



Designation: ~~F3230-21~~ **F3230 – 21a**

# Standard Practice for Safety Assessment of Systems and Equipment in Small Aircraft<sup>1</sup>

This standard is issued under the fixed designation F3230; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 This practice covers internationally accepted methods for conducting safety assessments of systems and equipment for “small” aircraft.

1.2 The applicant for a design approval must seek the individual guidance of their respective civil aviation authority (CAA) body concerning the use of this practice as part of a certification plan. For information on which CAA regulatory bodies have accepted this practice (in whole or in part) as a means of compliance to their Small Aircraft Airworthiness regulations (hereinafter referred to as “the Rules”), refer to ASTM F44 webpage ([www.ASTM.org/COMMITTEE/F44.htm](http://www.ASTM.org/COMMITTEE/F44.htm)) which includes CAA website links.

1.3 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 Following is a list of external standards referenced throughout this practice; the earliest revision acceptable for use is indicated. In all cases later document revisions are acceptable if shown to be equivalent to the listed revision, or if otherwise formally accepted by the governing CAA; earlier revisions are not acceptable.

### 2.2 ASTM Standards:<sup>2</sup>

[F3060 Terminology for Aircraft](#)

[F3061/F3061M Specification for Systems and Equipment in Small Aircraft](#)

### 2.3 EASA Standard:<sup>3</sup>

[ETSO-C26d Aircraft Wheels And Wheel-Brake Assemblies \(CS-23, -27 and -29 aircraft\)](#)

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee F44 on General Aviation Aircraft and is the direct responsibility of Subcommittee F44.50 on Systems and Equipment.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

<sup>3</sup> Available from European Union Aviation Safety Agency (EASA), Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, <https://www.easa.europa.eu/>.

2.4 *FAA Standard:*<sup>4</sup>

**TSO-C26d Aircraft Wheels, Brakes and Wheel/Brake Assemblies for Parts 23, 27, and 29 Aircraft**

2.5 *Military Standard:*<sup>5</sup>

**MIL-PRF-87257 Hydraulic Fluid, Fire Resistant, Low Temperature Synthetic Hydrocarbon Base, Aircraft and Missile**

2.6 *RTCA Standard:*<sup>6</sup>

**DO-160 Environmental Conditions and Test Procedures for Airborne Equipment**

2.7 *SAE Standards:*<sup>7</sup>

**SAE ARP4761 Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment**

**SAE AS5714 Minimum Performance Standard for Parts 23, 27, and 29 Aircraft Wheels, Brakes, and Wheel and Brake Assemblies**

### **3. Terminology**

3.1 Terminology specific to this practice is provided below. For general terminology, refer to Terminology **F3060**.

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<sup>4</sup> Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, <http://www.faa.gov>.

<sup>5</sup> Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil>.

<sup>6</sup> Available from RTCA, 1150 18th NW, Suite 910 Washington, D.C. 20036, <https://www.rtca.org>.

<sup>7</sup> Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *aircraft type code, n*—an aircraft type code (ATC) is defined by considering both the technical considerations regarding the design of the aircraft and the aeroplane certification level established based upon risk-based criteria; the method of defining an ATC applicable to this practice is defined in Specification **F3061/F3061M**.

3.2.2 *catastrophic failure condition, n*—a catastrophic failure condition is one that would result in multiple fatalities of the occupants, or incapacitation or fatal injury to a flight crew member, normally with the loss of the aircraft.

3.2.3 *complex system, n*—a complex system is a system whose operation, failure modes, or failure effects are difficult to comprehend without the aid of analytical methods or structured assessment methods, such as failure modes and effects analysis (FMEA) or fault tree analysis (FTA); increased system complexity is often caused by such items as sophisticated components and multiple interrelationships.

3.2.4 *conventional system, n*—a conventional system is a system whose function, the technological means to implement its function, and its intended usage are all the same as, or closely similar to, that of previously approved systems that are commonly used.

3.2.5 *design appraisal, n*—a design appraisal is a qualitative appraisal of the integrity and safety of the system design; an effective appraisal requires experienced judgment.

3.2.6 *extremely improbable, n*—extremely improbable means that an event is considered so unlikely that it is not anticipated to occur during the entire operational life of all aircraft of one type.

