Y; and
(2) Each reciprocating engine-powered commuter category airplane.

(h) A manifold pressure indicator for -
(1) Each altitude engine; and
(2) Each reciprocating engine-powered commuter category airplane.

(k) A fuel flowmeter for -
(1) Each turbine engine or fuel tank, if pilot action is required to maintain fuel flow within limits; and
(2) Each turbine-powered commuter category airplane.

"The source for this change was: part 135, Appendix A., § 58."

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 changed Amendment 23-43 as follows: *"This proposal clarifies the powerplant instrument requirements by separating the reciprocating engine, turbine engine, turbojet/turbofan, and turbopropeller requirements; and adding requirements for coolant temperature indicator, fuel low-level warning, manifold pressure indicator, and chip detector indicator."*

This amendment was added by Final Rule, Docket 26344 as follows: "This proposes to amend Sec. 23.1305 to clarify the powerplant instrument requirements by reorganizing the section and by defining the additional instruments that are required for the particular type of engine that is installed. Two commenters submitted comments on various paragraphs of this proposal.

One commenter suggests that the proposal for Sec. 23.1305(a)(1) cross-reference Sec. 23.1337(b)(5). The FAA does not agree that the suggested Sec. 23.1337(b)(5) is the proper reference but does agree with the intent of this suggestion. In reviewing this comment, it is noted that the intent of the words, "or for each assembly of interconnected tanks that function as one tank" in proposed Sec. 23.1305(a)(1) is provided by current Sec. 23.1337(b)(4), and that other provisions of Sec. 23.1337(b) address other applicable fuel quantity indicator requirements, such as their marking. To clarify the fuel quantity indicator requirement of part 23, the above quoted words from the proposal for Sec. 23.1305(a)(1) are removed and replaced by the words "installed in accordance with Sec. 23.1337(b). By this change, Sec. 23.1305 will make it clear that a fuel indicator is required for each tank and Sec. 23.1337 will provide the installation requirements for those indicators.

Both commenters requested that the FAA make it clear that a dipstick is an acceptable oil quantity measuring device for meeting the requirement of proposed Sec. 23.1305(a)(4). The FAA notes that Sec. 23.1337(d) identifies an acceptable means of measuring the oil quantity and identifies a stick gauge as being one acceptable means. To provide the clarification requested by these commenters, the proposal for Sec. 23.1305(a)(4) is revised by adding the words, "which meets the requirements of Sec. 23.1337(d)" to the end of the proposal.

One commenter asks the FAA to make it clear that N_1 is an acceptable parameter that can be related to the thrust indication required by proposed Sec. 23.1305(d)(1). The FAA has reviewed this request and finds that the indication of the N_1 speed is an acceptable means. For some installations, however, the applicant may be required to demonstrate that N_1 is acceptable. By the discussion of this comment, the requested clarification is provided and proposed Sec. 23.1305(d)(1) is not revised."

Amendment 23-51 and Subsequent

Amendment 23-51 was changed by a revision to NPRM 94-19 as follows: "The proposed revision to paragraph (b)(3) would delete paragraph (b)(3)(ii) which refers to compliance with Sec. 23.1041."

Amendment 23-52 and Subsequent

A proposed revision to NPRM 94-37 explains this amendment as follows: *"The intent of the fuel pressure indicator requirement for pump-fed engines is to advise the pilot of a fuel pressure deficiency before total engine failure. The term "indicator" in Sec. 23.1305 (b)(4) implies that the fuel pressure be constantly displayed.*

The proposal would change the current requirements in that a fuel pressure indicator or a fuel flow indicator would be acceptable. The fuel flow indicator would constantly display information that the pilot could use to evaluate engine power, fuel mixture, and other engine performance factors. Furthermore, it is technologically possible to have a microprocessor that monitors engine operation and triggers a warning if the fuel system operation does not match the other monitored engine trends. Therefore, this proposal would also change the rule to accept a means that monitors the fuel system and warns the pilot of any trend that could lead to engine failure.

Accordingly, this proposal would adopt a performance standard, instead of a requirement for specific equipment. In this way, the designer could show compliance with paragraph (b) of the proposed by developing any design that monitors the fuel system and warns the pilot of any trend that could lead to engine failure. The Aviation Rulemaking Advisory Committee (ARAC) did not believe this would reduce the level of safety originally intended by the requirement. A warning light system could possibly alert the pilot sooner than if the pilot relied on an instrument panel scan to notice a trend in the fuel pressure indication.

Microprocessing units that monitor engine operation and warn of fuel system problems have already been incorporated in transport aircraft and automobiles. Furthermore, pilots are not monitoring gauges like they use to; instead, they are increasingly relying on warnings to alert them. Late model automobiles, computers and other equipment are designed to protect the operators from mistakes by using built-in warnings. It is important to note that this NPRM does not propose to allow "idiot lights" to replace fuel pressure gauges. A light that comes on at the same time that the engine quits is useless. A warning light system that would comply with this proposal would be sophisticated enough to read transients and trends, and would give a useful warning to the pilot. The FAA expects this proposal to result in fuel systems that provide the pilot with useful engine operating information; thereby, it would offer more value to the operator.

Today, fuel pumps are more reliable than those built in the 1940s and 50s. Consequently, airplane operators are more concerned about reducing engine-operating costs than they are about the probability of a fuel pump failure.

A fuel flow indicator offers additional value compared to a fuel pressure indicator. It enables the operator to monitor the engine's fuel consumption and compare it to fuel consumption listed in the airplane flight manual. If a fuel monitoring system is installed that automatically controls the engine or helps the pilot to properly lean the fuel mixture, then engine operation would be optimized and the direct operating costs would go down through reduced fuel consumption. Reciprocating engines run better if the fuel to air mixture is leaned out according to the optimum (manufacturer's) specified setting. Furthermore, fuel flow also rotates to power, and pilots can use fuel flow readings to quickly access the health of their engine during critical phases of flight, such as takeoff.

Comprehensive engine monitors and redesigned electronic engine instrument displays are also being used in experimental aircraft. The FAA should encourage airplane manufacturers to utilize new technology to improve operation and reduce operating costs. New engine monitoring systems may improve reliability and engine life resulting in increased safety.

The proposal would achieve the same safety objective as the current rule; the crew would have sufficient warning of any negative trend that could lead to partial or total engine failure. However, the proposal recognizes that this objective can be achieved by measuring fuel pressure, fuel flow, or with a "smart" fuel monitoring system."

This proposal was further explained by Final Rule, Docket 28011 as follows: *"Transport Canada questions the ability to show compliance with the requirement in Sec. 23,1549 to identify maximum and, if applicable, minimum safe operating limits as well as the normal operating range of the instrument. This commenter points out that the typical fuel flow meter is a digital type, and it would be difficult for the applicant to provide equivalent markings. Engine manufacturers provide the information required by Sec. 23.1549, which is then usually transcribed to the installed fuel pressure gauge. It appears that this information would not be presented through the use of typical digital fuel flow meters. The commenter offers the following suggestion: "FAR 23.1549 was written with a traditional dial instrument in mind where the engine limitations could be easily displayed on the face of the unit and monitored by the crew. To allow flow meters or other fuel system monitors to satisfy the requirements of Sec. 23.1549 where such a gauge no longer exists, compliance could be shown by (1) different colors to indicate changing trends in system performance (e.g., amber color for a low pressure/flow condition, red for impending engine failure), or (2) placarding, if appropriate, to indicate the normal and abnormal operating ranges".*

The FAA agrees with the commenters' suggestions as an acceptable means of compliance with § 23.1549. Suggested items (1) and (2) above offer the pilot a means to determine fuel flow limitations, which may be needed if a fuel flow meter is installed.

A commenter from Australia supports the proposal; however, the commenter feels that the proposed text would require a monitoring system that provides a warning of any trend that could lead to engine failure, which is an extremely difficult compliance requirement. The commenter further states: *"The historic requirement, and the NPRM preamble, clearly addresses fuel pressure (as an indication of the availability of fuel flow) or fuel flow only. Such wording may stifle the development of monitoring instrumentation for small airplanes". The commenter suggests that, for clarification, the proposed text for Sec. 23.1305(b)(4)(ii), be amended to read as follows: "That continuously monitors the fuel system and warns the pilot of any fuel flow trend that could lead to engine failure".*

The FAA agrees with the commenter that the proposed wording may be too broad, making compliance difficult or the system unnecessarily complex. The FAA encourages "smart" systems; however, the intent of the proposal was to warn the pilot of any fuel flow trend and, for that reason, the final rule and the preamble adopt the commenters' language.

Section 23.1305 is adopted with the change in paragraph (b)(4)(ii) to add the words "fuel flow" before the word "trend"."

23.1307 Miscellaneous equipment

The corresponding rule in CAR 3 is CAR 3.655.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.5.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains a revision to this amendment as follows: *“This proposal deletes the word "an approved" in Section 23.1307, and adds a new requirement that all equipment items necessary for the airplane to operate in the NAS to its maximum approved altitude and in all kinds of operations for which it is approved must be included in the type design.*

Conference proposal 432 recommended deleting Section 23.1307(a) in its entirety, because it was redundant to Section 23.785(b). Conference proposal 433 recommended deleting only the word "approved" in Section 23.1307(a).

Both Sections 23.1307 and 23.785(b) contain seat requirements; however, Section 23.1307(a) only requires a seat or berth for each occupant, while Section 23.785(b) contains specific design requirements for each seat, berth, safety belt, and shoulder harness, but does not include requirements for a seat or berth to be provided for each occupant. The requirements of Section 23.1307(a) were added by amendment 23-23 to eliminate questions as to the maximum seating capacity and compliance with the emergency exit requirements. The FAA does not consider these requirements to be redundant and plans no further action on these recommendations.

A new paragraph (c) is added because the FAA considers it necessary to clarify the type design requirements for part 23 airplanes relative to equipment items. Frequently, manufacturers have requested their airplanes be approved relative to structural, performance, and propulsion requirements for a specific altitude without also requesting approval of necessary equipment to operate at that altitude. The FAA considers it necessary for the type design to include all equipment necessary for the type design to include all equipment necessary for operation in accordance with the limitations required by Sections 23.1559 and 23.1583.”

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21explains this rule as follows: *“This proposal would remove the requirement of Sec. 23.1307(a) which is being added to Sec. 23.785. The discussion of sec. 23.785 covers this change. Also, the provisions of*

Sec. 23.1307(b)(1), (b)(2), and (b)(3), are being removed from Sec. 23.1307. These requirements have been previously added to Secs. 23.1361, 23.1351, and 23.1357, respectively; therefore, they are redundant and may be removed. The designator for paragraph (c) has also been removed from the remaining text of this section."

23.1309 Equipment, systems, and installations

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.6.

Amendment 23-14 and Subsequent

A proposed revision to NPRM 71-13 explains the adoption of this rule as follows: *"Because of the increasing reliance on systems and equipment in the modern, complex, high performance airplanes, the FAA believes that the proposed amendments to Secs. 23.1301, 23.1305, and 23.1309 are necessary to insure the reliability of such systems and equipment."*

Adoption of this rule is also explained by Final Rule, Docket 11011 as follows: *"The other commentator objected to the proposed section on the ground that it could be interpreted to require the complete elimination of radio interference which is impossible. That is not the intent and the FAA does not agree with that interpretation. Similarly worded requirements already exist in the Federal Aviation Regulations and have not been misinterpreted to place an undue burden on manufacturers. However, based on further review, the proposed section has been revised to require that equipment installed in single engine airplanes be designed to minimize hazards to the airplane in the event of a probable malfunction or failure."*

The FAA has reviewed the part 1 definition of the word "instrument," and other data and has concluded as follows:

a. Where a light is sufficient, the instrument requirement should be changed to a warning means.

b. Where trend information is needed, the word "indicator" should be retained.

c. Where point information or steps in a sequence need to be shown, the words should be changed to "indicating means" (i.e., the functioning of the ice protection system).

Software

Order 8110.49 "Software Approval Guidelines", issued June 3, 2003, provides guidelines for the approval of software changes in legacy systems using RTCA DO-178B.

See AC 23.1309-1C, "Equipment, Systems, and Installations in Part 23 Airplanes," for additional guidance.

Airplane Parachute Recovery Systems

Use of a parachute recovery system is not covered by part 23. Applications for the installation of this system will require special conditions.

Amendment 23-17

A proposed revision to NPRM 75-10 had a minor editorial change in adding commas in the title.

Amendments 23-34 through 23-40

Amendment 23-34 added requirements for commuter category airplanes that were later adopted for all part 23 airplanes. A proposed revision to NPRM 83-17 "*added the requirements from part 135, Appendix A., § 59*".

Amendment 23-41 and Subsequent

A proposed revision to NPRM 89-6 explains this amendment as follows: "*Current Part 23 airplane airworthiness requirements are based on single-fault or fail-safe concepts and, when they were promulgated, the FAA did not envision use of complex, safety-critical systems in such airplanes. This proposal will require examination of systems and equipment for their criticality for continued safe flight and will permit the continued use of the existing reliability requirements of Part 23 for airplanes whose systems are not complex and do not perform safety-critical functions. For those cases where the manufacturer finds it necessary or desirable to include complex, safety-critical systems, the proposal includes requirements for identifying those systems and defines additional requirements needed for their certification. The proposed changes to Section 23.1309 are summarized as follows:*

Proposed paragraphs (a), (a)(1), (a)(2), and (a)(3) of Section 1309 are derived from current paragraphs (a), (b), and (c) of Section 23.1309. Under proposed Section 23.1309(a)(1), the systems and installations, as well as the items of equipment, will be required to meet those requirements contained in current Section 23.1309(a). Under proposed Section 23.1309(a)(2), the systems and installations, as well as the items of equipment for single-engine airplanes will be required to meet those requirements contained in current Section 23.1309(c) and proposed Section 23.1309(a)(3) will require these items on a multiengine airplane to meet the requirements contained in current Section 23.1309(b).

(2) A new Section 1309(b) is proposed which will require a detailed examination of each item of equipment, system, and installation. This examination is to determine whether a failure would effect the airplane's continued safe flight and landing. Each item of equipment, each system, and each installation identified by such an examination as being critical to the safe operation of the airplane would be required to meet additional requirements. This will permit the approval of more

advanced systems, that were not envisioned when Section 23.1309 was added to Part 23, without the need for special conditions.

A new Section 23.1309(c) is proposed to require identification of loads which are "essential loads" and requires the airplane power sources for these loads to meet requirements consistent with other airplane airworthiness requirements. These requirements are substantially equivalent to section 59(b) of Appendix A to Part 135.

A new Section 23.1309(d) is proposed to allow reduction of power loads when showing compliance with proposed Section 23.1309(c)(2). This provision is substantially equivalent to section 59(c)(3) of Appendix A to Part 135.

A new Section 23.1309(e) is proposed to require that the design of each electrical system, each item of equipment, and each installation take into account critical environmental conditions. Critical environmental and atmospheric conditions would include radio frequency energy and direct and indirect effects of lightning. Section 23.867 now requires the airplane structure to be protected from the effects of lightning and Section 23.954 now requires the airplane fuel system to be protected from the effects of lightning.

A new Section 23.1309(f) is proposed to provide a definition of the systems to which the requirements of this section are applicable and specifically identifies certain items to which they are not applicable.

Early in the development of minimum requirements for transport category airplanes, it was realized that more complex systems were being added to airplane designs and there was a need to include requirements which specifically addressed equipment, systems, and their installation. This was accomplished by the addition of Section 4b.606 to Part 4b of the Civil Air Regulations (CAR), Amendment 4b-6, effective March 5, 1952, in part, accomplished this objective. The preamble to that amendment included the following in regard to that addition:

An amendment clarifying the requirements for equipment, systems, and installations with regard to functioning and reliability is made in Subpart F. In addition, it specifies dual power supply for those installations the functioning of which is necessary to show compliance with the Civil Air Regulations.

This requirement, as adopted by that amendment, was retained in CAR Part 4b until that regulation was recodified to the Federal Aviation Regulations, Part 25, effective February 1, 1965. At that time, this requirement, substantially unchanged, was identified as Section 25.1309. For many years the "single fault" or "fail safe" concept of this requirement, along with experience based on service-proven designs and engineering judgment, were used to successfully evaluate most airplane systems and equipment.

However, in the late 1960's there appeared a number of safety-critical systems that were utilizing new technical complexity to accomplish safety-critical functions. Due to the increasing complexity of the technology being used to develop these systems, it was becoming increasingly difficult to apply engineering judgment as the only means of determining the effects or likelihood of failure conditions. The increasing difficulty in evaluating these complex systems, along with the potential hazards to the airplane that could result from their failure made it necessary to provide duplicate and triplicate systems to assure an acceptable level of safety.

At about this same time, the development of rational methods for safety assessment of systems led to the conclusion that an inverse relationship should exist between the probability of a failure condition and its effect on the airplane. That is, the more serious the effect, the lower the probability must be that it will occur.

The availability of this rational method for safety analysis of systems, along with the increasing difficulty in applying the then existing "single fault" or "fail safe" concept, prompted the FAA to propose an amendment to Section 25.1309 which would permit the use of this rational method as an acceptable means of accomplishing safety analysis. That proposed revision to Section 25.1309, which specified a level of safety in qualitative terms, and required assessments to be made, was adopted by Amendment 25-23 on April 1, 1970.

At that time, the FAA also realized that more complex systems were being utilized in small airplanes and that there was a need to add a reliability requirement to Part 23. Accordingly, rulemaking action was initiated which resulted in Section 23.1309 being added to Part 23 by Amendment 23.14, effective December 20, 1973. The requirements of that new Section 23.1309 were similar to those of Section 25.1309 prior to Amendment 25-23 which were based on the "single fault" or "fail safe" concept. At that time, it was not envisioned that complex safety-critical systems, utilizing technology now available, would be used in the designs of small airplanes. Therefore, there was no identified need to include provisions for use of the rational method of analysis in Part 23, as had been done in Part 25 by Amendment 25-23.

Experience has shown that the envisioned rate of technical growth of systems used in small airplanes was inaccurate and that safety-critical systems are now being proposed for use on Part 23 airplanes. As with the earlier experience with Part 25, the FAA is finding that it is difficult to apply "single fault" concepts to these complex systems and to utilize the application of engineering judgment as the only means of determining the effects or likelihood of certain failure conditions. Accordingly, there is now a need to revise the reliability requirements of Part 23 to allow the use of the latest available rational method for safety analysis of these complex safety-critical systems to assure continuation of the level of safety intended for airplanes certificated to Part 23. Such safety critical systems are currently being proposed for approval and there is an urgent need to accomplish this proposed rule change.

A recommendation for a complete change of Section 23.1309 was submitted as a part of the Small Airplane Airworthiness Review Program. That recommendation, conference proposal number 434, was discussed during the October 22-26, 1984, Small Airplane Airworthiness Review Program conference held in St. Louis, Missouri. A copy of the transcript of all discussions held during the conference is filed in Docket No. 23494, and may be examined by interested persons.

At that conference a commenter on the recommendation noted that it dealt with failures that cause hazards which do not have catastrophic potential, but does not deal with hazards which are potentially catastrophic. As noted in the above discussion, in the development of requirements for small airplane systems it was originally recognized that failures of systems could produce hazards and the earlier requirements addressed protection from those failures, but did not address safety-critical systems whose failures could be potentially catastrophic or would be catastrophic. As proposed, Section 23.1309 addresses all levels of hazards and the proposed requirements are based on the criticality of the system.

This would be accomplished by requiring all of the airplane's systems to be reviewed to determine (1) if the airplane is dependent upon a system function for continued safe flight and landing, and (2) if a failure of any system on the airplane, not limited to VFR conditions, would significantly reduce the ability of the crew to cope with the adverse operating conditions. For airplanes that do not include systems which perform either of these safety critical functions, the single-fault or fail-safe concept requirements would continue to be applicable as proposed in Section 23.1309(a).

If the design of the airplane includes systems that perform a function that is needed for continued safety flight and landing of the airplane and, accordingly, whose failure could be catastrophic, the systems would be required to meet standards that establish that failures of the system must be extremely improbable. In addition, on airplanes designed for any type of operation other than VFR, the systems whose failures would significantly reduce the airplane's capability, of the ability of the crew to cope with the adverse operating conditions and, thereby, be potentially catastrophic would be required to meet standards that establish that failures of these systems are improbable. This standard is applicable if a system failure would reduce the capability of the airplane or the crew to cope with adverse operating conditions. It was recognized that any failure will reduce the airplane's or crew's capability by some degree, but that reduction may not be of the degree that will make operation of the airplane potentially catastrophic. The intent of this proposed standard, Section 23.1309(b), is to have those systems whose failure would be catastrophic or potentially catastrophic be evaluated using the latest available techniques and, thereby, better assure that failures of such systems will not occur.

At the conference, a commenter expressed the opinion that the language of conference proposal 434 would require all system items to meet the analysis test *and proof of compliance means. This commenter noted that simple and conventional systems can be assessed on the basis of service experience and engineering judgment and noted that low performance, simple designed airplanes should be able to use the existing method of determining compliance. The FAA agrees with this commenter and, as previously stated, proposed Section 23.1309(a) is structured to allow the use of existing procedures for simple airplane system designs.*

Another conference commenter expressed a concern over the applicability of Section XX.1309 of any of the airworthiness parts. To clarify the applicability of Section 23.1309, a definition of "system" is included in proposed Section 23.1309(f).

One commenter noted the difference in the way Part 23 and Part 25 airplanes are used and suggested different probability values for Part 23, but did not provide recommended values. In reviewing this comment, it should be noted that the probability terms do not have values assigned in these proposed requirements of other airworthiness parts. Extremely improbable failure conditions have been defined in FAA guidance material as those which are so unlikely that they are to expected to occur within the total operational life of all airplanes of one type. If such a definition were to be applied to items of structure, a failure that would cause the loss of a wing would be a type of catastrophic failure that would not be expected to occur in the life of all airplanes of one type. As cited, current requirements applicable to other portions of Part 23 airplanes, such as structures, establish a level of safety that does not permit the occurrence of catastrophic failures and, accordingly, there is no justification for allowing a lower level of safety for possible catastrophic system failures. Accordingly, the proposed language of this proposal uses the term "extremely improbable" to define this critical type of failure condition. Less critical failure condition terms used in airworthiness requirements for other categories of aircraft are also included in this proposal.

Other review conference comments, not limited to any one commenter, questioned the applicability of the rational method for analysis to two-to-four-place airplanes. While this proposal allows the continued use of existing certification procedures for certification of simple airplane designs, it would, however, also require the use of rational procedures if the airplane's design includes systems for the accomplishment of safety-critical functions. Because the proposed additional requirements of this proposal are added in such a manner as to make their use dependent on the complexity of the affected design and because the degree of reliability required in a particular design will depend upon the criticality of the system function, there is no reason to limit these requirements to a size of airplane or to differentiate between single or multiengine types of airplanes.

One review conference commenter questioned the power supply requirements of the conference proposal number 434. This commenter asked if this proposed *requirement is related purely to electrical power, and if it is, shouldn't it be located elsewhere in Part 23. During the discussion of this question, it was pointed out by FAA panel members that the proposed requirement does not specify an "electrical" power supply and, therefore, would be applicable to any form of power supply provided for a system that is required by this chapter. No additional language has been added to identify the types of power supply. The proposal language, which is similar to that used in other airworthiness parts, identifies requirements for power supplies used for each item of equipment, system, and installation required by this chapter. By its applicability, it is clear that the requirements are not limited to electrical power supplies.*

Additional discussions at the conference suggested that current Section 23.1309 was adequate and that the only need was an Advisory Circular (AC) to identify acceptable means of compliance. At that time, the FAA made it known that was not the case, and cited instances in which a complex safety-critical system had been used in the design of small airplanes that could not be properly evaluated under the existing "single fault" concept of Section 23.1309. The FAA further noted that the number of occurrences where such a complex safety-critical system was being used in the design was increasing rapidly and noted the need to revise the requirements to keep them current with this rapid expansion of technology being applied to the design of small airplanes.

The FAA attempted to address some current issues relative to electronic flight instrument systems and autopilot monitors and limiters in advisory circulars. FAA review of resulting material in the draft advisory circulars determined that the contents were rulemaking in nature and not suitable in an advisory circular. The concern was relative to the complexity and criticality of such equipment. This proposal, when adopted, will provide a regulatory basis for determining the criticality level of such systems and require corresponding levels of reliability requirements which are based on the criticality of the system's function and will provide the updated standards needed for the certification of complex safety-critical systems in small airplanes.

This amendment is explained by Final Rule, Docket 25812 as follows: *This proposal would retain the existing reliability requirements of current Section 23.1309 for airplane equipment, systems, and installations that are not complex and do not perform safety-critical functions. For those cases where the applicant finds it necessary or desirable to include complex, safety-critical systems, this proposal also would provide additional requirements for identifying such equipment, systems, and installations and would define additional requirements needed for their certification. This proposal would permit the approval of more advanced systems having the capability to perform critical functions and whose failure condition would prevent the continued safe flight and landing of the airplane.*

Two commenters offer comments on proposed Section 23.1309. One of these commenters concurs with the concept of updating the reliability requirements applicable to airplanes not limited to Visual Flight Rules (VFR) flight, but does not concur with this updating for all airplanes. As discussed in Notice Number 89-6, this proposal addresses the systems installed on airplanes and is not limited to the operations approval of the airplane. The airworthiness standards, as adopted in Section 23.1309(a), are based on single-fault or fail-safe concepts and experience based on service-proven designs and engineering judgment. These requirements should be used for airplanes whose systems are not complex and do not perform safety-critical functions. Therefore, Section 23.1309(a) is structured to allow the use of existing procedures for simple airplane system designs.

