Comment Response Document (SC E-01 - Airworthiness Standard for CS-22H Electrical Retractable Engine to be operated in powered sailplanes)

Commentor:	UK CAA
Para:	All
Comment:	The Special Condition only addresses the requirements of CS-22 Subpart H. The introduction of an electrical engine affects other requirements than just those for the engine itself. In this regard the Special Condition should also address the following paragraphs CS 22.1521 powerplant limitations CS 22.1549 powerplant instruments CS 22.1553 fuel quantity indicator CS 22 Subpart F electrical systems and equipment
EASA Response	Noted, this may be considered for future aircraft projects. As written above, this SC is only about Certification of the Engine itself.

Commentor:	UK CAA
Para:	2.a Identification of issue
Comment:	The introduction states that a Special Condition is required because the product has novel or unusual design features relative to the design practices on which the applicable airworthiness code is based, but gives no information on these novel features. It would have been helpful if the Special Condition described what kind of unusual design features are being addressed.
EASA Response	The reason for application of the SC was the complete lack of requirements specific to electrical propulsion engines in CS-22

Commentor:	UK CAA
Para:	JAR/CS-22.1815 Materials
Comment:	The new paragraph (c) has the laudable aim of excluding materials that are hazardous to health. However, this requirement is almost impossible to comply with, unless detailed acceptable means of compliance are also given. Some of the difficult compliance questions include: Is the requirement applicable to manufacture and maintenance as well as operation? If so can advantage be taken for protective clothing during manufacture or maintenance to reduce the hazard? What level of hazard is permitted and under what conditions? Over what period of time should the hazards be considered? and so on.
EASA Response	Noted, such general statement which gives no specific instructions will be deleted in the future

Commentor:	UK CAA
Para:	Ref to CS-22.1835
Comment:	As Environmental issues such as HIRF do not appear to be called up here, or elsewhere, it is suggested that they are included here.
EASA	Noted, will be considered for future projects

Response	

Commentor:	UK CAA
Para:	JAR/CS-22.1849 Endurance test
Comment:	The new paragraph (a) states that the endurance test may be carried out with a reference propeller. The term "reference propeller" is not understood. The basic CS-22 code uses the term "representative propeller" which is more explicit and this term should also be used in the Special Condition.
EASA Response	Noted wording will be changed accordingly

Commentor:	UK CAA
Para:	JAR/CS-22.1849 Endurance test
Comment:	New paragraph (a)(2) specifies that for the endurance test 15 flights out of 30 should be carried out when temperatures are typical of a European summer day (ISO+10^{o}C) in order to demonstrate the presence of sufficient energy source capacity. It is well understood that hot day temperatures can be critical for aircraft performance. However, on the opposite side cold day temperatures can result in much reduced electrical power capacity. Therefore, it is proposed that the remaining 15 flights should be performed when temperatures are typical of a North European winter day in order to demonstrate the presence of sufficient energy source capacity.
EASA Response	Electrical Engines are not critical concerning low temperatures according to consulted experts. It is not the aim of the Endurance Test to demonstrate the presence of sufficient energy source capability. The comment may be considered in the case the battery belongs to the engine Type Design

Commentor:	UK CAA
Para:	Ref to CS-22.1849
Comment:	The proposed Endurance test appears to be considerably different and shorter than the current CS. The rationale for the change is not presented and therefore cannot be understood / evaluated. Furthermore, if the proposed changes are based on other previous applications, then they should be referenced.
EASA Response	The test should only cover the investigation about the combination of engine and propeller because electrical engines are not critical in the here mentioned time scales. There are no effects as typical for combustion engines which need specific consideration.

Commentor:	Austro Control
Para:	Ref to CS-22.1843
Comment:	This test should be mandatory <u>in any case</u> because of the Combination of Engine and Propeller can result in unexpected vibration patterns.
EASA Response	There is no change to the current requirements except to replace the “crankshaft” by “engine shaft”.

