SUBJECT: **Installation of Compression Ignition (Diesel) Engines on Small Rotorcraft**

CERTIFICATION SPECIFICATIONS incl. Amdt.: CS 27, Initial Issue to Amendment 7

ASSOCIATED IM/AMC[1]: Yes☒ / No ☐

ADVISORY MATERIAL: **N/A**

INTRODUCTORY NOTE:

The following Special Condition (SC) has been classified as important and as such shall be subject to public consultation in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) which states:

"*2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.*"

IDENTIFICATION OF ISSUE:

This Special Condition has been developed to support the certification of small rotorcraft powered by diesel (compression ignition) piston engines.

The applicable certification specifications for Small Rotorcraft (CS-27) do not contain appropriate standards for the installation of diesel engines. The standards for engine installation are partially related to the combustion principle assuming reciprocating/piston engines are spark ignition Otto cycle engines using petrol based fuel while turbine engines are continuous combustion turboshaft engines using kerosene based jet fuel. Due to those assumptions, the current CS-27 specifications for the installation of reciprocating engines are not all directly applicable to diesel engine installations. However some specifications for the installation of turbine engines are applicable to diesel engines, due to the similarity of the fuel characteristics.

I. Assessment of Design Features:

A. Design features not envisioned in CS-27:

The installation of a modern diesel engine into a small rotorcraft introduces design features that were not envisioned when CS-27 and previous equivalent specifications were established.

- A diesel engine operates on compression ignition (Diesel) power cycles rather than spark ignition (Otto) power cycles, having significantly higher cylinder pressure. There is a lack of historical experience of diesel engine installations on rotorcraft while some experience has been gained for installations in small airplanes.

[1] In case of SC, the associated Interpretative Material and/or Acceptable Means of Compliance may be published for awareness only and they are not subject to public consultation.

- A diesel engine is a reciprocating engine usually operating with "kerosene based jet fuel" in aviation applications, whereas reciprocating engines used on rotorcraft so far have been exclusively spark ignition (Otto) engines using "aviation gasoline (petrol based)" .
- A diesel engine can alternatively be proposed to be operated with automotive diesel fuel or other equivalent such as bio-diesel (FAME).
- A modern diesel engine is often controlled by a Full Authority Digital Engine Control (FADEC) and is usually turbocharged.
- Diesel engines are known to potentially have a higher vibration level compared to conventional (Otto cycle) reciprocating engines.
- Some common-rail diesel engine designs include a return fuel system so that unused fuel from the fuel rail is returned to the fuel tank. A high volume of fuel that returns from the fuel rail to the fuel tank potentially leads to an excessive increase of the fuel temperature in the fuel tank.

B. <u>Particular design features of diesel engines that require modifications compared to CS-27:</u>

1. Fuels:

The engine Type Certificate Data Sheet (TCDS) identifies the approved fuel(s) for use in a rotorcraft diesel engine. Any fuels, and required additives, to be used in rotorcraft diesel engines will need specifications and references in the Type Certificate Data Sheet (TCDS) and in the engine installation manual.

For single engine rotorcraft, to be certified under CS-27 and powered with a diesel engine, certain "turbine engine" fuel-related standards should be met in lieu of the gasoline fuel related standards. Additives that are needed for turbine fuels that will also be required by a rotorcraft diesel engine (ex. anti-icing and biocide additives) will be referred to as part of the rotorcraft fuel specifications.

In a rotorcraft diesel engine installation project, certain aspects of the diesel engine and its certificated fuel standards should be considered:

- The cetane number is one of the primary parameters that define diesel engine fuel (similarly to octane rating for conventional reciprocating engines).
- Using the appropriate cetane rated fuel in a diesel engine is critical to ensure proper engine starting at low temperatures and to avoid flame-out events in low power conditions especially at high altitude, at low temperatures, and at low engine speed (low rpm)
- Current commercial turbine fuel specifications do not include cetane standards; therefore, a minimum cetane standard needs to be specified for aircraft diesel engines. It should be recorded in the engine TCDS and should be provided below the actual cetane rating of fuels used in the field.
- If automotive diesel fuel is to be approved, appropriate specifications will need to be identified. Additional limitations (e.g. related to the climate grades/classes of the diesel fuel) may be necessary.