If the design of the airplane includes equipment, systems, and installations that perform functions whose failure condition would prevent continued safe flight and landing of the airplane, the occurrence of each failure conditions must be extremely improbable. In addition, on airplanes designed for any type of operation not limited to VFR, the systems whose failure conditions would significantly reduce the airplane's capability, or the ability of the crew, to cope with the adverse operating conditions must be improbable. It was recognized that any failure would reduce the airplane's or crew's capability by some degree, but that reduction may not be of the degree that would make operation of the airplane potentially catastrophic. The intent of Section 23.1309(b) is to require that systems whose failure would be catastrophic or potentially catastrophic be evaluated using the latest available analysis techniques.

Although future airplane designs limited to VFR operations are not likely to include equipment, systems, and installations whose failure condition would prevent continued safe flight and landing of the airplane, the applicability of this requirement, as discussed above, will provide airworthiness standards if the applicant elects to include such systems in the airplane's design. Therefore, the applicability of this requirement has not been revised as suggested by this commenter.

One commenter suggests that the critical environmental system considered in Section 23.1309(c) would be better defined by removing the words "such as" from the proposed paragraph and replacing them with the word "including." The FAA agrees that the suggested wording more accurately identifies the intent of this paragraph, as discussed in this notice. The wording of paragraph (e) of Section 23.1309 has been revised accordingly.

This same commenter notes that there are proposals being considered for a new Sections 25.1315 and 15.1317, which deal with the effects of lightning and external high energy radiated electromagnetic fields, and suggests that similar actions be considered for part 23 rules. Although this comment is beyond the scope of the actions proposed in Notice Number 89-6, the FAA recognizes the desirability of *having the various airworthiness standards address like requirements in the respective sections and will consider this comment in future rulemaking actions."*

Lightning Protection

See AC 23.1309-1C, "Equipment, Systems, and Installations in Part 23 Airplanes," AC 20-136, "Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning," and RTCA DO-160D, "Environmental Test Conditions and Test Procedures for Airborne Equipment," Section 22, for guidance on lightning certification of IFR airplanes. As part of the ongoing review of natural lightning by the SAE Lightning Committee AE2 and EUROCAE WG-31, the multiple stroke and burst environmental criteria was revised from the AC 20-136 requirement as defined in SAE ARP 5412, "Aircraft Lightning Environment and Related Test Waveforms."

Several SAE documents have been issued and the FAA finds the following SAE documents acceptable:

SAE ARP 5412, "Aircraft Lightning Environment and Related Test Waveforms", November 1, 1999.

SAE ARP 5413, "Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning," (it is being incorporated into an AC), May 14, 2002.

SAE ARP 5414, "Aircraft Lightning Zoning", December 1, 1999.

SAE ARP 5415, "Users Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning", May 14, 2002.

SAE ARP 5577, "Aircraft Lightning Direct Effects Certification", September 30, 2002.

High Intensity Radiated Fields (HIRF)

Special conditions will still be required for critical systems for HIRF, since the words "radio frequency energy" in this rule are not intended to include HIRF. RTCA DO-160D, section 20, is applicable for bench level testing for HIRF.

Electronic Engine Control (EEC) Systems

Section 23.1309 does not apply to powerplant systems provided as part of the certificated engines per paragraph (f). This rule did not envision digital engine controls. Special conditions will be required for electronic engine controls without a hydromechanical back-up system that has the reliability and performance of a traditional reciprocating engine without electronic engine controls. The special conditions will require compliance to HIRF and § 23.1309(a) through (e), per the latest amendment, for these digital engine controls. Appropriate engine certification data may be used for airplane certification. Even though an engine control may be certificated as part of the engine, the installation aspects of the installation require certification to part 23. Experience has shown that changes required for aircraft certification may require changes to the engine software with the associated engine certification of those changes.

Acceptance of either engine mounted and engine certificated Full Authority Digital Electronic Engine Control (FADEC) or EECs does not mean that approval at the airplane level is automatic. Flight-testing is still required to assure all part 23 requirements are met.

Software changes initiated either by the engine manufacturer, FADEC, or EEC manufacturer should be validated on each software change as to their effect on part 23 certification requirements. Any and all engine control software changes must be coordinated with the appropriate ACO to assess the impact on part 23 certification requirements.

Standardization of Application of 14 CFR, Part 23, § 23.1309, Regarding Hazardous Misleading Heading Information for Attitude-Heading Reference Systems (AHRS)

Purpose

The purpose of this guidance is to clarify FAA certification policy on the application of AC 23.1309-1C, "Equipment, Systems, and Installations in Part 23 Airplanes," regarding hazardous misleading heading information.

The issue in question is specifically about the application of AC 23.1309-1C for an airplane with a certification basis of amendment 23-41 or later. This clarification is limited to installations approved for operation in Instrument Meteorological Conditions (IMC) under IFR.

For operations in Visual Meteorological Conditions, a misleading heading indication is not considered hazardous.

Current Regulatory and Advisory Material

14 CFR part 23, § 23.1309, Equipment, systems, and installations

Technical Standard Order (TSO) TSO-C151b, "Terrain Awareness and Warning System", May 6, 2002.

AC 23.1309-1C, **"**Equipment, Systems, and Installations in Part 23 Airplanes", March 12, 1994.

AC 23-18, "Installation of Terrain Awareness and Warning System (TAWS) Approved for Part 23 Airplanes", June 14, 2000.

Summary

A Functional Hazard Assessment (FHA) and the related safety assessments should be made for the specific airplane type and configuration, as there can be a large number of combinations of failures, various mitigating factors, and other functions available to a pilot. Because of the numerous factors that affect the criticality of the heading indication, a safety assessment process using AC 23.1309-1C should be used to classify the failure conditions for misleading heading information.

A hazardously misleading heading is usually when the accuracy error is greater than 10 degrees on the primary heading instrument and it is an undetected error from the AHRS. The safety assessment process should consider appropriate mitigating factors that might alleviate failure conditions effects, including:

availability, accuracy, and reliability of magnetic compass;

independent heading instrument;

independent navigation information;

moving map if approved for IFR operations;

TAWS, if approved (for design and performance) in accordance with TSO-C151ab, Class A or B, and following AC 23-18 (for airworthiness approval for the installation);

air traffic control monitoring of the aircraft; and

exposure time.

Safety Assessment Process

A hazardously misleading heading is usually when the accuracy error is greater than 10 degrees due to a malfunction on the primary heading system using the AHRS. The normal accuracy should be within the guidelines under section 23.1301 in this AC. For Class I part 23 airplanes, the failure condition for misleading hazardous heading is usually considered major per AC 23.1309-1C.

For a major failure condition on Class I airplanes, the probability for the system to provide hazardously misleading heading information to the display should be less than or equal to 10^{-4} per flight hour due to undetected or latent failures. For Class II, III, and IV airplanes, the probability for the system to provide hazardously misleading heading information to the display should be less than or equal to 10^{-5} per flight hour due to undetected or latent failures. For major failure conditions, a qualitative analysis is usually sufficient.

NOTE 17: There is a difference between hazardous as used in general policy or regulations and hazardous failure condition as used in an FHA. When the term "hazard" or "hazardous" is used in general policy or regulations, it is generally defined as follows:

"Any condition that compromises the overall safety of the airplane or that significantly reduces the ability of the flight crew to cope with adverse operating conditions."

When used in an FHA, "hazardous failure condition" is one of the five different failure conditions classifications in AC 23.1309-1C. Hazardous failure conditions would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions to the extent that there would be the following:

A large reduction in safety margins or functional capabilities;

(1) Physical distress or higher workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or

(2) Serious or fatal injury to an occupant other than the flight crew.

Mitigating Factors

During the safety assessment process, mitigating factors should be considered if they are independent of the AHRS. These factors should provide additional qualitative and quantitative credit and alleviate failure conditions. The mitigating factors may include the following:

availability, accuracy, and reliability of magnetic compass;

independent heading instrument;

independent navigation information;

moving map if approved for IFR operations;

TAWS, if approved (for design and performance) in accordance with TSO-C151ab, Class A or B, and following AC 23-18 (for airworthiness approval of the installation);

air traffic control monitoring of the aircraft; and
exposure time.

Some of these factors may not be appropriate for higher performance and complex airplanes.

Normally, for Class I and some Class II airplanes, the pilot should be scanning the instruments for cues to determine misleading information. Therefore, the locations of primary instruments and secondary instruments should be within the primary and secondary fields-of-view. This is defined in GAMA Publication No. 10, "Recommended Practices and Guidelines for Part 23 Cockpit/Flight Deck Design," dated September 2000.

Magnetic Compass or Independent Heading Instrument

The usability of the magnetic compass, as a mitigating factor, is dependent on the airplane installation on a case-by-case basis. The following guidelines should be considered. A magnetic compass or independent heading instrument is considered acceptable if the accuracy is within 10 degrees and it is located in the secondary field-of-view. However, the compass may not be usable if it is susceptible to large errors induced by other onboard equipment. For example, an airplane approved for known icing may have an unusable compass when a windshield heater is affecting the compass; therefore, additional mitigating factors may be necessary to meet the appropriate safety level.

One general concern is that Class II airplanes may have a number of systems that can affect the magnetic compass that are not typically found in Class I airplanes. For this reason, the magnetic compass should be usable for many Class I airplanes, but it may not be usable for many Class II airplanes or higher. An evaluation should be conducted to determine if the magnetic compass is usable and accurate within 10 degrees.

Navigation Information

Credit should also be given for moving maps displaying position information from independent navigation systems such as GPS that are approved for IFR operations. The moving map should depict the airplane relative to the desired navigation track and the navigational tracks heading.

Navigation systems such as IFR-approved GPS systems can provide an independent relative heading source that can be used to verify the primary heading indication. Furthermore, the FAA expects that pilots will naturally crosscheck their moving map displays because they are easier to use for navigation than traditional deviation needles.

The moving map should be in the primary field-of-view (preferably) or the secondary field-of-view to get credit for the safety assessment process by AC 23.1309-1C.

TAWS

TAWS with a display provides the pilot with sufficient information and alerts to detect potentially hazardous terrain situations so that the pilot may take effective action to prevent CFIT events. Although a TAWS with a display is not approved for navigation under normal circumstances, under emergency conditions TAWS provides acceptable situational awareness to prevent CFIT.

TAWS may not be usable to determine misleading heading information, but TAWS should reduce or prevent a CFIT accident, which will mitigate the failure effect. TAWS that meet TSO-C151ab, Class A or B, and AC 23-18 should be acceptable when pilot confidence proficiency is achieved through service history.

Air Traffic Control Monitoring

For most IFR operations, the airplane will be in controlled airspace and under radar coverage. Air Traffic Control (ATC) has been the primary mitigating factor for heading indicator accuracy for many decades. ATC maneuvers airplanes based on a ground track. Heading errors in traditional mechanical Directional Gyros (DG) are still identified by ATC when pilots do not maneuver in the direction ATC expects. Most of the time ATC will identify heading errors when the pilot fails to adequately update their DG or their horizontal situation indicator has failed.

However, there are locations at some airports where radar coverage is not available. In these situations, there is usually some type of navigation signal that pilots can use to get into and out of the airport. These are the types of departures and approaches where heading accuracy may be important. Although ATC may be a mitigating factor, specific guidelines are not being provided at this time.

Exposure Time and Risk Assessment

Exposure time and risk factors that may be considered are as follows:

automatic pre-engagement self test;

monitoring capabilities;
maintenance intervals; and

phase of flight, and so forth.

In the SAE Standard ARP4761, "Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment," exposure time is defined as follows:

"The period of time between when an item was last known to be operating properly and when it will be known to be operating properly again."

In this guidance, risk is also being considered.

Risk assessment is the composite of:

the outcome or effect of the failure condition;

the average probability of the failure condition per flight hour; and

exposure time; and

likelihood of the outcome/effect of the hazard will occur.

the exposure time.

For risk assessments, a credit should be factored into the analysis that is proportional to the probability that a given failure condition will occur on the aircraft. This credit is related to the system level of the failure condition, the operational and environmental conditions, and the phase of flight.

To determine exposure time, the actual time that the pilot would only be using heading information to navigate should be considered. Only a percentage of a typical IFR flight is flown navigating solely on the heading instrument. The critical times for heading are when the pilot is not navigating with a navigation instrument but is only using the heading instrument.

The details on how to calculate the “Average Probability Per Flight Hour” for a Failure Condition are given in Appendix C of AC 23.1309-1C. A common assumption for 14 CFR, part 23 airplanes is that the average flight duration is one hour.

The FAAs General Aviation and Air Taxi Activity Survey gives estimated flight hours for IMC operations for specific airplanes. When researching the operations of specific airplane models, the result indicates that Class I airplanes are operated in IMC conditions about 20 percent of their total flight hours and Class II airplanes about 30 percent. Also, the FAA believes that only portions of most IFR flights are flown by navigating solely on the heading instruments.

Using the percentages for “phases of flight” from a Boeing accident study, the FAA estimates that on any given IFR flight, navigation solely by the heading instrument would only occur about 20 percent of the time.

Acceptable Configurations for IFR Use
Some acceptable configurations for IFR approval include:

Configuration A:

One dependable magnetic compass.

(1) A reliable magnetic gyroscopically stabilized heading system that together meets the AC 23.1309-1C reliability levels, such as 10^{-4} per flight hour for Class I airplane.

Configuration B:

A magnetic compass that meets the airworthiness requirements but cannot be given credit for AC 23.1309-1C purposes for the reasons stated above under Magnetic Compass or Independent Heading Instrument paragraphs in the **Safety Assessment Process**.

(2) One magnetic gyroscopically stabilized heading system that meets the AC 23.1309-1C reliability levels, such as 10^{-4} per flight hour for Class I airplane, alone or in combination with one or more of the mitigating factors addressed above such as moving map or TAWS with a display.

Configuration C:

(1) A magnetic compass that meets the airworthiness requirements but cannot be given credit for AC 23.1309-1C purposes for the reasons stated under Magnetic Compass or Independent Heading Instrument paragraphs in the **Safety Assessment Process**.

(2) Two magnetic gyroscopically stabilized heading systems that together meet the AC 23.1309-1C reliability levels, such as 10^{-4} per flight hour for a Class I airplane.

Configuration D:

A magnetic compass that meets the airworthiness requirements but cannot be given credit for AC 23.1309-1C purposes for the reasons stated under Magnetic Compass or Independent Heading Instrument paragraphs in the **Safety Assessment Process**.

(1) Two magnetic gyroscopically stabilized heading systems with each being less reliable than required by AC 23.1309-1C (such as 10^{-4} or 10^{-5}).

(1) A comparator monitor. In this case, the warning from the comparator monitor would alleviate a hazardous misleading heading. However, if the system still has a reliability problem, numerous nuisance alarms would cause the pilot to ignore the warnings.

Conclusion

There are numerous factors that affect the criticality/severity of hazardously misleading heading indication, so a safety assessment process using AC 23.1309-1C should be used to classify this failure condition.

The safety assessment process should consider appropriate mitigating factors that might alleviate failure conditions, including:

availability and reliability of magnetic compass;

independent heading instrument;

navigation information;

moving map;

terrain awareness warning system;

air traffic control monitoring of the aircraft; and

exposure time.

Amendment 23-49

A proposed revision to NPRM 94-21 explains this amendment as follows: "*Proposed new Sec. 23.1309(a)(4) would correct an inadvertent omission that occurred when the FAA issued Amendment No. 23-41 (55 FR 43306, October 26, 1990). The omitted requirement was adopted by Amendment No. 23-34 as a portion of Sec. 23.1309(d) and read: "In addition, for commuter category airplanes, system and installations must be designed to safeguard against hazards to the airplane in the event of their malfunction or failure." (52 FR 1833, January 15, 1987.) To correct this oversight, and to continue the single fault provision of this paragraph, Sec. 23.1309(a)(4) is being proposed.*"

INSTRUMENTS: INSTALLATION

23.1311 Electronic display instrument systems

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.13.

Amendment 23-41 through Amendment 23-48

Attitude and Heading

For part 23, there is not a specific requirement that instruments at each pilot station be independent unless two pilots are required by the airworthiness or operational rules, except that independent secondary attitude and rate-of-turn instruments that comply with Sec. 23.1321(a) if the primary electronic display instrument system for a pilot presents this information are required. Therefore, both electronic attitude and heading instruments can utilize the same attitude and heading reference source. An applicant for a single AHRS can present their rationale, including a hazard analysis, explaining how their single AHRS system can meet reliability requirements for a possible catastrophic failure. For a single AHRS, the AFM should include equipment-operating limitations to alert the pilot(s) that a failure of the AHRS could simultaneously affect both attitude and heading instruments. However, a single AHRS may not be acceptable if its affect on an autopilot system is a possible catastrophic failure caused by the AHRS, such as an unannunciated slowover (softover) failure.

Amendment 23-41 and Subsequent

A proposed revision to NPRM 89-6 has the following explanation: "*A significant number of electronic display systems have become available for installation in small airplanes. These systems include display of all parameters that are typically displayed on a small airplane instrument panel. Approval of these systems in small airplanes was addressed by several conference proposals that proposed to amend Sections 23.1303, 23.1305, 23.1321, 23.1323, and 23.1337.*

Conference proposal 420 from the General Aviation Manufacturers' Association (GAMA) recommended removing the words "instrument" and "indicator" from Section 23.1303 and require specific "data" be displayed rather than require specific "instruments". Conference proposal 428 recommended amending Section 23.1305 by changing "powerplant instruments" to "powerplant displays" and "indicators" and "indicating" to displays". Conference proposal 436 recommended amending Section 23.1321 by changing "instrument" to "display" or "data on the flight displays". Conference proposal 439 recommended amending Section 23.1323 by changing "instrument" and "indicator instrument" to "display". Conference proposal 450 *recommended amending Section 23.1337 by adding a new paragraph (a) to state "Displays other than individual indicators may be used if it is shown that adequate isolation is provided between engines and engine parameters."*

The basic justification given for all of the recommended changes is that the current requirements of Part 23 were written when the required data could only be supplied using individual instruments. New technology now allows this same data to be displayed in a different manner, possibly with all the data on a common display.

It is desirable to take advantage of available new technology. The benefits include safer (less prone to misreading) displays with less cockpit space and of equal or lower cost than the cluster of typical individual instruments. As technology advances, the amount of energy used for these displays and the cost can be further reduced.

The FAA agrees that when current requirements of Part 23 were written, only mechanical or electromechanical instruments that functioned independently for each parameter displayed were envisioned. The engine instruments and systems envisioned were isolated and independent. A single failure of any engine or any of its systems could not affect the operation of any other engine. The requirements were based on "single fault" or "fail safe" concepts and, when these current requirements were promulgated, the FAA did not envision use of complex, safety-critical systems in small airplanes. All envisioned instruments were single function; i.e., a failure would cause loss of only one instrument function, although several instrument functions may have been housed in a common indicator case.

Since the conference, the FAA has further studied the problems associated with installation of current technology indicators in small airplanes. As is discussed relative to amending Section 23.1309, these current technology systems have potential for being critical for continued safe flight of the airplane. The potential for increased clarity in data display and the concentration of data displays in a single indicator increases the potential criticality of failures. It is anticipated that pilots using these new instrument systems will become increasingly dependent on the use of them because of the tasks they perform for the pilot. After a period of time, where these electronic indicators are located in the primary instrument panel locations, it is anticipated that pilots will find it more difficult to transition to back-up or secondary indicators when failure occurs, such as reverting to use of needle-ball and airspeed for airplane attitude control when the artificial horizon instrument system fails.

The electronic indicators are expected to have significantly different modes of failure where they go from performing perfectly to total failure, whereas the mechanical and electromechanical indicators typically deteriorated in performance over a period of time such that they were replaced before a total failure that prevented them from providing useful information to the pilot.

Current technology instrument systems with electronic indicators for small airplanes may very considerably in functional capability, complexity, and cost. Due to the economic considerations, the most expensive, complex, and reliable electronic instrument systems will only be installed in airplanes fitting a like description.

The electronic instrument systems can readily provide digital indication of exact numbers, moving pointer on a scale, and various other formats and combinations of them all. The FAA is especially concerned that pilots be provided adequate sensory cues as to whether numbers displayed are increasing or decreasing and how fast they are changing. Also of concern is that digital indication may not show the normal operating range cues to direction or rate of change or operational limits.

As a result of these concerns and this further review of possible ways to address electronic instrument systems in Part 23, the FAA concluded that a new Section 23.1311 for these systems is better than amending several sections, which may result in an unclear treatment of the issue.

Relative to identifying the indicating means of the electronic instrument system, the FAA has reviewed existing materials and functions to be performed and has concluded the proper identifier is "indicator" rather than "display" as recommended.

Sections 23.1303(a), (b), and (c) require basic flight and navigational instruments for small airplane certification. These mechanical instruments have performed their intended function very well over the years and these basic instruments will remain necessary for safety even when the current technology systems are installed. Therefore, this proposal will allow displacement of these instruments from the primary location for such instruments for compliance with the requirements of 23.1321, provided their location in a secondary location is such that they are usable and in compliance with Section 23.1321(a) requirements. It is the FAA's intent that this will continue the requirements that airspeed, altitude, and magnetic compass information will remain available to the pilot after total failure of the airplane's electrical power system.

This proposal will allow electronic display indicators for engine parameters without isolation and independence of engine instruments as is now required. In developing this proposal the FAA considered the operational characteristics of airplane engines, the proposed amendment to Section 23.1309 in this notice for assessing failures and their consequences, and the cues available to the pilots for assuring an engine instrumentation failure would not create a condition where the pilot would encounter significant difficult in operating the engines.

Due to the dependence pilots are expected to place on use of electronic indicators when the indicators include information essential to airplane attitude control, the FAA is proposing secondary attitude and rate-of-turn instrument systems that comply *with Section 23.1321(a) when the electronic indicators include display of attitude and rate-of-turn.*

Electronic indicator legibility is expected to change as the cathode ray tubes (CRT) used in the electronic indicators age. Therefore, it is considered necessary that instructions for continued airworthiness relative to the useful life be addressed in compliance with Section 23.1529.

Electronic indicator systems will have great potential for inhibiting information to maximize the effect of other information in various phases of flight. Attitude, airspeed, altitude, and powerplant parameters needed to set power within established limits are information the FAA has concluded must be displayed during all normal modes of operations and, therefore, may not be inhibited during normal modes of operation. Information that is considered essential to continued safe flight must remain available on indicators usable by the pilot after any single failure or combination or probable failures without need for immediate crew action. At a minimum, without considering specific characteristics of an airplane's design, attitude, airspeed, and altitude must remain available without any crew action after such a failure, whereas a failure that would remove other essential information from displays, without resulting in an immediate hazard, would be acceptable provided the essential information could be returned to a usable indicator in a safe elapsed time."

This amendment is explained by Final Rule, Docket 25812, as follows: *"One commenter asks if the wording of proposed Section 23.1311(c), concerning electronic display indicators with features that make isolation and independence between powerplant instrument systems impractical, will be supported by an appropriate amendment to require such isolation. As discussed in Notice No. 89-6, the current requirements of part 23 address powerplant instruments that could provide the required data only by using individual instruments. Accordingly, the isolation and independence referred to in Section 23.1311(c) are currently required in Section 23.903(c). The objective of this regulation is to allow the use of electronic display indicators that will not provide the isolation and independence considered in the current requirements. The FAA is not considering an additional amendment to address this issue."*

See AC 23.1311-1A, "Installation of Electronic Displays in Part 23 Airplanes," for further guidance.

Altitude

Digital-Only (alphanumeric) displays for barometric altitude should not be approved.

Amendment 23-49

A proposed revision to NPRM 94-21 explains this amendment as follows: "*This proposal would revise Sec. 23.1311 to remove redundant requirements and to clarify which secondary instruments are required and the visibility requirements for these instruments are required and the visibility requirements for these instruments. When Sec. 23.1311 was adopted by Amendment No. 23-41 (55 FR 43306, October 26, 1990), several nonsubstantive changes were made to the proposals in Notice No. 89-6 (54 FR 9345, March 6, 1989) to remove the redundancy included in the notice. In the process certain provisions, such as the one that permitted the installation of mechanical secondary instruments, were inadvertently omitted from the final rule. Since the final rule, discussions with airplane manufacturer representatives have shown that the requirements defining the instrument panel location where secondary instruments may be installed are also not clear. Accordingly, the FAA is proposing to revise this section to correct and clarify these portions.*

Current Sec. 23.1311(a), which requires electronic display indicator installations that are independent to each pilot station, would be deleted because it is redundant with Sec. 23.1321(a). Section 23.1321(a) requires that each flight, navigation, and powerplant instrument for use by any required pilot shall be located so that any pilot seated at the controls can monitor the instruments with minimum head and eye movement. As stated in the preamble of Notice No. 89-6 (54 FR 9345, March 6, 1989) regarding the proposed revision to sec. 23.1321, "This revision also clarifies the rule relative to instrumentation that must be provided for each pilot required for type certification or by the applicable operating rules. If a pilot is required by any applicable requirement, then that pilot must be provided all instrumentation required for any operations for which the airplane is approved." Accordingly, the requirements of current Sec. 23.1311(a) would be removed.

In place of current paragraph (a), proposed Sec. 23.1311(a) would be a revision of current paragraph (c) that would clarify what instruments are required and the visibility of those instruments. Proposed new Sec. 23.1311(a)(1) would require electronic display instrument installations to meet the arrangement and visibility requirements of Sec. 23.1321(a).

Proposed Sec. 23.1311(a) (2), (3), and (4) would be redesignated with no changes from current Sec. 23.1311(c)(1), (2), and (3).

Proposed Sec. 23.1311(a)(5) would continue the requirement of Sec. 23.1303(c) for a magnetic direction indicator and, in addition, would require either an independent secondary mechanical altimeter, airspeed indicator, and attitude indicator or individual electronic display indicators for the altimeter, airspeed, and attitude that are independent from the airplane's primary electrical power.

These secondary instruments may be installed in panel positions other than the primary location as long as the selected location allows the pilot to properly monitor the instruments and control the airplane.