3.2.7 *extremely remote, n*—extremely remote means that an event is not anticipated to occur to each aircraft during its total life, but may occur a few times when considering the total operational life of all aircraft of the type.

3.2.8 *failure condition, n*—a failure condition is a condition having an effect on the aircraft or its occupants, or both, either direct or consequential, which is caused or contributed to by one or more failures or errors; the severity of a failure condition may be affected by flight phase, relevant adverse operational or environmental conditions, or other external events, or combinations thereof.

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3.2.9 *hazardous failure condition*—a hazardous failure condition is one that would reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions to the extent that there would be: a large reduction in safety margins or functional capabilities; physical distress or excessive workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely; or, serious or fatal injuries to a relatively small number of persons other than the flight crew.

3.2.10 *installation appraisal, n*—an installation appraisal is a qualitative appraisal of the integrity and safety of the installation; any deviations from normal industry-accepted installation practices should be evaluated.

3.2.11 *major failure condition, n*—a major failure condition is one that would reduce the capability of the aircraft or the ability of the flight crew to cope with adverse operating conditions to the extent that there would be: a significant reduction in safety margins or functional capabilities; a significant increase in flight crew workload or in conditions impairing the efficiency of the flight crew; discomfort to the flight crew; or, physical distress to passengers or cabin crew, possibly including injuries.

3.2.12 *minor failure condition, n*—a minor failure condition is one that would not significantly reduce aircraft safety, and which involves crew actions that are well within their capabilities; minor failure conditions may include: a slight reduction in safety margins or functional capabilities; a slight increase in crew workload, such as routine flight plan changes; or, some physical discomfort to passengers or cabin crew.

3.2.13 *negligible failure condition, n*—a negligible failure condition is one that would have no procedural or operational effect on the flight crew so as to interfere with the reliable performance of published and trained duties, or on the operation or capabilities of the aircraft; however, the event may result in an inconvenience to aircraft occupants.

3.2.14 *probable, n*—probable means that the event is anticipated to occur one or more times during the entire operational life of each aircraft.

3.2.15 *qualitative analysis, n*—a qualitative analysis relies on analytical processes that assess system and aircraft safety in an objective, non-numerical manner.

3.2.16 *quantitative analysis, n*—a quantitative analysis relies on analytical processes that apply mathematical methods to assess the system and aircraft safety.

3.2.17 *redundancy, n*—the term redundancy refers to the presence of more than one independent means for accomplishing a given function; each means of accomplishing the function need not be identical.

3.2.18 *remote, n*—remote means that the event is not anticipated to occur at each aircraft during its total life, but may occur several times when considering the total operational life of all aircraft of the type.

3.2.19 *similarity, n*—the term similarity refers to a condition where the equipment type, form, function, design, and installation have only minor differences to previously approved equipment. The safety and operational characteristics and other qualities of the new installation should have no appreciable effects on the airworthiness of the aircraft.

3.2.20 *simple system, n*—a simple system is a system that can be evaluated by only qualitative analysis and that is not a complex system; functional performance is determined by combination of tests and analyses.

3.2.21 *single failure, n*—a single failure is considered to be any occurrence, or set of occurrences, that: cannot be shown to be independent from each other; affects the operation of components, parts, or elements of a system such that they can no longer function as intended; or, results in inadvertent system operation.

#### 4. Basic Information

NOTE 1—Table 1 provides correlation between various ATCs and the individual requirements contained within this section; refer to 3.2.1. For each subsection, an indicator can be found under each ATC character field; three indicators are used:

An empty cell ( ) in all applicable ATC character field columns indicates that an aircraft must meet the requirements of that subsection.

A white circle (○) in multiple columns indicates that the requirements of that subsection are not applicable to an aircraft *only* if all such ATC character fields are applicable.

A mark-out (x) in any of the applicable ATC character field columns indicates that the requirements of that subsection are not applicable to an aircraft if that ATC character field is applicable.

