CS-29 AMENDMENT 5 — CHANGE INFORMATION

EASA publishes amendments to certification specifications as consolidated documents. These documents are used for establishing the certification basis for applications made after the date of entry into force of the amendment.

Consequently, except for a note '[Amdt No: 29/5]' under the amended paragraph, the consolidated text of CS-29 does not allow readers to see the detailed changes introduced by the new amendment. To allow readers to also see these detailed changes, this document has been created. The same format as for publication of notices of proposed amendments (NPAs) has been used to show the changes:

(a) deleted text is ~~struck through~~;

(b) new or amended text is highlighted in grey;

(c) an ellipsis '(…)' indicates that the remaining text is unchanged.

BOOK 1

SUBPART C — STRENGTH ~~REQUIREMENTS~~

Amend CS 29.563 as follows:

CS 29.563 Structural ditching and emergency flotation provisions

If certification with ditching provisions or if certification with emergency flotation provisions is requested by the applicant, structural strength ~~for ditching~~ must meet the requirements of this ~~paragraph~~ CS. If certification with ditching provisions is requested by the applicant, the requirements of ~~and~~ CS 29.801~~l~~(f~~e~~) must also be met. The loading conditions apply to all parts of the rotorcraft, unless otherwise stated by this CS and CS 29.802(b).

(a) *~~Forward speed l~~Landing conditions.* ~~The rotorcraft must initially contact the most critical wave for reasonably probable water conditions at forward velocities from zero up to 56 km/h (30 knots) in likely pitch, roll, and yaw attitudes. The rotorcraft limit vertical descent velocity may not be less than 1.5 m (5 ft) per second relative to the mean water surface.~~ The conditions considered must be those resulting from an emergency landing into the most severe sea conditions for which certification is requested by the applicant, at a forward ground speed not less than 15.4 m/s (30 knots), and a vertical speed not less than 1.5 m/s (5 ft/s), in likely pitch, roll and yaw attitudes. Rotor lift may be ~~used~~ assumed to act through the centre of gravity ~~throughout the landing impact~~ during water entry. This lift may not exceed two-thirds of the design maximum weight. ~~A maximum forward velocity of less than 56 km/h (30 knots) may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out touchdown~~.

(b) *~~Auxiliary or emergency float conditions~~ Loads*.

(1) *Floats fixed or intended to be deployed before initial water contact.* The loads to be considered are those resulting from the rotorcraft entering the water, in the conditions defined in (a), and in accordance with flight manual procedures. In addition ~~to the landing loads in sub-paragraph (a)~~, each ~~auxiliary or emergency~~ float, ~~or~~ and its support and attaching structure ~~in the airframe or fuselage~~, must be designed for the loads developed by a fully immersed float unless it can be shown that full immersion is unlikely. If full immersion is unlikely, the highest likely float buoyancy load must be applied. ~~The highest likely buoyancy load must include consideration of a partially immersed float creating restoring moments to compensate the upsetting moments caused by side wind, unsymmetrical rotorcraft loading, water wave action, rotorcraft inertia, and probable structural damage and leakage considered under CS 29.801(d). Maximum roll and pitch angles determined from compliance with CS 29.801(d) may be used, if significant, to determine the extent of immersion of each float. If the floats are deployed in flight, a~~ Appropriate air loads ~~flight limitations with~~

the floats deployed shall be used in substantiation of the floats and their attachment to the rotorcraft. For this purpose, the design airspeed for limit load is the maximum operating airspeed limit with fixed or deployed floats deployed airspeed operating limit multiplied by 1.11.

In the case of approval with ditching provisions, water entry with deployable floats in the unintended stowed position must also be accounted for. It must be established that in such a case, damage to the un-deployed floats, attachments or surrounding structure, that would prevent proper deployment and functioning of the floats, will not occur.

(2) *Floats intended to be deployed after initial water contact.* The loads to be considered are those resulting from the rotorcraft entering the water, in the conditions defined in (a), and in accordance with flight manual procedures. In addition, Eeach float and its support and attaching structure must be designed for full or partial immersion prescribed in sub-paragraph (b)(1). In addition, each float must be designed for combined vertical and drag loads. The vertical load must be that developed by a fully immersed float, unless it can be shown that full immersion is unlikely. If full immersion is unlikely, the highest likely float buoyancy load must be applied. The drag load must be determined assuming using a relative limit speed of 37 km/h 10.3 m/s (20 knots) between the rotorcraft and the water. The vertical load may not be less than the highest likely buoyancy load determined under sub-paragraph (b)(1).

SUBPART D — DESIGN AND CONSTRUCTION

Amend CS 29.725(d) as follows:

CS 29.725 Limit drop test

(…)

(d)

(…)

l L = ratio of assumed rotor lift to the rotorcraft weight.

(…)

Amend CS 29.783(h) as follows:

CS 29.783 Doors

(…)

(h) Non jettisonable doors used as ditching emergency exits must have means to enable them to be secured in the open position and remain secure for emergency egress in all sea state conditions for which ditching capability is requested by the applicant.

Amend CS 29.801 as follows:

CS 29.801 Ditching

(a) If certification with ditching provisions is requested by the applicant, the rotorcraft must meet the requirements of this ~~paragraph~~ CS and CS 29.563, CS 29.783(h), CS 29.803(c), CS 29.805(c), CS 29.807(d), CS 29.809(j), CS 29.811(h), CS 29.813(d), CS 29.1411 ~~and~~ CS 29.1415, CS 29.1470, CS 29.1555(d)(3) and CS 29.1561.

(b) Each practicable design measure, compatible with the general characteristics of the rotorcraft, must be taken to minimise the probability that ~~in an emergency landing on water~~ when ditching, the behaviour of the rotorcraft would cause immediate injury to the occupants or would make it impossible for them to escape.

(c) An emergency flotation system that is stowed in a deflated condition during normal flight must:

(1) be designed such that the effects of a water impact (i.e. crash) on the emergency flotation system are minimised.

(2) have a means of automatic deployment following water entry. Automatic deployment must not rely on any pilot action during flight.

(~~c~~d) The probable behaviour of the rotorcraft during ditching water entry ~~in a water landing~~ must be shown to exhibit no unsafe characteristics. ~~investigated by model tests or by comparison with rotorcraft of similar configuration for which the ditching characteristics are known. Scoops, flaps, projections, and any other factors likely to affect the hydrodynamic characteristics of the rotorcraft must be considered.~~

(~~d~~e) ~~It must be shown that, under reasonably probable water conditions, the flotation time and trim of the rotorcraft will allow the occupants to leave the rotorcraft and enter the life rafts required by CS 29.1415. If compliance with this provision is shown by buoyancy and trim computations, appropriate allowances must be made for probable structural damage and leakage. If the rotorcraft has fuel tanks (with fuel jettisoning provisions) that can reasonably be expected to withstand a ditching without leakage, the jettisonable volume of fuel may be considered as buoyancy volume~~. The rotorcraft must be shown to resist capsize in the sea conditions selected by the applicant. The probability of capsizing in a 5-minute exposure to the sea conditions must be substantiated to be less than or equal to 3.0 % with a fully serviceable emergency flotation system and 30.0 % with the critical float compartment failed, with 95 % confidence.

Allowances must be made for probable structural damage and leakage.

(~~e~~f) Unless the effects of the collapse of external doors and windows are accounted for in the investigation of the probable behaviour of the rotorcraft ~~in a~~ during ditching ~~water landing~~ (as prescribed in ~~subparagraphs~~ (~~c~~d) and (~~d~~e)), the external doors and windows must be designed to withstand the probable maximum local pressures.

(g) It must be shown that the rotorcraft will not sink following the functional loss of any single complete flotation unit.

Create a new CS 29.802 as follows:

CS 29.802 Emergency Flotation

If operational rules allow, and only certification for emergency flotation equipment is requested by the applicant, the rotorcraft must be designed as follows;

(a) The rotorcraft must be equipped with an approved emergency flotation system.

(b) For a rotorcraft with a passenger seating capacity of 9 or less, the flotation units and their attachments to the rotorcraft must comply with CS 29.563. For a rotorcraft with a passenger seating capacity of 10 or more, the rotorcraft must comply with CS 29.563.

(c) The rotorcraft must be shown to resist capsize in the sea conditions selected by the applicant. The probability of capsizing in a 5-minute exposure to the sea conditions must be demonstrated to be less than or equal to 10.0 % with a fully serviceable emergency flotation system, with 95 % confidence. No demonstration of capsize resistance is required for the case of the critical float compartment having failed.

Allowances must be made for probable structural damage and leakage.

(d) It must be shown that the rotorcraft will not sink following the functional loss of any single complete flotation unit.

Amend CS 29.803 as follows:

CS 29.803 Emergency evacuation

(...)

(c) ~~Reserved.~~ If certification with ditching provisions is requested by the applicant:

(1) ditching emergency exits must be provided such that following a ditching, in all sea conditions for which ditching capability is requested by the applicant, passengers are able to evacuate the rotorcraft and step directly into any of the required life rafts;

(2) any exit provided for compliance with (1), irrespective of whether it is also required by any of the requirements of CS 29.807, must meet all the requirements of CS 29.809(c), CS 29.811(a), (c), (d), (e) and CS 29.812(b); and

(3) flotation devices, whether stowed or deployed, may not interfere with or obstruct the ditching emergency exits.

(…)

Amend CS 29.805 as follows:

CS 29.805 Flight crew emergency exits

(…)

(c) *Underwater emergency exits for flight crew.* If certification with ditching provisions is requested by the applicant, ~~Each exit~~ none of the flight crew emergency exits required by (a) and (b) ~~must not~~ may be obstructed by water or flotation devices after a ditching~~. This must~~ and each exit must be shown by test, demonstration, or analysis to provide for rapid escape when the rotorcraft is in the upright floating position or capsized. Each operational device (pull tab(s), operating handle, 'push here' decal, etc.) must be shown to be accessible for the range of flight crew heights as required by CS 29.777(b) and for both the case of an un-deformed seat and a seat with any deformation resulting from the test conditions required by CS 29.562.

Amend CS 29.807 as follows:

CS 29.807 Passenger emergency exits

(…)

(d) ~~*Ditching*~~ *Underwater emergency exits for passengers*. If certification with ditching provisions is requested by the applicant, ~~ditching~~ underwater emergency exits must be provided in accordance with the following requirements and must be proven by test, demonstration, or analysis to provide for rapid escape with the rotorcraft in the upright floating position or capsized. ~~unless the emergency exits required by subparagraph (b) already meet these requirements:~~

(1) ~~For rotorcraft that have a passenger seating configuration, excluding pilots seats, of nine seats or less,~~ O~~o~~ne underwater emergency exit ~~above the waterline~~ in each side of the rotorcraft, meeting at least the dimensions of a Type IV exit~~.~~ for each unit (or part of a unit) of four passenger seats. However, the passenger seat-to-exit ratio may be increased for exits large enough to permit the simultaneous egress of two passengers side by side.

~~(2) For rotorcraft that have a passenger seating configuration, excluding pilots seats, of 10 seats or more, one exit above the waterline in a side of the rotorcraft meeting at least the dimensions of a Type III exit, for each unit (or part of a unit) of 35 passenger seats, but no less than two such exits in the passenger cabin, with one on each side of the rotorcraft. However, where it has been shown through analysis, ditching demonstrations, or any other tests found necessary by the Agency, that the evacuation capability of the rotorcraft during ditching is improved by the use of larger exits, or by other means, the passenger seat to exit ratio may be increased.~~

(~~3~~2) Flotation devices, whether stowed or deployed, may not interfere with or obstruct the underwater emergency exits.

(…)

Amend CS 29.809 as follows:

CS 29.809 Emergency exit arrangement

(a) Each emergency exit must consist of a ~~moveable~~ door, openable window, or hatch in the external walls of the fuselage and must provide an unobstructed opening to the outside.

(…)

(h) For rotorcraft having 30 or fewer passenger seats and having an exit threshold of more than 1.8 m (6 ft) above the ground, a rope or other assist means may be used in place of the slide specified in subparagraph (f), provided an evacuation demonstration is accomplished as prescribed in CS 29.803 (d) or (e).
(…)

(j) If certification with ditching provisions is requested by the applicant, each underwater emergency exit must meet the following:

(1) means of operation, markings, lighting and accessibility, must be designed for use in a flooded and capsized cabin;

(2) it must be possible for each passenger to egress the rotorcraft via the nearest underwater emergency exit, when capsized, with any door in the open and secured position; and

(3) a suitable handhold, or handholds, adjacently located inside the cabin to assist passengers in locating and operating the exit, as well as in egressing from the exit, must be provided.

Amend CS 29.811 as follows:

CS 29.811 Emergency exit marking

(a) Each ~~passenger~~ emergency exit, its means of access, and its means of opening must be conspicuously marked for the guidance of occupants using the exits in daylight or in the dark. ~~Such markings must be designed to remain visible for rotorcraft equipped for overwater flights if the rotorcraft is capsized and the cabin is submerged.~~

(…)

(h) If certification with ditching provisions is requested by the applicant, in addition to the markings required by (a) above:

(1) each underwater emergency exit required by CS 29.805(c) or CS 29.807(d), its means of access and its means of opening, must be provided with highly conspicuous illuminated markings that illuminate automatically and are designed to remain visible with the rotorcraft capsized and the cabin or cockpit, as appropriate, flooded; and

(2) each operational device (pull tab(s), operating handle, 'push here' decal, etc.) for these emergency exits must be marked with black and yellow stripes.

Amend CS 29.812 as follows:

CS 29.812 Emergency lighting

For ~~transport~~ Category A rotorcraft, the following apply:

(…)

(b) Exterior emergency lighting must be provided at each emergency exit as required by CS 29.807(a) and at each ditching emergency exit required by CS 29.803(c)(1). The illumination may not be less than 0.5 lux (0.05 foot-candle) (measured normal to the direction of incident light) for a minimum width ~~on the ground surface, with landing gear extended,~~ equal to the width of the emergency exit on the ground surface where an evacuee is likely to make first contact ~~with the ground~~ outside the cabin, with landing gear extended, and if applicable, on the raft surface where an evacuee is likely to make first contact when boarding the life raft. The exterior emergency lighting may be provided by either interior or exterior sources with light intensity measurements made with the emergency exits open.

(…)

Add a new CS 29.813(d) as follows:

CS 29.813 Emergency exit access

(…)

(d) If certification with ditching provisions is requested:

(1) passenger seats must be located in relation to the underwater emergency exits provided in accordance with CS 29.807(d)(1) in a way to best facilitate escape with the rotorcraft capsized and the cabin flooded; and

(2) means must be provided to assist cross-cabin escape when capsized.

Amend CS 29.865 as follows:

CS 29.865 External loads

(a) It must be shown by analysis, test, or both, that the rotorcraft external-load attaching means for rotorcraft-load combinations to be used for non-human external cargo applications can withstand a limit static load equal to 2.5, or some lower load factor approved under CS 29.337 through 29.341, multiplied by the maximum external load for which authorisation is requested. It must be shown by analysis, test, or both that the rotorcraft external-load attaching means and any complex ~~corresponding~~ personnel-carrying device system for rotorcraft-load combinations to be used for human external cargo applications can withstand a limit static load equal to 3.5 or some lower load factor, not less than 2.5, approved under CS 29.337 through 29.341, multiplied by the maximum external load for which authorisation is requested. The load for any rotorcraft-load combination class, for any external cargo type, must be applied in the vertical direction. For jettisonable rotorcraft-load combinations, for any applicable external cargo type, the load must also be applied in any direction making the maximum angle with the vertical that can be achieved in service, but not less than 30°º. However, the 30°º angle may be reduced to a lesser angle if:

(1) An operating limitation is established limiting external load operations to ~~such~~ those angles for which compliance with this paragraph has been shown; or

(2) It is shown that the lesser angle cannot be exceeded in service.

(b) The external-load attaching means, for jettisonable rotorcraft-load combinations, must include a quick-release system (QRS) to enable the pilot to release the external load quickly during flight. The QRS ~~quick-release system~~ must consist of a primary quick-release subsystem and a backup quick-release subsystem that are isolated from one another. The QRS~~quick-release system~~, and the means by which it is controlled, must comply with the following:

(1) A control for the primary quick-release subsystem must be installed either on one of the pilot's primary controls or in an equivalently accessible location and must be designed and located so that it may be operated by either the pilot or a crew member without hazardously limiting the ability to control the rotorcraft during an emergency situation.

(2) A control for the backup quick-release subsystem, readily accessible to either the pilot or another crew member, must be provided.

(3) Both the primary and backup quick-release subsystems must:

(i) Be reliable, durable, and function properly with all external loads up to and including the maximum external limit load for which authorisation is requested.

(ii) Be protected against electromagnetic interference (EMI) from external and internal sources and against lightning to prevent inadvertent load release.

(A) The minimum level of protection required for jettisonable rotorcraft-load combinations used for non-human external cargo is a radio frequency field strength of 20 volts per metre.

(B) The minimum level of protection required for jettisonable rotorcraft-load combinations used for human external cargo is a radio frequency field strength of 200 volts per metre.

(iii) Be protected against any failure that could be induced by a failure mode of any other electrical or mechanical rotorcraft system.

(c) For rotorcraft-load combinations to be used for human external cargo applications, the rotorcraft must:

(1) For jettisonable external loads, have a QRS ~~quick-release system~~ that meets the requirements of subparagraph (b) and that:

(i) Provides a dual actuation device for the primary quick-release subsystem, and

(ii) Provides a separate dual actuation device for the backup quick-release subsystem.

(2) ~~Have a reliable, approved personnel-carrying device system that has the structural capability and personnel safety features essential for external occupant safety,~~ Enable the safe utilisation of complex personnel-carrying device systems to transport occupants external to the helicopter or to restrain occupants inside the cabin. A personnel-carrying device system is considered complex if:

(i) it does not meet an European Norm (EN) standard under Directive

89/686/EEC[1] or Regulation (EU) 2016/425[2], as applicable, or subsequent revision;

(ii) it is designed to restrain more than a single person (e.g. a hoist or cargo hook operator, photographer, etc.) inside the cabin, or to restrain more than two persons outside the cabin; or

(iii) it is a rigid structure such as a cage, a platform or a basket.

Complex personnel-carrying device systems shall be reliable and have the structural capability and personnel safety features essential for external occupant safety through compliance with the specific requirements of CS 29.865, CS 29.571 and other relevant requirements of CS-29 for the proposed operating envelope.

(3) Have placards and markings at all appropriate locations that clearly state the essential system operating instructions and, for ~~the~~ complex personnel-carrying device systems, ingress and egress instructions,

(4) Have equipment to allow direct intercommunication among required crew members and external occupants,

(5) Have the appropriate limitations and procedures incorporated in the flight manual for conducting human external cargo operations, and

(6) For human external cargo applications requiring use of Category A rotorcraft, have one-engine-inoperative hover performance data and procedures in the flight manual for the weights, altitudes, and temperatures for which external load approval is requested.

(d) The critically configured jettisonable external loads must be shown by a combination of analysis, ground tests, and flight tests to be both transportable and releasable throughout the approved operational envelope without hazard to the rotorcraft during normal flight conditions. In addition, these external loads must be shown to be releasable without hazard to the rotorcraft during emergency flight conditions.

(e) A placard or marking must be installed next to the external-load attaching means clearly stating any operational limitations and the maximum authorised external load as demonstrated under CS 29.25 and this paragraph.

(f) The fatigue evaluation of CS 29.571 does not apply to rotorcraft-load combinations to be used for non-human external cargo except for the failure of critical structural elements that would result in a hazard to the rotorcraft. For rotorcraft-load combinations to be used for human external cargo, the fatigue evaluation of CS 29.571 applies to the entire quick-release and complex personnel-carrying device structural systems and their attachments.

---

[1] Council Directive 89/686/EEC of 21 December 1989 on the approximation of the laws of the Member States relating to personal protective equipment (OJ L 399, 30.12.1989, p. 18).

[2] Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC (OJ L 81, 31.3.2016, p. 51).

SUBPART E — POWERPLANT

Amend CS 29.917 as follows:

CS 29.917 Design

(a) *General.* The rotor drive system includes any part necessary to transmit power from the engines to the rotor hubs. This includes gearboxes, shafting, universal joints, couplings, rotor brake assemblies, clutches, supporting bearings for shafting, any attendant accessory pads or drives, lubricating systems for drive system gearboxes, oil coolers and any cooling fans that are part of, attached to, mounted on or driven by the rotor drive system.

(…)

Amend CS 29.927 as follows:

CS 29.927 Additional tests

(a) Any additional dynamic, endurance, and operational tests, and vibratory investigations necessary to determine that the rotor drive mechanism is safe, must be performed.

(…)

(c) *Lubrication system failure.* ~~For lubrication systems required for proper operation of rotor drive systems, the following apply~~For rotor drive system gearboxes required for continued safe flight or safe landing which have a pressurised normal-use lubrication system, the following apply:

(1) *Category A.* ~~Unless such failures are extremely remote, it must be shown by test that any failure which results in loss of lubricant in any normal use lubrication system will not prevent continued safe operation, although not necessarily without damage, at a torque and rotational speed prescribed by the applicant for continued flight, for at least 30 minutes after perception by the flight crew of the lubrication system failure or loss of lubricant.~~ Confidence shall be established that the rotor drive system has an in-flight operational endurance capability of at least 30 minutes following a failure of any one pressurised *normal-use lubrication system*.