- Fuels that do not have a specification (such as certain protein or plant-based fuels) will be handled on a case-by-case basis (e.g. compatibility issues of the fuel system materials must be addressed such as elastomers, sealants, seals, liners, hoses, composite parts, etc.).

2. Liquid Cooling:

Modern diesel engines are often equipped with liquid coolant systems, whereas aircooled spark ignition (petrol) engines have been widely used on rotorcraft so far.

3. Engine Controls:

Modern diesel engines commonly utilise a Full Authority Digital Engine Control (FADEC) or Electronic Engine Control (EEC). Even if such Electronic Control systems are not unique to rotorcraft diesel engines, recent conventional reciprocating engines controlled by FADEC have been certified on the basis of a Special Condition to accommodate this design feature which had not been envisaged in the development of CSs.

Compliance demonstration with CS 27.901 and 27.1309 and 27.1141 is impacted.

4. Vibration:

Rotorcraft diesel engines may yield a greater level of vibration compared to current rotorcraft powerplant systems.

As part of the basic compliance efforts for a rotorcraft diesel engine, the effects of higher vibration levels higher than those that are typical for conventional reciprocating engine powered Rotorcraft must be considered.

In addition, the one cylinder inoperative condition will need to be evaluated. The primary concern is that the vibratory loads imparted to the rotorcraft by a diesel engine with one cylinder inoperative may be in excess of what previous experience has shown on conventional reciprocating engines, thereby reducing the margin of design safety.

II. Assessment of existing certification standards and required new special conditions

This Section provides justifications for the need of a Special Condition where the existing certification specification is not appropriate or adequate.

I. **Existing CS-27 provisions that do not adequately address the specifics of diesel engine installations**:

<u>CS 27.361 Engine Torque:</u>

CS 27.361 defines different limit torque for the engines depending on whether the installed engine is a turbine or a reciprocating engine so that the critical torque value is used as design limit.

Diesel engine cylinder pressure is much higher than spark ignition engine with higher expected load levels and the failure modes might potentially be more severe.

Consequently, a stoppage criterion as defined in CS 27.361(a)(4) for turbine engines is made applicable for diesel engines instead of the CS 27.361(b) for reciprocating (spark ignition) engines, or a factor of four, for a four cylinders should conservatively be used to multiply the aircraft diesel engine's mean torque to calculate the limit torque, unless it is shown by the applicant that other (lower or higher) factors are adequate.

CS 27.927 Additional tests:

Considering that there is limited historical experience regarding the use of diesel engine on rotorcraft, and that much higher cylinder pressures exist in diesel engines, there is a possibility that the engine torque output to the transmission could exceed the highest engine to transmission torque limit when the output is not directly controlled by the pilot under normal operating conditions need to be evaluated. Therefore the turbine engine torque testing defined in CS 27.361(a)(4) is made applicable for diesel engines.

> *Note: For rotorcraft using drive belts for transmitting the engine torque output to the main gearbox, the above mentioned test might not be relevant depending on design architecture. Rational should be provided for not considering any additional test.*

CS 27.939 Turbine Engine operating characteristics:

Turbocharged engines have higher cylinder pressures than conventional reciprocating engines and have an important influence on engine performances, compression level in the air intake and engine admission. Turbocharger behaviour in the different flight phases is currently not considered in CS-27 but is important to be assessed.

Diesel turbocharged engine operating characteristics should be investigated in flight to determine that no adverse characteristics (such as overboost, surge) are present, during normal and emergency operation. Therefore a testing as defined in CS 27.939(a) and (c) for turbine engines is made applicable to diesel engines.

CS 27.951 Fuel System General:

A diesel engine operates with kerosene based fuel or diesel. CS-27 contains fuel icing standards that are limited to Turbine engines based on the fact that they are operating with kerosene based fuels which are more susceptible to water absorption and to icing. The standards in CS 27.951 regarding icing to be encountered in operation for turbine engines are made applicable for diesel engines. .

