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[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 21

[Docket No. FAA-2022-1548]

Airworthiness Criteria: Special Class Airworthiness Criteria for the Archer Aviation, Inc. Model M001 Powered-lift

AGENCY: Federal Aviation Administration (FAA), DOT

ACTION: Issuance of final airworthiness criteria.

SUMMARY: The FAA announces the special class airworthiness criteria for the Archer Aviation, Inc. (Archer) Model M001 powered-lift. This document sets forth the airworthiness criteria the FAA finds to be appropriate and applicable for the powered-lift design.

DATES: These airworthiness criteria are effective [INSERT DATE 30 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].

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SUPPLEMENTARY INFORMATION:

Background

On March 30, 2022, Archer applied for a type certificate for the Model M001 powered-lift. The Archer Model M001 powered-lift has a maximum gross takeoff weight of 6,500 lbs. and is capable of carrying a pilot and four passengers. The aircraft has a high-wing and V-tail[1] configuration with fixed tricycle landing gear. The aircraft uses 12 electric engines powered by onboard batteries for propulsion instead of conventional air and fuel combustion. Six engines with five-bladed variable-pitch propellers are mounted on the forward edge of the main wing, three to each side, which are capable of tilting to provide both vertical and forward thrust. The other six electric engines drive two-bladed fixed-pitch propellers and are mounted on the aft edge of the main wing, three to each side; they are fixed in place to provide only vertical thrust. The aft-mounted engines operate only during thrust-borne or semi-thrust- borne flight; in wing-borne forward flight, these engines are switched off and the propellers are faired in line with the aircraft fuselage. The aircraft structure and propellers are constructed of composite materials. The Archer Model M001 powered-lift is intended to be used for Title 14, Code of Federal Regulations (14 CFR) parts 91 and 135 operations, with a single pilot onboard, under visual flight rules (VFR).

The FAA issued a notice of proposed airworthiness criteria for the Model M001 powered-lift, which published in the *Federal Register* on December 20, 2022 (87 FR 77749).

Discussion

Because the FAA has not yet established powered-lift airworthiness standards in 14 CFR, the FAA type certificates powered-lift as special class aircraft. Under the procedures in § 21.17(b), the airworthiness requirements for special class aircraft, including the engines and propellers installed thereon, are the portions of the requirements in 14 CFR parts 23, 25, 27, 29, 31, 33, and 35 found by the FAA to be appropriate and applicable to the specific type design and any other airworthiness criteria found by the FAA to provide an equivalent level of safety to the existing standards. These

[1] A V-Tail aircraft design incorporates two slanted tail surfaces instead of the horizontal and vertical fins of a conventional aircraft empennage. The two fixed tail surfaces of a V-Tail act as both horizontal and vertical stabilizers and each has a moveable flight-control surface referred to as a ruddervator.

final airworthiness criteria announce the applicable regulations and other airworthiness criteria developed, under § 21.17(b), for type certification of the Model M001 powered-lift.

The Model M001 powered-lift has characteristics of both a rotorcraft and an airplane. It is designed to function as a rotorcraft for takeoff and landing and as an airplane cruising at speeds higher than a rotorcraft during the enroute portion of flight operations. The electric engines on the Model M001 powered-lift will use electrical power instead of air and fuel combustion to propel the aircraft through six five-bladed composite variable-pitch propellers for all phases of flight, and six two-bladed fixed-pitch propellers for vertical and transitional flight modes only. Accordingly, the Archer Model M001 powered-lift proposed airworthiness criteria contained standards from parts 23, 33, and 35 as well as other proposed airworthiness criteria specific for a powered-lift and the electric engines and propellers installed thereon.

For the existing regulations that were included without modification, the proposed airworthiness criteria included all amendments to the existing parts 23, 33, and 35 airworthiness standards in effect as of the application date of March 30, 2022. These are part 23, amendment 23-64, part 33, amendment 33-34, and part 35, amendment 35-10.

The Archer Model M001 powered-lift proposed airworthiness criteria also included new performance-based airworthiness criteria. The FAA developed these criteria because no existing standard captured the powered-lift's various flight modes and electric engines and some unique characteristics of their propellers. The new requirements specific to the Archer Model M001 in the proposed airworthiness criteria used an "AM1.xxxx" section-numbering scheme.

Because many of the proposed airworthiness criteria are performance-based, like the regulations found in part 23, the FAA has proposed to adopt § 23.2010 by reference, which would require that the means of compliance used to comply with the airworthiness criteria be accepted by the Administrator. Because no powered-lift consensus standards are currently accepted by the Administrator, the means of compliance will be accepted through the issue paper process.[2]

Summary of Changes from the Proposed Airworthiness Criteria

These final airworthiness criteria reflect the following changes, in addition to others as explained in more detail under Discussion of Comments: The FAA made changes to the aircraft performance section to incorporate an optional, "increased performance" approval, which requires greater aircraft performance capabilities beyond that of the baseline "essential performance" approval. The expectations for aircraft performance at both levels are clearly defined at the requirement level. Requirements to address various scenarios involving failures that can lead to loss of thrust were clarified and consolidated into a consistent terminology across all airworthiness criteria. Expectations were added for the aircraft to be capable of a controlled emergency landing following any condition where the aircraft can no longer provide the commanded power or thrust required for continued safe flight and landing (CSFL). The proposed requirement to incorporate a bird strike deterrent system was not adopted in these final airworthiness criteria, nor were other requirements not applicable to the Model M001, such as requirements for operations on water, approval for aerobatic flight, and others, as discussed in further detail under Discussion of Comments. The FAA modified and developed revised aeroelasticity criteria to more directly address concerns expressed by commenters related to "whirl flutter" and aeromechanical stability. The FAA revised requirements in response to numerous comments requesting clarification or recommending changes to address safety gaps in the proposed criteria, particularly in the areas of aircraft handling and control, structural airframe loads and durability, flight

[2] See Order 8110.112A, *Standardized Procedures for Usage of Issue Papers and Development of Equivalent Levels of Safety Memorandums*.

controls, protection of occupants, and protection of systems from high-intensity radiated fields (HIRF) and lightning. The FAA updated requirements for electric engines in response to requests for improved clarity on applicability and relationship to the airframe requirements. The FAA also updated definitions for “controlled emergency landing,” “CSFL,” and “sources of lift” and added a definition for “local events.”

Lastly, the FAA clarified that, should Archer apply to amend the type certificate to include another model powered-lift, these airworthiness criteria would apply to that model also, provided the criteria remain appropriate to the changed aircraft in accordance with part 21, subpart D. This change was necessary so that each future change to the aircraft will not necessarily require an application for a new type certificate.

Discussion of Comments

The FAA received responses from 22 commenters. The majority of commenters were government agencies, private companies, and organizations as follows: Agência Nacional de Aviação Civil (ANAC); Airbus; Air Line Pilots Association (ALPA); Alaka’i Technologies Corporation (Alaka’i); Aerospace, Security and Defence Industries Association of Europe (ASD-Europe); Association for Uncrewed Vehicle Systems International (AUVSI); United Kingdom Civil Aviation Authority (UKCAA); European Union Aviation Safety Agency (EASA); General Aviation Manufacturers Association (GAMA); IPR; Japan Civil Aviation Bureau (JCAB); Leonardo Helicopters (Leonardo); Lilium eAircraft GmbH (Lilium); Odys Aviation (Odys); Overair Inc. (Overair); Rolls-Royce Deutschland Ltd & Co KG (Rolls-Royce); SkyDrive, Inc. (SkyDrive); Transport Canada Civil Aviation (TCCA); Vertical Aerospace; and Volocopter GmbH (Volocopter). The FAA received comments from one individual commenter and from one anonymous commenter as well.

Support

AUVSI and ASD-Europe expressed support for type certification of the Model M001 as a special class of aircraft and establishing airworthiness criteria under § 21.17(b). ALPA expressed support for the use of 14 CFR part 35 propeller airworthiness standards.

Definitions

The FAA proposed criteria that created new or modified definitions for the Model M001 powered-lift. The FAA received and reviewed comments from ASD-Europe, ALPA, Alaka'i, ANAC, EASA, GAMA, Leonardo, Lilium, Odys, Overair, TCCA, UKCAA, and an individual commenter that requested the FAA clarify, revise, or adopt as proposed certain definitions. Specifically, these comments were focused on the topic areas of "CSFL," "controlled emergency landing (CEL)," and "loss of power/thrust," along with requests for clarification on other uses of the term "thrust." GAMA and Overair also proposed modifications to the "source of lift" definition. Additionally, comments from Airbus, ALPA, ASD-Europe, EASA, Odys, TCCA, UKCAA, and an individual commenter requested the establishment of a higher safety target for powered-lift like the Model M001. In response, the FAA created an "increased performance" approval that may be granted based on the aircraft's ability to meet higher performance standards for continued flight under certain failure conditions. The FAA modified AM1.2000(a) to provide for the higher safety target of "increased performance" as well as to establish the proposed minimum safety target for CSFL as "essential performance." The Model M001 must meet either the essential or increased performance requirements in this certification basis. Additionally, the Model M001 may be approved for both essential and increased performance with appropriate and different operating limitations.

The FAA has modified the definition of "CSFL" to establish the different expected outcomes based on the performance approval sought. The definition of "CSFL" was modified slightly for the essential performance approval to include pilot alertness; however, the ability to continue to the planned destination or alternate is a requirement to meet the increased performance approval. Increased performance is a higher level of safety that guarantees fly-away capability after any failure not shown to be extremely improbable. Essential performance does not require the aircraft to have the capability to land at the planned or an alternate landing site as is required for increased performance.

Several commenters suggested the FAA adopt EASA's special condition for vertical take-off and landing aircraft (SC-VTOL) requirements for powered-lift. The FAA disagrees and has instead adopted "essential" and "increased" performance approvals. Although the FAA's "essential" and increased" performance approvals are similar to EASA's "Category Basic" and "Category Enhanced" approvals, differences remain. The FAA is establishing these airworthiness criteria for the Model M001 to provide a certification basis for aircraft design approval, while the operational approval is accomplished outside of the aircraft certification process. Additionally, both the FAA's and EASA's performance levels include the aircraft's ability to conduct a controlled emergency landing after a condition when the aircraft can no longer provide the commanded power or thrust required for CSFL as specified in AM1.2105(g). To complete the integration of these defined levels of safety requirements, the FAA modified AM1.2115 "Takeoff performance," AM1.2120 "Climb requirements," and AM1.2130 "Landing" to incorporate the essential and increased performance requirements.

The FAA received several comments that the proposed definition of a "CEL" was not sufficient to ensure that the relevant instances that may be encountered in operation are addressed beyond a "critical loss of thrust" as required under the proposed AM1.2105(g). The FAA agrees with the concerns raised by these commenters. As such, the FAA revised the proposed CEL definition and the requirements of AM1.2105(g) to establish the minimum level of safety required when the aircraft can no longer provide the commanded power or thrust required for CSFL.

One commenter requested the FAA remove the part of the CEL definition that requires that the pilot be capable of choosing the direction and area of touchdown and instead require a controlled descent. As indicated by the term itself, “controlled emergency landing” is a defined airworthiness attribute in which the design maintains sufficient control to change direction to an area of touchdown, while reasonably protecting occupants from serious injury. However, the FAA has updated the definition of CEL by relocating the pilot reference to focus the requirement on aircraft functionality. Overall pilot controllability requirements are addressed in AM1.2135, which requires that the aircraft be controllable and maneuverable without requiring exceptional piloting skill, alertness, or strength. The intent of the definition of CEL is to provide equivalency to the part 23 airplane gliding requirements and the part 27 rotorcraft autorotation requirements. Both minimize the aircraft’s speed (forward and vertically) while still allowing directional control of the aircraft to an emergency landing.

One commenter requested the FAA clarify the statement “reasonably protecting occupants” in the definition of “CEL” and further commented that non-participants should also be protected since these aircraft plan to operate in highly-populated urban environments. The FAA agrees with the need to provide additional clarity and has modified the definition of CEL to clarify that the expected safety outcome is protection from serious injury, which inherently provides a level of protection for non-participants on the ground. This approach is similar to the level of safety in §§ 23.2270, 23.2320, and 23.2510 for normal category airplanes. The FAA also received comments seeking clarification of the term “some damage” in the definition of CEL. The allowance for some damage to the aircraft exists in the 14 CFR § 23.2000 definition of CSFL. For the Archer Model M001, this allowance was moved to the definition for CEL. The intent is that, although there may be aircraft damage, the occupants remain protected to the extent that egress may still be achieved following the landing.

The FAA received several comments requesting clarity on the meaning of "loss of thrust" and "critical loss of thrust" in AM1.2000 and throughout the airworthiness criteria. These terms were inherited from the existing airworthiness standards used to create the proposed airworthiness criteria. The FAA agrees that the "loss of thrust" term is inadequate for the Model M001, which incorporates distributed propulsion with an integrated flight and propulsion control system. Historically, this terminology was used to convey an assumed complete engine failure because of the critical nature that engines, propellers, and transmissions provided regarding continued flight or CSFL capability. With the advent of distributed propulsion, the underlying assumptions of design features, mitigations, and substantiation of capability under endurance testing established within the legacy requirements are no longer valid, requiring revision.

Distributed propulsion with an integrated flight and propulsion control system adjusts the aircraft's flight path using aerodynamic and/or propulsive forces. In addition to addressing the complete loss of thrust at any individual location and its effects, the design must address additional failures from the flight and propulsion control system that may inadvertently generate more or less thrust than commanded by a pilot. For powered-lift with tilting nacelle designs like the Model M001, the design must also address the possibility of any given nacelle to fail in an orientation that does not match its commanded position, and account for the subsequent thrust vector that results. In part, some of these failures are identified through the system safety process. However, other considerations exist outside of that process that are necessary for identifying other critical failures. As such, the FAA has included a definition of "critical change of thrust" to address the thrust's magnitude and orientation. Critical change of thrust may consist of more than one condition depending on what flight conditions it adversely affects (performance, handling qualities, or both). A critical change of thrust will require a dedicated assessment encompassing all the above elements.

Further, the proposed definition for “loss of power/thrust” was not adopted in these final airworthiness criteria. Since this term was only used in the proposed AM1.2105(g), the final AM1.2105(g) requirement was rewritten to directly incorporate the previous “loss of power/thrust” definition language and clarify that the condition represents any scenario in which commanded thrust is insufficient to ensure CSFL, regardless of cause.

The FAA also received recommendations to modify the proposed “source of lift” definition to use terminology consistent with the powered-lift definition in 14 CFR part 1. The FAA agrees and has revised this definition to align with the powered-lift definition more closely.

One commenter requested the FAA clarify the meaning of “predominately” and what was meant by “combination” in the definition of “source of lift.” The FAA has changed “predominantly” to “principally” in AM1.2000(b)(3) of these final criteria, as the term “principally” is used in the part 1 definitions of powered-lift and rotorcraft. The FAA intended for the definition of “source of lift” in AM1.2000(b)(3) to be aligned with the existing regulatory definitions of powered-lift and rotorcraft. The FAA intends the term “combination” to capture instances where the sources of lift involve both engine driven lift devices (e.g., rotors) and non-rotating airfoils (e.g., fixed wings), generally in a manner in which the balance between the two is varying during transition from wing-borne flight to thrust-borne flight and vice-versa. The FAA received a comment asking to replace the term “hover” with “taxi” in the listed phases of flight in AM1.2000(b)(2). The FAA disagrees as the term “hover” refers to an airborne flight condition and “taxi” refers to movement while on the ground. Another commenter requested that the FAA add “taxi” to the criteria, since the term is also used in AM1.2225. The FAA disagrees as the term "ground operations" in AM1.2000(b)(2) includes taxi operations. No changes were made as a result of this comment.

The FAA received comments asking that the terms "shutdown," "start," "restart," and "idle" be defined for electric engines. The FAA disagrees. The FAA intends that these terms have the same meaning as for existing engine technology, but recognizes that there may be some differences based on the specific design of the Model M001 and its engine operations. The FAA received a comment questioning the applicability of part 33 requirements that used the term "rotorcraft." Upon further review, the FAA found similar issues with the references to "airplane" within part 33 and part 35. The FAA agrees with the concern and updated AM1.2000(c) to clarify that part 33 and part 35 requirements that use the terms "airplane" and "rotorcraft" mean "aircraft." This also prompted the FAA to remove the inappropriate reference to typical airplane installations in § 35.37(c)(2). The FAA also received a comment questioning the use of the term "of this part" in part 33. The FAA agrees; the revision to AM1.2000(c) also clarifies that "this part" means "these airworthiness criteria" when used in part 33 and part 35 requirements.

Lastly, the FAA added a definition for the term "local events" in response to comments requesting clarification of this term as used in requirements in subparts H and I.

Applicable Criteria

The FAA proposed applicable criteria by determining the appropriate airworthiness requirements that apply to the Model M001 powered-lift. These criteria are tailored to the powered-lift's design, including its engines and propellers, as well as its construction, intended use, and suitability for compliance with operational requirements.

EASA, GAMA, Lilium, Overair, TCCA, Vertical Aerospace, Volocopter, and an anonymous commenter requested the FAA remove sections and terms from the proposed airworthiness criteria that do not specifically apply to the Model M001 design. The FAA agrees and did not adopt the following in these final airworthiness criteria as they were not specifically applicable to the Model M001:

- AM1.2225(c);
- AM1.2240(b) (a new AM1.2240(b) has been added);
- § 23.2310;
- AM1.2320(d), (e) (the remaining requirements of AM1.2320 have been transitioned to § 23.2320);
- AM1.2325(h);
- § 23.2420;
- § 23.2435;
- § 23.2530(e);
- AM1.2540; and
- § 35.43.

The following phrases were not adopted in these final airworthiness criteria as they are not specifically applicable to the Model M001 design:

- AM1.2400(a): “or provides auxiliary power to the aircraft;”
- AM1.2405(a), (b), (c): “reverser system;”
- AM1.2430(a)(3): “and auxiliary power unit;” and
- AM1.2430(c), (c)(1), (c)(3): “refilling or.”

The FAA received comments that questioned the inclusion of HIRF and lightning requirements for aircraft approved for Instrument Flight Rules (IFR) operations. The requirements are conditional for IFR approved designs. The FAA found it prudent to specify basic design requirements for HIRF and lightning based on the expectation that future design modifications could include an IFR approval. However, additional design and installation requirements beyond those specified in these airworthiness criteria would be needed for the aircraft to be approved to operate under IFR.

Lastly, the FAA received numerous comments noting that the airplane levels prescribed by § 23.2005 should no longer be referenced in these criteria, as they apply to conventional airplanes and not to a powered-lift. The FAA agrees and has revised the airworthiness criteria accordingly.

Technical Areas in General Order of the Airworthiness Criteria Sections

Aircraft Performance, Handling, and Control

The FAA received and reviewed comments from Alaka'i, Airbus, ALPA, ANAC, ASD-Europe, EASA, GAMA, Leonardo, Lilium, Odys, Overair, Rolls-Royce, Skydrive, TCCA, Vertical Aerospace, Volocopter, and an anonymous commenter requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to aircraft performance, handling, and control for the Model M001.

The FAA received a comment noting the inconsistent use of terms when referring to the applicable atmospheric references proposed in AM1.2105, AM1.2115, and AM1.2130. Under AM1.2105(a), performance requirements at atmospheric conditions must be applied to all requirements in Subpart B unless otherwise prescribed, including AM1.2115 and AM1.2130. The FAA modified AM1.2115 and AM1.2130 to include fixed performance parameters for takeoff and landing, respectively; however, this does not negate the requirement to account for atmospheric conditions as denoted in AM1.2105(a). One commenter suggested adding "at sea level" to AM1.2105(a), consistent with the language for levels 1 and 2 low-speed airplanes in part 23. The FAA disagrees. AM1.2105(a) as proposed achieves the intended safety objectives and aligns the airworthiness criteria with the appropriate level of safety intended by utilizing appropriate standards from both parts 23 and part 27, with revisions specific to the Model M001. The FAA did not modify AM1.2105(a) as a result of this comment.

The FAA received comments that stated a concern that proposed AM1.2105(b)(1) inadvertently limits airport altitudes to 10,000 ft. The FAA agrees and has changed the airworthiness requirement to develop performance data to the maximum altitude for which certification is being sought.

The FAA also received a comment requesting clarification whether the 10,000 feet specified in AM1.2105(b)(1) should be expressed in either mean sea level or above ground level. The language in AM1.2105 is consistent with the existing airworthiness standard § 23.2105 and is referenced to the altitude above sea level. No change was made as a result of this comment.

One commenter requested revision of AM1.2105(c), stating the rule is too vague and recommending that a minimum crosswind limit be established similar to parts 27 and 29. The FAA agrees with the need for a minimum crosswind limit and revised AM1.2135(a)(6) in response to similar comments to specify a minimum of 17 knots all azimuth capability. The FAA did not change AM1.2105(c) as a result of these comments.

The FAA received comments about AM1.2105(f) expressing confusion about what the phrase "critical loss of thrust" means relative to a powered-lift design of the Archer M001 type." As mentioned previously, the FAA replaced the phrase "critical loss of thrust," with a new term "critical change of thrust" which is defined in AM1.2000.

Several commenters noted inconsistent utilization of the term "flight envelope" and requested clarification. One such instance was identified in AM1.2135(a), where the criteria referenced an "operating envelope." The FAA's intent was not to imply this flight envelope was different from others referenced in these airworthiness criteria. To be consistent, the FAA has generally replaced "operating envelope" with "approved flight envelope" where applicable such as AM1.2105(f) and AM1.2135(a), except for AM1.2425(b) and AM1.2710(d), where the proposed requirements define operating envelopes specific to the engine. Additionally, the FAA included AM1.2135(a)(7) to incorporate the steepest approach gradient within the approved flight envelope.

The FAA received several comments requesting clarification of the new term "loss of power or thrust" defined in proposed AM1.2000(b)(4) and used in proposed AM1.2105(g) to specify the required level of safety after a condition when the aircraft can no longer provide commanded power or thrust required for CSFL. This proposed term generated confusion with similar terminology referring to loss of thrust in other sections of the criteria. The FAA agrees that clarification is necessary and therefore has not adopted the "loss of power/thrust" definition in final AM1.2000. The FAA has also revised AM1.2105(g) by replacing the term "loss of power or thrust" with the definitional language from proposed AM1.2000(b)(4).

Several commenters asked for clarification on AM1.2105(g) and the use of system safety or operational mitigations as the compliance showing. The FAA modified AM1.2105(g) to provide additional clarity. Revised AM1.2105(g) is intended to assure that in the event of cockpit mismanagement, energy exhaustion, improper maintenance, or other failures, a controlled emergency landing can be achieved. AM1.2105(g) establishes safety objectives and the FAA's acceptance of a specific means of compliance is beyond the scope of these airworthiness criteria.

A commenter asked for clarification on AM1.2105(g) as to whether a conventional forward landing would be an acceptable mitigation for loss of power or thrust. A conventional forward landing may be acceptable if the aircraft is capable of a controlled emergency landing in that configuration. No changes were made as a result of this comment.

The FAA received comments requesting that the FAA more explicitly state that the speed for thrust-borne flight in AM1.2110 and AM1.2150 may include hover. The minimum safe speed determined in AM1.2110 must cover all phases of flight (including hover) and all sources of lift, and AM1.2150 uses that minimum safe speed. As such, no change to the criteria is necessary.