~~*B.* The requirements of Category A apply except that the rotor drive system need only be capable of operating under autorotative conditions for at least 15 minutes.~~
For each rotor drive system gearbox necessary for continued safe flight or safe landing, a test shall be conducted simulating the effect of the *most severe failure mode* of the *normal-use lubrication system* as determined by the failure analysis of CS 29.917(b). The duration of the test shall be dependent upon the number of tests and the component condition after the test. The test shall be conducted such that it begins upon the indication to the flight crew that a lubrication failure has occurred, and its loading is consistent with 1 minute at maximum continuous power, followed by the minimum power needed for continued flight at the rotorcraft maximum gross weight. The test shall end with a 45-second out of ground effect (OGE) hover to simulate a landing phase. Test results must substantiate the *maximum period of operation following loss of lubrication* by means of an extended test duration, multiple test specimens, or another approach prescribed by the applicant and accepted by EASA, and must support the procedures published in the rotorcraft flight manual (RFM). Flight durations longer

than 30 minutes may be demonstrated by means of a correspondingly longer test with appropriate margin and substantiation.

(2) *Category B*. Confidence shall be established that the rotor drive system has an in-flight operational endurance capability to complete an autorotation descent and landing following a failure of any one pressurised *normal-use lubrication system*.

For each rotor drive system gearbox necessary for safe autorotation descent or safe landing, a test of at least 16 minutes and 15 seconds following the *most severe failure mode* of the *normal-use lubrication system* as determined by the failure analysis of CS 29.917(b) shall be conducted. The test shall be conducted such that it begins upon the indication to the flight crew that a lubrication failure has occurred and its loading is consistent with 1 minute at maximum continuous power, after which the input torque should be reduced to simulate autorotation for 15 minutes. The test shall be completed by the application of an input torque to simulate a minimum power landing for approximately 15 seconds.

SUBPART F — EQUIPMENT

Amend CS 29.1411 as follows:

CS 29.1411 General

(a) *Accessibility*. Required safety equipment to be used by the crew in an emergency~~, such as automatic life raft releases~~ must be readily accessible.

(b) *Stowage provisions*. Stowage provisions for required safety ~~emergency~~ equipment must be furnished and must:

(1) Be arranged so that the equipment is directly accessible and its location is obvious; and

(2) Protect the safety equipment from inadvertent damage.

(c) *Emergency exit descent device*. The stowage provisions for the emergency exit descent device required by CS 29.809 (f) must be at the exits for which they are intended.

~~(d) *Life rafts*. Life rafts must be stowed near exits through which the rafts can be launched during an unplanned ditching. Rafts automatically or remotely released outside the rotorcraft must be attached to the rotorcraft by the static line prescribed in CS 29.1415.~~

~~(e) *Long-range signalling device*. The stowage provisions for the long-range signalling device required by CS 29.1415 must be near an exit available during an unplanned ditching.~~

~~(f) *Life preservers*. Each life preserver must be within easy reach of each occupant while seated.~~

Amend CS 29.1415 as follows:

CS 29.1415 Ditching equipment

If certification with ditching provisions or emergency flotation provisions is requested by the applicant, the additional safety ~~(a) Emergency flotation and signalling~~ equipment required by any applicable operating rule must meet the requirements of this ~~paragraph~~ CS.

~~(b)~~(a) All equipment ~~Each life raft and each life preserver~~ must be approved. ~~In addition:~~

(b) Life rafts.

(1) Required life raft(s) must be remotely deployable for use in an emergency. Remote controls capable of deploying the life raft(s) must be located within easy reach of the flight crew, occupants of the passenger cabin and survivors in the water, with the rotorcraft in the upright floating or capsized position. It must be substantiated that life raft(s) sufficient to accommodate all rotorcraft occupants, without exceeding the rated capacity of any life raft, can be reliably deployed with the rotorcraft in any reasonably foreseeable floating attitude, including capsized, and in the sea conditions chosen for demonstrating compliance with CS 29.801(e). ~~Provide not less than two rafts, of approximately equal rated capacity and buoyancy, to accommodate all the occupants of the rotorcraft; and~~

(2) Each life raft must have a ~~trailing line, and must have a static~~ short retaining line designed to hold the life raft near the rotorcraft, and a long retaining line designed to keep the life raft attached to the rotorcraft. Both retaining lines must be designed ~~but~~ to break before submerging the empty raft to which they are attached ~~release it~~ if the rotorcraft becomes totally submerged. The long retaining line must be of sufficient length that a drifting life raft will not be drawn towards any part of the rotorcraft that would pose a danger to the life raft itself or the persons on board.

(3) Each life raft must be substantiated as suitable for use in all sea conditions covered by the certification with ditching or emergency flotation provisions.

(4) The number of life rafts installed must be no less than two. The life rafts must be of an approximately equal rated capacity and buoyancy to accommodate all the occupants of the rotorcraft and unless excess life rafts of sufficient capacity are provided, the buoyancy and seating capacity beyond the rated capacity of each life raft (overload rating) must accommodate all occupants of the rotorcraft in the event of loss of one life raft of the largest rated capacity.

(c) Life preservers.

If the applicable operating rule allows for life preservers not to be worn at all times, stowage provisions must be provided that accommodate one life preserver for each occupant for which certification with ditching provisions is requested. A life preserver must be within easy reach of each occupant while seated.

(~~c~~d) Survival equipment.

Approved survival equipment must be attached to each life raft.

~~(d) There must be an approved survival type emergency locator transmitter for use in one life raft.~~

Create a new CS 29.1470 as follows:

CS 29.1470 Emergency locator transmitter (ELT)

Each emergency locator transmitter, including sensors and antennae, required by the applicable operating rule, must be installed so as to minimise damage that would prevent its functioning following an accident or incident.

SUBPART G — OPERATING LIMITATIONS AND INFORMATION

Amend CS 29.1555 as follows:

CS 29.1555 Control markings

(…)

(d) For accessory, auxiliary, and emergency controls:

(1) Each essential visual position indicator, such as those showing rotor pitch or landing gear position, must be marked so that each crew member can determine at any time the position of the unit to which it relates; and

(2) Each emergency control must be ~~red and must be~~ marked as to the method of operation and be red unless it may need to be operated underwater, in which case it must be marked with yellow and black stripes.

(…)

Amend CS 29.1561 as follows:

CS 29.1561 Safety equipment

(a) Each safety equipment control to be operated by the crew or passenger in an emergency~~, such as controls for automatic life raft releases,~~ must be plainly marked with its identification and ~~as to~~ its method of operation.

(b) Each location, such as a locker or compartment that carries any fire extinguishing, signalling, or other safety ~~life saving~~ equipment, must be ~~so~~ appropriately marked in order to identify the contents and if necessary indicate how to remove the equipment.

~~(c) Stowage provisions for required safety emergency equipment must be conspicuously marked to identify the contents and facilitate removal of the equipment.~~

(~~d~~c) Each item of safety equipment carried ~~life raft~~ must be marked ~~for~~ with its identification and must have obviously marked operating instructions.

~~(e) Approved survival equipment must be marked for identification and method of operation.~~

Amend CS 29.1585 as follows:

CS 29.1585 Operating procedures

(a) The parts of the manual containing operating procedures must have information concerning any normal and emergency procedures, and other information necessary for safe operation, including the applicable procedures, such as those involving minimum speeds, to be followed if an engine fails.

(…)

(h) The maximum duration of operation after a failure resulting in a loss of lubrication of a rotor drive system gearbox and an associated oil pressure warning must be furnished and must not exceed the maximum period substantiated in accordance with CS 29.927(c).

Amend CS 29.1587 as follows:

CS 29.1587 Performance information

(…)

(c) The RFM must contain the substantiated sea conditions and any associated information relating to the certification obtained with ditching or emergency flotation provisions.

Book 2

Create a new AMC 29.563 as follows:

AMC 29.563

Structural ditching and emergency flotation provisions

This AMC replaces FAA AC 29.563 and AC 29.563A.

(a) Explanation.

This AMC contains specific structural conditions to be considered to support the ditching requirements of CS 29.801, and the emergency flotation requirements of CS 29.802.

For rotorcraft for which certification with ditching provisions is requested by the applicant, in accordance with CS 29.801(a), the structural conditions apply to the complete rotorcraft.

For rotorcraft for which certification with emergency flotation provisions is requested by the applicant, in accordance with CS 29.802(b): if the passenger capacity of the rotorcraft is less than 10 passengers, the structural conditions apply only to the flotation units and their attachments to the rotorcraft, otherwise they apply to the complete rotorcraft.

At Amendment 5, the requirement for flotation stability on waves was appreciably changed. A requirement for the substantiation of acceptable stability by means of scale model testing in irregular waves was introduced at this amendment. This change made the usage of Sea State (World Meteorological Organization) no longer appropriate. The sea conditions are now defined in terms of significant wave height (H_s) and mean wave period (T_z). These terms are therefore also used in this AMC when defining sea conditions.

(1) The landing conditions specified in 29.563(a) may be considered as follows:

(i) The rotorcraft contacts the most severe sea conditions for which certification with ditching or emergency flotation provisions is requested by the applicant, selected in accordance with Table 1 of AMC to CS 29.801(e) and 29.802(c) and as illustrated in Figure 1 a). These conditions may be simulated considering the rotorcraft contacting a plane of stationary water as illustrated in Figure 1 b), inclined with a range of steepness from zero to the significant steepness given by $S_s=2\pi H_s/(gT_z^2)$. Values of S_s are given in Table 1 of AMC to 29.801(e) and 29.802(c). The rotorcraft contacts the inclined plane of stationary water with a flight direction contained in a vertical plane. This vertical plane is perpendicular to the inclined plane, as illustrated in Figure 1 b). Likely rotorcraft pitch, roll and yaw attitudes at water entry that would reasonably be expected to occur in service, should also be considered. Autorotation, run-on landing, or one-engine-inoperative flight tests, or a validated simulation should be used to confirm the attitudes selected.

(ii) The forward ground speed should not be less than 15.4 m/s (30 kt), and the vertical speed not less than 1.5 m/s (5 ft/s).

(iii) A rotor lift of not more than two-thirds of the design maximum weight may be assumed to act through the rotorcraft's centre of gravity during water entry.

(iv) The above conditions may be simulated or tested using a calm horizontal water surface with an equivalent impact angle and speed relative to the water surface as illustrated in Figure 1 c).

(2) For floats that are fixed or intended to be deployed before water contact, CS 29.563(b)(1) defines the applicable load condition for entry into water, with the floats in their intended configuration.

CS 29.563(b)(1) also requires consideration of the following cases:

— The floats and their attachments to the rotorcraft should be designed for the loads resulting from a fully immersed float unless it is shown that full immersion is unlikely. If full immersion is shown to be unlikely, the determination of the highest likely buoyancy load should include consideration of a partially immersed float creating restoring moments to compensate for the upsetting moments caused by the side wind, unsymmetrical rotorcraft loading, water wave action, rotorcraft inertia, and probable structural damage and leakage considered under CS 29.801(e). The maximum roll and pitch angles established during compliance with CS 29.801(e) may be used to determine the extent of immersion of each float. When determining this, damage to the rotorcraft that could be reasonably expected should be accounted for.

— To mitigate the case when the crew is unable to, or omits to, deploy a normally stowed emergency flotation system before entering the water, it should be substantiated that the floats will survive and function properly. The floats in their un-deployed condition, their attachments to the rotorcraft and the local structure should be designed to withstand the water entry loads without damage that would prevent the floats inflating as intended. Risks such as the splintering of surrounding components in a way that might damage the un-deployed or deploying floats should be considered. There is, however, no requirement to assess the expected loading on other parts of the rotorcraft when entering the water, with unintended un-deployed floats.

— The floats and their attachments to the rotorcraft should be substantiated as capable of withstanding the loads generated in flight. The airspeed chosen for assessment of the loads should be the appropriate operating limitation multiplied by 1.11. For fixed floats, the operating limitation should be the rotorcraft VNE. For deployable floats, if an operating limitation for the deployment of floats and/or flight with floats deployed is given, the highest such limitation should be used, otherwise the rotorcraft VNE should be used.

(3) For floats intended to be deployed after water contact, CS 29.563(b)(2) requires the floats and their attachments to the rotorcraft to be designed to withstand the loads generated when entering the water with the floats in their intended condition.

Simultaneous vertical and drag loading on the floats and their attachments should be considered to account for the rotorcraft moving forward through the water during float deployment.

The vertical loads should be those resulting from fully immersed floats unless it is shown that full immersion is unlikely. If full immersion is shown to be unlikely, the determination of the highest likely buoyancy load should include consideration of a partially immersed float creating restoring moments to compensate for the upsetting moments caused by side wind, unsymmetrical rotorcraft loading, water wave action, rotorcraft inertia, and probable structural damage and leakage considered under CS 29.801(e). The maximum roll and pitch angles established during compliance with CS 29.801(e) may be used, if significant, to determine the extent of immersion of each float. When determining this, damage to the rotorcraft that could be reasonably expected should be accounted for.

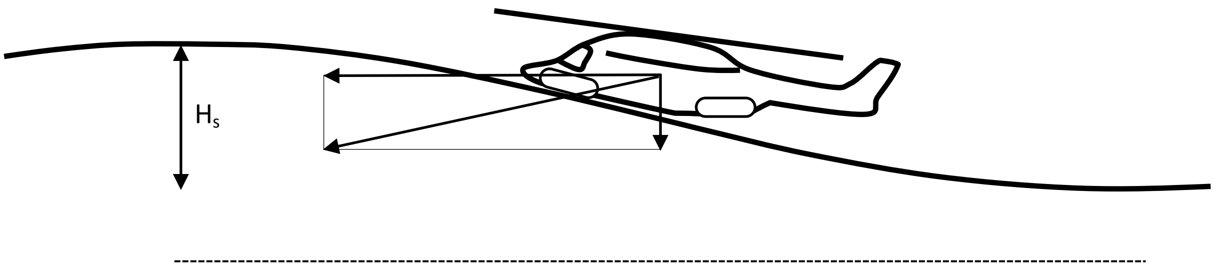
The drag loads should be those resulting from movement of the rotorcraft through the water at 10.3 m/s (20 knots).

(b) Procedures

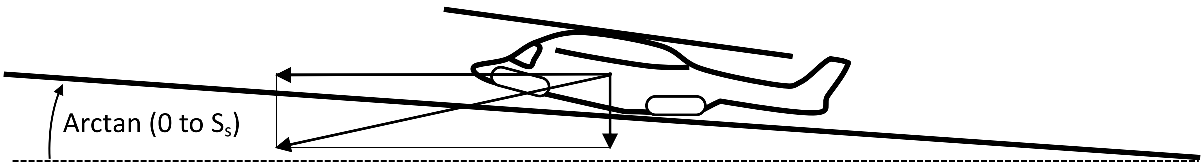
(1) The floats and the float attachment structure should be substantiated for rational limit and ultimate loads.

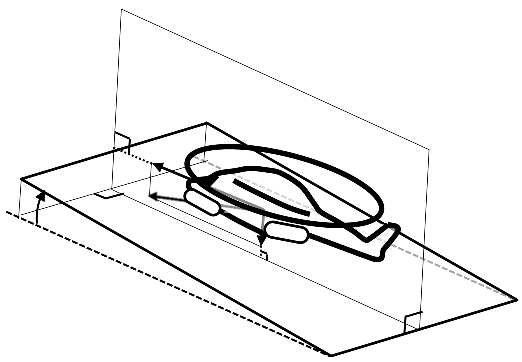
(2) The most severe sea conditions for which certification is requested by the applicant are to be considered. The sea conditions should be selected in accordance with the AMC to 29.801(e) and 29.802(c).

(3) Landing load factors and the water load distribution may be determined by water drop tests or validated analysis.

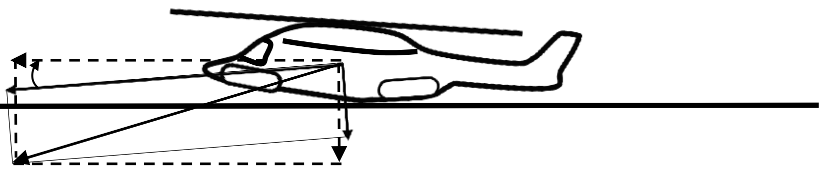


a) Water entry into wave





b) Water entry into inclined plane of stationary water,
steepness range - zero to significant steepness (S_s)
$S_s = 2\pi H_s/(gT_z^2)$



c) Water entry into a stationary horizontal water surface
using an equivalent water entry angle and velocity relative to the water surface
(Dashed arrows show required horizontal and vertical speeds)

Figure 1 – Illustration of water entry test or simulation conditions which may be considered for structural provisions assessment

Create a new AMC 29.801 as follows:

AMC 29.801 Ditching

This AMC replaces FAA AC 29.801.

(a) Definitions

(1) Ditching: a controlled emergency landing on the water, deliberately executed in accordance with rotorcraft flight manual (RFM) procedures, with the intent of abandoning the rotorcraft as soon as practicable.

(2) Emergency flotation system (EFS): a system of floats and any associated parts (e.g. gas cylinders, means of deployment, pipework and electrical connections) that is designed and installed on a rotorcraft to provide buoyancy and flotation stability in a ditching.

(b) Explanation

(1) Ditching certification is performed only if requested by the applicant.

(2) For a rotorcraft to be certified for ditching, in addition to the other applicable requirements of CS-29, the rotorcraft must specifically meet CS 29.801 together with the requirements referenced in CS 29.801(a).

(3) Ditching certification encompasses four primary areas of concern: rotorcraft water entry and flotation stability (including loads and flotation system design), occupant egress, and occupant survival. CS-29 Amendment 5 has developed enhanced standards in all of these areas.

(4) The scope of the ditching requirements is expanded at Amendment 5 through a change in the ditching definition. All potential failure conditions that could result in a controlled 'land immediately' action by the pilot are now included. This primarily relates to changes in water entry conditions. While the limiting conditions for water entry have been retained (15.4 m/s, 1.5 m/s), the

alleviation that previously allowed less than 15.4 m/s (30 kt) forward speed to be substantiated as the maximum applicable value has been removed (also from CS 29.563).

(5) Flotation stability is enhanced through the introduction of a new standard based on a probabilistic approach to capsizes.

(6) Failure of the EFS to operate when required will lead to the rotorcraft rapidly capsizing and sinking. Operational experience has shown that localised damage or failure of a single component of an EFS, or the failure of the flight crew to activate or deploy the EFS, can lead to the loss of the complete system. Therefore, the design of the EFS needs careful consideration; automatic arming and deployment have been shown to be practicable and to offer a significant safety benefit.

(7) The sea conditions, on which certification with ditching provisions is to be based, are selected by the applicant and should take into account the expected sea conditions in the intended areas of operation. The wave climate of the northern North Sea is adopted as the default wave climate as it represents a conservative condition. The applicant may also select alternative/additional sea areas with any associated certification then being limited to those geographical regions. The significant wave height, and any geographical limitations (if applicable – see the AMC to CS 29.801(e) and 29.802(c)) should be included in the RFM as performance information.

(8) During scale model testing, appropriate allowances should be made for probable structural damage and leakage. Previous model tests and other data from rotorcraft of similar configurations that have already been substantiated based on equivalent test conditions may be used to satisfy the ditching requirements. In regard to flotation stability, the test conditions should be equivalent to those defined in AMC to 29.801(e) and 29.802(c).

(9) CS 29.801(e) requires that after ditching in sea conditions for which certification with ditching provisions is requested by the applicant, the probability of capsizing in a 5 minute exposure is acceptably low in order to allow the occupants to leave the rotorcraft and enter life rafts. This should be interpreted to mean that up to and including the worst-case sea conditions for which certification with ditching provisions is requested by the applicant, the probability that the rotorcraft will capsize should be not higher than the target stated in the certification specification. An acceptable means of demonstrating post-ditching flotation stability is through scale model testing using irregular waves. The AMC to CS 29.801(e) and 29.802(c) contains a test specification that has been developed for this purpose.

(10) Providing a ‘wet floor’ concept (water in the cabin) by positioning the floats higher on the fuselage sides and allowing the rotorcraft to float lower in the water, can be a way of increasing the stability of a ditched rotorcraft (although this would need to be verified for the individual rotorcraft type for all weight and

loading conditions), or it may be desirable for other reasons. This is permissible provided that the mean static level of water in the cabin is limited to being lower than the upper surface of the seat cushion (for all rotorcraft mass and centre of gravity cases, with all flotation units intact), and that the presence of water will not unduly restrict the ability of occupants to evacuate the rotorcraft and enter the life raft.

(11) It should be shown by analysis or other means that the rotorcraft will not sink following the functional loss of any single complete ditching flotation unit. Experience has shown that in water impact events, the forces exerted on the emergency flotation unit that first comes into contact with the water surface, together with structural deformation and other damage, can render the unit unusable. Maintenance errors may also lead to a flotation unit failing to inflate. The ability of occupants to egress successfully is significantly increased if the rotorcraft does not sink. However, this requirement is not intended for any other purpose, such as aiding salvage of the rotorcraft. Therefore, consideration of the remaining flotation units remaining inflated for an especially long period, i.e. longer than required in the upright floating case, is not required.

(12) The sea conditions approved for ditching should be stated in the performance information section of the RFM.

(13) Current practices allow wide latitude in the design of cabin interiors and, consequently, of stowage provisions for safety and ditching equipment. Rotorcraft manufacturers may deliver aircraft with unfinished (green) interiors that are to be completed by a modifier.