CS 27.973 Fuel tank filler connection:

The modification of a small Rotorcraft with the installation of a diesel engine (on a product that is already powered by a conventional reciprocating engine) will lead to two different variants in operation:

- One powered with a Diesel engine using kerosene based fuel, and
- Another one, with similar external aspects, using Aviation Gasoline (Avgas).

This can lead to cross fuel contamination (misfuelling) because the same model or similar looking aircraft may then have different fuel requirements.

Specific design features might help in preventing improper refuelling, cf the standards included in CS 23 for normal category aeroplanes (ref: CS 23.973) and referred in AC20-122A and SAE AS1852D. This might not completely prevent misfuelling with AVGAS of a diesel engine, which may be critical for a Diesel engine installation and special attention might also be needed when assessing CS 27.1557 and CS 27.1521. Therefore a special condition is proposed to prevent misfuelling.

CS 27.977 Fuel tank outlet:

The standard listed under CS 27.977(a) requires a specific filtration capacity depending on if a Reciprocating engine or Turbine engine is installed. A diesel engine operates with kerosene based fuel that is equivalent to a turbine engine.

Consequently, a Rotorcraft diesel engine should demonstrate compliance with the turbine related standard of CS 27.977(a)(2) to prevent the possibility of injector or pump contamination.

CS 27.1141 Powerplant control:

When CS 27.1141 (e) was established regarding a “no single failure” or “malfunction” in any powerplant control system which may cause the failure of any powerplant function necessary for safety, this was based on FAR 23-1141 as revised at Amendment (23-7). This standard was initially limited to “turbine engine” based on the “historical simplicity and service experience” of reciprocating engines. Current reciprocating engine controlled by a FADEC do not show sufficient service history and their control systems use similar design principal as a turbine engine.

CS 27.1141(e) is made applicable for Diesel engines directly controlled by a FADEC.

CS 27.1145 Ignition switches:

A diesel engine is a compression ignition engine. The ignition source is the heat created by compressing the air-fuel mixture in the cylinder without any ignition plugs or an ignition circuit. Consequently, CS 27.1145 (a) that requires a means to quickly shut off all ignition is not applicable.

An alternative and appropriate means of stopping the engine shall be provided, such as shutting off the engine control (FADEC or similar) or appropriate components.

CS 27.1305 and CS 27.1521 Powerplant Instruments and Powerplant Limitations:

The installation of a diesel engine will be in accordance with the engine's installation manual and operated within the standards of its Type Certificate. The instrumentation standards in CS 27.1305 were established for conventional reciprocating engines and for turbine engines, and did not consider the use of diesel engines.

The integration of a diesel engine may result in the need to have specific monitoring means depending on the limitations of the engine. In such case, CS 27.1305 needs to be complemented to provide a means of monitoring and to provide indications to the pilot. As an example, CS 27.1521(f) regarding ambient temperature is only applicable to turbine engines, however, the fuel freezing point might be lower on diesel engine fuel and ambient temperature limitations would then be required.

In addition, it is assumed that diesel fuel according to EN590 is available to the pilot but without any reliable information about the seasonal grade. Consequently, the most critical diesel fuel quality should be established within the approved range of EN590 for which certification is requested.

Operation at low ambient temperatures will be one of the critical applications for pure diesel fuel use.

Additional considerations should also be given to the operational aspects which might be in different environmental conditions. Tests and analyses used for determining limitations should then be based on the critical diesel fuel quality.

Diesel fuel is not always available at aircraft fuelling facilities in a controlled manner. Consequently, instructions, procedures, and limitations set for helping the pilot in determining the suitability of the diesel fuel should be established.

CS 27.1557 Miscellaneous markings and placards:

CS 27.1557 Fuel and filler opening standards are based on fuel types and currently refer to reciprocating and turbine engines. The turbine engine standard for kerosene based fuel is made applicable to diesel Engine. A standard for marking of coolant filler openings is introduced in a similar manner to CS 23.1557.

