UK Civil Aviation Authority

UK CAA Hydrogen Challenge

CS-25 Gap Analysis for a Hydrogen Fuel System

CAP 3124

Published by the Civil Aviation Authority 2025

Civil Aviation Authority
Aviation House
Beehive Ring Road
Crawley
West Sussex
RH6 0YR

First published June

Enquiries regarding the content of this publication should be addressed to: content@caa.co.uk

The latest version of this document is available in electronic format at: www.caa.co.uk/CAP3124

Contents

Executive Summary

An initial gap analysis has been conducted for CS-25 Airworthiness requirements in anticipation of the introduction of a Hydrogen Powered Aircraft (HPA).

This would include an aircraft with either a hydrogen gas turbine engine or an aircraft with a Hydrogen Fuel System (HFS) supplying an Electric Propulsion System (EPS).

The gap analysis concludes that a significant update of the current CS-25 requirements would be required to address the introduction of a Hydrogen Powered Aircraft.

Based on a review of the latest CS-25 requirements at Amendment 28, the following changes have been identified and are summarised below:

Proposed Changes to CS-25 requirements / AMCs:

Total number of **CS-25 requirements** – 438

Proposed changes to **CS requirements** – 65 (Approximately 15%)

Total number of **AMCs** – 201

Total number of proposed changes to **AMCs** – 46 (Approximately 22%)

Proposed Changes to CS-25 Appendices

Total number of CS-25 **Appendices** – 16

Total number of proposed changes to CS-25 **Appendices** - 3 (Approximately 18%)

The change to the current CS-25 requirements (including AMC Material) will not be possible in the short-term due to level of co-ordination and consultation with other Authorities and the Public.

However, a Generic Special Condition or number of Certification Review Items (CRIs) for a Hydrogen Fuel System could be used to address a Type Certification (TC) or Supplemental Type Certification (STC) application.

The proposed Special Condition would be based on the highlighted areas of the CS requirements that have been identified in the Gap Analysis, which are summarised in **Tables 1 and 2** of this report.

The information in **Table 3** provides a list of proposed CRIs that could be used for a TC / STC application for a Hydrogen Powered Aircraft.

Additional Work:

It is considered that in addition to the CS-25 gap analysis, a similar analysis would be required for CS -E (Engines) to address the possibility of a Hydrogen Gas Combustion Engine.

The development of a **UKTSO** (UK Technical Standard Order) should also be considered to cover the requirements for a stand-alone approval of a Hydrogen Fuel Cell, as this would assist with the Certification process for a TC / STC application.

Definitions

The following are some definitions of terms used in this document.

Acceptable Means of Compliance (AMC) are non-binding. The AMC serves as a means by which the requirements contained in the Basic Regulation, and the IR, can be met. However, applicants may decide to show compliance with the requirements using other means. Both NAAs and organisations may propose alternative means of compliance. 'Alternative Means of Compliance' are those that propose an alternative to an existing AMC. Those Alternative Means of Compliance proposals must be accompanied by evidence of their ability to meet the intent of the IR. Use of an existing AMC gives the user the benefit of compliance with the IR.

Certification Specifications (CS) are non-binding technical standards adopted by the CAA to meet the essential requirements of the Basic Regulation. CSs are used to establish the certification basis (CB) as described below.

Special Conditions (SC) are non-binding special detailed technical specifications determined by the NAA if the certification specifications established by the CAA are not adequate.

Special Conditions, like Certification Specifications, become binding on an individual basis to the applicant as part of an agreed Certification Basis.

Guidance Material (GM) is non-binding explanatory and interpretation material on how to achieve the requirements contained in the Basic Regulation, the IRs, the AMCs and the CSs. It contains information, including examples, to assist the user in the interpretation and application of the Basic Regulation, its IRs, AMCs and the CSs.

Introduction

This document provides an initial gap analysis of Certification Specifications (CS-25) requirements for a Hydrogen Powered Aircraft. The gap analysis looks at the potential changes that would be required to existing certification requirements to address the main airworthiness/safety considerations for a Hydrogen Powered Aircraft and includes a review of the associated Acceptable Means of Compliance (AMC).

Based on developing technology, there is the possibility that a Hydrogen Fuel System will be used for a large transport aircraft to supply electrical power to an electrically driven propulsion system or used to supply Hydrogen as a fuel for a Hydrogen Combustion Engine (HCE).

The Hydrogen Fuel System would require Hydrogen Fuel Cells, a storage system for the Liquid / Gaseous Hydrogen, a distribution system for the connected systems and the necessary Control and Monitoring systems.

Hydrogen Fuel Systems will introduce safety hazards that are not adequately addressed by the current Certification Specifications (CS-25) for a large transport aircraft.

It is important to identify the certification challenges and to properly identify any safety concerns that may result from the introduction of a Hydrogen Fuel System on an aircraft that will be certificated to CS-25 requirements.

Scope of the gap analysis

A gap analysis using the Certification Specification, CS-25 at Amendment 28, has been performed to identify any specific requirements that may require an update to address a Hydrogen Fuel System. This includes a review of associated Acceptable Means of Compliance (AMCs), Appendices and General AMCs, which are included in the CS-25 Requirements.

The gap analysis is the first step in understanding the gaps in current certification requirements and provides indicators as to potential needed to address these areas to enable certification of a new or modified aircraft. and later reaching a set of Certification Review Items (CRIs), Special Conditions (SCs), Guidance Material (GM), Acceptable Means of Compliance (AMC) and other applicable material to be

able to guide industry in certification of an aeroplane which utilises a Hydrogen Fuel System.

CS-25 Gap analysis overview

There is a growing need to ensure that Certification requirements are updated to enable the safe certification of new technologies.

A gap analysis is the first step to identify whether existing requirements are applicable to the new technologies.

For new and novel technologies, it is often necessary to adopt a Special Condition to address the shortfalls in the Certification requirements.

The FAA report Energy Supply Device Aviation Rulemaking Committee DOT/FAA/TC-19/16 final report dated April 2019 (Reference 2) contains a CFR /CS-25 Gap Analysis for a Hydrogen Fuel Cell and has been used to compile some of the aircraft level Gap Analysis for a Hydrogen Powered Aircraft.

The current Certification requirements for a “turbine powered” Large Aeroplane is CS-25.

CS-25 is divided into the following subparts:

Subpart A: General

Subpart B: Flight

Subpart C: Structures

Subpart D: Design and Construction

Subpart E: Powerplant

Subpart F: Equipment

Subpart G: Operating Limitations and Information

Subpart H: Electrical Wiring Interconnection Systems

Subpart J: Auxiliary Power Unit Installations

Appendices to CS-25 – A, C, D, F, H, I, J, K, L, M, N, O, P, Q, R, S.