(i) Segmented certification is permitted to accommodate this practice. That is, the rotorcraft manufacturer shows compliance with the flotation time, stability, and emergency exit requirements while a modifier shows compliance with the equipment and egress requirements with the interior completed. This procedure requires close cooperation and coordination between the manufacturer, modifier, and EASA.

(ii) The rotorcraft manufacturer may elect to establish a token interior for ditching certification. This interior may subsequently be modified by a supplemental type certificate (STC). The ditching provisions should be shown to be compliant with the applicable requirements after any interior configuration or limitation change.

(iii) The RFM and any RFM supplements deserve special attention if a segmented certification procedure is pursued.

(c) Procedures

(1) Flotation system design

(i) Structural integrity should be established in accordance with CS 29.563.

(ii) Rotorcraft handling qualities should be verified to comply with the applicable certification specifications throughout the approved flight envelope with floats installed. Where floats are normally deflated, and deployed in flight, the handling qualities should be verified for the approved operating envelopes with the floats in:

(A) the deflated and stowed condition;

(B) the fully inflated condition; and

(C) the in-flight inflation condition; for float systems which may be inflated in flight, rotorcraft controllability should be verified by test or analysis, taking into account all possible emergency flotation system inflation failures.

(iii) Reliability should be considered in the basic design to assure approximately equal inflation of the floats to preclude excessive yaw, roll, or pitch in flight or in the water:

(A) Maintenance procedures should not degrade the flotation system (e.g. by introducing contaminants that could affect normal operation, etc.).

(B) The flotation system design should preclude inadvertent damage due to normal personnel traffic flow and wear and tear. Protection covers should be evaluated for function and reliability.

(C) The designs of the floats should provide means to minimise the likelihood of damage or tear propagation between compartments. Single compartment float designs should be avoided.

(D) When showing compliance with CS 29.801(c)(1), and where practicable, the design of the flotation system should consider the likely effects of water impact (i.e. crash) loads. For example:

(a) locate system components away from the major effects of structural deformation;

(b) use redundant or distributed systems;

(c) use flexible pipes/hoses; and

(d) avoid passing pipes/hoses or electrical wires through bulkheads that could act as a 'guillotine' when the structure is subject to water impact loads.

(iv) The floats should be fabricated from highly conspicuous material to assist in the location of the rotorcraft following a ditching (and possible capsize).

(2) Flotation system inflation.

Emergency flotation systems (EFSs) that are normally stowed in a deflated condition and are inflated either in flight or after contact with water should be evaluated as follows:

(i) The emergency flotation system should include a means to verify its system integrity prior to each flight.

(ii) Means should be provided to automatically trigger the inflation of the EFS upon water entry, irrespective of whether or not inflation prior to water entry is the intended operation mode. If a manual means of inflation is provided, the float activation switch should be located on one of the primary flight controls and should be safeguarded against inadvertent actuation.

(iii) The inflation system should be shown to have an appropriately low probability of spontaneous or inadvertent actuation in flight conditions for which float deployment has not been demonstrated to be safe. If this is achieved by disarming of the inflation system, this should be achieved by the use of an automatic system employing appropriate input parameters. The choice of input parameters, and architecture of the system, should such that rearming of the system occurs automatically in a manner that will assure the inflation system functions as intended in the event of a water impact. As required by CS 29.801(c), in achieving this, it is not acceptable to specify any pilot action during flight. Float disarming is typically required at high airspeeds, and could be achieved automatically using an airspeed switch. However, this would retain the possibility of inadvertent flight into the water at high airspeed, with the risk that the floats would not deploy. This scenario could be addressed by providing an additional or alternative means of rearming the floats as the aircraft descends through an appropriate height threshold. A height below that of the majority of offshore helidecks could be chosen in order to minimise exposure to inadvertent activation above the demonstrated float deployment airspeed.

(iv) The maximum airspeeds for intentional in-flight actuation of the emergency flotation system and for flight with the floats inflated should be established as limitations in the RFM unless in-flight actuation is prohibited by the RFM.

(v) Activation of the emergency flotation system upon water entry (irrespective of whether or not inflation prior to water entry is the intended operation mode) should result in an inflation time short enough to prevent the rotorcraft from becoming excessively submerged.

(vi) A means should be provided for checking the pressure of the gas storage cylinders prior to take-off. A table of acceptable gas cylinder pressure variation with ambient temperature and altitude (if applicable) should be provided.

(vii) A means should be provided to minimise the possibility of over inflation of the flotation units under any reasonably probable actuation conditions.

(viii) The ability of the floats to inflate without puncturing when subjected to actual water pressures should be substantiated. A demonstration of a full-scale float immersion in a calm body of water is one acceptable method of substantiation. Precautions should also be taken to avoid floats being punctured due to the proximity of sharp objects, during inflation in flight and with the helicopter in the water, and during subsequent movement of the helicopter in waves. Examples of objects that need to be considered are aerials, probes, overboard vents, unprotected split-pin tails, guttering and any projections sharper than a three-dimensional right-angled corner.

(ix) The inflation system design should, where practicable, minimise the possibility of foreseeable damage preventing the operation or partial operation of the EFS (e.g. interruption of the electrical supply or pipework). This could be achieved through the use of redundant systems or through distributed systems where each flotation unit is capable of autonomous operation (i.e. through the provision of individual inflation gas sources, electrical power sources and float activation switches).

(x) The inflation system design should minimise the probability that the floats do not inflate properly or inflate asymmetrically in the event of a ditching. This may be accomplished by interconnecting inflation gas sources, for which flexible hoses should be used to minimise potential damage, or by synchronising the deployment of autonomous flotation units. Note that the main concern in the event of a water impact is to prevent the rotorcraft from sinking; asymmetric deployment is a lesser concern.

(xi) CS 29.801(g) requires it to be shown that the rotorcraft will not sink following the functional loss of any complete flotation unit. A ’complete flotation unit’ shall be taken to mean a discrete, independently located float. The qualifying term ‘complete’ means that the entire structure of the flotation unit must be considered, not limited to any segregated compartments.

The loss of function of a flotation unit is most likely to be due to damage occurring in a water impact. However, there may be other reasons, such as undetected damage during maintenance, or incorrect maintenance. All reasonably probable causes for the loss of functionality of a flotation unit, and the resultant effect(s) on the remainder of the inflation system, should therefore be taken into account.

In the case of inflatable flotation units, irrespective of whether the intended operation is to deploy the system before or after water entry, the following shall be taken into account when assessing the ability of the rotorcraft to remain afloat;

- Following the functional loss of a deployed flotation unit, the capability to maintain pressure in the remaining inflation units should be justified on the basis of the inflation system design, for example:
    - Individual inflation gas sources per flotation unit,
    - Installation of non-return valves at appropriate locations.

- Following the functional loss of a non-deployed flotation unit, the capability of the remaining flotation units to deploy should be justified on the basis of the inflation system design, for example:

- The functionality of the inflation gas sources integrated with the functionally lost flotation unit in question should also either be assumed to be lost, or justification should otherwise be provided,
- The degree of inflation of the remaining undamaged flotation units, which share parts of the inflation system with the damaged unit, bearing in mind that the damaged unit will be venting, should be determined.

(3) Injury prevention during and following water entry.

An assessment of the cabin and cockpit layouts should be undertaken to minimise the potential for injury to occupants in a ditching. This may be performed as part of the compliance with CS 29.785. Attention should be given to the avoidance of injuries due to arm/leg flailing, as these can be a significant impediment to occupant egress and subsequent survivability. Practical steps that could be taken include:

(i) locating potentially hazardous equipment away from the occupants;

(ii) installing energy-absorbing padding onto interior components;

(iii) using frangible materials; and

(iv) designs that exclude hard or sharp edges.

(4) Water entry procedures.

Tests or simulations (or a combination of both) should be conducted to establish procedures and techniques to be used for water entry, based on the conditions given in (5). These tests/simulations should include determination of the optimum pitch attitude and forward velocity for ditching in a calm sea as well as entry procedures for the most severe sea condition to be certified. Procedures for all failure conditions that may lead to a ‘land immediately’ action (e.g. one engine inoperative, all engines inoperative, tail rotor/drive failure) should be established. However, only the procedures for the most critical all-engines-inoperative condition need be verified by water entry test data.

(5) Water entry behaviour.

CS 29.801(d) requires the probable behaviour of the rotorcraft to be shown to exhibit no unsafe characteristics, e.g. that would lead to an inability to remain upright.

This should be demonstrated by means of scale model testing, based on the following conditions:

(i) For entry into a calm sea:

(A) the optimum pitch, roll and yaw attitudes determined in (c)(5) above, with consideration for variations that would reasonably be expected to occur in service;

(B) ground speeds from 0 to 15.4 m/s (0 to 30 kt); and

(C) descent rate of 1.5 m/s (5 ft/s) or greater;

(ii) For entry into the most severe sea condition:

(A) the optimum pitch attitude and entry procedure as determined in (c)(5) above;

(B) ground speed of 15.4 m/s (30 kt);

(C) descent rate of 1.5 m/s (5 ft/s) or greater;

(D) likely roll and yaw attitudes; and

(E) sea conditions may be represented by regular waves having a height at least equal to the significant wave height (H_s), and a period no larger than the wave zero-crossing period (T_z) for the wave spectrum chosen for demonstration of rotorcraft flotation stability after water entry (see (c)(7) below and AMC to CS 29.801(e) and 29.802(c));

(iii) Scoops, flaps, projections, and any other factors likely to affect the hydrodynamic characteristics of the rotorcraft should be considered;

(iv) Probable damage to the structure due to water entry should be considered during the water entry evaluations (e.g. failure of windows, doors, skins, panels, etc.); and

(v) Rotor lift does not have to be considered.

Alternatively, if scale model test data for a helicopter of a similar configuration has been previously successfully used to justify water entry behaviour, this data could form the basis for a comparative analytical approach.

(6) Flotation stability tests.

An acceptable means of flotation stability testing is contained in the AMC to CS 29.801(e) and 29.802(c). Note that model tests in a wave basin on a number of different rotorcraft types have indicated that an improvement in seakeeping performance can consistently be achieved by fitting float scoops.

(7) Occupant egress and survival.

The ability of the occupants to deploy life rafts, egress the rotorcraft, and board the life rafts (directly, in the case of passengers), should be evaluated. For configurations which are considered to have critical occupant egress capabilities due to the life raft locations or the ditching emergency exit locations and the proximity of the float (or a combination of both), an actual demonstration of egress may be required. When a demonstration is required, it may be conducted on a full-scale rotorcraft actually immersed in a calm body of water or using any other rig or ground test facility shown to be representative. The demonstration should show that the floats do not impede a satisfactory evacuation. Service experience has shown that it is possible for occupants to have escaped from the cabin, but to have not been able to board a life raft and to have had difficulty in finding handholds to stay afloat and together. Handholds or lifelines should be provided on appropriate parts of the rotorcraft. The normal attitude of the rotorcraft and the possibility of capsizing should be considered when positioning the handholds or lifelines.

Create a new AMC to CS 29.801(e) and 29.802(c) as follows:

AMC to CS 29.801(e) and 29.802(c)

Model test method for flotation stability

This AMC should be used when showing compliance with CS 29.801(e) or CS 29.802(c) as introduced at Amendment 5.

(a) Explanation

(1) Model test objectives

The objective of the model tests described in the certification specification is to establish the performance of the rotorcraft in terms of its stability in waves. The wave conditions in which the rotorcraft is to be certified should be selected according to the desired level of operability (see (a)(2) below).

This will enable the overall performance of the rotorcraft to be established for inclusion in the rotorcraft flight manual (RFM) as required by CS 29.1587(c). In the case of approval with ditching provisions, the wave conditions selected for substantiation of behaviour during the water entry phase must also be taken into account.

The rotorcraft design is to be tested, at each mass condition (see paragraph b(1)(ii) below), with its flotation system intact, and with its single most critical flotation compartment damaged (i.e. the single-puncture case which has the worst adverse effect on flotation stability).

(2) Model test wave conditions

The rotorcraft is to be tested in a single sea condition comprising a single combination of significant wave height (H_s) and zero-crossing period (T_z). The values of H_s and T_z should be no less than, and no more than, respectively, those chosen for certification, i.e. as selected from table 1. This approach is necessary in order to constrain the quantity of testing required within reasonable limits and is considered to be conservative. The justification is detailed in Appendix 2.

The applicant is at liberty to certify the rotorcraft to any significant wave height H_s. This significant wave height will be noted as performance information in the RFM.

Using reliable wave climate data for an appropriate region of the ocean for the anticipated flight operations, a T_z is selected to accompany the H_s. This T_z should be typical of those occurring at H_s as determined in the wave scatter table for the region. The mode or median of the T_z distribution at H_s should be used.

It is considered that the northern North Sea represents a conservatively 'hostile' region of the ocean worldwide and should be adopted as the default wave climate for certification. However, this does not preclude an applicant from certifying a rotorcraft specifically for a different region. Such a certification for a specific region would require the geographical limits of that certification region to be noted as performance information in the RFM. Certification for the default northern North Sea wave climate does not require any geographical limits.

In the case of an approval with emergency flotation provisions, operational limitations may limit flight to 'non-hostile' sea areas. For simplicity, the northern North Sea may still be selected as the wave climate for certification, or alternatively a wave climate derived from a non-hostile region's data may be used. If the latter approach is chosen, and it is desired to avoid geographical limits, a 'non-hostile' default wave climate will need to be agreed with EASA.

Wave climate data for the northern North Sea were obtained from the United Kingdom Meteorological Office (UK Met Office) for a typical 'hostile' helicopter route. The route selected was from Aberdeen to Block 211/27 in the UK sector of the North Sea. Data tables were derived from a UK Met Office analysis of 34 years of 3-hourly wave data generated within an 8-km, resolved wave model hindcast for European waters. This data represents the default wave climate.

Table 1 below has been derived from this data and contains combinations of significant H_s and T_z. Table 1 also includes the probability of exceedance (P_e) of the H_s.

Table 1 — Northern North Sea wave climate

	Spectrum shape: JONSWAP, peak enhancement factor γ = 3.3			
	Significant wave height H_s	Mean wave period T_z	Significant steepness $S_s = 2\pi H_s/(gT_z^2)$	H_s probability of exceedance P_e
Intact flotation system	6 m	7.9	1/16.2	1.2 %
	5.5 m	7.6	1/16.4	2 %
	5 m	7.3	1/16.6	3 %
	4.5 m	7.0	1/17.0	5 %
	4 m	6.7	1/17.5	8 %
	3.5 m	6.3	1/17.7	13 %
	3 m	5.9	1/18.1	20 %
	2.5 m	5.5	1/18.9	29 %
	2 m	5.1	1/20.3	43 %
	1.25 m	4.4	1/24.2	72 %

(3) Target probability of capsizing

Target probabilities of capsizing have been derived from a risk assessment. The target probabilities to be applied are stated in CS 29.801(e) and 29.802(c), as applicable.

For ditching, the intact flotation system probability of capsizing of 3 % is derived from a historic ditching rate of 3.32 x 10^{-6} per flight hour and an AMC 29.1309 consequence of hazardous, which implies a frequency of capsizing of less than 10^{-7} per flight hour. The damaged flotation system probability of capsizing is increased by a factor of 10 to 30 % on the assumption that the probability of failure of the critical float compartment is 0.1; this probability has been estimated, as there is insufficient data on flotation system failure rates.

For emergency flotation equipment, an increase of half an order (√10) is allowed on the assumption of a reduced exposure to the risk, resulting in a probability of capsizing of 10 %. The probability of a capsizing with a damaged flotation system is consequently increased to 100 %, hence no test is required.

(4) Intact flotation system

For the case of an intact flotation system, if the northern North Sea default wave climate has been chosen for certification, the rotorcraft should be shown to resist capsize in a sea condition selected from Table 1. The probability of capsizing in a 5-minute exposure to the selected sea condition is to be demonstrated to be less than or equal to the value provided in CS 29.801(e) or 29.802(c), as appropriate, with a confidence of 95 % or greater.

(5) Damaged flotation system

For the case of a damaged flotation compartment (see (1) above), the same sea condition may be used, but a 10-fold increased probability of capsizing is permitted. This is because it is assumed that flotation system damage will occur in approximately one out of ten emergency landings on water. Thus, the probability of capsizing in a 5-minute exposure to the sea condition is to be demonstrated to be less than or equal to 10 times the required probability for the intact flotation system case, with a confidence of 95 % or greater. Where a 10-times probability is equal to or greater than 100 %, it is not necessary to perform a model test to determine the capsize probability with a damaged flotation system.

Alternatively, the applicant may select a wave condition with 10 times the probability of exceedance P_e of the significant wave height (H_s) selected for the intact flotation condition. In this case, the probability of capsizing in a 5-minute exposure to the sea condition is to be demonstrated to be less than or equal to the required value (see CS 29.801(e) or 29.802(c)), with a confidence of 95 % or greater.

(6) Long-crested waves

Whilst it is recognised that ocean waves are in general multidirectional (short-crested), the model tests are to be performed in unidirectional (long-crested) waves, this being regarded as a conservative approach to capsize probability.

(b) Procedures

(1) Rotorcraft model

(i) Construction and scale of the model

The rotorcraft model, including its emergency flotation, is to be constructed to be geometrically similar to the full-scale rotorcraft design at a scale that will permit the required wave conditions to be accurately represented in the model basin. It is recommended that the scale of the model should be not smaller than 1/15.

The construction of the model is to be sufficiently light to permit the model to be ballasted to achieve the desired weight and rotational inertias specified in the mass conditions (see (b)(1)(ii) below)[3].

Where it is likely that water may flood into the internal spaces following an emergency landing on water, for example through doors opened to permit escape, or any other opening, the model should represent these internal spaces and openings as realistically as possible.

It is permissible to omit the main rotor(s) from the model, but its (their) mass is to be represented in the mass and inertia conditions[4].

(ii) Mass conditions

As it is unlikely that the most critical condition can be determined reliably prior to testing, the model is to be tested in two mass conditions:

(A) maximum mass condition, mid C of G; and

(B) minimum mass condition, mid C of G.

(iii) Mass properties

The model is to be ballasted in order to achieve the required scale weight, centre of gravity, roll and yaw inertia for each of the mass conditions to be tested.

Once ballasted, the model's floating draft and trim in calm water is to be checked and compared with the design floating attitude.

[3] It should be noted that rotorcraft tend to have a high centre of gravity due to the position of the engines and gearbox on top of the cabin. It therefore follows that most of the ballast is likely to be required to be installed in these high locations of the model.

[4] Rotors touching the waves can promote capsize, but they can also be a stabilising influence depending on the exact circumstances. Furthermore, rotor blades are often lost during the ditching due to contact with the sea. It is therefore considered acceptable to omit them from the model.

The required mass properties and floating draft and trim, and those measured during model preparation, are to be fully documented and compared in the report.

(iv) Model restraint system

The primary method of testing is with a restrained model, but an alternative option is for a free-floating model (See (3)(iii) below).

For the primary restrained method, a flexible restraint or mooring system is to be provided to restrain the model in order for it to remain beam-on to the waves in the model basin[5].

This restraint system should fulfil the following criteria:

(A) be attached to the model on the centre line at the front and rear of the fuselage in such a position that roll motion coupling is minimised; an attachment at or near the waterline is preferred; and

(B) be sufficiently flexible that the natural frequencies of the model surging/swaying on this restraint system are much lower than the lowest wave frequencies in the spectrum.

(v) Sea anchor

Whether or not the rotorcraft is to be fitted with a sea anchor, such an anchor is not to be represented in these model tests[6].

(2) Test facility

The model test facility is to have the capability to generate realistic long non-repeating sequences of unidirectional (long-crested) irregular waves, as well as the characteristic wave condition at the chosen model scale. The facility is to be deep enough to ensure that the waves are not influenced by the depth (i.e. deep-water waves).

The dimensions of the test facility are to be sufficiently large to avoid any significant reflection/refraction effects influencing the behaviour of the rotorcraft model.

The facility is to be fitted with a high-quality wave-absorbing system or beach.

The model basin is to provide full details of the performance of the wave maker and the wave absorption system prior to testing.

---

5 In general the model cannot be permitted to float freely in the basin because in the necessarily long wave test durations, the model would otherwise drift down the basin and out of the calibrated wave region. Constraining the model to remain beam-on to the waves and not float freely is regarded as a conservative approach to the capsize test. . A free-floating test is optional after a specific capsize event, in order to investigate whether the restraint system contributed to the event. It may also be possible to perform a complete free-floating test campaign by combining many short exposures in a wave basin capable of demonstrating a large calibrated wave region.

6 A sea anchor deployed from the rotorcraft nose is intended to improve stability by keeping the rotorcraft nose into the waves. However, such devices take a significant time to deploy and become effective, and so, their beneficial effect is to be ignored. The rotorcraft model will be restrained to remain beam-on to the waves.

(3) Model test set-up

(i) General

The model is to be installed in the wave facility in a location sufficiently distant from the wave maker, tank walls and beach/absorber such that the wave conditions are repeatable and not influenced by the boundaries.

The model is to be attached to the model restraint system (see (b)(1)(iv) above).

(ii) Instrumentation and visual records

During wave calibration tests, three wave elevation probes are to be installed and their outputs continuously recorded. These probes are to be installed at the intended model location, a few metres to the side and a few metres ahead of this location.

The wave probe at the model location is to be removed during tests with the rotorcraft model present.