The substance of proposed paragraph (a)(5) is both a substantive change and a combination of the current Sec. 23.1311(b), which states that certain electronic display indicators must be independent of the airplane's electrical power system, and current Sec. 23.1311(c)(4) which requires independent secondary attitude and rate-of-turn instruments and specifies the location of those instruments and specifies the location of those instruments. Proposed Sec. 23.1311(a)(5) would delete the requirement for a rate-of-turn instrument (in current sec. 23.1311(c)(4)) and specify that the required secondary instruments are those that provide altitude, airspeed, magnetic direction, and attitude. The information that would be provided by a secondary rate-of-turn instrument would not appreciably add to the safe operations of the airplane if the pilot has the information provided by the secondary attitude instrument.

Current Sec. 23.1311(b) requires that electronic display indicators required by Sec. 23.1303(a), (b), and (c) be independent of the airplane's electrical power system. The original intent of the requirement for secondary instruments, as stated in Notice No. 89-6, was to require the installation of either mechanical instruments or independent electronic display indicators powered by a source independent of the airplane's electrical system. However, the current rule does not clearly state this and does not address the installation of mechanical instruments. Proposed Sec. 23.1311(a)(5), would allow either secondary electronic display indicators or mechanical instruments to provide a crew with information essential for continued flight and landing in the event of failure in the airplane's electrical power system.

Current Sec. 23.1311(c) (5) and (6) would be redesignated as Sec. 23.1311(a)(6) and (7) without change.

Proposed new Sec. 23.1311 (b) and (c) would continue the requirements of current Sec. 23.1311 (d) and (e) without change.

This proposal would revise Sec. 23.1311 to remove redundant requirements and to clarify which secondary instruments are required and the visibility requirements for these instruments. No comments were received on the proposal, and it is adopted as proposed.”

This amendment is explained by Final Rule, Docket 27806 as follows: *“This proposal would revise Sec. 23.1311 to remove redundant requirements and to clarify which secondary instruments are required and the visibility requirements for these instruments. No comments were received on the proposal, and it is adopted as proposed.”*

23.1321 Arrangement and visibility

The corresponding rules in CAR 3 are CAR 3.661 and 3.662.

The corresponding rules in the Airship Design Criteria, FAA-P-8110-2, Change 2, are sections 6.4 and 6.7.

Original Issue and Subsequent

When applying this rule to powerplant instruments in multiengine airplanes, assure there is no confusion as to the engine/instrument relationship. For instance, powerplant instruments for the right engine in a twin-engine airplane may not be placed over, under, or to the left of the left-engine instruments.

Amendment 23-14 and Subsequent

A proposed revision to NPRM 71-13 explains this amendment as follows: *"This proposal is considered necessary because of the increasing complexity of the new high performance airplanes and the increasing volume of air traffic. In addition, the proposed new paragraph (d) is in furtherance of the principle of cockpit standardization."*

The NPRM for magnetic direction indicators was revised by Final Rule, Docket 11011 as follows: *"Proposed Sec. 23.1321(d)(4) has been revised to provide that the magnetic direction indicator required by Sec. 23.1303(c) need not be mounted in the instrument panel position proposed. The proposed requirement might create difficulties in calibrating and adjusting those indicators in the proposed position."*

For all installations, the evaluation should consider the different environmental conditions under which the airplane may be operated as defined by § 23.1559.

Basic "T"

This rule applied the Basic "T" to standardize flight instrument locations. This was not intended to require a "perfect T."

Also, for all installations, the FAA has always intended that § 23.1321(d) apply to **each pilot's** station for both type certification and for any operations for which the airplane is approved. Therefore, when an airplane is type certificated with the "basic T" instrumentation at only one pilot's station, that **airplane is limited to operations where only one pilot is required** in accordance with §§ 23.1525 and 23.1583(h).

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains this amendment as follows: *"The present visibility requirement in Sec. 23.1321(a) pertains only to flight, navigation, and powerplant instruments. Since other devices may be intended for use in flight and a pilot may develop vertigo by his head movements to see these devices, the location of all visual indicators for use in flight needs to be considered. Of course, flight safety will remain the primary consideration in position priority. The standard of "minimum practicable deviation" will remain, if the rule is adopted as proposed, thus allowing considerations of all factors related to utilization and flight safety. The same proposal is also made for Secs. 25.1321(a), 27.1321(a), and 29.1321(a).*

The proposed Sec. 23.1321(e), if adopted, would extend the requirement of the present and proposed Sec. 23.1321(a) to require consideration of all possible cockpit lighting conditions for visibility of required malfunction indicators.

The FAA considered the question whether the proposal should apply only to required malfunction indicators or to all indicators, and believes that if a malfunction indicator has been provided for the crew it should be effective under all cockpit lighting conditions."

A revision to NPRM by Final Rule Docket, 14625, was in response to comments as follows: *"Several commentators questioned proposed Secs. 23.1321(a), 25.1321(a), 27.1321(a) and 29.1321(a) (Proposals 5-3, 5-23, 5-42, and 5-56, respectively) concerning the visibility of instruments with a visual indicator for use in flight by any pilot. It was stated that the proposed standard did not adequately provide for instruments that were monitored infrequently during flight as contrasted with instruments more critical to flight safety. With respect to rotorcraft, one commentator also objected on the ground that the space available for mounting instruments was extremely limited. The FAA agrees that priority of instruments location needs to be more definitive. Therefore, proposed Secs. 23.1321(a), 25.1321(a), 27.1321(a) and 29.1321(a) are withdrawn.*

Several commentators objected to the phrase "under all cockpit lighting conditions "in proposed Secs. 23.1321(e), 25.1321(e), 27.1321(d), and 29.1321(g), contending that it includes everything from lightning to total darkness resulting from complete electrical failure at night. In light of these comments and after further FAA review, proposed Secs. 23.1321(e), 25.1321(e), 27.1321(d), and 29.1321(g) are revised to require consideration of all probable cockpit lighting conditions with respect to the visibility of malfunction indicators."

Amendment 23-41 and Subsequent

A proposed revision to NPRM 89-6 explains this amendment as follows: *"This proposal would require those instruments used during certain maneuvers to be located such that minimum eye or head movement is needed to monitor the airplanes flight path and these instruments. Powerplant instruments for which the location requirements apply would be limited to those needed to set power within powerplant limitations. The proposed revision of paragraph (d) would extend the T-arrangement of flight instruments to include all small airplanes certificated for all flight under instrument flight rules. This revision also clarifies the rule relative to instrumentation that must be provided for each pilot required for type certification or by the applicable operating rules. If a pilot is required by any applicable requirement, then that pilot must be provided all instrumentation required for any operations for which the airplane is approved.*

Airplanes certificated to Part 23, in most cases, are certificated with only one required pilot. However, many of such airplanes subsequently enter Part 135 operations where two pilots are required. A significant function of the second required pilot is to monitor the airplanes flight path regardless of whether or not this second pilot is controlling the flight path. Therefore, this second pilot must have flight instruments available that are installed in accordance with all of the criteria of Part 23 and the affected operating rules, with specific emphasis on the requirements of Section 23.1321."

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this amendment as follows: *"The proposed revision to Sec. 23.1321(d) would remove the wording that limits the instrument location requirement to airplanes certificated for flight under instrument flight rules or airplanes weighing more than 6,000 pounds. Instruments are for the pilot and should be located near that pilots vertical plane of vision without regard to what flight rules are approved for the airplane's operation or the maximum weight of the airplane."*

23.1322 Warning, caution, and advisory lights

Policy is available in AC 23.1311-1A.

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.8.

Amendment 23-17 and Subsequent

A proposed revision to NPRM 75-10 added this rule with an explanation as follows: *"The use of lights as sources of information in airplanes is common practice. The FAA considers that standardization of the colors of these lights is an appropriate extension of cockpit standardization. Parts 27 and 29 currently contain color standards and it is proposed that further changes in those standards be made. One of these changes, of a clarifying nature, that should be noted is in the description of warning lights as contained in proposed paragraph (a). This proposal is one of four identical proposals affecting Secs. 23.1322, 25.1322, 27.1322, and 29.1322. These proposals provide standardized light requirements and also provide for approved variance from the colors specified for lights such as marker beacon lights, if found to be appropriate. It should be noted that the proposals also specify blue as the color for position indication, agreement, and correct response lights, blue being a color currently used successfully in service."*

Amendment 23-17 was revised by Final Rule, Docket 14324, to add the following: "in the cockpit" in the heading and removed the proposed requirement for blue lights. The explanations in the final rule are: "One commentator suggested a clarification of the lead-in of the proposal to limit its applicability to lights installed in the cockpit as indicated in the explanation to the proposal. The FAA agrees, and the lead-ins of Secs. 23.1322, 25.1322, 27.1322, and 29.1322 have been clarified" and "The commentator noted that requiring a blue light for position indication was not always appropriate since blue was difficult to see in direct sunlight but was readily distinguishable in heavily shaded installations. The FAA agrees that blue should not be an established standard applicable to all installations. Therefore proposed Secs. 23.1322(d), 25.1322(d), 27.1322(d) and 29.1322(d), concerning blue lights, are withdrawn."

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"This proposal is addressed in conference proposal 438. It requires that the specific colors be consistent with change in brightness over the full range of ambient light conditions in the cockpit and that the luminance difference and/or color difference be sufficient to preclude confusion or ambiguity under all probable cockpit lighting conditions. Light color is not controlled by a lens color cathode ray tube (CRT) displays now being incorporated into airplanes. Cockpit lighting evaluations are required in Section 23.1321 and clarification if needed in this section to assure compliance with these requirements."*

This amendment clarifies Final Rule, Docket 26344 as follows: *"This proposes to amend Sec. 23.1322 to require the warning, caution, and advisory lights to be effective under all probable cockpit lighting conditions. One commenter recommended the words "all probable cockpit lighting conditions" be revised to "all normal cockpit illumination." The reason given for the recommendation is that the proposed words could include the need to consider a blinding lightning flash.*

The FAA disagrees. If conditions exist where a "blinding" lightning flash occurs, none of the lights will be visible while the pilot(s) are blinded and this would not be considered to be a probable light condition. The lights should be evaluated for the lighting conditions that will occur immediately after that flash to ensue that, as quickly as vision is restored after the exposure to the blinding flash, they will provide effective warnings, cautions, and advisories. As noted in the NPRM, these lights need to be consistent over a full range of ambient light conditions. The words used in this proposal describe the need to evaluate the lights over this range of light conditions. One commenter supports the proposal. This proposal is adopted as proposed."

See AC 23.1311-1A for additional guidance for electronic displays.

23.1323 Airspeed indicating system

The corresponding rule in CAR 3 is CAR 3.663.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.9.

Original Issue and Subsequent

Part 135, Operating Requirements: Commuter and On-Demand Operations, requires that IFR airplanes have a heated pitot tube for each airspeed system. In consideration of a four-pound bird strike, the minimum distance between pitot tubes that can be accepted is 14 inches, measured in a straight line.

Amendment 23-7 and Subsequent

A proposed revision to NPRM 67-14 changed five MPH to five knots with an explanation as follows: *"Nautical units of speed and distance. Consistent with the gradual transition from statute miles to nautical miles being made throughout the Federal Aviation Regulations, it is proposed, in addition to certain specific changes made in this notice, to amend Part 23 by changing all references to "miles" and "miles per hour," to "nautical miles" and "knots," respectively, wherever the former are used."*

Amendment 23-17 is additionally explained by Final Rule, Docket 8083, as follows: *"The amendments are therefore adopted as proposed, using the following criteria: (1) Conversions from miles per hour to knots are rounded off to whole units to avoid fractions of a knot unless a more accurate measurement is necessary under the present rule, and (2) current requirements expressing extremely low airspeeds such as 5 or 10 miles per hour, are not changed numerically (such as to 4 or 9 knots, respectively) since the substantive difference in these cases is approximately 1 mile per hour and is not practically significant."*

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains this change to the amendment as follows: *"Proposed Sec. 23.1545(a) would require airspeed limitation marks be located at the corresponding indicated airspeeds instead of at the calibrated airspeeds, thereby providing a more useful indicator dial for operation of the airplane. However, to ensure uniformity, it is also proposed to revise Sec. 23.1323 to require that the airspeed instrument be calibrated according to the standard relationship between pressure and airspeed. (See the proposal for Sec. 23.1323.) The allowable airspeed system error would then include position error, but exclude the airspeed instrument calibration error, consistent with Part 25. The airspeed* *range for calibration, as set forth in proposed Sec. 23.1323, would encompass the airspeed limitations in proposed Sec. 23.1545(a).”*

Indicated airspeed was changed to calibrated airspeed in Amendment 23-20 by Final Rule, Docket 14625, based on the following: *“Another commentator (who concurred with the intent of the proposal to revise Section 25.1323) questioned whether the allowable error, in proposed Section 23.1323(b), should be expressed in terms of calibrated airspeed rather than indicated airspeed and whether the airspeed ranges specified in proposed Section 23.1323(b)(1) and (b)(2) were unnecessarily severe accuracy requirements. The FAA agrees that the error allowed by proposed Section 23.1323(b) should be expressed in terms of calibrated airspeed to be in accord with normal practices. However, the FAA believes that the airspeed ranges in proposed Secs. 23.1323(b)(1) and (b)(2) are needed to encompass the airspeed limitations in proposed Section 23.1545. The FAA also believes that, as a practical matter, the accuracy requirements in proposed Section 23.1323 are not significantly more restrictive than the current requirements.”*

Amendment 23-34 and Subsequent

See AC 23-8B, “Flight Test Guide for Certification of Part 23 Airplanes,” for additional guidance.

A proposed revision to NPRM 83-17 added commuter category rules based on the following: *“Part 135, App. A., Sec. 13(b) and (d).”*

Amendment 23-42 and Subsequent

This amendment added the requirement for a heated pitot tube when a plane is approved for flight in instrument meteorological conditions or flight into known icing conditions. The NPRM states the following: *“Maintaining a functional and accurate airspeed system is essential to safe and reliable control of an airplane in instrument meteorological conditions and flight in icing conditions.”* The proposal was considered necessary as a minimum airworthiness standard when the above operations in the airplane are to be approved. Therefore, the use of a drain trap/sump in meeting the requirement for a positive means of drainage is allowable, but an applicant must consider a failure condition of an overflowing trap/sump that causes misleading readings of airspeed. Waiting for an airspeed error to occur from excess moisture is not acceptable for an airplane approved for flight in instrument meteorological conditions or flight in icing conditions.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this change to this amendment as follows: *“The proposed new Sec. 23.1323(c) would add a requirement that each* *airspeed indicating system design and installation should provide positive drainage of moisture from the system. This proposal is consistent with the provisions required for a static system by Sec. 23.1325(b).*

If moisture enters, or accumulates in, an airspeed indicating system, that moisture could cause erroneous airspeed indications or the complete loss of airspeed information. The resulting loss of accurate airspeed information would be hazardous to the operation of the airplane; therefore, to assure the safety of the airplane, the FAA would need to apply the more general airworthiness requirements of Secs. 23.1301 and 23.1309 to such a system and require provisions for drainage of moisture. Accordingly, this proposed revision of the airspeed indicating systems requirements only clarifies the criteria that must be applied to airspeed indicating systems.

To better organize the requirements that are applicable to the airspeed systems on all airplane categories and those that would be additional requirements for the airspeed systems of commuter category airplanes, the FAA proposes to redesignate existing paragraphs (c) and (e), respectively, as paragraphs (e) and (d). By this redesignation, paragraphs (a), (b), (c), and (d) would apply to all airplanes, and paragraphs (e) and (f) would include additional requirements applicable to commuter category airplanes.

The proposal for redesignated paragraph (e) would also remove the words "in flight and" from the first sentence of that paragraph. This would remove the requirement for the airspeed indicating system to be calibrated in flight. The requirement for an in flight calibration is provided in paragraph (b). Proposed redesignated paragraph (e) would apply to the calibration needed to determine the system error during the accelerate-takeoff ground run.

As identified in the background section of this notice, the FAA is issuing additional notices that address proposed changes to the requirement for powerplant, flight, and airframe. Proposed revisions to subpart G in the flight NPRM include placing all of the requirements for what must appear in the AFM in that subpart. With the proposals to revise the AFM requirements, the flight NPRM also proposes that the requirement in existing Sec. 23.1323(d) (to show the relationship between IAS and CAS in the AFM) be added to Sec. 23.1587 as proposed new paragraph (d)(10). Because the AFM requirement would be added Sec. 23.1587, it no longer needs to appear in Sec. 23.1323. Accordingly, this notice proposes to remove the text of existing Sec. 23.1323(d).

Proposed new Sec. 23.1323(f) would provide that, on those commuter airplanes where duplicate airspeed indicators are required, the airspeed pitot tubes must be located far enough apart so that both tubes will not be damaged by a single bird strike."

23.1325 Static pressure system

The corresponding rule in CAR 3 is CAR 3.665.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.10.

Amendment 23-1 and Subsequent

This amendment is explained by Final Rule, Docket 1186, as follows: *"The notice of proposed rule making provided that the influence of airplane characteristics not seriously affect the accuracy of instruments having static pressure connections, further specified certain static system design and installation details, required a system proof test, and made provision for countering icing conditions.*

Section 23.1325(a) has been amended to specify that static pressure connections be vented so that external forces least affect instrument accuracy. This change relaxes the requirement of the notice and parallels the wording in the comparable section of Part 25.

Two commentators objected to proof testing the static pressure system in each production airplane. The rule, however, does not require test of each production airplane although that would be one way to demonstrate conformity to the approved type design. As suggested by another commentator, sample testing and production flight check could be another acceptable means of showing conformity if there were a showing of an adequate quality control system and compliance with the equipment function and installation requirements of Section 23.1301.

The Agency does not concur with various comments recommending that it adopt the Air Force static system leakage rate at an arbitrary specified altitude with associated instruments disconnected. Since many static system leaks occur at instrument disconnect points, it is considered that a realistic test for Part 23 airplanes should be made with the instruments connected. Section 23.1325(b)(2) has been amended, however, to allow a reasonable leakage loss tolerance with associated instruments connected at the airplane maximum operating altitude.

With regard to negating the effect of icing conditions, one commentator recommended deleting the requirement altogether in low-performance airplanes operating under VFR conditions. Two other commentators recommended that a protected alternate source of static pressure be allowed, while a fourth recommended use of an optional ice-free static pressure source of less accuracy where calibration is given the pilot.

Since static vent icing may occur during both VFR and IFR conditions with hazardous consequences, the Agency believes there is ample justification for anti-icing as a certification requirement on all airplanes employing a static pressure *system for required instruments. In response to the comments, the proposed rule has been expanded to permit the use of an alternate static source having a prescribed accuracy tolerance, and, where needed, a correction card."*

Both VFR and IFR airplanes should meet the requirements of § 23.1325 in paragraph (b)(3) of this regulation because static vent icing can occur during both VFR and IFR conditions with hazardous consequences. The rule provides for either an anti-icing means or an alternate static source as follows:

a. If installed, the alternate static source is not restricted to emergency conditions but may be used to monitor the primary static system.

b. We suggest marking the secondary static source with the word "Alternate."

c. This rule also requires a correction card in the cockpit if the altimeter changes by more than 50 feet on the alternate source. The correction card does not need to be in clear view of the pilot as long as it is available to a pilot seated in the flight position. An acceptable means for alternate-static-source correction data is located in the performance section of AFMs with other airspeed and altimeter calibration graphs. A placard that the correction data is available in the performance section, which is noted in the limitations section of the AFM, may be provided for additional clarification. The alternate static source is separate, and its correction card should provide correction data for the alternate source only.

d. The alternate static source is subject to all parts of § 23.1325, as is the primary static source, except it may have reduced accuracy with compensation from a correction card.

See AC 20-124, "Water Ingestion Testing for Turbine Powered Airplanes," for guidance on testing the airspeed and static systems for water ingestion susceptibility.

Amendment 23-6 and Subsequent

A proposed revision to the NPRM 66-44 explains this rule as follows: *"One of the major objections to the current requirements is the 100-foot per minute leak rate specified in Secs. 23.1325(b)(2) and 25.1325(c)(2). In this connection, representatives of industry recognized that a 100-foot per minute leak rate at maximum cabin differential pressure would result in altitude errors of from 0 to 3 feet on most aircraft. Furthermore, on many aircraft, the altitude error resulting from leak rates as high as 3,000 feet per minute at maximum cabin differential pressure would not exceed 20 feet. It was recommended that a leak rate equivalent to 2 percent of the maximum cabin differential pressure at the maximum cabin differential pressure is considered an adequate performance criteria for pressurized aircraft, while aircraft without cabin pressurization should have static systems with leak rates* *that do not exceed 100 feet per minute at a test pressure equivalent to 1,000 feet pressure differential. It was pointed out that the leak test should be considered a convenient and simple method of proving the integrity of the static pressure system and not a quantitative test of the system error. The Agency agrees with these comments and changes to the leak rate requirements of Secs. 23.1325 and 25.1325 consistent with the recommendations are proposed herein.*

In addition to the foregoing, it is also proposed to change the requirements of Sec. 23.1325 to require that a correction card be provided if the altimeter indication on the alternate system differs by more than 50 feet from the altimeter indication on the normal system. The present requirement permits the use of a correction card if the reading of an altimeter on the alternate static pressure system exceeds a 2-percent tolerance. The Agency considers that this latter value is too small at low altitudes and too large at high altitudes."

The proposed rule was changed by Final Rule, Docket 7831, as follows: *"One commentator pointed out that the requirement that the proof tests of the static pressure systems on unpressurized aircraft be conducted with the static pressure system evacuated to a pressure differential based on an altimeter reading of 1,000 feet at sea level could be confusing to people located at elevations above 1,000 feet mean sea level. The FAA agrees and Secs. 23.1325(b) (2) (i) and 25.1325 (c) (2) (i) have been further amended to permit the proof test of unpressurized aircraft with the static pressure system evacuated to an altimeter reading of 1,000 feet above the airplane elevation at the time of the test. One commenter stated that the proposed Sec. 23.1325(b)(3) requirement for a correction card where altimeter readings on primary and alternate static systems differ by more than 50 feet, is too restrictive at high altitudes and high Mach numbers and suggested clarification as to the range of altitude and Mach numbers applying to this tolerance. However, the FAA believes that the proposed requirement is necessary to assure proper vertical separation considering the entire altitude-speed range. In the high Mach-high altitude regime, the static system accuracy may be marginal at best and errors introduced while on the alternate system could lead to hazardous operation if the pilot is not informed of the magnitude of the error. In the low speed-low altitude regime, static system errors are minimized so that correspondence between the two systems should pose no problem."*

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-10 explains this amendment as follows: *"The proposal would provide more complete duality of static pressure sources if both primary and alternate sources are installed. Service experience, however, indicates no need for an additional requirement that the selector be secured in the primary source position."*

Amendment 23-34 and Subsequent

See AC 23-8B, "Flight Test Guide for Certification of Part 23 Airplanes," for additional guidance.

This amendment added commuter category requirements from *"Part 135, Appendix A., section 14."*

Amendment 23-42

Paragraph (g) was added. For airplanes specifically prohibited from flight in instrument meteorological conditions and icing conditions in accordance with § 23.1559(b) of this part, paragraph (b)(3) of this section does not apply.

This proposal would allow airplanes that are specifically prohibited from flight in instrument meteorological conditions and IFR icing conditions to be certificated without an alternate static air source.

A proposed revision to NPRM 89-5 explains Amendment 23-42 as follows: *"The FAA reviewed the rationale supporting the requirements in Sec. 23.1325(b)(3) that "each static pressure port must be designed or located in such a manner that the correlation between air pressure in the static pressure system and true ambient pressure is not altered when the airplane encounters icing condition," and "an anti-icing means or an alternate source of static pressure may be used in showing compliance with this requirement."* The primary concern was that airframe ice accumulation would disturb airflow in the vicinity of static port(s) causing errors in the static pressure systems and altimeter indications.

The need for such a requirement, as stated in Notice 64-14 (29 FR 3310, March 12, 1964) was based on IFR operations at higher airspeeds and altitudes above 14,500 feet. The purpose was *"to increase safety and improve airspace utilization"* (vertical separation of air traffic).

In the case of an airplane certificated for flight in IFR conditions, an applicant can show compliance without flying the airplane in icing conditions; e.g., if the airplane were equipped with a pitot-static probe, anti-icing would be appropriate. If the airplane had static pressure ports installed on the fuselage an alternate static pressure source would suffice.

Under the present requirements, an airplane limited to approval for flight in VFR conditions must meet a requirement intended to provide better vertical separation for airplanes flying in IFR conditions or icing conditions at altitudes above 14,500 feet. Section 23.1325(b)(3) requires that all small airplanes, including an airplane, which isn't required to have a sensitive altimeter or a heated pitot, must either be tested in icing conditions or show compliance by means of a heated static pressure source or an alternate static pressure source.

In view of the above, it is considered inappropriate to continue to impose a requirement for an alternate static source or a means for anti-icing the static source on airplanes specifically prohibited from flight in IFR or icing conditions. It is considered unlikely that a midair collision could be caused by the altitude error in an airplane flying VFR that inadvertently enters icing conditions. Continued flight in such conditions cannot be sustained for long periods of airplanes without anti-icing or deicing equipment and most airplanes certificated for VFR only do not fly above 14,500 feet. Furthermore, an FAA review of incidents of static system malfunction in VFR icing conditions for the past five years showed no reported incidents or accidents."

Amendment 23-49 and Subsequent

Static pressure system icing was addressed in Amendment 23-49 as follows: "Current Sec. 23.1325(b)(3) establishes certain static pressure system requirements for airplanes that encounter icy conditions. Current Sec. 23.1325(g) exempts from the requirements of (b)(3) airplanes that are prohibited from flight in instrument meteorological conditions in accordance with Sec. 23.1559(b). After the adoption of Sec. 23.1325(g), it came to the FAAs attention that there are conditions other than instrument meteorological conditions where icing may be encountered and, therefore, that this paragraph should also exempt from the provisions of Sec. 23.1325(b)(3) airplanes that are prohibited from flight in icing conditions. Accordingly, Sec. 23.1325(g) would be revised to read, "For airplanes prohibited from flight in instrument meteorological or icing conditions."