Commentor:	Austro Control
Para:	Ref to CS-22.1845

Comment:	Unlike Ignition engines Electric Motors are very predictive in their operational behavior. However, it´s the Control unit that will influence the operational performance to a very high degree. For Electric Motors it would be necessary to test especially the Motor Control during this test. This may give an accurate reading of the Quality of the Control laws used in the engine control. (E.G. The control unit for an electric Engine is responsible for over speed protection, max torque protection and Temperature protection!) It should also be noted that a stable operating temperature shall be established during this test which should allow the engine to operate at max power continuously without overheating. This should verify the adequacy of the actions taken under 1821. The parameters established during these tests shall also include max Power input (Voltage and current). These Parameters are necessary for verifying the adequacy of the electrical supply system (Wire gauge and switches/sources).
EASA Response	This is not the objective of the Calibration Test. Specific operational characteristics of the engine (including control system) are subject to the Operation Test.

Commentor:	Austro Control
Para:	Ref to CS-22.1849
Comment:	The endurance test for an electric engine is not equivalent to that for a reciprocating engine. All aspects of an electric engine are very well established during the calibration tests. The operational aspects will be covered in the operational tests. So when performing a n endurance test of an electric Motor, this should be driven by the idea to break in the engine and verify the limits established during calibration tests. Also the copy of a test cycle program from an Spark engine is not adequate. Electric Motors may not require cooling periods (There are a lot of different operational Modes that an electric Motor can be certified to!) Therefore a more realistic sequence shall be used: 1: Low Power setting (equivalent to Idle) for 3 Minutes 2: Full Power setting 5 min. 3: Max cont. Power setting 15 minutes (should equal full power!) 4: Low Power for 2 Minute 5: Shutdown for 30 minutes This will give a much better idea of how a realistic stress will affect the engine. The most important item for endurance is the combination of Battery and motor system. For this reason the battery, including the cable system should be part of the engine system, and considered during the endurance test. Otherwise other special conditions would be required to cover the battery endurance under all environmental conditions (Temp/Aging/humidity etc).

	In addition to the ISO+10°C summer case, an ISO -15°C winter case should be considered to test the installations low temperature capacity.
EASA Response	The test should only cover the investigation about the combination of engine and propeller because electrical engines are not critical in the here mentioned time scales. The test cycles have been adjusted according to the expected operating conditions of the engine and the available energy. If changes are considered, they should be underpinned by practical examples.

Commentor:	Austro Control
Para:	Ref to CS-22.1851
Comment:	This test shall cover the Installation in the Aircraft and the verification that the before measured and verified Parameters are still valid in the installed state. Also effects of rapid accelleration/decelleration shall be tested when installed. The most important item for Operation is the combination of Battery and motor system. For this reason the battery, including the cable system should be part of the engine system, and considered during the endurance test. Otherwise other special conditions would be required to cover the battery endurance under all environmental conditions (Temp/Aging/humidity etc).
EASA Response	This Subpart H considers only the engine by itself. Installation and combination with the energy source is handled by another part of the Airworthiness Standard.

Commentor:	Austro Control
Para:	General
Comment:	There are a lot of other aspects that needs to be addressed when dealing with electric engines: • These engines may be certified for several operating Modes. When selecting the engine, these Modes shall correspond to the expected utilization. • Electric engines allow a wider range of controlled speeds on the engine, and engine overspeed is not that critical as for fuel engines. This need to be considered when selecting max speeds and speed control range. Also electric engines do not have a state called idle. They have full stop in that case. • When dealing with control of engines there is great difference between a gasoline engine and an electric motor: Electric Motors are fully controllable via this device (that means that the torque and speed may be variable over ranges from 0 to full nearly independent with adequate motor and control). This allows to specify the control laws to be adjusted to specific applications very precisely. Also the method of control the engine