The FAA also received a request to revise AM1.2110 to require minimum safe speed for “each flight condition and configuration” instead of only for each flight condition. The FAA disagrees. The phrase “flight condition” includes the aircraft configuration, phases of flight, and the sources of lift. No change to the criteria is necessary.

Several commenters stated that the proposed airworthiness criteria for takeoff performance in AM1.2115, climb performance in AM1.2120, and landing performance in AM1.2130 do not establish sufficient minimum performance requirements to meet the public’s expectations and levels of safety. One commenter recommended rewording paragraph (b) of AM1.2115, AM1.2120, and AM1.2130 to require the applicant to account for a range of engine or distributed propulsion system failures instead of accounting for loss of thrust.

As explained previously, the FAA recognizes the need to clarify the difference in requirements for “essential” and “increased” performance levels as defined in AM1.2000(b)(1) for the Model M001 with respect to the takeoff, climb, and landing performance criteria of AM1.2115, AM1.2120, and AM1.2130, respectively. The FAA has revised these performance requirements to include scenarios for all engines operating and for critical changes of thrust. As revised, AM1.2115, “Takeoff performance” addresses all engines operating, as well as critical change of thrust conditions, for both essential and increased performance levels. Essential performance level requirements ensure all engines operating takeoff capability and the capability to perform either a safe stop or safe landing following a critical change of thrust. Increased performance, while similar for safe stops, defines the requirements for continued takeoff following a critical change of thrust, including the capability to continue the climb and then subsequently achieve the configuration and airspeed specified for increased performance in AM1.2120, “Climb Performance.”

The FAA revised AM1.2120 to establish targets for both essential and increased climb performance for all engines operating, as well as after a critical change of thrust, as defined in AM1.2000. The FAA developed essential and increased climb performance requirements with all engines operating using part 23 requirements. Essential performance also requires that the applicant assess critical change of thrust impacts on takeoff and climb performance capabilities. Increased performance after a critical change of thrust defines minimum criteria utilizing part 23 and part 27 Category A climb requirements, dependent on the takeoff flight path and sources of lift defined in AM1.2000 along that path.

Multiple commenters requested clarity on where glide and autorotation performance are captured. The FAA added AM1.2120(e), which requires the applicant determine the performance for gliding or autorotation.

The FAA received a number of comments noting the lack of specificity in proposed AM1.2130. The comments noted that AM1.2130 was overly vague and did not provide enough substantive detail to support the intent of the criteria. The FAA agrees and has revised AM1.2130 to ensure the level of safety and capability for essential and increased performance for takeoff in AM1.2115 is consistent with the level of safety and capability for essential and increased performance for landing in AM1.2130. Landing under AM1.2130 now contains requirements for both essential and increased performance levels, such that the aircraft must be able to make a landing upon a critical change of thrust. For increased performance, the FAA has also included a minimum criterion to safely transition to a balked landing condition following a critical change of thrust.

The FAA received a comment that determining the performance for all potential partial loss of power conditions in proposed subpart B may be impractical. The FAA agrees. As mentioned previously, a new term, “critical change of thrust” has been defined in AM1.2000 to identify the most critical thrust-related failure condition(s) for the Model M001 powered-lift. This term requires consideration of the most adverse effect on performance or handling qualities. The FAA modified AM1.2115, AM1.2120, AM1.2125, and AM1.2130 to use this new definition of critical loss of thrust.

A commenter requested clarification on the phrase "applicable sources of lift" in AM1.2135(a)(2). During a specific phase of flight, an aircraft design may only allow for a singular source of lift during that phase of flight. In other phases of flight, one or more sources of lift may be possible. Therefore, "applicable sources of lift" refers to only those allowable by the aircraft design. No changes were made as a result of the comment.

Multiple commenters requested the FAA establish an additional limit flight envelope which would establish the controllability limits of the aircraft. The FAA does not agree with this request. The FAA intended proposed AM1.2135 to establish the regulatory requirement for controllability that is used to define the approved flight envelope. The FAA recognizes that excursions outside of the aircraft's approved flight envelope can occur and must be considered from a safety perspective. The FAA has replaced the proposed requirement of § 23.2160(a) with new AM1.2160 to address speed excursions beyond the approved flight envelope.

The FAA received multiple comments requesting the FAA utilize the multiple flight envelope concept in EASA's SC-VTOL, in lieu of the proposed minimum safe speed requirement in AM1.2110. The commenters stated that the FAA's proposed requirement may be appropriate for wing-borne flight, but it is not appropriate for other aircraft configurations. The FAA determined that the establishment of a minimum safe speed and an approved flight envelope establishes a level of safety for the Model M001 that is consistent with the safety levels as established in parts 23 and 27.

The FAA also received comments seeking clarification on atmospheric effects, scoping, and sources of lift in regard to AM1.2110. The intent of that requirement is to address flight conditions in normal operation considering the most adverse conditions, which includes adverse atmospheric effects. Accordingly, no change to this requirement is necessary. Establishment of minimum safe speeds in regard to specific sources of lift will be established through the issue paper process.

Regarding controllability, the FAA received comments asking the FAA to adopt the requirement in § 23.2135(a)(3), to address “likely reversible flight control or propulsion system failure,” instead of proposed AM1.2135(a)(3), which requires addressing “likely flight-control or propulsion-system failure.” Commenters further clarified that they believed flight controls are fully addressed by the proposed requirement that the Model M001 comply with § 23.2510. The FAA disagrees and determined that specific airworthiness criteria for controllability are needed to address the integration of the advanced flight-control system and the propulsion-system. In addition, AM1.2135(a)(3) is to ensure that likely failures not included in the system safety process of § 23.2510 are addressed and that failures that are included have an adequate handling quality assessment which is outside the scope of § 23.2510. No changes were made as a result of these comments.

The FAA also received a comment requesting that the flight control system be subjected to the same requirements found in AM1.2705, AM1.2710, AM1.2713, and AM1.2727 for the engine control system due to the highly integrated nature of these systems. The FAA disagrees as the engine control system and flight control system are not integrated into one system. No changes were made as a result of this comment.

One commenter asked the FAA to remove AM1.2135(a)(5) because the requirements of proposed Subpart F would sufficiently mitigate this hazard. The FAA disagrees. AM1.2135(a)(5) requires controllability evaluation using approved flight test methods of compliance. The requirements in Subpart F, which apply to equipment, do not adequately address this concern. No changes were made as a result of this comment.

The FAA received a comment to modify AM1.2135(a)(5) to remove the phrase "not shown to be extremely improbable." The FAA disagrees. Removing this phrase would require the applicant to address all failure conditions regardless of their probability. The FAA included this phrase to limit the cases where handling qualities are evaluated to those conditions not shown to be extremely improbable to limit the applicant's burden. No changes were made as a result of this comment.

Several commenters requested that a minimum level of safety be established with respect to proposed AM1.2135(a)(6), which requires that the aircraft can land safely in wind conditions. Multiple commenters questioned whether AM1.2135(a)(6) was only applicable to thrust-borne flight. The FAA concurs that a minimum level of safety should be defined and has amended AM1.2135(a)(6) to contain a more prescriptive all-azimuth minimum wind speed requirement of 17 knots. This minimum wind limit is applicable to the thrust-borne operations and is consistent with requirements for parts 27 and 29 rotorcraft.

The FAA received a comment that the term "loading" in proposed AM1.2135(a)(1) needed to be revised to include energy level considerations (i.e., degraded or low battery). Energy level considerations are covered under AM1.2135(a)(3), (a)(5), and (b), which address propulsion system failures, flight control system operating modes and critical control parameters such as limited-control power margins, respectively. Propulsion system failures include the electrical distribution and batteries. The same commenter proposed adopting a new requirement to address a rolling takeoff in maximum crosswind. The situation noted by the commenter is already addressed by AM1.2135(a)(2), which covers all phases of flight (e.g., takeoff for the approved flight envelope including crosswinds). No changes were made as a result of these comments.

Multiple commenters asked for clarity on the phrases “critical control parameters” and “limited control power margins” in AM1.2135(b). The phrase "critical control parameters, such as limited control power margins" is intended to capture parameters or limits in which the aircraft is control or performance limited. The applicant must define these parameters as they apply to their unique design. No changes were made as a result of these comments.

The FAA received a comment recommending that “change from one flight condition to another” be replaced with “transition from one flight condition to another” in AM1.2135(c). The FAA agrees and has updated AM1.2135(c) accordingly.

Several commenters stated that the language utilized from part 23, pre-amendment 23-64, in the development of proposed AM1.2145 did not provide appropriate granularity between static and dynamic stability and sources of lift for a powered-lift. The FAA agrees and has revised the requirements in AM1.2145 to account for the difference in stability requirements that arise between wing-borne, semi-thrust-borne, and thrust-borne flight for the Model M001.

The FAA received comments asking the FAA to provide specific likely failure cases to be considered in addition to more detailed control feel requirements in proposed AM1.2145(a). The FAA partially concurs with these comments. The intent of AM1.2145(a) is for the applicant to identify likely failures that may be encountered in service that are not addressed by system safety analysis; those could include mechanical or other single point failures. The FAA has revised the language in AM1.2145(a) to improve clarity but did not concur with the commenters' request to identify specific failure conditions, including detailed control feel requirements.

The FAA also received a comment seeking clarity on the term “unstable” in AM1.2145(b). The FAA revised proposed AM1.2145(b) (now AM1.2145(c), due to changes discussed previously) to clarify that the intent is to ensure dynamic stability characteristics. The FAA intends "unstable" to mean the same as is stated in the criteria: that the characteristics do not increase the pilot's workload or otherwise endanger the aircraft and its occupants.

The FAA also received comments regarding aerobatics and whether such proposed criteria are applicable to this class of vehicle or if instead the criteria should be better tailored to Archer's design. The FAA agreed and revised AM1.2145 and AM1.2150 accordingly with the recognition that Archer is not seeking approval for aerobatics for the Model M001.

The FAA received a comment that proposed AM1.2150 may be adequate for wing-borne operation but not thrust-borne operation. The FAA agrees and has revised AM1.2150 to address all sources of lift.

The FAA also received a comment questioning the terminology "critical loss of thrust" in proposed AM1.2150(b). The FAA agrees this term was inappropriate for an aircraft capable of vertical takeoff and landing operations because it requires a hazardous test condition that would result in an initial adverse environment, which was not the intent. The FAA has updated AM1.2150(c) (previously proposed AM1.2150(b)) to replace "critical loss of thrust" with "sudden change of thrust" to remove this hazardous condition and to distinguish it from the term "critical change of thrust" defined in AM1.2000. The FAA intends the term "sudden change of thrust" to refer to short-term commanded thrust changes, whether directly by the pilot or from the flight control system in normal operation. The FAA received comments on proposed AM1.2150 that a maximum speed limitation may be necessary to prevent loss of control on a powered-lift. The FAA agrees with the commenters, but because AM1.2150 relates to minimum safe speed requirements, the FAA has revised AM1.2160 to include this safety requirement in AM1.2160(b).

The FAA received a comment requesting clarification on the applicability of § 23.2155. The commenter questioned the necessity for this requirement with the assumption that powered-lift do not taxi under their own power. The FAA disagrees that this requirement should not be adopted as proposed, as the Model M001 has the ability to taxi. No changes were made as a result of the comment.

The FAA also received a comment on proposed AM1.2140(c) suggesting the removal of "multi-engine." The commenter stated that because the Model M001 is a multi-engine aircraft, including this term adds no value and may create confusion. The FAA agrees and did not adopt the reference to "multi-engine aircraft."

Finally, the FAA received several comments about AM1.2140(c)'s use of the language, "loss of thrust not shown to be extremely improbable" in the context of trim system requirements. As mentioned previously, a new term, "critical change of thrust" was defined in AM1.2000 to provide an equivalent term adapted to the Model M001 design. The FAA modified AM1.2140(c) to use "critical change of thrust" as a result.

One commenter noted that proposed AM1.2140(a) should not be limited to just cruise flight. The FAA agrees and has removed the reference limiting the requirement to cruise flight. Additionally, commenters expressed a concern that normal phases of flight utilized in proposed AM1.2140(a) and the flight conditions identified in proposed AM1.2140(b) may create some confusion. The FAA agrees and has revised the language in AM1.2140(a) to specify "normal operations" instead of "normal phases of flight."

One commenter requested the FAA change the phrase "level flight" to "cruise" in AM1.2140(b)(2). AM1.2140(b)(2) references flight conditions and not phases of flight, and therefore "level flight" is appropriate. The commenter also requested the FAA add "hover" to AM1.2140(b). Hover does not have a longitudinal component, and as such trim in that axis is not applicable. Adjustments of trim may not apply any discontinuities as identified in AM1.2140(c). No changes were made as a result of these comments.

The FAA received comments concerning the use of the term “trim” in proposed AM1.2140 and questioning its appropriateness with fly-by-wire control systems that do not use traditional trimming arrangements. The FAA finds the requirements in AM1.2140 applicable because the Model M001 fly-by-wire flight controls may implement a trimming function rather than conventional trim device tabs or bias springs. Such a function would be equivalent to a trim or auto-trim device. No changes were made as a result of these comments.

One commenter requested that the FAA replace the term “primary flight controls” in proposed AM1.2140(a) and (b) with the term “inceptor.” The FAA disagrees. Although inceptors and effectors may fall under the term “primary flight controls,” the FAA does not find this change necessary as it prescribes a specific implementation of technology. No changes were made as a result of this comment.

Icing

The FAA received and reviewed comments from Airbus, ALPA, EASA, GAMA, Overair, and TCCA requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to flight into known icing (FIKI) conditions as well as inadvertent icing encounters. Specifically, commenters requested the FAA explain why references to icing conditions requirements were excluded, revise the level of prescriptiveness of the criteria, and remove FIKI requirements because the Model M001 is not seeking FIKI approval at this time. At the same time, the FAA received comments requesting the FAA include more specific requirements for FIKI conditions.

Based on numerous comments received noting that Archer does not seek approval for FIKI on the Model M001 at this time, the FAA did not adopt proposed AM1.2165(a). Proposed AM1.2165(b) and (c), which address inadvertent icing encounters, remain applicable to the Model M001, and have been renumbered to AM1.2165(a) and (b), accordingly. AM1.2415 is similarly intended to capture any aircraft icing during an inadvertent encounter that adversely affects powerplant operation.

The FAA received comments requesting the FAA include requirements for recirculating snow and accumulation of ice and snow, because smaller rotors and airfoils, such as those on the Model M001, are known to be susceptible to the effects of snow and icing. The FAA agrees with concerns regarding the effect of scale on ice accretion, but finds they are addressed by proposed AM1.2165(b) (AM1.2165(a) in these final criteria) for an inadvertent icing encounter. Recirculating and accumulation of snow are foreseeable conditions addressed by § 23.2415(a) for engine operation and by AM1.2600(a) for flightcrew visibility considering accumulations on the windshield due to recirculating snow.

The FAA received requests to remove proposed AM1.2165(b) since the Model M001 powered-lift is not seeking FIKI approval. The FAA does not agree, as proposed AM1.2165(b) (AM1.2165(a) in these final criteria) addresses inadvertent icing encounters, not FIKI. The relatively low revolution speed and resulting low centrifugal acceleration effect on ice shedding capability, as well as the effect of increased torque on electric engines, need to be addressed in an inadvertent icing encounter.

Lastly, the FAA received several comments on proposed AM1.2165(a), requesting that the FAA explain why the reference to the icing conditions defined in appendix C of part 25 was excluded from these airworthiness criteria. Because Archer is not seeking FIKI approval at this time, the FAA determined in response to comments from EASA, GAMA, and Overair, that proposed AM1.2165(a) should not be adopted in these final airworthiness criteria. Should Archer seek icing certification through an amendment to their type certificate after initial type certification, appropriate icing standards will be defined as part of that project. This will allow Archer to seek a standard that reflects their operating limitations and specifics of their design.

Structural Design Loads

The FAA received comments from Airbus, ALPA, EASA, Rolls-Royce, and TCCA requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to structural design loads for the Model M001, including vibration and buffeting, flight modes, and wing borne vs. thrust-borne design loads.

The FAA received a comment to modify § 23.2215(a) to cover the whole operational envelope of the aircraft. The FAA does not agree. The objective of this criteria covers the structural design envelope, which may exceed the operational envelope requirement recommended by the commenter. No changes were made as a result of this comment.

A commenter recommended the FAA include the structural requirement for vibration and buffeting and harmonize with EASA's SC-VTOL.2215(b) for powered-lift, by adding "Vibration and buffeting must not result in structural damage up to dive speed, within the limit flight envelope" to § 23.2215.

The FAA agrees that vibration and buffeting must not result in structural damage, but the FAA does not agree to use the SC-VTOL.2215(b) language. The FAA finds that EASA's scope for vibration and buffeting in SC-VTOL is not sufficient for powered-lift. The FAA instead moved the proposed requirement to comply with § 23.2215 to AM1.2215(a) and added a new paragraph (b), which states, "There must be no vibration or buffeting severe enough to result in structural damage, at any speed up to dive speed, within the structural design envelope, in any configuration and power-setting."

Two commenters requested the FAA clarify the transitional flight mode for engine-driven lifting-device assembly provisions per AM1.2225(d). The commenters pointed out that the structural loads requirements for this special class of aircraft include loads resulting from the transitional flight phase that are not considered under loading conditions in parts 23 and 27. Specifically, the commenters were concerned that propellers, when repositioned in-flight relative to the aircraft primary axis, may introduce unique load cases relative to conventional propeller loads that would impact the static strength evaluations. The commenters recommended the FAA capture requirements for loads in all phases of flight by revising AM1.2225(d). One commenter requested revising AM1.2225(d) to read "Engine-driven lifting-device assemblies, considering loads resulting from flight (including transitional flight mode) and ground conditions, as well limit input torque at any lifting-device rotational speed." Another commenter requested revising AM1.2225(d) to read "Engine-driven lifting device assemblies, considering loads resulting from flight and ground conditions, limit input torque at any lifting-device rotational speed as well as propeller holding or clocking (locking) conditions of applicable."

The FAA agrees that all powered-lift flight configurations need clarification for the calculation of structural design loads for transitional flight phases. The FAA also recognizes that changes in propeller "disk" orientation during flight will affect aircraft loads resulting from the aerodynamic influence of the propellers on the aircraft. Similarly, the FAA considers it likely that aircraft aerodynamics loads will influence the propeller aerodynamic loads. Therefore, the FAA concluded that proposed AM1.2200 Structural Design Envelope should be revised instead of AM1.2225 (as suggested by the commenters) to include, "Thrust-borne, wing-borne, and semi-thrust-borne flight configurations, with associated flight load envelopes." The FAA added AM1.2200(g) accordingly.

Multiple commenters asked for clarity on the requirements in AM1.2225(d) and whether the intent of that criteria could be shown through means of compliance with AM1.2225(a). The FAA disagrees. AM1.2225(a) is specific to loads for the engine mount, whereas AM1.2225(d) is specific to lifting device assemblies.

Multiple commenters requested the FAA provide clarification in AM1.2200(b) with respect to appropriate design maneuvering load factors for powered-lift designs. The intent of AM1.2200 is to describe the various design envelopes that must be considered by the applicant in the loads analysis. No changes were made as a result of these comments.

One commenter requested that the FAA define the term "sufficiently" in AM1.2200(a)(1) and (2). As explained in the notice of proposed criteria, the FAA based proposed AM1.2200 on § 23.2200, with revisions to address the powered-lift structural design envelope. The terms "be sufficiently greater" in AM1.2200(a)(1) and "provide sufficient margin" in AM1.2200(a)(2) have the same meaning, and will be applied to the Model M001 in the same manner, as in § 23.2200(a)(1) and (2). No changes were made as a result of the comment.

EASA stated that AM1.2200(e), which proposed to require that the applicant account for each critical altitude up to the maximum altitude, does not consider redistribution of loads if deflections under load would significantly change the distribution of external or internal loads. EASA also requested the FAA revise AM1.2200(e) similar to EASA SC-VTOL.2200(e). The FAA does not concur, as the critical altitude and redistribution of loads requirement in SC-VTOL.2200(e) is already captured by AM1.2200(e) and § 23.2210. No changes were made as a result of this comment.

The FAA received multiple comments questioning the requirement to use service history in the development of the design load maneuvering factors in AM1.2200(b), since the Model M001 has no service history. One commenter requested the FAA add specific language to the airworthiness criteria that points to using service history from existing normal category aircraft. The FAA agrees that the service history utilized in this showing should come from service experience from both rotorcraft and small airplane service history. However, the FAA disagrees that a change to the airworthiness criteria is necessary.

One commenter recommended the FAA revise proposed AM1.2225 to be more generic by specifying source of loads for any relevant structural components, and not only the components specific to the Model M001. The FAA disagrees, as these airworthiness criteria are specific to the applicant's design.

Structures

The FAA received and reviewed comments from ASD-Europe, Airbus, EASA, GAMA, Leonardo, Lilium, Overair, Odys, TCCA, Volocopter, and an anonymous commenter requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to aircraft structure for the Model M001.

Several commenters suggested adding the level 4 airplane requirements for damage tolerance in § 23.2240(b) to AM1.2240 to incorporate damage tolerance principles. The FAA partially concurs with the recommendations of the commenters and has clarified AM1.2240(b) consistent with the FAA's long-standing policies regarding use of fail-safe methodology in conjunction with damage tolerance inspections. Fail-safe methodologies, also referred to as safety-by-design, incorporate multi-load-path structure (i.e., redundant load paths) to act as back-up structure should any one of the original load paths (i.e., fail-safe structure) fail. Damage tolerance (i.e., safety-by-inspection) is a property of structure relating to its ability to sustain defects safely until those defects can be detected.

The FAA does not agree that adoption of § 23.2240(b) is necessary or appropriate, as this requirement is specific to airplanes that meet the definition in § 23.2005 for a Level 4 airplane that can carry 10-19 passengers. The § 23.2240(b) requirement for Level 4 airplanes was derived from § 23.574 at amendment 23-48 and excluded the option to use fail-safe methodologies for commuter category airplanes

(Level 4). In addition, § 23.574(a) requires the use of damage tolerance and allows the use of safe-life in § 23.574(b) only when damage tolerance is found to be impractical.

Damage tolerance is one available option to use when complying with AM1.2240(a), along with the options to use safe-life and fail-safe methodologies, provided the fail-safe option relies on damage tolerance or safe life as stipulated in numerous FAA policies including AC 27-1B, “Certification of Normal Category Rotorcraft”; AC 23-13A, “Fatigue, Fail-Safe, and Damage Tolerance Evaluation of Metallic Structure for Normal, Utility, Acrobatic, and Commuter Category Airplanes”; and AC 91-82A, “Fatigue Management Programs for In-Service Issues.” The FAA notes further that the intent of adding AM1.2240(b) to these final criteria was to incorporate inspection when the fail-safe method is used. Incorporating inspections addresses long-standing and known deficiencies with fail-safe methodologies on all part 23 airplanes, as clarified in the preamble to the Notice of Proposed Rulemaking (NPRM) for amendment 23-64, in which the FAA identified potential shortcomings in the ability to detect all possible failure scenarios and ensure that all structural failures would be immediately obvious and corrected before further flight. The intent of structural durability requirements in both §§ 23.2240(a) and 27.571 is to use the appropriate application of safe-life or damage tolerance principles to ensure that fail-safe structure maintains the required safety margins without extended periods of operation with reduced safety margins.