Amendment 23-50 and Subsequent

A proposed revision to NPRM 94-22 explains this amendment as follows: *"This proposal would revise Sec. 23.1325 (e) to clarify that the calibration must be conducted in flight, which is standard practice. The text of Sec. 23.1325 (f) would be removed and the paragraph would be reserved. The text of paragraph (g) would be moved to paragraph (f) in a future rulemaking action. The results of the calibration would be required in the proposed Sec. 23.1587."*

23.1326 Pitot heat indication systems

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this rule as follows: *"Due to advancements in technology, many part 23 airplane installations now utilize equipment whose data sources are critical to the accurate and dependable operation of that equipment. The heated pitot tube is one such data source. The pitot heat indicating system will advise the pilots of any inoperative heating element in the pitot tube and that subsequent inaccuracies may result.*

Part 23 airplanes certificated for flight under instrument flight rules or for flight in icing conditions are required by current Sec. 23.1323(e) to have a heated pitot system or an equivalent means of preventing an airspeed indicating system malfunction due to ice accumulation. This proposal would require such airplanes equipped with a heated pitot tube to be equipped with a pitot tube heat indicating system. This requirement will provide greater assurance that the pilots will not be dangerously misled by faulty flight instrument indications caused by pitot tube icing.

When pitot tube heat indicating system requirements were added to part 25, the FAA noted the occurrence of at least one accident and several incidents in which an airspeed indicating error occurred that might have been avoided if a pitot tube heat indicating system had been installed. Part 23 airplanes operate at lower airspeeds and over shorter distances that do part 25 airplanes; therefore, their exposure to moisture and temperature conditions where icing may occur is higher than it is for transport category airplanes. Because of this environmental exposure, the potential for an inoperative heated pitot tube becoming a hazard to part 23 airplanes is greater."

This rule requires a caution annunciation whenever the pitot heat is off or there is a failed heating circuit in the pitot tube heater. The second annunciation cause is fully justified in that it represents a failure condition. The first can have a positive safety effect if it causes pilots to activate the pitot heat in all environmental conditions. This eliminates the loss of the pitot static system due to the pilot error of failing to operate pitot heat when conditions warrant it.

A caution annunciation when the pitot heat is off has two negative issues as follows:

(1) It violates the "dark cockpit" where caution and warning lights only represent failure conditions; and

(2) Adherence to a "dark cockpit" will cause pitot heat operation in all environmental conditions, which will shorten the life of the system.

The Small Airplane Directorate is proposing rulemaking to delete § 23.1326(b)(1) (the requirement for a caution annunciation when the pitot heat is off). An aircraft design that does not include a caution annunciation when the pitot heat is off may be eligible for an ELOS finding that preserves a "dark cockpit" provided a placard or flight manual prescribes when to operate the pitot heat.

23.1327 Magnetic direction indicator

The corresponding rule in CAR 3 is CAR 3.666.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.11.

Original Issue and Subsequent

If the magnetic compass that is required by § 23.1303 is the only heading instrument, then it should meet the requirements of this section. With an approved secondary system such as a directional gyro, and with an appropriate placard to dictate which electrical devices should be switched off when reading the magnetic compass, per § 23.1547, equivalent safety pursuant to part 21, § 21.21(b)(1) may be shown.

Regarding magnetic direction indicators, heading information is considered an essential flight instrument function because its loss could result in reduced capability of the flight crew to cope with adverse operating conditions, especially for IFR flights. The indicator specified in this rule was intended to be a magnetic compass (non-stabilized). The requirement for a magnetic direction indicator existed before remote indicating compasses were available. If a magnetic stabilized direction indicator is installed as an additional instrument, the magnetic non-stabilized direction indicator (magnetic compass) is still required as the primary source of magnetic direction.

a. A magnetic direction indicator with remote magnetic sensor can be approved under § 21.21 of part 21 if it can be substantiated that it provides a level of safety equal to that provided by the magnetic compass required by § 23.1303(c). The reliability of the system should consider the effects of loss of the airplanes electrical system, the performance of the equipment under environmental conditions that may be encountered by the airplane, the integrity of the interface wiring, and the reliability of the components.

b. For a magnetically stabilized direction indicator approved under an ELOS finding, the system should be powered from a source that is independent of a single electrical generating system. This other source should be installed so that it is operative without manual selection after total failure of a single electrical generating system. Dual independent stabilized indicator installations with split electrical bus systems may also be approved on multiengine airplanes under an ELOS finding. The airplanes battery is not considered an acceptable source unless the state of charge of the battery is displayed to the pilot.

c. The following installation requirements of §§ 23.1327 and 23.1547 are also directly related to approval of either type of magnetic indicator:

(1) The accuracy is not excessively affected by the airplanes vibration or magnetic fields.

(2) Deviations of more than 10 degrees in level flight are not permissible, unless a magnetic stabilized direction indicator, which does not have a deviation in level flight greater than 10 degrees on any heading, or a gyroscopic direction indicator, is installed. If a gyroscopic direction indicator is installed, it is subject to compliance with § 23.1301 in that it must perform its intended function. It must, therefore, meet the accuracy requirements of TSO-C5, which represent the minimum allowable performance for gyroscopic direction indicators.

(3) A placard should show the calibration of the instruments in level flight with the engine(s) operating and whether the calibration was made with the radio receivers on or off.

(4) If deviations of more than 10 degrees caused by operation of electrical equipment are approved, the placard should state which electrical loads or combination of loads would cause deviations of more than 10 degrees.

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains this amendment as follows: *"This proposal would allow deviation (exceeding 10 degrees) in a magnetic nonstabilized direction indicator caused by operation of electrically powered systems if the airplane is equipped with another direction indicator that meets the standard specified in paragraph (b) and the airplane is placarded in accordance with proposed Sec. 23.1547(e). Under these conditions, safety would not be adversely affected."*

The proposed rule, revised by Final Rule, Docket 14625, is explained as follows: "One commentator objected to the proposal to amend Section 23.1327 on the ground that it would allow an indefinite amount of interference, which would confuse the pilot. The FAA believes that the placard that would be required by proposed Section 23.1327(c) would serve to alert the pilot to the fact that certain electrical loads, when switched on, cause excessive deviations of the magnetic nonstabilized direction indicator. The commentator further stated that if an additional magnetic direction indicator (having a deviation less than 10 degrees) were installed, there would no longer be a need for the magnetic nonstabilized direction indicator. The FAA agrees that an additional magnetic nonstabilized direction indicator is not a practical alternative, and proposed Section 23.1327 is revised to delete that alternative. However, the FAA believes that the proposed exception is appropriate for those instances in which a magnetic stabilized direction indicator or gyroscopic direction indicator is installed along with a magnetic nonstabilized direction indicator. The commentator also contended that the gyroscopic direction indicator *alternative is not a practical solution because it must be reset frequently, thus increasing the pilots workload. The FAA does not believe that the need to periodically reset the gyroscopic direction indicator adds significantly to the pilot's workload. Finally, this commentator stated that proposed Section 23.1327(c) would allow interference that is contrary to current Secs. 23.1327(a) and 23.1301(a)(4). With respect to current Section 23.1327(a), the FAA believes the comment is valid, and that paragraph is revised for clarification. In view of this change, the requirements in current Section 23.1327(a) and proposed Section 23.1327(b) are combined into Section 23.1327(a), and proposed Section 23.1327(c) is redesignated Section 23.1327(b). With respect to current Section 23.1301(a)(4), the FAA does not believe the comment is valid, since the system consisting of a magnetic nonstabilized direction indicator and either a magnetic stabilized type or a gyroscopic type would meet that requirement."*

23.1329 Automatic pilot system

The corresponding rule in CAR 3 is CAR 3.667.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.12.

Original Issue and Subsequent

A single malfunction may not result in a hardover signal in more than one axis. When the result of any single malfunction is shown not to be hazardous (no hardover signals) (slowover signals are acceptable if they are determined to be easily controllable without requiring exceptional skill or strength), then multiple axes being affected is acceptable providing the following:

a. The malfunction evaluations are acceptable even with the maximum drive signal due to the limited rate of change authority of the powered controlling element and flight control surfaces,

b. The monitor/limiting device is independent of the automatic pilot element,

c. The signal is less than the hardover signal due to the monitor/limiting device; and

d. An acceptable fault analysis shows the functional hazard of a combined monitor failure and automatic pilot malfunction is not catastrophic, including the following:

(1) The functional hazard of a failure of a lockout device/system to inhibit autopilot engagement until the pre-engagement check is successfully completed is hazardous or less,

(2) Pre-engagement check of the monitor system is mandatory with either a manual or automatic activation means, and,

(3) Automatic pilot authority is not greater than necessary to satisfactorily control the airplane.

Alterations of increased engine horsepower (and either engine horsepower or major changes in exterior cowlings and surfaces, etc.), in part 23 airplanes, should consider the compatibility of the autopilot system with the increased horsepower, since the malfunction and performance tests of the autopilot are conducted with a defined amount of engine power. Generally, an increase in engine horsepower beyond 10 percent may adversely affect the autopilot system malfunctions, performance, controllability, and longitudinal stability characteristics. Therefore, flight testing may be necessary to verify that the original approval of the autopilot system is still valid.

a. The results of malfunction testing determine which flight condition is most critical. The effects of autopilot runaways are more pronounced at aft CG. Furthermore, the phase of flight with the largest contribution to adverse conditions varies with airplane model.

b. Airplane longitudinal stability is a factor in autopilot system malfunctions. Generally, there is an inverse relationship between engine horsepower and longitudinal stability. Although the turbine engine installations replacing reciprocating engines may be flat rated, the turbine is capable of producing increased horsepower at higher temperatures and altitudes, which could reduce longitudinal stability. Therefore, autopilot performance, especially the pitch axis hardover malfunction, should be evaluated for acceptability. This policy is also applicable to power increases on airplanes with reciprocating engines, either engine replacement or engine modifications that add a turbocharger.

c. Performance and controllability evaluations should be considered, including the configuration of most forward CG and minimum autopilot authority. This configuration is used to demonstrate that the airplane can be safely controlled by the autopilot when the control surface hinge moment is the highest and the autopilot controllability is at its lowest during corresponding longitudinal trim and airspeed changes.

To show compliance with part 23, § 23.1329, applicable to autopilot system installations in small airplanes, the following is acceptable.

1. RELATED REGULATIONS AND DOCUMENTS

a. Regulations

These acceptable means of compliance refer to certain provisions of part 23. They may be used in showing compliance with the corresponding provisions of the former CAR in the case of airplanes to which the CAR regulations are applicable. For convenience, the part 3, section reference is shown in parenthesis following the part 23 section reference:

§ 23.143 (3.106)	Controllability and Maneuverability, General.
§ 23.253	High speed characteristics.
§ 23.395 (3.231)	Control system loads.
§ 23.397 (3.212)	Limit control forces and torques.
§ 23.689 (3.345)	Cable systems.
§ 23.777 (3.384)	Cockpit controls.
§ 23.779 (3.384)	Motion and effect of cockpit controls.
§ 23.1301 (3.651 and 3.652)	Function and installation.
§ 23.1309	Equipment, systems, and installations.
§ 23.1321 (3.661 and 3.662)	Arrangement and visibility.

§ 23.1322	Warning, caution, and advisory lights.
§ 23.1329 (3.667)	Automatic pilot system.
§ 23.1351 (3.681)	Electrical Systems and Equipment, General.
§ 23.1381 (3.696 and 3.697)	Instrument lights.
§ 23.1431 (3.721)	Electronic equipment.
§ 23.1555 (3.762, 3.763, and 3.765)	Control markings.
§ 23.1581 (3.77)	Airplane Flight Manual and Approved Manual Material, General.
§ 23.1583 (3.778)	Operating limitations.
§ 23.1585 (3.779)	Operating procedures.

b. Advisory Circulars

AC 21-16D	"RTCA Document DO-160D", July 21, 1998.
AC 23.1309-1C	"Equipment, Systems, and Installations in Part 23 Airplanes", March 12, 1999.

c. Technical Standard Order (TSO)

TSO-C9c	"Automatic Pilots", September 15, 1960.

d. Industry Documents

RTCA/DO-160D	"Environmental Conditions and Test Procedures for Airborne Equipment", July 29, 1997.
RTCA/DO-178B	"Software Considerations in Airborne Systems and Equipment Certification", December 1, 1993.

2. BACKGROUND

AC 23.1329-1, "Automatic Pilot Systems Approval," which set forth an acceptable means for showing compliance with the autopilot installation requirements, was issued December 23, 1965. Although AC 23.1329-1 was inadvertently cancelled in 1977, criteria essentially equivalent to that contained therein continued to be used to show compliance with the applicable autopilot installation requirements. AC 23.1329-1 was canceled by incorporation into this AC. The airworthiness regulations prescribe the requirements for autopilot installation approval. The following criteria have been applied and found reasonable and acceptable in previous type certification programs for complying with specific sections related to these approvals:

a. Compliance with the regulations necessitated the conversion of the force exerted by one pilot to overpower an engaged autopilot into measurable terms when either an autopilot quick disconnect or interrupt switch was **not** provided. The values in the table under § 23.143 are maximums. There may be circumstances where a maximum force less than 75 pounds is required for safety. For example, if a pilot is trying to overpower a nose-up malfunction during climb and reduce power at the same time, a maximum safe force may be less than 75 pounds. Consequently, these forces, as measured at the pilots' controls, were equated to the following temporary and prolonged forces:

(1) The maximum temporary force to overpower the autopilot has not been allowed to exceed 30 pounds in roll (force applied at the rim of the wheel), 50 pounds in pitch, and 150 pounds in yaw. These forces are applicable only to initially overpowering the autopilot system.

(2) The maximum prolonged force to overpower the autopilot should not exceed five pounds in roll, 10 pounds in pitch, and 20 pounds in yaw.

b. A reasonable period of time has been established for pilot recognition between the time a malfunction is induced into the autopilot system and the beginning of pilot corrective action following hands-off or unrestrained operation. The following time delays have been acceptable:

(1) A three-second delay following pilot recognition of an autopilot system malfunction, through a deviation of the airplane from the intended flight path, abnormal control movements, or by means of a reliable failure warning system in the climb, cruise, and descent flight regimes.

(2) A one-second delay following pilot recognition of an autopilot system malfunction, through a deviation of the airplane from the intended flight path, abnormal control movements, or by means of a reliable warning system, in maneuvering and approach flight regimes.

3. ACCEPTABLE MEANS OF COMPLIANCE

The following procedure, in accordance with the forces and times above, is acceptable as a means of showing that an autopilot system installation is in compliance with the airworthiness rules:

a. Cockpit Controls

Evaluation of cockpit controls should include the following:

(1) The location of autopilot system controls should be readily accessible to the pilot, or both pilots, if a minimum of two pilots is required.

(2) Annunciators should conform to the proper color as specified in § 23.1322.

(3) A determination that the controls are usable under bright sunlight and night lighting conditions (§ 23.1381).

(4) **Either** a quick disconnect or interrupt switch for the autopilot system are located on the side of the control wheel opposite the throttle(s) and are red in color. A disconnect switch stops all movement of the autopilot system. An interrupt switch momentarily interrupts all movement of the autopilot system.

(5) A determination that any automatic disconnects of the autopilot is adequately annunciated by an aural warning. If warning lights are utilized to supplement the aural warning, they should meet the requirements of § 23.1322. Use of a visual warning as the sole means of annunciating automatic disconnects is not considered acceptable.

(6) Motion and effect of autopilot cockpit controls should conform to the requirements of §§ 23.1329(c) and 23.779.

b. Malfunction Evaluations

(1) Malfunction evaluation flights should be conducted with the airplane loaded at the most critical weight or the most critical CG/weight combination. Maximum untrimmed fuel imbalance should be considered during the evaluation. If autothrottles are installed, they should be operating, and autopilot servo torque should be set to the upper tolerance limit. The simulated malfunctions should be induced at various airspeeds and altitudes throughout the airplanes airspeed and altitude envelopes. These envelopes should include the maximum operating altitude for turbocharged or high altitude airplanes, or be within 10 percent of the service ceiling for normally aspirated airplanes, and when the airplane is stabilized in the normal operational attitudes. Vertical gyro mechanical failures should not be considered. The simulated failures and subsequent corrective actions are not acceptable if they result in any of the following:

(i) Loads that exceed the substantiated structural design limit loads.

(ii) Acceleration that is outside the 0 to 2g envelope. The positive "g" limitation may be increased up to the positive design limit maneuvering load factor if it has been previously determined analytically that neither the simulated failure nor subsequent corrective action would result in loads beyond the design limit loads of the airplane.

(iii) Speeds in excess of V_{NE} or for airplanes with an established V_{MO}/M_{MO}, a speed midway between V_{MO}/M_{MO} and the lesser of V_D/M_D, or the speed demonstrated under § 23.253.

(iv) Deviations from the flight path including bank angle in excess of 60 degrees or pitch attitude in excess of $\pm$ 30 degrees deviation from the attitude at which the malfunction was introduced.

(v) A hazardous dynamic condition.

(2) Normal Flight Malfunctions

The airplanes performance should be evaluated when the effect caused by the most critical single failure condition that can be expected to occur to the system and can be detected by the pilot is induced into the autopilot system. Hidden or latent failures, in combination with detectable failures, should be considered when determining the most critical failure condition. Normal flight includes climb, cruise, and descent flight regimes with the airplane properly trimmed in all axes. Airplane configurations (combinations of gear and flaps), speeds, and attitudes should be evaluated for unsafe conditions. The more critical of the following simulated malfunctions are the following:

(i) A simulated malfunction about any axis equivalent to the cumulative effect of any failure or combination of hidden failures, including manual-electric or automatic trim, if installed.

(ii) The combined signals about all affected axes, if multiple axis failures can result from the malfunction of any single component. Since Amendment 3-2 to part 3 of the CAR, effective August 12, 1957, the requirements are that an autopilot system should be designed so that a single malfunction will not produce a hardover signal in more than one control axis (reference §§ 3.667(e) and 23.1329(e)).

NOTE 18: A three-second delay following pilot recognition of an autopilot system malfunction, as indicated in item 2b(1), should be applied for normal flight malfunction evaluations.

(3) Maneuvering and Approach Malfunction

Maneuvering flight tests should include turns with the malfunction induced at the maximum bank angle for normal operation, up to and including the autopilot authority limits. Airplane configurations (combinations of gear and flaps), airspeeds, and altitudes should be evaluated to determine if unsafe conditions exist. Simulated malfunctions described for normal flight malfunctions as indicated in items 3b(2)(i) and (ii) (titled, “Normal

Flight Malfunctions") are applicable for introduction during maneuvering flight malfunction evaluation. The resultant accelerations, loads, and speeds should be within limits described for normal flight malfunctions. Malfunctions introduced during coupled approaches should not place the airplane in a hazardous attitude or an attitude that would prevent the pilot from conducting a missed approach or safe landing. Altitude losses resulting from the simulated malfunctions are to be measured accurately and presented in the limitations section of the AFM or approved manual material. In maneuvering and approach flight regimes, the pilot should recognize an autopilot system malfunction within one-second. This recognition should occur as the result of a deviation of the airplane from the intended flight path, abnormal control movements, or by means of a reliable warning system that is applied.

NOTE 19: Accurate measurement of altitude loss, due to an autopilot malfunction during an instrument landing approach, is essential. This altitude loss during a critical phase of flight provides the basis for establishing the minimum approach altitude during autopilot-coupled approaches. The loss should be determined by measuring from the altitude at which the malfunction is induced to the lowest altitude observed during the recovery maneuver, unless instrumentation is available to measure the vertical deviation from the intended glide path to the lowest point in the recovery maneuver. In this section, Appendix 1 contains a method of measurement for approach altitude loss. Altitude losses due to malfunctions in other flight regimes, though less critical, may be determined by measuring the deviation from the flight path in a manner similar to that used for the glide slope.

(4) Alternate Means of Compliance for Autopilots Incorporating Electronic Monitors/Limiting Devices

Listed below are alternate means of compliance. These alternate means cite considerations for evaluating both monitors and limiting devices when functioning of such devices is necessary to prevent the airplane from exceeding the malfunction limits identified in paragraph 3b(1) of this AC.

(i) Alternate Means No. 1

(A) Monitor/Limiter Inhibited

With the monitor/limiter inhibited, autopilot malfunction flight testing may **not** cause any of the following:

(1) Roll to exceed 80 degrees.

(2) Pitch to exceed +45 degrees, -35 degrees.

(3) Accelerations outside the 0g to 2.5g envelope.

(4) Airspeed exceeding V_{NE} or for an airplane having an established V_{MO}/M_{MO}, a speed not greater than a speed midway between V_{MO}/M_{MO} and the lesser of V_D/M_D or the speed demonstrated under § 23.253.

(B) Reliability and Prerequisite Criteria

(1) A fault analysis should show that the failure effect of a monitor failure, combined with an autopilot malfunction, is less than major; and

(2) Pre-engagement check of the monitor is mandatory. No credit is allowed for a pilot-activated pre-engagement check unless there is a lockout device or system.

(ii) Alternate Means No. 2

(A) Monitor/Limiter Inhibited

With the monitor/limiter inhibited, autopilot malfunction flight testing may **not** cause any of the following:

(1) Roll to exceed 80 degrees.

(2) Pitch to exceed +45 degrees, -35 degrees.

(3) Accelerations outside the -0.2g to 2.5g envelope.

(4) Airspeed exceeding V_{NE} or for an airplane having an established V_{MO}/M_{MO}, a speed not greater than a speed midway between V_{MO}/M_{MO} and the lesser of V_D/M_D or the speed demonstrated under § 23.253.

(B) Reliability and Prerequisite Criteria

(1) An acceptable fault analysis showing that the failure effect of a combined monitor failure and an autopilot malfunction is less than hazardous. In addition, the failure effect of failure of a lockout device to inhibit autopilot engagement, as identified in Item (3) below, is less than major;

(2) Pre-engagement check of the monitor is mandatory with either a manual or automatic activation means; and

(3) Autopilot engagement is inhibited until pre-engagement check is successfully completed.

(iii) Alternate Means No. 3

(A) Flight tests with monitors inhibited are not required.

(B) Reliability and prerequisite Criteria

(1) An acceptable fault analysis showing that the failure effect of a combined monitor failure and autopilot is less than catastrophic. In addition, failure of a lockout device/system to inhibit autopilot engagement, as identified in item (3) below, is less than hazardous;

(2) Pre-engagement check of the monitor is mandatory with either a manual or automatic activation means;

(3) Autopilot engagement inhibited until the pre-engagement check is successfully completed; and

(4) Autopilot authority not greater than necessary to satisfactorily control the airplane.

c. Recovery of Flight Control

Evaluate the ability to recover flight control from the engaged autopilot system either by manual use of a quick disconnect or by physically overpowering the system.

d. Performance Flights

Performance evaluation tests should be conducted with the airplane loaded to its most adverse CG and weight condition. Autopilot performance with the servo torque values at the lowest production torque tolerance limit should be used to demonstrate safe controllability and stability. Flight tests are necessary to ensure the autopilot system performs its intended function, including all modes of operation presented for approval (reference § 23.1301).

e. Single-Engine Approach

For multiengine airplanes, an engine failure during a normal Instrument Landing System (ILS) approach should not cause a lateral deviation of the airplane from the flight path at a rate greater than three degrees per second or produce hazardous attitudes. This rate should be measured and averaged over a five-second period. If approval is sought for ILS approaches initiated with one engine inoperative, the autopilot should be capable of conducting the approach.

f. Airplane Flight Manual (AFM) Information

The following information should be placed in the AFM (or, if the airplane does not have an AFM, it should be placed in the Pilots Operating Handbook (POH) or presented to the pilot in the form of placards) as follows:

(1) In the operating limitations section, the airspeed limitations, maximum altitude for operation if different from the maximum certificated altitude of the airplane, category of ILS approaches for which approval is granted, minimum approach height, and any other applicable limitations.

(2) In the operating procedures section, the normal operating information, including navigation and glide slope intercept recommendations. For those autopilot systems, which incorporate either monitors or limiter devices, the pre-engagement procedures and the means of indicating that, the pre-engagement has been successfully completed.

(3) In the emergency operation procedures section

(i) A statement of the altitude loss in the cruise, climb, and descent configurations; and maneuvering flight conditions, due to possible malfunctioning of the autopilot system.

(ii) A statement of the altitude loss due to malfunctions while in the approach configuration. If engine inoperative approach is approved, the altitude loss should be included.

(iii) Any other procedure related to emergency procedures associated with either the autopilot or associated systems. (See Figure 1.)

Altitude Loss

1. Malfunction inducement point.
2. Malfunction recognition by pilot.
3. Initiation of manual recovery action by pilot.
4. Altitude loss with no instrumentation.
5. Altitude loss with instrumentation.