All tests are to be continuously recorded on digital video. It is required that at least two simultaneous views of the model are to be recorded. One is to be in line with the model axis (i.e. viewing along the wave crests), and the other is to be a three-quarter view of the model from the up-wave direction. Video records are to incorporate a time code to facilitate synchronisation with the wave elevation records in order to permit the investigation of the circumstances and details of a particular capsize event.

(iii) Wave conditions and calibration

Prior to the installation of the rotorcraft model in the test facility, the required wave conditions are to be pre-calibrated.

Wave elevation probes are to be installed at the model location, alongside and ahead of the intended model location.

The intended wave spectrum is to be run for the full exposure duration required to demonstrate the required probability of capsizing. The analysis of these wave calibration runs is to be used to:

(A) confirm that the required wave spectrum has been obtained at the model location; and

(B) verify that the wave spectrum does not deteriorate appreciably during the run in order to help establish the maximum duration test that can be run before the test facility must be allowed to become calm again.

It should be demonstrated that the wave spectrum measured at each of the three locations is the same.

If a free-floating model is to be used, then the waves are to be calibrated for a range of locations down the basin, and the spectrum measured in each of these locations should be shown to be the same. The length of the basin covered by this range will be the permitted test region for the free-floating model, and the model will be recovered when it drifts outside this region (See paragraph 4 below). It should be demonstrated that the time series of the waves measured at the model location does not repeat during the run. Furthermore, it should be demonstrated that one or more continuation runs can be performed using exactly the same wave spectrum and period, but with different wave time series. This is to permit a long exposure to the wave conditions to be built up from a number of separate runs without any unrealistic repetition of the time series.

No wind simulation is to be used[7].

(iv) Required wave run durations

The total duration of runs required to demonstrate that the required probability of capsizing has been achieved (or bettered) is dependent on that probability itself, and on the reliability or confidence of the capsize probability required to be demonstrated.

With the assumption that each 5-minute exposure to the wave conditions is independent, the equations provided in (b)(5) below can be used to determine the duration without a capsize that is required to demonstrate the required performance[8]. (See Appendix 1 below for examples.)

(4) Test execution and results

Tests are to start with the model at rest and the wave basin calm.

Following the start of the wave maker, sufficient time is to elapse to permit the slowest (highest-frequency) wave components to arrive at the model, before data recording starts.

Wave runs are to continue for the maximum permitted duration determined in the wave calibration test, or in the free-floating option for as long as the model remains in the calibrated wave region. Following sufficient time to allow the basin to become calm again, additional runs are to be conducted until the necessary total exposure duration (T_{Test}) has been achieved (see (b)(5) below).

In the case of the free-floating option, the model may be recovered and relaunched without stopping the wave maker, provided that the maximum permitted duration has not been exceeded. See paragraph (4)(iv) for requirements regarding relaunching the free-floating model.

[7] Wind generally has a tendency to redirect the rotorcraft nose into the wind/waves, thus reducing the likelihood of capsize. Therefore, this conservative testing approach does not include a wind simulation.

[8] Each 5-minute exposure might not be independent if, for example, there was flooding of the rotorcraft, progressively degrading its stability. However, in this context, it is considered that the assumption of independence is conservative.

If and when a model capsize occurs, the time of the capsize from the start of the run is to be recorded, and the run stopped. The model is to be recovered, drained of any water, and reset in the basin for a continuation run to be performed.

There are a number of options that may be taken following a capsize event:

(i) Continuing with the same model configuration

If the test is to be continued with the same model configuration, the test can be restarted with a different wave time series, or continued from the point of capsizing in a pseudorandom time series.

(ii) Reducing the wave severity to achieve certification at a lower significant wave height.

Provided that the same basic pseudorandom wave time series can be reproduced by the wave basin at a lower wave height and corresponding period, it is permitted to restart the wave maker time series at a point at least 5 minutes prior to the capsize event, and if the model is now seen to survive the wave sequence that caused a capsize in the more severe condition, then credit can then be taken for the run duration successfully achieved prior to the capsize. Clearly, such a restart is only possible with a model basin using pseudorandom wave generation.

This method is only permitted if the change in significant wave height and period is sufficiently small that the same sequence of capsizing waves, albeit at a lower amplitude, can be seen in the wave basin. If this is not the case, then credit cannot be taken for the exposure time prior to capsize, and the wave time series must be restarted from the beginning.

(iii) Modifying the model with the intention of avoiding a capsize

If it is decided to modify the model flotation with the intention of demonstrating that the modified model does not capsize in the wave condition, then the pseudorandom wave maker time series should be restarted at a point at least 5 minutes prior to the capsize event so that the model is seen to survive the wave that caused a capsize prior to the modification. Credit can then be taken for the duration of the run successfully achieved prior to the capsize.

(iv) Repeating a restrained capsize event with a free-floating model

If it is suspected that the model restraint system might have contributed to the capsize, then it is permitted to repeat that part of the pseudorandom time series with a free-floating model. The model is to be temporally restrained with light lines and then released beam-on to the waves such that the free-floating model is seen to experience the same wave time series that caused a capsize in exactly the same position in the basin. It is accepted that it might require several attempts to find the precise model release time and position to achieve this.

If the free-floating, model having been launched beam-on to the waves, is seen to yaw into a more beneficial heading once released, and seen to survive the wave that caused a capsize in the restrained model, then this is accepted as negating the capsize seen with the restrained model.

The test may then continue with a restrained model as with (i) above.

(v) Special considerations regarding relaunching a free-floating model into the calibrated wave region

If a free-floating model is being used for the tests, then it is accepted that the model will need to be recovered as it leaves the calibrated wave region, and then relaunched at the top of that region. It is essential that this process does not introduce any statistical or other bias into the behaviour of the model. For example, there might be a natural tendency to wait for a spell of calmer waves into which to launch the model. This particular bias is to be avoided by strictly obeying a fixed time delay between recovery and relaunch.

Any water accumulated inside the model is not to be drained prior to the relaunch.

If the model has taken up a heading to the waves that is not beam-on, then it is permissible to relaunch the model at that same heading.

In all the above cases continuation runs are to be performed until the total duration of exposure to the wave condition is sufficient to establish that the 5-minute probability of capsizing has been determined with the required confidence of 95 %.

(5) Results analysis

Given that it has been demonstrated that the wave time series are non-repeating and statistically random, the results of the tests may be analysed on the assumption that each five-minute element of the total time series is independent.

If the model rotorcraft has not capsized during the total duration of the tests, the confidence that the probability of capsizing within 5 minutes is less than the target value of $P_{capsize(target)}$, as shown below:

$$C = 1 - (1 - P_{capsize(target)})^{\left[T_{test} / T_{criterion} \right]}$$

(i) $$\approx 1 - exp\left(- \frac{P_{capsize(target)} T_{test}}{T_{criterion}} \right)$$

and so the total duration of the model test required without capsize is provided by:

$$T_{test} \approx -\frac{T_{criterion} \ln(1-C)}{P_{capsize(target)}}$$

where:

(A) T_{test} is the required full-scale duration of the test (in seconds);

(B) $P_{capsize(target)}$ is the required maximum probability of capsizing within 5 minutes;

(C) $T_{criterion}$ is the duration (in seconds) in which the rotorcraft must meet the no-capsize probability (= 5 x 60 s), as defined in CS 29.801(e); and

(D) C is the required confidence that the probability of capsizing has been achieved (0.95).

If the rotorcraft has capsized $N_{capsize}$ times during the tests, the probability of capsizing within 5 minutes can be estimated as:

$$P_{capsize} = \frac{N_{capsize} T_{criterion}}{T_{test}}$$

and the confidence that the required capsize criteria have been met is:

$$C = 1 - \sum_{k=0}^{N_{capsize}} \frac{([T_{test}/T_{criterion}])!}{([T_{test}/T_{criterion}]-k)!} \left\{ (P_{capsize(target)})^k (1-P_{capsize(target)})^{([T_{test}/T_{criterion}]-k)} \right\}$$

$$\approx 1 - \left\{ \sum_{k=0}^{N_{capsize}} \frac{1}{k!} \left(\frac{P_{capsize(target)} T_{test}}{T_{criterion}} \right)^k \right\} exp\left(-\frac{P_{capsize(target)} T_{test}}{T_{criterion}} \right)$$

It should be noted that, if the rotorcraft is permitted to fly over sea conditions with significant wave heights above the certification limit, then $P_{capsize(target)}$ should be reduced by the probability of exceedance of the certification limit for the significant wave height (P_e) (see Appendix 2 below).

(c) Deliverables

(1) A comprehensive report describing the model tests, the facility they were performed in, the model properties, the wave conditions used, the results of the tests, and the method of analysis to demonstrate compliance with CS 29.801(d) and (e).

(2) Conclusions in this report are to clarify the compliance (or otherwise) with those requirements.

(3) Digital video and data records of all tests performed.

(4) A specification for a certification model test should also be expected to include:

(i) an execution plan and time scale;

(ii) formal progress reports on content and frequency; and

(iii) quality assurance requirements.

Appendix 1 — Worked example

The target 5-minute capsize probabilities for a rotorcraft certified to CS 29.801 are:

Certification with ditching provisions;

Fully serviceable emergency flotation system (EFS) - 3 %

Critical flotation compartment failed - 30 %

Certification with emergency flotation provisions;

Fully serviceable emergency flotation system (EFS) - 10 %

Critical flotation compartment failed - no demonstration required

One option available to the rotorcraft designer is to test at the selected wave height and demonstrate a probability of capsizing no greater than these values. However, to enhance offshore helicopter safety, some national aviation authorities (NAAs) have imposed restrictions that prevent normal operations (i.e. excluding emergencies, search and rescue (SAR), etc.) over sea conditions that are more severe than those for which performance has been demonstrated. In such cases, the helicopter may be operationally limited.

These operational restrictions may be avoided by accounting for the probability of exposure to sea conditions that exceed the selected wave height by certifying the rotorcraft for a lower probability of capsizing. Since it is conservatively assumed that the probability of capsizing in sea conditions that exceed the certified wave height is unity, the lower capsize probability required to be met is the target value minus the probability of the selected wave height being exceeded. However, it should also be noted that, in addition to restricting normal helicopter overwater operations to the demonstrated capability, i.e. the applicant’s chosen significant wave height limit ($H_{s(limit)}$), an NAA may declare a maximum limit above which all operations will be suspended due to the difficulty of rescuing persons from the sea in extreme conditions. There will, therefore, be no operational benefit in certifying a rotorcraft for sea conditions that exceed the national limits for rescue.

In the following examples, we shall use the three target probabilities of capsizing without any reduction to avoid operational restrictions. The test times quoted are full-scale times; to obtain the actual model test run time, these times should be divided by the square root of the model scale.

Certification with ditching provisions — fully serviceable EFS

Taking this first case, we need to demonstrate a ≤ 3 % probability of capsizing with a 95 % confidence. Applying equation (5)(i) above, this can be achieved with a 499-minute (full-scale time) exposure to the sea condition without a capsize.

Rearranging this equation, we have:

$$T_{test} \approx -\ln(1-C)\frac{T_{criterion}}{P_{capsize(target)}}$$

$$T_{test} \approx -\ln(1-0.95)\frac{5\times 60}{0.03} = 29957 \text{ s} = 499 \text{ min}$$

Alternatively, applying equation (5)(ii) above, the criterion would also be met if the model were seen to capsize just three times (for example) in a total 21.5 hours of exposure to the sea condition, or four times (for example) in a total of 25.5 hours of exposure.

Equation (ii) cannot be readily rearranged to solve T_{test}, so the easiest way to solve it is by using a spreadsheet on a trial-and-error method. For the four-capsize case, we find that a 25.5-hour exposure gives a confidence of 0.95.

$$C \approx 1 - \left\{ \sum_{k=0}^{4e} \frac{1}{k!} \left(\frac{0.03 \times 25.5 \times 60 \times 60}{5 \times 60} \right)^k \right\} exp\left(-\frac{0.03 \times 25.5 \times 60 \times 60}{5 \times 60} \right) = 0.95$$

Certification with ditching provisions — critical flotation compartment failed

In this case, we need to demonstrate a ≤ 30 % probability of capsizing with a 95 % confidence. This can be achieved with a 50-minute (full-scale time) exposure to the sea condition without a capsize.

$$T_{test} \approx -\ln(1-0.95)\frac{5 \times 60}{0.30} = 2996 \text{ s} = 50 \text{ min}$$

As above, the criterion would also be met if the model were seen to capsize just three times (for example) in a total 2.2 hours of exposure to the sea condition, or four times (for example) in a total of 2.6 hours of exposure.

Solving by trial and error in a spreadsheet, we find that a 2.6-hour exposure with no more than four capsizes gives a confidence of 0.95.

$$C \approx 1 - \left\{ \sum_{k=0}^{4e} \frac{1}{k!} \left(\frac{0.30 \times 2.6 \times 60 \times 60}{5 \times 60} \right)^k \right\} exp\left(-\frac{0.30 \times 2.6 \times 60 \times 60}{5 \times 60} \right) = 0.95$$

Certification with emergency flotation provisions — fully serviceable EFS

In this case, we need to demonstrate a ≤ 10 % probability of capsizing with a 95 % confidence. By solving the equations as above, this can be achieved with a 150-minute (full-scale time) exposure to the sea condition without a capsize.

$$T_{test} \approx -\ln(1-0.95)\frac{5 \times 60}{0.10} = 8987 \text{ s} = 150 \text{ min}$$

As above, the criterion would also be met if the model were seen to capsize just three times (for example) in a total 6.5 hours of exposure to the sea condition, or four times (for example) in a total of 7.6 hours of exposure.

Solving by trial and error in a spreadsheet we find that a 7.6-hour exposure with no more than four capsizes gives a confidence of 0.95.

$$C \approx 1 - \left\{ \sum_{k=0}^{4e} \frac{1}{k!} \left(\frac{0.10 \times 7.6 \times 60 \times 60}{5 \times 60} \right)^k \right\} exp\left(-\frac{0.10 \times 7.6 \times 60 \times 60}{5 \times 60} \right) = 0.95$$

Certification with ditching provisions — critical flotation compartment failed

As stated in CS 29.802(c), no demonstration of capsize resistance is required for the case of the critical float compartment having failed.

This is because the allowed factor of ten increase in the probability of capsizing, as explained in (a)(3) above, results in a probability of 100 %.

Appendix 2 — Test specification rationale

(a) Introduction

The overall risk of capsizing within the 5-minute exposure period consists of two components: the probability of capsizing in a given wave condition, and the probability of experiencing that wave condition in an emergency landing on water.

If it is assumed that an emergency landing on water occurs at random and is not linked with weather conditions, the overall risk of a capsize can be established by combining two pieces of information:

(1) The wave climate scatter table, which shows the probability of meeting any particular combination of H_s and T_z. An example scatter table is shown below in **Figure 1 — Example of all-year wave scatter table**. Each cell of the table contains the probability of experiencing a wave condition with H_s and T_z in the range provided. Thus, the total of all cells in the table adds up to unity.

(2) The probability of a capsize in a 5-minute exposure for each of these height/period combinations. This probability of capsizing is different for each helicopter design and for each wave height/period combination, and is to be established through scale model testing using the method defined above.

In theory, a model test for the rotorcraft design should be performed in the full range of wave height/period combinations covering all the cells in the scatter table. Clearly, wave height/period combinations with zero or very low probabilities of occurrence might be ignored. It might also be justifiably assumed that the probability of a capsize at very high wave heights is unity, and at very low wave heights, it is zero. However, there would still remain a very large number of intermediate wave height/period combinations that would need to be investigated in model tests, and it is considered that such a test programme would be too lengthy and costly to be practicable.

The objective here is therefore to establish a justifiable method of estimating the overall 5-minute capsize probability using model test results for a single-wave condition. That is a single combination of H_s and T_z. Such a method can never be rigorously linked with the safety objective, but it is proposed that it may be regarded as a conservative approximation.

(b) Test methodology

The proposed test methodology is as follows:

The rotorcraft designer selects a desired significant wave height limit $H_{s(limit)}$ for the certification of his helicopter. Model tests are performed in the sea condition $H_{s(limit)}$

$T_{z(limit)}$ (where $T_{z(limit)}$ is the zero-crossing period most likely to accompany $H_{s(limit)}$) with the selected spectrum shape using the method specified above, and the 5-minute probability of capsizing ($P_{capsize}$) established in this sea condition.

The way in which $P_{capsize}$ varies for other values of H_s and T_z is not known because it is not proposed to perform model tests in all the other possible combinations. Furthermore, there is no theoretical method to translate a probability of capsizing from one sea condition to another.

However, it is known that the probability of capsizing is related to the exposure to breaking waves of sufficient height, and that this is in turn linked with wave steepness. Hence:

(1) the probability of capsizing is likely to be higher for wave heights just less than $H_{s(limit)}$ but with wave periods shorter than $T_{z(limit)}$; and

(2) the probability of capsizing will be lower for the larger population of wave conditions with wave heights less than $H_{s(limit)}$ and with wave periods longer than $T_{z(limit)}$.

So, a reasonable and conservative assumption is that on average, the same $P_{capsize}$ holds good for all wave conditions with heights less than or equal to $H_{s(limit)}$.

A further conservative assumption is that $P_{capsize}$ is unity for all wave heights greater than $H_{s(limit)}$.

Using these assumptions, a comparison of the measured $P_{capsize}$ in $H_{s(limit)}$ $T_{z(limit)}$ against the target probability of capsizing ($P_{capsize(target)}$) can be performed.

In jurisdictions where flying is not permitted when the wave height is above $H_{s(limit)}$, the rotorcraft will have passed the certification criteria provided that $P_{capsize} \le P_{capsize(target)}$.

In jurisdictions where flying over waves greater than $H_{s(limit)}$ is permitted, the rotorcraft will have passed the certification criteria provided that $P_{capsize} \le P_{capsize(target)} - P_e$, where P_e is the probability of exceedance of $H_{s(limit)}$. Clearly, in this case, it can be seen that it would not be permissible for the rotorcraft designer to select an $H_{s(limit)}$ which has a probability of exceedance greater than $P_{capsize(target)}$.

Hs (m) >=	Hs (m) <																						TOTALS
12.5	13																		0.00000	0.00000			0.0000
12	12.5																						0.0000
11.5	12																	0.00000	0.00000				0.0000
11	11.5																0.00000	0.00000	0.00001				0.0000
10.5	11															0.00000	0.00002	0.00001	0.00001	0.00000			0.0000
10	10.5															0.00000	0.00003	0.00002	0.00001				0.0001
9.5	10														0.00000	0.00003	0.00004	0.00003	0.00000				0.0001
9	9.5														0.00001	0.00013	0.00007	0.00002	0.00000				0.0002
8.5	9													0.00000	0.00010	0.00024	0.00006	0.00001					0.0004
8	8.5												0.00000	0.00003	0.00030	0.00028	0.00005	0.00001					0.0007
7.5	8												0.00002	0.00015	0.00064	0.00019	0.00004	0.00000					0.0010
7	7.5											0.00000	0.00009	0.00061	0.00081	0.00016	0.00002	0.00000					0.0017
6.5	7										0.00000	0.00003	0.00046	0.00164	0.00052	0.00010	0.00001	0.00000	0.00000	0.00000	0.00000		0.0028
6	6.5										0.00001	0.00021	0.00199	0.00187	0.00033	0.00006	0.00001	0.00001	0.00000	0.00000			0.0045
5.5	6									0.00000	0.00007	0.00145	0.00447	0.00116	0.00023	0.00006	0.00003	0.00000	0.00000	0.00000	0.00000		0.0075
5	5.5								0.00000	0.00004	0.00083	0.00632	0.00373	0.00073	0.00019	0.00008	0.00004	0.00001	0.00001	0.00001	0.00000		0.0120
4.5	5								0.00001	0.00047	0.00624	0.00960	0.00214	0.00057	0.00025	0.00012	0.00005	0.00003	0.00002	0.00001			0.0195
4	4.5							0.00000	0.00019	0.00490	0.01618	0.00605	0.00152	0.00064	0.00031	0.00016	0.00007	0.00007	0.00004	0.00001	0.00000		0.0301
3.5	4						0.00000	0.00005	0.00350	0.02208	0.01287	0.00379	0.00160	0.00081	0.00047	0.00022	0.00015	0.00009	0.00003	0.00001	0.00000		0.0457
3	3.5						0.00002	0.00221	0.02645	0.02324	0.00831	0.00348	0.00203	0.00118	0.00075	0.00034	0.00017	0.00007	0.00002	0.00000	0.00000		0.0683
2.5	3					0.00000	0.00146	0.02986	0.03679	0.01483	0.00705	0.00395	0.00268	0.00171	0.00101	0.00036	0.00009	0.00002	0.00000	0.00000			0.0998
2	2.5				0.00000	0.00112	0.03519	0.05068	0.02272	0.01123	0.00754	0.00526	0.00323	0.00175	0.00070	0.00015	0.00004	0.00001	0.00000				0.1396
1.5	2			0.00000	0.00178	0.04564	0.05983	0.02953	0.01691	0.01196	0.00869	0.00491	0.00222	0.00082	0.00022	0.00006	0.00002	0.00000					0.1826
1	1.5		0.00000	0.00481	0.05424	0.06075	0.03455	0.02317	0.01709	0.01047	0.00471	0.00184	0.00058	0.00019	0.00006	0.00001	0.00000	0.00000					0.2125
0.5	1	0.00007	0.00741	0.03757	0.03952	0.02823	0.02033	0.01233	0.00540	0.00181	0.00055	0.00016	0.00003	0.00001	0.00000								0.1534
0	0.5	0.00002	0.00100	0.00446	0.00513	0.00427	0.00196	0.00050	0.00012	0.00003	0.00001	0.00000											0.0175
	Tz (s) >=	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	1.0000
	Tz (s) <	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	

Figure 1 — Example of all-year wave scatter table

Create a new AMC 29.802 as follows:

AMC 29.802 Emergency Flotation

This AMC replaces FAA AC 29 MG 10.