II. New Special Conditions required for Diesel engine integration:

Turbo charger systems:

Turbochargers have an important influence on engine performances, compression level in the air intake and engine admission. Their behaviour in the different flight phases should be assessed and the safety assessment should encompass the potential failure modes and associated effects (temperature, high energy debris, vibration, etc.).

CS-27 does not adequately address these design features and CS-23 Amendment 4 can be used as a reference for current turbocharged engine integration, in particular CS 23.909 (a), (b) and (c). Therefore, a new special condition is required similar to the mentioned CS 23 paragraphs.

Liquid Cooling – Installation and coolant tank tests:

CS-27 does not provide adequate specifications for the installation and qualification of liquid cooling system equipment and mainly only addresses the performances aspects of the cooling system under CS 27.1041, CS 27.1045 and CS 27.1047 which were considered sufficient for air cooled reciprocating engines. For the installation of liquid cooled engines, experience from CS-23 is used to define additional specifications. The related new special conditions address the installation of liquid cooling systems and coolant tank testing.

Considering all the above, the following Special Conditions are proposed:

Special Conditions to CS-27

Installation of Diesel engines on Rotorcraft

SC-DIE.361 Engine Torque

CS.27.361 is completely replaced by the following:

(a) For diesel reciprocating engine, unless shown otherwise by the applicant, the limit torque must not be less than the highest of:

(1) The mean torque for maximum continuous power multiplied by 4 with 4 cylinders

(2) The torque required by CS 27.923;

(3) The torque required by CS 27.927;

Or

(4) The torque imposed by sudden engine stoppage due to malfunction or structural failure.

SC-DIE.909 Turbo charger systems

(a) Each turbo charger system is considered to be part of engine therefore it must be certified within the scope of the engine type certificate or it must be shown that the turbo charger system, while in its normal engine installation and operating in the certified engine environment –

(1) Can withstand, without defect, an endurance test of 150 hours that meets the applicable standards of CS-E 440, and

(2) Will have no adverse effect upon the engine.

(b) Control system malfunctions, vibrations and abnormal speeds and temperatures expected in service shall not result in damage to the turbo charger compressor or turbine.

(c) Each turbo charger case must be able to contain fragments of a compressor or turbine that fails at the highest speed that is obtainable with normal speed control devices in-operative.

SC-DIE.927 Additional tests

CS 27.927 (b) only is replaced by the following:

(b) If diesel engine torque output to the transmission can exceed the highest engine or transmission torque rating limit, and that output is not directly controlled by the pilot under normal operating conditions (such as where the primary engine power control is accomplished through the flight control), the following test must be made:

(1) Under conditions associated with all engines operating, make 200 applications, for 10 seconds each, of torque that is at least equal to the lesser of:

(i) The maximum torque used in meeting CS 27.923 plus 10%; or

(ii) The maximum attainable torque output of the engines, assuming that torque limiting devices, if any, function properly.

SC-DIE.939 Engine operating characteristics

CS.27.939 is replaced by the following:

(a) Diesel turbocharged Engine operating characteristics must be investigated in flight to determine that no adverse characteristics (such as overboost, surge) are present, to a hazardous degree, during normal and emergency operation within the range of operating limitations of the rotorcraft and of the engine.

(b) [Reserved]

(c) For governor-controlled engines, it must be shown that there exists no hazardous torsional instability of the drive system associated with critical combinations of power, rotational speed, and control displacement.

SC-DIE.951 Fuel System General

CS.27.951 (c) only is replaced by the following:

(d) Each fuel system for a kerosene based engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 27°C (80°F) and having 0.198 cc of free water per litre (0.75 cc per US gallon) added and cooled to the most critical condition for icing likely to be encountered in operation.

SC-DIE.961 Fuel System hot weather operation

CS.27.961 is replaced by the following:

(a) The maximum fuel temperature in the fuel tank likely to occur under the most adverse normal operating conditions must be determined.

