U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: EQUIPMENT, SYSTEMS, AND INSTALLATIONS IN PART 23 AIRPLANES

Date: 9/19/89
Initiated by: ACE-100

AC No: 23.1309-1
Change:

1. PURPOSE. This advisory circular (AC) provides an acceptable means, but not the only means for showing compliance with the requirements of § 23.1309 through amendment 23-33 of the Federal Aviation Regulations (FAR), for equipment, systems, and installations in Part 23 airplanes. This material is neither mandatory nor regulatory in nature and does not constitute a regulation.

2. RELATED REGULATIONS. Section 23.1301 of Part 23 of the Federal Aviation Regulations (FAR) (through amendment 23-34); Part 91; and Part 135.

3. BACKGROUND. Prior to amendment 23-14 to Part 23 of the FAR (effective 12/20/73), neither Part 3 of the Civil Air Regulations (CAR) nor Part 23 of the FAR contained safety requirements for equipment, systems, and installations for small airplanes. In 1968, the FAA instituted an extensive review of the airworthiness standards of Part 23 in light of the worldwide experience with small airplanes. Because of the increased use in all weather operations and the increased reliance on systems and equipment in Part 23 airplanes, the FAA promulgated § 23.1309 to provide for an acceptable level of reliability for such equipment, systems, and installations in the interest of safety. When § 23.1309 was adopted, it was not envisioned that critical equipment, systems, or installations would be used in the design of small airplanes; therefore, this section does not contain adequate safety standards for evaluating such critical systems, the operation of which is necessary for continued safe flight and landing. When such equipment, systems, and installations are included in the airplane design, they should be evaluated under special conditions in accordance with the procedures of Part 21 of the FAR.

4. APPLICABILITY. Section 23.1309 (through amendment 23-33) and this AC are applicable to the installation of all airplane systems and equipment (including pneumatic systems, fluid systems, electrical/electronic systems and mechanical systems) except for the following:

a. Systems approved as part of a type-certificated engine or propeller and whose malfunction or failure could have no adverse effect on other airplane systems or equipment.

b. The flight structure (such as wings, fuselage, empennage, control surfaces, mechanical flight control cables, pushrods, control horns, engine mounts and structural elements of the landing gear).

c. Systems or equipment determined to be critical to safe operation. (Equipment critical to safe operation is any equipment whose failure would prevent the continued safe flight and landing of the airplane.)

5. DEFINITIONS.

a. Adverse Effect. An effect that influences the response or accuracy of equipment such that the equipment no longer performs within its specified limits. Trivial or short duration, momentary effects that could have no affect on the safety of the airplane are not considered to be adverse effects.

b. Adverse Operating Conditions. A set of circumstances in which a failure or other emergency situation results in a significant increase in flight crew workload.

c. Continued Safe Flight and Landing. This phrase means that the airplane is capable of continued controlled flight and landing, possibly using emergency procedures but without requiring exceptional pilot skill or strength. Some airplane damage may occur as a result of the failure condition or upon landing.

d. Equipment Essential to Safe Operation. Equipment installed in order to comply with the applicable certification requirements of Part 23 or operational requirements of Parts 91 and 135.

e. Equipment Not Essential to Safe Operation. Equipment whose failure or malfunction would not have any appreciable impact on the safe operation of the airplane or reduce the ability of the flight crew to cope with adverse operating conditions. The following are typical of this equipment:

(1) Galley and entertainment equipment.

(2) Non-required heating and cooling equipment.

(3) Non-required equipment installed for completion of a specific mission, such as photography, banner towing, medical evacuation, etc.

(4) Any other equipment whose functions have not been approved for fulfilling any airplane certification or operational requirement.

f. Failure. Loss of function.

g. Hazard. Any condition which compromises the overall safety of the airplane or which significantly reduces the ability of the flight crew to cope with adverse operating conditions.

h. Malfunction. Failure of a system, subsystem, unit or part to operate in the normal or usual manner.

i. Minimize. To reduce, lessen, or diminish a hazard to the least practical amount. 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.

j. Probable. A probable malfunction or failure is any single malfunction or failure which is expected to occur during the life of any single airplane of a specific type. This may be determined on the basis of past service experience with similar components in comparable airplane applications. This definition should be extended to multiple malfunctions or failures when:

(1) The first malfunction or failure would not be detected during normal operation of the system, including periodic checks established at intervals which are consistent with the degree of hazard involved; or

(2) The first malfunction or failure would inevitably lead to other malfunctions or failures.

k. Qualitative. The term used to describe those analytical processes which assess the attributes possessed by a design in a subjective, non-numerical manner.

l. Redundancy. The existence of more than one independent means for accomplishing a given function. Each means of accomplishing the function need not necessarily be identical.

m. Reliability. The determination that a system, subsystem, unit, or part will perform its intended function for a specified interval under stated operational and environmental conditions.