(a) Definitions

(1) Ditching: a controlled emergency landing on water, deliberately executed in accordance with rotorcraft flight manual (RFM) procedures, with the intent of abandoning the rotorcraft as soon as practicable.

NOTE: Although the term 'ditching' is most commonly associated with the design standards related to CS 29.801, a rotorcraft equipped to the less demanding requirements of CS 29.802, when performing an emergency landing on water, would nevertheless be commonly described as carrying out the process of ditching. The term 'ditching' is therefore used in this AMC in this general sense.

(2) Emergency flotation system (EFS): a system of floats and any associated parts (e.g. gas cylinders, means of deployment, pipework and electrical connections) that is designed and installed on a rotorcraft to provide buoyancy and flotation stability in a ditching.

(b) Explanation

(1) Approval of emergency flotation equipment is performed only if requested by the applicant. Operational rules may accept that a helicopter conducts flights over certain sea areas provided it is fitted with approved emergency flotation equipment (i.e. an EFS), rather than being certified with full ditching provisions.

(2) Emergency flotation certification encompasses emergency flotation system loads (as specified in CS 29.802) and design, and rotorcraft flotation stability.

(3) Failure of the EFS to operate when required will lead to the rotorcraft rapidly capsizing and sinking. Operational experience has shown that localised damage or failure of a single component of an EFS can lead to the loss of the complete system. Therefore, the design of the EFS needs careful consideration.

(4) The sea conditions on which certification with emergency flotation is to be based are selected by the applicant and should take into account the expected sea conditions in the intended areas of operation. Capsize resistance is required to meet the same requirements as for full ditching approval, but with the allowable capsize probability being set at 10 %. The default wave climate specified in this requirement is that of the northern North Sea, as it represents a conservative condition. This might be considered inappropriate in so far as it represents a hostile sea area. The applicant may therefore propose a different wave climate based on data from a non-hostile sea area. The associated certification will then be limited to the geographical region(s) thus represented. Alternatively, a non-hostile default wave climate might be agreed, with no associated need for geographical limits to the certification. The significant wave

height, and any geographical limitations (if applicable, see the AMC to 29.801(e) and 29.802(c)) should be included in the RFM as performance information.

(5) During scale model testing, appropriate allowances should be made for probable structural damage and leakage. Previous model tests and other data from rotorcraft of similar configurations that have already been substantiated based on equivalent test conditions may be used to satisfy the emergency flotation requirements. In regard to flotation stability, test conditions should be equivalent to those defined in the AMC to 29.801(e) and 29.802(c).

(6) CS 29.802 requires that in sea conditions for which certification with emergency flotation is requested by the applicant, the probability of capsizing in a 5-minute exposure is acceptably low in order to allow the occupants to leave the rotorcraft and enter the life rafts. This should be interpreted to mean that up to and including the worst-case sea conditions for which certification with emergency flotation is requested by the applicant, the probability that the rotorcraft will capsize should be not higher than the target stated in CS 29.802(c). An acceptable means of demonstrating post-ditching flotation stability is through scale model testing using irregular waves. The AMC to 29.801(e) and 29.802(c) contains a test specification that has been developed for this purpose.

(7) Providing a 'wet floor' concept (water in the cabin) by positioning the floats higher on the fuselage sides and allowing the rotorcraft to float lower in the water can be a way of increasing the stability of a ditched rotorcraft (although this would need to be verified for the individual rotorcraft type for all weight and loading conditions), or it may be desirable for other reasons. This is permissible provided that the mean static level of water in the cabin is limited to being lower than the upper surface of the seat cushion (for all rotorcraft mass and centre of gravity cases, with all flotation units intact), and that the presence of water will not unduly restrict the ability of occupants to evacuate the rotorcraft and enter the life raft.

(8) The sea conditions approved for ditching should be stated in the performance information section of the RFM.

(9) It should be shown by analysis or other means that the rotorcraft will not sink following the functional loss of any single complete ditching flotation unit. Experience has shown that in water-impact events, the forces exerted on the emergency flotation unit that first comes into contact with the water surface, together with structural deformation and other damage, can render the unit unusable. Maintenance errors may also lead to a flotation unit failing to inflate. The ability of occupants to egress successfully is significantly increased if the rotorcraft does not sink. However, this requirement is not intended for any other purpose, such as aiding in the salvage of the rotorcraft. Therefore, consideration of the remaining flotation units remaining inflated for an especially long period, i.e. longer than required in the upright floating case, is not required.

(c) Procedures

(1) Flotation system design

(i) Structural integrity should be established in accordance with CS 29.563. For a rotorcraft with a seating capacity of maximum 9 passengers, CS 29.802(a) only requires the floats and their attachments to the rotorcraft to be designed to withstand the load conditions defined in CS 29.563. Other parts of the rotorcraft (e.g. fuselage underside structure, chin windows, doors) do not need to be shown to be capable of withstanding these load conditions. All parts of rotorcraft with a seating capacity of 10 passengers of more should be designed to withstand the load conditions defined in CS 29.563 (i.e. the same design standards as for full ditching approval).

(ii) Rotorcraft handling qualities should be verified to comply with the applicable certification specifications throughout the approved flight envelope with floats installed. Where floats are normally deflated and deployed in flight, the handling qualities should be verified for the approved operating envelopes with the floats in:

(A) the deflated and stowed condition;

(B) the fully inflated condition; and

(C) the in-flight inflation condition; for float systems which may be inflated in flight, rotorcraft controllability should be verified by test or analysis taking into account all possible emergency flotation system inflation failures.

(iii) Reliability should be considered in the basic design to assure approximately equal inflation of the floats to preclude excessive yaw, roll, or pitch in flight or in the water:

(A) Maintenance procedures should not degrade the flotation system (e.g. introducing contaminants that could affect normal operation, etc.).

(B) The flotation system design should preclude inadvertent damage due to normal personnel traffic flow and wear and tear. Protection covers should be evaluated for function and reliability.

(C) The designs of the floats should provide means to minimise the likelihood of damage or tear propagation between compartments. Single compartment float designs should be avoided.

(iv) The floats should be fabricated from highly conspicuous material to assist in locating the rotorcraft following a ditching (and possible capsize).

(2) Flotation system inflation

Emergency flotation systems (EFSs) which are normally stowed in a deflated condition and are inflated either in flight or after water contact should be evaluated as follows:

(i) The emergency flotation system should include a means to verify system integrity prior to each flight.

(ii) If a manual means of inflation is provided, the float activation switch should be located on one of the primary flight controls and should be safeguarded against inadvertent actuation.

(iii) The maximum airspeeds for intentional in-flight actuation of the emergency flotation system and for flight with the floats inflated should be established as limitations in the RFM unless in-flight actuation is prohibited by the RFM.

(iv) Activation of the emergency flotation system upon water entry (irrespective of whether or not inflation prior to water entry is the intended operation mode) should result in an inflation time short enough to prevent the rotorcraft from becoming excessively submerged.

(v) A means should be provided for checking the pressure of the gas stowage cylinders prior to take-off. A table of acceptable gas cylinder pressure variation with ambient temperature and altitude (if applicable) should be provided.

(vi) A means should be provided to minimise the possibility of over-inflation of the flotation units under any reasonably probable actuation conditions.

(vii) The ability of the floats to inflate without puncturing when subjected to actual water pressures should be substantiated. A demonstration of a full-scale float immersion in a calm body of water is one acceptable method of substantiation. Precautions should also be taken to avoid floats being punctured due to the proximity of sharp objects, during inflation in flight or with the helicopter in the water, and during subsequent movement of the helicopter in waves. Examples of objects that need to be considered are aerials, probes, overboard vents, unprotected split-pin tails, guttering and any projections sharper than a three dimensional right angled corner.

(viii) CS 29.802(d) requires the rotorcraft to not sink following the functional loss of any complete flotation unit. Complete flotation unit shall be taken to mean a discrete, independently located float. The qualifying term ‘complete’ means that the entire structure of the flotation unit must be considered, not limited to any segregated compartments.

The loss of function of a flotation unit is most likely to be due to damage that occurs in a water impact. However, there may be other reasons, such as undetected damage during maintenance, or incorrect maintenance. All reasonably probable causes for the loss of functionality of a flotation unit, and the resultant effect(s) on the remainder of the inflation system, should therefore be taken into account.

In the case of inflatable flotation units, irrespective of whether the intended operation is to deploy the system before or after water entry, the following shall be taken into account when assessing the ability of the rotorcraft to remain afloat;

- Following the functional loss of a deployed flotation unit, the capability to maintain pressure in the remaining inflation units should be justified on the basis of the design of the inflation system, for example:
    - individual inflation gas sources per flotation unit;
    - installation of non-return valves at appropriate locations.
- Following the functional loss of a non-deployed flotation unit, the capability of the remaining flotation units to deploy should be justified on the basis of the design of the inflation system, for example:
    - functionality of inflation gas sources integrated with the functionally lost flotation unit in question should also either be assumed to be lost, or justification for otherwise provided;
    - the degree of inflation of remaining undamaged flotation units, which share parts of the inflation system with the damaged unit, bearing in mind the damaged unit will be venting, should be determined.

(3) Injury prevention during and following water entry.

An assessment of the cabin and cockpit layouts should be undertaken to minimise the potential for injury to occupants in a ditching. This may be performed as part of the compliance with CS 29.785. Attention should be given to the avoidance of injuries due to leg/arm flailing, as these can be a significant impediment to occupant egress and subsequent survivability. Practical steps that could be taken include:

(i) locating potentially hazardous items away from the occupants;

(ii) installing energy-absorbing padding onto interior components;

(iii) using frangible materials; and

(iv) designs that exclude hard or sharp edges.

(4) Water entry procedures.

Tests or simulations (or a combination of both) should be conducted to establish procedures and techniques to be used for water entry. These tests/simulations should include determination of the optimum pitch attitude and forward velocity for ditching in a calm sea, as well as entry procedures for the most severe sea condition to be certified. Procedures for all failure conditions that may lead to a ‘land immediately’ action (e.g. one engine inoperative, all engines inoperative, tail rotor/drive failure) should be established.

(5) Flotation stability tests.

An acceptable means of flotation stability testing is contained in AMC to 29.801(e) and 29.802(c). Note that model tests in a wave basin on a number of different rotorcraft types have indicated that an improvement in seakeeping performance can consistently be achieved by fitting float scoops.

(6) Occupant egress and survival.

The ability of the occupants to deploy life rafts, egress the rotorcraft, and board the life rafts should be evaluated. For configurations which are considered to have critical occupant egress capabilities due to the life raft locations or the emergency exit locations and proximity of the float (or a combination of both), an actual demonstration of egress may be required. When a demonstration is required, it may be conducted on a full-scale rotorcraft actually immersed in a calm body of water or using any other rig or ground test facility shown to be representative. The demonstration should show that floats do not impede a satisfactory evacuation. Service experience has shown that it is possible for occupants to have escaped from the cabin but to have not been able to board a life raft and to have had difficulty in finding handholds to stay afloat and together. Handholds or lifelines should be provided on appropriate parts of the rotorcraft. The normal attitude of the rotorcraft and the possibility of a capsize should be considered when positioning the handholds or lifelines.

Create a new AMC 29.803(c) as follows:

AMC 29.803(c)

Emergency evacuation

This AMC supplements FAA AC 29.803 and AC 29.803A.

(a) Explanation

At Amendment 5, the usage of the term ‘ditching emergency exit’ was changed.

CS 29.803(c) was created with the intention that the rotorcraft design will allow all passengers to egress the rotorcraft and enter a life raft without undue effort or skill, and with a very low risk of falling and entering the water surrounding of the ditched rotorcraft. Boarding a life raft from the water is difficult, even in ideal conditions, and survival time is significantly increased once aboard a life raft, particularly if the survivor has remained at least partly dry. CS 29.803(c) requires that ditching emergency exits be provided to facilitate boarding into each of the required life rafts.

(b) Procedures

(1) The general arrangement of most rotorcraft and the location of the deployed life rafts may be such that the normal entry/egress doors will best facilitate entry to a life raft. It should also be substantiated that the life rafts can be restrained in a position that allows passengers to step directly from the cabin into the life rafts. This is expected to require provisions to enable a cabin occupant to pull the deployed life raft to the exit, using the retaining line, and maintain it in that position while others board.

(2) It is not considered disadvantageous if opening the normal entry/egress doors will result in water entering the cabin provided that the depth of water would not be such as to hinder evacuation. However, it should be substantiated that water pressure on the door will not excessively increase operating loads.

(3) If exits such as normal entry/egress doors, which are not already being used to meet the requirements for emergency exits or underwater emergency exits (or both), are used for compliance with CS 29.803(c)(1), they should be designed to meet certain of the standards applied to emergency exits. Their means of opening should be simple and obvious and not require exceptional effort (see CS 29.809(c)), their means of access and opening should be conspicuously marked, including in the dark (see CS 29.811(a)), their location should be indicated by signs (see CS 29.811(c) and (d)), and their operating handles should be clearly marked (see CS 29.811(e)).

Create a new AMC 29.805(c) as follows:

AMC 29.805(c) Flight crew emergency exits

This AMC supplements FAA AC 29.805 and replaces AC 29.805A.

(a) Explanation

To facilitate a rapid escape, flight crew underwater emergency exits should be designed for use with the rotorcraft in both the upright position and in any foreseeable floating attitude. The flight crew underwater emergency exits should not be obstructed during their operation by water or floats to the extent that rapid escape would not be possible or that damage to the flotation system may occur. This should be substantiated for any rotorcraft floating attitude, upright or capsized, and with the emergency flotation system intact and with any single compartment failed. With the rotorcraft capsized and floating, the flight crew emergency exits should be usable with the cabin flooded.

(b) Procedures

(1) It should be shown by test, demonstration or analysis that there is no interference with the flight crew underwater emergency exits from water or from any stowed or deployed emergency flotation devices, with the rotorcraft in any foreseeable floating attitude.

(2) Flight crew should be able to reach the operating device for their underwater emergency exit, whilst seated, with restraints fastened, with seat energy absorption features at any design position, and with the rotorcraft in any attitude.

(3) Likely damage sustained during a ditching should be considered.

(4) It is acceptable for the underwater emergency exit threshold to be below the waterline when the rotorcraft is floating upright, but in such a case, it should be substantiated that there is no obstruction to the use of the exit and that no excessive force (see FAA AC 29.809) is required to operate the exit.

(5) It is permissible for flight crew to be unable to directly enter life rafts from the flight crew underwater emergency exits and to have to take a more indirect

route, e.g. by climbing over a forward flotation unit. In such a case, the feasibility of the exit procedure should be assessed. Handholds may need to be provided on the rotorcraft.

(6) To make it easier to recognise underwater, the operating device for the underwater emergency exit should have black and yellow markings with at least two bands of each colour of approximately equal widths. Any other operating feature, e.g. highlighted 'push here' decal(s) for openable windows, should also incorporate black-and-yellow-striped markings.

Create a new AMC 29.807(d) as follows:

AMC 29.807(d) Underwater emergency exits for passengers

This AMC replaces FAA AC 29.807 and AC 29.807A.

(a) Explanation

CS-29 Amendment 5 re-evaluates the need for and the concept behind emergency exits for rotorcraft approved with ditching provisions. Prior to CS-29 Amendment 5, rotorcraft that had a passenger seating configuration, excluding pilots' seats, of nine seats or less were required to have one emergency exit above the waterline in each side of the rotorcraft, having at least the dimensions of a Type IV exit. For rotorcraft that had a passenger seating configuration, excluding pilots' seats, of 10 seats or more, one emergency exit was required to be located above the waterline in one side of the rotorcraft and to have at least the dimensions of a Type III exit, for each unit (or part of a unit) of 35 passenger seats, but no less than two such exits in the passenger cabin, with one on each side of the rotorcraft. These exits were referred to as 'ditching emergency exits'.

Operational experience has shown that in a ditching in which the rotorcraft remains upright, use of the passenger doors can be very beneficial in ensuring a rapid and orderly evacuation onto the life raft(s). However, when a rotorcraft capsizes, doors may be unusable and the number and availability of emergency exits that can be readily used underwater will be crucial to ensuring that passengers are able to escape in a timely manner. Experience has shown that the number of emergency exits required in the past by design requirements has been inadequate in a capsized situation, and a common design solution has been to use the passenger cabin windows as additional emergency egress means by including a jettison feature. The jettison feature has commonly been provided by modifying the elastomeric window seal such that its retention strength is either reduced, or can be reduced by providing a removable part of its cross section, i.e. the so called 'push out' window, although other design solutions have been employed. The provision of openable windows has been required by some air operations regulations.

In recognition of this identified need for an increased number of exits for underwater escape, Amendment 5 created a new set of exit terminology and CS 29.807(d)(1) was revised to require one pair of 'underwater emergency exits', i.e. one on each side of the rotorcraft, to be provided for each unit, or part of a unit, of four passenger seats.

This new terminology was seen as better describing the real intent of this higher number of required emergency exits for rotorcraft approved with ditching provisions.

Furthermore, CS 29.813(d)(1) requires passenger seats to be located relative to these exits in a way that best facilitates escape. The objective is for no passenger to be in a worse position than the second person to egress through an exit. The size of each underwater emergency exit should at least have the dimensions of a Type IV exit (0.48 m x 0.66 m or 19 in. x 26 in.).

The term 'ditching emergency exit' is retained for the exits required by the newly created CS 29.803(c). These exits are required to enable passengers to step directly into the life rafts when the rotorcraft remains upright. This is the normally expected case in a ditching and thus it is considered that this term is appropriate to describe these exits.

It is intended that training and briefing materials for passengers carried on helicopters that meet these new requirements will be designed to reflect the two types of emergency exits (ditching and underwater emergency exits) and the two associated scenarios that are assumed for their intended use (directly boarding a life raft from an upright helicopter following ditching, and immediate underwater escape should the helicopter capsize, respectively).

(b) Procedures

(1) The number and the size of underwater emergency exits should be as specified in paragraph (a) above.

(2) Care should be taken regarding oversized exits to avoid them becoming blocked if more than one passenger attempts to use the same exit simultaneously.

(3) A higher seat-to-exit ratio may be accepted if the exits are large enough to allow the simultaneous escape of more than one passenger. For example, a pair of exits may be approved for eight passengers if the size of each exit provides an unobstructed area that encompasses two ellipses of 0.48 m x 0.66 m (19 in. x 26 in.) side by side.

(4) Test, demonstration, compliance inspection, or analysis is required to substantiate that an exit is free from interference from stowed or deployed emergency flotation devices. In the event that an analysis or inspection is insufficient or that a given design is questionable, a test or demonstration may be required. Such a test or demonstration would consist of an accurate, full-size replica (or true representation) of the rotorcraft and its flotation devices, both while stowed and after their deployment.

(5) The cabin layout should be designed so that the seats are located relative to the underwater emergency exits in compliance with CS 29.813(d)(1).

Create a new AMC 29.809 as follows:

AMC 29.809 Emergency exit arrangement

This AMC supplements FAA AC 29.809 and AC 29.809A.

(a) Explanation

CS 29.809 covers all types of emergency exit. These may be a door, openable window or hatch. These terms are used to cover the three generic types expected. The term door implies a floor level, or close to floor level, opening. Openable window is self-explanatory, and hatch is used for any other configuration, irrespective of its location or orientation, e.g. located in the cabin ceiling, side wall or floor.

CS-29 Amendment 5 added a new requirement (j) to CS 29.809 related to the design, installation and operation of underwater emergency exits. Underwater emergency exits should be optimised for use with the rotorcraft capsized and flooded.

So-called ‘push-out’ windows (see AMC 29.807(d)) have some advantages in that they are not susceptible to jamming and may open by themselves in a water impact due to flexing of the fuselage upon water entry and/or external water pressure.

Openable windows might require an appreciable pushing force from the occupant. When floating free inside a flooded cabin, and perhaps even if still seated, generation of this force may be difficult. An appropriately positioned handhold or handholds adjacent to the underwater emergency exit(s) should be provided to facilitate an occupant in generating the opening force. Additionally, in the design of the handhold, consideration should be given to it assisting in locating the underwater emergency exit and in enabling buoyancy forces to be overcome during egress.

Consideration should be given to reducing the potential confusion caused by the lack of standardisation of the location of the operating devices (pull tab, handle) for underwater emergency exits. For instance, the device could be located next to the handhold. The occupant then has only to find the handhold to locate the operating device. Each adjacent occupant should be able to reach the handhold and operating device whilst seated, with restraints fastened, with seat energy absorption features in any design position, and with the rotorcraft in any attitude. If a single underwater emergency exit is designed for the simultaneous egress of two occupants side by side, a handhold and an operating device should be within reach of each occupant seated adjacent to the exit.