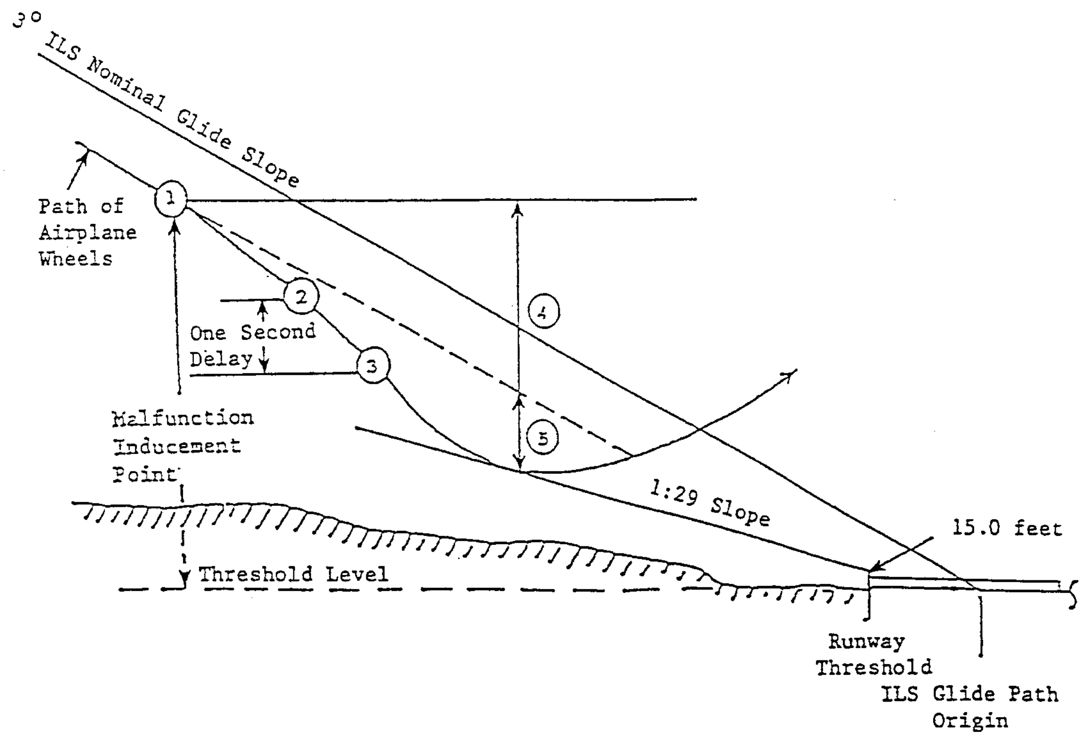


FIGURE 1. ACCEPTABLE METHOD FOR DETERMINING ALTITUDE LOSS IN APPROACH

FIGURE 1—CONTINUATION

Malfunction Evaluations. The airplane should be established on the ILS glide slope and localizer in the configuration(s) with the approach speed(s) specified by the applicant for approach. Simulated automatic flight control system malfunctions should be induced at critical points along the ILS taking into consideration all design variations and their limits in automatic flight control system sensitivity and authority. The malfunctions should be induced in each axis. While the pilots may know the purpose of the flight, they should not be informed when a malfunction is to be or has been applied except through a deviation of the airplane from the intended flight path, abnormal control movements, or by means of a reliable failure warning system. After a failure, recovery should be initiated one second after the pilot recognizes the failure.

a. A three-degree glide slope should be used for these tests in order to determine the malfunction effects to be expected in service.

b. For use during a coupled ILS approach, the automatic control system should not fail in such a way that it causes the airplane wheels to descend below a limit line lying below the glide slope, sloping upward at 29:l from a point 15 feet above the runway threshold. With the airplane established on the glide slope in approach configuration, at approach speed, the most critical malfunction is induced at a test altitude referenced to the runway threshold. Measure the altitude loss between the test altitude and the lowest point of the manual recovery, unless instrumentation is available to measure the vertical deviation from the intended glide path to the lowest point in the recovery maneuver. The altitude loss and the known distance to the threshold from the lowest recovery altitude are compared to the limit line. The lowest test altitude, from which malfunction and manual recovery can be completed, without the airplane wheels descending below the limit line, is considered the minimum height for use of the automatic flight control system.

c. Recovery from all malfunctions should be demonstrated either by overpowering or by manual use of an emergency quick disconnect device after the appropriate delay. The pilot should be able to return the airplane to its normal flight altitude under full manual control without exceeding the defined limits.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 added a requirement for a quick release explained as follows: *"This proposal would standardize the location of the quick release (emergency) control for autopilot systems. Standardization permits consistency of pilot responses in preventing hazardous airplane attitudes during autopilot malfunctions. The location specified is consistent with the requirements for part 25 airplanes, except this proposal allows the control to also be located on a stick control."*

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 clarified the quick release rule explained as follows: *"New Sec. 23.1329(b), adopted by Amendment No. 23-24 (58 FR 18958, April 9, 1993), does not state clearly that stick controlled airplanes must be equipped with the same autopilot quick release controls that are required for airplanes with control wheels. This proposed revision of Sec. 23.1329(b) would clarify that a quick release control must be installed on each control stick of an airplane that can be operated from either pilot seat."*

23.1331 Instruments using a power source

The corresponding rule in CAR 3 is CAR 3.668.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.14.

Original Issue and Subsequent

Paragraph (a) in § 23.1331 applies only to gyroscopic instruments, but paragraph (b) in this section applies to any instrument that depends on external power or external energy for proper operation.

The requirement for two independent power sources in paragraph (b)(1) in § 23.1331 applies to either vacuum or electrically driven gyroscopic instruments.

NOTE 20: Section 23.1331 does not apply to pitot and static systems.

Electrical Systems

When complying with paragraph (b) in this section, a single battery required for starting is acceptable if the electrical system is capable of continuous normal operation without external excitation or stability, and there is no probable failure of the battery that will adversely affect the electrical system once it is operating. However, the airplane battery cannot be accepted toward showing compliance to the power source requirements of §§ 23.1331 and 23.1351 unless the state of charge of the battery is displayed to the pilot.

A single electrical bus is unacceptable for a multiengine airplane.

The multiengine requirement is for two **independent** power sources. Therefore, an installation with a single primary power source for all flight instruments and a manually operated backup is not acceptable.

a. This system could conceivably fail in such a way that all the flight instruments could be simultaneously damaged or disabled (i.e., loss of voltage regulation). This would not be remedied by switching to the backup power source.

b. Also, an electrical system with a primary power source that employed a backup source with common circuitry or components is not truly independent.

Standby Vacuum Systems

The intended function of a standby vacuum system is to provide a second vacuum source for the gyroscopic instruments after a failure of the primary vacuum system.

The standby system should either supply sufficient vacuum to maintain the accuracy and reliability of the gyroscopic instruments throughout the phases of flight, or there should be limitations on operation in the AFM. When operating on the standby system, the pilot should predicate operations on other certified systems (partial panel) and use the gyroscopic instruments as an aid, provided the pilot determines these instruments give acceptable information. Also, the pilot should not manipulate the throttle, other than for normal flight, in an attempt to control vacuum pressure within the limitations.

If a second vacuum system were not required, the standby installation would be for non-required equipment per this rule. In addition, § 21.21(b)(2) requires there be no feature that results in an unsafe condition. To comply with these requirements, it should be shown that neither operation nor failure of the standby vacuum system interfere with the normal operation of the primary system or result in any unsafe condition. The pilot should also be kept apprised of when the standby system is in operation either by manual source selection or by red visual annunciation (§ 23.1322) if an automatic switching system is installed. To assure that no unsafe condition will result, the standby system should be flight evaluated in each unique airplane installation. In addition, operating information, emergency procedures, and limitations should be available in an AFMS or placards, as appropriate. This information should meet the requirements of §§ 23.1583 and 23.1585 of this part, and it should emphasize that the standby vacuum system is for emergency use only and should not be utilized for dispatch purposes.

Amendment 23-43 and Subsequent

Independent Power Sources

A proposed revision to NPRM 90-23 explains this amendment as follows: *"This proposal requires a visual annunciation to indicate when power for gyroscopic instruments is not adequate, and two independent sources of power for all airplanes. Requirements in current paragraphs (a)(1) and (a)(2) are being deleted because the general requirements of §§ 23.1301 and 23.1309 will adequately address these issues."*

The proposal to Amendment 23-43 by Final Rule, Docket 26344, is based on comments as follows: *"Several comments were received on this proposal. One commenter supports the proposal but notes that it does not address non-gyroscopic instruments, and would result in power supply requirements for such instruments being omitted from regulations. This commenter also believes the word "adjacent" in proposed Sec. 23.1331(a) is too restrictive and requests the meaning of the word "independent" in proposed Sec. 23.1331(c) in context of sources of power for single-engine airplanes. Finally, this commenter identifies support for the provisions of proposed Sec. 23.1331(b)(2).*

The FAA has reviewed this proposal and agrees that by inserting the word "gyroscopic" in the introductory text of this proposal, other types of instruments that use a power source for their function would be omitted from the regulations. To correct this omission and retain the current provision of the regulations that address all instruments, the word "gyroscopic" is being removed from the introductory text. To further clarify the applicability of these requirements, the words "that uses a power source" are being added between the words "instrument" and "the".

The FAA also reviewed this commenters position on the word "adjacent" and agrees that its application could be too restrictive. The intent of this proposal is to require any installed separate power indicator to be located so that a pilot who is using that instrument will notice the loss of that instrument's power. To clarify and preclude restrictive application of this requirement, the word "adjacent" is removed and replaced with words similar to those used in Sec. 23.1321(a).

In regard to the commenters question on the word "independent" in context of sources of power for single-engine airplanes, this word has the same meaning for all airplanes, except that on single-engine airplanes the second source cannot be driven by a separate engine.

Adverse service experience that has resulted from power source failures and the subsequent loss of flight instrumentation has shown that it is necessary to provide a backup power source for the flight instruments. In the case of instruments that use a vacuum power source, the second source has been provided by installing a smaller electric driven vacuum pump and by arranging the vacuum system so that this pump is isolated from the normal vacuum system and so that it provides power to the instruments only after the normal engine driven pump fails."

This amendment adds the requirement for independent power sources for required instruments for single-engine as well as multiengine airplanes. This was considered appropriate due to the number of single-engine airplane accidents that were attributed to the loss of power to required flight instruments. Also, the reference to "gyroscopic" was removed to include both gyroscopic and non-gyroscopic instruments since non-gyroscopic flight instruments are in use.

a. Instruments that provide required flight information and use an external power source are now required to have two independent power sources. This requirement has the same intent for single-engine airplanes as for multiengine airplanes: to functionally isolate flight instruments such that any failure of one power source or instrument will not cause the complete loss of a required flight instrument function. Thus, in the case of failure of a heading instrument, that failure may not result in the loss of the proper supply of energy to the attitude indicator powered by the same source, and loss of a single power supply may not cause loss of any required instrument function.

b. Ships batteries used in normal operations are acceptable as backup power sources only if their state of the charge can be reliably verified to the pilot.

c. This regulation is not intended to apply to circuit protection devices, which are to be considered in §§ 23.1351 and 23.1357.

d. <u>These changes are meant to apply to those instruments that rely on a power source and provide required flight information.</u> Such instruments are those that provide information for direct control of flight that are required by the kinds of operation for which the airplane has been approved. Consequently, this section applies to all flight instruments required by 14 CFR, part 23, § 23.1303 and part 91, § 91.205. So, instruments in airplanes limited to VFR operations that are not required for VFR would not have to comply with the requirements of § 23.1331. Exemptions would not be necessary or appropriate.

e. Each independent power source must provide sufficient power for normal operations throughout the approved flight envelope of the airplane and for any operations for which the airplane is approved. For example, an IFR approved airplane must have independent power sources for the display of attitude that are not limited to altitudes below the approved service ceiling of the airplane.

f. Section 23.1331(c) does not require the installation of dual alternators or vacuum systems on single engine airplanes. Other options include a dedicated battery with a 30-minute capacity for electrical instrument loads essential to continued safe flight and landing, use of differently powered types of instruments for primary and standby, or verifying the aircraft battery used for starting by a system safety analysis per § 23.1309. The last option would:

(1) Require reliability and probability data for the aircraft battery that is acceptable to the FAA (applicants have not provided such data to date); and

(2) Require that the state of charge be available to the pilot during all stages of flight and include a caution alert per § 23.1322 when the state of charge is less than 30 minutes.

23.1335 Flight director systems

The corresponding rule in CAR 3 is CAR 3.669.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.15.

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explained the commonality between parts 23 and 25 as follows: *"Service experience has shown that safety is compromised when the flight crew is not informed as to the current mode of operation of the flight director system. Moreover, experience has also shown that the position of the mode selector switch is not a reliable means of providing that information. This proposal would ensure that an indication entirely independent of the mode selector switch is provided."*

The proposals for both parts 23 and 25 for Amendment 23-20, of Final Rule, Docket 14625, is based on the following comment: *"One commentator criticized the proposed phrase "independent of the mode selector switch" because it would tend to dictate design. Another commentator objected to the same phrase on the ground that it does not take into account modern panels, which incorporate illuminated mode indications that give positive indication of the selected mode, but are not independent of the mode selector switch since they are incorporated in it. The FAA agrees with these comments. The phrase "independent of the mode selector switch" is deleted from proposed Section 25.1335 and another sentence is added thereto reading, "Selector switch position is not acceptable as a means of indication."*

23.1337 Powerplant instruments installation

The corresponding rules in CAR 3 are CAR 3.670, 3.671, 3.672, 3.673, and 3.674.

The corresponding rules in the Airship Design Criteria, FAA-P-8110-2, Change 2, are sections 6.4 and 6.16.

Original Issue and Subsequent

No specific criteria have been established for the minimum orifice size for fuel and oil lines. We believe that .020 inches for fuel lines and .060 inches for oil lines can be accepted (per Air Force Systems Command Manual 80-1, Part C, Chapter 5, paragraphs 3.1.1.3.7 and 3.1.2.3.3).

See AC 23-16A, "Powerplant Guide for Certification of Part 23 Airplanes and Airships," § 23.959, for unusable fuel test procedures for guidance on § 23.1337(b)(1). AC 23-16 incorporated the guidance in canceled AC 23.959-1, "Unusable Fuel Test Procedures for Small Airplanes." The quantity of unusable fuel is determined by compliance to § 23.959, and AC 23-16A provides an acceptable means of compliance.

Changes to total fuel quantity by incorporation of a fuel tank filler connection (§ 23.973) outboard of the existing connection will require changing the fuel quantity indicator to indicate the new quantity of fuel. The new indicator should meet the accuracy as specified in TSO-C55, "Fuel and Oil Quality Instruments (Reciprocating Engine Aircraft)," or MIL-G-9798.

The rule requires that fuel quantity be calibrated as zero when only unusable fuel (as determined under § 23.959) is left in the tank. Some fuel tank system designs can result in a lowest reading obtainable in level flight being greater than the unusable fuel supply. In this case, an ELOS is acceptable by placing a red radial at the "lowest reading obtainable in level flight," and mounting a placard stating the amount of usable fuel remaining at the red radial.

Fuel quantity indicators are also governed by § 23.1301, as are all 14 CFR, part 23, Subpart F appliances. This regulation requires the installed indicators function as designed and not create a hazard in their operation. This precludes indicators that read higher than the actual fuel level since this would constitute a hazard. 14 CFR, part 23, does not require an applicant to install a TSO fuel quantity indicator, but when installed in a reciprocating engine airplane and produced under TSO-C55 authorization, the allowable error of the indicator is no more than three percent of full scale. It is believed that ground and cruise attitude(s) are the minimum attitudes required for operation within the three percent tolerance. Evaluation of the gauge function throughout the normal and expected operation of the airplane is needed to assess gauge indications outside the ground and cruise attitude conditions. The purpose of this evaluation is to establish that the ground and cruise attitude(s) gauge tolerance is functional and adequate for the airplane.

Amendment 23-7 and Subsequent

This amendment moved the requirement for cylinder head temperature indication from this section to § 23.1305.

Amendment 23-18 and Subsequent

See AC 23-8B, "Flight Test Guide for Certification of Part 23 Airplanes," for guidance on fuel quantity indicators and auxiliary tanks.

A proposed revision to NPRM 75-19 revised paragraph (a) and is explained as follows: *"Powerplant instruments and instrument lines sometimes utilize flammable fluids. The proposal would require that those instruments and lines be installed and located so that leakage of the fluid would not create a hazard. The proposal would also editorially revise Sec. 23.1337(a) for clarity."*

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 adds auxiliary power unit requirements and clarifies a fuel quantity rule in paragraph (b)(5) as follows: *"This proposal adds APU installation requirements and clarifies fuel quantity indicator requirements.*

Conference Proposal 449 recommended amending this section to include APU requirements for the reason that applications have been received for approval of auxiliary power unit installations in part 23 airplanes. These installations also need protection from the escape of flammable fluids. The proposed revision to paragraph (b)(5) will maintain compatibility with proposed changes to Section 23.955(d)."

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this amendment as follows: *"This proposal would revise the heading of this section to reflect the powerplant instrument installation requirements that it contains. The difference between this section and Sec. 23.1305 is clarified by this change.*

Section 23.1337(b) would be revised by removing the wording that authorizes installation of only those fuel indicators marked in gallons and pounds. In countries that use the metric system, other acceptable units of measure for marking fuel indicators are used. This proposed revision would allow the use of any appropriate measurement unit.

Section 23.1337(b) would also be revised by adding the word "usable" to the first sentence of this section. This revision is consistent with the requirements of Sec. 23.1337(b)(1), which requires the fuel quantity indicator to be calibrated to read "zero" when the fuel in the tank is equal to the unusable fuel determined under Sec. 23.959.

Proposed new Sec. 23.1337(b)(4) would require a "means to indicate" the amount of usable fuel in each tank when the airplane is on the ground. This requirement would ensure that a reliable means is provided for the pilot to determine before takeoff that the amount of fuel that is in the airplane is adequate for the intended flight. The ability to make this preflight determination will help reduce the number of accidents that have resulted from fuel starvation. This proposal, which is patterned after Sec. 23.1337(d) and (d)(1), would not require a separate fuel indicating system. The means to determine the amount of fuel while on the ground may be provided by a calibrated dipstick separate markings on the inflight fuel indicator, or any other acceptable means selected by the manufacturer. Accordingly, this proposal would contribute to the safe operation of the airplane and would not appreciably add to the cost of the airplane design."

Amendment 23-51 and Subsequent

A proposed revision to NPRM 94-19 clarifies the reference to Subpart E as follows: *"Under the area of "Installation," the reference in Sec. 23.1337 (b)(1) to Sec. 23.959 would be changed to Sec. 23.959 (a), in accordance with the revision to Sec. 23.959 proposed in this notice. The revision would redesignate the existing Sec. 23.959 text as Sec. 23.959 (a); there is no change in the requirement itself."*

ELECTRICAL SYSTEMS AND EQUIPMENT

23.1351 General

The corresponding rules in CAR 3 are CAR 3.681, 3.682, 3.686, and 3.687.

The corresponding rules in the Airship Design Criteria, FAA-P-8110-2, Change 2, are sections 6.4 and 6.17.

Original Issue

This rule does not allow a failure or malfunction of any electrical power source to impair the ability of any other source to supply essential circuits.

Amendment 23-7 and Subsequent

This amendment allows one exception to the original rule. This exception would allow loss of an alternator that is dependent on a battery for initial excitation or stabilization when that battery has failed. This exception was adopted under the premise that the advantages of having a battery connected for initial excitation or stabilization for alternators needing it outweighed the consequences of that battery failing. This exception is only applicable to alternator installations that need a battery. Loss of an alternator due to battery failure was considered of no greater consequence than the intrinsic failure of the alternator itself. In the case of single-engine airplanes, loss of the battery and alternator would result in the loss of the electrical system, which would be no worse than other single failures (i.e., shorts to ground, conductor failure, etc.) that would also result in loss of the electrical system.

Wire, meeting MIL-W-5086, has been removed from the listing of approved wire in AC 43.13-1B, Change 1, due to its flammability characteristics, corrosive vapors, and toxic gases of Polyvinyl Chloride (PVC) insulation. See AC 43.13-1B, Change 1, “Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair,” Section 3, for allowable wire in airplane manufacture and alteration.

Wire that is not listed in AC 43.13-1B, Change 1, should be shown by tests and analyses to meet the airworthiness requirements of § 23.863, 23.1351, 23.1359, and 23.1365 as applicable.

Amendment 23-14 and Subsequent

This amendment added requirements so designed that the risk of electrical shock to crew, passengers, and ground personnel is reduced to a minimum. There must also be a means to give immediate warning to the flight crew of a failure of any generator.

Fire resistance. Electrical equipment must be so designed and installed that in the event of a fire in the engine compartment, during which the surface of the firewall adjacent to the fire is heated to 2000 degrees F for five minutes or to a lesser temperature substantiated by the applicant, the equipment essential to continued safe operation and located behind the firewall will function satisfactorily and will not create an additional fire hazard.

Amendment 23-17 and Subsequent

A proposed revision to NPRM 75-10 requires overvoltage control of generators with the following explanation: *"Complete electrical system failures on both single and twin engine aircraft continue to occur. The electrical failure that causes this problem is often the loss of voltage control in the voltage regulator. This usually results in a bus voltage well above the capabilities of the electrical equipment connected to the bus. This overvoltage condition frequently destroys electronic equipment and boils the electrolyte in the battery. The proposal is only directed at this overvoltage problem and therefore differs from Sec. 23.1351(b). The proposal would not require a specific method of overvoltage control."*

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 added external power requirements with the following explanation: *"If an external power supply with reverse polarity or reverse phase sequence were to supply power to the airplanes electrical system extensive damage to the system could result. This proposal would require a means to prevent such an occurrence."*

Amendment 23-34 and Subsequent

A proposed revision to NPRM 83-17 added commuter category requirements from "*part 135, Appendix A, sections 61 and 63"*.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"This proposal would allow a generator to be installed and operate below its continuous rating when it has a rating higher than necessary, allow methods other than reverse current cutouts for protecting against reverse current, and would require the airplane to operate safely for 5 minutes without normal electrical power.*

Conference proposal 453 recommended revising paragraphs (c)(1) and (c)(3) essentially as proposed herein. The justification given is that the generator-rated output may be higher than required for the electrical loads of the airplane and, in such case, the electrical system (generator output) is limited by its regulation system.

The consensus at the conference supported the objective of this conference proposal. The FAA agrees with the need for changing paragraph (c)(1) to clarify its intent and to revise paragraph (c)(3) to relieve the burden to install a specific type of reverse current control where more efficient and less costly controls are now available.

Conference proposal 456 recommended adding paragraph (g), essentially as proposed herein except the requirement would only be applicable for airplanes operated above 25,000 feet. The justification was that part 23 airplanes that operate at high altitudes above 25,000 feet depend upon electrical power for safe operation. Emergencies involving loss of normal electrical power at or above this altitude typically result in the loss of other systems, such as electric fuel pumps, pressurization system, warning system, navigation, communications, and instrumentation. The FAA developed special conditions for part 25 that initiated the requirement in this proposal and it was later adopted into part 25 by amendment 25.41, in 1977. Conference proposal 456 was essentially developed from the part 25 requirements except for the 25,000 foot applicability. When offered for comment at the conference, there were no objections on conference proposal 456. After further review, FAA has concluded that the proposal should not be limited to airplanes that operate above 25,000 feet since emergencies resulting in the loss of normal electrical power are critical for all airplanes. Five minutes is considered adequate time to cope with such an emergency so that pilot can operate the airplane safely and assess the reason for the loss of normal electrical power.

Conference proposal 452 recommended changing the phrase "essential for safe operation" to "essential to flight safety" for consistency in the regulations. A word search of the regulations indicated that there were other phrases such as "essential to safety of flight," and "essential to continued safe operation." All of these phrases have been interpreted to have the same meaning. Since the affected regulations have been administered effectively without significant problems, the FAA does not consider the recommended changes to be beneficial."

Final Rule, Docket 26324, has the following clarification: *"It has been brought to the FAAs attention that many electrical generating devices that are used on part 23 are now referred to as "alternators" and that there is some confusion about such units acceptability because Sec. 23.1351(c) continues to address "generators." To provide clarifications, ten locations in Sec. 23.1351, paragraphs (c), (c)(1), (c)(2), (c)(3), (c)(4), and (c)(5), are being revised by changing the word "generator" to "generator/alternator." This proposal is adopted with the aforementioned change."*

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this amendment as follows: *"The proposal would revise current Sec. 23.1351 by removing portions of paragraphs (b)(2) and (b)(3) and by removing all of paragraph (b)(4). The removed requirements* *are applicable to alternators that depend upon the battery for initial excitation or for stabilization. This revision responds to a Joint Aviation Authority recommendation to remove the provisions that allow a battery failure to result in the loss of the alternator. Information in this recommendation showed that self-excited alternators are now available for installation on newly certificated airplanes. The FAA has verified that self-excited alternators are now available; therefore, there is no longer a need for the regulations to address alternators that depend upon a battery for initial excitation and stabilization.*

Revised Sec. 23.1351(c)(3) would require an automatic means for reverse current protection. Reverse current protection is accomplished by means that automatically detect changes in the current. The proposed revised wording would more accurately define this function and the equipment that would accomplish the protection.

Finally, Sec. 23.1351(f) would be revised by adding a requirement that would require the ground power receptacle to be located where its use will not result in a hazard to the airplane or to people on the ground using the receptacle."

Final Rule, Docket 27806, has the following clarification: *"The proposals are adopted as proposed, except that paragraph (c)(3) has been revised to clarify that protection for any generator/alternator and the airplane electrical system must be provided."*

EASA AMC 23.1351(a)(2) is acceptable for FAA certification.

EASA AMC 23.1351(b)(5)(iv) is acceptable for FAA certification to 14 CFR, part 23, § 23.1351(b)(4)(iv).

23.1353 Storage battery design and installation

The corresponding rule in CAR 3 is CAR 3.683.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.18.

Original Issue and Subsequent

See AC 43.13-1B, Change 1, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair," Section 8, for battery installation guidance. Replacement batteries would require PMA, unless exempted under the provisions of part 21, § 21.303(b), whether the replacements are lead-acid or nickel-cadmium. The airworthiness standards of 14 CFR, part 23, §§ 23.1301, 23.1309, 23.1351, and 23.1353 should be considered for replacement battery installations.

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains this amendment as follows: *"Proposed Sec. 23.1353(b)(1) would add "or power" to the battery recharging standard. The proposal by adding an alternative standard is intended to clarify the present rule to more appropriately include all battery charging means and parameters. In some battery charging techniques, voltage is not a controlled factor except by response of the battery. Also, power is a measure of heat input to the battery. A similar proposal is made for Secs. 25.1353(c)(1)(i), 27.1353(b)(1), and 29.1353(c)(1)(i).*

Short circuits of nickel cadmium batteries (either internally or to the airplane structure through the battery caps) have occurred in service. The heat generated by such short circuits may in some circumstances damage nearby structure or essential systems. It is therefore proposed to require provisions to prevent any hazardous effect from this cause. See also proposed new Sec. 23.1353(f) in Airworthiness Review Notice No. 2 (Notice 75-10), which is aimed at reducing the occurrence of short circuits that are caused by excessive battery charging current."