6. APPLICATION OF § 23.1309. The intent of § 23.1309 is to provide an acceptable level of reliability for equipment, systems, and installations in small airplanes. In order to show compliance with the requirements of § 23.1309, it will be necessary to verify that the installed systems and equipment will cause no unacceptable adverse effects and also verify that the airplane is adequately protected against any hazards that could result from probable malfunctions or failures. A probable malfunction or failure is any single malfunction or failure which is considered probable on the basis of past service experience with like or similar components in airplane applications. Multiple malfunctions or failures should be considered probable when the first malfunction or failure would not be detected during normal operation of the system or if the first malfunction or failure would inevitably lead to other malfunctions or failures. Equipment, systems, and installations should be analyzed, inspected, and tested to ensure compliance with the requirements of § 23.1309. These requirements are further amplified by figure 1 and as follows:

a. Evaluate all airplane systems and equipment in order to determine whether they are:

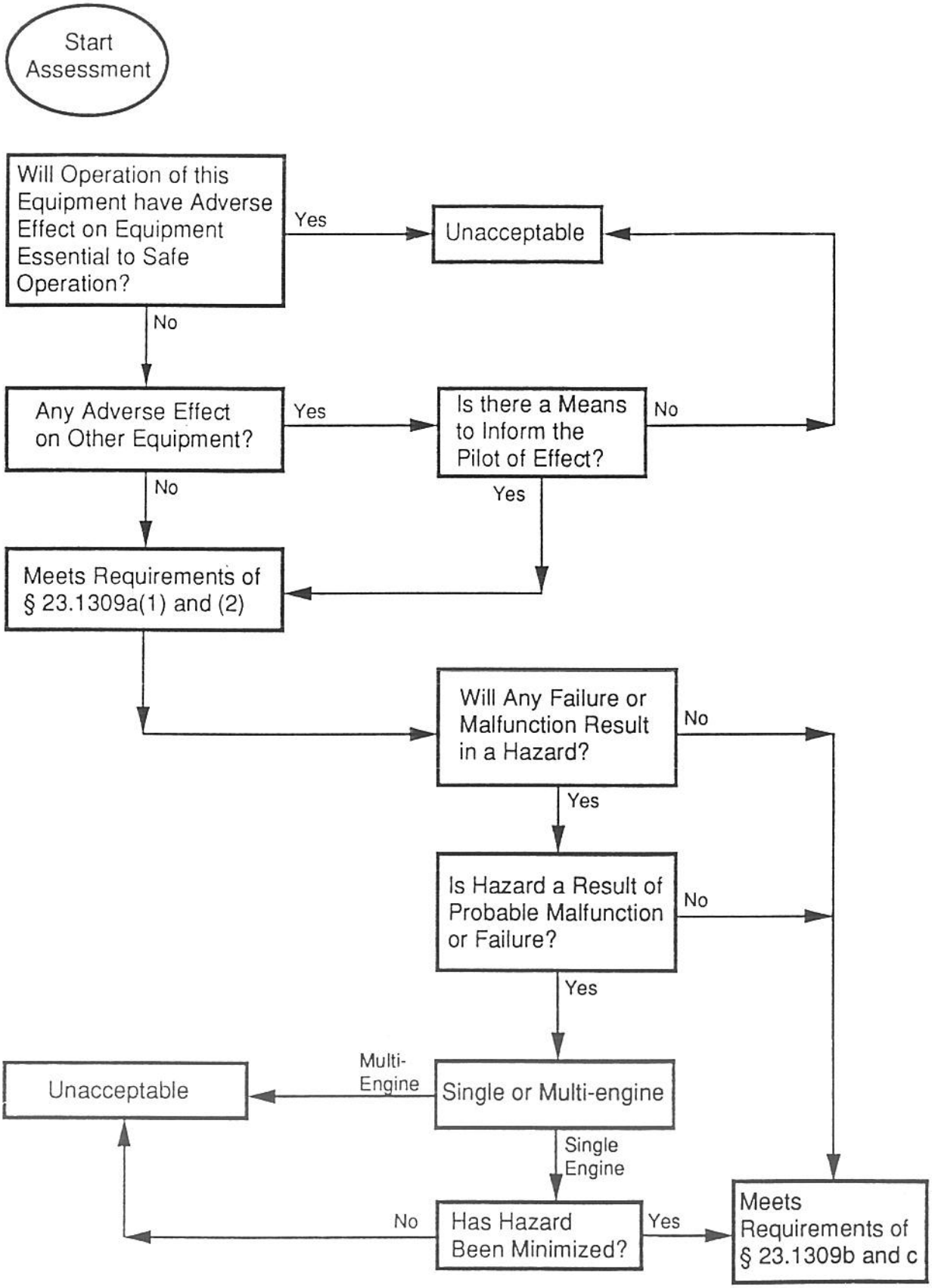

FIGURE 1 - LOGIC DIAGRAM OF § 23.1309

(1) Essential to safe operation; or

(2) Not essential to safe operation.

b. Determine that operation of installed equipment has no unacceptable adverse effects. This can be verified by applicable flight or ground checks as follows:

(1) If it can be determined that the operation of the installed equipment will not adversely affect equipment essential to safe operation, the requirements of § 23.1309(a)(1) have been satisfied.

(2) If it is determined that the operation of the installed equipment has an adverse effect on equipment not essential to safe operation and a means exists to inform the pilot of the effect, the requirements of § 23.1309(a)(2) have been met. An acceptable means to inform the pilot would include any visual or aural method (flags, lights, horns, loss of display, etc.) that will indicates to the pilot that the affected system is not performing properly.

c. Determine that failure or malfunction of the installed equipment could not result in unacceptable hazards.

(1) All equipment should be evaluated for general installation hazards. These types of hazards would normally include those hazards that would directly compromise the safety of the airplane or its occupants, such as fire, smoke, explosion, toxic fumes, depressurization, etc. A hazard can also result from loss of essential equipment or systems when minimum required functions are lost. (Individual failure of redundant equipment would not necessarily be considered a hazard. For example, if one of the communication or navigation receivers was to fail, there would be no hazard as long as the minimum required communication or navigation performance is maintained.)