General AMCs.

The Gap Analysis for CS-25 is provided in Table 1 of this report and was based on current information from industry / academia. The table summarises the proposed changes to the current CS-25 Certification / AMC.

In addition, Table 2 provides the proposed changes to CS-25 Appendices and Table 3 provides the proposed Special Condition (SC) / Certification Review Items (CRIs) that may be necessary for the certification of a Hydrogen Powered Aircraft.

Gap analysis conclusions

The conclusions from the CS-25 gap analysis are summarised as follows:

The following identifies each of the CS-25 Subparts and CS requirements where it is considered that a change to the Requirement or AMC (including Appendices) may be required based on the introduction of a Hydrogen Fuel System.

In the longer term, it may be possible to make changes to the CS-25 requirements as part of the amendment process. However, it the short term, it may be necessary to create Special Conditions and Certification Review Items, to cover the shortfall in the CS-25 requirements regarding the introduction of a Hydrogen Fuel System.

Fuel Cell – Special Condition

It is considered that a generic Special Condition may be required to specifically address the use of a Hydrogen Fuel Cell and the associated safety concerns. This has been documented in the FAA report (Reference 2).

Proposed Changes to CS-25 Subparts

The changes identify the specific CS-25 Certification requirements / AMCs that need to be considered either as an Amendment to the CS-25 requirements / AMCs or raised as a CRI/Special Condition for a Hydrogen Fuel System.

Refer to Table 1 - Proposed Changes to CS-25 requirements / AMCs and Table 2 - Proposed Changes to CS-25 Appendices.

Proposal of Certification Review Items (CRIs) / Generic Special Condition

Refer to Table 3 – Hydrogen Powered Aircraft (HPA) – Proposed Special Condition (SC) / Certification Review Items (CRIs

The gap analysis has identified potential Certification Review Items (CRIs) for any future Type Certification (TC) or STC (Supplemental Type Certification) application.

The CRIs would Impact the majority pf the Certification Panels.

The CRIs could also be used as the basis for a Hydrogen Powered Aircraft “Generic Special Condition”.

Next steps

The next steps in the gap analysis would be to perform a detailed assessment for each of the CS-25 Subparts. This could involve the various Subject Matter Experts from the departments in the UK CAA providing feedback and inputs into each Subpart. A set of draft Special Conditions or CRI’s have been included in the report. Industry / EUROCAE Working Group could also be contacted to provide their feedback on the gap analysis. A comparison with industry gap analysis could then be performed.

It is understood that EUROCAE WG-80 Sub-Group has a Task to review the current CS-25 requirements and produce a gap analysis for a Hydrogen Powered Aircraft.

List of Abbreviations

AMC – Acceptable Means of Compliance

CS – Certification specifications

CRI – Certification Review Item

FCS – Fuel Cell System

H2 – Hydrogen

HMS – Hydrogen Management System

HPA – Hydrogen Powered Aircraft

SC – Special Conditions

SME – Subject Matter Expert

STC – Supplemental Type Certification

TC – Type Certification

References

1. Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes (CS-25)