Amendment 23-21 and Subsequent

A proposed revision to NPRM 75-10 explains paragraph (g) as follows: *"The proposal conforms to paragraph (b) of AD 72-19-4, which applies to all nickel-cadmium batteries that are capable of being used to start an aircraft engine or auxiliary power unit."*

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains the 30-minute rule in this amendment as follows: *"Proposed new Sec. 23.1353(h) would require that, the event of a complete loss of the primary electrical power generating system, airplane battery capacity must be sufficient to supply at least 30 minutes of electrical power to those loads essential to the continued safe flight and landing of the airplane.*

This proposal is not limited to airplanes that are approved for any particular type of operation. Although the battery capacity needed for an airplane approved for day VFR operations would be much less than the capacity for an airplane approved for day/night IFR operations, the same level of safety should be provided for all airplanes. While this proposal would add an additional requirement to part 23 for normal, utility, acrobatic, and commuter category airplanes, in practice this requirement to provide a battery capacity sufficient to supply at least 30 minutes of electrical power is not new to many airplane manufacturers. Certain other countries in which part 23 airplanes have been certificated have requirements for such a 30-minute battery capacity. Manufacturers experience with these requirements has shown that the only design impact that results from complying with these requirements is the need to install a battery with greater capacity than might otherwise be installed. Experience has also shown that a load shedding procedure may be necessary for certain airplanes. No other airplane design changes would be needed.

Despite the above referenced experience record, this requirement would be new to some manufacturers and they may have questions on how it would be applied. For that reason, this notice discusses compliance considerations that have emerged from experience based on substantively equivalent requirements.

This compliance experience has shown that the rating of the battery selected for the airplane should be sufficient to cover the loss of capacity that would occur with battery age and the reduced capacity that results from a realistic state of charge, which may be less than a full charge. Using a design battery capacity that is only 75 percent of the battery nameplate rating would be an acceptable way of accounting for these losses.

In addition to determining the battery rating that would be needed, the manufacturer would also need to determine the functions that would be necessary for 30 minutes of safe flight and the landing of the airplane. Again, experience has identified several functions. For a day VFR approved airplane, no functions may require battery power; however, it may be necessary to supply power for certain communication capacities or, if the airplane has electrically powered retractable landing gear. Providing a secondary means for lowering the gear would be an acceptable alternative to providing electrical power or battery power for this function.

For other types of operating approvals, providing power for the following functions and equipment should be considered:

1. *Any required flight and navigation instruments. Air driven instruments that would function over the required period can also be accepted for this function.*
2. *Cockpit and instrument lighting.*
3. *For IFR and icing approvals, power for the heated pitot tube.*
4. *For radio communication, usually one VHF communication system with power for three to five minutes of transmission would be acceptable.*
5. *Functions needed for safe night flight and night landing for the airplane.*
6. *Electronic engine ignition systems.*
7. *Any functions that cannot be readily shed following the loss of generator power.*
8. *Engine inlet heat or deicing protection required for normal operation of the airplane.*

Although power for the listed functions may provide for the safe operation and landing of most airplanes, individual airplane designs may require the consideration of additional functions.

In applying these rules it may be assumed that airframe and engine icing protection equipment would not be operating at the time of the generator system failure. Power for icing protection would not be required if the icing protection equipment is not required for the normal operation of the airplane.

This proposal would require additional battery capacity and would not alter or supersede any other requirements in this part for separate or dedicated emergency power supplies. When requirements such as those in current Sec. 23.1331(a) or in proposed Sec. 23.1311(a)(5) are applicable to the airplane design, these power supplies are required to provide a needed level of safety for that function; therefore, that power source must be supplied."

The requirements of § 23.1353(h) are as follows:

"In the event of a complete loss of the primary electrical power generating system, the battery must be capable of providing at least 30 minutes of electrical power to those loads that are essential to continued safe flight and landing. The 30 minute time period includes the time needed for the pilots to recognize the loss of generated power and take appropriate load shedding action."

Per previous guidance on this issue, the airplanes primary electrical power includes the airplanes electrical generation system and the airplanes starter battery when only one battery is installed. The battery for the 30-minute criteria, therefore, should be an independent power source from the airplanes starter battery. If adequate monitoring and procedures are incorporated so the pilot knows that the airplanes starter battery meets the 30-minute criteria after an engine start and during all other operations, an ELOS finding may be an acceptable method for using the airplanes starter battery. Please refer to the guidance in AC 23.1309-1C, "Equipment, Systems, and Installations in Part 23 Airplanes," for determining the loads that are essential to continued safe flight and landing. Continued safe flight and landing is defined as follows:

"This phrase means that the airplane is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional pilot skill or strength. Upon landing, some airplane damage may occur as a result of a failure condition."

The 30-minute power bus should include all systems that could cause a catastrophic failure condition under the § 23.1309, Failure Hazard Assessment. In some cases, it may not be practical to include all systems on the 30-minute power bus that could cause a catastrophic failure condition. For example, systems with large heating loads for ice protection may not be included on the 30-minute electrical power bus; however, the possible hazards that could cause catastrophic failure conditions should be minimized.

To minimize the hazard either is to reduce, lessen, or diminish to the least practical amount with current technology and materials. The least practical amount is that point at which the effort to further reduce a hazard significantly exceeds any benefit in terms of safety derived from that reduction. Additional efforts would not result in any significant improvements to safety and would inappropriately add to the cost of the product.

Assuming operations under IFR conditions for parts 91 or 135 operations, the following systems should be included on the 30-minute power bus:

- If needed to comply with § 23.1325, one airspeed indicator and altimeter with a heated pitot tube and heated static pressure source;
- The magnetic compass, and any display necessary for continued safe flight and landing, sufficiently illuminated for night operation;
- One navigation system installation appropriate to the ground facilities to be used;
- One communication installation system;
- One gyroscopic pitch and bank indicator;
- One clock;
- Any display for the powerplant parameter necessary for continued safe flight and landing; and

- Any electrical loads unique for the airplane characteristics and needed for continued safe flight and landing for the intended operations.

Tests and analyses should be considered for determining the rated operating capacity of the battery, the normal service life, and the continued airworthiness requirement of § 23.1529. For these tests and analyses, the following should be established as follows:

(1) For the operating capacity: the discharge rate, temperature, end-point voltage, etc.; and

(2) For the airworthiness requirement: the inspection schedule, useful battery life, end-of-life, etc.

23.1357 Circuit protective devices

The corresponding rules in CAR 3 are CAR 3.690, 3.691 and 3.692.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.19.

Original Issue and Subsequent

This rule allows only one essential circuit on one circuit protective device. The intent of the rule is met for installations that integrate position and anticollision lights on one wire when no single failure can cause the loss of any of the following:

(a) More than all anticollision lights.

(b) More than all position lights.

(c) More than one position light and the anticollision light adjacent to it.

The requirement in § 23.1357(e) applies to fuses for all circuits, not just essential circuits. Although spare fuses for non-essential systems and equipment do not have to be resettable in flight.

The phrase "essential to safe operation," as used in part 135, Appendix A, paragraph 64, and the phrase "essential to flight safety" in § 23.1357(b) have the same meaning as "essential to safety in flight" in § 23.1357(d) and "essential to flight safety" in § 23.1357(b). All of these phrases are descriptive of equipment installed in order to comply with the airworthiness or operational requirements. The FAA recognizes that some required circuit protection devices are associated with circuits that can have no significant impact on safety in flight. Therefore, the responsible ACO, in conjunction with the applicant, should identify which circuits and circuit protection devices are essential to safety in flight. The identified circuits should comply with § 23.1357(d) regarding the pilot's ability to reset them in flight.

Fuel quantity indicators are required by regulation but are not essential to safety in flight. The loss of an indicator will increase the pilot's workload, but it will not, in itself, cause either a loss or a forced landing of the airplane. It is acceptable, therefore, to have a protected circuit that includes more than one required indicator, which includes a fuel quantity indicator. Good design practice would include placing multiple indicators of the same parameter on separate protected circuits, and we encourage the use of warnings for low fuel, high oil temperature, etc., to mitigate the effects of loss of indication.

For part 23 applications, the definitions of a switch and a circuit breaker are as follows: 1) A switch is a device for opening and closing or for changing the connection of a circuit; 2) A circuit breaker is a device designed to open and close a circuit by non-automatic means and to open the circuit automatically at a predetermined overload of current, without injury to itself when properly applied within its rating. Consequently, circuit breakers used for operational functions are not acceptable because they are not performing their intended function, which is protection against overloads. Circuit breakers, even those suitable for frequent operation, should not be used as a switch to perform procedural functions.

A combination switch/circuit breaker is a device which can perform both as a switch for opening and closing a circuit as well as a circuit breaker, automatically opening the circuit at a predetermined overload current.

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains § 23.1357(b) as follows: *"Proposed paragraph (b) would clarify the present rule by specifically prohibiting the use of a single protective device to protect an essential and a nonessential circuit, or more than one essential circuit. A protective device protecting two circuits would trip in response to a fault in either one; thus a fault in the nonessential circuit would render the essential circuit inoperative."*

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"The intent has historically been to protect the airplane from the hazards of all electrical faults. Paragraph (a)(1) exempted starting motor circuits because they did not have power applied, except during engine starting. It is proposed to clarify the intent of paragraph (a)(1). The existing rules of paragraph (e) require spare fuses for all electric circuits. This proposal would require spare fuses for fuses identified as replaceable in flight, which would be those required by paragraph (d) and any other fuses identified as replaceable in flight. This proposal would also require the fuses be readily accessible and available."*

23.1359 Electrical system fire protection

See guidance in section 23.853 of this AC.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this rule as follows: *"Proposed new Sec. 23.1359 would require smoke and fire protection for electrical system installations. The provisions of Sec. 23.1359(a) of this proposal state that electrical systems must meet the applicable requirements of Secs. 23.863 and 23.1182.*

Proposed Sec. 23.1359(b) would require that the electrical systems components installed in designated fire zones and used during emergency procedures be fire resistant. This provision is needed to clarify the requirements for electrical system components that may be installed in the designated fire zones identified in Sec. 23.1181.

Finally, Sec. 23.1359(c) provides burn criteria for electrical wire and cables. A proposed revision to appendix F of part 23 that would add appropriate wire testing criteria is included in this notice.

This proposed burn criteria for wire is necessary because of the increased use of electrical systems in the design of part 23 airplanes and the resulting increase in the amount of electrical wire being installed. This increased use results in the need to ensure that wire insulating material does not become the source of an in-flight fire and/or that it does not propagate a fire from another source. The electrical wire burn requirements in this proposal, along with the testing identified in revised appendix F, would ensure that installed electrical wire has insulating material that reduces the possibility of hazardous in-flight fires."

23.1361 Master switch arrangement

The corresponding rule in CAR 3 is CAR 3.688.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.20.

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains this amendment as follows: *"Circuits by-passing the master switch remain energized after the master switch is opened. If such circuits fail during a crash landing they might possibly ignite nearby flammable fluids or vapors. This proposal would reduce that possibility."*

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"The proposal clarifies the master switch arrangement requirement and permits new generations of engines to operate with the master switch turned off, as is necessary to isolate hazardous electrical faults.*

Subsequent to the receipt of the proposals submitted for the Part 23 Review, engine designs have been developed that depend on an electrical power source for normal ignition and/or fuel pressure. An electrical fault that makes it necessary to turn off the master switches must not cause unintentional disabling of such designed engines. However, the pilot must retain the capability to isolate all sources of electrical energy that might ignite flammable fluids that are likely to escape during a survivable crash landing.

When conference proposal 461 was discussed, a commenter specifically noted that he had no objections to the multiple circuits restriction in the proposal and supported that position. The commenter did express a concern that the proposal, "Load, circuits, such as cabin entry lights whose functions are needed prior to entering the cockpit," may unnecessarily limit those circuits to those functions that are needed before entering the cockpit. It was noted that there are other continuously energized circuits that do meet the "needed prior to entering the cockpit" definition in the proposal. A circuit for an electrical clock was cited as an example.

The FAA has reviewed the proposal and this discussion and agrees that while the proposed wordage was only intended to provide an example of the type of circuit that was permitted by this section, it could be interpreted as more restrictive than intended; therefore, this example language has not been included in this proposal. This action by FAA should not be interpreted as an endorsement to install an unlimited number of circuits that bypass the master switch. This provision was added *to, and retained in, the requirements because it was recognized that there are a limited number of electrical functions that are needed when the master switch is in the position. The requirements of this section provide for the safe installation of these circuits. The five-ampere load restriction of a new paragraph (b)(3) was added because the FAA was made aware of an installation in which this provision was being used to circumvent the master switch arrangements by using up to four five-ampere fuses to supply a 20-ampere circuit. This restrictive provision should make it clear that such installations are not permitted."*

The proposal in NPRM 90-23 was revised by Final Rule, Docket 26344 as follows: *"This proposes to amend Sec. 23.1361 to clarify the requirement for the master switch arrangement and to permit new generations of engines to operate with the master switch turned off. No comments were received; however, an editorial revision has been made that revises the text of the last sentence from one that permits the master switch arrangement to use separate switches to text that provides requirements for the master switch arrangement if separate switches are installed. This proposal is adopted with the aforementioned change."*

Amendment 23-49 and Subsequent

This amendment is explained by Final Rule, Docket 29806 as follows: *"To harmonize with the JAR this proposal would revise Sec. 23.1361(c) by making an editorial change to remove the last two words of the paragraph that read "in flight." This change will not alter the meaning of the requirement."*

23.1365 Electric cables and equipment

The corresponding rule in CAR 3 is CAR 3.693.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.21.

Original Issue and Subsequent

Section 23.1365 requires that each cable that would overheat in a circuit overload or malfunction be at least flame resistant and not emit dangerous quantities of toxic fumes. The compliance methods for the flame resistance requirement are in AC 23-2, "Flammability Tests." To aid in meeting the toxic fume requirement, the FAA has removed MIL-W-5086 wire from the listing of approved wires in AC 43.13-1B, Change 1, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair."

See guidance in section 23.853 of this AC for flammability.

Amendment 23-14 and Subsequent

The flame resistance and toxic fume requirements are applicable to equipment associated with the cable as well as the cable itself. A proposed revision to NPRM 71-13 explains this amendment as follows: "*This proposal is considered necessary because of the higher powered electrical systems being installed in part 23 airplanes. Such systems are more likely to cause heat damage and the emission of toxic fumes in the event of malfunction.*"

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: "*This proposal provides crashworthiness standards for electrical cables. It would require that electrical cables be designed to allow a reasonable degree of deformation and stretching without failure and be isolated from flammable fluid lines or must be shrouded in insulated flexible conduit.*"

The proposal in NPRM 90-23 was changed by Final Rule, Docket 26344, and is explained as follows: "*One commenter believes the word "isolated" used in proposed Sec. 23.1365(c)(1) is not compatible with current practices and suggests the word "separated" be used in its place. The FAA reviewed this recommended change and agrees that "separate" better describes the current practice of keeping electrical cables and flammable fuel lines spaced a part. This proposal is adopted with the aforementioned change.*"

Amendment 23-49 and Subsequent

The proposed revision to NPRM 94-21 has the following explanation for this amendment: *“This proposal would revise Sec. 23.1365(b) and would add three new paragraphs.*

Section 23.1365(b) would be revised in relation to proposed new Sec. 23.1359(c), which would require self-extinguishing insulated electrical wires and cables. Current Sec. 23.1365(b) requires that cable and associated equipment that would overheat in the event of circuit overload or fault must be flame resistant and may not emit dangerous quantities of toxic fumes. The proposed revisions to Sec. 23.1365(b) would remove the reference to electrical cables from the flame resistance requirement since the cables would be required to have self-extinguishing insulation under Sec. 23.1359(c). The requirement for electrical cables and the associated equipment that would overheat to not emit dangerous quantities of toxic fumes has been retained.

The text of Sec. 23.1365(b) that includes the words "at least flame resistant" would also be revised by removing the words "at least". The removed words implied that there were burn requirements, other than the ones in this section that must be met.

The three paragraphs that would be added by this proposal would require: (1) The identification of electrical cables, terminals, and connectors; (2) the protection of electrical cables from damage by external sources; and (3) installation criteria for cables that cannot be protected by a circuit protection device.

As identified in the discussion of proposed Sec. 23.1359, there is an increasing use of electrical systems in part 23 airplanes. The resulting increase in the number of electrical wires used in part 23 airplanes makes proper installation difficult. The proposal for electrical cable identification would provide better assurance that the cables will be correctly installed initially and correctly reinstalled when airplane maintenance or modifications are accomplished. The other proposed new requirements would provide installation criteria that will ensure the protection of cables under circumstances that can be expected from the increased use of electrical systems.”

23.1367 Switches

The corresponding rule in CAR 3 is CAR 3.694.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.22.

Original Issue and Subsequent

This rule was adopted on February 1, 1965 as a recodification of CAR 3.694 and 3.695.

Switches are required to be labeled as to operation and the circuit controlled. A switch that operates by a push once for ON and once for OFF should be labeled "PUSH OFF/ON."

Switches are also required to be accessible to the flight crew. The intent of this rule is that those switches that are installed in the cockpit should be accessible to a flight crewmember **if** manual operation is necessary for safety of flight.

LIGHTS

23.1381 Instrument lights

No policy available as of September 30, 2003.

This rule was adopted on February 1, 1965 as a recodification of CAR 3.696 and 3.697.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.23.

23.1383 Taxi and landing lights

The corresponding rules in CAR 3 are CAR 3.698 and 3.699.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.24.

Amendment 23-49 and Subsequent

This amendment was revised to add taxi lights to the original rule. A proposed revision to NPRM 94-21 explains this amendment as follows: *"The landing light requirements of Sec. 23.1383 would be revised by adding taxi lights to this section. When the landing light requirements were included in the normal, utility, acrobatic, and commuter category requirements, the same lights were used for both night landing and taxiing of the airplane. Due to availability of different types of lights, separate lights are now frequently installed for landing and for taxiing. Including the word "taxi" in the heading would clarify that the requirements cover both kinds of lights.*

Current Sec. 23.1383(a), which requires the lights to be acceptable, would be deleted because it is unnecessary to state this. All lights that are found to meet the requirements of this section and other directly related airworthiness requirements are acceptable. The paragraphs would be redesignated accordingly.

Current Sec. 23.1383(b)(3) requires that a landing light must be installed to provide enough light for a night landing. Proposed Sec. 23.1383(c) would revise "night landing" to "night operation" since the requirements would also cover taxiing and parking. Proposed new paragraph (d) would require the lights to be installed so that they do not cause a fire hazard. This clarifies the need for such an evaluation."

23.1385 Position light system installation

The corresponding rule in CAR 3 is CAR 3.700.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.25.

Original Issue and Subsequent

Guidance on light measurements can be found in AC 20-74, "Aircraft Position and Anticollision Light Measurements." Additional guidance on position lights can be found in AC 20-30B, "Aircraft Position Light and Anticollision Light Installation."

Guidance on flame resistance can be found in AC 23-2, "Flammability Tests."

The intent of the rule in § 23.1357 is met for installations that integrate position and anticollision lights on one wire when no single failure can cause the loss of any of the following:

(a) More than all anticollision lights.

(b) More than all position lights.

(c) More than one position light and the anticollision light adjacent to it.

Position lights are not required for airplanes limited to day VFR operation (placarded for VFR day). If approved for night VFR or IFR, then position lights are required per §§ 23.1385 through 23.1395. They should be listed on the kinds of operation equipment list (§ 23.1559(b)) and included in the limitations section of the AFM (§ 23.1583(h)).

Amendment 23-17 and Subsequent

A proposed revision to NPRM 75-10 explains this amendment as follows: "*By amending Sec. 23.1385 in a manner substantively identical to that proposed for Sec. 25.1385. The proposal would revise Sec. 25.1385 to make more clear the circumstances in which forward and rear position lights may be located at other than the appropriate airplane extremities.*"

The proposed amendment was revised by Final Rule, Docket 14324, and is explained as follows: "*Two commentators, also suggested that proposed Secs. 23.1385(c) and 25.1385(c) be revised to permit a new position light to be installed on each wing tip. The FAA agrees that further study is necessary to develop factors of general applicability for position lights on all aircraft but that a rear position light as far aft* *as practical on each wing tip of an airplane is a reasonable alternative location. Accordingly, proposed Secs. 23.1385(c) and 25.1385(c) have been revised."*

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"This proposal clarifies the location requirements for the position lights, deletes the requirement for a single circuit, and removes the redundant statement "must be approved". Conference proposal 464 recommended changing paragraph (b) so the location of position lights can be compatible with airplane configurations such as tandem wing, canards, and swept wings. The words "forward on the airplane" in paragraph (b) have been interpreted to mean the first 50 percent of the airplane length.*

Conference proposal 465 recommended deleting paragraph (d) since it had been interpreted to prohibit multiple circuits from being installed. A consensus at the conference supported both of these recommendations.

The FAA has further studied these issues and concludes clarification is required and that the proposed requirements are substantively equivalent to the current rule."

23.1387 Position light system dihedral angles

The corresponding rule in CAR 3 is CAR 3.701.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.26.

Amendment 23-12 and Subsequent

This amendment is explained by Final Rule, Docket 11479 as follows: *"Sections 23.1387, 25.1387, 27.1387, and 29.1387 presently require, in part, that the rear position light show unbroken light within a dihedral angle formed by two intersecting vertical planes making angles of 70° to the right and left, respectively, of a vertical plane passing through the longitudinal axis. Other related provisions of the regulations require that the rear position light be mounted as far aft as practicable.*

In certain aircraft designs incorporating swept vertical tail surfaces, the obstructed visibility requirements may be met only by locating the rear position light on the trailing edge of the rudder. Because this location may cause a number of problems, including complex electrical installation and adverse rudder flutter characteristics, some manufacturers consider the aft most tip of the fuselage to be a more suitable location. Thus, while the rudder position may be farther aft, the fuselage location is as far aft as is practicable. At the same time, however, the fuselage location does not comply with the obstructed visibility requirements where parts of the rudder and vertical stabilizer of a swept tail project into space required to be unobstructed.

For aircraft having this problem, the obstruction resulting from use of the aft fuselage location would, nevertheless, be relatively small because of the thinness of the vertical stabilizer and rudder. Moreover, the obstruction occurs at a high angle above the longitudinal axis of the aircraft so that except for the near-zenith position, the rear position light shows unbroken light.

Related requirements for position lights allow diminishing light intensity with increasing angle above or below the horizontal. Thus, for angles 40° and more above and below the horizontal plane, the position light intensity need be only 5 percent of the light intensity in the horizontal plane. This provision thus recognizes that the significance of a position light decreases as zenith is approached.

A provision similar to that being here established for the rear position light already exists with respect to the anticollision light. In this connection, minor visibility obstructions permitted in the rearward direction in the field of coverage of the anticollision light have been determined not to be detrimental to safety.

In light of the foregoing, obstructions within the dihedral angle in which the rear position light must show, which do not exceed 0.04 steradians in coverage and which occur within 30- of a vertical line through the rear position light, would not adversely affect safety. In addition, these amendments permitting minor obstructions in the field of coverage of rear position lights are consistent with the provisions of Secs. 23.1385(c), 25.1385(c), 27.1385(c), and 29.1385(c) which recognize practicable considerations in the location of rear position lights."

Amendment 23-43 and Subsequent

This amendment removed the words "forward and rear" from paragraph (a). These changes are necessary for compatibility with revised § 23.1385.

23.1389 Position light distribution and intensities

The corresponding rule in CAR 3 is CAR 3.702.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.27.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *“Section 23.1389 is amended in paragraph (b) by removing words "Forward and rear" from the heading, by changing the word "position" in the heading to read "Position", and by removing the words "forward and rear" from the first sentence; in paragraph (b)(3) by removing the word "forward" in the last sentence and inserting in its place the words "left and right".*

These changes are necessary for compatibility with revised § 23.1385.

23.1391 Minimum intensities in the horizontal plane of position lights

The corresponding rule in CAR 3 is CAR 3.702.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.28.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"Section 23.1391 is amended in the section heading by removing the words "forward and rear" and in the table by removing the words "(forward red and green)" and inserting in their place "(red and green)"."*

These changes are necessary for compatibility with revised § 23.1385.

23.1393 Minimum intensities in any vertical plane of position lights

The corresponding rule in CAR 3 is CAR 3.702.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.29.

Amendment 23-43 and Subsequent

This amendment removed the words "forward and rear" in the section heading. These changes are necessary for compatibility with revised § 23.1385.

23.1395 Maximum intensities in overlapping beams of position lights

The corresponding rule in CAR 3 is CAR 3.702.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.30.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"Section 23.1395 is amended in the section heading by removing the words "forward and rear"."*

This change is necessary for compatibility with revised § 23.1385.

23.1397 Color specifications

The corresponding rule in CAR 3 is CAR 3.703.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.31.

Original Issue and Subsequent

See AC 20-74, “Aircraft Position and Anticollision Light Measurements,” for guidance on color measurements.

Amendment 23-11 and Subsequent

A proposed revision to NPRM 70-21 changed the color requirements for Aviation White as follows: *“It is proposed to expand the chromaticity-coordinate range for the color Aviation White in order to provide for the use of white condenser-discharge anticollision lights, including Xenon types, in the implementation of proposal 1.”*

23.1399 Riding light

No policy available as of September 30, 2003.

This rule was adopted on February 1, 1965 as a recodification of CAR 3.704.

There is no corresponding rule in the Airship Design Criteria.

23.1401 Anticollision light system

The corresponding rule in CAR 3 is CAR 3.705.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.32.

Original Issue and Subsequent

If certification for night operation is requested, an anticollision light system, per this section, is required.

See AC 20-74, “Aircraft Position and Anticollision Light Measurements,” for guidance on anticollision light measurements.