(2) Systems and equipment essential to safe operation should also be assessed for probability of malfunction or failure (since loss of required functions will result in a hazard). Where the installation is relatively simple and where there is a high degree of similarity in installations and a significant amount of service history is available for review, this determination can be an engineering judgment. More complex designs or systems with less service history should be evaluated in more detail by a more formal means. Recognized methods such as failure modes and effect analysis, fault tree analysis, etc. (described in SAE Aeronautical Recommended Practice ARP 926A, "Fault/Failure Analysis Procedure") can be utilized in these instances.

(3) Hazards that have been identified and found to result from probable failures are not acceptable in multiengine airplanes. In these situations, some design changes may be required to remove the hazard or reduce the probability of failure, such as increasing redundancy, substitution of more reliable equipment, etc.

(4) If it has been determined that a probable failure or malfunction could result in a hazard to a single engine airplane, that hazard should be minimized. To sufficiently minimize a hazard, all appropriate means to reduce the hazard should be exhausted, up to the point where further effort becomes impractical (that point where additional effort would not result in any significant improvement of reliability). This determination should be an experienced engineering judgment, based on the criticality of the hazard and the kinds of operation for which the airplane is approved or will be approved.

7. Assessment of Software Based Systems. The same general requirements apply to software based systems as to non-software based systems. The methodology recommended to evaluate these systems has been developed by the Radio Technical Commission for Aeronautics (RTCA) in Document DO-178A. This methodology is accepted by the FAA and should be followed when designing and evaluating software based systems which perform nonessential or essential functions. The instructions for use of this document are outlined in AC 20-115A titled Radio Technical Commission for Aeronautics (RTCA)/DO-178A.

Barry D. Clements

BARRY D. CLEMENTS
Manager, Small Airplane Directorate
Aircraft Certification Service