2. Energy Supply Device Aviation Rulemaking Committee – DOT/FAA/TC-19/16 (April 2019)

Table 1 - Proposed Changes to CS-25 requirements / AMCs

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart A – General	CS 25.1 Applicability	1. Scope and applicability need to be extended beyond "turbine powered". 2. Hydrogen fuelled gas turbines will be within the current scope and applicability of CS 25. 3. Need to account for possibility for a Hydrogen/ Electric Propulsion system. Note: There will be ramifications for CS-E, which will need addressed in a similar Gap Analysis.	No AMC.
Subpart B – Flight	CS 25.23 Load distribution limits	No change anticipated.	1. New AMC 25.23 - Impact of gaseous hydrogen tank weight, reduction in the difference between Maximum Take Off Weight (MTOW) and Maximum Landing Weight (MLW) and maintaining an adequate static margin for longitudinal stability. 2. LH2 tanks may be even more demanding with respect to weight. These tanks may require passive or active thermal protection schemes.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart B – Flight	CS 25.25 Weight Limits	No change anticipated.	1. New AMC 25.25 - Impact of gaseous hydrogen tank weight, reduction in the difference between Maximum Take Off Weight (MTOW) and Maximum Landing Weight (MLW) and maintaining an adequate static margin for longitudinal stability. 2. New AMC 25.25- LH2 tanks may be even more demanding with respect to weight. These tanks may require passive or active thermal protection schemes.
	CS 25.27 Centre of gravity limits	No change anticipated.	New AMC 25.27 - Impact of gaseous hydrogen tank weight, reduction in the difference between Maximum Take Off Weight (MTOW) and Maximum Landing Weight (MLW) and maintaining an adequate static margin for longitudinal stability.
	CS 25.121 Climb: one-engine-inoperative	No change anticipated.	New or revised AMC for CS-25.121 Climb one engine inoperative
	CS 25.143 General	No change anticipated.	New or revised AMC to CS 25.143(a) and (b) Control and manoeuvrability as regards to the effect of installed heavy Hydrogen tanks.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart C – Structure	CS 25.561 General	The hydrogen tank and fuel cell system installation shall be able to withstand the expected loads in case of an emergency landing.	New or revised AMC to CS 25.561(c) Emergency landing Conditions – LH2 Fuel System.
	CS 25.563 Structural ditching provisions	1. Specific requirement may be required to address ditching and precautions required to prevent contact with LH2 fuel system elements. 2.LH2 ignites on contact with water so what design precautions are taken to prevent this?	New AMC will be needed with respect to ditching with a cryogenic LH2 fuel system. What happens if the water contacts the LH2 fuel system elements? LH2 ignites on contact with water so what design precautions are taken to prevent this?
Subpart D – Design and Construction	CS 25.603 Materials	No change anticipated.	1. This requirement is used for aircraft structures only. The fuel cell systems include vessels containing the hydrogen which are often (partially) made of composite materials. The AMC 20-29 (Composite Aircraft Structure) is applicable but should be reviewed and changed to support these kinds of vessels. 2. New AMC or Guidance needed on a materials susceptibility to hydrogen permeation and acceptable rate of permeation – particularly for composite materials.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart D – Design and Construction	CS 25.613 Material strength properties and Material Design Values	No change anticipated.	1. New or revised AMC CS 25.613 Material strength properties at cryogenic temperatures based on ANSI/AIAA G-095A Sections 6.3 Thermal Considerations in Material Selection. 2. In addition to strength at cryogenic temperature hydrogen embrittle for certain metals needs consideration as hydrogen absorption can result in changed mechanical properties leading to reduced ductility.
	CS 25.801 Ditching	1. Specific requirement may be required to address ditching and precautions required to prevent contact with LH2 fuel system elements. 2. LH2 ignites on contact with water so what design precautions are taken to prevent this?	AMC will be needed with respect to ditching with a cryogenic LH2 fuel system. What happens if the water contacts the LH2 fuel system elements? LH2 ignites on contact with water so what design precautions are taken to prevent this?
	CS 25.803 Emergency evacuation	No change anticipated.	New or revised AMC 25.803 Emergency evacuation in the presence of buoyant and invisible hydrogen flames.
	CS 25.809 Emergency exit arrangement	1. Specific requirement may be required to address ditching and precautions required to prevent contact with LH2 fuel system elements. 2. LH2 ignites on contact with water so what design precautions are taken to prevent this?	New or revised AMC 25.809(a)(2) Emergency evacuation in the presence of buoyant and invisible hydrogen flames.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart D – Design and Construction	CS 25.831 Ventilation	1. Hazard of asphyxiation, harmful chemical generation. Noxious gases generated in case of fire. Leakages in system due to possible failures like cell reversal or brittle fracture of ceramic electrolyte. 2. Paragraph (b) addresses safe levels of CO and CO2. With the addition of hydrogen as a fuel and cryogenic cooling (Helium), this paragraph needs expanding to address these specific pollutants with respect to: a) Quality of air in crew and passenger compartments b) Maintain levels of hydrogen below 2% in relation to explosive quantities (maybe covered by another paragraph). 3. Review required as to positioning of extinguishers, with propulsion system compartment now directly rearward of passenger compartment as part of the main fuselage there should perhaps be additional requirements both for passenger and propulsion system compartments to have additional/different extinguisher systems and perhaps different agents that take care of fires from hydrogen/helium/fuel cell materials. Perhaps whole new CS paragraph to address propulsion system compartment.	New AMC to address proposed changes to CS 25.831 Requirements.
	CS 25.856 Thermal/acoustic insulation materials	Identifies that materials in fuselage must meet flame propagation requirements of Part V of Appendix F to CS-25. Perhaps specific section or CS paragraph specific to the propulsion system compartment and having fireproof or flame-retardant materials specific to the gases/liquids in the propulsion system compartment, Hydrogen/Helium which may have different fire intensity considerations	New or revised AMC and Guidance on damage to thermal insulation material for cryogenic liquid hydrogen fuel system elements, but not necessarily within the fuselage.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart D – Design and Construction	CS 25.863 Flammable fluid fire protection	No change anticipated.	1. New or revised AMC to 25.863 Flammable Fluid Fire Protection to provide information about flammability limits and characteristics of H2 leakage into zones adjacent to H2 fuel systems. 2. Refers to leakage of flammable fluids or vapours, there must be a means to minimise probability of ignition and resultant hazards if ignition does occur. Potential for a more expansive version of this requirement due to now having Hydrogen and potential for explosion - needs addressed more specifically when all risks are fully understood. Risk with Helium too.
	CS 25.869 Fire protection: systems	CS 25.869 - Add a new subparagraph (d) for hydrogen lines in equivalence with existing (c) for O2 lines.	New AMC for hydrogen lines.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart D – Design and Construction	CS 25.899 Electrical bonding and protection against static electricity	No change anticipated.	1. AMC needs to be reviewed with respect to hydrogen system components and may require specific guidance in section 3 relating to the Accumulation of static charges during refuelling and fuel transfer (LH2 and GH2). 2. Perhaps more expansive requirements / specs required in view of having flammable Hydrogen onboard as part of the propulsion system and near electrical system.
Subpart E – Powerplant	CS 25.901 Installation	CS 25.901 (a) to (c) defines "powerplant installation" and "powerplant" and what is included therein. Hydrogen system needs to be defined.	1. AMC identifies electrical bonding specific to the "Engine". Needs to address Hydrogen components. 2. AMC Safety Assessment needs to include Hydrogen System.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.903 Engines	1. Should be explained what intent is for fuel cell system. What about other sub requirements? (f) depending on whether system support non-essential / essential APU. 2. Makes the whole reference to "engine" according to CS-E. 3. Paragraph (e) refers to restart capability with respect to altitude and airspeed envelope which will need redefining with respect to a hybrid propulsion system. Paragraph (b) refers to engine isolation such that any engine or system failure that can affect the engine will not prevent continued operation of the other engine or require immediate crew attention. 4. Will there be a different definition of "engine" c.f. e.g. propulsion system. 5. Theoretically restart will be possible at all corners of the flight (altitude/airspeed) envelope but may be determined / limited by available power - controlling parameters of restart require redefining. Paragraph (b) perhaps needs expansion in terms of propulsion system such as electrical power?	1. New or revised AMC 25.903(e)(2)/E 910 Relighting In-Flight. Not related to regulation – but relevant background information from engine manufacturers. 2. New or revised AMC 25.903(d)(1) Torching Flame as regards H2 flame temperature (cf. kerosene). There are established test methods and equipment for assessing suitability and compatibility of materials in contact with GH2/LH2.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.939 Turbine engine operating characteristics	1. Paragraph (a) refers to turbine engine operating characteristics being investigated to determine that no adverse characteristics such as stall/surge/flame out are present to a hazardous degree. 2. Gas turbine may no longer be present and there are other possibilities e.g. large fan powered by an electrical motor so this paragraph will need reworded accordingly as flame out would no longer be relevant and is more akin to loss of electrical power. Compressor stall/surge no longer relevant. 3. A hydrogen fuelled gas turbine introduces the potential hazard of deflagration to detonation transition. If the engine floods with a flammable mixture of air and hydrogen, there is the risk that the very fast-moving hydrogen flame front supplies enough heat through adiabatic compression to ignite the entire mixture. Perhaps a concern for starting and inflight relight.	New or revised AMC for new requirements.
	CS 25.943 Negative acceleration	No hazardous malfunction of an engine or any component or system associated with the powerplant may occur when the aeroplane is operated at the negative accelerations within the flight envelopes prescribed in CS 25.333. This must be shown for the greatest duration expected for the acceleration. (See also CS 25.1315.) Powerplant needs to be defined.....propulsion system? EHPS?	No AMC.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.951 General	1. CS 25.951(a) - Proposal to extend the wording in this regulation as needed to say Fuel / Reactant supply system. 2. Specifies general fuel requirements to ensure fuel flow rate and pressure is sufficient for all operating conditions and to ensure flameout will not occur. Sustained operation must prevail with specified water saturation. Fuel in the context of this paragraph relates to a gas turbine/prop, i.e. conventional aviation fuel/gasoline/petrol. 3. Needs a complete rewrite as hydrogen no longer feeds to an engine but instead fuels the fuel cell to create electricity. No longer relevant in its current form. Water saturation levels will also not be relevant. Control of hydrogen quality as a fuel to be defined. 4. A cryogenic hydrogen fuel system would also have to supply fuel in the correct thermodynamic state, particularly for a hydrogen combusting gas turbine.	No AMC.
	CS 25.952 Fuel system analysis and test	1. CS 25.952(a) - Proposal to extend the wording in this regulation as needed with "Fuel / Reactant Supply System". 2. CS 25.952(B) - Proposal to extend the wording in this regulation as needed with "Fuel / Reactant Supply System". 3. Needs a rewrite in line with hydrogen being the "fuel".	No AMC.
	CS 25.953 Fuel system independence	Needs to be rewritten to reference to "fuel cells" rather than "engines". Subsequent wording required to be specific to the fuel cell stacks and that redundancy is built into the system if fuel cells stack(s) may fail during operation/flight.	No AMC.