	power may vary from a switch (Off-On) over multiposition switches(Off-Low Power-Climb power-T/O Power) to full continuous Power levers. There should be a guidance which Controls shall be used. This will influence the necessary tests for the engine very much. • Some Electric Engines develop a peak Start current which is very high. Also the currents during normal operation are very high compared to other installations. The Electrical Systems of a sailplane need to be able to cope with these conditions (not only at engine start, also during Power setting changes). Maybe a total separation from other Electric/electronic Equipment will be necessary. • Some Electric Motors produce distortions on the power line. This may influence other electric equipment on the airplane. The Motor shall be protected against such distortions and the remaining influence on the electrical system shall be evaluated. Again, this may lead to a complete separation of the Engine from the electrical system of the airplane. • Electric motors also produce strong electric and magnetic fields that can influence the rest of the systems on board of the airplane(like magnetic heading indicator, electric sensors, VHF Com´s , etc). The electromagnetic effects of the Motor on the airplane shall be evaluated and placarded if necessary. • The power of an electric engine is not dependent on altitude! An engine capable of delivering 10kW on Ground will continue to deliver this power up to 40.000ft. The Overspeed protection has to ensure that the engine will not overspeed the propeller in altitudes. • The windmilling/power generation case needs to be addressed. • We assume for the installation, numerous other special conditions are required to cover the whole battery driven electric engine case. A CS-22 Subpart H certification for the electric motor alone seems inadequate.
EASA Response	It should be noted that there are other SCs at the aircraft level covering aircraft aspects which are out of the scope of an engine certification.

Commentor:	DGAC-F
Para:	General
Comment:	- each individual special condition should be numbered. This would ease cross referencing when discussing them. - the information on the design of the engine is insufficient for judging the adequacy of the proposed special conditions. Is there any high energy rotating parts ? is there a risk of non containment of high energy debris ? Is there a lubrication

	system of rotating parts (CS 22.1839 is not addressed)? Is there a risk of electrical shock to people on board or on ground when the engine is running ? etc. - the rationale for each and every proposed special condition should be given (see detailed comments below). - the EASA's web site states the following "the public consultation of this Special Condition will not result in a change to this TC Basis.". It is recommended to revise this position in consultation with the agency's lawyers, because some of the applied special conditions cannot be complied with, resulting in a false statement under 21A.20 (b) and a non compliance with 21A.21 (c) (1). There is apparently no legal basis for issuing a type certificate to this engine in such conditions.
EASA Response	Noted, after consultation within EASA it was confirmed that this certification project is subject to Article 2.4 of (EC) 1702/2003. The comments for improvement of the Special Condition are noted and will be considered for future projects.

Commentor:	DGAC-F
Para:	Ref to CS-22.1801
Comment:	The SC should simply state that they adapt subpart H to this type of engines (something like : "these special conditions extend the applicability of CS 22.1801 to certification of electrical engines"). Otherwise EASA would need to define what is meant by "decisive for the certifications".
EASA Response	Noted, will be considered for future projects

Commentor:	DGAC-F
Para:	Ref to CS-22.1807
Comment:	Instead of trying to define new text for CS-22, it would be much more simple and consistent to make use of CS-E 40 (a) and (d). Note that this would be consistent with the fact that 22.1808 is very close to CS-E 40 (f).
EASA Response	Noted, will be considered for future projects Only “pressure, fuel and oil” should have been replaced by acceptable words. There is no need to mix CS-22 up with CS-E.

Commentor:	DGAC-F
Para:	Ref to CS-22.1815
Comment:	This proposal should be entirely cancelled. How is defined "damaging to health" ? Which medical authority will check compliance with this certification specification ? How many years of experience would need to be made on how many people to ensure compliance? Considering abestos case, one could assume that 30 years before certifying the engine would be necessary. This is totally impractical. It must be noted that any material when made in form of a knife used to kill someone is damaging to health. EASA should note that CS-E 510 (g)(2)(ii) has been very carefully worded to avoid such "too much open" specification. But in the absence of comprehensive safety analysis in CS-22, this CS-E concept cannot be simply copied into these SC.
EASA	Noted, see also response to CAA-UK comments

Response	

Commentor:	DGAC-F
Para:	Ref to CS-22.1833
Comment:	The numerous changes in wording, which significantly modify the meaning or intent, are not justified. The only point here is to replace "crankshaft" by "engine shafts". This SC should not do more than that.
EASA Response	Noted, will be considered

Commentor:	DGAC-F
Para:	Ref to CS-22.1835
Comment:	The text is proposed to be in lieu of 22.1835. Then, why is there reference to "(b) to (d) inclusive" when there is none proposed in these SC ? It should be 22.XXXX Energy and air supply system. But ... why is the title referring to air supply when the proposed SC does not include any reference to air supply? We find reference to energy supply system, to energy system, to energy supply : how are defined these 3 different concepts ? What kind of energy is being considered here? One could expect that the subject would be "electrical power supply" but in the absence of technical information on the design (see general comment (2)) no one can be sure of the intent of this special condition. This text cannot be understood in itself: too much information is missing. On a more general issue, how can a system be designed to "ensure" that the energy will be available for all failures cases whatever the occurrence rate could be? It is likely to be impossible to comply with such very stringent specification. As far as engine certification is concerned, is the "energy" part of the engine type design? If not, then this proposal is not relevant: it looks like an aircraft certification requirement.
EASA Response	"(b) to (d) inclusive" can be deleted. This SC is specific to powered sailplanes. A failure of the required energy supply to the engine will not hazard the aircraft.