*Example*—An aircraft with an ATC of 1SRLLDLN is being considered. Since all applicable columns are empty for 4.1, that subsection is applicable to the aircraft. Since the “1” aeroplane certification level column, the “L” stall speed column, and the “D” meteorological column for 4.2.1 all contain white circles, then that subsection is not applicable; however, for an aircraft with an ATC of 1SRMLDLN, 4.2.1 would be applicable since the “M” stall speed column does not contain a white circle.

**TABLE 1 ATC Compliance Matrix, Section 4**

Section	Aeroplane Certification Level				Number of Engines		Type of Engine(s)		Stall Speed			Cruise Speed		Meteorological Conditions			Altitude		Maneuvers	
	1	2	3	4	S	M	R	T	L	M	H	L	H	D	N	I	L	H	N	A
4																				
4.1																				
4.2	○								○					○						
4.2.1	○								○					○						
4.2.2	○								○					○						
4.2.3	○								○					○						
4.2.3.1	○								○					○						
4.2.3.2	○								○					○						
4.2.3.3	○								○					○						
4.2.3.4	○								○					○						
4.2.4	○								○					○						
4.2.4.1	○								○					○						
4.2.4.2	○								○					○						
4.2.4.3	○								○					○						
4.2.5	○								○					○						

4.1 *Failure Condition Classification*—An assessment of the aircraft and system functions must be performed to identify and classify the various failure conditions associated with each function; refer to 3.2.8 and Table 2. A functional hazard assessment (FHA) in accordance with the methodology outlined in SAE ARP4761 is one means of performing this assessment; however, other simpler methodologies (for example, a design and installation appraisal) may be employed as appropriate to the complexity and criticality of the system(s).

4.2 *Classification-Based Analyses*—Based on the results of the assessment in accordance with 4.1, the depth of analysis required to show compliance may be determined using Fig. 1 and the Assessment Levels defined in Table 3.

4.2.1 In showing compliance with the provisions of 4.2, for negligible failure conditions (refer to 3.2.13), a design and installation appraisal to establish independence from other functions is necessary for the safety assessment. In general, common design practice provides physical and functional isolation from related components which are essential to safe operation.

4.2.2 In showing compliance with the provisions of 4.2, for minor failure conditions (refer to 3.2.12), a design and installation appraisal to establish independence from other functions is necessary for the safety assessment. This appraisal should consider the effects of system failures on other systems and their functions. In general, common design practice provides physical and functional isolation from related components which are essential to safe operation.

4.2.3 In showing compliance with the provisions of 4.2, for major failure conditions (refer to 3.2.11), a qualitative analysis (refer to 3.2.15) must be performed to determine compliance with the requirements of Table 4; in certain circumstances, a quantitative analysis (refer to 3.2.16) may also be required. There are several methods of performing a valid qualitative analysis.

4.2.3.1 A “similarity argument” allows validation of a requirement by comparison to the requirements of similar certified systems. A similarity argument gains strength as the period of experience with the system increases. If the system is similar in its relevant attributes to those used in other aircraft and if the functions and effects of failure would be the same, then a design and installation appraisal and satisfactory service history of either the equipment being analyzed or of a similar design is usually acceptable for showing compliance. It is the applicant’s responsibility to provide data that: is accepted, approved, or both; and, supports any claims of similarity to a previous installation.

4.2.3.2 For systems that are not complex, and where similarity arguments cannot be used, “qualitative occurrence arguments” may be presented to demonstrate that the major failure conditions of the system, as installed, are consistent with the requirements of Table 4; for example, redundant systems may qualify for this approach.

4.2.3.3 For systems that are complex and possess low redundancy (for example, a system with a self-monitoring microprocessor), a qualitative functional FTA or FMEA supported by failure rate data and fault detection coverage analysis must be presented to demonstrate that the major failure conditions of the system, as installed, are consistent with the requirements of Table 4.