The FAA agrees with the commenters that further clarification on the stipulations that govern the use of fail-safe methodologies should be included in the Model M001 criteria to reiterate the FAA’s requirements in this regard. Consequently, the FAA has added a new AM1.2240(b) that reflects the intent of § 27.571(d) together with amendment 23-64 and associated policies to incorporate damage tolerance principles into powered-lift. The requirements in AM1.2240(b) will mitigate deficiencies in the fail-safe option and will apply to the Model M001 structure beyond those elements specifically identified by § 27.571. This is consistent with § 21.17(b), which directs the FAA to use the requirements from existing airworthiness standards, as appropriate, to determine the level of safety for the aircraft.

Multiple commenters requested that the FAA align AM1.2240(c) with EASA SC-VTOL.2240(d). The FAA notes that AM1.2240(c) is similar to SC-VTOL.2240(d), although SC-VTOL.2240(d) refers to "lift/thrust unit" instead of "engine." The EASA term "lift/thrust unit" includes the engine and propeller or rotor assembly. This topic is an ongoing discussion with foreign certification authorities. For the Model M001, other rotating parts within the system, except for propeller blades or rotors, should be evaluated using typical rotor burst methods, including shielding where practical.

The FAA received a comment to move AM1.2240(c) to outside of Subpart C Structures. The FAA disagrees as AM1.2240(c) is a requirement specific to structural durability and is appropriately included in AM1.2240, which is consistent with § 23.2240. No changes were made as a result of this comment.

Several commenters requested the FAA align § 23.2250(c) with the failure criteria in EASA SC-VTOL.2250(c). SC-VTOL.2250(c) contains a requirement for Category Enhanced that a single failure must not have a catastrophic effect upon the aircraft. The FAA's airworthiness criteria do not contain requirements equivalent to EASA's "Category Enhanced" requirements. However, the changes to AM1.2240(b) in these final criteria require inspections capable of reliably detecting damage before it leads to structural failure, thereby mitigating the occurrence of catastrophic failures. The FAA also changed the proposed requirement to comply with § 23.2250(c) to new AM1.2250(c) to require the applicant to prevent single failures from resulting in a catastrophic effect upon the aircraft.

The FAA received a comment requesting the airworthiness criteria include a requirement to address corrosion on metallic or semi-metallic structure components resulting from high voltage difference of electric potential. The FAA does not concur. AM1.2240(a) provides an appropriate regulatory framework for addressing corrosion, as it embodies the safety intent of the prescriptive requirements in pre-amendment 64 regulations §§ 23.573 and 23.574, which directly address corrosion, among other factors, in both composite and metallic structure. This framework will be applied to the Model M001 in the same manner as § 23.2240 for normal category airplanes to address corrosion resulting from any source, including high voltage difference of electric potential. No changes were made as a result of this comment.

Multiple commenters requested clarification on the lack of environmental requirements in § 23.2260(e), which applies to only thermal effects. Environmental effects are addressed in § 23.2260(a), and as such the FAA made no change as a result of these comments.

Aeroelasticity & Aeromechanical Stability

The FAA received and reviewed a comment from Volocopter requesting the FAA revise the proposed requirement to comply with § 23.2245 to provide further clarity regarding definitions used in the requirement, specifically whether the probabilities of malfunctions that can affect aeroelastic stability are aligned with those in EASA's SC-VTOL.2245. The FAA has revised the proposed requirement as new AM1.2245 to specifically require that component and rotating surfaces be free of any aeroelastic instability under each appropriate speed and power condition. Additionally, the FAA determined that the related issue of aeromechanical stability should similarly be addressed but does not consider it to be covered under the subject of aeroelasticity. Therefore, the FAA created a new section AM1.2241, "Aeromechanical stability," incorporating requirements from rotorcraft airworthiness standards, similar to ground resonance requirements in § 27.241, to address aeromechanical instabilities considered possible for the Model M001 when operating in thrust-borne and semi-thrust-borne flight.

Flight Controls

The FAA received and reviewed comments from Airbus, ANAC, ASD-Europe, EASA, GAMA, Leonardo, Lilium, Overair, and TCCA, requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to flight controls for the Model M001.

The FAA received a comment stating that 14 CFR part 23 amendment 23-64's requirements for flight controls should be sufficient for the Model M001 and the FAA should use those requirements. The FAA disagrees. Part 23 at amendment 23-64 did not envision the type or complexity of the design of powered-lift flight controls, such as those on the Model M001. No changes were made as a result of this comment.

The FAA received several comments that raised concerns with the suitability of proposed AM1.2300(b), which was developed from part 23 requirements for trim systems on normal category airplanes, for fly-by-wire powered-lift with distributed propulsion. The FAA concurs with the comments and modified proposed AM1.2300(b)(2) by replacing the specific trim indications with a requirement that the trim systems and functions provide information necessary for safe operation. The specific indications listed in proposed AM1.2300(b)(2)(i) – (b)(2)(iv), which summarize the prescriptive indications from 23.677(a) and ASTM F3232 section 4.4, may be used as means of compliance with final AM1.2300(b)(2) if they are applicable, or they may be modified for the novel implementation of trim functions on the Archer Model M001.

Commenters raised concerns over the flightcrew control margin awareness for fly-by-wire flight control systems and recommended including a requirement addressing this issue. The FAA concurs with the comments and has added AM1.2300(a)(3) requiring the flightcrew to be made suitably aware whenever the means of primary flight control approaches the limits of control authority. For the context of this airworthiness criteria, “suitably aware” indicates an appropriate balance between nuisance alerting and necessary operation.

Two commenters asked for clarification of the term “indirect flight-control systems” in AM1.2300(c). The FAA agrees that this term caused confusion. The FAA did not adopt this term and instead revised AM1.2300(c) for clarity.

Several commenters stated that proposed AM1.2300 was overly prescriptive because the requirements could be better addressed in means of compliance and could conflict with automation in fly-by-wire flight controls. In contrast, other commenters stated that proposed AM1.2300 was insufficiently prescriptive and noted that regulations need to explicitly guide applicants, especially for novel aircraft, and specific requirements for awareness of reduced flight envelopes should be provided.

The FAA considered these comments and revised proposed AM1.2300 to be less prescriptive in instances where other requirements adequately address the same safety objective. The FAA did not adopt the proposed requirements in AM1.2300(c)(1), (c)(2)(i), and (c)(2)(iii) because they were redundant with other requirements and were unnecessarily prescriptive. The FAA added a more prescriptive requirement specifically for control margin awareness in response to these recommendations.

One commenter suggested a revision to the phrase “the onset characteristics of each protection feature is appropriate for the phase of flight and type of maneuver” in proposed AM1.2300(c)(2)(i). The FAA notes there should be no discontinuous inputs into the flight control system from envelope protection systems, but agrees that abrupt inputs may be necessary in some situations (e.g., preventing stall in response to an atmospheric disturbance). The FAA determined that this requirement is adequately addressed by AM1.2300(a)(1) and therefore did not adopt proposed AM1.2300(c)(2)(i).

The FAA received comments requesting clarification as to why the term "catastrophic" is not used in proposed AM1.2300(c)(2)(iii) while the term "hazardous" is used in proposed AM1.2710(f)(3). The FAA reviewed the comments and determined that AM1.2300(c)(2)(iii) is redundant to § 23.2510, and therefore did not adopt proposed AM1.2300(c)(2)(iii). For clarification, the FAA notes that AM1.2710 applies to the engines and addresses failure effects up to the hazardous level, whereas § 23.2510 applies to the aircraft and addresses failure effects up to the catastrophic level. These safety levels are intentionally different. No engine failure is allowed to result in a catastrophic aircraft event. In addition, unlike § 23.2510, AM1.2710 does not permit using a probabilistic means to manage certain single-element parts that can fail and cause hazardous engine effects.

A commenter recommended defining the term "simultaneous limiting event" in AM1.2000. The FAA notes this term originates from unique conditions applied to fly-by-wire systems with envelope protection. It pertains to scenarios where multiple envelope limits could be exceeded. The FAA does not consider it necessary to define this term in AM1.2000.

The FAA received a comment on § 23.2305 requesting that the FAA add a requirement for parking brakes. The FAA disagrees. Section 23.2305(b) requires a reliable means of stopping the aircraft. One means to accomplish this may include a parking brake; however, the applicant may propose other means. No changes were made as a result of this comment.

Occupant System Design Protection

The FAA received comments from ALPA, EASA, GAMA, Lilium, Overair, Rolls-Royce, and TCCA on occupant system design protection requirements.

The FAA received comments seeking clarification on the proposed inclusion of the ditching exclusion in § 23.2315(a)(1) and a comment that this contradicts the proposed requirement to comply with § 23.2310 for seaplanes and amphibians. The FAA concurs that the language proposed caused confusion and has revised these proposed requirements. The FAA did not adopt the proposed requirement to comply with § 23.2310 as it is not applicable to the Model M001. The FAA maintained the scope of § 23.2315 (now AM1.2315) specific to the "cabin configured for takeoff or landing" but did not adopt the exclusion for ditching because the Model M001 is not seeking ditching approval. One commenter requested that the FAA require shrouding on propellers as these aircraft are planned to operate close to people or property. The FAA does not concur with the comment. AM1.2315(a)(1), originally proposed as § 23.2315, requires that passenger doors are not located where propellers would endanger persons using the door. Operational requirements are also used to ensure safety of passengers, ground crews, and property, as required for existing aircraft. No changes were made as a result of the comment.

The FAA received comments regarding aerobatics and whether such criteria are applicable to this class of vehicle or if the proposed criteria for aerobatics should be removed. The FAA removed the proposed requirement to comply with § 23.2315(b) because the Model M001 does not seek approval for aerobatics.

The FAA received comments asking the FAA to include the protection of occupants in proposed AM1.2320(a)(2). Another commenter asked for clarification of proposed AM1.2320(a)(2). Another commenter asked the FAA to modify proposed AM1.2320(a)(2) to protect the pilot, flight controls, and propulsion electrical power and control from propellers. The intent of proposed AM1.2320(a)(2) (now § 23.2320(a)(2) in these final criteria) is to protect the pilot and systems so the pilot can land the aircraft in the event of a propeller failure. Protection of the occupants embarking and disembarking is required by AM1.2315. Propulsion control is required by § 23.2320(a)(2) as a part of the flight controls on the Model M001. No changes were made as a result of these comments.

Bird Strike

The FAA received and reviewed comments from Airbus, Alaka'i, ALPA, ASD-Europe, EASA, GAMA, JCAB, Leonardo, Overair, TCCA, UKCAA, Vertical Aerospace, and Volocopter, requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to bird strike requirements for the Model M001.

Some commenters requested that the FAA increase the bird-impact size, while other commenters requested that the bird mass should not be prescribed, or a lower bird mass should be used with considerations for multiple bird strikes. Some commenters requested complete removal of the requirement, while other commenters only requested removal of the requirement for bird deterrence devices. Several commenters questioned the bird mass differences between the aircraft level requirement in proposed AM1.2320, the propeller requirement in § 35.36, and the bird ingestion evaluation in AM1.2718. One commenter requested the FAA align bird strike requirements with those in EASA SC-VTOL.

The FAA maintains the rationale presented in the notice of proposed airworthiness criteria for the proposed level of bird strike protection for the Model M001. The proposed requirements were based on the increased exposure to birds in the environment in which the Model M001 is expected to operate, the expectation of public safety, and the recommendations presented in the Aviation Rulemaking Advisory Committee (ARAC) Rotorcraft Bird Strike Working Group (RBSWG) report.[3]

The safety level obtained with the 2.2-lb bird strike requirement for transport category rotorcraft (as established in § 29.631) has been demonstrated in service to be

[3] ARAC RBSWG Report, Rev. B, May 8, 2019, page 15, Section "Bird Mass" (ARAC RBSWG Report), https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/ARAC%20RBSWG%20Final%20Report%20Rev.%20B.pdf.

sufficient. Similarly, the existing bird strike requirement with a 4.0-lb bird for type certificated propellers (established in § 35.36) has also been demonstrated in service to be sufficient. The bird ingestion requirements in AM1.2718 are not driven by either of these bird sizes. Therefore, the proposed bird impact protection requirement remains unchanged and will retain the proposed 2.2-lbs at the aircraft level, while maintaining propeller requirements at 4.0-lbs in § 35.36.

The FAA also considered the comments received on the bird deterrent system requirement in proposed AM1.2320(b), and the FAA concurs with not adopting this proposal. Although the FAA is aware of some research supporting the use of such devices, the FAA agrees the data is insufficient to mandate such a system at this time. The FAA encourages applicants such as Archer to consider voluntary implementation of these systems or similar bird deterrence mitigations, as good design practice.

The FAA also received comments that questioned whether the bird strike requirement should be listed under proposed AM1.2320, "Occupant Physical Environment," since as written, it applies to more than just the occupant physical environment. The FAA agrees with these comments. The bird strike requirement placed in proposed AM1.2320 was intended and described in the notice as an aircraft-level requirement. Therefore, the FAA did not adopt proposed AM1.2320(b) and instead placed some of the requirements from proposed AM1.2320(b) into a new AM1.2311, "Bird Strike" in Subpart D, "Design and Construction," to reinforce its intent as a general, aircraft-level requirement. Lastly, several commenters expressed concern with flocking bird strikes that could affect multiple engines at the same time and recommended this be addressed by the ingestion requirements in AM1.2718(a). The FAA notes that the airworthiness criteria in Subpart H apply to each single engine used in the aircraft distributed propulsion system. The requirements in AM1.2718(a) address ingestion from likely sources such as foreign objects, birds, ice, and hail, and are intended to capture engine effects from any ingestion source determined to be applicable to the Archer electric engine design. Common cause effects across multiple engines will be addressed under the applicable aircraft-level requirements, including § 23.2510, so no change to the engine airworthiness criteria is necessary.

Fire and High Energy Protection

The FAA received and reviewed comments from Airbus, EASA, GAMA, JCAB, Lilium, Odys, Overair, TCCA, and Volocopter requesting that the FAA revise, remove, or clarify proposed airworthiness criteria related to fire and high energy protection on the Model M001.

Several commenters recommended the FAA revise §§ 23.2325 and 23.2270 to protect against fires in baggage and cargo compartments propagating and creating an unsafe condition. The commenters suggested incorporating requirements similar to those in EASA SC-VTOL.2270, and further recommended clarifying proposed § 23.2325 by removing the references to part 23 airplane certification levels.

The FAA agrees with the need to mitigate the risk of fires in baggage and cargo compartments, commensurate with the intended level of safety for the Model M001. The FAA reviewed the baggage and cargo compartment fire protection requirements in parts 23 and 27, the intended operational uses of the Model M001, and the EASA SC-VTOL requirements. The proposed airworthiness criteria did not require the design to alert the pilot of a fire in a baggage or cargo compartment, or require these compartments be constructed of or lined with fire resistant materials to protect the aircraft and occupants if the pilot was unaware of a baggage or cargo compartment fire. However, part 27 contains requirements to protect rotorcraft occupants from the risk of fire in a baggage compartment through the use of flame and fire resistant materials in its construction. The FAA revised proposed § 23.2325 (now AM1.2325) by removing the part 23 airplane certification levels. The FAA also added AM1.2325(e) requiring that the Model M001 baggage and cargo compartments be constructed of or lined with fire resistant materials, similar to § 27.855(a)(2), or be equipped with a fire or smoke detection system to allow the pilot to take immediate action to land, or be located where a fire would be visible to the pilots and accessible for the manual extinguishing of a fire, which adopts some elements of SC-VTOL.2270.

A commenter recommended the FAA revise proposed § 23.2325 to be more generic by specifying performance-based safety objectives. The FAA does not agree, as the revisions to proposed § 23.2325 (now AM1.2325) discussed previously are specific to the Model M001.

The FAA received comments recommending retaining the language in § 23.2330 of "designated fire zone" in lieu of the proposed AM1.2330 "fire zone." The term "fire zone" includes designated fire zones and new fire zones developed to address fire threats from new technologies. Much of existing guidance is defined for designated fire zones, which assume a fire involving kerosene or aviation gasoline. Other terms will be determined by the applicant, including designated fire zones, to distinguish between different types of fire zones and the fire threat that exists in those zones. The difference in language does not impose requirements beyond the intent of part 23, and also allows new fire zones to be established for aircraft using non-conventional propulsion and energy supply. No changes were made as a result of these comments.

The FAA received a comment to align the language in AM1.2330(a) and AM1.2330(b) ("fire zone") with the language in SC-VTOL.2330 ("designated fire zone"). As discussed above, the FAA has moved away from using the term "designated fire zone." EASA SC-VTOL.2330(a) is broader than AM1.2330(a) and includes additional components by applying to "flight critical systems" instead of only "flight controls." Although AM1.2330 is not as broad as EASA SC-VTOL.2330(a) as far as the scope of components, it is broader with respect to the types of fire zones that those components must address, by using the term “fire zone” instead of “designated fire zone.” Protection of flight critical systems other than flight controls and ensuring CSFL after a fire or release of stored energy are addressed in AM1.2440 and § 23.2510.

The FAA received multiple comments to add survivable emergency landing fire protection requirements to § 23.2325. The FAA notes that such conditions are already covered by AM1.2430(a)(6), which states that each energy system must be “...designed to retain energy under all likely operating conditions and to minimize hazards to occupants and first responders following an emergency landing or otherwise survivable impact (crash landing).” No changes are necessary as a result of these comments.

The FAA received a comment to add a requirement to AM1.2335 to minimize the risk of electrical shock to the crew, passengers, and service and maintenance personnel, similar to the requirement in § 27.610(d)(2). This concern is adequately addressed by proposed AM1.2335(b), which requires the appropriate protection against hazardous effects caused by accumulation of electrostatic charge. No changes were made as a result of this comment.

The FAA also received a comment to revise AM1.2335(b) to require protection against catastrophic and hazardous effects. The proposed airworthiness criteria state that the aircraft must be protected from hazardous effects, which represent the minimum hazard level that must be addressed; by definition, this requires that catastrophic effects must also be addressed. No changes are necessary as a result of this comment.

The FAA received comments questioning proposed AM1.2440 in lieu of requiring compliance with § 23.2440 for powerplant fire protection. AM1.2440 is more performance-based, allowing for all powerplant related fire protection concerns to be covered by a singular airworthiness criteria. No changes are necessary as a result of this comment. The FAA received comments recommending replacing the term “powerplant system” in AM1.2440 with “powerplant” or “powerplant installation.” The FAA does not concur as the proposed terminology is consistent with § 23.2410. No changes were made as a result of these comments.

Propulsion Safety and Integration

The FAA received comments from Airbus, ASD-Europe, EASA, GAMA, Leonardo, Lilium, Odys, Overair, TCCA, Rolls-Royce, and Volocopter requesting that the FAA revise, remove, or clarify the proposed airworthiness criteria related to propulsion safety and integration on the Model M001.

Proposed AM1.2405(d) specifies "extremely remote" as an acceptable probability of failure for power or thrust control systems, assuming manual backup capability. Several commenters stated that reliance on manual backup control of power or thrust on distributed propulsion powered-lift is unlikely to be acceptably achievable to ensure CSFL, and that failure of the propulsion control system is potentially catastrophic. Commenters also stated that specifying the power or thrust control system failure probability as extremely remote may be inconsistent with the extremely improbable requirement in AM1.2135.

The FAA agrees the airworthiness criteria should not specify an acceptable failure probability for power or thrust controls systems on a distributed propulsion powered-lift. Additionally, the FAA agrees that control of distributed propulsion powered-lift, using manual control of individual engines and propellers, should not be assumed. The FAA revised AM1.2405 by not adopting proposed paragraph (d). The appropriate hazard classification and failure probability for power or thrust control systems will be determined using the aircraft-level system safety process in § 23.2510, as well as AM1.2135, if controllability is affected.

The FAA received a comment that AM1.2405(b) and § 23.2410(a) contradict one another, with the suggestion to remove the phrase "if continued safe flight and landing cannot be ensured, the hazard has been minimized" from § 23.2410(a). The FAA disagrees. AM1.2405 establishes the safety objective for power or thrust control systems, whereas § 23.2410 is applicable to all powerplant systems and permits minimization of the hazard in limited cases. No changes were made as a result of this comment.

Multiple commenters recommended the FAA replace proposed AM1.2405 (power or thrust control systems) and AM1.2425 (powerplant operational characteristics) with a requirement to comply with §§ 23.2405 (automatic power or thrust control systems) and 23.2420 (reversing systems), or otherwise address those systems under the safety analysis requirements of § 23.2510. Commenters also recommended the airworthiness criteria be revised to allow the propulsion-control system to be evaluated along with the flight control system within the aircraft-level safety analyses required by § 23.2510. The FAA does not agree with these recommendations and notes that §§ 23.2405 and 23.2420 are not limited to functions defined in former §§ 23.904 and 23.933, as discussed in the preamble to part 23 amendment 23-64.[4] As noted previously, the FAA agrees that for the Model M001, the engines and propellers should be considered part of the flight control system, to include at a minimum all equipment and systems used for control of pitch, roll, yaw, and vertical motion. Furthermore, the subsystem analysis required by AM1.2405 for the engine power or thrust control system does not relieve the applicant from aircraft-level requirements such as AM1.2300, § 23.2500, or § 23.2510 when incorporated into a system such as the flight control system. Conversely, specific subsystem requirements, such as AM1.2405, are not imposed on other subsystems that make up a higher-level system simply because they become part of a higher-level system. The FAA did not change the proposed criteria as a result of these comments; however, as noted previously, references to the "reverser system" in proposed AM1.2405 have not been adopted because that system is not applicable to the Model M001.

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[4] 81 FR 96639 (Dec. 30, 2016).

Multiple commenters requested the FAA consider modifying AM1.2425(b), “Powerplant Operational Characteristics,” to include wording from SC-VTOL.2425(b) that would only require inflight engine shutdown and restart capability if the safety benefits outweigh the hazards. Another commenter requested clarity on AM1.2425, which requires a means for shutdown and restart of the powerplant within an established operational envelope. It does not prohibit procedures or control logic that would restrict engine restart under certain conditions. The FAA disagrees with modifying the criteria. The FAA will address the requirements of appropriate shutdown and restart procedures through the aircraft flight manual limitations and operating procedures. No changes were made as a result of these comments.

One commenter suggested the FAA change AM1.2430(a)(1) to include “control and management systems” along with energy storage and supply systems. The FAA agrees that battery control and management systems are covered by AM1.2430(a)(1) in addition to § 23.2525, but does not consider a change necessary as the FAA considers the term “energy storage and supply systems” to include battery control and management systems. The FAA received another comment requesting to remove § 23.2525(b) as it was duplicative to AM1.2340(a)(1). The FAA does not agree with this request and made no changes from the comment as § 23.2525 addresses required power for intended operations for all aircraft systems that use the electrical storage system, whereas AM1.2430(a)(1) contains propulsion criteria that ensures the independence between multiple electrical storage systems providing electrical power to the propulsion system.

Commenters requested the FAA clarify “where the exposure to lightning is likely” in AM1.2430(a)(2), which they believe could be interpreted in different ways. One interpretation suggested by commenters is to consider “likely” as it applies to areas of the aircraft where lightning may strike, while another interpretation is in reference to operating environments where lightning is likely. The FAA agrees with this concern and has revised the airworthiness criteria by removing the phrase "where the exposure to lightning is likely." The FAA notes that AM1.2430(a)(2) and § 35.38 assume the aircraft will be exposed to lightning regardless of any environmental operating limitations and require protection of the energy system from catastrophic events. The applicant will show compliance with AM1.2430(a)(2) for the Model M001 consistent with other type certificated products by identifying areas of the powered-lift where direct attachment of lightning is "likely," and evaluating the resulting effects.