The risk of a capsize during evacuation onto the life rafts can be mitigated to some extent by instructing passengers to open all the underwater emergency exits as a matter of course soon after the helicopter has alighted on the water, thus avoiding the delay due to opening the exits in the event that the exits are needed. This may be of particular benefit where the helicopter has a ditching emergency exit which overlaps one or more underwater emergency exits when open (e.g. a sliding door). Such advice should be considered for inclusion in the documentation provided to the helicopter operator.

(b) Procedures

(1) Underwater emergency exits should be shown to be operable with the rotorcraft in any foreseeable floating attitude, including with the rotorcraft capsized.

A particular issue exists in regard to doors (e.g. a sliding door) which overlap underwater emergency exits when open, and which are designated as the ditching emergency exits as required by CS 29.803(c). In the case of a rotorcraft with such an arrangement, it should be substantiated that passengers could still have a viable egress route should the helicopter capsize after the door has been opened but before all occupants have egressed.

Where the open door does not offer an opening of sufficient size and location to provide immediate and usable underwater egress possibility for all occupants, wherever they are located, the intent could be achieved by opening two push-out windows, one in the fuselage and one in the open door. Such a solution will depend on the rotorcraft design ensuring that the windows will be sufficiently aligned when the door is fully opened and secured (the resultant unobstructed opening should permit at least an ellipse of 0.48 m x 0.66 m (19 in. x 26 in.) to pass through it). Availability of such an opening is more likely if the windows are opened by cabin occupants as a matter of course following a ditching, as explained in (a) above.

(2) Underwater emergency exits should be designed so that they are optimised for use with the rotorcraft capsized. For example, the handhold(s) should be located close to the bottom of the window (top if inverted) to assist an occupant in overcoming the buoyancy loads of an immersion suit, and it should be ensured that markings and lighting will help identify the exit(s)and readily assist in an escape.

(3) The means to open an underwater emergency exit should be simple and obvious and should not require any exceptional effort. Designs with any of the following characteristics (non-exhaustive list) are considered to be non-compliant:

(i) more than one hand is needed to operate the exit itself (use of the handhold may occupy the other hand);

(ii) any part of the opening means, e.g. an operating handle or control, is located remotely from the exit such that it would be outside of a person’s direct vision when looking directly at the exit, or that the person should move away from the immediate vicinity of the exit in order to reach it; and

(iii) the exit does not meet the opening effort limitations set by FAA AC 29.809.

(4) It should be possible to readily grasp and operate any operating handle or control using either a bare or a gloved hand.

(5) Handholds, as required by CS 29.809(j)(3), should be mounted close to the bottom of each underwater emergency exit such that they fall easily to hand for

a normally seated occupant. In the case of exits between face-to-face seating, the provision of two handholds is required. Handholds should be designed such that the risk is low of escapees' clothing or emergency equipment snagging on them.

(6) The operating handle or tab for underwater emergency exits should be located next to the handhold.

Create a new AMC 29.811(h) as follows:

AMC 29.811(h) Underwater emergency exit markings

This AMC supplements FAA AC 29.811 and AC 29.811A.

(a) Explanation

This AMC provides additional means of compliance and guidance material relating to underwater emergency exit markings.

CS-29 Amendment 5 extended the requirements for exit markings to remain visible in a submerged cabin. CS 29.811(h) requires all underwater emergency exits (i.e. for both passengers and flight crew) and the exits and doors for use when boarding life rafts (as required by CS 29.803(c)) to be provided with additional conspicuous illuminated markings that will continue to function underwater.

Disorientation of occupants may result in the normal emergency exit markings in the cockpit and passenger cabin being ineffective following the rotorcraft capsizing and the cabin flooding. Additional and more highly conspicuous illuminated markings should be provided along the periphery of each underwater emergency exit, giving a clear indication of the aperture.

(b) Procedures

(1) The additional markings of underwater emergency exits should be in the form of illuminated strips that give a clear indication in all environments (e.g. at night, underwater) of the location of an underwater emergency exit. The markings should be sufficient to highlight the full periphery.

(2) The additional illuminated markings should function automatically, when needed, and remain visible for at least 10 minutes following rotorcraft flooding. The method chosen to automatically activate the system (e.g. water immersion switch(es), tilt switch(es), etc.) should be such as to ensure that the markings are illuminated immediately, or are already illuminated, when the rotorcraft reaches a point where a capsize is inevitable.

(3) The location of the operating device for an underwater emergency exit (e.g. a handle, or pull tab in the case of a 'push-out' window) should be distinctively illuminated. The illumination should provide sufficient lighting to illuminate the handle or tab itself in order to assist in its identification. In the case of openable windows, the optimum place(s) for pushing out (e.g. in a corner) should be illuminated.

(4) To make it easier to recognise underwater, the operating device for the underwater emergency exit should have black and yellow markings with at least two bands of each colour of approximately equal widths. Any other operating features, e.g. highlighted 'push here' decal(s) for openable windows, should also incorporate black- and yellow-striped markings.

Create a new AMC 29.813 as follows:

AMC 29.813 Emergency exit access

This AMC supplements FAA AC 29.813.

(a) Explanation

The provision for underwater emergency exits for passengers (see CS 29.807(d)) is based on the need to facilitate egress in the case of a capsize occurring soon after the rotorcraft has alighted on the water or in the event of a survivable water impact in which the cabin may be immediately flooded. The time available for evacuation is very short in such situations, and therefore, CS-29 Amendment 5 has increased the safety level by mandating additional exits, in the form of underwater emergency exits, to both shorten available escape routes and to ensure that no occupant should need to wait for more than one other person to escape before being able to make their own escape. The provision of an underwater emergency exit in each side of the fuselage of at least the size of a Type IV exit for each unit (or part of a unit) of four passenger seats will make this possible, provided that seats are positioned relative to the exits in a favourable manner.

Critical factors in an evacuation are the distance to an emergency exit and how direct and obvious the exit route is, taking into account that the passengers are likely to be disorientated.

Furthermore, consideration should be given to occupants having to make a cross-cabin escape due to the nearest emergency exit being blocked or otherwise unusable.

(b) Procedures

(1) The most obvious layout that maximises achievement of the objective that no passenger is in a worse position than the second person to egress through an exit is a four-abreast arrangement with all the seats in each row located appropriately and directly next to the emergency exits. However, this might not be possible in all rotorcraft designs due to issues such as limited cabin width, the need to locate seats such as to accommodate normal boarding and egress, and the installation of items other than seats in the cabin. Notwithstanding this, an egress route necessitating movement such as along an aisle, around a cabin item, or in any way other than directly towards the nearest emergency exit, to escape the rotorcraft, is not considered to be compliant with CS 29.813(d).

(2) If overall rotorcraft configuration constraints do not allow for easy and direct achievement of the above, one alternative may be to provide one or more underwater emergency exits larger than a Type IV in each side of the fuselage.

(3) The means provided to facilitate cross-cabin egress should be accessible to occupants floating freely in the cabin, should be easy to locate and should, as far as practicable, provide continuous visual and tactile cues to guide occupants to an exit. An effective solution could take the form of guide bars/ropes fitted to the front of the seat row structure below seat cushion height, in order to be accessible to passengers floating freely inside a capsized cabin. Where it is impractical for guide bars to be run across the full width of the cabin, e.g. due to the presence of an aisle, the ends of the guide bars should be designed to make them easier to find, e.g. enlarged and highlighted/lit end fittings to provide additional visual and tactile location cues. The provisions should be designed to minimise the risk of escapees' clothing or emergency equipment snagging on them.

Create new AMC 29.865 as follows:

AMC 29.865 External Loads

This AMC provides further guidance and acceptable means of compliance to supplement FAA AC 29-2C Change 4 AC 29.865B § 29.865 (Amendment 29-43) EXTERNAL LOADS to meet EASA's interpretation of CS 29.865. As such, it should be used in conjunction with the FAA AC but should take precedence over it, where stipulated, in the showing of compliance.

AMC No 1 below addresses the specificities of complex personnel-carrying device systems for human external cargo applications.

AMC No 2 below contains a recognised approach to the approval of simple PCDSs if required by the applicable operating rule or if an applicant elects to include simple PCDSs within the scope of type certification.

AMC No 1 to CS 29.865 EXTERNAL LOADS

a. Explanation

(1) This advisory material contains guidance for the certification of helicopter external-load attaching means and load-carrying systems to be used in conjunction with operating rules such as Regulation (EU) No 965/2012 on Air Operations[9]. The four RLC classes are summarised in Figure AMC 29.865-1 and discussed in paragraph d. Under the operating rules, RLC Classes A, B, and C are eligible, under specific restrictions, for both human external cargo (HEC) and non-human external cargo (NHEC) operations. Paragraph AC 29.25 (ref.: CS 29.25) also concerns, in part, jettisonable external cargo.

(2) CS 29.865 provides a minimum level of safety for large category rotorcraft designs to be used with operating rules, such as Regulation (EU) No 965/2012 on Air Operations. Certain aspects of operations, such as microwave tower and high-line wirework, may also be regulated separately by other agencies or entities. For applications that could come under the regulations of more than one agency or entity, special certification emphasis will be required by both the applicant and the approving authority to assure all relevant safety requirements are identified and met. Potential additional requirements, where thought to exist, are noted herein.

[9] Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council (OJ L 296, 25.10.2012, p. 1).

b. Definitions

(1) Applicable cargo type: the cargo type (i.e. non-human external cargo (NHEC), human external cargo (HEC), or both) that each RLC class is eligible to use by regulation.

(2) Backup quick-release subsystem (BQRS): the secondary or 'second choice' subsystem used to perform a normal or emergency jettison of external cargo.

(3) Cargo: the part of any rotorcraft-load combination that is removable, changeable, and is attached to the rotorcraft by an approved means.

(4) Cargo hook: a hook that can be rated for both HEC and NHEC. It is typically used by being fixed directly to a designated hard point on the rotorcraft.

(5) Dual actuation device (DAD): this is a sequential control that requires two distinct actions in series for actuation. One example is the removal of a lock pin followed by the activation of a 'then free' switch or lever for load release to occur (in this scenario, a load release switch protected only by an uncovered switch guard is not acceptable). For jettisonable HEC applications, a simple, covered switch does not qualify as a DAD. Familiarity with covered switches allows the pilot to both open and activate the switch in one motion. This has led to inadvertent load release.

(6) Emergency jettison (or complete load release): the intentional, instantaneous release of NHEC or HEC in a preset sequence by the quick-release system (QRS) that is normally performed to achieve safer aircraft operation in an emergency.

(7) External fixture: a structure external to and in addition to the basic airframe that does not have true jettison capability and has no significant payload capability in addition to its own weight. An example is an agricultural spray boom. These configurations are not approvable as 'External Loads' under CS 29.865.

(8) Hoist: a hoist is a device that exerts a vertical pull, usually through a cable and drum system (i.e. a pull that does not typically exceed a 30-degree cone measured around the z-rotorcraft axis).

(9) Hoist demonstration cycle (or 'one cycle'): the complete extension and retraction of at least 95 % of the actual cable length, or 100 % of the cable length capable of being used in service (i.e. that would activate any extension or retraction limiting devices), whichever is greater.

(10) Hoist load-speed combinations: some hoists are designed so that the extension and retraction speed slows as the load increases or nears the end of a cable extension. Other hoist designs maintain a constant speed as the load is varied. In the latter designs, the load-speed combination simply means the variation in load at the constant design speed of the hoist.

(11) Human external cargo (HEC): a person (or persons) who, at some point in the operation, is (are) carried external to the rotorcraft. See non-human external cargo (NHEC).

(12) Non-human external cargo (NHEC): any external cargo operation that does not at any time involve a person (or persons) carried external to the rotorcraft.

(13) Normal jettison (or selective load release): the intentional release, normally at optimum jettison conditions, of NHEC.

(14) Personnel-carrying device system (PCDS) is a device that has the structural capability and features needed to transport occupants external to the helicopter during HEC or helicopter hoist operations. A PCDS includes but is not limited to life safety harnesses (including, if applicable, a quick-release and strop with a connector ring), rigid baskets and cages that are either attached to a hoist or cargo hook or mounted to the rotorcraft airframe.

(15) Primary quick-release subsystem (PQRS): the primary or 'first choice' subsystem used to perform a normal or emergency jettison of external cargo.

(16) Quick-release system (QRS): the entire release system for jettisonable external cargo (i.e. the sum total of both the primary and backup quick-release subsystem). The QRS consists of all the components including the controls, the release devices, and everything in between.

(17) Rescue hook (or hook): a hook that can be rated for both HEC and NHEC. It is typically used in conjunction with a hoist or equivalent system.

(18) Rotorcraft-load combination (RLC): the combination of a rotorcraft and an external load, including the external-load attaching means. RLCs are designated as Class A, Class B, Class C, and Class D as follows:

- (i) Class A RLC means one in which the external load cannot move freely, cannot be jettisoned, and does not extend below the landing gear.
- (ii) Class B RLC means one in which the external load is jettisonable and is lifted free of land or water during the rotorcraft operation.
- (iii) Class C RLC means one in which the external load is jettisonable and remains in contact with land or water during the rotorcraft operation.
- (iv) Class D RLC means one in which the external load is other than a Class A, B or C and has been specifically approved by the relevant authority for that operation (i.e. HEC operations for which the operator is receiving remuneration from the person being transported).

(19) Spider: a spider is a system of attaching a lowering cable or rope or a harness to an NHEC (or HEC) RLC to eliminate undesirable flight dynamics during operations. A spider usually has four or more legs (or load paths) that connect to various points of a PCDS to equalise loading and prevent spinning, twisting, or other undesirable flight dynamics.

(20) True jettison capability: the ability to safely release an external load using an approved QRS in 30 seconds or less.

NOTE: In all cases, a PQRS should release the external load in less than 5 seconds. Many PQRSs will release the external load in milliseconds, once the activation device is triggered. However, a manual BQRS, such as a set of cable cutters, could take as much as 30 seconds to release the external load. The 30 seconds would be measured starting from the time the release command was given and ending when the external load was cut loose.

(21) True payload capability: the ability of an external device or tank to carry a significant payload in addition to its own weight. If little or no payload can be carried, the external device or tank is an external fixture (see definition above).

(22) Winch: a winch is a device that can employ a cable and drum or other means to exert a horizontal (i.e. x-rotorcraft axis) pull. However, since a winch can be used to perform a hoist function by use of a 90-degree cable direction change device (such as a pulley or pulley system), a winch system may be considered to be a hoist.

c. Procedures

The following certification procedures are provided in the most general form. Where there are significant differences between the cargo types, the differences are highlighted.

(1) General Compliance Procedures for CS 29.865: The applicant should clearly identify both the RLC and the applicable cargo types (NHEC or HEC) for which application is being made. The structural loads and operating envelopes for each RLC class and applicable cargo type should be determined and used to formulate the flight manual supplement and basic loads report. The applicant should show by analysis, test, or both, that the rotorcraft structure, the external-load attaching means, and the complex PCDS, if applicable, meet the specific requirements of CS 29.865 and any other relevant requirements of CS-29 for the proposed operating envelope.

NOTE: It is possible, if approved, to carry both HEC and NHEC externally, simultaneously as two separate external loads. However, in no case is it intended that the approved maximum internal gross weight should be exceeded for any approved HEC configuration (or combined NHEC and HEC configuration) in normal operations.

Reliability of the external load system. A failure of the external load system, including the complex PCDS where applicable, and its attachments to the rotorcraft should be shown to be extremely improbable (i.e. 1×10^{-9} failures per flight) for all failure modes that could cause a catastrophic failure, serious injury or a fatality anywhere in the total airborne system. All significant failure modes of lesser consequence should be shown to be improbable (i.e. 1×10^{-5} failures per flight). An acceptable method of achieving this goal is to submit the following for subsequent approval for:

(i) a failure modes and effects analysis (FMEA) showing that all potential failure modes of the airborne system that may result in catastrophic failures, serious injuries or fatalities are extremely improbable and any less significant failures are improbable;

(ii) a repetitive test of all the functional devices that cycles these devices at least 30 times under critical structural conditions, operational conditions, or a combination of both;

(iii) an environmental qualification review covering the proposed operating environment.

Figure AMC 29.865-1

Rotorcraft-Load Combination Versus Applicable Cargo Type Data And Definition Summary

Possible RLCs and Cargo Types		Category 'A' rating and one-engine-inoperative (OEI) hover capability	Notes	Direct two-way voice communications required See paragraph (d)(10)
HEC	RLC A	No	Note 2	No
NHEC	RLC A	No		N/A
HEC	RLC B	No	Note 2	No
NHEC	RLC B	No		N/A
HEC	RLC C	No	Note 2	No
NHEC	RLC C	No		N/A
HEC	RLC D	Yes, see paragraph d(12)	Note 1, 3, 4	Yes

NOTES:

1. A person (or persons) being carried or transported for remuneration outside the rotorcraft can only be carried as a Class D RLC.
2. A person (or persons) who is (are) not being carried or transported for remuneration is (are) knowledgeable of the risks involved, and at some point is (are) required to be outside the rotorcraft in order to fulfil the mission. This (these) person (persons) is (are) considered to be RLC Class A, B, or C HEC as appropriate to the operation.
3. The rotorcraft is approved to the Category A engine isolation requirements of Part 29 and has a one-engine-inoperative/out-of-ground effect (OEI/OGE) hover performance capability, for the requested operating and weight envelopes, to be eligible for certification to the Class D RLC (ref.: paragraph c (12)).
4. A Class D RLC operation may be conducted with an external cargo design having a physical configuration that meets the definitions of § 1.1 for RLC Class A, B, or C.

(2) CS 29.865(a) Static Structural Substantiation Procedures: The following static structural substantiation methods should be used:

(i) Critical Basic Load Determination. The critical basic loads and corresponding flight envelope are determined by statically substantiating the gross weight range limits, the corresponding vertical limit load factors (N_{ZW}) and the safety factors applicable for the type of external load for which the application is being made.

NOTE: In cases where NHEC or HEC can have more than one shape, centre of gravity, centre of lift, or be carried at more than one distance in-flight from the rotorcraft attachment, a critical configuration for certification purposes may not be determinable. If such a critical configuration can be determined, it may be examined for approval as a 'worst case' to satisfy a particular certification criterion or several criteria, as appropriate. If such a critical configuration cannot be determined, the extreme points of the operational external load configuration envelope should be examined, with consideration given to any other points within the envelope that experience or any other rationale indicates as points that need to be investigated.

(ii) Vertical Limit and Ultimate Load Factors. The basic N_{ZW} is converted to the ultimate load by multiplying the maximum vertical limit load by the appropriate safety factor (for restricted category approvals, see the guidance in paragraph AC 29 MG 5). This ultimate load is used to substantiate all the existing structure affected by, and all the added structure associated with, the load-carrying device, its attachments and its cargo. Casting factors, fitting factors, and other dynamic load factors should be applied where appropriate.

(A) NHEC applications. In most cases, it is acceptable to perform a standard static analysis to show compliance. A vertical limit load factor (N_{ZW}) of 2.5 g is typical for heavy gross weight NHEC hauling configurations (ref.: CS 29.337). This vertical load factor should be applied to the maximum external load for which the application is being made, together with a minimum safety factor of 1.5.

(B) HEC applications. If a safety factor of 3.0 or more is used, it is acceptable to perform a standard static analysis to show compliance. The safety factor should be applied to the yield strength of the weakest component in the system (QRS, complex PCDS, and attachment load path). If a safety factor of less than 3.0 is used, both an analysis and a full-scale ultimate load test of the relevant parts of the system should be performed.

Since HEC applications typically involve lower gross weight configurations, a higher vertical limit load factor is required to assure that the limit load is not exceeded in service. The applicant should use either the conservative value of 3.5 g or an analytically derived maximum vertical limit load factor for the requested operating envelope. Linear interpolation between the vertical load factors of the maximum and minimum design weights may be used. However, in no case may the vertical limit load factor be less than 2.5 g for any RLC application for HEC.

For the purpose of structural analysis or test, applicants should assume a 101.2-kg (223-pound) man as the minimum weight of each occupant carried as HEC.

NOTE: If the HEC is engaged in work tasks that employ devices of significant added weight (e.g. heavy backpacks, tools, fire extinguishers, etc.), the total weight of the 101.2-kg (223-pound) man and their equipment should be assumed in the structural analysis or test.

(iii) Critical Structural Case. For applications involving more than one RLC class or cargo type, the structural substantiation is required only for the most critical case. The most critical case should be determined by rational analysis.

(iv) Jettisonable Loads. For the substantiating analyses or tests of all jettisonable RLC external loads, including HEC, the maximum external load should be applied at the maximum angle that can be achieved in service, but not less than 30 degrees. The angle should be measured from the sling-load-line to the rotorcraft vertical axis (z axis) and may be in any direction that can be achieved in service. The 30-degree angle may be reduced in some or all directions if it is impossible to obtain due to physical constraints or operating limitations. The maximum allowable cable angle should be determined and approved. The angle approved should be based on structural requirements, mechanical interference limits, and flight-handling characteristics over the most critical conditions and combinations of conditions in the approved flight envelope.

(v) Hoist System Limit Load.

NOTE: If a hoist cable or a long-line cable is utilised, a new dynamic system is established. The characteristics of the system should be evaluated to assure that either no hazardous failure modes exist or that they are acceptably minimised. For example, the hoist cable or long-line cable may exhibit a natural frequency that could be excited by sources internal to the overall structural system (i.e. the rotorcraft) or by sources external to the system. Another example is the loading effect of the cable acting as a spring between the rotorcraft and the suspended external load.