The flash rate of supplemental lights does not have to be applied to the anticollision light flash rate, but these lights should be checked to verify there is no unsafe condition associated with their use.

Amendment 23-11 and Subsequent

A proposed revision to NPRM 70-21 explains this amendment as follows: *“(1) It is proposed to amend Sec. 23.1401 (and the corresponding sections of Parts 25, 27, and 29) to permit the use of either aviation red or Aviation White anticollision lights. The regulations now require that each anticollision light must be aviation red. However, neither the research conducted in the past by the FAA, and by others, nor the arguments submitted in response to Notice 70-7 by proponents of each color have conclusively established that one color is superior to the other at comparable intensities. Current FAA/NASA research may shed new light on this question.*

It is clear, however, that if the red color for anticollision lights were changed to white, the anticollision light intensity could be increased by a factor of 3 to 5 (without increasing the electric power consumption) by merely removing the red filter needed to meet current standards, or by replacing it with a white light (condenser discharge or other type) that uses about the same amount of power. Alternatively, if the regulation permitted Aviation White anticollision lights, the currently prescribed intensities could be produced with one-fifth to one-third of the electric power now being used by the red anticollision lights. Although it is true that the use of Aviation White could introduce a backscatter problem on some aircraft, we believe that this problem can be solved by the relocation of lights, by appropriate masking, or by other methods, as has already been done with respect to the white "supplementary" high-intensity lights installed on many aircraft now in service.

Some of the comments suggested that safety might be compromised by permitting aircraft using differently colored anticollision lights to operate in the same airspace. The FAA does not agree. Many aircraft currently operating in the United States do not now display red anticollision lights exclusively, since the current regulations permit the display of high-intensity flashing white lights (and even red and green lights) as "supplementary" lights. Frequently, the "supplementary" white lights are seen first as the aircraft is approached. The use of such "supplementary" lights has been permitted for more than 10 years and there has been no adverse effect on safety. Therefore, there is no reason to believe that the optional use of either red or white anticollision lights in the future would compromise safety in any way.

On the other hand, since the standards of the International Civil Aviation Organization (ICAO) now specify red as the color for anticollision lights, the adoption of this proposal would make it necessary to file a formal notice of difference with ICAO.

(2) It is proposed to expand the chromaticity-coordinate range for the color Aviation White in order to provide for the use of white condenser-discharge anticollision lights, including Xenon types, in the implementation of proposal 1.

(3) It is proposed to increase the minimum effective intensities for anticollision lights and to make that increase applicable to both red and white lights on aircraft TC in the future. A majority of the persons responding to Notice 70-7 indicated that the currently prescribed intensity level for anticollision lights should be raised. In view of the fact that this increase would apply only to anticollision lights installed on aircraft for which an application for TC is made after the effective date of any final amendment containing this proposal, and in view of the current state-of-the-art in anticollision lights, the FAA considers that the application of the proposal of all aircraft is feasible.

On the question of what increase in anticollision light intensity should be made, those who responded to Notice 70-7 offered suggestions that varied widely; but most recommended a four-fold increase over current levels. This corresponds roughly to the increase in intensity that would be attained by removing the red filter from existing anticollision lights, and is within the performance capability of state-of-the-art condenser-discharge lights. The FAA believes this intensity recommendations has merit, and it is proposed to increase currently prescribed anticollision light intensities by a factor of four.

Contrary to the suggestion contained in various comments on Notice 70-7, the FAA believes that an intensity level standard that includes a specified infrared signal content for use with Pilot Warning Indicators (PWI) would be premature. The FAA considers that mandatory action on infrared signal content should await completion of current evaluations of the PWI system concept on civil aircraft. However, the proposed standard would not prevent any manufacturer from providing an infrared signal in his anticollision lights.

There were also suggestions that the current anticollision light intensity should be retained for ground operation. However, the FAA does not consider that this is necessary since, under current rules, the anticollision lights may be dimmed or even turned off during ground operations."

This amendment is clarified by Final Rule, Docket 10129, as follows: *"One commentator indicated that the FAA may have underestimated the problems associated with removal of the red filter on the anticollision light on existing aircraft. The commentator pointed out that it may be impossible to meet the current field-of-coverage requirements because of the need to mask the unfiltered light to eliminate back-scatter. While the FAA recognizes this problem, it should be noted that it was not proposed to require anyone to remove the red filters on existing aircraft. Moreover, if an operator elected to do so, he would not be required to meet the new intensity requirements. Furthermore, he could relocate the light to minimize the back-scatter problem. Another comment expressed an objection to the proposed increase in the intensity level of anticollision light systems for future aircraft on the grounds that for small aircraft using red anticollision lights, power requirements would be unreasonable, service life short and reliability low, and that for small aircraft using the white anticollision lights, it would be possible to shield them for purposes of back-scatter without a reduction in the required field-of-coverage. The FAA is aware that for red anticollision lights more electrical power would be needed to meet the new requirements than has been provided in the past. However, the FAA believes that this additional power capacity can be provided on future aircraft at reasonable cost, without incurring a low-service-life or low-reliability penalty. Moreover, a manufacturer would now have the option of installing a white anticollision light, thereby eliminating the power problem. The back-scatter problems referred to by the commentator can be solved without diminishing the field-of-coverage by installing a system consisting of three lights, one at each wing-tip and one on the tail."*

There is no restriction on mixing aviation red and Aviation White anticollision lights on the same airplane. Likewise, there is no restriction on the ratio of red to white provided that the light displayed in any one direction is **either** aviation red **or** Aviation White.

Some white supplementary lights have been presented for certification as anticollision lights. The visible limit of such lights may converge at some point forward and aft of the airplane such that from this point to the airplane neither light is visible. The maximum allowable distance to such convergence is 1,200 feet.

The regulations (§ 23.1397) require that Aviation Whites "X" coordinate be no less than 0.300 and no greater than 0.540 (ICAO) Annex 8 requirement). Xenon flash tubes can exceed the "X" limit for some energy levels (20 to 40 joule range). For the function of an anticollision light, an occasional excursion beyond the 0.300 limit would not adversely affect safety or the performance of the intended function. We have been advised by the National Bureau of Standards (NBS) that the measurement accuracy of the "X" value of chromaticity coordinates includes an error tolerance of plus or minus 0.008. It was not envisioned that filtering would be required on Xenon flash tubes to meet the Aviation White limits since the color can be effectively limited by capacitor circuitry to control the energy level of individual flashes. The maximum joules per flash should be such that the 0.300 will not be exceeded more than 68 percent of the time and 0.292 will not be exceeded 99.7 percent of the time (3 sigma), which includes the measurement error tolerance suggested by NBS.

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains this amendment as follows: *"The present anticollision light rule in Sec. 23.1401(b) requires that the field of coverage extend in each direction within at least 30° above and 30° below the horizontal plane of the airplane. The FAA believes that this minimum coverage should be increased. Under the present rule, visibility of the light may be less than is needed when the airplane is approached by another aircraft ascending or descending, or when the airplane is banked at more than 30°. This proposal would expand the present field of coverage so that it extends in each direction within at least 75° above and 75° below the horizontal plane of the airplane. In addition, this proposal would specify at least a 20-candle effective intensity in the 30° to 75° field of coverage, thereby increasing the probability of seeing the airplane from other aircraft (including air rescue aircraft) and from control towers."*

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 revises § 23.1401 to require the installation of an anticollision light system on all part 23 airplanes. Current § 23.1401 requires an anticollision light system only if certification for night operations is requested.

SAFETY EQUIPMENT

23.1411 General

The corresponding rules in CAR 3 are CAR 3.711, 3.713, 3.714 and 3.715.

The corresponding rules in the Airship Design Criteria, FAA-P-8110-2, Change 2, are sections 6.33, 6.34 and 6.35.

Amendment 23-17 and Subsequent

A proposed revision to NPRM 75-10 explains this amendment as follows: *"By amending Sec. 23.1411 in a manner substantively identical to that proposed for Sec. 27.1411. The proposal would add a requirement for stowage provisions for all safety equipment in Sec. 27.1411 and would provide standards applicable to such stowage provisions."*

Amendment 23-36 and Subsequent

There is no proposed change to § 23.1411 by the NPRM, but Final Rule, Docket 25147, explains this amendment as follows: *"One commenter suggests that the regulatory references in the notice should be crosschecked with the latest revisions of Part 23. As a result of reviewing the FAR, the FAA identified several sections of Part 23, which need to be changed for compatibility with the new requirements for dynamic testing of seat/restraint systems. The regulatory changes identified by this review are not substantive but provide consistency with the other changes made by this amendment. This review resulted in several additions to this final rule. Section 23.1411 is revised so that paragraph (b)(2) refers to section 23.561(b)(3)."*

23.1413 Safety Belts and Harnesses [Removed]

See guidance for section 23.785 in this AC.

23.1415 Ditching equipment

No policy available as of September 30, 2003.

This rule was adopted on February 1, 1965 as a recodification of CAR 3.716, 3.717 and 3.718.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.36.

23.1416 Pneumatic de-icer boot system

The corresponding rule in CAR 3 is CAR 3.712.

There is no corresponding rule in the Airship Design Criteria.

Policy is available in AC 23.1419-2B.

23.1419 Ice protection

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.37.

The § 23.1419 guidance in this AC is focused on the ice protection systems at the component and system level. For information pertaining to airplane performance and handling in icing conditions please refer to AC 23.1419-2B, "Certification of Part 23 Airplanes for Flight In Icing Conditions," and AC 20-73, "Aircraft Ice Protection."

Original Issue and Subsequent

Icing Policy for Small Airplanes

The CAR 3 airplanes and 14 CFR, part 23 airplanes with a certification basis preceding Amendment 23-14, are permitted to fly in known icing conditions if their TCs do not include a prohibition against this operation. Some of these airplanes may be placarded against flight into known icing because they lack de-ice/anti-ice equipment specified in the type design data. Installation of equipment required for icing approval per type design data is justification for removing the placard. However, the part 91 and part 135 operating rules in icing have limitations for these aircraft.

If the above airplanes type design data prohibits flight into known icing, then these airplanes can be approved for flight into known icing only if compliance is shown to part 23, § 23.1419, Amendment 23-14, and subsequent.

Amendment 23-14 and Subsequent

To certificate a single-engine airplane for flight in icing conditions, part 21, § 21.101 would require the same criteria to be applied as in VFR, IFR, day and night flight, which is to keep the airplane in the air and flying even if performance is compromised somewhat. This may require redundancy in ice protection system components to minimize hazards to the airplane in the event of a probable malfunction or failure.

There is no requirement or allowance for making adjustments in the icing certification program for the frequency of encountering icing conditions. A probability of one is to be used for encountering discrete environmental conditions such as instrument meteorological conditions. Icing conditions are environmental conditions, and an encounter frequency of less than one for compliance with §§ 23.1093 and 23.1419 is not appropriate.

Amendment 23-43 and Subsequent

See ACs 23.1419-2, 23-143-1, 23-8 and 20-73.

EASA AMC 23.1419 accepts FAA AC 23.1419-2 as an AMC to CS 23.1419.

MISCELLANEOUS EQUIPMENT

23.1431 Electronic equipment

The corresponding rule in CAR 3 is CAR 3.721.

There is no corresponding rule in the Airship Design Criteria.

Original Issue and Subsequent

Mercury cell battery packs for use in Emergency Locator Transmitters (ELT) should be manufactured by controlled processes. Service experience has shown that ELT mercury cell battery packs fabricated by individuals without a controlled process can result in the following:

a. Degradation of the cell seal causing leaks and a shorter shelf life.

b. Creation of internal shorts.

c. Internal corrosion.

d. Creation of highly explosive mercury fulminate.

The possibility of adverse interaction between communication and navigation equipment should be evaluated. Momentary indicator deflection or flicker is acceptable. However, loss of a required function due to interaction of assignable frequencies in the NAS is not acceptable.

Guidance for TCAS II installations is given in AC 20-131A, "Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders."

Automatic Air Navigation Facility (NAVAID) selection tuning (Auto-tune) of VHF Omnirange Station/Distance Measuring Equipment (VOR/DME) for flight management or multisensor navigation systems is designed to enhance the navigation accuracy for enroute flight. Under certain conditions, and depending on the particular implementation, the auto-tune function can cause a hazard if auto-tune remains operative during VOR and ILS operations. In this case, automatic selection of a NAVAID different than that wanted by the flight crew is a possibility. Visual cues indicating the auto-tune is still active may be quite subtle and may go unnoticed during a high workload period. If the auto-tune NAVAID is reasonably in line with the projected track, the anomaly can go undetected—causing the airplane to fly an erroneous track based on the auto-tune NAVAID. This may occur either when steering manually or when the flight guidance system has been engaged. System installations that employ auto-tune should be mechanized in a manner that addresses these safety issues. An acceptable method of auto-tune implementation is to automatically inhibit the auto-tune feature when a navigation function other than the one utilizing auto-tune has been selected for display on the Horizontal Situation Indicator/Electronic Horizontal Situation Indicator (HSI/EHSI).

Moving Map Displays (MMD) used for primary command guidance during IFR flight should be evaluated with the particular navigation receiver (GPS, LORAN-C, etc.) to be used. It should also be restricted to use with that particular type of receiver on that particular airplane. If a separate command or deviation indicator is used to certify the system for IFR use, the MMD should be placarded “For Reference Only” and used only if it can be shown that failure of the MMD would not fail the navigation system.

An MMD to be used for and placarded for “VFR Only” guidance would need verification that it performs its intended function when used with a particular navigation receiver. It could then be used on any other airplane with the same type navigation receiver.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *“This proposal would include electronic equipment that is being installed in part 23 airplanes as well as radio equipment. When the existing regulation was adopted, radio equipment was the primary electronic equipment installed. For standardization in the application of FAA requirements, this proposal is consistent with Section 25.1431(a) and (c). Section 23.1309(b)(1) and (2) that are referenced are the proposed regulations in Notice 5, Small Airplane Airworthiness Review Program.”*

This amendment is clarified by Final Rule, Docket 26344, as follows: *“This proposes to amend Sec. 23.1431 to revise the current rule that addresses radio equipment only by including other electronic equipment that is installed in a part 23 airplane. Two comments were received. One commenter asks for a definition of the words, "critical environmental conditions" used in proposed Sec. 23.1431(a). Critical environmental conditions are those environmental conditions under which a piece of equipment will not perform its intended function. By including this requirement, conditions that may be critical to the operation of a piece of equipment must be considered. Consideration of such conditions would include, but not be limited to, temperature extremes, vibration levels, and humidity.*

The other commenter agrees with the proposal and suggests that Sec. 23.1431 be expanded to cover communications between pilots, radio transmission switches, and the effectiveness of aural warnings when headsets are being worn. Because these suggested expansion items were not included in the notice, their addition would be beyond the scope of the NPRM. This proposal is adopted as proposed.”

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this change to Amendment 23-49 as follows: *"This proposal would add three new paragraphs to Sec. 23.1431. Proposed new paragraph (c) would require that airplanes required to be operated by more than one flightcrew member must be evaluated to determine if the flightcrew members can converse without difficulty when they are seated at their duty stations. Accident investigations have shown that, in some instances, conversation between the flightcrew members was severely hindered by the noise level in the cockpit and that the inability to communicate contributed to the accident. If the required evaluation shows that the noise level does not impair conversation, no further action is required. However, if the evaluation shows that conversation will be difficult, an intercommunication system would be required.*

Proposed new paragraph (d) would require that if installed communication equipment includes any means of switching from receive to transmit, the equipment must use "off-on" transmitter switching that will ensure that the transmitter is turned off when it is not being used. Transmitting equipment that remains in the transmit mode when not being used blocks the frequency being used and can create an unsafe condition by preventing other needed communication.

Proposed new paragraph (e) would require that if provisions for the use of communications headsets are provided, it must be demonstrated that flightcrew members can hear aural warnings when a headset is being used. Aural warnings are required to warn the pilot of a condition that necessitates the pilots taking action; therefore, it is necessary to ensure that such warnings would be effective even when headsets are being used.

During the development of the proposed new requirements in paragraphs (c) and (e), the FAA considered proposing a requirement that compliance demonstrations should be conducted under actual cockpit noise conditions when the airplane is being operated. The FAA, however, ultimately determined that such a requirement could result in demonstrations conducted under more severe noise conditions than needed. Accordingly, no such requirement is being proposed. If the FAA determines in the future that noise conditions for demonstrations need to be specified, the FAA will define these conditions in advisory material."

The proposal to include testing under actual noise conditions in paragraphs (c) and (e) was revised by Final Rule, Docket 27806, as follows: *"This proposal would add three new paragraphs to Sec. 23.1431. Proposed new paragraph (c) would provide that airplanes required to be operated by more than one flightcrew member be evaluated to determine if the flightcrew members can converse without difficulty when they are seated at their duty stations. Proposed new paragraph (d) would require installed communication equipment to use "off-on" transmitter switching that will ensure that the transmitter is turned off when it is not being used. Proposed new* *paragraph (e) would require that, if provisions for communication headsets are provided, the applicant must demonstrate that flightcrew members will receive all warnings when a headset is being used. The demonstration must be made under actual cockpit noise conditions. To clarify the conditions under which these evaluations should be conducted, not withstanding earlier harmonization agreements, these two paragraphs are being revised to include the phrase, "under actual cockpit noise conditions when the airplane is being operated."*

EASA AMC 23.1431(e) is acceptable for FAA certification.

23.1435 Hydraulic systems

The corresponding rule in CAR 3 is CAR 3.3.726.

The corresponding rules in the Airship Design Criteria, FAA-P-8110-2, Change 2, are sections 6.4 and 6.38.

Amendment 23-7 and Subsequent

A proposed revision to NPRM 67-14 revised paragraph (c) to add the words "or propeller" after the words "part of an engine."

Amendment 23-14 and Subsequent

A proposed revision to NPRM 71-13 explains this amendment as follows: *"This proposal is appropriate because of increased reliance on hydraulic systems and the increasing complexity or such systems in Part 23 airplanes."*

The NPRM was revised by Final Rule, Docket 11011, as follows: *"Sec. 23.1435(a)(2) has been revised to indicate that the required indication must be to the flight crew."*

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"Conference proposal 469 recommended adding to Section 23.1435(c) a requirement that propeller unfeathering accumulators be considered as an integral part of the propeller and small (1 quart max.) nonpressurized reservoirs be acceptable. Propeller unfeathering accumulators have been accepted as an integral part of a propeller. The conference discussion supported clarification of the requirement and the allowance of some small accumulators, such as for the brake systems on single-engine airplanes. The FAA has further considered these issues and concludes such accumulators should be allowed provided their total capacity is limited to one quart or less."*

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 clarifies paragraph (c) with the following explanation: *"Since the close of the comment period for the Small Airplane Airworthiness Review Program Notice No. 3 (55 FR 40598, October 3, 1990), now adopted by Amendment No. 23-43 (58 FR 18958, April 9, 1993), the FAA has been involved in discussions of the installation of hydraulic accumulators that are permitted by Sec. 23.1435(c). These discussions have shown that applicants are likely to find Sec. 23.1435(c) difficult to understand because of the way it is worded.*

This notice would further revise Sec. 23.1435(c) to clarify under what circumstances a hydraulic accumulator and reservoir may be installed on the engine side of any firewall."

23.1437 Accessories for multiengine airplanes

No policy available as of September 30, 2003.

This rule was adopted on February 1, 1965 as a recodification of CAR 3.725.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.39.

23.1438 Pressurization and pneumatic systems

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.40.

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains this rule as follows: *"Components (such as ducts and couplings) of pressurization and pneumatic systems have failed at an unacceptable rate in service. The proposed standards for these components have been effective in preventing design deficiencies in the past."*

The rule proposed in NPRM 75-23 was revised by Final Rule, Docket 14625, and is explained as follows: *"For comments related to the proposal to add a new Section 23.1438, and for an explanation of revisions made to proposed Section 23.1438, see Proposal 5-33. Proposal 5-33 includes: One commentator stated that if the term "components" in proposed Secs. 25.1438(a) and (b) included all parts of the system it would not be compatible with other Secs. of Part 25, which use the term "elements". The FAA intended that the term "components" include all parts of the system. Therefore, in order to be consistent with current Section 25.1435, which uses the term "elements", that term is substituted for the term "components" in proposed Secs. 25.1438(a) and (b).*

One commentator questioned the need to specify a higher burst pressure for pneumatic systems than for pressurization systems, contending that pneumatic systems do not necessarily operate at higher pressure and that some are derived from pressurization systems. The FAAs experience has been that pneumatic systems in airplanes are operated at higher pressures, even when a common pressure source is provided for both pneumatic and pressurization systems.

One commentator objected to the provision in proposed Section 25.1438(b) requiring a burst pressure test of 4.0 times maximum normal operating pressure, contending that the industry has historically designed and tested pneumatic systems to a burst pressure of 3.0 times maximum normal operating pressure and that service experience over millions of flight hours has proven the integrity of those systems. Another commentator pointed out that pneumatic deicer boots in general use today cannot sustain a pressure of 4.0 times maximum normal operating pressure. The FAA agrees with these comments, and proposed Section 25.1438(b) is revised to specify a burst pressure of 3.0 times maximum normal operating pressure.

One commentator suggested revision of proposed Section 25.1438 to allow the use of analysis, or a combination of analysis and test, as an alternative method of compliance to eliminate unnecessary testing. The FAA agrees that there are *instances where an analysis, or a combination of analysis and test, may be equivalent to a test under proposed Section 25.1438(a) or (b). Accordingly, a new Section 25.1438(c) is added to provide this alternative."*

Burst and proof tests are required at multiples of the maximum normal operating pressure. Temperature effects are not required as part of these tests if pressurization and pneumatic system elements are constructed of materials that can withstand the operational pressures and temperatures. If sufficiently overstrength material elements are part of a design, then reduced material strength due to temperature variations is not a concern and testing may be performed at ambient temperature. The "sufficiently overstrength" determination must consider temperature cycles/extremes for materials that may exhibit structural property phenomenon and structural strength changes due to temperature changes. Certain composite materials may be characteristic of adverse performance in certain temperature environments. Furthermore, the "sufficiently overstrength" determination must consider both the duct system and its attach/clamping/stabilization devices. This advice is consistent with §§ 23.1301, Function and Installation; 23.307, Proof of Structure; and 23.603(a), Materials and Workmanship.

23.1441 Oxygen equipment and supply

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-9 and Subsequent

A revision to NPRM 67-30 proposed this rule based on the following explanation: *"In a study concerning the physiological requirements for oxygen entitled "Oxygen in General Aviation" dated December 1964, the Office of Aviation Medicine of the FAA reported that, while individual oxygen requirements may be influenced by factors such as fatigue, age, use of drugs and tobacco, night, etc., nevertheless supplemental oxygen, dependent on altitude, is a physiological necessity for all humans. For this reason and because of the increasing number of small airplanes having high altitude capability, there appears to be a need for airplane airworthiness standards and for general operating rules relating to oxygen system requirements.*

In the past, type certification of small airplanes with oxygen equipment installed has been handled on a case-by-case basis either by application of special conditions or under the general operating limitations of Sec. 23.1501. This amendment proposes uniform airworthiness standards for oxygen equipment and supply. It also proposes performance standards relating to oxygen mass flow and equipment standards for oxygen dispensing units.

Parts 121 and 135 of the Federal Aviation Regulations currently prescribed oxygen requirements for pilots and passengers. For consistency in the interest of safety, all other aircraft operating in the same airspace and environmental conditions should be under comparable standards. The FAA, therefore, considers it appropriate to propose general operating and flight rules governing the use of supplemental oxygen in pressurized and unpressurized cabin aircraft.

FAA studies have indicated that for any person in a pressurized cabin subjected to decompression at the higher altitudes, the short time available to don an oxygen mask before losing consciousness may be critical. In such case, the smaller the cabin volume, the more aggravated the situation becomes. As an added operational consideration, the FAA, therefore, believes it necessary for safety, at flight altitudes above 35,000 feet, that at least one pilot at the controls be required to wear an oxygen mask. The corresponding altitude for Part 121 operations had originally been established at 35,000 feet. However, it was subsequently raised, in steps, to 41,000 feet, on the basis of the extensive operating experience with the large transport-category airplanes. This satisfactory operating experience is attributable, in part, to the stringent Part 121 crew training and maintenance requirements. Such compensating conditions do not presently exist for operations conducted under Part 91 and the proposed cutoff altitude has been accordingly set at 35,000 feet.

A new Sec. 91.32 would be added to the general operating rules of Part 91 to regulate the use of supplemental oxygen throughout the range of cabin altitudes and specify the oxygen supply to be carried, including the oxygen necessary for emergency descent. Supplemental oxygen refers to any oxygen, by whatever means supplied, that is furnished in addition to the oxygen normally present in the air."

Amendment 23-9 is clarified by Final Rule, Docket 8281, as follows: *"Several commentators objected to the proposal on the basis that it would require the owners of small airplanes that are not designed to operate at altitudes where oxygen is required to purchase expensive oxygen equipment for their airplanes. This, however is not the case. The proposal would not require the installation of oxygen equipment on all small airplanes. Oxygen equipment would have to be installed only on small airplanes that are to be used in operations conducted at the altitudes for which supplemental oxygen must be provided and used in accordance with the requirements of Part 91. The need for oxygen in such operations far outweighs any economic burden that may be involved in the installation and maintenance of the oxygen equipment.*

Several commentators suggested revising proposed Sec. 23.1441(a) which states that there must be a means to allow the crew to readily determine during flight the quantity of oxygen available in each source of supply. It was recommended that the proposal be changed to specify a means for determining the remaining number of hours of available oxygen. These commentators are primarily concerned with the pressure gauges being furnished with oxygen systems. They believe that a pressure gauge is not an adequate instrument for determining the quantity of oxygen available. The FAA does not agree. In most instances, a pressure gauge in the oxygen system will indicate the quantity of oxygen available in the source of supply. If, in any particular installation, it is determined that a pressure gauge would not satisfy the requirement, then some other means to allow the crew to determine, during flight, the quantity of oxygen available in each source of supply would have to be provided. In any event, the remaining number of hours of available oxygen can be readily obtained once the quantity of oxygen available in each source of supply is known.