	CS 25.954 Fuel system lightning protection	Needs to be reworded specific to hydrogen and the different/heightened risk(s) of combustion.	New or revised AMC for change to Requirements.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.955 Fuel flow	1. CS 25.955(a) - The relevant parts of this requirement should be reworded for the fuel cell system. 2. Identifies "engine" being supplied with fuel – there may be fuel cells being supplied with fuel creating electrical power which is fed to the engines. 3. CS 25.955(b) - Proposed wording to cover fuel cell system: Add a new (b)(3): If a fuel cell stack can be supplied with reactants from more than one reactant tank, the reactant supply system. ”- For each fuel cell stack, in addition to having appropriate manual switching capability, be designed to prevent interruption of reactant flow to that stack, without attention by the flight crew, when any tank supplying reactants to that stack is depleted of usable reactants during normal operation, and any other tank, that normally supplies reactants to that stack alone, contains usable reactants.	New or revised AMC for change to CS requirements.
	CS 25.957 Flow between interconnected tanks	CS 25.957 - Needs to be rewritten: Replace fuel by fuel / reactants.	No AMC.
	CS 25.959 Unusable fuel supply	CS 25.959 - Needs to be rewritten: Replace fuel by fuel / reactants and engine by engine & fuel cell system.	No AMC.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.961 Fuel system hot weather operation	1. Sets out fuel requirements under hot weather operations. 2. Identifies "engine malfunction" which perhaps not relevant in the context of we supply fuel cells so perhaps fuel cell malfunction requires consideration. Engines are supplied by electrical power so the whole chain of events differs compared to a standard gas turbine. Paragraph (a) (5) also specifies a minimum fuel temperature of 43.3C (110F) which is not applicable to hydrogen.	No AMC.
	CS 25.963 Fuel tanks: general	1. CS 25.963(a)(d) - Revision needed: Replace the word “fuel’ with the phrase “fuel / reactant”. 2. Each fuel cell system supplying fuel/reactant tank must be able to withstand without failure, the vibration, inertia, fluid, and structural loads that it may be subjected to in operation. 3. Sets the general requirements for fuel tank design, inspection, maintenance, location, strength, fire resistance……etc. 4. Identifies "engine malfunction" which perhaps not relevant in the context of fuel cells so fuel cell malfunction will require consideration. Electric Propulsion System is supplied with electrical power so the whole chain of events differs compared to a standard gas turbine. Paragraph (a) (5) also specifies a minimum fuel temperature of 43.3C (110F) which is not applicable to Hydrogen.	1. AMC 25.963(a)(d) - Revision needed: Replace the word “fuel’ with the phrase “fuel / reactant”. 2. New or revised AMC for changed Requirements.
	CS 25.965 Fuel tank tests	May require a rewrite for hydrogen tanks.	AMC may require additional information for hydrogen tanks.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.967 Fuel tank installations	1. CS 25.967(a) - Revision is needed: Replace fuel by fuel / reactant. 2. CS 25.967(b) - Revision is needed: replace drain holes by drain and ventilation holes. 3. CS 25.967 (c) - Revision is needed: replace fuel-proof by fuel / reactant-proof. 4. Needs reviewed / rewritten specific to Hydrogen tank requirements. 5. Hydrogen fuel tank installations will be like ACTs and Trim tanks on today's aeroplanes so AC 25-8 Auxiliary Fuel Systems would be a good starting point.	New or revised AMC to address Hydrogen fuel tank.
	CS 25.969 Fuel tank expansion space	1. Fuel tank expansion space requirements of not less than 2% of tank capacity. 2. Hydrogen differs from kerosene so needs a rewrite. 3. Conventional kerosene tanks are vented to ambient air pressure and not filled beyond 98% to allow for fuel expansion. Under no circumstances whatsoever should air be present in a hydrogen fuel tank (GH2 explosion risk, LH2 freezing of O2 with an even greater explosion risk).	No AMC.
	CS 25.971 Fuel tank sump	1. Sump capacity and drainage requirements which will need reassessment according hydrogen sump capacity and drainage. 2. Air contamination of a LH2 tank will result in freezing of H2O, H2 and O2 and it will extremely be difficult to "drain" this cryogenic "grit".	No AMC.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.973 Fuel tank filler connection	1. More stringent requirements may be required for Hydrogen in terms of cooling, H2 content in air (2%). 2. Proposed CRI/Special Condition for 25.973 Fuel tank filler connection.	No AMC.
	CS 25.975 Fuel tank vents	Venting requirements specific to H2 tanks need defined.	AMC on air/fuel ratio mixes will need to be amended to address hydrogen/air mixes
	CS 25.977 Fuel tank outlet	Defines fuel strainer for fuel tank outlet or booster pump. Requires consideration for hydrogen fuel strainer requirements.	No AMC.
	CS 25.979 Pressure fuelling system	Defines requirements for pressure fuelling systems. Paragraph requires reconsideration regarding pressure fuelling for Hydrogen as opposed to aviation fuel.	New or revised AMC 25.979(d) Pressure fuelling system.
	CS 25.981 Fuel tank explosion prevention	Rewrite required specific to Hydrogen tanks and the inherent risks.	1. New or revised AMC for CS 25.981(a) Ignition Source Prevention and to outline different ignition energies for H2 and different ignition sources such as solid oxygen. 2. New or revised AMC CS 25.981(d) CDCCLs (Critical Design Configuration Control Limitations) to define typical features of H2 fuel systems to be defined as CDCCL.
	CS 25.991 Fuel pumps	Needs a rewrite in line with hydrogen being the "fuel".	No change anticipated.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.993 Fuel system lines and fittings	Needs a review for hydrogen lines with hydrogen having different operating conditions (Very cold) and leakage and handling requirements. Insulation, fire cryogenic?	No AMC.
	CS 25.994 Fuel system components	Refers to "fuel system components" being protected sufficient to ensure that in event of wheels up landing on paved runway (25.721), fuel spillage insufficient to result in fire hazard. May require a better definition of what constitutes fuel system components?	New or revised AMC may be required to address hydrogen fuel tank and hydrogen fuel system.
	CS 25.997 Fuel strainer or filter	Rewording required specific to a hydrogen fuel system and required strainers/filters……if any.	No AMC.
	CS 25.999 Fuel systems drains	Consideration to be given to any hydrogen specific requirements pertaining to system drains.	No AMC.
	CS 25.1001 Fuel jettisoning system	1. Consideration to be given to any hydrogen specific requirements pertaining to jettisoning. 2. Hydrogen is a highly galvanometrical energetic fuel, jettisoning hydrogen would do little to reduce the aeroplane's weight, but the hydrogen tanks are where the weight is located.	No AMC.
	CS 25.1041 General	Requirement is specific to powerplant components and engine fluids. Rewording required to address potential for cryogenic cooling of electrical system and other impacted units/systems. May require a separate paragraph specific to cryogenic systems / components.	No AMC.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.1043 Cooling tests	Acceptable as is but may need additional information in terms of ensuring that sufficient cryogenic cooling is provided at all levels of electrical current sufficient to maintain electrical system operating temperatures.	AMC needs to be revised for cryogenic cooling.
	CS 25.1045 Cooling test procedures	Although CS 25.1041 to CS 25.1045 is generically still applicable it is perhaps necessary to have more extensive specifications appropriate to usage of cryogenics in the propulsion system.	No AMC.
	CS 25.1091 Air intake	In paragraph (a)(2), it refers to "fuel metering and mixture distribution" which may not be applicable to a specific hydrogen system.	AMC 25.1091(e) may require update for Hydrogen system air intake - where applicable.
	CS 25.1093 Air intake system de-icing and anti-icing provisions	Paragraph (b) is specific to "turbine engines" in the conventional meaning (gas turbine) - Hydrogen or electric propulsion needs to be considered.	AMC 25.1093(b)refers to power plant icing - Hydrogen or electric propulsion needs to be considered.
	CS 25.1103 Air intake system ducts and air duct systems	Acceptable but may need adapting, as engine surging (b)(1) not applicable, as there is no compressor - fan flutter/stall?	AMC 25.1103(d) may need to consider H2 system with air intake.
	CS 25.1143 Engine controls	Paragraphs (d) & (e) refer to fuel injection and fuel shut off - may require rewording/rewriting appropriate to hydrogen fuel tank and system.	No AMC.
	CS 25.1145 Ignition switches	References "engine ignition" which is perhaps not appropriate terminology for hydrogen system……fuel cell activation?	No AMC.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant **SUBPART E – POWERPLANT**	CS 25.1165 Engine ignition systems	Rewrite required as the entire propulsion system may be electrically driven based upon hydrogen fed Fuel Cells. Engine ignition is not a single event and more a sequence of individual systems - Hydrogen to Fuel Cells to Electricity to Electric Motor.	No AMC.
	CS 25.1181 Designated fire zones: regions included	1. A fuel cell is not a combustion engine, but some work with high temperatures (e.g., SOFC - Solid Oxide Fuel Cell). 2. Needs a rewrite considering propulsion system now incorporated into the aircraft fuselage with new constituent systems including fuel cells, H2, Cryogenic, resulting in alternative fire requirements/zoning.	No change anticipated.
	CS 25.1182 Nacelle areas behind firewalls, and engine pod attaching structures containing flammable fluid lines	No change anticipated.	No change anticipated.
	CS 25.XXXX	Need to consider a Fuel Cell fire withstanding zone for Fuel Cell fire containment. This would be based on CS.1182.	AMC may be required for the new Requirement.
	CS 25.1183 Flammable fluid-carrying components	Will need a rewrite regarding the inclusion of hydrogen into the propulsion system and inherent fire/explosive considerations that need to be addressed. Also, propensity for fuel cell-initiated fire/overheating.	No AMC.
	CS 25.1185 Flammable fluids	Will need a rewrite regarding the inclusion of hydrogen into the propulsion system and inherent fire/explosive considerations that need to be addressed. Also, propensity for fuel cell-initiated fire/overheating.	New AMC 25.1185(c) Flammable fluids.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart E – Powerplant	CS 25.1187 Drainage and ventilation of fire zones	CS 25.1187 (e) - As for designated fire zone, needs to be addressed in fuel cell system safety baseline regulation.	No AMC.
	CS 25.1189 Shut-off means	CS 25.1189(b)- Propose to add following for fuel cells: The closing of any reactant shutoff valve for any fuel cell stack may not make reactants unavailable for the remaining stacks. CS 25.1189 (e) - This regulation is applicable for fuel cell systems. Replace the word “drain” with the phrase “drain or vent.” The advisory material to the new fuel cell system safety baseline regulation should include wording on means to shut-off, as one of the possibilities regarding the new regulation. e.g. Means must be available for controlling or extinguishing a fire, such as stopping flow of fluids, gasses, or vapours, shutting down equipment, fire containment, or use of extinguishing agents.	New AMC may be required for change in Requirements.
	CS 25.1195 Fire-extinguisher systems	1. Rewording for specific aspects hydrogen systems, i.e. paragraph (a) refers to turbine engine installations, turbine & combustor. 2. The only effective way to extinguish a hydrogen fire is to shut-off H2 and LH2 supplies.	New AMC may be required to address hydrogen systems.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart F – Equipment	CS 25.1329 Flight Guidance System	No change anticipated.	New or revised AMC 25.1329 Flight Guidance System and contrail avoidance algorithms.
	CS 25.1337 Powerplant instruments	Specifics may be required in relation to hydrogen and fuel cell monitoring. Also, specific to cryogenic fluid monitoring.	No AMC.
	CS 25.1351 General	Need to account for electrical power system used as the primary means of propulsion using hydrogen fuel cells as the source of electrical energy.	New or revised AMC to cover H2 system.
	CS 25.1353 Electrical equipment and installations	May need a review to include hydrogen fuel cells.	New or revised AMC to cover H2 system.
	CS 25.1419 Ice Protection	Some wording may require reshaping such as "turbine engine powered aeroplanes" in paragraph (d).	New or revised AMC for thermal analysis.
	CS 25.1433 Vacuum systems	1. Needs to be expanded to account for hydrogen vacuum systems (hydrogen tank).	No AMC.
	CS 25.1435 Hydraulic Systems	CS 25.1435(a), (b), (c) - A similar regulation for high pressure H2 storage vessels needs to be developed.	New or revised AMC will also be required.
	CS 25.1436 Pneumatic systems – high pressure	CS 25.1436(a), (b), (c) - Appendix L may need to be revised to address the high-pressure parts of a fuel cell system.	New or revised AMC will also be required.
	CS 25.1438 Pressurisation and low-pressure pneumatic systems	1. CS 25.1438 - A similar regulation applicable for the high-pressure parts of a fuel cell system should be written. 2. Needs expansion/rewording to address the requirements of the compressor air used to feed the fuel cells.	New or revised AMC will also be required.