4.2.3.4 A Qualitative Analysis of a redundant system is usually complete if it shows isolation between redundant system channels

**TABLE 2 Failure Condition Classifications**

		Classification of Failure Conditions				
Classification Considerations <sup>B</sup>		Negligible <sup>A</sup>	Minor <sup>A</sup>	Major <sup>A</sup>	Hazardous <sup>A</sup>	Catastrophic <sup>A</sup>
Classification Considerations <sup>B</sup>	Effect on Aircraft	No effect on operational capabilities or safety	Slight reduction in functional capabilities or safety margins	Significant reduction in functional capabilities or safety margins	Large reduction in functional capabilities or safety margins	Normally with hull loss
	Effect on Occupants	Inconvenience for passengers	Physical discomfort for passengers	Physical distress to passengers, possibly including injuries	Serious or fatal injury to an occupant	Multiple fatalities
	Effect on Flight Crew	No effect on flight crew	Slight increase in workload or use of emergency procedures	Physical discomfort or a significant increase in workload	Physical distress or excessive workload impairs ability to perform tasks	Fatal injury or incapacitation

<sup>A</sup> Refer to Section 3.

<sup>B</sup> These phrases are descriptions of likely consequences for a given failure condition and not necessarily absolute criteria for classifying that failure condition; for example, the phrase “normally with hull loss” is a description of likely consequences for a catastrophic failure condition and not necessarily criteria for classifying a failure condition as catastrophic.