Commentor:	DGAC-F
Para:	Ref to CS-22.1843
Comment:	Again, the numerous changes in wording, which significantly modify the meaning or intent, are not justified. The only point here is to replace "crankshaft" by "engine shafts". This SC should not do more than that. How is justified the change from 103% to 105% ? Note that the reference, in CS 22.1843 and in these SC, to "desired take off speed" is an argument in favour of my comments (2) above (see CS-E 40 (a)).
EASA Response	Accepted, will be considered. 103 % as applied to other engine design will also be applied.

Commentor:	DGAC-F
Para:	Ref to CS-22.1845
Comment:	The changes should be explained: the rationale cannot be

	understood. In first sentence "must" has been changed into "shall": this is not consistent with EASA's policy. The second sentence changes totally the intent of the paragraph which was to identify the engine power characteristics on which the ratings are based and not to establish operational data (see last sentence of 22.1845). The special condition should be limited to a change of "crankshaft rotational speeds, manifold pressures, and fuel/air mixture settings."into more appropriate parameters (may be "shafts rotational speeds and electrical power supply conditions" ?). The requirement for measuring the energy consumption changes the intent of this paragraph and should be deleted form this special condition. This subject is already addressed in 22.1849 (d).
EASA Response	Noted, will be considered for future projects

Commentor:	DGAC-F
Para:	Ref to CS-22.1849(a)
Comment:	Why is the well known reference to " a representative propeller" changed into something which is not defined ("reference propeller") ? This is not a change which can be justified by the special design of this engine. Similarly, the third sentence is not a result of the novelties in the engine design and is more an acceptable means of compliance than a special condition. How is justified a change from 50 hours to 6 hours only ? This extremely significant change in safety objective of CS-22 sub-part H is not explained and creates an unfair situation for other engine designs. This cannot be justified by the novelties in the engine design. In (a)(1) (reminder : the proposed text is in lieu of 22.1849) there is a cross reference to 22.1849 (c) which is the existing (unmodified) CS-22 paragraph but at same time there is a cross reference to "table below" which is the modified schedule : this is inconsistent. What is really requested? The test specified in (a)(2) appears has not being related to the engine certification but to the aircraft certification. "Sufficient energy source" is not usually an engine matter unless in this case, the energy source is declared as being part of the engine type design (which is unknwon to the commenter, see general comment (2)). If the applicant elects to perform 8 cycles under (a)(1), there would remain only 16 minutes to perform the 50 take offs and 30 climbs of (a)(2). This is illogical and impossible. This special condition is not clear enough.
EASA Response	The concept of engine-propeller combination developed in this project does not correspond to other well known concepts. The requirements have been adapted to cover this fact. See also response to comment to 22.1849 (ACG).

Commentor:	DGAC-F
Para:	Ref to CS-22.1849(b)
Comment:	there is no reason for a change to existing 22.1849 (b) because of the special design of this engine, except that cross reference to 22.1843 should be changed to special conditon xx (see general comment (1)). What is the rationale for such change in wording ?
EASA Response	Accepted

Commentor:	DGAC-F
Para:	Ref to CS-22.1849(c)
Comment:	See comment on 22.1849 (a).
EASA Response	See also response to comment to 22.1849 a) (DGAC-F and ACG).