(A) Determine the basic loads that would result in the failure or unspooling of the hoist or its installation, respectively.

NOTE: This determination should be based on static strength and any significant dynamic load magnification factors.

(B) Select the lower of the two values as the ultimate load of the hoist system installation.

(C) Divide the selected ultimate load by 1.5 to determine the true structural limit load of the system.

(D) Determine the manufacturer's approved 'limit design safety factor' (or that which the applicant has applied for). Divide this factor into the true structural limit load (from (C) above) to determine the hoist system's working (or placarded) limit load.

(E) Compare the system's derived limit load to the applied for one 'g' payload multiplied by the maximum downward vertical load factor (N_{ZWMAX}) to determine the critical payload's limit value.

(F) The critical payload limit should be equal to or less than the system's derived limit load for the installation to be approvable.

(3) CS 29.865(b) and CS 29.865(c) Procedures for Quick-Release Systems and Cargo Hooks: for jettisonable RLCs of any applicable cargo type, both a primary quick-release system (PQRS) and a backup quick-release system (BQRS) are required. Features that should be considered are:

(i) The PQRS, BQRS and their load-release devices and subsystems (such as electronically actuated guillotines) should be separate (i.e. physically, systematically, and functionally redundant).

(ii) The controls for the PQRS should be installed on one of the pilot's primary controls, or in an equivalently accessible location. The use of an 'equivalent accessible location' should be reviewed on a case-by-case basis and utilised only where equivalent safety is clearly maintained.

(iii) The controls for the BQRS may be less sophisticated than those of the PQRS. For instance, manual cable cutters are acceptable provided they are listed in the flight manual as a required device and have a dedicated, placarded storage location.

(iv) The PQRS should release the external load in less than 5 seconds. The BQRS should release the external load in less than 30 seconds. This time interval begins the moment an emergency is declared and ends when the load is released.

(v) Each quick-release device should be designed and located to allow the pilot or a crew member to accomplish external cargo release without hazardously limiting the ability to control the rotorcraft during emergency situations. The flight manual should reflect the requirement for a crew member and their related functions.

(vi) Other Load Release Types. In some current configurations, such as those used for high line operations, a load release may be present that is not on the rotorcraft but is on the complex PCDS itself. Examples are a tension release device that lets out line under an operationally induced load or a personal rope cutter. These devices are acceptable if:

(A) the off-rotorcraft release is considered to be a 'third release'. This type of release is not a substitute for a required release (i.e. PQRS or BQRS);

(B) the release meets all other relevant requirements of CS 29.865 and the methods of this AMC or equivalent methods; and

(C) the release has no operational or failure modes that would affect continued safe flight and landing under any operations, critical failure modes, conditions, or combination of either.

(vii) Cargo Hooks or Equivalent Devices and their Related Systems. All cargo hooks or equivalent devices should be approved to acceptable aircraft industry standards. The applicant should present these standards, and any related manufacturer's certificates of production or qualification, as part of the approval package.

(A) General. Cargo hook systems should have the same reliability goals and should be functionally demonstrated under the critical loads for NHEC and HEC, as appropriate. All engagement and release modes should be demonstrated. If the hook is used as a quick-release device, then the release of critical loads should be demonstrated under conditions that simulate the maximum allowable bank angles and speeds and any other critical operating conditions. Demonstration of any re-latching features and any safety or warning devices should also be conducted. Demonstration of actual in-flight emergency quick-release capability may not be necessary if the quick-release capability can be acceptably simulated by other means.

NOTE 1: Cargo hook manufacturers specify particular shapes, sizes, and cross sections for lifting eyes to assure compatibility with their hook design (e.g. Breeze Eastern Service Bulletin CAB-100-41). Experience has shown that, under certain conditions, a load may inadvertently hang up because of improper geometry at the hook-to-eye interface that will not allow the eye to slide off an open hook as intended.

NOTE 2: For both NHEC and HEC designs, the phenomenon of hook dynamic roll-out (inadvertent opening of the hook latch and subsequent release of the load) should be considered to assure that QRS reliability goals are not compromised. This is of particular concern for HEC applications. Hook dynamic roll-out occurs during certain ground-handling and flight conditions that may allow the lifting eye to work its way out of the hook.

Hook dynamic roll-out typically occurs when either the RLC's sling or harness is not properly attached to the hook, is blown by down draft, is dragged along the ground or through water, or is otherwise placed into a dangerous hook-to-eye configuration.

The potential for hook dynamic roll-out can be minimised in design by specifying particular hook-and-eye shape and cross-section combinations. For non-jettisonable RLCs, a pin can be used to lock the hook-keeper in place during operations.

NOTE: Some cargo hook systems may employ two or more cargo hooks for safety. These systems are approvable. However, a loss of any load by a single hook should be shown to not result in a loss of control of the rotorcraft. In a dual hook system, if the hook itself is the quick-release device (i.e. if a single release point does not exist in the load path between the rotorcraft and the dual hooks), the pilot should have a dual PQRS that includes selectable, co-located individual quick releases that are independent for each hook used. A BQRS should also be present for each hook. For cargo hook systems with more than two hooks, either a single release point should be present in the load path between the rotorcraft and the multiple hook system, or multiple PQRSs and BQRSs should be present.

(B) Jettisonable Cargo Hook Systems. For jettisonable applications, each cargo hook:

(1) should have a sufficient amount of slack in the control cable to permit cargo hook movement without tripping the hook release;

(2) should be shown to be reliable.

(3) For HEC systems, unless the cargo hook is to be the primary quick-release device, each cargo hook should be designed so that operationally induced loads cannot inadvertently release the load. For example, a simple cargo hook should have a one-way, spring-loaded gate (i.e. 'snap hook') that allows load attachment going into the gate but does not allow the gate to open (and subsequently lose the HEC) when an operationally induced load is applied in the opposite direction. For HEC applications, cargo hooks that also serve as quick-release devices should be carefully reviewed to assure they are reliable.

(4) CS 29.865(b)(3) Reliability Determination for QRSs and Devices: QRSs are required to be reliable. The primary electrical and mechanical failure modes that should be identified and minimised are: (1) load release by any means, and (2) loss of continued safe flight and landing capability due to a QRS failure. However, any failure that could result in catastrophic failure modes, serious injuries or fatalities should also be identified and shown to be extremely improbable. All other failure modes should be shown to be improbable. The reliability of each QRS system should be demonstrated by completion and approval of all of the following:

(i) An FMEA showing that all potential failure modes of the QRS which may result in catastrophic failures, serious injuries or fatalities are extremely improbable and any less-significant failures are improbable.

(ii) A repetitive test of all functioning devices that affect or comprise the QRS, which tests all the critical conditions or combinations of critical conditions at least 10 times each for NHEC and 30 times each for HEC, using both the primary and backup quick-release subsystems.

(iii) An environmental qualification programme that includes consideration of high and low temperatures (typically – 40 °C (– 40 °F) to + 65.6 °C (+ 150 °F)), altitudes up to 12 000 feet, humidity, salt spray, sand and dust, vibration, shock, rain, fungus, and acceleration. Testing should be conducted in accordance with RTCA/DO-160 or MIL-STD-810 for high- and low-temperature tests and for vibrations.

(iv) Using the methods of compliance in other relevant paragraphs of AC 29-2C including where supplemented and amended by CS-29 Book 2 or equivalent methods.

(5) Functional Reliability and Durability Compliance Procedures for Hoist Systems under CS 29.865(b)(3)(i) and (c)(2): hoist systems and their installations in the rotorcraft should be designed, approved, and demonstrated as follows:

(i) Reserved

(ii) Reserved

(iii) It is assumed that only one hoist cycle will typically occur per flight. This rationale has been used to determine the requirement for 10 demonstration cycles for NHEC applications and 30 demonstration cycles for HEC applications. However, if a particular application requires more than one hoist cycle per flight, then the number of demonstration cycles should be increased accordingly.

(iv) The hoist or rescue hook system should be reliable for the phases of flight in which it is operable, unstowed, partially unstowed, or in which cargo is carried. The hoist should be disabled (or an overriding, fail-safe mechanical safety device such as either a flagged removable shear pin or a load-lowering brake should be utilised) to prevent inadvertent load unspooling or release during any extended flight phases in which hoist operation is not intended. Loss of hoist operational control should also be considered. The reliability of the system should be demonstrated by completion and approval of all of the following:

(A) An FMEA showing that all potential failure modes of the hoist or rescue hook system which may result in catastrophic failures, serious injuries or fatalities are extremely improbable and any less-significant failures are improbable.

(B) Unless a more rational test method is presented and approved, at least 10 repetitive tests of all functional devices, which exercise the entire system's functional parameters, should be conducted. These repetitive tests may be conducted on the rotorcraft, or by using a bench simulation that accurately replicates the rotorcraft installation.

(C) A hoist unit environmental qualification programme that includes consideration of high and low temperatures (typically – 40 °C (– 40 °F) to + 65.6 °C (+ 150 °F)), altitudes up to 12 000 feet, humidity, salt spray, sand and dust, vibration, shock, rain, fungus, and acceleration. Testing in accordance with RTCA/DO-160 or MIL-STD-810 for high- and low-temperature tests and for vibrations. Hoist manufacturers should submit a test plan and follow-on test reports to the applicant and the authority following the completion of the qualification. It is intended that the hoist itself either be prequalified to the EMI and lightning threat levels specified for NHEC or HEC, as applicable for the requested operation, or that it be qualified as part of the entire on-board QRS to these threat levels.

(D) All instructions and documents necessary for continued airworthiness, normal operations, and emergency operations.

(v) Cable Attachment. Either the cable should be positively attached to the hoist drum and the attachment should have ultimate load capability, or equivalent means should be provided to minimise the possibility of inadvertent, complete cable unspooling.

(vi) Cable Length and Marking. A length of the cable nearest to the cable's attachment to the hoist drum should be visually marked to indicate to the operator that the cable is near to its full extension. The length of cable to be marked is a function of the maximum extension speed of the system and the operator's reaction time needed to prevent cable run-out. It should be determined during certification demonstration tests. In no case should the length be less than 3.5 drum circumferences.

(vii) Cable Stops. Means should be present to automatically stop cable movement quickly when the system's extension and retraction operational limits are reached.

(viii) Hoist System Load-Speed Combination Ground Tests. The load versus speed combinations of the hoist should be demonstrated on the ground (either using an accurate engineering mock-up or a rotorcraft) by showing the repeatability of the no load-speed combination, the 50 per cent load-speed combination, the 75 per cent load-speed combination and the 100 per cent (i.e. system-rated limit) load-speed combination. If more than one operational speed range exists, the preceding tests should be performed at either all speeds or at the most critical speed.

(A) At least 1/10 of the demonstration cycles (see definition) should include the maximum aft angular displacement of the load from the drum, applied for under CS 29.865(a).

(B) A minimum of 6 consecutive, complete operation cycles should be conducted at the system’s 100 per cent (i.e. system limit rated) load-speed combination.

(C) In addition, the demonstration should cover all normal and emergency modes of intended operation and should include operation of all control devices such as limit switches, braking devices, and overload sensors in the system.

(D) All quick-release devices and cable cutters should be demonstrated at 0, 25, 50, 75 and 100 per cent of the system limit load or at the most critical percentage value.

NOTE: Some hoist designs have built-in cable-tensioning devices that function at the no load-speed combination, as well as at other load-speed combinations. These devices should be shown to work during the no load-speed and other load-speed cable-cutting demonstrations.

(E) All electrical and mechanical systems and load-release devices for any jettisonable NHEC or HEC RLC should be shown to be reliable by both analysis and testing.

(F) Any devices or methods used to increase the mechanical advantage of the hoist should also be demonstrated.

(G) During a portion of each demonstration cycle, the hoist should be operated from each station from which it can be controlled.

NOTE: A reasonable amount of starting and stopping during demonstration cycles is acceptable.

(ix) Hoist System Continued Airworthiness. The design life of the hoist system and any life-limited components should be clearly identified, and the Airworthiness Limitations Section of the maintenance manual should include these requirements. For STCs, a maintenance manual supplement should be provided that includes these requirements.

NOTE: Design lives of hoist and cable systems are typically between 5 000 and 8 000 cycles. Some hoist systems have usage time meters installed. Others may have cycle counters installed. Cycle counters should be considered for HEC operations and high-load or other operations that may cause low-cycle fatigue failures.

(x) Hoist System Flight Tests. An in-flight demonstration test of the hoist system should be conducted for helicopters designed to carry NHEC or HEC. The rotorcraft should be flown to the extremes of the applicable manoeuvre flight envelope and to all conditions that are critical to strength, manoeuvrability, stability, and control, or any other factor affecting airworthiness. Unless a lesser load is determined to be more critical for either dynamic stability or other reasons, the maximum hoist system rated load or, if less, the maximum load requested for approval (and the associated limit load data placards) should be used for these tests. The minimum hoist system load (or zero load) should also be demonstrated in these tests.

(6) CS 29.865(b)(3)(ii) Electromagnetic Interference: protection of the QRS against potential internal and external sources of electromagnetic interference (EMI) and lightning is required. This is necessary to prevent inadvertent load releases from sources such as lightning strikes, stray electromagnetic signals, and static electricity.

(i) Jettisonable NHEC systems should be able to absorb a minimum of 20 volts per metre (i.e. CAT U) radio frequency (RF) field strength per RTCA/DO-160.

(ii) Jettisonable HEC systems should be able to absorb a minimum of 200 volts per metre (i.e. CAT Y) RF field strength per RTCA/DO-160.

NOTE 1: These RF field threat levels may need to be increased for certain special applications such as microwave tower and high-voltage high line repairs. Separate criteria for special applications under the regulations of more than one agency or entity (such as the Institute of Electrical and Electronics Engineers (IEEE) or Occupational Safety and Health Administration (OSHA) standards) should also be addressed, as applicable, during certification. When necessary, the issue paper process can be used to establish a practicable level of safety for specific high-voltage or other special application conditions. For any devices or means added to meet the regulations of more than one agency or entity, their failure modes should not have an adverse effect on flight safety. Other certification authorities may require higher RF field threat levels than those required by CS 29.865 (e.g. CS-29 Appendix E).

NOTE 2: An approved standard rotorcraft test that includes the full HIRF frequency and amplitude external and internal environments on the QRS and complex PCDS (or the entire rotorcraft including the QRS and complex PCDS) could be substituted for the jettisonable NHEC and HEC systems tests defined by c(6)(i) and c(6)(ii) respectively, as long as the RF field strengths directly on the QRS and complex PCDS are shown to equal or exceed those of c(6)(i) and c(6)(ii).

NOTE 3: The EMI levels specified in c(6)(i) and c(6)(ii) are total EMI levels to be applied to the QRS (and affected QRS component) boundary. The total EMI level applied should include the effects of both external and internal EMI sources. All aspects of internally generated EMI should be carefully considered including peaks that could occur from time to time due to any combination of on-board systems being operated. For example, special attention should be given to EMI from hoist operations that involve the switching of very high currents. Those currents can generate significant voltages in closely spaced wiring that, if allowed to reach some squib designs, could activate the device. Shielding, bonding and grounding of wiring associated with the operation of the hoist and the quick-release mechanism should be clearly and adequately evaluated in design and certification. This evaluation may require testing. One acceptable test method to demonstrate the adequacy of QRS shielding, bonding and grounding would be to actuate the hoist under maximum load together with likely critical combinations of other aircraft electrical loads and demonstrate that the test squibs (which are more EMI sensitive than the squibs specified for use in the QRS) do not inadvertently operate during the test.

(7) CS 29.865(c)(1) QRS Requirements for Jettisonable HEC Operations: For jettisonable HEC operations, both the PQRS and BQRS are required to have a dual actuation device (DAD) for external cargo release. Two distinct actions are required to minimise inadvertent jettison of HEC. The DAD is intended for emergency use during the phases of flight that the HEC is carried or retrieved. The DAD can be used for both NHEC and HEC operations. However, because it can be used for HEC, the Instructions for Continued Airworthiness should be carefully reviewed and documented. The DAD can be operated by the pilot from a primary control or, after a command is given by the pilot, by a crew member from a remote location. If the backup DAD is a cable cutter, it should be properly secured, placarded and readily accessible to the crew member intended to use it.

(8) CS 29.865(c)(2) PCDS: for all HEC applications that use complex PCDSs, an approval is required. The complex PCDS may be either previously approved or is required to be approved during certification. In either case, its installation should be approved. The complex PCDS is required to be reliable. The failure of the complex PCDS, and its attachments to the rotorcraft, should be shown to be extremely improbable (i.e. 1×10^{-9} failures per flight) for all failure modes that could cause a catastrophic failure, serious injury or fatality. All significant failure modes of lesser consequence should be shown to be improbable (i.e. 1×10^{-5} failures per flight). An acceptable method of achieving this goal is to submit the following for subsequent approval:

(i) a failure modes and effects analysis (FMEA) showing that all the potential failure modes of the complex PCDS that may result in catastrophic failures, serious injuries or fatality, are extremely improbable and any less-significant failures are improbable.

(ii) a repetitive test of all functional devices that cycles these devices at least 30 times under critical structural conditions, operational conditions, or a combination.

(iii) an environmental qualification review of the proposed operating environment.

NOTE: Complex PCDS designs can include relatively complex devices such as multiple occupant cages or gondolas. The purpose of the PCDS is to provide a minimum acceptable level of safety for personnel being transported outside the rotorcraft. The personnel being transported may be healthy or injured, conscious or unconscious.

(iv) Regulation (EU) No 965/2012 on Air Operations contains the minimum performance specifications and standards for simple PCDSs, such as HEC body harnesses.

(v) Static Strength. The complex PCDS should be substantiated for the allowable ultimate load and loading conditions as determined under paragraph c(2).

(vi) Fatigue. CS 29.865(f) requires the metallic components of the complex PCDSs to be substantiated for fatigue in accordance with CS 29.571 (ref.: c (14)).

(vii) Personnel Safety. For each complex PCDS design, the applicant should submit a design evaluation that assures the necessary level of personnel safety is provided. As a minimum, the following should be evaluated.

(A) The complex PCDS should be easily and readily entered or exited.

(B) It should be placarded with its proper capacity, the internal arrangement and location of occupants, and ingress and egress instructions.

(C) For door latch fail-safety, more than one fastener or closure device should be used. The latch device design should provide direct visual inspectability to assure it is fastened and secured.

(D) Any fabric used should be durable and should be at least flame-resistant.

(E) Reserved

(F) Occupant retention devices and the related design safety features should be used as necessary. In simple designs, rounded corners and edges with adequate strapping (or other means of HEC retention relative to the complex PCDS) and head supports or pads may be all the safety features that are necessary. Complex PCDS designs may require safety features such as seat belts, handholds, shoulder harnesses, placards, or other personnel safety standards.

(viii) EMI and Lightning Protection. All essential, affected components of the complex PCDS, such as intercommunication equipment, should be protected against RF field strengths to a minimum of RTCA/DO-160 CAT Y.

(ix) Instructions for Continued Airworthiness. All instructions and documents necessary for continued airworthiness, normal operations and emergency operations should be completed, reviewed and approved during the certification process.

(x) Flotation Devices. Complex PCDSs that are intended to have a dual role as flotation devices or life preservers should meet the relevant requirements for 'Life Preservers'. Also, any complex PCDS design to be used in the water should have a flotation kit. The flotation kit should support the weight of the maximum number of occupants and the complex PCDS in the water and minimise the possibility of the occupants floating face down.

(xi) Aerodynamic Considerations. Some complex PCDS designs may spin, twist or otherwise respond unacceptably in flight. Each of these designs should be structurally restrained with a device such as a spider, a harness, or an equivalent device to minimise undesirable flight dynamics.

(xii) Medical Design Considerations. Complex PCDSs should be designed to the maximum practicable extent and placarded to maximise the HEC's protection from medical considerations such as blocked air passages induced by improper body configurations and excessive losses of body heat during operations. Injured or water-soaked persons may be exposed to high body heat losses from sources such as rotor washes and airstreams. The safety of occupants of complex PCDSs from transit-induced medical considerations can be greatly increased by proper design.

(9) CS 29.865(c)(3) QRS Design, Installation and Placarding: for jettisonable HEC applications, the QRS design, installation and associated placarding should be given special consideration to assure the proper level of occupant safety.

(10) CS 29.865(c)(4) Intercom Systems for HEC Operations: for all HEC operations, the rotorcraft is required to be equipped for, or otherwise allow, direct intercommunication under any operational conditions among crew members and the HEC. For some systems, voice or hand signals to PCDS occupants may be acceptable. For other systems and for RCL Class D operations, more sophisticated devices such as two-way radios or intercoms should be employed.

(11) CS 29.865(c)(5) Flight Manual Procedures: appropriate flight manual procedures and limitations for all HEC operations should be presented. All limitations are required to be approved for all RLCs of Class A, B, or C that employ HEC. The flight manual should clearly define the method of communication between the flight crew and the HEC. These instructions and manuals should be validated during flight testing.

(12) CS 29.865(c)(6) Limitations for HEC Operations: for jettisonable HEC operations, a rotorcraft may be required by operations requirements to meet the Category A engine isolation requirements of CS-29 and to have one-engine-inoperative/out-of-ground effect (OEI/OGE) hover performance capability in its approved, jettisonable HEC weight, altitude, and temperature envelope.