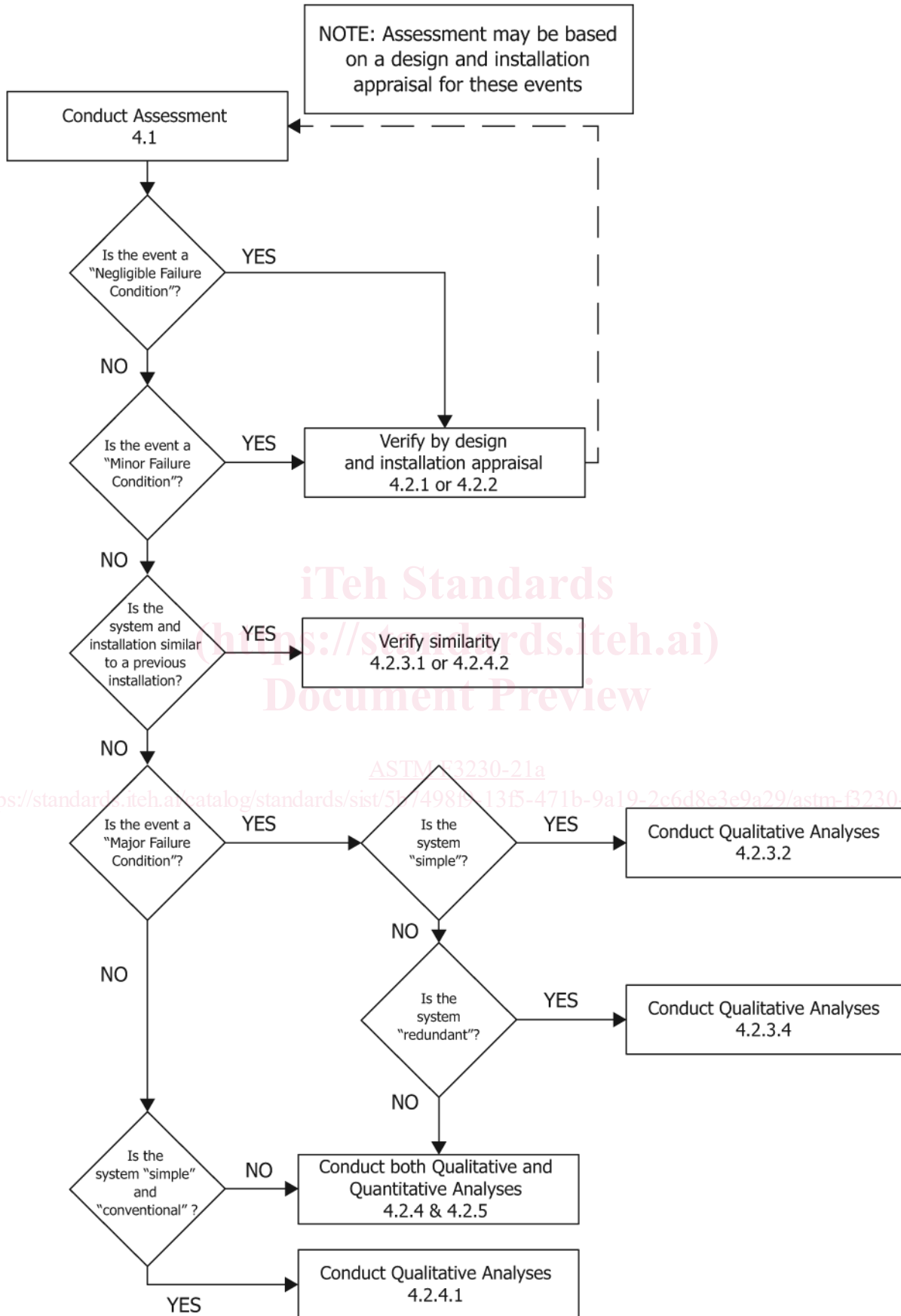


FIG. 1 Depth of Analysis Flowchart

**TABLE 3 Assessment Level Selection Matrix**

Aeroplane Certification Level	Propulsion Information			
	Reciprocating/Electric <sup>B</sup>		Turbine	
Level	1	>1	1	>1
Level 1 <sup>A</sup>	I	II	II	II
Level 2 <sup>A</sup>	I	II	II	II
Level 3 <sup>A</sup>	III	III	III	III
Level 4 <sup>A</sup>	IV	IV	IV	IV

<sup>A</sup> Refer to Specification F3061/F3061M.

<sup>B</sup> The term "electric" as used in this table is intended to cover conventional normal category aircraft that are powered by electric motors. It does not include hybrids or electric vertical takeoff and landing (eVTOL) aircraft at this time. Unique architectures may require specific policy, guidance, or approval by the appropriate certifying authority.

**TABLE 4 Allowable Qualitative Probability**

All Assessment Level <sup>A</sup>	Failure Condition Classification (from Table 2)				
	Negligible <sup>B</sup>	Minor <sup>B</sup>	Major <sup>B</sup>	Hazardous <sup>B</sup>	Catastrophic <sup>B</sup>
ALL	No Probability Requirement	Probable <sup>B</sup>	Remote <sup>B</sup>	Extremely Remote <sup>B</sup>	Extremely Improbable <sup>B</sup>

<sup>A</sup> Refer to Table 3.

<sup>B</sup> Refer to Section 3.

**TABLE 5 Allowable Quantitative Probabilities<sup>A</sup>**

Assessment Level <sup>B</sup>	Failure Condition Classification (from Table 2)				
	Negligible <sup>C</sup>	Minor <sup>C</sup>	Major <sup>C</sup>	Hazardous <sup>C</sup>	Catastrophic <sup>C</sup>
I	No Probability Requirement	<10 <sup>-3</sup>	<10 <sup>-4</sup>	<10 <sup>-5</sup>	<10 <sup>-6</sup> (See <sup>D</sup> )
II		<10 <sup>-3</sup>	<10 <sup>-5</sup>	<10 <sup>-6</sup>	<10 <sup>-7</sup> (See <sup>D</sup> )
III		<10 <sup>-3</sup>	<10 <sup>-5</sup>	<10 <sup>-7</sup>	<10 <sup>-8</sup> (See <sup>D</sup> )
IV		<10 <sup>-3</sup>	<10 <sup>-5</sup>	<10 <sup>-7</sup>	<10 <sup>-9</sup> (See <sup>D</sup> )

<sup>A</sup> Numerical values indicate an order of probability range and are provided here as a reference; refer to 4.2.5.

<sup>B</sup> Refer to Table 3.

<sup>C</sup> Refer to Section 3.

<sup>D</sup> At the aircraft function level, no single failure resulting in a catastrophic failure condition is permitted.

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and satisfactory reliability for each channel. For complex systems where functional redundancy is required, a qualitative functional FTA or FMEA may be necessary to demonstrate that redundancy actually exists (for example, no single failure affects all functional channels).

4.2.4 In showing compliance with the provisions of 4.2, for Hazardous and Catastrophic Failure Conditions (refer to 3.2.9 and 3.2.2, respectively) a thorough safety assessment is necessary. Except as allowed in 4.2.4.1 – 4.2.4.3, a detailed safety analysis must be completed for each hazardous and catastrophic failure condition identified in accordance with 4.1. Such an assessment usually consists of an appropriate combination of qualitative and quantitative analyses; a system safety analysis (SSA) in accordance with the methodology outlined in SAE ARP4761 is one means of performing these analyses; however, other simpler methodologies may be employed as appropriate.