(b) Each suction lift fuel system and other fuel systems with features conducive to vapour formation must be shown by test to operate satisfactorily (within certification limits) when using fuel at the maximum temperature determined under paragraph (a) under critical operating conditions including, if applicable, the engine operating conditions defined by CS 27.927 (b)(1) and (b)(2).

SC-DIE.973 Fuel tank filler connection

CS 27.973 is applicable with the following additional paragraph:

(c) Each filler connection must prevent misfuelling.

SC-DIE.977 Fuel tank outlet

CS.27.977 is applicable with the following additional sub-paragraph:

(a) (3) For diesel engine powered rotorcraft, the strainer must prevent the passage of any object that could restrict fuel flow or damage any fuel system component.

SC-DIE.1061 Liquid Cooling – Installation

(a) Each liquid-cooled engine must have an independent cooling system (including coolant tank) installed so that:

(1) Each coolant tank is supported so that tank loads are distributed over a large part of the tank surface; and

(2) There are pads or other isolation means between the tank and its supports to prevent chafing; and

(3) Pads or any other isolation means that is used must be non-absorbent or must be treated to prevent absorption of flammable fluids; and

(4) Air or vapour is prevented from being trapped in any part of the system, except the coolant tank expansion space, during filling or during operation.

(b) The coolant tank capacity must be capable of holding the cooling system liquid capacity with additional margin. In addition:

(1) Each coolant tank must be able to withstand the vibration, inertia and fluid loads to which it may be subjected in operation;

(2) Each coolant tank must have an expansion space of at least 10% of the total cooling system capacity; and

(3) The expansion space shall be prevented from being inadvertently filled with the aircraft in the normal ground attitude.

(c) Each coolant tank filler connection must be marked as specified in CS 27.1557 (c). In addition:

(1) Any coolant that is spilled must be prevented from entering the coolant tank compartment or any part of the rotorcraft other than the tank itself; and

(2) Each recessed coolant filler connection must have a drain that discharges clear of the entire rotorcraft.

(d) Each coolant system line and fitting must meet the standards of CS 27.993, except that the inside diameter of the engine coolant inlet and outlet lines may not be less than the diameter of the corresponding engine inlet and outlet connections.

(e) Each coolant radiator must be able to withstand any vibration, inertia and coolant pressure load to which it may normally be subjected. In addition –

(1) Each radiator must be supported to allow expansion due to operating temperatures and prevent the transmittal of harmful vibration to the radiator; and

(2) If flammable coolant is used, the air intake duct to the coolant radiator must be located so that (in case of fire) flames from the nacelle cannot strike the radiator.

(f) An accessible drain shall be provided that:

(1) Enables the draining of the entire cooling system (including the coolant tank, radiator and the engine) when the rotorcraft is in the normal ground attitude;

(2) Discharges clear of the entire rotorcraft; and

(3) Has a means to positively lock it in a closed position.

SC-DIE.1063 Liquid Cooling - Coolant tank tests

Each coolant tank, unless already demonstrated as part of the engine Type Certificate in compliance with CS-E, must be tested in accordance with CS 27.965, except that:

(a) The test required by CS 27.965 (b) must be replaced with a similar test using the sum of the pressure developed during the maximum ultimate acceleration with a full tank or a pressure of 24 kPa (3.5 psi), whichever is greater, plus the maximum working pressure of the system; and

(b) For a tank with a non-metallic liner the test fluid must be coolant rather than fuel as specified in CS 27.965 (d) and the slosh test on a specimen liner must be conducted with the coolant at operating temperature.

SC-DIE.1141 Powerplant Control

CS.27.1141 is applicable except (e) which is replaced by the following:

(e) For electronically controlled reciprocating engine rotorcraft, no single failure or malfunction, or probable combination thereof, in any powerplant control system may cause the failure of any powerplant function necessary for safety.

SC-DIE.1145 Ignition control

CS.27.1145 is replaced by the following:

(a) There must be means to quickly shut off the engine.