Subpart	Section	Change to CS-25 Requirements	Change to AMCs
Subpart G – Operating Limitations and Information	CS 25.1557 Miscellaneous markings and placards	CS 25.1557(b) - Revise to account for H2 fuel refilling. This could be accomplished by replacing the word “fuel” with “fuel and reactants”	No change anticipated.
	CS 25.1705 Systems and Functions; EWIS	25.1705(b) - Add reference to 25.XXX Hydrogen Fuel Cell System Safety.	No AMC.
	CS 25.1707 System Separation; EWIS	1. 25.1707 - Proposal to add a new paragraph (m) based on existing paragraph (g) for O2 “Except to the extent necessary to provide electrical connection to hydrogen storage components and lines, EWIS must be designed and installed with adequate physical separation from hydrogen lines and other hydrogen system components, so that a EWIS component failure will not create a hazardous condition. 2. Or, based on 25.1707(e) (fuel lines and fuel system components): Except to the extent necessary to provide electrical connection to the fuel systems components, the EWIS must be designed and installed with adequate physical separation from fuel lines and other fuel system components, so that: (1) A EWIS component failure will not create a hazardous condition. (2) Any fuel leakage onto EWIS components will not create a hazardous condition.	Revised AMC may be required specific to H2 system
	CS 25.1723 Flammable fluid protection; EWIS	Revise this to add flammable gas (i.e., for the H2 gas). So, it would say: "…in each area where flammable fluid, gas, or vapours might escape...".	No change anticipated.