The FAA received a comment asking the FAA to consider the failure due to overload of the landing system in AM1.2430(a)(6). The Model M001 is not required to address specific failures due to overload of the landing system since its landing system is not located near its energy storage systems. No changes were made as a result of the comment.

The FAA received a comment requesting that airworthiness criteria be added to protect occupants from possible hazards from the energy systems. The FAA notes that proposed AM1.2430(a)(6), as written, covers this and therefore did not make changes as a result of this comment.

The FAA also received a comment recommending that AM1.2430(a)(6) be expanded to include minimizing hazards to emergency service responders in addition to occupants. The FAA concurs with this suggestion and adds first responders to the airworthiness criteria.

Commenters requested the FAA explain the reservation of proposed AM1.2430(a)(7) and AM1.2430(c)(2). A commenter also recommended the FAA adopt EASA SC-VTOL.2430(a)(7) and add it as AM1.2430(a)(7) to ensure appropriate power quality within the energy system. The FAA did not incorporate the requirements from 23.2430(a)(7), which are similar to the requirements from EASA SC-VTOL.2430(a)(7), or (c)(2) into the Model M001 proposed criteria, and instead listed them as "Reserved," because they cover physical contamination of stored energy. Stored electrical energy is not susceptible to physical contamination in the way that convention fuel is. Damaged or failed electrical storage and distribution systems may prevent delivery of stored electrical energy to an intended load, which is a different condition than contaminated energy. The FAA notes these concerns are covered by uninterrupted energy supply and fluctuation requirements under AM1.2430(a)(4). To avoid confusion, the FAA did not adopt the proposal to “reserve” paragraphs AM1.2430(a)(7) and (c)(2) and renumbered (c)(3) accordingly.

The FAA received a comment that likely hazards for energy systems are not limited to temperature influences as mentioned in AM1.2430(b)(2). The FAA agrees and did not adopt the qualifier “due to unintended temperature influences” in these final airworthiness criteria.

Several commenters suggested clarification on the application of system safety requirements, propulsion requirements, and flight control system requirements due to the integration of these functions on the aircraft. The commenters questioned whether power or thrust control system requirements need to be applied to flight control systems or if flight control system requirements need to be applied to power or thrust control systems. The FAA concurs with the commenters’ request to consider the engines and propellers as part of the flight control system. The flight control system includes, at a minimum, all equipment and systems used for control of pitch, roll, yaw, and vertical motion. The FAA notes that the subsystem analysis required by AM1.2405 for the engine power or thrust control system does not relieve the applicant from higher-level requirements such as those in AM1.2300, § 23.2500, or § 23.2510, when engine or thrust control systems are incorporated into a higher-level system such as the flight control system. Conversely, specific subsystem requirements such as AM1.2405 would not be imposed on other subsystems that make up a higher-level system simply because they become part of that higher-level system. The safety requirements in § 23.2510 apply at the aircraft level to the integrated functions of all systems on the aircraft, in addition to specific system requirements such as AM1.2300 and AM1.2405.

Several commenters expressed concern regarding the appropriateness of the system-level safety objectives in proposed AM1.2405 and § 23.2425 for such highly integrated systems. The commenters suggested AM1.2405 and AM1.2425 are not necessary, since compliance with § 23.2510 can require the applicant to define both system and aircraft level safety objectives.

The FAA recognizes there may be inconsistencies between safety objectives required at the powerplant installation level and those at the aircraft level, but notes this is the case for type certificated airplanes and rotorcraft. Existing powerplant rules define a minimum level of safety that permits certification of a broad range of products for single and multi-engine aircraft. One common requirement for powerplant installations has been the “no single failure” concept, which is practically applied given the number of engines installed. This concept remains critical even for highly integrated and distributed powerplant systems. Aircraft level safety objectives may not drive the level of safety typically provided in a powerplant installation, such as isolation between all engines on a multi-engine aircraft with more than two engines, so the powerplant requirements establish a minimum safety objective that may not always align with those at the aircraft level. As powered-lift and distributed propulsion systems evolve, there may be less need to capture powerplant installation unique safety requirements. Until then, the FAA will use AM1.2405 to capture those requirements for the Model M001 and ensure the powerplant installation level of safety is appropriate regardless of the aircraft level safety objectives.

Multiple commenters requested clarification regarding the definition of “energy” and the instances in the criteria where liquid fuel is still relevant, despite the consideration of electric propulsion systems. The term “fuel” is used in part 23 and includes any form of energy used by an engine or powerplant installation such as provided by carbon-based fuels or electrical potential.[5] The FAA recognizes that using the term “fuel” instead of “energy” has implied the criteria are limited to non-fossil-fuel-based propulsion systems and is inconsistent with language used by other airworthiness authorities. As such, the FAA has replaced the term “fuel” with “energy” throughout these Model M001 airworthiness criteria. The FAA notes that “energy” includes any form of energy, including carbon-based fuels, electrical potential, and other means of energy storage or power generation for propulsion.

Several commenters requested that the FAA revise proposed AM1.2400(b) to clarify that the Model M001 engines and propellers will not be individually issued type certificates, but rather approved under the aircraft's type certificate, and as such, any requirements mentioning the “type certificate” should be excluded. The FAA agrees and has revised AM1.2400(b) to remove the requirement that each engine and propeller installed on the Model M001 have a type certificate.

The FAA received a comment to distinguish between airplane and engine hazards in AM1.2000(e). The requirement in AM1.2400(e) addresses powerplant components at the aircraft level. Engines are one of many powerplant components installed at the aircraft level, each of which must meet any limitations or installation instruction provided with that component or be shown to not to create a hazard. Engine specific hazards for the Model M001 are found in subpart H of the airworthiness criteria. The FAA disagrees that the distinction requested by the commenter is necessary, and no changes were made as a result of this comment.

The FAA received comments requesting the FAA either remove § 23.2525(c) and modify AM1.2430(a)(3) to explicitly include energy storage systems, or revise

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[5] 81 FR 96641 (Dec. 30, 2016).

§ 23.2525(c) to remove the primary source failure consideration. The FAA disagrees. Section 23.2525 addresses required power considering the failures and malfunctions of the primary source at the aircraft level, whereas the requirements in AM1.2430(a)(3) are specific to energy systems used for propulsion. No changes were made as a result of these comments.

System Safety

The FAA received and reviewed comments from ASD-Europe, Airbus, ALPA, EASA, Leonardo, Lilium, Odys, Vertical Aerospace, Rolls-Royce, TCCA, Volocopter, an individual commenter, and an anonymous commenter, requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to system safety and cybersecurity requirements for the Model M001.

Several commenters cited differences between EASA's SC-VTOL and the proposed FAA airworthiness criteria for the Model M001 with regard to EASA's creation of a "Category Enhanced" set of requirements. EASA included a structural requirement in SC-VTOL.2250, "Design and construction principles," that for Category Enhanced a single failure must not have a catastrophic effect upon the aircraft. The FAA acknowledges that the airworthiness criteria for the Model M001 as a special class aircraft differ from the requirements in EASA's SC-VTOL, which is a set of generalized requirements intended to cover a class of aircraft. The FAA's long-standing technical practice manages risk due to structural failures through the use of critical or life-limited parts, which mitigates any need to address potential catastrophic structural failure modes under the system safety requirements of § 23.2510. While this practice differs from that of EASA's approach, the FAA finds both approaches comparable and acceptable for risk mitigation. As discussed previously, the FAA revised proposed § 23.2250(c) (now AM1.2250(c)) to add a requirement that single failures must not result in a catastrophic effect upon the aircraft.

Several commenters identified that these criteria do not include specific failure condition probability targets or required development assurance level criteria and requested that they be included with appropriate rationale. The FAA does not agree, as existing aircraft airworthiness standards (parts 23, 25, 27, and 29) also do not prescribe specific failure condition probability targets or development assurance level criteria. This guidance may be found in advisory circulars or industry consensus standards, which provide one means, but not the only means, for showing compliance with the regulatory requirements. These means will likely need to be modified to consider powered-lift designs such as the Model M001.

One commenter recommended the FAA revise the proposed requirement to comply with § 23.2510 to include a clarification on the applicability of the standard, as it pertains to systems and equipment installed in the aircraft and how it relates to other requirements contained in other sections of the airworthiness standards. The FAA disagrees. The FAA proposed that the Model M001 comply with § 23.2510 without modification because the FAA intentionally developed that rule as a regulation of general requirements that do not supersede any requirements contained in other part 23 sections. The FAA intends the same application for the Model M001.

Several commenters expressed concern over the absence of a "no single failure" catastrophic failure condition criteria in these airworthiness criteria, citing its inclusion in EASA SC-VTOL.2510(a)(1). The FAA does not agree that a specific requirement prohibiting catastrophic single failures is necessary in the airworthiness criteria. Existing parts 23, 25, 27, and 29 airworthiness standards do not contain a "no single failure" requirement for catastrophic failure conditions, and the FAA considers these longstanding existing airworthiness standards acceptable. Although preventing "single failures" is addressed in FAA guidance material (e.g., Advisory Circulars 25.1309-1A and Advisory Circular 27-1B), it is one means, but not the only means, for showing compliance with the regulatory requirements. The FAA intends the same application for the Model M001.

Several commenters recommended the FAA clarify requirements for addressing cybersecurity. The FAA acknowledges that these aircraft involve many new technologies which are highly integrated, and any cybersecurity vulnerabilities must be appropriately assessed and addressed. The FAA is addressing cybersecurity through AM1.1529 and § 23.2500, § 23.2505, and § 23.2510. No changes were made as a result of these comments.

Lightning Protection

The FAA received and reviewed comments from EASA, GAMA, Lilium, Overair, and TCCA requesting the FAA revise, remove, or clarify proposed airworthiness criteria intended to address hazards that may result from a lightning attachment on the Model M001. These requirements include consideration for lightning common cause effects due to the potential for simultaneously affecting multiple systems. The proposed airworthiness criteria considered inadvertent exposure to lightning producing environments, including flight into clouds, as well as cold or icy weather conditions. The FAA determined that the highly integrated systems of the Model M001 aircraft require lightning protection.

One commenter requested the FAA clarify why the lightning indirect effects requirements are not applicable to systems with major failure conditions. The FAA notes that the lightning requirements are intended to be applicable to systems with major failure conditions for aircraft approved for IFR operations. For aircraft approved for IFR operations, proposed AM1.2515(b) is applicable to systems with hazardous or major failure conditions, similar to § 27.1316(b).

Multiple commenters recommended the FAA revert proposed AM1.2515 to § 23.2515 to limit the applicability of lightning requirements to aircraft approved for IFR operations that cannot show exposure to lightning is unlikely. The Model M001 incorporates systems that are critical in VFR and IFR operations that require protection against indirect effects of a lightning strike. A lightning attachment may occur during flight, when operating through or in the vicinity of lightning producing environments. Aircraft operating in instrument meteorological conditions (IMC) may encounter lightning, and aircraft operating in day or night visual meteorological conditions may inadvertently encounter lightning producing environments such as flight into clouds and freezing or icy weather conditions. Systems that perform functions essential to CSFL must demonstrate immunity to lightning for all operations to achieve the intended safety objectives for catastrophic failure conditions. The FAA finds the requirements in AM1.2515 to be appropriate for the systems on the Model M001 and made no changes as a result of these comments.

The FAA received a comment asking for clarification of AM1.2515(a)(2) stating that it could be incorrectly interpreted as the system could be allowed to fail when exposed to lightning without recovery after exposure. The FAA does not agree that AM1.2515(a)(2) may be misinterpreted. Demonstration of lightning immunity is required for systems with catastrophic failure conditions. The exception for recovery conflicts in AM1.2515(a)(2) is based on aircraft operational or functional requirements independent of lightning exposure. The expectation is that a system recovers normal operation of a function without impact to safety of flight by design. No changes were made as a result of this comment.

Multiple commenters recommended the FAA consider whether systems with hazardous and major failure conditions meet lightning requirements for aircraft not approved for IFR operations. The FAA notes that aircraft not approved for IFR operations are restricted from flight into IMC and must use outside visual references. An aircraft operating in IMC may encounter lightning producing environments, a hazard which requires more stringent requirements than aircraft certified exclusively for VFR operations. Limiting AM1.2515(b) to IFR operations therefore maintains the level of safety intended for protection against lightning threats. Section AM1.2515(b) is applicable to IFR operations and systems with hazardous (level B) or major (level C) failure conditions. Section AM1.2515(a) is applicable to all operations and systems with catastrophic failure conditions. This approach achieves the intended safety objectives.

Commenters recommended deleting the word “significantly” from the text of AM1.2515(b) so that the requirement is clearly identified as applicable to electrical and electronic systems with hazardous and major failure conditions. The FAA concurs since AM1.2515(b) is applicable to IFR operations and systems with hazardous or major failure conditions. The FAA did not adopt the term “significantly” from proposed AM1.2515(b) to ensure both major and hazardous failure conditions are appropriately assessed.

HIRF

The FAA received and reviewed comments from EASA, Overair, and TCCA requesting the FAA revise, remove, and clarify proposed airworthiness criteria related to HIRF exposure.

Commenters requested consideration for HIRF common cause effects due to the potential of affecting multiple systems simultaneously, since radio frequency transmitters are continuously evolving, and future spectrum expansions are anticipated. The FAA agrees that the HIRF environment and sources are unpredictable and that the aircraft and highly integrated systems require robust HIRF protection, but considers the proposed requirements adequate to address this concern.

One commenter requested the FAA clarify why operation under IFR is considered to relax the HIRF requirements, but not the lightning criteria. Another commenter requested the FAA clarify why the HIRF requirements are not applicable to systems with major failure conditions. Several commenters also requested the FAA remove the limitation that § 23.2520(b) be only applicable for aircraft approved for IFR operations, similar to SC-VTOL.2520(b).

The FAA notes that proposed AM1.2515 and AM1.2420 provide consistent requirements for the protection of electrical and electronic systems from the effects of lightning and HIRF, respectively. The FAA does not concur that the HIRF requirements are relaxed for IFR. The FAA changed the proposed requirement to comply with § 23.2520(a) and (b) to new AM1.2520, to remove the qualifier "significantly" from § 23.2520(b). AM1.2520(a) is applicable for all operations and systems with catastrophic failure conditions, aligned with AM1.2515(a). Limiting AM1.2520(b) to IFR operations maintains an acceptable level of safety, as AM1.2520(b) is intended to be applicable to systems with hazardous or major failure conditions. This also aligns with similar requirements in AM1.2515(b) for lightning. The FAA did not adopt the term "significantly" from proposed AM1.2420(b), similar to AM1.2515(b), to ensure that major and hazardous failure conditions are appropriately assessed for HIRF as well as for lightning. This approach achieves the intended safety objectives and aligns the airworthiness criteria with the appropriate level of safety intended by utilizing appropriate standards from both parts 23 and 27, revised to be appropriate for the Model M001.

Flightcrew Interface

The FAA received and reviewed comments from ALPA, ANAC, EASA, GAMA, Lilium, Odys, Overair, TCCA, and an anonymous commenter requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to flightcrew interface requirements on the Model M001.

The FAA received comments requesting that the FAA replace the language in AM1.2600(a) and (b) with the language in § 23.2600(a) and (b). The Model M001 is capable of using one or more sources of lift to perform a particular phase of flight. Therefore, using the unchanged wording from § 23.2600(a) is not sufficient and does not include hover. AM1.2000 incudes definitions for "sources of lift" and "phases of flight," and those defined terms were used in proposed AM1.2600(a). The FAA included "without excessive concentration, skill, alertness, or fatigue" in proposed AM1.2600(b) to address the human factors elements used to control the aircraft. The Model M001 includes increased levels of automation and technology that may impact pilot concentration, alertness, and fatigue, so the inclusion of "without excessive concentration, skill, alertness, or fatigue" language is necessary. No changes were made as a result of these comments.

The FAA also received a comment requesting clarification between human factor differences in AM1.2135(a) and AM1.2600(a). The same commenter suggested revising AM1.2160(a). AM1.2135(a) describes human factors requirements as they relate to controllability of the aircraft while AM1.2160(a) focuses on the human factors in the context of the flightcrew interface. No changes were made as a result of these comments.

The FAA received a comment to restructure the header paragraph of AM1.2620 such that the manufacturer must present pertinent information for the aircraft for all possible configurations of thrust or flight. The FAA disagrees as the requirement is applicable to the overall aircraft and must contain information concerning aircraft configurations as necessary for defining the required information in AM1.2620. No change is necessary as a result of this comment.

One commenter requested clarification on procedures for the flightcrew following an abnormal battery anomaly. The FAA notes that AM1.2620(a)(5) addresses this concern by requiring information necessary for safe operation because of design, operating, or handling characteristics to be specified in the Airplane Flight Manual, which provides procedural guidance for flightcrew. Procedures following an abnormal battery anomaly are necessary for safe operation. No changes were made as a result of this comment.

One commenter requested that the FAA include AM1.2620(a)(5) as information that must be approved by the FAA. The FAA disagrees, as this requirement is consistent with the existing airworthiness standards for normal category aircraft. No changes were made as a result of this comment.

One commenter requested clarification on whether the requirements in proposed AM1.1529 (ICA) and AM1.2615 (flight, navigation, and powerplant instruments) would also address EASA SC-VTOL.2445, Lift/thrust system installation information. Although the Model M001 airworthiness criteria do not contain a requirement that directly aligns with EASA's SC-VTOL.2445, the commenter is correct that AM1.1529 and AM1.2615 address the lift/thrust installation requirements in EASA SC VTOL.2445. In addition, the lift/thrust installation requirements in EASA SC-VTOL.2445 would be addressed for the Model M001 by the requirements in §§ 23.2605 and 23.2610. The FAA received multiple comments to modify § 23.2605 to add a requirement that information related to safety equipment must be easily identifiable and its method of operation must be clearly marked, as specified in SC-VTOL.2605(d). The language requested by the commenters is already required by § 23.2535 and therefore no changes are necessary as a result of these comments.

One commenter requested the FAA revise proposed AM1.2615(b)(2) to delete criteria for single failure and probability. The FAA does not agree and notes that this requirement is essential for CSFL after probable failures, both singular and in combination.

Electric Engines

The FAA received and reviewed comments from Airbus, ANAC, EASA, GAMA, JCAB, Lilium, Odys, Overair, Rolls-Royce, TCCA, Vertical Aerospace, and Volocopter requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to electric engines for the Model M001.

One commenter recommended replacing the phrase “intended aircraft application” throughout subpart H with language specific to the Model M001 design. Another commenter recommended replacing “declared environmental limits” with “aircraft environmental and operating limitations” throughout subpart H. The FAA does not agree that more specific language is necessary, as “intended aircraft application” and “declared environmental limits” are sufficient to meet the electric engine certification requirements. No changes were made as a result of these comments.

The FAA received comments recommending the removal of § 33.5 (a), (b), and (c) and § 33.29 from the engine requirements in Subpart H. One commenter stated these requirements should not be imposed for an engine that is not being type certificated as an independent product, as is the case for the Model M001. This commenter also stated the engines for the Model M001 are being certified under the umbrella of the aircraft type certificate; as a result, the installation and operating instructions will already be part of the type design data package at the aircraft level. Other commenters stated that no additional burden from individual “engine-only” requirements for data sheet content is necessary, from § 33.5(a), (b), and (c), AM1.2702, AM1.2706, AM1.2710(j)(2), AM1.2718(c) and (d), AM1.2719(b) and (e), and AM1.2733(d)(2). The FAA recognizes the engines will be approved with the Model M001 aircraft, but instructions for installing and operating the engines are required, as well as other engine airframe interfaces such as instruments, connections, sensors, etc., whether the engines are approved with the aircraft or certificated under their own type certificate. The FAA made no changes in response to these recommendations.

The FAA received comments on the applicability of subsystems equipment installed in an electric hybrid propulsion system (EHPS), as referenced in EASA Special

Condition E-19 EHPS.330. The FAA acknowledges these comments but notes that they are not applicable to the Model M001, since the Archer engine architecture does not include the electric hybrid propulsions systems associated with E-19 EHPS.330.

One commenter questioned whether the requirements of EASA Special Condition E-19 EHPS.80, which accounts for the complete inability to isolate components that could cause a hazard to aircraft, should be added to the airworthiness criteria for the Model M001. The FAA does not agree, as the requirement to isolate components that could cause a hazard to the aircraft is in EHPS.350(d), EHPS Control System, not in EHPS.80. The requirement in EHPS.350 raised by the commenter is addressed by AM1.2710 Engine Control Systems, AM1.2717 Safety Analysis, and AM1.2733 Engine Electrical Systems. Since the Archer M001 is a special class aircraft and the engines will be approved with the aircraft, the means by which components prevent a hazard from developing may be implemented either at the engine-level or at the aircraft-level. No changes were made as a result of these comments.

Another commenter noted the proposed requirement to comply with § 33.75(e)(1) includes a reference to § 33.4 (ICA), although the proposed airworthiness criteria do not include a requirement to comply with § 33.4. The commenter recommended either removing the reference to § 33.4 or adding a reference to Appendix 1, AAM1.2701, A33.2, A33.3, and A33.4. The FAA agrees with the comment. The FAA proposed AM1.2717 to include those safety analysis standards from § 33.75 that could not be required directly for the Model M001 without modification. Proposed AM1.2717(c) contained requirements for how the applicant must comply with § 33.75(e). The FAA has modified proposed AM1.2717(c) to reference the ICA in AM1.1529 for compliance with § 33.75(e)(1). During the review of this comment, it was determined that §33.75(a)(1) should be included in AM1.2717(a) and the applicability of AM1.2717(b) should be clarified using information from the existing standard § 33.75(c). The FAA has revised AM1.2717 accordingly.

The FAA received a comment asking for clarification of the term “duty cycle” in proposed AM1.2702(b). The FAA also received a comment to remove the requirement in proposed AM1.2702(b) to list the duty cycle on the type certificate data sheet. The FAA disagrees. A duty cycle is intrinsic with engine ratings. Engine ratings are declared to support aircraft performance objectives, whereas duty cycles are an electric engine property that limits the usage of the ratings. The duty cycle, combined with the rating at that duty cycle, establishes the capability and the limits for engine usage. A commenter also noted that the takeoff power time limitation is not defined. While traditional combustion engines adhere to “takeoff power time limitations,” the operational considerations for electric aircraft engines, such as duty cycle and rating, are more pertinent due to their distinct propulsion system characteristics. A duty cycle and rating at each duty cycle must be declared, which covers this concern. No changes were made as a result of these comments.

The FAA received a comment to add specific operating limits to proposed AM1.2702. The FAA also received a comment to add § 33.7(d) to the airworthiness criteria to address the accuracy of the engine control system and necessary instrumentation. Section 33.7(d) applies to engine performance and operating limitations. The FAA did not propose to require that the Model M001 comply with § 33.7(d), because § 33.7(d) focuses on engine control system components (e.g., speed sensors, actuators, feedback mechanisms) that typically operate using low voltage power and hydraulic systems. Electric engines, such as those that are part of the Model M001 design, are controlled differently. In addition, the Model M001 engine electrical systems are integrated with aircraft systems instruments that are necessary for control of the engine, which would not be addressed by § 33.7(d). Instead, for the Model M001, the engine performance and operating limitations referenced by § 33.7(d) are addressed by the airworthiness criteria for the engine control system in AM1.2710 and the engine electrical system in AM1.2733. No changes were made as a result of these comments.