(b) Each control means provided must have a means to prevent its inadvertent operation.

SC-DIE.1521 Powerplant limitations

CS.27.1521 is applicable except (f) which is replaced by the following:

(f) Ambient temperature. For kerosene-based engines, ambient temperature limitations (including limitations for winterization installations, if applicable) must be established as the maximum ambient atmospheric temperature at which compliance with the cooling provisions of CS 27.1041 to 27.1045 is shown.

SC-DIE.1557 Miscellaneous markings and placards

CS.27.1557 is applicable except (c) which is replaced by the following:

(c) Fuel and oil filler openings. The following apply:

(1) Fuel filler openings must be marked at or near the filler cover with:

(i) The words 'Jet Fuel';
(ii) For Aviation gasoline based engine powered rotorcraft, the minimum fuel grade;
(iii) For Kerosene based engine-powered rotorcraft, the permissible fuel designations; and
(iv) For pressure fuelling systems, the maximum permissible fuelling supply pressure and the maximum permissible defuelling pressure.

(2) Oil filler openings must be marked at or near the filler cover with the word 'oil'.
(3) Coolant filler openings must be marked at or near the filler cover with the word „Coolant“.

Associated Interpretative Material / Means of Compliance

The following associated Interpretative Material / Means of Compliance is published for awareness only and is not subject to public consultation.

IM to AMC CS 27.251 and 27.907 Vibration

In respect to the existing AMC to CS 27.251 and CS.27.907 which is applicable, the following should be considered for diesel engine installations:
Rotorcraft diesel engines may yield a greater level of vibration than current Rotorcraft powerplant systems.
As part of the basic compliance activity for a Rotorcraft diesel engines, the effects of vibration levels higher than those typical for conventional reciprocating engine powered Rotorcraft should be considered.
In addition, the one cylinder inoperative condition will need to be evaluated. The primary concern is that the vibratory loads imparted to the Rotorcraft by a diesel engine may be in excess of what experience has shown on conventional reciprocating engines, thereby reducing the margin of design safety.

IM to AMC to CS 27.603, MOC to SC-DIE.961, IM to AMC to CS 27.963 Materials, Fuel System hot weather operation and Fuel Tanks general

In respect to the existing AMC to CS.27.603, AMC to CS.27.961 (which is applicable to MOC SC-DIE.961) and AMC to CS.27.963 which are applicable, the following should be considered for diesel engine installations:
Diesel engines usually integrate a return fuel system so that unused fuel from each injector is returned to the fuel tank. Such system may provide a high volume of fuel returning from the injectors to the fuel tank. The fuel temperature at injector level is relatively high and this might consequently lead to an excessive increase of the fuel temperature in the fuel tank.
The potential impact of elevated fuel temperature on fuel system hot weather operation, fuel tank flammability, and fuel tank structure should be assessed.

IM to AMC to CS 27.901 Installation

In respect to the existing AMC to CS.27.901 which is applicable, the following should be considered for diesel engine installations:
The vibration levels of a diesel engine might be greater than those for conventional reciprocating engines and could under certain circumstances be significantly higher (such as in the case of an inoperative cylinder). The potential effect on the rotorcraft should be evaluated.
A Diesel engine usually integrates a return fuel system so that unused fuel from each injector is returned to the fuel tank. Depending on the design, such system may provide a high volume of fuel returning from the injectors to the fuel tank. Fuel temperature at injector level is relatively high and might consequently lead to an excessive increase of the fuel temperature in the fuel tank. Due to the physical, chemical, and thermal properties of JET A-1 fuel an ignitable fuel/air vapour within the tank should be assumed during all operating conditions.

MOC SC-DIE.961 Fuel System hot weather operation

A test should be performed to determine the maximum fuel temperature under the worst conditions, in terms of ambient temperature, engine maximum operating temperature without exceeding the limits, and minimum fuel quantity to be expected during normal operating conditions.
A significant increase in fuel tank temperature should also be considered for the potential effects on structural integrity and fuel tank ignition prevention.