4.2.4.1 For simple and conventional installations (that is, low complexity and similarity in relevant attributes), it may be possible to assess a hazardous or catastrophic failure condition as being extremely remote (refer to 3.2.7) or extremely improbable (refer to 3.2.6), respectively, on the basis of experienced engineering judgment using only qualitative analysis. The basis for such an assessment will be the degree of redundancy, the established independence and isolation of the channels, and the reliability record of the technology involved. Satisfactory service experience on similar systems commonly used in many aircraft may be sufficient when a close similarity is established regarding both the system design and operating conditions.

4.2.4.2 For complex systems where true similarity can be rigorously established in all relevant attributes, including installation attributes, it may be possible to assess a hazardous or catastrophic failure condition as being extremely remote or extremely improbable, respectively, on the basis of experienced engineering judgment using only qualitative analysis. The basis for such an assessment will be a high degree of similarity in both design and application.

4.2.4.3 No catastrophic failure condition should result from the failure of a single component, part, or element of a system. Experienced engineering judgment and service history should show that a catastrophic failure condition due to a single failure mode is not a practical possibility. The logic and rationale used in the assessment should be straightforward and obviously substantiate that the failure mode simply would not occur unless it is associated with an unrelated failure condition that would, in itself, be Catastrophic.

4.2.5 In showing compliance with the provisions of 4.2.4, where Quantitative Analysis is required by Fig. 1, the analysis should demonstrate that the probability of the failure condition occurrence meets the probability range shown in Table 5. It is recognized that there is inherent variance in predictions used to demonstrate that these probabilities are met; it may therefore be acceptable, provided the analysis can be shown to be conservative and is acceptable to the governing CAA, to be slightly above the probabilities shown in Table 5.

## 5. Keywords

5.1 catastrophic; failure condition; FHA; FMEA; FTA; hazardous; major; minor; qualitative; quantitative; similarity; SSA; system safety

## APPENDIXES

### (Nonmandatory Information)

#### X1. SUPPORTING INFORMATION FOR REVISIONS

##### X1.1 Revisions to Table 3

X1.1.1 *Revision 16 to Previous Location (Specification F3061/F3061M, Table 2):*

X1.1.1.1 *Discussion*—Section 3.2.1.1 of Specification F3061/F3061M defines the risk-based criteria that establish the various Airworthiness Levels. Each of the row header cells in the “Airworthiness Level” column of Table 2 of Specification F3061/F3061M currently contains a condensed version of the corresponding definition, which is redundant to 3.2.1.1 of Specification F3061/F3061M.

X1.1.1.2 *Proposal*—Remove the redundant language from the row header cells identified as Affected Content, and instead add a reference to 3.2.1.1 of Specification F3061/F3061M.

X1.1.1.3 *Rationale for Change(s)*—The proposal is for the removal of redundant information only; no technical content is added, deleted, or modified.

##### X1.2 Revisions to Table 5

X1.2.1 *Revision 16 to Previous Location (Specification F3061/F3061M, Table 3):*

X1.2.1.1 *Discussion*—In the “Allowable Quantitative Probabilities” portion of Table 3 of Specification F3061/F3061M, under the “Catastrophic” column, the original intent as to apply Note D to all Assessment Levels (Note D currently reads “At the aircraft function level, no single failure resulting in a Catastrophic Failure Condition is permitted.”); this is consistent with the pre-existing regulatory guidance material from which Table 3 of Specification F3061/F3061M was derived, and is reflected in the approved version of the document. However, during final editing the note-reference was inadvertently removed from Assessment Levels I through III.



X1.2.1.2 *Proposal*—Restore “(See Note D)” to Assessment Levels I through III under the “Catastrophic” column within the “Allowable Quantitative Probabilities” portion of Table 3 of Specification F3061/F3061M.

X1.2.1.3 *Rationale for Change(s)*—The proposal is for the reintroduction of the originally intended and approved material. This will serve to realign the technical content with the pre-existing regulatory guidance material from which Table 3 of Specification F3061/F3061M was derived.