The FAA also received a comment that proposed AM1.2702 provided a redundant definition of the engine ratings with that in § 33.8. The FAA disagrees. These two engine requirements accomplish different objectives. AM1.2702 establishes the engine's ratings and limits, while § 33.8 ensures each rating applies to the lowest power that all engines of the same type may be expected to produce under the conditions used to determine that rating. No changes were made as a result of this comment.

A commenter suggested the FAA remove the word "turbine" from § 33.17(a), as it is not applicable to the Archer Model M001. The FAA notes that proposed AM1.2704, "Fire Protection," was initially drafted to consider potential arc-fault-initiated fires occurring anywhere inside or outside the electric engine. However, the commenter highlighted that the second statement in § 33.17(a) specifically applies to internal fires in turbine engines and is not relevant to Archer engines. Consequently, the FAA has modified the airworthiness criteria to remove the applicability of § 33.17(a) to the Model M001 and add a new statement to AM1.2704 emphasizing the design and construction requirements to minimize the occurrence and spread of fire during normal operation and failure conditions. This modification results in AM1.2704 having two paragraphs, (a) and (b). This modification makes a suggestion by another commenter to change the title of the airworthiness criteria to "High Voltage Arc Faults and Fire Protection" inapplicable.

The FAA received a comment questioning the applicability of § 33.17(b) through (g), which address flammable fluids. The FAA notes that flammable fluids and flammable fluid storage components could be used in the Model M001 design. As such, the FAA finds these criteria applicable and no changes were made. Another commenter suggested that the requirements of § 33.17 be made more prescriptive, specifically to require fireproof materials. The FAA notes that this concern is addressed overall in the Archer design through requirements specified in AM1.2704, § 33.75(g)(2)(iv), and AM1.2733. Additionally, § 33.17 applies to engine fires resulting from ignition of flammable fluids. No changes were necessary as a result of this comment.

The FAA received a comment that pass and fail criteria should be defined for the requirement in proposed AM1.2705 to minimize the development of an unsafe condition in the engine and recommended using the criteria in AM1.2717(d)(2). The FAA does not concur. An unsafe condition is determined by a risk assessment and not solely by the hazards identified by the hazardous effects in AM1.2717(d)(2). No changes were made as a result of this comment.

The FAA also received a comment to add “removal from service” to the maintenance actions in proposed AM1.2705. The FAA disagrees. The statement “removal from service” is appropriate to address simple engine designs that are life limited. However, this statement is not needed in the Model M001 airworthiness criteria because any maintenance involving a life limited engine is addressed by AM1.2729(b) and AM1.2713. No changes were made as a result of this comment.

The FAA received a comment asking why proposed AM1.2720 did not include “engine fault conditions.” The FAA determined it was necessary to revise AM1.2720(b) to clarify the vibration sources applicable to this requirement.

The FAA received two comments requesting clarification regarding whether proposed AM1.2729 (b) allows the applicant the option of not performing the teardown inspection. The FAA clarifies that the agency intends AM1.2729(b) to require a teardown inspection except for any engine parts or components that cannot be torn down. The FAA has changed proposed AM1.2729(b) to clarify that it only applies to engine components where a teardown cannot be performed in a non-destructive manner.

A commenter requested clarification on the difference between the durability requirements of proposed AM1.2705 and AM1.2726. AM1.2705 is criteria for durability requirements for design and construction of the engine, whereas AM1.2726 provides requirements for a durability demonstration. The FAA modified AM1.2726 to distinguish it from AM1.2705 by explaining its purpose, which is to establish when the initial maintenance is required.

A commenter questioned where the requirements in EASA's E-19 EHPS.200 are captured. The FAA notes that § 33.23 establishes the loads associated with the engine mounting attachments and structure similar to what would be expected under EHPS.200 for an electric engine such as in the Model M001. No changes were made as a result of this comment.

Multiple commenters requested clarification on proposed AM1.2709 concerning failure conditions leading to rotor overspeed. Proposed AM1.2709 was based on § 33.27 "Turbine, Compressor, Fan, and Turbosupercharger Rotor Overspeed." The FAA intended the approach used for establishing the highest possible rotor overspeed in proposed AM1.2709 to be consistent with the approach in § 33.27(b), except for the prescriptive overspeed margins. The margins in § 33.27(b) are based on the physics of what drives the rotors in turbine engines and turbosupercharger rotors. The mechanisms that can drive electric engines to an overspeed condition are different from those that govern combustion engines. No changes were made as a result of these comments.

One commenter recommended that the pertinent characteristics and capabilities of the Model M001 the applicant must analyze should be prescriptively included in proposed AM1.2710(g) and AM1.2717(e). The FAA does not agree that all the pertinent aircraft details that must be analyzed under AM1.2710(g) and AM1.2717(e) should be prescribed within the airworthiness criteria as existing aircraft airworthiness standards also do not prescribe these pertinent aircraft details. This guidance may be found in advisory circulars or industry consensus standards, which provide one means, but not the only means, for showing compliance with the existing regulatory requirements. These means will likely need to be modified to consider powered-lift designs such as the Model M001.

During review of the requirements of AM1.2710(j), the FAA also identified an error in AM1.2710(j)(2), which was originally intended to cover all engine electrical systems, leading to confusion regarding the applicability in paragraph (a). The FAA clarifies that the engine control requirements in AM1.2710 apply to any aspects of the engine control that interface with aircraft control systems that are necessary for safe flight and landing. The FAA has corrected this error in the final criteria by removing the reference to electrical power supplied to the aircraft by energy regeneration from paragraph (j)(2).

The FAA received a comment to update proposed AM1.2710(e) to declare the engine control system and the engine electrical environmental limits, similar to proposed AM1.2823(a)(2). This concern is already addressed by the airworthiness criteria. Since the engines are approved with the aircraft, environmental conditions and limits that were used to substantiate the Model M001 aircraft and its engines will be used to develop compliance with AM1.2620, "Aircraft Flight Manual." No changes were made to AM1.2710(e) as a result of this comment. However, this comment revealed a need to clarify the requirement in proposed AM1.2727. The purpose of AM1.2727 is to supplement engine testing with additional component-level and systems-level tests that expose engine components and systems to operational conditions that cannot not be achieved in the engine test environment or with the specified test duration. Also, demonstration shortfalls for certain electrical properties might occur with other engine tests, such as the durability demonstration, because the test duration required to show deterioration in electrical hardware may be impracticable.

One commenter requested the FAA remove proposed AM1.2711(b)(2), which specifies that the aircraft design is not required to enable the flight crew to monitor the engine cooling system for a cooling system failure that would not result in a hazardous engine effect. The FAA disagrees. Not adopting proposed AM1.2711(b)(2) would result in a requirement for instrumentation enabling the flightcrew to monitor the engine cooling system regardless of the hazard level resulting from a cooling system failure. Although monitoring the engine cooling system would enable the crew to respond to leading indicators of an overheated engine and prevent the aircraft from the subsequent effects, the severity of the effects from an overheated engine, and the appropriate engine-level protection and mitigation standards, are addressed by the engine safety analysis. No changes were made as a result of the comment.

One commenter suggested changing the word “electromagnetic” to “electrical” in proposed AM1.2712(a). The FAA does not concur with this change, as electrical system hazards are covered in AM1.2733. However, the FAA acknowledges that the requirement in proposed AM1.2712(a) could be clarified and made changes to that effect.

Multiple commenters recommended adding the demonstration to operate above temperature limits on turbine engines for short-duration ratings in proposed AM1.2724, and to consider updating proposed AM1.2709 and AM1.2730 to add the requirements in E-19 EHPS.250(a), “the failure of any rotating component or part of an equipment, electric engine or generator must not lead to the release of high energy debris.” The FAA has revised AM1.2724 to remove its applicability to all engine ratings and also revised the introductory text of AM1.2730 to be more aligned with part 33 subpart B. The FAA did not find the recommended language appropriate for AM1.2709 and did not make any changes to AM1.2709.

The FAA received a comment asking for clarification on whether proposed AM1.2715(c) only applies to engines having torque operating limitations. AM1.2715(c) applies to an electric engine regardless of whether the engine is torque limited. Archer can propose ratings and limits in accordance with AM1.2702 using relevant engine parameters such as horsepower, torque, rotational speed, and temperature. AM1.2715 and AM1.2725 require tests that range from ground idle and flight idle, to the rated power or thrust prescribed by these rules. Electric engines can create torque much faster than combustion engines, and sudden changes in torque could present a hazard to the aircraft installation. Therefore, the power response characteristics must account for the intended aircraft application to ensure the torque characteristics of the engine and intended aircraft are compatible. These requirements correspond to §§ 33.73 and 33.89 respectively, so the minimum torque or power settings are established in the procedures that assess the operational capabilities of the electric engines. The FAA modified proposed AM1.2715(c) to clarify that this is an engine-level requirement.

One commenter requested the FAA consider EASA's Special Condition E-19 EHPS.260. The commenter states that proposed AM1.2716 only addresses hazardous engine effects and applicants should evaluate, as required by EHPS.260, the effects of any continued rotation on the system, such as windmilling propellers. The concerns raised by the commenter are addressed by AM1.2733, "Engine Electrical Systems." AM1.2733(b) (both proposed and final) ensures that the generation and transmission of electrical power, and electrical load shedding, do not result in any unacceptable engine operating characteristics or cause the engine to exceed its operating limits. New AM1.2733 (e)(2) requires the characteristics of any electrical power supplied from the engine to the aircraft via energy regeneration to be identified and declared in the engine installation manual.

The FAA received multiple comments to change the proposed definition of a minor engine effect in proposed AM1.2717(d)(1). The commenters recommended using the criteria in § 33.75(g)(1) to classify the effects of a partial or total loss of engine power in the Model M001. The Model M001 engine airworthiness criteria do not classify the engine effect from a complete loss of engine power because the aircraft level assumptions are different than those used in § 33.75(g)(1). The Model M001 engine airworthiness criteria allow a complete loss of power in one engine to be classified based on the effects on the aircraft. No changes were made as a result of these comments.

Multiple commenters stated that due to the integrated nature of the Model M001, the system safety analyses required in support of § 23.2510 are adequate and sufficient, and that § 33.75, AM1.2717, and AM1.2733(f) and (g) should be removed from these airworthiness criteria. The FAA does not agree with this recommendation, and notes that § 23.2510 establishes the safety objective for aircraft systems and equipment "whose failure or abnormal operation has not been specifically addressed by another requirement." The proposed subpart H and I requirements include specific engine and propeller design and testing requirements not covered under aircraft-level airworthiness criteria and establish a minimum level of safety equivalent to the existing part 33 and part 35 airworthiness standards as required under § 21.17(b). Additionally, these airworthiness criteria prescribe the same requirements for installed engines and propellers on the Model M001 that would apply to these engines and propellers if they received separate type certificates under parts 33 and 35, respectively. The aircraft-level requirements of § 23.2510 are not sufficient on their own to ensure engines and propellers will meet the intended level of safety required by § 21.17(b) for parts 33 and 35. Since the engines will be approved with the Archer aircraft, these compliance details may be documented in the appropriate aircraft-level documents with references to the engine-level requirements in Subpart H.

One commenter recommended removing the prescriptive airworthiness criteria of subparts H and I and to defer their development to the means of compliance. Another commenter proposed to use performance-based aircraft requirements that consign the engines and propellers to aircraft equipment or systems and relegate engine and propeller certification requirements to a means of compliance to an aircraft requirement. The FAA does not agree with these comments and considers the requirements in subparts H and I to provide an equivalent level of safety for the Model M001. No changes were made as a result of these comments.

A commenter requested the FAA reword proposed AM1.2717(d)(1) to remove an extraneous phrase “does not prohibit the engine from meeting its type-design requirements.” The FAA concurs that the phrase was unclear and updated AM1.2717(d)(1) for clarity.

A commenter requested clarification regarding why blockage of a cooling system as described in proposed AM1.2717(d)(2)(ii) is considered a hazardous engine effect. The FAA notes that the blockage of a cooling system is not by itself a hazardous engine condition, but it could contribute to the development of one. Accordingly, the FAA modified AM1.2717(d)(2)(ii).

A commenter requested the FAA align proposed AM1.2713 with the safety expectations in EASA’s SC-VTOL. The commenter recommended changing proposed AM1.2713 to specify that no single failure may lead to a catastrophic event and to exclude the criteria for critical parts. The FAA does not find the level of safety outlined in SC-VTOL for “Category Enhanced” to be applicable to the Model M001 engine failure classifications, which could be minor, major, or hazardous, but not catastrophic. The FAA will apply failure classifications that are consistent with those established in part 33 to provide the equivalent level of safety required by § 21.17(b). No changes were made as a result of this comment.

A commenter requested clarification as to whether proposed AM1.2713 would require the same activity for both critical parts and life-limited parts. An engineering plan, manufacturing plan, and service management plan will be needed for critical parts and for life-limited parts as stated in AM1.2713(b).

Commenters requested the FAA clarify what is meant by the definition of a "life limited part" in proposed AM1.2713(a)(2), as it includes phrases that make it open-ended and indistinguishable from the definition of a critical part in proposed AM1.2713(a)(1). The FAA agrees regarding the need for clarification in the definition of life-limited parts. While retaining the examples in the definition, the FAA has revised the definition of life-limited part in AM1.2713(a)(2) to be distinguished by the failure mode related to low-cycle fatigue (LCF) mechanisms. The revised definition specifies that life-limited parts may involve rotors or major structural static parts, among other parts with failure potentially leading to hazardous engine effects due to LCF mechanisms.

A commenter noted that the FAA made a reference to § 33.70 in proposed AM1.2713(b) when § 33.70 was not included as a part of the Model M001 airworthiness criteria and recommended adding § 33.70. The FAA agrees and § 33.70(a), (b), and (c) have been added to the airworthiness criteria. The introductory paragraph of § 33.70, however, is not part of the airworthiness criteria.

A commenter also requested that the FAA specifically address high-cycle fatigue (HCF) effects in proposed AM1.2713. The FAA notes that HCF effects are included in the life limit calculation under § 33.70. The influence of HCF on life limits is addressed as part of the vibration requirement in AM1.2720, which characterizes and quantifies all vibration stresses in a part. It also requires the vibration stresses to be less than the material endurance limits, when combined with steady stresses. No changes were made as a result of this comment.

A commenter noted that the FAA has historically not applied the classification of "critical part" in FAA airworthiness standards and asked for clarification. The use of critical parts is consistent with the FAA's certification approach for electric engines and is necessary for an acceptable level of safety. No changes were made as a result of this comment.

One commenter questioned why the FAA included transient maximum overtemperature and transient maximum overspeed as part of the endurance demonstration in proposed AM1.2721. The FAA notes that electric engines typically establish power or thrust ratings using shaft torque. Therefore, torque is managed directly, or by another governing parameter, such as electrical current. The airworthiness criteria in AM1.2721 are performance-based, but the applicant may use the procedures in § 33.84(a) as a means of compliance with the overtorque requirement. Transient rotor speed in electric and combustion engines is controlled by different technologies. Transient overspeed in a combustion engine is typically a design feature that allows an engine to exceed a maximum steady state rotor speed temporarily in order to meet certain performance requirements. Electric engines use electrical current and have fast response times, so transient rotor overspeed is not typically needed to meet performance requirements and would most likely occur from a failure or design flaw, which are occurrences within the scope of AM1.2721. No changes were made as a result of this comment.

The FAA received a comment requesting clarity on the endurance demonstration requirement in proposed AM1.2723(b). The FAA notes that the endurance demonstration is an accelerated severity test intended to demonstrate the engine has acceptable performance characteristics throughout the operating range, up to and including engine ratings and operating limits without the need for maintenance after being exposed to these extreme conditions. Therefore, the engine cycles that are used for the endurance demonstration do not correlate well with the engine cycles that are used during in-service operation. The FAA concurs with the commenter that additional clarification is needed and modified AM1.2723(b) to require that the endurance demonstration must be for a duration sufficient to verify the limit capabilities of the engine.

One commenter identified a need for clarification regarding electromagnetic stresses in proposed AM1.2712, "Stress Analysis," which also corresponds to § 33.62. The FAA has updated AM1.2712(a) to address the interaction between electrical systems and magnetic components, specifically considering electromagnetic forces, which are not covered in existing airworthiness standards for aircraft engines. The revised paragraph (a) requires a comprehensive stress analysis, including mechanical, thermal, and electromagnetic forces, to ensure an adequate design margin that prevents hazardous engine effects and unacceptable operating characteristics.

Another commenter requested that the FAA add "at the declared operating limits" to proposed AM1.2712(a). The FAA does not concur. AM1.2712 includes mechanical, thermal, and electromagnetic stress. These criteria were created to account for design limits specific to electric engines that, if exceeded, could develop into hazardous engine conditions. The airworthiness criteria ensure design margins account for any relevant declared operating limits. No changes were made as a result of this comment.

A commenter asked for clarification of the term "minimum material properties" in proposed AM1.2712(b). AM1.2712(b) requires determining maximum stresses in the engine without exceeding minimum material properties. The Model M001 must comply with § 33.15, which establishes the requirements for engine materials. Compliance with § 33.15 will determine "minimum material properties." No changes were made as a result of this comment.

One commenter proposed that the FAA consider that the single fault tolerance criteria in proposed AM1.2710(f)(2) be understood at the aircraft "propulsion system level" rather than at the engine level when addressing Loss of Power Control (LOPC). Commenters requested similar clarification regarding the single fault criteria in proposed

AM1.2733(f)(2). The FAA disagrees that the requested change would be appropriate. The airworthiness criteria in Subpart H apply to a single engine, not to the entire distributed propulsion system. No changes were made to the airworthiness criteria in response to these comments.

Multiple commenters requested that the FAA qualitatively and quantitively define LOPC in the airworthiness criteria. The FAA does not agree. The LOPC airworthiness criteria for the Model M001 are contained in portions of § 33.28 and AM1.2710. Existing engine airworthiness standards in part 33 do not prescribe the level of detail requested by the commenters. LOPC will depend on the performance data and system analysis for the Model M001 and its intended aircraft application. No changes were made as a result of these comments.

One commenter noted that § 33.28(d)(4) effectively requires that the engine control system be resilient to local events, while the proposed airworthiness criteria in AM1.2710(f)(4) does not allow local events to occur. The commenter requested the FAA revise AM1.2710(f)(4) to maintain the safety intent of § 33.28(d)(4). The FAA agrees with the suggested change. AM1.2710(f)(4) has been changed to require the engine control system to "ensure failures or malfunctions that lead to local events in the aircraft do not result in hazardous engine effects as defined in AM1.2717(d)(2) due to engine control system failures or malfunctions."

One commenter proposed that the FAA differentiate between the ingestions that must not lead to a hazardous event (such as a large bird impact) and the ones that cannot lead to a loss of power that would become incompatible with the aircraft performances and CSFL capabilities. Another commenter questioned the use of the broad term "foreign objects" in proposed AM1.2718. The FAA modified AM1.2718 to incorporate ingestion sources identified in §§ 33.68, 33.76, 33.77, and 33.78. Revised AM1.2718 uses general terminology when distinguishing abnormal operation, hazardous engine effects, and unacceptable power loss which accounts for aircraft level effects and clarifies the term "foreign objects" by specifying the ingestion source.

Multiple commenters requested clarification regarding applicability differences between § 33.28 and proposed AM1.2710. The FAA notes that the applicability of both requirements is covered by AM1.2710(a). The FAA intends the applicant to employ the elements of § 33.28 specified as applicable to the Model M001 in combination with the additional requirements of AM1.2710.

Another commenter requested the FAA clarify whether § 33.29(f) applies to the Model M001. Section 33.29(f) requires a safety assessment of incorrect fit of instruments, sensors, or connectors, and references a § 33.75 turbine engine safety analysis that is not applicable to the Archer M001 electric engines. The airworthiness criteria have been revised to exclude paragraph (f) from the requirement to comply with certain paragraphs of § 33.29.

One commenter asked if compliance with § 33.64 is necessary to satisfy the proposed pressurized cooling requirements in § 33.21 and AM1.2706, as stated in ASTM Standard F3338-21 section 5.7.4. The ASTM Standard applies to liquid engine cooling systems, but the requirements in § 33.21 and AM1.2706 apply to air and liquid engine cooling systems. The FAA notes that although § 33.64, which contains requirements for pressurized engine static parts, is not part of the Archer airworthiness criteria, pressurized engine static parts are addressed by AM1.2719. Paragraph (a) specifies requirements for systems used for lubrication or cooling engine components. Paragraph (c) includes airworthiness criteria for static parts subjected to pressurized systems. The FAA also revised the heading of AM1.2719 from "Liquid Systems" to "Liquid and Gas Systems" to clarify the applicability of the requirement and to differentiate it from ASTM Standard F3338-21.

Another commenter requested the FAA generalize the terminology in proposed AM1.2728 to recognize electro-mechanical implementations in addition to traditional mechanisms and functions. The commenter proposed replacing “locking” with “holding” and “unlocking” with “release.” AM1.2728 does not prescribe specific implementation of the rotor lock, other than the prevention of the rotor from turning. A rotor locking (or holding) function in an electric engine could have both mechanical and electro-mechanical purposes. The FAA determined the criteria in AM1.2728 will achieve the intended objectives for the Model M001. No changes are necessary as a result of the comment.

A commenter questioned the use of service limits in determining acceptability during the teardown evaluation in proposed AM1.2729(a)(1), as the service limits can be lower than those demonstrated as a part of the certification process. The FAA agrees that the intent is that each engine part must conform to the type design and be eligible for incorporation into an engine for continued operation and updated AM1.2729(a)(1) to remove the reference to service limits.

The FAA received multiple comments asking to define or qualify what would be an acceptable margin for purposes of proposed AM1.2730(a) and whether a rotor burst analysis is required at the aircraft level. The FAA disagrees. The FAA will determine an acceptable margin similar to the way the agency determines acceptable margins for engines under part 33. No changes were made as a result of these comments.

In regard to compliance with the functional demonstrations required by proposed AM1.2731, a commenter asked whether there will be a basic standard test-run program, or whether the demonstration will depend on the individual case. The FAA notes that AM1.2731 uses performance-based language to describe the functional demonstrations if they are not accomplished concurrent with other required engine tests. Currently, there are no industry-wide accepted standards for conducting electric engine tests with variable pitch propellers, so the demonstration will depend on the individual case.

A commenter requested the FAA merge proposed AM1.2733(c)(1), which addresses the electrical-power distribution system, and proposed AM1.2733(d)(1), which addresses protection systems. Paragraph (c) addresses the safe transfer of power throughout the power plant whereas paragraph (d) addresses a protection system's response to power conditions that exceed design limits. These systems perform different functions, and therefore they are treated by separate airworthiness criteria. No changes were made as a result of the comment.

The same commenter noted that the type of electrical fault isolation required in proposed AM1.2733(c)(3) should be linked to the possible effects of the fault on the safety of flight and the aircraft. AM1.2733(c) protects engine electrical systems from faulted electrical energy generation or storage devices. The means of compliance should be tied to the safety assessment, which includes aircraft-level effects from faulted electrical-energy generation or storage device. The FAA updated AM1.2733(c)(3) to recognize this link.

A commenter questioned the numbering scheme of the airworthiness criteria in proposed AM1.2733(d). The FAA agrees that the numbering scheme needed better clarity. AM1.2733(d)(1) was merged with the introductory text of AM1.2733(d). Proposed AM1.2733(d)(2) does not fit under Protection Systems and was moved to AM1.2733(e). Proposed AM1.2733(e) through (g) have been renumbered as AM1.2733(f) through (h).