In response to numerous comments, Sec. 23.1441 has been revised to make it clear that portable oxygen equipment may be used to meet the supplemental oxygen requirements."

Plastic lines (nylon, PVC and Teflon) are **not** acceptable for use in continuously pressurized, non-portable oxygen systems.

Plastic lines can be used in non-portable oxygen systems that are pressurized only when cabin decompression occurs with the following precautions:

a. Swaged metal type end fittings should be used to prevent leakage from cold flow.

b. Lines should be protected from abrasion by use of a reinforcing sleeve of fabric braid.

c. Lines should be routed away from areas where they might be subjected to elevated temperatures, electrical arcing (relays and switches), and flammable fluids.

d. Refer to AC 43.13-2A, “Acceptable Methods, Techniques, and Practices—Aircraft Alterations,” and American Society for Testing and Materials (ASTM) Manual 36, “Safe Use of Oxygen and Oxygen Systems, Guidelines for Oxygen System Design, Materials Selection, Operations, Storage, and Transportation”, dated 2000Chapter 6; for additional guidance material.

Design and install oxygen tubes/hoses in such a manner that the hoses are stable during all phases of flight. It is not adequate to require the applicant to design tube/hose routings and chaffing protection without ensuring (by design) that the installed tubes/hoses will not vibrate/flap in a manner that would either defeat the chaffing prevention wrap, or to impact other system elements such as sensors, wires, and mechanisms.

Part 23 is unique in that it allows oxygen system requirements to be met with portable systems. For those portable systems, information should be provided to the flight crew in the form of limitations stating which portable system is approved, which components constitute the system, and any operating limitations.

Part 23 airplanes may be certified with or without an oxygen system. The necessity for supplemental oxygen is a function of the operational altitude not the airplane design. Therefore, the requirements for when supplemental oxygen is required can be found in General Operating and Flight Rules. If installed, the system should meet the following part 23 airworthiness requirements as follows: (a) §§ 23.1441 through 23.1449 (and § 23.1450 if chemical oxygen generators are used), and (b) it may be a basic part of the airplane or a portable system. Section 23.1525 requires the airplane operational limits be established in accordance with the installed equipment or lack thereof. If an airplane is delivered without an oxygen system, its AFM should have a limitation or there should be a placard prohibiting flight above 14,000 feet MSL.

Amendment 23-43 and Subsequent

Under the previous amendment, certification of an oxygen system was at the discretion of the applicant. Under this amendment, an oxygen system “must be provided” if an airplane is certificated to operate at altitudes where the operational rules require oxygen use. This rule is applicable to any airplane with a certification basis of Amendment 23-43 or later.

The rule permits portable systems to be designed by a TC holder subject to actions to prevent the portable system from being a hazard by not being properly secured in an emergency landing (per § 23.561). The precise requirement regarding portable systems should be determined in reference to the specifics of the airplane type (i.e., its service ceiling, number of seats, etc.). The rulemaking history does not state a safety deficiency in current methods of providing supplemental oxygen by the use of operator-provided, portable, constant flow oxygen systems either attached to the seatback or restrained by a seatbelt.

If a TC holder does not plan to provide an oxygen system, it must specify a maximum weight and size of portable oxygen bottle and a specific means of restraining the bottle in an emergency landing per § 23.561 either by attachment to a seatback or a seatbelt. This could be commercially available or produced by the TC holder and available with the airplane as standard equipment or as an option.

If an applicant does not provide the oxygen system or restraint information for portable bottles, the airplane will be limited to operational altitudes where oxygen is not required.

Amendment 23-43 added § 23.1441(e). It requires there be a means readily available to the flight crew to both turn ON and turn OFF the oxygen supply at the high-pressure source. A flow fuse that senses a rupture in an oxygen line and automatically shuts off is not an ELOS to the required pilot operated switch since it only applies to one failure where oxygen shutoff is needed. It was made clear by the NPRM that the switch was needed to turn ON and OFF the oxygen system, to shutoff in the event of a rupture, and to shutoff in the event of a fire.

23.1443 Minimum mass flow of supplemental oxygen

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Original Issue and Subsequent

When there is full compliance to this regulation, there is no need to consider the probability of a pressurization failure or to require an immediate descent in altitude in the event of a failure. Compliance should include the consideration of a rapid explosive decompression to ambient pressure with a pilot recognition and reaction time of 17 seconds to initiate a descent.

(a) The airplane may be altitude-limited to meet this requirement, or

(b) The applicant may provide an ELOS finding.

Amendment 23-9 and Subsequent

A proposed revision to NPRM 67-30 explains this amendment as follows: *"In connection with the standards for minimum mass flow of supplemental oxygen, the proposed Sec. 23.1443 contains requirements for continuous flow but not for demand flow oxygen equipment. The requirements of the more commonly used continuous flow systems are thus covered, while the mass flow of demand systems, where such systems are used, would be approved on a case-by-case basis as before."*

This amendment is clarified by Final Rule, Docket 8281, as follows: *"One commentator suggested incorporating a provision in Sec. 23.1443 which would require compliance with the proposed graph (depicting oxygen mass flow rates) only up to the cruising altitude for which type certification of the airplane is desired. The recommendation is premised on the contention that it is unnecessary and economically unreasonable to install oxygen equipment capable of a specified mass flow rate at 40,000 feet if the airplane will be operated at a much lower altitude. The purpose of Sec. 23.1443 is to show the minimum oxygen mass flow rates which would be required for each occupant of an airplane at the corresponding cabin pressure altitudes. The applicant for a type certificate would not be required to install oxygen equipment capable of supplying the minimum oxygen mass flow rates for the entire range of cabin pressure altitudes shown in the graph unless his airplane is capable of operating through the entire range. Accordingly, Sec. 23.1443 is revised to state that the oxygen equipment installed in the airplane must be capable of supplying to each occupant the appropriate flow of oxygen for all altitudes up to and including the maximum operating altitude of the airplane."*

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"This proposal modifies the oxygen flow rates for small airplanes. These new requirements are needed for current and future airplanes that will be certificated to higher altitudes where oxygen is required.*

Conference proposal 472 recommended revising Section 23.1443 by designating the present paragraph as paragraph (a) and adding a new paragraph (b) to read essentially the same as Section 25.1443(b). The justification given was that "The oxygen flow rate requirements of parts 23 and 25 are different. However, both regulations provide requirements needed to ensure continuous flow rates up to cabin pressure altitudes of 40,000 feet. Proposed Section 23.1443 is a combination of these requirements. Proposed Section 23.1443(a) contains current Section 23.1443 with regard to continuous flow requirements, and Section 23.1443(b) is derived from Section 25.1443 for demand system requirements. The language of the recommended change would allow Section 23.1443 to cover both continuous flow oxygen and demand systems without interpretation from part 25."

"Conference proposal 473 recommended revising § 23.1443 essentially as shown in this proposal since the oxygen flow rate requirements of parts 23 and 25 are different. However, both regulations provide requirements needed to assure continuous flow rates up to cabin pressure altitudes of 40,000 feet. Proposed § 23.1443 is a combination of these requirements. Sections 23.1443 (a)(1) and (a)(2) contain the continuous flow requirements of part 25 and allow the applicant to comply with those requirements or with paragraph (a)(3), which is the current continuous flow requirement of part 23. Demonstrating compliance with proposed § 23.1443(a)(3) is easier, but results in a larger volume of oxygen and more weight. Demonstrating compliance with § 23.1443 (a)(1) and (a)(2) is harder, but results in a lesser volume of oxygen. By allowing the applicant to choose either method of compliance, this requirement permits freedom of design.

When presented for comment at the conference, the FAA confirmed that this conference proposal would allow alternatives of continuous flow oxygen equipment or demand oxygen equipment. With a good face-fitting mask, less oxygen will be used with a demand system than with a continuous flow system. Studies on altitude sickness and the impairment of ability to function on continuous flow equipment at altitudes above 25,000 feet leads the FAA to reconsider this issue, especially for flight crews.

Proposed paragraph (c) provides the flow rate requirements for first-aid oxygen equipment if installed, but does not require its installation. These requirements are identical to the first-aid oxygen flow rate requirements in part 25. With the recent addition on commuter category airplanes in part 23, first-aid oxygen equipment is more likely to be installed in part 23 airplanes.

Proposed paragraph (d) is clarifying by providing definitions of the term "BTPS" and "STPD" as used in this section.

Post conference review of these comments and the oxygen requirements of parts 91, 121, and 135 led to the conclusion that (1) adding the equivalent of the part 25 oxygen requirements to part 23 will provide adequate protection for both flight crew and passengers; and (2) that crewmembers should have demand oxygen equipment for operations above 25,000 feet."

This amendment is clarified by Final Rule, Docket 26344, as follows: *"This proposes to amend Sec. 23.1443 to modify the oxygen flow rates for part 23 airplanes by providing alternate procedures that may be used to substantiate satisfactory continuous flow oxygen equipment. One commenter requested that the FAA make it clear that the 40,000 foot altitude limit in this proposal is not an absolute altitude limit for part 23 airplanes. The FAA agrees. The altitude limit in this proposal does not constitute an absolute altitude limit for the approval of part 23 airplanes; however, the approval of individual airplanes would be limited to those altitudes where safe occupant protection is provided."*

23.1445 Oxygen distribution system

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this amendment as follows: *"This proposal will establish standards for oxygen distribution systems not heretofore required. These requirements will prevent installation of plastic hoses in pressurized oxygen systems.*

Conference proposal 474 recommended adopting equipment standards for oxygen systems essentially the same as proposed here. The justification given was that several accidents have occurred in airplanes where nylon tubing was used in an oxygen system pressurized to 70 psi. Because oxygen can support vigorous combustion, oxygen system installations warrant special attention in certification programs.

When presented for comment at the conference, the two commenters agreed that pressurized plastic tubing is inappropriate for oxygen system but did not completely agree with the proposal because they believed the rules should not specifically preclude all nonmetallic tubing. Some composite airplanes may need nonmetallic oxygen lines for lightning strike protection. In view of these comments, a phrase that allows a showing of suitability to the installation was added to the proposal."

The guidance in this AC for § 23.1441, Amendment 23-9 and subsequent, for plastic lines is applicable to this regulation.

23.1447 Equipment standards for oxygen dispensing units

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-9 and Subsequent

This amendment is clarified by Final Rule, Docket 8281, as follows: *"It was recommended that paragraphs (b) and (c) of proposed Sec. 23.1447 be revised to specify that they are applicable only to pressurized airplanes. The commentator asserts that these proposals should not apply to nonpressurized airplanes, which are not subject to sudden-decompression occurrences. The FAA agrees and this has been made clear in the final rule. In addition, further FAA studies have shown that for those pressurized aircraft designed to operate at 25,000 feet MSL or below, the pilot will have sufficient time to descend to safer altitudes prior to the onset of any symptoms of hypoxia in the event of a sudden decompression. For this reason, the proposal in paragraph (b) of Sec. 23.1447, requiring an oxygen supply terminal and unit of oxygen dispensing equipment within reach of each member of the required minimum flight crew for those airplanes designed to operate at flight altitudes up to and including 25,000 feet, is unnecessary and has not been adopted."*

The Small Airplane Directorate was recently asked for applicable policy regarding the requirements for (1) operation above 25,000 feet, dispensing units be immediately available to each occupant wherever seated, and for (2) operation above 30,000 feet, dispensing units be automatically presented to each occupant before the cabin pressure altitude exceeds 15,000 feet. Item (1) was incorporated into part 23 by Amendment 23-9 and item (2) above by Amendment 23-20. These rules were based on seats that were fixed in location and orientation. The question arises from the use of swiveling and tracked seats where it is possible for some occupants to move their seat into an orientation where an automatically presented dispensing unit will not be in view.

The following guidance is applicable to an airplane with a certification basis of Amendment 23-9 or subsequent. This guidance is taken from AC 25-17, section 25.1447, where the issue of tracked and swiveled seats has been addressed.

Automatic presentation is acceptable if the dispensing unit (mask) is presented in front of the eyes when the person's head is resting on the seat back cushion with the seat in any position, either as upright, reclined, swiveled or tracked. The mask need not be presented in front of all persons if there is sufficient "crowd awareness," i.e., the vast majority has proper presentation and the others can readily see that the masks have been presented. These latter people should have a preflight briefing clearly showing them the location of their mask. The mask should be reachable with the seat belt fastened. In some seating arrangements, such as executive interiors, the various seating positions result in many different group combinations. Each combination should have an adequate number of masks reachable by every person. Consideration should be given to minimizing the likelihood of persons taking the wrong masks, thus depriving another person of their mask. If the mask must be pulled to initiate oxygen flow, the mask should be presented so that the person must pull the mask to don it. The fifth percentile female and ninety-fifth percentile male should be considered. Either as sleeper seats, bunks or lavatories a streamer of webbing attached to the mask is acceptable to enable the person to pull the mask down to them.

Amendment 23-30 and Subsequent

A proposed revision to NPRM 75-23 explains this amendment as follows: *"The proposal would require automatic presentation of oxygen dispensing units on airplanes certificated under Part 23 for operations above 30,000 feet. Should loss of pressurization occur at those altitudes, the time of useful consciousness varies between 90 seconds at 30,000 feet and 10-12 seconds at 40,000 feet, necessitating automatic presentation of oxygen dispensing units. It is also proposed to specify 14,000 feet as the cabin pressure altitude at which they must be automatically presented so that they would be ready for use not only when the cabin pressure altitude goes very rapidly to very high values but also in the event of a pressurization system failure or malfunction after which (under present Sec. 23.841(a)) the cabin pressure altitude may go to 15,000 feet. The 14,000-foot cabin pressure altitude for automatic presentation is also being proposed for Part 25.*

In addition, since service experience has shown that the automatic presentation feature may fail, it is proposed that a manual means be provided to enable each occupant to gain access to his oxygen dispensing unit. This manual means is also being proposed for Part 25."

This amendment is clarified by Final Rule, Docket 14625, as follows: *"For comments related to the proposal to add new Secs. 23.1447(c) and (d), and for an explanation of the revisions made to proposed Secs. 23.1447(c) and (d), see Proposal 5-34. One commentator objected to the provision in proposed Section 25.1447(c)(1) which would require that oxygen dispensing units be automatically presented before the cabin pressure altitude exceeds 14,000 feet, contending that long-standing FAA policy has been that the altitude for automatic presentation should be 15,000 feet and service experience over the last 16 years has not shown a need to reduce that altitude. The commentator further stated that the flight crew is given a warning when or before the cabin pressure altitude reaches 10,000 feet and is therefore alerted (in the event of a gradual increase in cabin pressure altitude) to the need for appropriate action either to maintain a safe cabin pressure altitude or manually deploy the dispensing units. Another commentator suggested that the presentation altitude be 14,500 feet, rather than 14,000 feet, to take equipment tolerances into account.*

In light of the comments received and after further review, the FAA believes that there is insufficient evidence at the present time to justify a requirement for the automatic presentation of oxygen dispensing units before the cabin pressure altitude exceeds 14,000 feet, and that the widely-used value of 15,000 feet provides an adequate level of safety. Proposed Section 25.1447(c)(1) is revised accordingly.

Several commentators disagreed with the provision in proposed Section 25.1447(c)(1) that would require that each occupant be provided with a manual means to make the oxygen dispensing unit immediately available, contending that manual back-up for the automatic presentation system should be provided for use by the crew only, to avoid tampering by the passengers. Another commentator stated that the average passenger would not be capable of operating such manual means properly and quickly, and that manual means are not feasible for ceiling or hatrack mounted dispensing units.

The FAA believes that a manual means must be provided to back up the automatic presentation system, but is persuaded that it may not be in the interest of safety to require that a manual means be provided for passengers. Accordingly, proposed Section 25.1447(c)(1) is revised to require only that a manual means for the development of the dispensing units be provided for the crew."

Amendment 23-30 and Subsequent

This amendment allows the use of nasal cannulas for operation up to an altitude of 18,000 feet MSL. These are simple devices with no known service problems, and the FAA has not developed a design standard for them.

Section 23.1447(e) requires that oxygen masks be automatically presented to each occupant before the cabin pressure exceeds 15,000 feet for airplanes certificated for operation above 30,000 feet MSL. Before the cabin pressure altitude exceeds 15,000 feet, the oxygen mask should fall down automatically and present itself to a 95th percentile human occupant at mouth level within the visual periphery. All the occupant should have to do is pull the mask from the hanging position, don the mask, and start breathing.

Amendment 23-43 and Subsequent

A proposed revision to NPRM 90-23 explains this change to Amendment 23-43 as follows: "*This proposal would add presentation requirements for the demand oxygen equipment required by Section 23.1441(d) and allow the option of quick-donning type oxygen dispensing units."*

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this amendment as follows:
"Proposed new Sec. 23.1447(a)(4) would require that if radio equipment is installed in an airplane, flightcrew oxygen dispensing units must be designed to allow the use of communication equipment when oxygen is being used. If radio equipment is installed, that equipment cannot perform its intended function if the flightcrew is not provided the proper means for its utilization under all operating conditions, including operations when oxygen is being used.

This proposal would not require all flightcrew oxygen dispensing units to be equipped with communication equipment. Since an airplane may be operated in uncontrolled airspace, where two-way radio communication is not required and, at the same time, be at altitudes where oxygen is required for the flightcrew members, some airplanes have a crew oxygen system but no radio equipment. It would be inappropriate to require the flightcrew dispensing units of those airplanes to be equipped with communication equipment.

The proposed revisions to Sec. 23.1447(d) would require the flightcrew oxygen dispensing units to be automatically presented before the cabin pressure altitude exceeds 15,000 feet or be the quick-donning type if the airplane is certificated for operation above 25,000 feet. The requirement in paragraph (e) for the passenger dispensing units to be automatically presented if the airplane is approved for operation above 30,000 feet has not been revised. The revision to paragraph (d) would provide the flightcrew and the airplane passengers the same level of safety as provided by other airworthiness standards. This proposed revision is also consistent with the proposed revision of Sec. 23.841 in this notice."

23.1449 Means for determining use of oxygen

No policy available as of September 30, 2003.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

23.1450 Chemical oxygen generators

No policy available as of September 30, 2003.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

23.1451 Fire protection for oxygen equipment

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this rule as follows: *"This proposed new section would specify that fire protection is needed for oxygen equipment installations. Section 23.1451(a) and (b) would, respectively, prohibit the installation of oxygen equipment in designated fire zones and require that oxygen system components be protected from the heat from designated fire zones.*

Proposed Sec. 23.1451(c) would require oxygen equipment and lines to be separated from other equipment or to be protected in a manner that would prevent escaping oxygen from striking grease, fluids, or vapors. The impingement of pure oxygen on certain materials will lower their combustion point to a value where ignition will occur in ambient conditions thereby creating a potential source for an airplane fire. In one instance, an airplane was destroyed by fire that resulted when escaping oxygen impinged on lubricating material during maintenance of the airplane. The proposed new section would ensure that oxygen systems are protected to prevent fire hazards that can result from escaping oxygen."

23.1453 Protection of oxygen equipment from rupture

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 explains this rule as follows: *"This proposed new section would clarify the rupture protection needed for oxygen system installation. Rupture protection for oxygen systems is currently required by the application of the structures load requirements of part 23. The addition of Sec. 23.1453(a) would clarify the application of these load requirements and would identify the need to consider maximum temperatures and pressures that may be present. Section 23.1453(b) would identify the protection to be provided for high pressure oxygen sources and the high pressure lines that connect such sources to the oxygen system shutoff valves."*

Amendment 23-49 is clarified by Final Rule, Docket 27806, as follows: *"Proposed new Sec. 23.1453 would clarify the rupture protection needed for oxygen system installation. Rupture protection for oxygen systems is currently required by the application of the structure load requirements of part 23. The addition of Sec. 23.1453(a) would clarify the application of these load requirements and would identify the need to consider maximum temperatures and pressures that may be present. Section 23.1453(b) would identify the protection to be provided for high pressure oxygen sources and the pressure lines that connect such sources to the oxygen system shutoff valves.*

The comments received on this proposal from the JAA and the Civil Aviation Authority (CAA). CAA noted that the word "high" in paragraph (b) could lead to confusion and require interpretation. Accordingly, they suggested that the words "High pressure oxygen sources" be revised to read as follows: "Oxygen pressure sources." This is the same text that is used in JAR 23.

The FAA agrees with the suggested wording change. When the proposal was originally drafted, the FAA was considering the oxygen source side of the oxygen regulator, the high pressure side, and the passenger dispensing side of the regulator, the low pressure side; thus, the word "high" was used.

The suggested change will not alter the requirements applicability and will be more clearly understood. It is also noted that the suggested text change will more closely align with the same requirement in Sec. 25.1453. Section 23.1453 is changed by revising the first four words of proposed paragraph (b) to read, "Oxygen pressure sources.

This section is adopted with the above change."

23.1457 Cockpit voice recorders

EASA AMC 23.1459(b) is acceptable for FAA certification.

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-35 and Subsequent

This rule is explained by Final Rule, Docket 25530, as follows: *"Significant changes between the proposed rule and the final rule are summarized below. These changes were discussed in the appropriate sections of the Comment Discussion above:*

(1) *The compliance dates have been extended from 2 years to 3 years.*

(2) *Pre-wiring requirements in Sec. 91.35 and Sec. 135.52 have been deleted.*

(3) *The requirements for airplanes currently equipped with a digital date bus are clarified in Secs. 121.343(e) and 125.225(c).*

(4) *Certain of the parameters in Appendix B of Part 121 have been made optional.*

(5) Aircraft required to be upgraded under Sec. 135.152(b) must meet the 11-parameter or 17-parameter flight recorder requirements (currently required of certain airplanes used under Part 121) except those manufactured after October 11, 1991.

(6) Requirements pertaining to the use of boom microphones have been clarified.

(7) The resolution readout column in each of the appendices has been made applicable only to aircraft manufactured after October 11, 1991.

The changes above were coordinated with the NTSB staff who have indicated agreement that this final rule meets the intent of the NTSB recommendations in its letter of June 19, 1987.

In addition the above changes, Parts 23 and 27 have been revised to include airworthiness requirements for flight and voice recorders. In the proposal such airworthiness requirements were only in Parts 25 and 29, and all operators subject to flight and voice recorder requirements were referred to those parts. In the interest of consistency, the final rule includes airworthiness requirements for flight and voice recorders in Parts 23, 25, 27, and 29. References in the operating rule have been revised accordingly."

23.1459 Flight recorders

There is no corresponding rule in CAR 3 or the Airship Design Criteria.

Amendment 23-35 and Subsequent

Significant changes between the proposed rule and the final rule are summarized below. These changes were discussed in the appropriate sections of the comment discussion above:

"**(1)** The compliance dates have been extended from 2 years to 3 years.

(2) Pre-wiring requirements in Sec. 91.35 and Sec. 135.52 have been deleted.

(3) The requirements for airplanes currently equipped with a digital date bus are clarified in Secs. 121.343(e) and 125.225(c).

(**4)** Certain of the parameters in Appendix B of Part 121 have been made optional.

(5) Aircraft required to be upgraded under Sec. 135.152(b) must meet the 11-parameter or 17-parameter flight recorder requirements (currently required of certain airplanes used under Part 121) except those manufactured after October 11, 1991.

(6) Requirements pertaining to the use of boom microphones have been clarified.

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23.1461 Equipment containing high energy rotors

There is no corresponding rule in CAR 3.

The corresponding rule in the Airship Design Criteria, FAA-P-8110-2, Change 2, is section 6.41.

Amendment 23-20 and Subsequent

A proposed revision to NPRM 75-23 explains this rule as follows: *"By adding a new Sec. 23.1461, following Sec. 23.1449, that would be substantively identical to the proposed new Sec. 25.1461. By adding a new Sec. 25.1461: This proposal would add requirements for protection against the failure of equipment containing high energy rotors, such as turbine engine starters, air cycle machines, and certain cooling fans. Experience has shown that failures which release the energy stored in these rotors may result in engine or structural damage, fires, or injury to occupants. The language in this proposal is identical to Secs. 27.1461 and 29.1461."*

This regulation requires that equipment containing high-energy rotors meet § 23.1461(b), (c) or (d). An acceptable means of compliance to § 23.1461 is given in AC 20-128A, "Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure."

Amendment 23-49 and Subsequent

A proposed revision to NPRM 94-21 clarifies this rule as follows: *"This proposal would revise paragraph (a) of this section to clarify that the requirements apply to high energy rotors included in an auxiliary power unit (APU). Following the addition of this section to part 23, the FAA issued a policy message that showed Sec. 23.1461 was adopted to cover equipment such as APUs and constant speed drives that may be installed on small airplanes. The proposed revision of paragraph (a) will clarify the applicability of this section as identified in that policy material."*

Amendment 23-49 is additionally clarified by Final Rule, Docket 27806, as follows: *"This proposal would revise paragraph (a) of this section to clarify that the requirements apply to high energy rotors included in an auxiliary power unit (APU).*

One comment was received on this proposal. The JAA and the CAA noted that the JAA does not agree that the requirements of this section are applicable to APUs. They suggest that the proposed changes to paragraph (a) not be adopted.

In the preamble of the notice, the FAA identified policy issued after this section was adopted. That policy indicated that the section was applicable to "equipment such as APUs and constant speed drives," but this policy was not widely distributed to all FAA offices. The proposal in the notice does not alter the policy applicability, but it does clarify the policy.

Removing the proposed change would not alter the situation. The FAA defines "Equipment containing high energy rotors" to include APUs and constant speed drives. In cases where rotor containment has been demonstrated by complying with JAA-APU or FAA TSO C77a, this compliance will be examined by the FAA office responsible for the airplane certification. If it is found that this demonstration also meets the requirements of Sec. 23.1461, it will be accepted for the airplanes compliance."