Commentor:	DGAC-F
Para:	Ref to CS-22.1849(d)
Comment:	One would expect only a change from "the fuel and oil consumption " to "the electrical power consumption". Why is there a need for the proposed changes to the intent of this requirement? By the way, here there is reference to "individual power stages" when in proposed replacement for 22.1851 there is reference to "operational stages": again the lack of information on the design does not allow understanding the proposals. At least these proposals are apparently not consistent.
EASA Response	Accepted

Commentor:	DGAC-F
Para:	Ref to CS-22.1851
Comment:	In addition to inconsistency noted above, the rationale for such significant changes to the intent of the paragraph should be explained. One would have expected a simple deletion of the words "backfire characteristics".
EASA Response	Noted, will be considered for future projects

Commentor:	J. Elser
Para:	Ref to CS-22.1849(c)
Comment:	Die Übernahme der Zyklen aus der Zulassungsvorschrift für Verbrennungstriebwerke könnte dem Konzept elektrischer Antriebe besser angepasst sein: 1.) Die Energieversorgung von elektrischen Antrieben unterscheidet sich grundlegend von der verbrennungsgetriebener Antriebe und ist im wesentlichen durch eine Begrenzung der z. V. stehenden Gesamtenergiemenge charakterisiert: a) Durch das hohe Akkugewicht ist es bei vielen Konfigurationen nicht sinnvoll längere Motorlaufzeiten im Konzept zu berücksichtigen. Bsp.: Eine bei elektrischen Antrieben aus Kosten und Gewichtsgründen ökonomische Auslegung auf ca. 800 m Steighöhe mit 2,5 m/s führt zu maximal 5 min 20 s Motorlaufzeit unter Vollast. In der Vorschrift sind jedoch 12 min mit

	Take-off power und weitere 20 min mit reduzierter Leistung gefordert. b) Die bei verbrennungsgetriebenen Antrieben vergleichsweise einfache Erhöhung der Laufzeit durch Mitnahme einer zusätzlichen Kraftstoffmenge ist bei elektrischen Antrieben aus Gewichtsgründen nicht möglich. Die Akkukonfiguration und die damit die z. V. stehende Energiemenge sollte damit bei der Auslegung und Zulassung des Gesamtantriebes, im Gegensatz zur Zulassung von Verbrennungsmotoren daher immer mit betrachtet werden (vgl. 3). c) Ein Nachweis der Gesamtlaufdauer am Boden erfordert beim Verbrennungsmotoren lediglich eine ausreichende Kraftstoffmenge. Im Falle eines elektrischen Antriebes müssen jedoch entweder entsprechende netzbetriebene Hochstromeinrichtungen vorhanden sein, oder eine Versorgung mit erhöhter Akkukapazität z. V. stehen. Die benötigte Akkukapazität entspricht in dem unter a) aufgeführten Beispiel einem Faktor 5 bis 9 der im Flug installierten Kapazität. Der Aufwand und die Kosten für die Bereitstellung der Hochstromnetze oder der Akkukapazität ist erheblich größer, als der Aufwand für die Bereitstellung der Kraftstoffmenge eines Verbrennungsmotors und steht nicht in einem vertretbaren Verhältnis zum Nutzen der Prozedur. Eine Verkürzung des unter JAR 22.1849 angegebenen Zyklen, aufgrund der unter 1a) bis 1c) aufgeführten Verhältnisse beim Einsatz von elektrischen Antrieben, entsprechend den vorgesehenen Akkukapazitäten, erscheint daher sinnvoll. 2.) Die Kühlung verbrennungsgetriebener Antriebe durch den Propellerstrom unterscheidet sich wesentlich von der Kühlung elektrischer Antriebe. Ein direkt angetriebener Elektromotor befindet sich i. A. konzentrisch angeordnet hinter der Propellernabe. Er wird daher vom Propellerluftstrom deutlich weniger gekühlt als die üblicherweise versetzt hinter der Nabe im Propellerluftstrom angeordneten Zylinder eines Verbrennungsmotors. Die Kühlung eines in der konzentrisch hinter der Propellernabe angeordneter Elektromotor ist daher deutlich mehr von der Kühlung durch den Fahrtwind abhängig, als die Kühlung von im Luftstrom liegenden Verbrennungsmotoren. Es wird angeregt, aufgrund der unter 2) dargelegten Verhältnisse, für eine Zulassung des Elektromotors alternative Bodenprüfstandläufe vorzusehen, mit einer Anblasung, die der minimalen tatsächlichen Fluggeschwindigkeit entspricht.
EASA Response	See also response to comment to 22.1849 a) (DGAC-F and ACG).