Table 2 - Proposed Changes to CS-25 Appendices

CS-*25* APPENDICES	
Appendix F	1. New or revised part to CS 25 Appendix F Flammability of Materials in a Low-Concentration Hydrogen Environment based on DOT/FAA/TC-17/23. 2. New or revised part to CS-25 Appendix F Electrical System Components to define test criteria and procedure for self-extinguishing of fuel cell fires once H2 and air supplies are stopped.
Appendix H – Instructions for Continued Airworthiness	New or revised AMC Appendix H Instructions for Continued Airworthiness with respect to hydrogen leakage. “Stains” and “Seeps” in conventional kerosene wing tanks are termed “minor leaks” and require recording and documenting. “Heavy Seeps” and “Runs” require rectification at the next tank opening or scheduled maintenance and must be fully documented. kerosene leaks of more than 10 drips per minute are unacceptable (AMC 25.963(e) defines hazardous leaks).
Appendix I	Add information related to the high-pressure parts of a fuel cell system.
Appendix M – Fuel Tank Flammability Reduction Means (FRM)	1. Requirement currently specific for kerosene fuel systems. 2. Delete and develop new Appendix or possibly amend to include requirements specific for H2 fuel systems.
Appendix N – Fuel Tank Flammability Exposure	1. Methodology specific for kerosene fuel systems to comply with Appendix M and therefore not relevant for H2 fuel systems. 2. Applicable to kerosene fuel tanks only, based on kerosene flash point to get into vapour phase and then mixing with air in the tank. Hydrogen tanks must not have any air in them whatsoever. Completely new guidance needed for areas adjacent to hydrogen fuel systems where leaked/permeated hydrogen could mix with air to form a flammable mixture.

Table 3 – Hydrogen Powered Aircraft (HPA) – Proposed Special Condition (SC) / Certification Review Items (CRIs)

Subpart	Section	Statement of Issue
Subpart A – General	CS 25.1 Applicability	Applicability to be extended beyond “turbine powered” to cover Electric Propulsion System (EPS). The EPS would be supplied with electrical energy from a Hydrogen Fuel Cell System.
Subpart C - Structure	CS 25.561 General	The hydrogen tank and fuel cell system installation shall be able to withstand the expecting loads in case of an emergency landing.
	CS 25.563 Structural ditching provisions	Needs to address ditching and precautions required to prevent contact with LH2 fuel system elements.
Subpart D – Design & Construction	CS 25.801 Ditching	Specific requirement may be required to address ditching and precautions required to prevent contact with LH2 fuel system elements
	CS 25.809 Emergency exit arrangement	Need to address ditching and precautions required to prevent contact with LH2 fuel system elements.
	CS 25.831 Ventilation	Need to consider hazard of asphyxiation, harmful chemical generation. Noxious gases generated in the event of a fire and leakages in the system due to possible failures like cell reversal or brittle fracture of ceramic electrolyte.