The same commenter noted that proposed AM1.2733(d) was too prescriptive in specifically requiring transmission interruption. The FAA agrees and changed the language to reflect that the Model M001 must be designed such that certain conditions would not result in a hazardous engine effect.

Lastly, the commenter requested that the FAA revise proposed AM1.2733(e), which addresses environmental limits, to make it less prescriptive. The commenter suggested that proposed AM1.2733(e) contain similar language as that in the equivalent requirement for the propeller control system in AM1.2823(a)(2). The FAA disagrees. AM1.2733(e) and AM1.2823(a)(2) are not equivalent requirements as stated by the commenter. Proposed AM1.2733(e) (AM1.2733(f) in these final criteria) requires demonstrating environmental limits through system and component tests when substantiation methods are insufficient, while AM1.2823(a)(2) requires ensuring propeller control system functionality remains unaffected by declared environmental conditions and documenting validated environmental limits in propeller manuals. No changes were made as a result of this comment.

Propellers

The FAA received and reviewed comments from ALPA, Airbus, ASD-Europe, EASA, GAMA, Leonardo, Overair, TCCA, and Volocopter requesting the FAA revise, remove, or clarify proposed airworthiness criteria related to propellers for the Model M001.

Multiple commenters requested changes to proposed AM1.2823 regarding the causal direction of hazardous propeller effects and local events. The FAA concurs and has revised AM1.2823(b)(2) to require that local events not cause hazardous propeller effects. One commenter suggested that "local event" needs to be defined. Due to the comments received on "local events," the FAA concurs that the definition of "local events," in the context of AM1.2823, should be as defined as it is in AC 33.28-3, "Guidance Material for 14 CFR § 33.28, Engine Control Systems," with minor wording changes that are appropriate for the Model M001. The FAA has added this definition to AM1.2000(b)(6). The FAA noted during review of AM1.2823 that two requirements from § 35.23 were missing in the proposed airworthiness criteria and should be added.

The FAA added §§ 35.23(b)(3) and 35.23(b)(4) to the airworthiness criteria as paragraphs AM1.2823(b)(3) and AM1.2823(b)(4).

One commenter asked why the functional test in proposed AM1.2840 is limited to forward pitch and not to the entire pitch range. The FAA notes that the test is limited because the Model M001 does not have reversible pitch capability. Additionally, commenters suggested that the number of propeller pitch cycles should be increased from thirteen hundred to fifteen hundred in proposed AM1.2840(a) to align it with § 35.40(b). The FAA agrees and has revised AM1.2840(a) accordingly.

Several commenters requested the FAA elaborate on how the FAA differentiated between requirements for lift generating rotors compared to propellers, and whether icing ingestion requirements are needed for propellers. The FAA does not concur with suggestions to add additional requirements for lift generating rotors or ice ingestion requirements for the AM1.2800 series criteria. The design and the expected failure modes of Archer's propellers are expected to be similar to conventional propellers type certificated under part 35 despite being used in the vertical thrust mode. Ice ingestion requirements for the engines already exist in other parts of the Model M001 airworthiness criteria.

Commenters suggested that proposed AM1.2815, which requires a safety analysis of the propeller system, is inadequate because the rate of hazardous propeller effects was not conservative enough and propeller release and unbalance should be treated as catastrophic events and not as hazardous propeller effects. Further, commenters suggested that determining the rate of hazardous propeller effects should be less ambiguous. The FAA does not concur with the suggestion that the acceptable hazardous propeller failure rate is too high. The criteria are derived from part 35 requirements, which provide an acceptable level of safety for both part 23 and 25 airplanes. The FAA does not concur with the suggestion that propeller release and unbalance should be treated as catastrophic and not hazardous effects. Catastrophic effects are treated at the aircraft level and the criteria for single propellers provide an acceptable level of safety. The FAA does not concur with the request to make the quantitative prediction of a hazardous propeller effect less ambiguous due to inherent limitations on the availability of reliable data.

One commenter questioned the need for a propeller critical part designation. The FAA does not concur with the suggestion to not make the propellers critical parts. The critical part requirements are integral for creating a propeller with an equivalent level of safety and are retained for the Model M001.

Commenters suggested that the current § 35.35 centrifugal load requirements are inappropriately prescriptive and that overspeed requirements derived from parts 27 or 29 rotorcraft rules are more appropriate. The FAA does not concur with the suggestion to substitute rotorcraft overspeed requirements for the propeller centrifugal load tests in § 35.35(a) and (b) because the design and failure modes of Archer's propellers are expected to be similar to conventional propellers type certificated under part 35. The consequential propeller loads are expected to primarily be centrifugal loads, and therefore the prescriptive centrifugal test requirement of § 35.35, with its requirement for a large margin of safety, is needed to ensure an equivalent level of safety.

A commenter stated that the propeller-specific lightning strike requirements of § 35.38, which prevent major or hazardous effects, are inconsistent with aircraft-level lightning requirements in AM1.2335, which prevents catastrophic effects. The commenter proposed modifying the airworthiness criteria to remove the inconsistency. The FAA disagrees. The propeller requirements prescribe a particular safety level for an uninstalled propeller only; an uninstalled propeller does not need the same safety requirements as the aircraft. The aircraft safety analysis uses the propeller failure rate data to show that the aircraft will not experience any catastrophic effects. No changes were made as a result of this comment.

One commenter requested a definition for maximum propeller overspeed and overtorque as used in § 35.41. The FAA does not concur with the request to define propeller overspeed or overtorque because the applicant defines these ratings, if applicable, to show compliance with AM1.2805 and § 35.41. No changes were made as a result of this comment.

Another commenter requested a definition of acceptable "propellers of similar design" for purposes of compliance with AM1.2840(c). By a propeller of "similar design" in AM1.2840(c), the FAA means that expected failure modes, materials, construction, normal operating characteristics, and features of the propeller are unchanged or have only insignificant differences compared to another propeller. No changes were made as a result of this comment.

Requests to Include Additional Criteria

The FAA received comments from Airbus, ALPA, ASD-Europe, EASA, GAMA, IPR, Lilium, and TCCA, that additional criteria should be added for the Model M001 powered-lift.

One commenter requested the FAA provide reasoning on the omission of § 23.2005, which defines certification levels for normal category airplanes based on maximum seating configuration and speed, or an equivalent airworthiness criterion. The commenter requested the FAA discuss how the agency is establishing the minimum safety requirements for various special class powered-lift products to provide an equivalent level of safety. The FAA did not include § 23.2005 in these airworthiness criteria as that regulation was developed specifically for part 23 airplanes, and the Model M001 is a powered-lift with novel flight phases that are not representative of airplanes; instead, the FAA is establishing a level of safety for the Model M001 that is equivalent with the level of safety in both part 23 and part 27 for airplanes and rotorcraft performing similar operations. Additionally, the criteria in this notice are specific for the Model M001 and are not generally applicable to powered-lift of various sizes.

An individual requested more criteria for HIRF environment applied to urban air mobility operations and vertiports. The FAA notes AM1.2520(a), HIRF protection, requires compliance for systems associated with catastrophic failure conditions. No changes were made as a result of this comment.

Several commenters requested the FAA require provisions for in-service monitoring such as a Health and Usage Monitoring System (HUMS) system to validate assumptions pertaining to airframe structure designs. The FAA is charged under § 21.17(b) to provide an equivalent level of safety to the existing airworthiness standards. The FAA does not currently require in-service monitoring for critical parts on other aircraft types, and the FAA does not plan to require any provisions for in-service monitoring of critical parts for powered-lift. No changes were made as a result of these comments.

Several commenters noted that no specific requirement is mentioned for aircraft batteries and recommended the FAA create new, specific criteria to address topics such as fire protection, fire propagation, crashworthiness, high-voltage current disconnection, protection from lightning transients, punctures and leakage of toxic gas or liquid, and effects of temperature and battery health on battery performance. The FAA acknowledges the risk posed by these hazards but does not agree that additional specific requirements are necessary. All risks identified are adequately addressed by the requirements of Subparts E and F, AM1.1529, and the Appendix A ICA requirements for airframe, engines, and propellers, with specific safety objectives and means of compliance to address these risks that will be developed and tailored to the specific aspects of the Model M001 powered-lift.

Out of Scope Comments

The FAA received and reviewed numerous comments that were general, stated the commenter's viewpoint or opposition without a suggestion specific to the proposed criteria, did not make a request the FAA can act on, requested clarification on existing airworthiness standards, requested changes or clarification to means of compliance, requested changes to type certification procedures defined in 14 CFR part 21, requested requirements for features not included on the Model M001, improperly assumed the Model M001 was an Unmanned Aircraft System, addressed issues covered by operational requirements including IFR under which the Model M001 will not be operating or other 14 CFR parts not related to airworthiness, or asked generalized questions about the Model M001 powered-lift. These comments are beyond the scope of this document. The FAA also reviewed several comments relating to the pursuit of future rulemaking for powered-lift, which is beyond the scope of these airworthiness criteria.

Additional Changes Made to the Proposed Criteria

From October 31, 2023, through November 2, 2023, the FAA met with representatives from EASA regarding the proposed airworthiness criteria. This discussion did not pertain specifically to the Model M001, but instead concerned harmonization activities between EASA and the FAA on the requirements and means of compliance for type certification of powered-lift/VTOL aircraft generally. As a result of this meeting, and for consistency with the harmonized general criteria, the FAA changed the proposed requirement to comply with § 23.2250(c). The FAA added the sentence “The applicant must prevent single failures from resulting in a catastrophic effect upon the aircraft” to § 23.2250(c) (now AM1.2250(c)) to clarify that while single point failures are allowed in the design, they must be prevented from resulting in a catastrophic effect on the aircraft.

Applicability

These airworthiness criteria, established under the provisions of § 21.17(b), are applicable to the Archer Model M001 powered-lift. Should Archer apply at a later date for a change to the type certificate to include another model, these airworthiness criteria would apply to that model as well, provided the FAA finds them appropriate in accordance with the requirements of subpart D to part 21.

Conclusion

This action affects only certain airworthiness criteria for the Model M001 powered-lift. It is not a standard of general applicability.

Authority Citation

The authority citation for these airworthiness criteria is as follows:

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

Airworthiness Criteria

Pursuant to the authority delegated to me by the Administrator, the following airworthiness criteria are issued as part of the type certification basis for the Model M001 powered-lift. The FAA finds these criteria to be appropriate for the aircraft and applicable to the specific type design and provide an equivalent level of safety to existing airworthiness standards.

AIRCRAFT-LEVEL REQUIREMENTS

§ 23.1457 Cockpit voice recorders.

(a) through (g) [Applicable to Model M001]

§ 23.1459 Flight data recorders.

(a) through (e) [Applicable to Model M001]

AM1.1529 Instructions for continued airworthiness.

The applicant must prepare Instructions for Continued Airworthiness (ICA), in accordance with Appendices A, A1, and A2, that are acceptable to the Administrator. ICA for the aircraft, engines, and propellers may be shown in a single aircraft ICA manual if the engine and propeller approvals are sought through the aircraft certification program. Alternatively, the applicant may provide individual ICA for the aircraft, engines, and propellers. The instructions may be incomplete at the time of type certification if a program exists to ensure their completion prior to delivery of the first aircraft, or issuance of a standard certificate of airworthiness, whichever occurs later.

SUBPART A—GENERAL

AM1.2000 Applicability and definitions.

(a) These airworthiness criteria prescribe airworthiness standards for the issuance of a type certificate, and changes to that type certificate, for the Archer Aviation, Inc. Model M001 powered-lift. This aircraft must be certificated in accordance with either the “essential performance” or “increased performance” requirements of these airworthiness criteria. This aircraft may also be type certificated as both “essential performance” and “increased performance” with appropriate and different operating limitations for each approval.

(b) For purposes of these airworthiness criteria, the following definitions apply:

(1) *Continued safe flight and landing* –

(i) for powered-lift approved for “essential performance” means the aircraft is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional pilot skill, strength, or alertness.

(ii) for powered-lift approved for “increased performance” means the aircraft is capable of climbing to a safe altitude, on a flightpath clear of obstacles, and maintaining level flight to a planned destination or alternate landing, possibly using emergency procedures, without requiring exceptional pilot skill, strength, or alertness.

(2) *Phases of flight* means ground operations, takeoff, climb, cruise, descent, approach, hover, and landing.

(3) *Source of lift* means one of three sources of lift: thrust-borne, wing-borne, and semi-thrust-borne. Thrust-borne is defined as when the weight of the aircraft is principally supported by lift generated by engine-driven lift devices. Wing-borne is defined as when the weight of the aircraft is principally supported by aerodynamic lift from fixed airfoil surfaces. Semi-thrust-borne is the combination of thrust-borne and wing-borne, where both forms of lift are used to support the weight of the aircraft.

(4) *Controlled emergency landing* means the aircraft design retains the capability to allow the pilot to choose the direction and area of touchdown while reasonably protecting occupants from serious injury. Upon landing, some damage to the aircraft may be acceptable.

(5) *Critical change of thrust* means the most adverse effect on performance or handling qualities resulting from failures of the flight control or propulsive system, either singular or in combination, not shown to be extremely improbable.

(6) *Local events* are failures of aircraft systems and components, other than the engine and propeller control system, that may affect the installed environment of the engine and propeller control system.

(c) Terms used in the part 23, part 33, and part 35 provisions that are adopted in these airworthiness criteria will have the following meaning:

“Airplane” means “aircraft.”

“This part” means “these airworthiness criteria.”

“Rotorcraft” means “aircraft.”

§ 23.2010 Accepted means of compliance.

(a) through (b) [Applicable to Model M001]

SUBPART B—FLIGHT

Performance

§ 23.2100 Weight and center of gravity.

(a) through (c) [Applicable to Model M001]

AM1.2105 Performance data.

(a) Unless otherwise prescribed, the aircraft must meet the performance requirements of this subpart in still air and standard atmospheric conditions.

(b) Unless otherwise prescribed, the applicant must develop the performance data required by this subpart for the following conditions:

(1) Altitudes from sea level to the maximum altitude for which certification is being sought.; and

(2) Temperatures above and below standard day temperature that are within the range of operating limitations, if those temperatures could have a negative effect on performance.

(c) The procedures used for determining takeoff and landing performance must be executable consistently by pilots of average skill in atmospheric conditions expected to be encountered in service.

(d) Performance data determined in accordance with paragraph (b) of this section must account for losses due to atmospheric conditions, cooling needs, installation losses, downwash considerations, and other demands on power sources.

(e) The hovering ceiling, in and out of ground effect, must be determined over the ranges of weight, altitude, and temperature, if applicable.

(f) Continued safe flight and landing must be possible from any point within the approved flight envelope following a critical change of thrust.

(g) The aircraft must be capable of a controlled emergency landing, following a condition when the aircraft can no longer provide the commanded power or thrust required for continued safe flight and landing, by gliding or autorotation, or an equivalent means to mitigate the risk of loss of power or thrust.

AM1.2110 Minimum safe speed.

The applicant must determine the aircraft minimum safe speed for each flight condition encountered in normal operations, including applicable sources of lift and phases of flight, to maintain controlled safe flight. The minimum safe speed determination must account for the most adverse conditions for each flight configuration.

AM1.2115 Takeoff performance.

(a) The applicant must determine takeoff performance accounting for:

(1) All sources of lift for each takeoff flight path for which certification is sought,

(2) Minimum safe speed safety margins,

(3) Minimum control speeds, and

(4) Climb requirements.

(b) For aircraft approved for essential performance, the applicant must determine the takeoff performance to 50 feet above the takeoff surface such that a rejected takeoff resulting in safe stop or landing can be made at any point along the takeoff flight path following a critical change of thrust.

(c) For aircraft approved for increased performance, the applicant must determine the takeoff performance so that-

(1) Following a critical change of thrust prior to reaching the takeoff decision point, a rejected takeoff resulting in a safe stop or landing can be made. The takeoff decision point may be a speed, an altitude, or both.

(2) Following a critical change of thrust after passing the takeoff decision point, the aircraft can—

(i) Continue the takeoff and climb to 50 feet above the takeoff surface; and

(ii) Subsequently achieve the configuration and airspeed used in compliance with AM1.2120.

AM1.2120 Climb requirements.

(a) The applicant must demonstrate minimum climb performance at each weight, altitude, and ambient temperature within the operating limitations using the procedures published in the flight manual.

(b) For aircraft approved for essential and increased performance, the applicant must determine the following all engines operating (AEO) climb performance requirements:

(1) A steady climb gradient at sea level of at least 8.3 percent in the initial takeoff configuration(s) and a climb speed selected by the applicant or V_y, and

(2) For a balked landing, a climb gradient of 3 percent without creating undue pilot workload with the landing gear extended and flaps in the landing configuration(s).

(c) For aircraft approved for essential performance, the climb performance after a critical change of thrust must be determined–

(1) Using applicable sources of lift along the takeoff flight path for which certification is being sought at the speeds and configurations selected by the applicant; and

(2) For the transition from the takeoff to the enroute configuration. The total altitude loss must be determined for the weight, altitude, and ambient temperature where level flight cannot be maintained.

(d) For aircraft approved for increased performance, the climb performance after a critical change of thrust must be such that –

(1) In thrust-borne and semi-thrust-borne flight:

(i) The steady rate of climb without ground effect, 200 feet above the takeoff surface, is at least 100 feet per minute,

(ii) The steady rate of climb without ground effect, 1000 feet above the takeoff surface, is at least 150 feet per minute,

(iii) The steady rate of climb (or descent) enroute is determined in feet per minute, at each weight, altitude, and temperature at which the aircraft is expected to operate for which certification is requested.

(2) In wing-borne flight, the steady gradient of climb:

(i) During takeoff at the takeoff surface, is at least 0.5 percent with the aircraft in its takeoff configuration(s),

(ii) During takeoff at 400 feet above the takeoff surface, is at least 2.6 percent with the aircraft in its second segment configuration,

(iii) Enroute at 1,500 feet above the takeoff or landing surface, as appropriate, is at least 1.7 percent with the aircraft in a cruise configuration, and

(iv) During a discontinued approach at 400 feet above the landing surface, is not less than 2.7 percent in an approach configuration.

(e) The applicant must determine the performance accordingly for the appropriate sources of lift for gliding, autorotation, or the equivalent means established under AM1.2105(g).

AM1.2125 Climb information.

(a) The applicant must determine climb performance at each weight, altitude, and ambient temperature within the operating limitations using the procedures published in the flight manual.

(b) The applicant must determine climb performance accounting for any critical change of thrust.

AM1.2130 Landing.

The applicant must determine the following, for standard temperatures at critical combinations of weight and altitude within the operational limits:

(a) The approach and landing speeds and procedures, which allow a pilot of average skill to land within the published landing distance consistently and without causing damage or injury, and which allow for a safe transition to the balked landing conditions of these airworthiness criteria accounting for:

(1) All sources of lift for each approach and landing flight path for which certification is sought,

(2) Any minimum or maximum speed safety margins, and

(3) Minimum control speeds.

(b) For aircraft approved for essential performance, the applicant must determine the landing performance from a height of 50 feet above the landing surface. Additionally, the aircraft must be capable of performing a safe landing at any point along the approach flight path following a critical change of thrust.

(c) For aircraft approved for increased performance, the applicant must determine the landing performance from a height of 50 feet above the landing surface so that, following a critical change of thrust that occurs prior to the landing decision point, the aircraft can-

(1) Land and stop safely on the landing surface; or

(2) Transition to the balked landing condition and performance established in AM1.2120.

FLIGHT CHARACTERISTICS

AM1.2135 Controllability.

(a) The aircraft must be controllable and maneuverable, without requiring exceptional piloting skill, alertness, or strength, within the approved flight envelope—

(1) At all loading conditions for which certification is requested;

(2) During all phases of flight while using applicable sources of lift;

(3) With likely flight control or propulsion system failure;

(4) During configuration changes;

(5) In all degraded flight control system operating modes not shown to be extremely improbable;

(6) In thrust-borne operation, and must be controllable in wind velocities from zero to at least 17 knots from any azimuth angle; and

(7) The aircraft must be able to safely complete a landing using the steepest approach gradient procedures.

(b) The applicant must determine critical control parameters, such as limited control power margins, and if applicable, account for those parameters in appropriate operating limitations.

(c) It must be possible to make a smooth transition from one flight condition to another (changes in configuration and in source of lift and phase of flight) without exceeding the approved flight envelope.

AM1.2140 Trim.

(a) The aircraft must maintain lateral and directional trim without further force upon, or movement of, the primary flight controls or corresponding trim controls by the pilot, or the flight control system, under all normal operations while using applicable sources of lift.

(b) The aircraft must maintain longitudinal trim without further force upon, or movement of, the primary flight controls or corresponding trim controls by the pilot, or the flight control system, under the following conditions:

(1) Climb.

(2) Level flight.

(3) Descent.

(4) Approach.

(c) Residual control forces must not fatigue or distract the pilot during normal operations of the aircraft and likely abnormal or emergency operations, including a critical change of thrust.

AM1.2145 Stability.

(a) The aircraft must exhibit static stability characteristics inclusive of likely failures.

(b) The aircraft must exhibit suitable short period dynamic stability inclusive of likely failures.

(c) For wing borne and semi-thrust-borne operations:

(1) No aircraft may exhibit any divergent longitudinal dynamic stability characteristics so unstable as to increase the pilot's workload or otherwise endanger the aircraft and its occupants, and

(2) The aircraft must exhibit lateral-directional dynamic stability inclusive of likely failures.

(d) For thrust borne operations, no aircraft may exhibit any divergent dynamic stability characteristics so unstable as to increase the pilot's workload or otherwise endanger the aircraft and its occupants.

AM1.2150 Minimum safe speed characteristics and warning.

(a) When part of the lift is generated from a fixed wing, the aircraft must have controllable stall characteristics in straight flight, turning flight, and accelerated turning flight with a clear and distinctive stall warning that provides sufficient margin to prevent inadvertent stalling and not have a tendency to inadvertently depart controlled safe flight.

(b) For other sources of lift, the aircraft must have controllable characteristics in straight flight, turning flight, and accelerated turning flight with a clear and distinctive warning that provides sufficient margin to prevent inadvertent departures from controlled safe flight.

(c) For all sources of lift, the aircraft must not have the tendency to inadvertently depart controlled safe flight after a sudden change of thrust.

§ 23.2155 Ground and water handling characteristics.

[Applicable to Model M001]

AM1.2160 Vibration, buffeting, and high-speed characteristics.

(a)) Each part of the aircraft must be free from excessive vibration and buffeting under each appropriate speed and power condition. Vibration and buffeting, for operations up to V_D/M_D, must not interfere with the control of the aircraft or cause excessive fatigue to the flightcrew. Stall warning buffet within these limits is allowable.

(b) For inadvertent excursions beyond the maximum approved speed, the aircraft must be able to safely recover back to its approved flight envelope without requiring exceptional piloting skill, strength, or alertness. This recovery may not result in structural damage or loss of control.

AM1.2165 Performance and flight characteristics requirements for flight in atmospheric icing conditions.

(a) The applicant must provide a means to detect icing conditions for which certification is not requested and show the aircraft's ability to avoid or exit those icing conditions.

(b) The applicant must develop an operating limitation to prohibit intentional flight, including takeoff and landing, into icing conditions for which the aircraft is not certified to operate.

SUBPART C—STRUCTURES

AM1.2200 Structural design envelope.