### X1.3 Revisions to Table 3

#### X1.3.1 Revision 21:

##### X1.3.1.1 Discussion:

(1) Table 3 provides a mapping from airworthiness level (determined by occupant risk exposure based on passenger seating configuration, according to Part 23 Amendment 64 or CS 23 Amendment 5) to assessment level. Assessment level is used to assign allowable quantitative probabilities for failure conditions. When airworthiness levels were introduced in Amendment 64/ Amendment 5 as a replacement for the class system, it resulted in some airworthiness level 1 and 2 aircraft being held to a higher standard than previously required. Table 3 was created to ensure consistency with AC 23.1309-1E.

(2) To maintain this desired consistency, propulsion information (type of engines and number installed) is used to determine assessment level. This criterion has served as an acceptable proxy for a number of associated factors, such as low speed performance, system complexity, pilot workload expectations, and power availability. The current propulsion type classifications used in Table 3 are reciprocating and turbine. The only practical difference in allowable quantitative probabilities for failure are for single-engine reciprocating aircraft; for all other cases, assessment levels are consistent for a given airworthiness level.

(3) This proposal modifies Table 3 to include pure electric propulsion. The result of this modification would result in an airworthiness level 1 or 2 aircraft with an electric motor being held to the same standard as a reciprocating engine aircraft.

(4) Hybrid propulsion vehicles are not being directly addressed in this ballot. Hybrid concepts span a diverse range of architectures (series, parallel, turboelectric, etc) and may rely on either reciprocating or turbine components. How these systems map to Table 3 deserves greater thought and consideration.

(5) This change does not directly address all considerations for appropriate assessment levels for eVTOL aircraft. Unique architectures may require specific policy, guidance, or approval by the appropriate certifying authority.

X1.3.1.2 *Proposal*—Change the column header “Engine Information” to “Propulsion Information”; change “Reciprocating” to “Reciprocating/Electric<sup>B</sup>”; and add note “<sup>B</sup> The term “electric” as used in this table is intended to cover conventional normal category aircraft that are powered by electric motors. It does not include hybrids or electric vertical takeoff and landing (eVTOL) aircraft at this time. Unique architectures may require specific policy, guidance, or approval by the appropriate certifying authority”.

X1.3.1.3 *Rationale for Change(s)*—To allow conventional Part 23 aircraft with electric propulsion to use this practice.

### X1.4 Revisions to Table 2

#### X1.4.1 Revision 21a:

##### X1.4.1.1 Discussion:

(1) Last year, we balloted a proposed change to Practice F3230, Table 2, that received negative votes from EASA and TCCA that were found to be persuasive. That ballot proposed adding a new “Note B” to explain that the text in the “Classification Consideration” rows are descriptions of likely consequences for a given failure condition—not necessarily absolute criteria for

classifying that failure condition. That ballot went on to provide two examples that accompanied Note B; it is with these examples that the negative commenters took exception.

(2) The first example addressed the phrase “normally with hull loss”, stating that the phrase is a description of likely consequences for a catastrophic failure condition and not necessarily criteria for classifying a failure condition as catastrophic. It went on to state that, with advancements being made in the area of crashworthiness, it is possible that the hull could be sacrificed to avoid catastrophic loss of life. The negative commenters objected to asserting that advances in crashworthiness could be used to reduce the classification of the failure condition. After further discussion within task group, it was decided to delete that assertion to address the commenters’ concern.

(3) The second example stated that incapacitation of the crew may not necessarily be catastrophic if the aircraft was equipped with systems that provided for continued safe flight and landing. The commenters noted that any failure condition that caused crew incapacitation must still be shown to be extremely improbable irrespective of aircraft equipage. They did acknowledge that autonomous aircraft systems may be able to mitigate the effects but ultimately, they disagreed with the inclusion of this example. After further discussion, it was decided to completely remove this example.

NOTE X1.1—The wording proposed in the previous ballot is already included in the equivalent table in Practice F3309/F3309M. A separate ballot will be generated to modify Practice F3309/F3309M to match the changes proposed in this ballot.