Subpart	Section	Statement of Issue
Subpart D – Design & Construction	CS 25.856 Thermal / acoustic insulation materials	Paragraph specific to the propulsion system compartment and having fireproof or flame-retardant materials specific to the hydrogen gases/liquids.
	CS 25.869 Fire protection: systems	Requires a new subparagraph (d) for hydrogen lines in equivalence with existing (c) for O2 lines.
Subpart E – Powerplant	CS 25.901 Installation	CS 25.901 (a) to (c) defines "powerplant installation" and "powerplant" and what is included therein. Hydrogen system needs to be defined.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.903 Engines	Needs to explain what intent is for fuel cell system. What about other sub requirements? Reference to "Engine" and needs to consider Electrical Propulsion System. Paragraph (b) refers to engine isolation such that any engine or system failure that can affect the engine will not prevent continued operation of the other engine or require immediate crew attention. Paragraph (e) refers to restart capability with respect to altitude and airspeed envelope which will need redefining with respect to a hybrid propulsion system. Theoretically restart will be possible at all corners of the flight (altitude/airspeed) envelope but may be determined/limited by available power - controlling parameters of restart require redefining. Paragraph (b) perhaps needs expansion in terms of propulsion system such as electrical power? Definition of "Engine" to be provided and needs to consider alternative propulsion systems.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.939 Turbine engine operating characteristics	Paragraph (a) refers to turbine engine operating characteristics being investigated to determine that no adverse characteristics such as stall/surge/flame out are present to a hazardous degree. Gas turbine may no longer be present and there are other possibilities e.g. large fan powered by an electrical motor so this paragraph will need reworded accordingly as flame out would no longer be relevant and is more akin to loss of electrical power. Compressor stall/surge no longer relevant. A hydrogen fuelled gas turbine introduces the potential hazard of deflagration to detonation transition. If the engine floods with a flammable mixture of air and hydrogen, there is the risk that the very fast-moving hydrogen flame front supplies enough heat through adiabatic compression to ignite the entire mixture. Perhaps a concern for starting and inflight relight.
	CS 25.943 Negative acceleration	No hazardous malfunction of an engine or any component or system associated with the powerplant may occur when the aeroplane is operated at the negative accelerations within the flight envelopes prescribed in CS 25.333. This must be shown for the greatest duration expected for the acceleration. (See also CS 25.1315.) Powerplant needs to be defined.....propulsion system? EHPS?

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.951 General	CS 25.951(a) - Proposal to extend the wording in this requirement as needed to state Fuel/Reactant supply system. Specifies general fuel requirements to ensure fuel flow rate and pressure is sufficient for all operating conditions and to ensure flameout will not occur. Sustained operation must prevail with specified water saturation. Fuel in the context of this paragraph relates to a gas turbine/prop, i.e. conventional aviation fuel/gasoline/petrol. Needs a complete rewrite as Hydrogen no longer feeds to an engine but instead fuels the fuel cell to create electricity. No longer relevant in its current form. Water saturation levels will also not be relevant. Control of Hydrogen quality as a fuel to be defined. A cryogenic hydrogen fuel system would also have to supply fuel in the correct thermodynamic state, particularly for a hydrogen combusting gas turbine.
	CS 25.952 Fuel system analysis and test	CS 25.952(a) - Extend the wording in this requirement as needed with "Fuel/Reactant Supply System". CS 25.952(B) - Extend the wording in this regulation as needed with "Fuel / Reactant Supply System". Needs a rewrite in line with Hydrogen being the "fuel".
	CS 25.953 Fuel system independence	Needs to be rewritten to reference to "fuel cells" rather than "engines". Subsequent wording required to be specific to the fuel cell stacks and that redundancy is built into the system if fuel cells stack(s) may fail during operation/flight.
	CS 25.954 Fuel system lightning protection.	Needs to be reworded specific to hydrogen and the different/heightened risk(s) of combustion.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.955 Fuel flow	CS 25.955(a) - The relevant parts of this requirement should be reworded for the fuel cell system. Wording is based on "engine" being supplied with fuel. Need to consider fuel cells being supplied with fuel creating electrical power which is fed to the engines. CS 25.955(b) - Proposed wording to cover fuel cell system. Add a new (b)(3): If a fuel cell stack can be supplied with reactants from more than one reactant tank, the reactant supply system. ”- For each fuel cell stack, in addition to having appropriate manual switching capability, be designed to prevent interruption of reactant flow to that stack, without attention by the flight crew, when any tank supplying reactants to that stack is depleted of usable reactants during normal operation, and any other tank, that normally supplies reactants to that stack alone, contains usable reactants.
	CS 25.957 Flow between interconnected tanks	Needs to be rewritten: Replace fuel by fuel / reactants.
	CS 25.959 Unusable fuel supply.	Needs to be rewritten: Replace fuel by fuel / reactants and engine by engine & fuel cell system.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.961 Fuel system hot weather operation	Sets out fuel requirements under hot weather operations. Identifies "engine malfunction" which perhaps not relevant in the context of we supply fuel cells so perhaps fuel cell malfunction requires consideration. Engines are supplied by electrical power so the whole chain of events differs compared to a standard gas turbine. Paragraph (a)(5) also specifies a min fuel temperature of 43.3C (110F) which is not applicable to Hydrogen.
	CS 25.963 Fuel tanks: general	CS 25.963(a)(d) - Revision needed: Replace the word “fuel’ with the phrase “fuel / reactant”. Each fuel cell system supplying fuel/reactant tank must be able to withstand without failure, the vibration, inertia, fluid, and structural loads that it may be subjected to in operation. Sets the general requirements for fuel tank design, inspection, maintenance, location, strength, fire resistance……etc. Identifies "engine malfunction" which perhaps not relevant in the context of we supply fuel cells so perhaps fuel cell malfunction requires consideration. Engines are supplied by electrical power so the whole chain of events differs compared to a standard gas turbine. Paragraph (a)(5) also specifies a min fuel temperature of 43.3C (110F) which is not applicable to Hydrogen.
	CS 25.965 Fuel tank tests	May require a rewrite for hydrogen tanks but some fundamental requirements will read across.
	CS 25.967 Fuel tank installations	CS 25.967(a) - Revision is needed: Replace fuel by fuel / reactant. CS 25.967(b) - Revision is needed: replace drain holes by drain and ventilation holes. CS 25.967 (c) - Revision is needed: replace fuel-proof by fuel/reactant-proof. Needs reviewed/rewritten specific to Hydrogen tank requirements.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.969 Fuel tank expansion space	Fuel tank expansion space requirements of not less than 2% of tank capacity. Hydrogen differs from gasoline so needs a rewrite. Conventional kerosene tanks are vented to ambient air pressure and not filled beyond 98% to allow for fuel expansion. Under no circumstances whatsoever should air be present in a hydrogen fuel tank (GH2 explosion risk, LH2 freezing of O2 with an even greater explosion risk).
	CS 25.971 Fuel tank sump	Sump capacity and drainage requirements which will need reassessment according hydrogen sump capacity and drainage. Air contamination of a LH2 tank will result in freezing of H2O, H2 and O2 and it will extremely be difficult to “drain” this cryogenic “grit”.
	CS 25.973 Fuel tank filler Connection	More stringent requirements required for Hydrogen in terms of cooling, H2 content in air (2%). Note: Special Condition for 25.973 Fuel tank filler connection.
	CS 25.975 Fuel tank vents	Venting requirements specific to H2 tanks needs to be defined.
	CS 25.977 Fuel tank outlet	Requires consideration for hydrogen fuel strainer requirements.
	CS 25.979 Pressure fuelling system	Needs to consider pressure fuelling for Hydrogen as opposed to aviation fuel.
	CS 25.981 Fuel tank explosion prevention	Rewrite required specific to Hydrogen tanks and the inherent risks.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.991 Fuel pumps	Rewrite in line with hydrogen being the "fuel".
	CS 25.993 Fuel system lines and fittings	Needs reconsidering according to hydrogen lines with hydrogen having altogether different operating conditions (Very cold) and leakage and handling requirements. Insulation, fire cryogenic?
	CS 25.994 Fuel system components	Statement of Issue: Refers to "fuel system components" being protected sufficient to ensure that in event of wheels up landing on paved runway (25.721), fuel spillage insufficient to result in fire hazard. Need to consider what constitutes fuel system components?
	CS 25.997 Fuel strainer or filter	Refers to "fuel system components" being protected sufficient to ensure that in event of wheels up landing on paved runway (25.721), fuel spillage insufficient to result in fire hazard. Need to consider what constitutes fuel system components?
	CS 25.999 Fuel systems Drains	Needs to consider hydrogen specific requirements pertaining to system drains.
	CS 25.1001 Fuel jettisoning system	Needs to consider hydrogen specific requirements pertaining to jettisoning.
	CS 25.1041 General	Requirement is specific to powerplant components and engine fluids. Rewording required to address potential for cryogenic cooling of electrical system and other impacted units/systems. May require a separate paragraph specific to cryogenic systems / components.
	CS 25.1043 Cooling tests	Requires additional information in terms of ensuring that sufficient cryogenic cooling is provided at all levels of electrical current sufficient to maintain electrical system operating temperatures.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.1045 Cooling test Procedures	Needs more extensive specifications appropriate to usage of cryogenics in the propulsion system.
	CS 25.1091 Air intake	In paragraph (a)(2), it refers to "fuel metering and mixture distribution" which may not be applicable to a specific hydrogen system.
	CS 25.1093 Air intake system de-icing and anti-icing provisions	Paragraph (b) is specific to "turbine engines" in the conventional meaning (gas turbine) - Hydrogen or electric propulsion needs to be considered.
	CS 25.1103 Air intake system ducts and air duct systems	Needs adapting, as engine surging (b)(1) not applicable, as there is no compressor - fan flutter/stall?
	CS 25.1143 Engine controls	Paragraphs (d) & (e) refer to fuel injection and fuel shut off. Rewording/rewriting appropriate to hydrogen fuel tank and system.
	CS 25.1145 Ignition switches	References "engine ignition" which is perhaps not appropriate terminology for hydrogen system……fuel cell activation?
	CS 25.1165 Engine ignition systems	Rewrite required as the entire propulsion system may be electrically driven based upon hydrogen fed Fuel Cells. Engine ignition is not a single event and more a sequence of individual systems - Hydrogen to Fuel Cells to Electricity to Electric Motor.
	CS 25.1181 Designated fire zones: regions included	Needs to consider propulsion system incorporated into the aircraft fuselage with constituent systems including fuel cells, H2, Cryogenic, resulting in alternative fire requirements/zoning.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.1183 Flammable fluid-carrying components	Inclusion of hydrogen into the propulsion system and inherent fire/explosive considerations that need to be addressed.
	CS 25.1185 Flammable fluids	Inclusion of hydrogen into the propulsion system and inherent fire/explosive considerations that need to be addressed.
	CS 25.1187 Drainage and ventilation of fire zones	Needs to be addressed in fuel cell system safety baseline regulation.
	CS 25.1189 Shut-off means	CS 25.1189(b) - Propose to add following for fuel cells: The closing of any reactant shutoff valve for any fuel cell stack may not make reactants unavailable for the remaining stacks. CS 25.1189 (e) - This regulation is applicable for fuel cell systems. Replace the word “drain” with the phrase “drain or vent.” The advisory material to the new fuel cell system safety baseline regulation should include wording on means to shut-off, as one of the possibilities regarding the new regulation e.g. Means must be available for controlling or extinguishing a fire, such as stopping flow of fluids, gasses, or vapours, shutting down equipment, fire containment, or use of extinguishing agents.
	CS 25.1195 Fire-extinguisher systems	Requires rewording for specific hydrogen systems, i.e. paragraph (a) refers to turbine engine installations, turbine & combustor.