The applicant must determine the structural design envelope, which describes the range and limits of aircraft design and operational parameters for which the applicant will show compliance with the requirements of this subpart. The applicant must account for all aircraft design and operational parameters that affect structural loads, strength, durability, and aeroelasticity, including:

(a) Structural design airspeeds, landing descent speeds, and any other airspeed limitation at which the applicant must show compliance to the requirements of this subpart. The structural design airspeeds must—

(1) Be sufficiently greater than the minimum safe speed of the aircraft to safeguard against loss of control in turbulent air; and

(2) Provide sufficient margin for the establishment of practical operational limiting airspeeds.

(b) Design maneuvering load factors not less than those, which service history shows, may occur within the structural design envelope.

(c) Inertial properties including weight, center of gravity, and mass moments of inertia, accounting for—

(1) Each critical weight from the aircraft empty weight to the maximum weight; and

(2) The weight and distribution of occupants, payload, and energy-storage systems.

(d) Characteristics of aircraft control systems, including range of motion and tolerances for control surfaces, high lift devices, or other moveable surfaces.

(e) Each critical altitude up to the maximum altitude.

(f) Engine-driven lifting-device rotational speed and ranges, and the maximum rearward and sideward flight speeds.

(g) Thrust-borne, wing-borne, and semi-thrust-borne flight configurations, with associated flight load envelopes.

§ 23.2205 Interaction of systems and structures.

[Applicable to Model M001]

Structural Loads

§ 23.2210 Structural design loads.

(a) through (b) [Applicable to Model M001]

AM1.2215 Flight load conditions.

(a) The applicant must determine the structural design loads resulting from the following flight conditions:

(1) Atmospheric gusts where the magnitude and gradient of these gusts are based on measured gust statistics.

(2) Symmetric and asymmetric maneuvers.

(3) Asymmetric thrust resulting from the failure of a powerplant unit.

(b) There must be no vibration or buffeting severe enough to result in structural damage, at any speed up to dive speed, within the structural design envelope, in any configuration and power setting.

§ 23.2220 Ground and water load conditions.

[Applicable to Model M001]

AM1.2225 Component loading conditions.

The applicant must determine the structural design loads acting on:

(a) Each engine mount and its supporting structure such that both are designed to withstand loads resulting from—

(1) Powerplant operation combined with flight gust and maneuver loads; and

(2) For non-reciprocating powerplants, sudden powerplant stoppage.

(b) Each flight control and high-lift surface, their associated system and supporting structure resulting from—

(1) The inertia of each surface and mass balance attachment;

(2) Flight gusts and maneuvers;

(3) Pilot or automated system inputs;

(4) System induced conditions, including jamming and friction; and

(5) Taxi, takeoff, and landing operations on the applicable surface, including downwind taxi and gusts occurring on the applicable surface.

(c) [Reserved]

(d) Engine-driven lifting-device assemblies, considering loads resulting from flight and ground conditions, as well limit input torque at any lifting-device rotational speed.

§ 23.2230 Limit and ultimate loads.

(a) through (b) [Applicable to Model M001]

Structural Performance

§ 23.2235 Structural strength.

(a) through (b) [Applicable to Model M001]

AM1.2240 Structural durability.

(a) The applicant must develop and implement inspections or other procedures to prevent structural failures due to foreseeable causes of strength degradation, which could result in serious or fatal injuries, or extended periods of operation with reduced safety margins. Each of the inspections or other procedures developed under this section must be included in the Airworthiness Limitations Section of the ICA, required by AM1.1529.

(b) If safety-by-design (fail-safe) is used to comply with paragraph (a) of this section, safety-by-inspection (damage tolerance) must also be incorporated to reliably detect structural damage before the damage could result in structural failure.

(c) The aircraft must be designed to minimize hazards to the aircraft due to structural damage caused by high-energy fragments from an uncontained engine or rotating machinery failure.

AM1.2241 Aeromechanical stability.

The aircraft must be free from dangerous oscillations and aeromechanical instabilities for all configurations and conditions of operation on the ground and in flight.

AM1.2245 Aeroelasticity.

(a) The aircraft must be free from flutter, control reversal, and divergence—

(1) At all speeds within and sufficiently beyond the structural design envelope;

(2) For any configuration and condition of operation;

(3) Accounting for critical structural modes, and

(4) Accounting for any critical failures or malfunctions.

(b) The applicant must establish tolerances for all quantities that affect aeroelastic stability.

(c) Each component and rotating aerodynamic surface of the aircraft must be free from any aeroelastic instability under each appropriate speed and power condition.

Design

AM1.2250 Design and construction principles.

(a) The applicant must design each part, article, and assembly for the expected operating conditions of the aircraft.

(b) Design data must adequately define the part, article, or assembly configuration, its design features, and any materials and processes used.

(c) The applicant must determine the suitability of each design detail and part having an important bearing on safety in operations. The applicant must prevent single failures from resulting in a catastrophic effect upon the aircraft.

(d) The control system must be free from jamming, excessive friction, and excessive deflection when the aircraft is subjected to expected limit airloads.

(e) Doors, canopies, and exits must be protected against inadvertent opening in flight, unless shown to create no hazard when opened in flight.

§ 23.2255 Protection of structure.

(a) through (c) [Applicable to Model M001]

§ 23.2260 Materials and processes.

(a) through (g) [Applicable to Model M001]

§ 23.2265 Special factors of safety.

(a) through (c) [Applicable to Model M001]

Structural Occupant Protection

§ 23.2270 Emergency conditions.

(a) through (e) [Applicable to Model M001]

SUBPART D—DESIGN AND CONSTRUCTION

AM1.2300 Flight control systems.

(a) The applicant must design flight control systems to:

(1) Operate easily, smoothly, and positively enough to allow proper performance of their functions;

(2) Protect against likely hazards; and

(3) Ensure that the flightcrew is made suitably aware whenever the means of primary flight control approaches the limits of control authority.

(b) The applicant must design trim systems or trim functions, if installed, to:

(1) Protect against inadvertent, incorrect, or abrupt trim operation; and

(2) Provide information that is required for safe operation.

(c) Features that protect the aircraft against loss of control or exceeding critical limits must be designed such that there are no adverse flight characteristics in aircraft response to flight-control inputs, unsteady atmospheric conditions, and other likely conditions, including simultaneous limiting events.

§ 23.2305 Landing gear systems.

(a) through (c) [Applicable to Model M001]

AM1.2311 Bird Strike.

The aircraft must be capable of continued safe flight and landing after impact with a 2.2-lb (1.0 kg) bird.

Occupant System Design Protection

AM1.2315 Means of egress and emergency exits.

(a) With the cabin configured for takeoff or landing, the aircraft is designed to:

(1) Facilitate rapid and safe evacuation of the aircraft in conditions likely to occur following an emergency landing.

(2) Have means of egress (openings, exits, or emergency exits), that can be readily located and opened from the inside and outside. The means of opening must be simple and obvious and marked inside and outside the aircraft.

(3) Have easy access to emergency exits when present.

(b) [Reserved]

§ 23.2320 Occupant physical environment.

(a) and (c) [Applicable to Model M001]

(b), (d), and (e) [Not applicable to Model M001]

Fire and High Energy Protection

AM1.2325 Fire protection.

(a) The following materials must be self-extinguishing -

(1) Insulation on electrical wire and electrical cable; and

(2) Materials in the baggage and cargo compartments inaccessible in flight.

(b) The following materials must be flame resistant -

(1) Materials in each compartment accessible in flight; and

(2) Any equipment associated with any electrical cable installation and that would overheat in the event of circuit overload or fault.

(c) Thermal/acoustic materials in the fuselage, if installed, must not be a flame propagation hazard.

(d) Sources of heat within each baggage and cargo compartment that are capable of igniting adjacent objects must be shielded and insulated to prevent such ignition.

(e) Each baggage and cargo compartment must -

(1) Be located where a fire would be visible to the pilots and be accessible for the manual extinguishing of a fire,

(2) Be equipped with a smoke or fire detection system that warns the pilot, or

(3) Be constructed of, or lined with, fire resistant materials.

(f) There must be a means to extinguish any fire in the cabin such that the pilot, while seated, can easily access the fire extinguishing means.

(g) Each area where flammable fluids or vapors might escape by leakage of a fluid system must -

(1) Be defined; and

(2) Have a means to minimize the probability of fluid and vapor ignition, and the resultant hazard, if ignition occurs.

AM1.2330 Fire protection in fire zones and adjacent areas.

(a) Flight controls, engine mounts, and other flight structures within or adjacent to fire zones must be capable of withstanding the effects of a fire.

(b) Engines in a fire zone must remain attached to the aircraft in the event of a fire.

(c) In fire zones, terminals, equipment, and electrical cables used during emergency procedures must perform their intended function in the event of a fire.

AM1.2335 Lightning and static electricity protection.

(a) The aircraft must be protected against catastrophic effects from lightning.

(b) The aircraft must be protected against hazardous effects caused by an accumulation of electrostatic charge.

SUBPART E—POWERPLANT

AM1.2400 Powerplant installation.

(a) For the purpose of this subpart, the aircraft powerplant installation must include each component necessary for propulsion, which affects propulsion safety.

(b) Each aircraft engine and propeller must be approved under the aircraft type certificate using standards found in subparts H and I.

(c) The applicant must construct and arrange each powerplant installation to account for—

(1) Likely operating conditions, including foreign-object threats;

(2) Sufficient clearance of moving parts to other aircraft parts and their surroundings;

(3) Likely hazards in operation including hazards to ground personnel; and

(4) Vibration and fatigue.

(d) Hazardous accumulations of fluids, vapors, or gases must be isolated from the aircraft and personnel compartments and be safely contained or discharged.

(e) Powerplant components must comply with their component limitations and installation instructions or be shown not to create a hazard.

AM1.2405 Power or thrust control systems.

(a) Any power or thrust control system or powerplant control system must be designed so no unsafe condition results during normal operation of the system.

(b) Any single failure or likely combination of failures or malfunctions of a power or thrust control system or powerplant control system must not prevent continued safe flight and landing of the aircraft.

(c) Inadvertent flightcrew operation of a power or thrust control system or powerplant control system must be prevented, or if not prevented, must not prevent continued safe flight and landing of the aircraft.

§ 23.2410 Powerplant installation hazard assessment.

(a) through (c) [Applicable to Model M001]

§ 23.2415 Powerplant ice protection.

(a) through (b) [Applicable to Model M001]

AM1.2425 Powerplant operational characteristics.

(a) Each installed powerplant must operate without any hazardous characteristics during normal and emergency operation within the range of operating limitations for the aircraft and the engine.

(b) The design must provide for the shutdown and restart of the powerplant in flight within an established operational envelope.

AM1.2430 Energy systems.

(a) Each energy system must—

(1) Be designed and arranged to provide independence between multiple energy-storage and supply systems, so that failure of any one component in one system will not result in loss of energy storage or supply of another system;

(2) Be designed to prevent catastrophic events due to lightning strikes, taking into account direct and indirect effects on the aircraft;

(3) Provide the energy necessary to ensure each powerplant functions properly in all likely operating conditions;

(4) Provide the flightcrew with a means to determine the total useable energy available and provide uninterrupted supply of that energy when the system is correctly operated, accounting for likely energy fluctuations;

(5) Provide a means to safely remove or isolate the energy stored in the system from the aircraft; and

(6) Be designed to retain energy under all likely operating conditions and to minimize hazards to occupants and first responders following an emergency landing or otherwise survivable impact (crash landing).

(b) Each energy-storage system must—

(1) Withstand the loads under likely operating conditions without failure; and

(2) Be isolated from personnel compartments and protected from likely hazards.

(c) Each energy-storage recharging system must be designed to—

(1) Prevent improper recharging; and

(2) Prevent the occurrence of hazard to the aircraft or to persons during recharging.

AM1.2440 Powerplant fire protection

There must be means to isolate and mitigate hazards to the aircraft in the event of a powerplant system fire or overheat in operation.

SUBPART F—EQUIPMENT

§ 23.2500 Airplane level systems requirements.

(a) through (b) [Applicable to Model M001]

§ 23.2505 Function and installation.

[Applicable to Model M001]

§ 23.2510 Equipment, systems, and installations.

(a) through (c) [Applicable to Model M001]

AM1.2515 Electrical- and electronic-system lightning protection.

(a) Each electrical or electronic system that performs a function, the failure of which would prevent the continued safe flight and landing of the aircraft, must be designed and installed such that—

(1) The function at the aircraft level is not adversely affected during and after the time the aircraft is exposed to lightning; and

(2) The system recovers normal operation of that function in a timely manner after the aircraft is exposed to lightning unless the system's recovery conflicts with other operational or functional requirements of the system.

(b) For an aircraft approved for operation under instrument flight rules (IFR), each electrical and electronic system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the aircraft is exposed to lightning.

AM1.2520 High-intensity Radiated Fields (HIRF) protection.

(a) Each electrical or electronic system that performs a function, the failure of which would prevent the continued safe flight and landing of the aircraft, must be designed and installed such that—

(1) The function at the aircraft level is not adversely affected during and after the time the aircraft is exposed to the HIRF environment; and

(2) The system recovers normal operation of that function in a timely manner after the aircraft is exposed to the HIRF environment, unless the system's recovery conflicts with other operational or functional requirements of the system.

(b) For aircraft approved for IFR operations, each electrical and electronic system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the flightcrew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the aircraft is exposed to the HIRF environment.

§ 23.2525 System power generation, storage, and distribution.

(a) through (c) [Applicable to Model M001]

§ 23.2530 External and cockpit lighting.

(a) through (d) [Applicable to Model M001]

(e) [Not applicable to Model M001]

§ 23.2535 Safety equipment.

[Applicable to Model M001]

§ 23.2545 Pressurized systems elements.

[Applicable to Model M001]

§ 23.2550 Equipment containing high-energy rotors.

[Applicable to Model M001]

SUBPART G—FLIGHTCREW INTERFACE AND OTHER INFORMATION

AM1.2600 Flightcrew interface.

(a) The pilot compartment, its equipment, and its arrangement to include pilot view, must allow each pilot to perform their duties for all sources of lift and phases of flight and perform any maneuvers within the approved flight envelope of the aircraft, without excessive concentration, skill, alertness, or fatigue.

(b) The applicant must install flight, navigation, surveillance, and powerplant controls and displays, as needed, so qualified flightcrew can monitor and perform defined tasks associated with the intended functions of systems and equipment, without excessive concentration, skill, alertness, or fatigue. The system and equipment design must minimize flightcrew errors, which could result in additional hazards.

§ 23.2605 Installation and operation.

(a) through (c) [Applicable to Model M001]

§ 23.2610 Instrument markings, control markings, and placards.

(a) through (c) [Applicable to Model M001]

AM1.2615 Flight, navigation, and powerplant instruments.

(a) Installed systems must provide the flightcrew member who sets or monitors parameters for the flight, navigation, and powerplant, the information necessary to do so during each source of lift and phase of flight. This information must —

(1) Be presented in a manner that the crewmember can monitor the parameter and determine trends, as needed, to operate the aircraft; and

(2) Include limitations, unless the limitations cannot be exceeded in all intended operations.

(b) Indication systems that integrate the display of flight or powerplant parameters to operate the aircraft, or are required by the operating rules of title 14, chapter I, must—

(1) Not inhibit the primary display of flight or powerplant parameters needed by any flightcrew member in any normal mode of operation; and

(2) In combination with other systems, be designed and installed so information essential for continued safe flight and landing will be available to the flightcrew in a timely manner after any single failure or probable combination of failures.

AM1.2620 Aircraft flight manual.

The applicant must provide an Aircraft Flight Manual that must be delivered with each aircraft.

(a) The Aircraft Flight Manual must contain the following information—

(1) Aircraft operating limitations;

(2) Aircraft operating procedures;

(3) Performance information;

(4) Loading information; and

(5) Other information that is necessary for safe operation because of design, operating, or handling characteristics.

(b) The portions of the Aircraft Flight Manual containing the information specified in paragraphs (a)(1) through (a)(4) of this section must be approved by the FAA in a manner specified by the Administrator.

SUBPART H—ELECTRIC ENGINE REQUIREMENTS

§ 33.5 Instruction manual for installing and operating the engine.

(a) through (c) [Applicable to Model M001]

§ 33.7 Engine ratings and operating limitations.

(a) [Applicable to Model M001]

(b) through (d) [Not applicable to Model M001]

AM1.2702 Engine ratings and operating limits.

Ratings and operating limits must be established and included in the type certificate data sheet based on:

(a) Shaft power, torque, rotational speed, and temperature for:

(1) Rated takeoff power;

(2) Rated maximum continuous power; and

(3) Rated maximum temporary power and associated time limit.

(b) Duty cycle and the rating at that duty cycle. The duty cycle must be declared in the type certificate data sheet.

(c) Cooling fluid grade or specification.

(d) Power-supply requirements.

(e) Any other ratings or limitations that are necessary for the safe operation of the engine.

§ 33.8 Selection of engine power and thrust ratings.

(a) through (b) [Applicable to Model M001]

§ 33.15 Materials.

(a) through (b) [Applicable to Model M001]

§ 33.17 Fire protection.

(a) [Not applicable to Model M001]

(b) through (g) [Applicable to Model M001]

AM1.2704 Fire protection.

(a) The design and construction of the engine and the materials used must minimize the probability of the occurrence and spread of fire during normal operation and failure conditions and must minimize the effect of such a fire.

(b) High-voltage electrical wiring interconnect systems must be protected against arc faults that can lead to hazardous engine effects as defined in AM1.2717(d)(2). Non-protected electrical wiring interconnects must be analyzed to show that arc faults do not cause a hazardous engine effect.

AM1.2705 Durability.

The engine design and construction must minimize the development of an unsafe condition of the engine between maintenance intervals, overhaul periods, or mandatory actions described in the applicable ICA.

§ 33.21 Engine cooling.

[Applicable to Model M001]

AM1.2706 Engine cooling.

If cooling is required to satisfy the safety analysis as described in AM1.2717, the cooling-system monitoring features and usage must be documented in the engine installation manual.

§ 33.23 Engine mounting attachments and structure.

(a) through (b) [Applicable to Model M001]

§ 33.25 Accessory attachments.

[Applicable to Model M001]

AM1.2709 Overspeed.

(a) A rotor overspeed must not result in a burst, rotor growth, or damage that results in a hazardous engine effect, as defined in AM1.2717(d)(2). Compliance with this paragraph must be shown by test, validated analysis, or a combination of both. Applicable assumed rotor speeds must be declared and justified.

(b) Rotors must possess sufficient strength with a margin to burst above approved operating conditions and above failure conditions leading to rotor overspeed. The margin to burst must be shown by test, validated analysis, or a combination thereof.

(c) The engine must not exceed the rotor-speed operational limitations that could affect rotor structural integrity.

§ 33.28 Engine control systems.

(b)(1)(i), (b)(1)(iii), and (b)(1)(iv) [Applicable to Model M001]

(a), (b)(1)(ii), and (b)(2) through (m) [Not applicable to Model M001]

AM1.2710 Engine control systems.

(a) Applicability.

These requirements apply to any system or device that is part of the engine type design that controls, limits, monitors, or protects engine operation and is necessary for the continued airworthiness of the engine.

(b) Engine control.

The engine control system must ensure the engine does not experience any unacceptable operating characteristics or exceed its operating limits, including in failure conditions where the fault or failure results in a change from one control mode to another, from one channel to another, or from the primary system to the back-up system, if applicable.

(c) Design assurance.

The software and complex electronic hardware, including programmable logic devices, must be—

(1) Designed and developed using a structured and systematic approach that provides a level of assurance for the logic commensurate with the hazard associated with the failure or malfunction of the systems in which the devices are located; and

(2) Substantiated by a verification methodology acceptable to the Administrator.

(d) Validation.

All functional aspects of the control system must be substantiated by test, analysis, or a combination thereof, to show that the engine control system performs the intended functions throughout the declared operational envelope.

(e) Environmental limits.

Environmental limits that cannot be adequately substantiated by endurance demonstration, validated analysis, or a combination thereof must be demonstrated by the system and component tests in AM1.2727.

(f) Engine control system failures.

The engine control system must—

(1) Have a maximum rate of Loss of Power Control (LOPC) that is suitable for the intended aircraft application. The estimated LOPC rate must be specified in the engine installation manual;

(2) When in the full-up configuration, be single fault tolerant, as determined by the Administrator, for electrical, electrically detectable, and electronic failures involving LOPC events;

(3) Not have any single failure that results in hazardous engine effects as defined in AM1.2717(d)(2); and

(4) Ensure failures or malfunctions that lead to local events in the aircraft do not result in hazardous engine effects as defined in AM1.2717(d)(2) due to engine control system failures or malfunctions.

(g) System safety assessment.

The applicant must perform a system safety assessment. This assessment must identify faults or failures that affect normal operation, together with the predicted frequency of occurrence of these faults or failures. The intended aircraft application must be taken into account to ensure the assessment of the engine control system safety is valid.

(h) Protection systems.

The engine control devices and systems' design and function, together with engine instruments, operating instructions, and maintenance instructions, must ensure that engine operating limits that can lead to a hazard will not be exceeded in-service.

(i) Aircraft-supplied data.

Any single failure leading to loss, interruption, or corruption of aircraft-supplied data (other than power command signals from the aircraft), or aircraft-supplied data shared between engine systems within a single engine or between fully independent engine systems, must—

(1) Not result in a hazardous engine effect, as defined in AM1.2717(d)(2), for any engine installed on the aircraft; and

(2) Be able to be detected and accommodated by the control system.

(j) Engine control system electrical power.

(1) The engine control system must be designed such that the loss, malfunction, or interruption of the control system electrical power source will not result in a hazardous engine effect, as defined in AM1.2717(d)(2), the unacceptable transmission of erroneous data, or continued engine operation in the absence of the control function. The engine control system must be capable of resuming normal operation when aircraft-supplied power returns to within the declared limits.

(2) The applicant must identify and declare, in the engine installation manual, the characteristics of any electrical power supplied from the aircraft to the engine control system, including transient and steady-state voltage limits, and any other characteristics necessary for safe operation of the engine.

§ 33.29 Instrument connection.

(a), (e), and (g) [Applicable to Model M001]

(b) through (d), (f), and (h) [Not applicable to the Model M001]

AM1.2711 Instrument connection.

(a) In addition, as part of the system safety assessment of AM1.2710(g) and AM1.2733(h), the applicant must assess the possibility and subsequent effect of incorrect fit of instruments, sensors, or connectors. Where practicable, the applicant must take design precautions to prevent incorrect configuration of the system.

(b) The applicant must provide instrumentation enabling the flightcrew to monitor the functioning of the engine cooling system unless evidence shows that:

(1) Other existing instrumentation provides adequate warning of failure or impending failure;

(2) Failure of the cooling system would not lead to hazardous engine effects, as defined in AM1.2717(d)(2), before detection; or

(3) The probability of failure of the cooling system is extremely remote.

AM1.2712 Stress analysis.

(a) A mechanical and thermal stress analysis, as well as an analysis of the stress caused by electromagnetic forces, must show a sufficient design margin to prevent unacceptable operating characteristics and hazardous engine effects as defined in AM1.2717(d)(2).

(b) Maximum stresses in the engine must be determined by test, validated analysis, or a combination thereof, and must be shown not to exceed minimum material properties.

§ 33.70 Engine life limited parts

Introductory paragraph [Not applicable to Model M001]

(a) through (c) [Applicable to Model M001]

AM1.2713 Critical and life-limited parts.

(a) The applicant must show, by a safety analysis or means acceptable to the Administrator, whether rotating or moving components, bearings, shafts, static parts, and non-redundant mount components should be classified, designed, manufactured, and managed throughout their service life as critical or life-limited parts.