X1.4.1.2 *Proposal*—Add superscript “B” after the phrase “Classification Considerations”; below Table 2, add “Note B” that explains that those phrases in under each failure condition classification are descriptions of likely consequence of a given failure condition and not necessarily absolute criteria for classifying that failure condition. Provide a single example that states that explains loss of the hull in and of itself may not necessarily be catastrophic.

X1.4.1.3 *Rationale for Change(s)*—The existing, unclarified wording has been used in the past to push classifications to catastrophic due only to the anticipated damage to the hull. Loss of the hull in and of itself is a financial impact. It is true that in most catastrophic events the hull is damaged significantly. However, the note clarifies that if the other criteria for catastrophic are not met, loss of the hull by itself should not force a catastrophic classification.

## X2. GUIDANCE FOR QUALITATIVE PROBABILITY ANALYSIS

### X2.1 Introduction

X2.1.1 This appendix contains supplemental information on how to perform the qualitative analysis for hazardous and catastrophic failure conditions for systems that have been accepted as simple and conventional in accordance with 4.2.4.1.

X2.1.1.1 *Qualitative Probability Requirements*—Requirements for the qualitative analysis are based on failure condition classifications, which usually come from the FHA in accordance with 4.1. The definitions of *extremely improbable* and *extremely remote* from Section 3 are used for the qualitative analysis and not the quantitative values from Table 5.

(1) Catastrophic failure conditions must be so unlikely that they are not anticipated to occur during the entire operational life of all aircraft of one type.

(2) Hazardous failure conditions must be so unlikely that they are not anticipated to occur to each aircraft during its total life, but may occur a few times when considering the total operational life of all aircraft of the type.

X2.1.1.2 *Substantiation*—It is difficult to prove definitively how frequently a failure condition will occur in the future. However, there must be justification supporting the claim that the failure condition can reasonably be anticipated to be so unlikely that the requirement is met. The basis of this assessment is experienced engineering judgment, which can make it difficult for designers, analysts, and reviewers to know when the assessment is sufficient. The goal of this appendix is to provide information on acceptable substantiation and an example that shows sufficient detail in the substantiation.

X2.1.1.3 *Qualitative Analysis Steps*—There are three steps to performing qualitative analysis for 4.2.4.1. The first step of the

analysis is to establish that the design is conventional. In other words, is the design consistent with existing system designs that have established an acceptable service history? The second step is to show that the design is simple. A design may be considered simple if its failure modes can be evaluated without the aid of structured analysis such as FMEA or a FTA. The third step is to establish that the likelihood of the failure condition is acceptable. This evaluation identifies failures or combinations of failures that must occur to result in the failure condition and considers redundancy, independence, isolation, and common causes. The evaluation considers component qualification data or other data that supports the conclusion that failures aren't expected during various operating conditions and environments. The evaluation considers latent failures that could contribute to the failure condition. Fig. X2.1 shows the high-level process described above.

X2.1.1.4 *Example Analysis*—Appendix X2.6 contains an example qualitative analysis for a simple and conventional brake system. The example is not intended to show a complete system safety assessment. The intent is to show how a qualitative assessment could be constructed using this guidance.

### X2.2 Establish that System is Conventional

X2.2.1 The foundation of the qualitative analysis for 4.2.4.1 is that the system is conventional. A system is considered “conventional” if its function, the technological means to implement its function, and its intended usage are all the same as, or closely similar to, that of previously approved systems that are commonly used and that have established an acceptable service history. The use of service history in this context is not to show that the probability of the failure condition has been met but rather to show that similar systems have performed acceptably in service. Fig. X2.2 shows the decision path that should be used to determine that a system is “conventional.” A good example of this would be a tailwheel steering system that uses pulleys and cables to move the tailwheel. The function is to provide directional control during ground operation. This implementation has been used on many small aircraft for decades and designs of this nature have acceptable service history. Consideration should be given to any differences between the system under evaluation and similar in-service designs to ensure that there are no design features, or other considerations such as operating environment, that could invalidate the claim that the system is conventional.

### X2.3 Establish that System is Simple

X2.3.1 To demonstrate that the design is simple, the analyst must justify that the system operation and its failure modes and effects