MOC SC-DIE.973 Fuel tank filler connection

In respect to the existing AMC to CS.27.973 which is applicable, the following should be considered for diesel engine installations:
A different filler connection diameter could be used as specified in CS-23 Amd 4 , or adequate markings in proximity of the refuelling port could be provided.

MOC SC-DIE.1061 Liquid Cooling – Installation

Experience has shown that recommended coolants may vary depending on engine manufacturers. However, depending on the chemical characteristic of the liquids, their flammability may vary. The most common products used on reciprocating engine are:

- Propylene Glycol, also recommended as "waterless" coolant and commonly used pure (100%)
- Ethylene Glycol, used pure in some cases or most commonly mixed with water at a different concentration level (commonly 50%).

Propylene Glycol and Ethylene Glycol both have a relatively low flash point and are flammable when in contact with ignition sources (hot surface, ignition spark etc). When mixed with water, the flammability aspect of Ethylene Glycol is significantly lower but a few reports from the car industry and laboratory experiences have shown that under certain atmospheric conditions, and depending on the water concentration, a residual part of the mixture can still be flammable when water is evaporated (boiling, spray on ignition surface etc).
EASA considers that the coolant used in the engine cooling system should be in accordance with the engine installation manual as per CS 27.901 (c). However, as the engine TCH might provide different possibilities (waterless or mix with water under different concentrations) it is important to correctly define the expected approach at installation level so that the appropriate design criteria will adequately cover the potential fire risk.

Waterless coolant (Propylene Glycol)

The use of waterless coolant (such as Propylene Glycol) would automatically imply "flammable fluid" which would need to be considered as such during the compliance demonstration of the coolant tank, coolant lines and pipes, radiator, drainage, etc. EASA and other authorities have already published an Airworthiness Directive to prohibit the use of waterless coolant in engine cooling installations that are non-compliant with "flammable fluid" related standards at aircraft level.

Mixed – water and Ethylene Glycol

Considering that Ethylene Glycol when mixed with water has a low fire risk exposure compared to waterless coolant it has been accepted at engine level to not consider the liquid as being "flammable" to facilitate the installation and heat dispersion with simpler design; this was also supported by in-service experience.
When installing such a system at aircraft/rotorcraft level it is important to consider in the design that a mixture of Ethylene Glycol and water decreases the flammability characteristic based on the water presence/ concentration. Depending on the atmospheric conditions, operating temperatures, the fluid characteristics might change and impact the fire risk exposure if in the presence of ignition sources.

According to some car industry papers, those cases might be limited but have already been seen in service.
The installer should then clearly define which coolant mix is authorised for the engine cooling system, assess the fluid characteristics and potential influencing parameters which could lead to a higher exposure to fire risk, and define any necessary limitations. Those limitations could be on water concentration in the aircraft maintenance manual in accordance with CS 27.1529, engine temperature to limit the water evaporation or/and boiling point, complete and regular servicing to maintain coolant characteristics, etc.
In addition, even if not considered "flammable" fluid as per CS-Definitions, for the fluid tank, lines, radiator characteristic, design precautions should still be taken to minimise the risk of having a leak in direct exposure to ignition surfaces such as exhaust pipes or turbocharger surfaces, especially in a vaporised form which could lead to rapid evaporation of the water. This could impact the location and routing of the fluid tank and pipes, potential deflectors, draining and ventilation aspects. The installer should present the certification approach, substantiating any limitations and design minimisation measures which might be necessary for the engine cooling systems.

IM to AMC to CS 27.1309 Equipment system installation

In respect to the existing AMC to CS.27.1309 which is applicable, the following should be considered for diesel engine installations:
FADEC controlling diesel engines are certified at engine level as part of the engine type certification process. The FADEC will need electrical power for continuous operation and will include inputs from rotorcraft data, power sources and outputs to other rotorcraft systems (i.e. engine instruments, electrical power supply and there control).
The safety assessment performed in accordance with CS 27.1309 should accurately define and consider the engine rotorcraft interfaces (ref. AMC 20-1).