(1) *Critical part* means a part that must meet prescribed integrity specifications to avoid its primary failure, which is likely to result in a hazardous engine effect as defined in AM1.2717(d)(2).

(2) *Life-limited parts* may include but are not limited to a rotor and major structural static part, the failure of which can result in a hazardous engine effect, as defined in AM1.2717(d)(2), due to low-cycle fatigue.

(b) In establishing the integrity of each critical part or life-limited part, the applicant must provide to the Administrator the following three plans for approval: an engineering plan, a manufacturing plan, and a service-management plan, as defined in § 33.70.

AM1.2714 Lubrication system.

(a) The lubrication system must be designed and constructed to function properly between scheduled maintenance intervals in all flight attitudes and atmospheric conditions in which the engine is expected to operate.

(b) The lubrication system must be designed to prevent contamination of the engine bearings and lubrication system components.

(c) The applicant must demonstrate by test, validated analysis, or a combination thereof, the unique lubrication attributes and functional capability of paragraphs (a) and (b) of this section.

AM1.2715 Power response.

The design and construction of the engine, including its control system, must enable an increase—

(a) From the minimum power setting to the highest rated power without detrimental engine effects;

(b) From the minimum obtainable power while in flight, and while on the ground, to the highest rated power within a time interval determined to be appropriate for the intended aircraft application; and

(c) From the minimum torque to the highest rated torque without detrimental engine effects in the intended aircraft application.

AM1.2716 Continued rotation.

If the design allows any of the engine main rotating systems to continue to rotate after the engine is shut down while in-flight, this continued rotation must not result in hazardous engine effects, as specified in AM1.2717(d)(2).

§ 33.75 Safety analysis.

(a)(1) through (a)(2), (d), (e), and (g)(2) [Applicable to Model M001]

(a)(3) through (c), (f), (g)(1), and (g)(3) [Not applicable to Model M001]

AM1.2717 Safety analysis.

(a) The applicant must comply with § 33.75(a)(1) and (2) using the failure definitions in paragraph (d) of this section.

(b) The primary failure of certain single elements cannot be sensibly estimated in numerical terms. If the failure of such elements is likely to result in hazardous engine effects as defined in paragraph (d)(2) of this section, then the applicant may show compliance by reliance on the prescribed integrity requirements such as § 33.15, AM1.2709, AM1.2713, or combinations thereof, as applicable. The failure of such elements and associated prescribed integrity requirements must be stated in the safety analysis.

(c) The applicant must comply with § 33.75(d) using the failure definitions in paragraph (d) of this section, § 33.75(e)(1) using the ICA in AM1.1529 Appendix 1, and with § 33.75(e)(4) using the failure definitions in paragraph (d) of this section.

(d) Unless otherwise approved by the Administrator, the following definitions apply to the engine effects when showing compliance with these airworthiness criteria:

(1) A minor engine effect does not prohibit the engine from performing its intended functions in a manner consistent with § 33.28(b)(1)(i), (b)(1)(iii), and (b)(1)(iv), and the engine complies with the operability requirements such as AM1.2715, AM1.2725, and AM1.2731, as appropriate.

(2) The engine effects in § 33.75(g)(2) are hazardous engine effects, as are:

(i) Electrocution of the crew, passengers, operators, maintainers, or others; and

(ii) Blockage of cooling systems that could cause the engine effects described in § 33.75(g)(2) and paragraph (d)(2)(i) of this section.

(3) Any other engine effect is a major engine effect.

(e) The intended aircraft application must be taken into account to assure that the analysis of the engine system safety is valid.

AM1.2718 Ingestion.

(a) Rain, ice, and hail ingestion must not result in an abnormal operation such as shutdown, power loss, erratic operation, or power oscillations throughout the engine operating range.

(b) Ingestion from other likely sources (birds, induction system ice, foreign objects—ice slabs) must not result in hazardous engine effects, as defined in AM1.2717(d)(2), or unacceptable power loss.

(c) If the design of the engine relies on features, attachments, or systems that the installer may supply, for the prevention of unacceptable power loss or hazardous engine effects as defined in AM1.2717(d)(2) following potential ingestion, then the features, attachments, or systems must be documented in the engine installation manual.

(d) Ingestion sources described in paragraph (b) of this section that are not evaluated must be declared in the engine installation manual.

AM1.2719 Liquid and Gas Systems.

(a) Each system used for lubrication or cooling of engine components must be designed and constructed to function properly in all flight attitudes and atmospheric conditions in which the engine is expected to operate.

(b) If a system used for lubrication or cooling of engine components is not self-contained, the interfaces to that system must be defined in the engine installation manual.

(c) The applicant must establish by test, validated analysis, or a combination of both, that all static parts subject to significant pressure loads will not:

(1) Exhibit permanent distortion beyond serviceable limits or exhibit leakage that could create a hazardous condition when subjected to normal and maximum working pressure with margin.

(2) Exhibit fracture or burst when subjected to the greater of maximum possible pressures with margin.

(d) Compliance with paragraph (c) of this section must take into account:

(1) The operating temperature of the part;

(2) Any other significant static loads in addition to pressure loads;

(3) Minimum properties representative of both the material and the processes used in the construction of the part; and

(4) Any adverse physical geometry conditions allowed by the type design, such as minimum material and minimum radii.

(e) Approved coolants and lubricants must be listed in the engine installation manual.

AM1.2720 Vibration demonstration.

(a) The engine must be designed and constructed to function throughout its normal operating range of rotor speeds and engine output power, including defined exceedances, without inducing excessive stress in any of the engine parts because of vibration and without imparting excessive vibration forces to the aircraft structure.

(b) Each engine design must undergo a vibration survey to establish that the vibration characteristics of those components that may be subject to induced vibration are acceptable throughout the approved flight envelope and engine operating range for the specific installation configuration. The possible sources of the induced vibration that the survey must assess are mechanical, aerodynamic, acoustical, internally induced electromagnetic, installation induced effects that can affect the engine vibration characteristics, and likely environmental effects. This survey must be shown by test, validated analysis, or a combination thereof.

AM1.2721 Overtorque.

When approval is sought for a transient maximum engine overtorque, the applicant must demonstrate by test, validated analysis, or a combination thereof, that the engine can continue operation after operating at the maximum engine overtorque condition without maintenance action. Upon conclusion of overtorque tests conducted to show compliance with this subpart, or any other tests that are conducted in combination with the overtorque test, each engine part or individual groups of components must meet the requirements of AM1.2729.

AM1.2722 Calibration assurance.

Each engine must be subjected to calibration tests to establish its power characteristics and the conditions both before and after the endurance and durability demonstrations specified in AM1.2723 and AM1.2726.

AM1.2723 Endurance demonstration.

(a) The applicant must subject the engine to an endurance demonstration, acceptable to the Administrator, to demonstrate the engine's limit capabilities.

(b) The endurance demonstration must include increases and decreases of the engine's power settings, energy regeneration, and dwellings at the power settings or energy regeneration for sufficient durations that produce the extreme physical conditions the engine experiences at rated performance levels, operational limits, and at any other conditions or power settings that are required to verify the limit capabilities of the engine.

AM1.2724 Temperature limit.

The engine design must demonstrate its capability to endure operation at its temperature limits plus an acceptable margin. The applicant must quantify and justify the margin to the Administrator. The demonstration must be repeated for all declared duty cycles and ratings, and operating environments, that would impact temperature limits.

AM1.2725 Operation demonstration.

The engine design must demonstrate safe operating characteristics, including but not limited to power cycling, starting, acceleration, and overspeeding throughout its declared flight envelope and operating range. The declared engine operational characteristics must account for installation loads and effects.

AM1.2726 Durability demonstration.

The engine must be subjected to a durability demonstration to show that each part of the engine has been designed and constructed to minimize any unsafe condition of the system between overhaul periods or between engine replacement intervals if the overhaul is not defined. This test must simulate the conditions in which the engine is expected to operate in service, including typical start-stop cycles, to establish when the initial maintenance is required.

AM1.2727 System and component tests.

The applicant must show that systems and components that cannot be adequately substantiated in accordance with the endurance demonstration or other demonstrations will perform their intended functions in all declared environmental and operating conditions.

AM1.2728 Rotor locking demonstration.

If shaft rotation is prevented by locking the rotor(s), the engine must demonstrate:

(a) Reliable rotor locking performance;

(b) Reliable unlocking performance; and

(c) That no hazardous engine effects, as specified in AM1.2717(d)(2), will occur.

AM1.2729 Teardown inspection.

(a) Teardown evaluation.

(1) After the endurance and durability demonstrations have been completed, the-engine must be completely disassembled. Each engine component and lubricant must be eligible for continued operation in accordance with the information submitted for showing compliance with AM1.1529.

(2) Each engine component having an adjustment setting and a functioning characteristic that can be established independent of installation on or in the engine must retain each

setting and functioning characteristic within the established and recorded limits at the beginning of the endurance and durability demonstrations.

(b) Non-Teardown evaluation.

If a teardown cannot be performed for all engine components in a non-destructive manner, then the inspection or replacement intervals for these components and lubricants must be established based on the endurance and durability demonstrations and documented in the ICA in accordance with AM1.1529.

AM1.2730 Containment.

The engine must be designed and constructed to protect against likely hazards from rotating components as follows—

(a) The design of the case surrounding rotating components must provide for the containment of the rotating components in the event of failure, unless the applicant shows that the margin to rotor burst precludes the possibility of a rotor burst.

(b) If the margin to burst shows the case must have containment features in the event of failure, the case must provide for the containment of the failed rotating components. The applicant must define by test, validated analysis, or a combination thereof, and document in the engine installation manual, the energy level, trajectory, and size of fragments released from damage caused by the main rotor failure, and that pass forward or aft of the surrounding case.

AM1.2731 Operation with a variable-pitch propeller.

The applicant must conduct functional demonstrations including feathering, negative torque, negative thrust, and reverse thrust operations, as applicable, with a representative propeller. These demonstrations may be conducted in a manner acceptable to the Administrator as part of the endurance, durability, and operation demonstrations.

AM1.2732 General conduct of tests.

(a) Maintenance of the engine may be made during the tests in accordance with the service and maintenance instructions submitted in compliance with AM1.1529, ICA.

(b) The applicant must subject the engine or its parts to maintenance and additional tests that the Administrator finds necessary if—

(1) The frequency of the service is excessive;

(2) The number of stops due to engine malfunction is excessive;

(3) Major repairs are needed; or

(4) Replacement of a part is found necessary during the tests or due to the teardown inspection findings.

(c) Upon completion of all demonstrations and testing specified in these airworthiness criteria, the engine and its components must be—

(1) Within serviceable limits;

(2) Safe for continued operation; and

(3) Capable of operating at declared ratings while remaining within limits.

AM1.2733 Engine electrical systems.

(a) Applicability.

Any system or device that provides, uses, conditions, or distributes electrical power, and is part of the engine type design, must provide for the continued airworthiness of the engine and maintain electric engine ratings.

(b) Electrical systems.

The electrical system must ensure the safe generation and transmission of power, electrical load shedding, and that the engine does not experience any unacceptable operating characteristics or exceed its operating limits.

(c) Electrical-power distribution.

(1) The engine electrical-power distribution system must be designed to provide the safe transfer of electrical energy throughout the electrical power plant. The system must be designed to provide electrical power so that the loss, malfunction, or interruption of the electrical power source will not result in a hazardous engine effect, as defined in AM1.2717(d)(2).

(2) The system must be designed and maintained to withstand normal and abnormal conditions during all ground and flight operations.

(3) The system must provide mechanical or automatic means to mitigate a faulted electrical-energy generation or storage device from leading to hazardous engine effects, as defined in AM1.2717(d)(2), or detrimental effects in the intended aircraft application.

(d) Protection systems.

The engine electrical system must be designed such that the loss, malfunction, interruption of the electrical power source, or power conditions that exceed design limits will not result in hazardous engine effects, as defined in AM1.2717(d)(2), or detrimental effects in the intended aircraft application.

(e) Electrical Power Characteristics.

The applicant must identify and declare, in the engine installation manual, the characteristics of any electrical power—

(1) Supplied from the aircraft to the engine electrical system, for starting and operating the engine, including transient and steady-state voltage limits, or

(2) Supplied from the engine to the aircraft via energy regeneration, and any other characteristics necessary for safe operation of the engine.

(f) Environmental limits.

Environmental limits that cannot be adequately substantiated by endurance demonstration, validated analysis, or a combination thereof must be demonstrated by the system and component tests in AM1.2727.

(g) Electrical-system failures.

The engine electrical system must—

(1) Have a maximum rate of Loss of Power Control (LOPC) that is suitable for the intended aircraft application;

(2) When in the full-up configuration, be single fault tolerant, as determined by the Administrator, for electrical, electrically detectable, and electronic failures involving LOPC events;

(3) Not have any single failure that results in hazardous engine effects as defined in AM1.2717(d)(2); and

(4) Not have any likely failure or malfunction that leads to local events in the intended aircraft application.

(h) System safety assessment.

The applicant must perform a system safety assessment. This assessment must identify faults or failures that affect normal operation, together with the predicted frequency of occurrence of these faults or failures. The intended aircraft application must be taken into account to assure the assessment of the engine system safety is valid.

SUBPART I—PROPELLER REQUIREMENTS

AM1.2805 Propeller ratings and operating limitations.

Propeller ratings and operating limitations must be established by the applicant and approved by the Administrator, including ratings and limitations based on the operating conditions and information specified in this subpart, as applicable, and any other information found necessary for safe operation of the propeller.

§ 35.7 Features and characteristics.

(a) through (b) [Applicable to Model M001]

AM1.2815 Safety analysis.

(a) The applicant must:

(1) Analyze the propeller system to assess the likely consequences of all failures that can reasonably be expected to occur. This analysis will take into account, if applicable:

(i) The propeller system when installed on the aircraft. When the analysis depends on representative components, assumed interfaces, or assumed installed conditions, the assumptions must be stated in the analysis.

(ii) Consequential secondary failures and dormant failures.

(iii) Multiple failures referred to in paragraph (d) of this section, or that result in the hazardous propeller effects defined in paragraph (g)(1) of this section.

(2) Summarize those failures that could result in major propeller effects or hazardous propeller effects defined in paragraph (g) of this section, and estimate the probability of occurrence of those effects.

(3) Show that hazardous propeller effects are not predicted to occur at a rate in excess of that defined as extremely remote (probability of 10^{-7} or less per propeller flight hour). Because the estimated probability for individual failures may be insufficiently precise to enable the applicant to assess the total rate for hazardous propeller effects, compliance may be shown by demonstrating that the probability of a hazardous propeller effect arising from an individual failure can be predicted to be not greater than 10^{-8} per propeller flight hour. In dealing with probabilities of this low order of magnitude, absolute proof is not possible, and reliance must be placed on engineering judgment and previous experience, combined with sound design and test philosophies.

(b) If significant doubt exists as to the effects of failures or likely combination of failures, the Administrator may require assumptions used in the analysis to be verified by test.

(c) The primary failures of certain single propeller elements (for example, blades) cannot be sensibly estimated in numerical terms. If the failure of such elements is likely to result in hazardous propeller effects, those elements must be identified as propeller critical parts. For propeller critical parts, the applicant must meet the prescribed integrity specifications of AM1.2816. These instances must be stated in the safety analysis.

(d) If reliance is placed on a safety system to prevent a failure progressing to hazardous propeller effects, the possibility of a safety system failure, in combination with a basic propeller failure, must be included in the analysis. Such a safety system may include safety devices, instrumentation, early warning devices, maintenance checks, and other similar equipment or procedures.

(e) If the safety analysis depends on one or more of the following items, those items must be identified in the analysis and appropriately substantiated.

(1) Maintenance actions being carried out at stated intervals. This includes verifying that items that could fail in a latent manner are functioning properly. When necessary to prevent hazardous propeller effects, these maintenance actions and intervals must be published in the ICA required under AM1.1529. Additionally, if errors in maintenance of the propeller system could lead to hazardous propeller effects, the appropriate maintenance procedures must be included in the relevant propeller manuals.

(2) Verification of the satisfactory functioning of safety or other devices at pre-flight or other stated periods. The details of this satisfactory functioning must be published in the appropriate manual.

(3) The provision of specific instrumentation not otherwise required. Such instrumentation must be published in the appropriate documentation.

(4) A fatigue assessment.

(f) If applicable, the safety analysis must include, but not be limited to, assessment of indicating equipment, manual and automatic controls, governors and propeller-control systems, synchrophasers, synchronizers, and propeller thrust reversal systems.

(g) Unless otherwise approved by the Administrator and stated in the safety analysis, the following failure definitions apply to compliance with these airworthiness criteria.

(1) The following are regarded as hazardous propeller effects:

(i) The development of excessive drag.

(ii) A significant thrust in the opposite direction to that commanded by the pilot.

(iii) The release of the propeller or any major portion of the propeller.

(iv) A failure that results in excessive unbalance.

(2) The following are regarded as major propeller effects for variable-pitch propellers:

(i) An inability to feather the propeller for feathering propellers.

(ii) An inability to change propeller pitch when commanded.

(iii) A significant uncommanded change in pitch.

(iv) A significant uncontrollable torque or speed fluctuation.

AM1.2816 Propeller critical parts.

The integrity of each propeller critical part identified by the safety analysis required by AM1.2815 must be established by:

(a) A defined engineering process for ensuring the integrity of the propeller critical part throughout its service life,

(b) A defined manufacturing process that identifies the requirements to consistently produce the propeller critical part as required by the engineering process, and

(c) A defined service-management process that identifies the continued airworthiness requirements of the propeller critical part as required by the engineering process.

§ 35.17 Materials and manufacturing methods.

(a) through (c) [Applicable to Model M001]

§ 35.19 Durability.

[Applicable to Model M001]

AM1.2821 Variable- and reversible-pitch propellers.

(a) No single failure or malfunction in the propeller system will result in unintended travel of the propeller blades to a position below the in-flight low-pitch position. The extent of any intended travel below the in-flight low-pitch position must be documented by the applicant in the appropriate manuals. Failure of structural elements need not be considered if the occurrence of such a failure is shown to be extremely remote under AM1.2815.

(b) For propellers incorporating a method to select blade pitch below the in-flight low-pitch position, provisions must be made to sense and indicate to the flightcrew that the propeller blades are below that position by an amount defined in the installation instructions. The method for sensing and indicating the propeller blade pitch position must be such that its failure does not affect the control of the propeller.

§ 35.22 Feathering propellers.

(a) through (c) [Applicable to Model M001]

AM1.2823 Propeller control system.

The requirements of this section apply to any system or component that controls, limits, or monitors propeller functions.

(a) The propeller control system must be designed, constructed and validated to show that:

(1) The propeller control system, operating in normal and alternative operating modes and in transition between operating modes, performs the functions defined by the applicant throughout the declared operating conditions and approved flight envelope.

(2) The propeller control system functionality is not adversely affected by the declared environmental conditions, including temperature, electromagnetic interference (EMI), high intensity radiated fields (HIRF), and lightning. The environmental limits to which the system has been satisfactorily validated must be documented in the appropriate propeller manuals.

(3) A method is provided to indicate that an operating mode change has occurred if flightcrew action is required. In such an event, operating instructions must be provided in the appropriate manuals.

(b) The propeller control system must be designed and constructed so that, in addition to compliance with AM1.2815:

(1) No single failure results in a hazardous propeller effect;

(2) Local events in the intended aircraft installation will not result in hazardous propeller effects;

(3) The loss of normal propeller pitch control does not cause a hazardous propeller effect under the intended operating conditions; and

(4) The failure or corruption of data or signals shared across propellers does not cause a hazardous propeller effect.

(c) Electronic propeller-control-system embedded software must be designed and implemented by a method approved by the Administrator that is consistent with the criticality of the performed functions and that minimizes the existence of software errors.

(d) The propeller control system must be designed and constructed so that the failure or corruption of aircraft-supplied data does not result in hazardous propeller effects.

(e) The propeller control system must be designed and constructed so that the loss, interruption, or abnormal characteristic of aircraft-supplied electrical power does not result in hazardous propeller effects. The power quality requirements must be described in the appropriate manuals.

§ 35.24 Strength.

[Applicable to Model M001]

§ 35.33 General.

(a) through (c) [Applicable to Model M001]

§ 35.34 Inspections, adjustments, and repairs.

(a) through (b) [Applicable to Model M001]

§ 35.35 Centrifugal load tests.

(a) through (c) [Applicable to Model M001]

§ 35.36 Bird impact.

[Applicable to Model M001]

§ 35.37 Fatigue limits and evaluation.

(a) through (c)(1) [Applicable to Model M001, except replace the reference to § 35.15 with AM1.2815, and the reference to "§ 23.2400(c) or § 25.907" with AM1.2400(c)]

(c)(2) [Not applicable to Model M001]

§ 35.38 Lightning strike.

[Applicable to Model M001]

§ 35.39 Endurance test.

(a) through (c) [Applicable to Model M001, except replace the reference to "part 33" with "these airworthiness criteria"]

AM1.2840 Functional test.

The variable-pitch propeller system must be subjected to the applicable functional tests of this section. The same propeller system used in the endurance test of § 35.39 must be used in the functional tests and must be driven by a representative engine on a test stand or on the aircraft. The propeller must complete these tests without evidence of failure or malfunction. This test may be combined with the endurance test for accumulation of cycles.

(a) Governing and reversible-pitch propellers. Fifteen hundred complete cycles must be made across the range of forward pitch and rotational speed. In addition, 200 complete cycles of control must be made from lowest normal pitch to maximum reverse pitch. During each cycle, the propeller must run for 30 seconds at the maximum power and rotational speed selected by the applicant for maximum reverse pitch.

(b) Feathering propellers. Fifty cycles of feather and unfeather operation must be made.

(c) An analysis based on tests of propellers of similar design may be used in place of the tests of this section.

§ 35.41 Overspeed and overtorque.

(a) through (b) [Applicable to Model M001]

§ 35.42 Components of the propeller control system.

[Applicable to Model M001]

APPENDIX A TO PART 23 - INSTRUCTIONS FOR CONTINUED AIRWORTHINESS

A23.1 through A23.3(g) and A23.4 [Applicable to Model M001]

A23.3(h) [Not applicable to Model M001]

APPENDIX A1 – INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (ELECTRIC ENGINE)

AAM1.2701 General.

(a) This appendix specifies requirements for the preparation of ICA for the engines as required by AM1.1529.

(b) The ICA for the engine must include the ICA for all engine parts.

(c) The applicant must submit to the FAA a program to show how the applicant's changes to the ICA will be distributed, if applicable.

A33.2 Format.

(a) through (b) [Applicable to Model M001]

A33.3 Content.

(a) and (b) [Applicable to Model M001]

(c) [Not applicable to Model M001]

A33.4 Airworthiness limitations section.

(a) [Applicable to Model M001]

(b) [Not applicable to Model M001]

APPENDIX A2 - INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (PROPELLERS)

AAM1.2801 General.

(a) This appendix specifies requirements for the preparation of ICA for the propellers as required by AM1.1529.

(b) The ICA for the propeller must include the ICA for all propeller parts.

(c) The applicant must submit to the FAA a program to show how changes to the ICA made by the applicant or by the manufacturers of propeller parts will be distributed, if applicable.

A35.2 Format.

(a) through (b) [Applicable to Model M001]

A35.3 Content.

(a) through (b) [Applicable to Model M001]

A35.4 Airworthiness limitations section.

[Applicable to Model M001]

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