Subpart	Section	Statement of Issue
Subpart E – Powerplant	CS 25.1337 Powerplant instruments	Specifics required in relation to hydrogen and fuel cell monitoring. Also, specific to cryogenic fluid monitoring.
	CS 25.1351 General	Need to account for an electrical power system used as the primary means of propulsion using Hydrogen fuel cells as the source of electrical energy.
	CS 25.1353 Electrical equipment and installations	Include Hydrogen Fuel Cells.
	CS 25.1419 Ice Protection	May require rewording such as "turbine engine powered aeroplanes" in paragraph (d).
	CS 25.1433 Vacuum systems	Needs to be expanded to account for hydrogen vacuum systems (Hydrogen tank).
	CS 25.1435 Hydraulic Systems	Requirement for high pressure H2 storage vessels needs to be developed.
	CS 25.1436 Pneumatic systems – high pressure	Appendix L may need to be revised to address the high-pressure parts of a fuel cell system.
	CS 25.1438 Pressurisation and low-pressure pneumatic systems	A similar regulation applicable for the high-pressure parts of a fuel cell system should be written. Needs expansion/rewording to address the requirements of the compressor air used to feed the fuel cells.

Subpart	Section	Statement of Issue
Subpart G – Operations & Information	CS 25.1557 Miscellaneous markings and placards	Revise to account for H2 fuel refilling. This could be accomplished by replacing the word “fuel” with “fuel and reactants”
	CS 25.1705 Systems and Functions; EWIS	25.1705(b) - Add reference to 25.XXX Hydrogen Fuel Cell System Safety.
	CS 25.1707 System Separation; EWIS	Add a new paragraph (m) based on existing para (g) for O2 “Except to the extent necessary to provide electrical connection to hydrogen storage components and lines, EWIS must be designed and installed with adequate physical separation from hydrogen lines and other hydrogen system components, so that a EWIS component failure will not create a hazardous condition. Or, based on 25.1707(e) (fuel lines and fuel system components): Except to the extent necessary to provide electrical connection to the fuel systems components, the EWIS must be designed and installed with adequate physical separation from fuel lines and other fuel system components, so that: (1) An EWIS component failure will not create a hazardous condition. (2) Any fuel leakage onto EWIS components will not create a hazardous condition.
	CS 25.1723 Flammable fluid protection; EWIS	Add flammable gas (i.e. for the H2 gas). So, it would say: "…in each area where flammable fluid, gas, or vapours might escape...".