(i) In determining OEI hover performance, dynamic engine failures should be considered. Each hover verification test should begin from a stabilised hover at the maximum OEI hover weight, at the requested in-ground-effect (IGE) or OGE skid or wheel height, and with all engines operating. At this point, the critical engine should be failed and the aircraft should remain in a stabilised hover condition without exceeding any rotor limits or engine limits for the operating engine(s). As with all performance testing, engine power should be limited to the minimum specification power. Engine failures may be simulated by rapidly moving the throttle to idle provided a 'needle split' is obtained between the rotor and engine RPM.

(ii) Normal pilot reaction time should be used, following the engine failure, to maintain the stabilised hover flight condition. When hovering OGE or IGE at the maximum OEI hover weight, an engine failure should not result in an altitude loss of more than 10 per cent or 4 feet, whichever is greater, of the altitude established at the time of engine failure. In either case, a sufficient power margin should be available from the operating engine(s) to regain the altitude lost during the dynamic engine failure and to transition to forward flight.

(iii) Consideration should also be given to the time required to recover (winch up and bring aboard) the Class D external load and to transition to forward flight. This time increment may limit the use of short-duration OEI power ratings. For example, for a helicopter that sustains an engine failure at a height of 40 feet, the time required to re-stabilise in a hover, recover the external load (given the hoist speed limitations), and then transition to forward flight (with minimal altitude loss) would likely preclude the use of the 30-second engine ratings and may encroach upon the 2 ½-minute ratings. Such an encroachment into the 2 ½-minute ratings is not acceptable.

(iv) For helicopters that incorporate engine-driven generators, the hoist should remain operational following an engine or generator failure. A hoist should not be powered from a bus that is automatically shed following the loss of an engine or generator. Maximum two-engine generator loads should be established so that when one engine or generator fails, the remaining generator can assume the entire rotorcraft electrical load (including the maximum hoist electrical load) without exceeding the approved limitations.

(v) The rotorcraft flight manual (RFM) should contain information that describes the expected altitude loss, any special recovery techniques, and the time increment used for recovery of the external load when establishing maximum weights and wheel or skid heights. The OEI hover chart should be placed in the performance section of the RFM or RFM supplement. The allowable altitude extrapolation for the hover data should not exceed 2 000 feet.

(13) CS 29.865(d) Flight Test Verification Work: flight test verification work (or an equivalent combination of analysis and ground testing, either in conjunction with or in addition to operating rules such as Regulation (EU) No 965/2012 on Air Operations) that thoroughly examines the operational envelope should be conducted with the external cargo carriage device for which approval is requested (especially those that involve HEC). The flight test programme should show that all aspects of the operations applied for are safe, uncomplicated, and can be conducted by a qualified flight crew under the most critical service environment and, in the case of HEC, under emergency conditions. Flight tests should be conducted for the simulated representative NHEC and HEC loads to demonstrate their in-flight handling and separation characteristics. Each placard, marking and flight manual supplement should be validated during flight testing.

(i) General. Flight testing (or an equivalent combination of analysis and testing) should be conducted under the critical combinations of configurations and operating conditions for which basic type certification approval is sought. Additional combinations of external loads and operating conditions may be subsequently approved under the relevant operational requirements as long as the structural limits and reliability considerations of the basic certification approval are not exceeded (i.e. equivalent safety is maintained). The qualification flight test work of this subparagraph is intended to be accomplished primarily by analysis or bench testing. However, at least one in-flight limit load drop test should be conducted for the critical load case. If one critical load case cannot be clearly identified, then more than one drop test might be necessary. Also, in-flight tests for the minimum load case (i.e. typically the cable hook itself) with the load trailing both in the minimum and maximum cable length configurations should be conducted. Any safety-of-flight limitations should be documented and placed in the rotorcraft flight manual (RFM). In certain low gross weight, jettisonable HEC configurations, the complex PCDS may act as a trailing aerofoil that could result in entangling the complex PCDS and the rotorcraft. These configurations should be assessed on a case-by-case basis by analysis or flight test to assure that any safety-of-flight limitations are clearly identified and placed in the RFM.

(ii) Separation Characteristics of Jettisonable External Loads. For all jettisonable RLCs of any applicable cargo type, the satisfactory post-jettison separation characteristics of all loads should meet the following minimum criteria:

(A) Immediate ‘clean’ operation of the QRS, including ‘clean’ separate functioning of the PQRS and BQRS.

(B) No damage to the helicopter during or following actuation of the QRS and load jettisoning.

(C) A jettison trajectory clear of the helicopter.

(D) No inherent instability of the jettisonable (or just jettisoned) HEC or NHEC while in proximity to the helicopter.

(E) No adverse or uncontrollable helicopter reactions at the time of jettison.

(F) Stability and control characteristics after jettison should be within the originally approved limits.

(G) No unacceptable degradation of the helicopter performance characteristics after jettison.

(iii) Jettison Requirements for Jettisonable External Loads. For representative cargo types (low-, medium- and high-density loads on long and short lines), emergency and normal jettison procedures should be demonstrated (by a combination of analysis, ground tests, and flight tests) at sufficient combinations of flight conditions to establish a jettison envelope that should be placed in the RFM.

(iv) QRS Demonstration. Repetitive jettison demonstrations should be conducted that use the PQRS. The BQRS should be utilised at least once.

(v) QRS Reliability (i.e. failure modes) Affecting Flight Performance. The FMEA of the QRS (ref.: c (4)) should show that no single system failure will result in unsatisfactory flight characteristics, including any QRS failures that result in asymmetric loading conditions.

(vi) Flight Test Weight and CG Locations. All flight tests should be conducted at the extreme or critical combinations of weight and longitudinal and lateral CG conditions within the flight envelope that is applied for. The rotorcraft should remain within the approved weight and CG limits both with the external load applied and after jettison of the load.

(vii) Jettison Envelopes. Emergency and normal jettison demonstrations should be performed at sufficient airspeeds and decent rates to establish any restrictions for satisfactory separation characteristics. Both the maximum and minimum airspeed limits and the maximum descent rate for safe separation should be determined. The sideslip envelope as a function of airspeed should be determined.

(viii) Altitude. Emergency and normal jettison demonstrations should be performed at altitudes consistent with the approvable operational envelope and with the manoeuvring requirements necessary to overcome any adverse effects of the jettison.

(ix) Attitude. Emergency and normal jettison demonstrations should be performed from all attitudes appropriate to normal and emergency operational usage. Where the attitudes of HEC or NHEC with respect to the helicopter may vary, the most critical attitude should be demonstrated. This demonstration would normally be accomplished by bench testing.

(x) Hoist and Rescue Hook Systems or Cargo Hook Systems. An in-flight demonstration test of the hoist system should be conducted for helicopters designed to carry NHEC or HEC. The rotorcraft should be flown to the extremes of the applicable manoeuvre flight envelope and to all conditions that are critical to strength, manoeuvrability, stability, and control, or any other factor affecting its airworthiness. Unless a lesser load is determined to be more critical for either dynamic stability or other reasons, the maximum hoist system rated load or, if less, the maximum load requested for approval (and the associated limit load data placards) should be used for these tests. The minimum hoist system load (or zero load) should also be demonstrated in these tests.

(14) CS 29.865(e) External Loads Placards and Markings: placards and markings should be installed next to the external-load attaching means, in a clearly noticeable location, that state the primary operational limitations — specifically including the maximum authorised external load. Not all operational limitations need be stated on the placard (or equivalent markings); only those that are clearly necessary for immediate reference in operations. Other more detailed operational limitations of lesser immediate importance should be stated either directly in the RFM or in an RFM supplement.

(15) CS 29.865(f) Fatigue Substantiation: the fatigue evaluation of CS 29.571 should be applied as follows:

NOTE: The term 'hazard to the rotorcraft' is defined to include all hazards to either the rotorcraft, to the occupants thereof, or both.

(i) Fatigue Evaluation of NHEC Applications. Any critical components of the suspended system and their attachments (such as the cargo hook or bolted or pinned truss attachments), the failure of which could result in a hazard to the rotorcraft, should undergo an acceptable fatigue analysis in accordance with AC 27 MG 11, paragraph e.

(ii) Fatigue Evaluation of HEC Applications. The entire complex PCDS and its attachments should be reviewed on a component-by-component basis to determine which components, if any, are fatigue-critical or damage-intolerant. These components should be analysed or tested (per AC 27 MG 11, AC 29 MG 11, or other equivalent methods) to assure their fatigue life limits are properly determined and placed in the limited life section of the maintenance manual.

(16) Other Considerations

(i) Agricultural Installations (AIs): AIs can be approved for either jettisonable or non-jettisonable NHEC or HEC operations as long as they meet relevant certification and operations requirements and follow appropriate compliance methods. However, most current AI designs are external fixtures (see definition), not external loads. External fixtures are not approvable as jettisonable external cargo because they do not have a true payload (see definition), true jettison capability (see definition), or a complete QRS. Many AI designs can dump their solid or liquid chemical loads by use of a 'purge port' release over a relatively long time period (i.e. greater than 30 seconds). This is not considered to be a true jettison capability (see definition) since the external load is not released by a QRS and since the release time span is typically greater than 30 seconds (ref.: b(20) and c(7)). Thus, these types of AIs should be approved as non-jettisonable external loads. However, other designs that have the entire AI (or significant portions thereof) attached to the rotorcraft, that have short time frame jettison (or release) capabilities provided by QRSs that meet the definitions herein and that have no post-jettison characteristics that would endanger continued safe flight and landing may be approved as jettisonable external loads. For example, if all the relevant criteria are properly met, a jettisonable fluid load can be approved as an NHEC external cargo. AC 29 MG 5 discusses other AI certification methodologies.

(ii) External Tanks: external tank configurations that have true payload (see definition) and true jettison capabilities (see definition) should be approved as jettisonable NHEC. External tank configurations that have true payload capabilities but do not have true jettison capabilities should be approved as non-jettisonable NHEC. An external tank that has neither a true payload capability nor true jettison capability is an external fixture; it should not be approved as an external load under CS 29.865. If an external tank is to be jettisoned in flight, it should have a QRS that is approved for the maximum jettisonable external tank payload and is either inoperable or is otherwise rendered reliable to minimise inadvertent jettisons above the maximum jettisonable external tank payload.

(iii) Logging Operations: These operations are very susceptible to low-cycle fatigue because of the large loads and relatively high load cycles that are common to this industry. It is recommended that load-measuring devices (such as load cells) be used to assure that no unrecorded overloads occur and to assure that cycles producing high fatigue damage are properly considered. Cycle counters are recommended to assure that acceptable cumulative fatigue damage levels are identifiable and are not exceeded. As either a supplementary method or an alternate method, maintenance instructions should be considered to assure proper cycle counting and load recording during operations.

(17) Reserved

(18) Instructions for Continued Airworthiness. Maintenance manuals (and RFM supplements) developed by applicants for external load applications should be presented for approval and should include all appropriate inspection and maintenance procedures. The applicant should provide sufficient data and other information to establish the frequency, extent, and methods of inspection of critical structures, systems and components. This information is required by CS 29.1529 to be included in the maintenance manual. For example, maintenance requirements for sensitive QRS squibs should be carefully determined, documented, approved during certification, and included as specific mandatory scheduled maintenance requirements that may require either ‘daily’ or ‘pre-flight’ checks (especially for HEC applications).

AMC No 2 to 29.865 EXTERNAL LOADS OPERATIONS USING SIMPLE PERSONNEL-CARRYING DEVICE SYSTEMS

If required by the applicable operating rule or if an applicant elects to, this AMC provides a means of compliance for the airworthiness certification of a simple personnel-carrying device system (PCDS) and attaching means to the hook, providing safety factors and consideration of calendar life replacement limits in lieu of a dedicated fatigue analysis and test.

A PCDS is considered to be simple if:

(a) it meets an EN standard under EC Directive 89/686/EEC, or Regulation (EU) 2016/425, as applicable, or subsequent revision;

(b) it is designed to restrain no more than a single person (e.g. hoist or cargo hook operator, photographer, etc.) inside the cabin, or to restrain no more than two persons outside the cabin;

(c) it is not a rigid structure such as a cage, a platform or a basket.

PCDSs that cannot be considered to be simple are considered to be complex.

Note 1: EASA or the relevant Authority should be contacted to confirm the classification in the event that:

— a PCDS includes new or novel features;

— a PCDS has not been proven by appreciable and satisfactory service experience; or

— there is any doubt in the classification.

Approval of Simple PCDSs

If the approval of a simple PCDS is requested, then Directive 89/686/EEC, or Regulation (EU) 2016/425 are an acceptable basis for the certification of a simple PCDS provided that:

(a) the applicable Directive 89/686/EEC or Regulation (EU) 2016/425, as applicable, or subsequent revision and corresponding EN standards for the respective components are complied with (EC Type Examination Certificate);

(b) the applicant for the minor change has obtained from the manufacturer and keeps on record the applicable EC Conformity Certificate(s).

Note 2: A simple PCDS has an EC Type Examination Certificate (similar to an STC), issued by a Notified Certification Body and, for the production and marketing, an EC Conformity Certificate (similar to an EASA Form 1) issued by the manufacturer.

Note 3: In cases where ropes or elements connect simple PCDSs to the hoist/cargo hook or internal helicopter cabin, the EN certification can be achieved by a body meeting the transposition into national law of the applicable EC/EU regulation.

The EC-certified components are appropriately qualified for the intended use and the environmental conditions.

Note 4: The intended use and corresponding risks must be considered when selecting EN standards. For example hoist operators and rescuers that have to work at the edge of the cabin or outside should have full body harnesses to address the risk of inversion. Litters and the corresponding restraint systems should be adequately designed for the loads that can be generated during spinning.

Note 5: The assembly of the different components should also consider the intended use. For example the attachment of the tethering strap to the harness of a hoist operator should be of a quick-release type to allow quick detachment from the aircraft following a ditching or emergency landing. The tethering strap should also be adjustable to take up slack and avoid shock loads being transmitted to other components.

(c) The maximum load applied to each component between the HEC and the hook is conservatively estimated. This is particularly important when more than one person is attached by a single system to the cargo hook/ hoist. Appendix 1 defines the appropriate minimum ultimate load (ULmin). If UL_{min} is above the static strength currently declared by the supplier of the PCDS or of a component of the attachments, through compliance with an EN standard, then proof of sufficient strength is to be provided by static tests. All possible service load cases (including asymmetric load distribution) are to be considered. In this case, the PCDS and/or the attaching means (e.g. rope, carabineer, shackles, etc.) must be capable of supporting UL_{min} for a minimum of 3 minutes without failure. There should be no deformation of components that could allow the release of the HEC. Components and details added to the EN-approved equipment (such as splicing, knots, stitching, seams, press fits, etc.) or the materials used (textiles, composites, etc.) that might reduce the strength of a product or could (in combination) have other detrimental effects have been investigated by the applicant and accounted for in the substantiation.

(d) The effects of ageing (due to sunlight, temperature, water immersion, etc.) and other operational factors that may affect the strength of the PCDS are accounted for through appropriate inspections and the application of a calendar life limit as appropriate. The PCDS and the related attachment elements are limited to the carriage of HEC.

(e) The risk of fatigue failure is minimised. See section below for further details.

(f) Instructions for Continued Airworthiness (ICA) should be provided. Typically, the ICA would comprise an inspection programme and maintenance instructions based on the applicable manufacturer's data. The ICA should ensure that specific operational uses of the system that might affect its strength are accounted for. A calendar life limit should be applied when appropriate.

(g) When the harness is not designed to transport an incapacitated or untrained person, then the labelling and/or the user/flight manual should include a specific limitation of use as applicable.

Note 6: The following considerations and corresponding instructions/limitations should be taken for EN 1498 Type A and C rescue loops due to their potential detrimental physiological effects and the risk falling out:

(a) whether life is in imminent risk;

(b) the physical condition of the person to be hoisted, particularly whether the rescuee will remain conscious and coherent during the hoist process;

(c) the potential for the person to remain compliant with the brief given prior to hoisting;

(d) alternative methods and devices to recover the person; and

(e) whether the risk of falling from the device would result in further serious injury or death.

Simple PCDS Helicopter Compatibility

The ingress/egress of the simple PCDS in the cabin should be verified on the specific rotorcraft by means of a test. The compatibility with the hoist hook, unless the ring is already specified in the RFM, should also be verified by means of a test.

The verification of the hook and simple PCDS compatibility should also verify the absence of any roll-out/jamming phenomenon in order to:

(a) prevent any inadvertent release of the load from the cargo hook; and/or

(b) prevent the ring from jamming on the load beam during the release.

Manufacturing and Identification

Simple PCDSs that comply with Directive 89/686/EEC, or Regulation (EU) 2016/425, as applicable, or subsequent revision and the corresponding EN standards for the respective components are labelled by the manufacturer according to the applicable standard. If not already contained in the manufacturer labelling, the following additional information, as applicable, should be made visible on labelling on simple PCDSs:

(a) manufacturing date;

(b) life-limit date (if different from any existing one marked on the personal protective equipment (PPE));

(c) manufacturer's identification;

(d) part number;

(e) serial number or unique identification of the single PCDS;

(f) STC/minor change approval number (if applicable);

(g) authorised load in kg;

(h) authorised number of persons;

(i) Any other limitation not recorded in the manufacturer labelling.

Simple PCDS Static Strength

The PCDS should be substantiated for the loading conditions determined under the applicable paragraphs of FAA AC 29.865. For a PCDS to be certified separately from the hoist, using the guidance of this certification memo, the minimum ultimate load (UL_{min}) to be substantiated is defined as follows:

$$ULmin = M \times n \times j \times jf \times K \times g \ (units\ are\ Newtons)$$

Where:

M is the total mass of the PCDS equipment/component and persons restrained by the part being substantiated (this is equivalent to the working load rating of an EN). The mass of each person should be assumed to be 100 kg.

NOTE: If the person(s) or their task requires the personal carriage of heavy items (backpacks, tools, fire extinguishers, etc.), these must be accounted for in the total mass M, in addition to the person's mass of 100 kg.

n is the helicopter manoeuvring limit load factor and must be assumed = 3.5 (CS 29.337 and 29.865).

j is the ultimate load factor of safety for all parts = 1.5 (CS 29.303).

K is an additional safety factor for textiles = 2.0 (see NOTE 1) (CS 29.619).

jf is an additional fitting factor = 1.33 applying to all joints, fittings, etc. (CS 29.619).

g is the acceleration due to gravity of 9.81 m/s^2.

The resulting values to ensure compliance with the CS-29 static strength requirements are:

UL_{min} for metallic elements with a fitting factor (needed for all joints and fittings): = 7 Mg.

(NOTE: To address fatigue, a value of 10 Mg may be required; see the section below on fatigue.)

UL_{min} for textiles (webbing, ropes, etc.) with fitting factor: = 14 Mg (see NOTE 1).

UL_{min} may be compared to the strength of the PCDS components already substantiated according to Directive 89/686/EEC, or Regulation (EU) 2016/425, as applicable, or subsequent revision and the corresponding EN Standards or Directive 2006/42/EC Annex I Point 6. Where UL_{min} is greater than that laid down in the Directives/EN requirements, a static test to not less than UL_{min} will be necessary. The test load must be sustained for 3 minutes. In addition, there should be no detrimental or permanent deformation of the metallic components at 3.5 Mg (CS 29.305).

NOTE 7: Directive 2006/42/EC Annex I Point 6 recommends a safety factor of 14 (2 × 7) for textiles applied to the working load (equivalent to 14 M above) for equipment lifting humans, whereas for a rescue harness, EN 1497 requires a static test load of not less than the greater of either 15 kN or 10 times the working load. Considering this difference, for each textile component within the PCDS certified to one of the following ENs, the value of K may be reduced, such that UL_{min} is not less than 10 Mg, where M is not more than 150 kg:

For harnesses, EN 361, EN 1497 or EN 12277A, EN 813 or EN 12277C apply; for belts or straps and for lanyards, EN 354 applies. This allowance is not applicable to ropes.

Furthermore, to allow this reduced value of UL_{min} and to address any potential deterioration of textiles due to environmental and other hidden damage, the ICA must include a life limitation of 5 years (or the life indicated by the PCDS manufacturer, if less) and an annual detailed inspection of the general condition of the harness.

Simple PCDS Fatigue

When the simple PCDS and the related attachment elements are limited to the carriage of HEC only, no further specific fatigue substantiation is necessary for each part of the simple PCDS that is either:

(a) certified in accordance with an applicable EN that is referenced in this AMC for which the allowable working load is not exceeded by the mass M; or

(b) substantiated for static strength as described above with UL_{min} not less than 10 Mg.

Amend AMC 29.917 (amendment of AC 29.917) as follows:

AMC 29.917 Rotor drive system design

This AMC provides further guidance and acceptable means of compliance to supplement FAA AC 29-2C § AC 29.917, to meet EASA’s interpretation of CS 29.917. As such it should be used in conjunction with the FAA AC.

Vibration Health Monitoring: Where Vibration Health Monitoring is used as a compensating provision to meet CS 29.917(b), the design and performance of the vibration health monitoring system should be approved by requesting compliance with CS 29.1465(a).

For lubrication systems: a dedicated safety assessment should be performed that addresses all the lubrication systems of rotor drive system gearboxes and, in particular, the following:

(a) Identification of any single failure, malfunction, or reasonably conceivable combinations of failures that may result in a loss of oil pressure, a loss of oil supply to the dynamic components or a loss of the oil scavenge function. This normally takes the form of a failure mode and effects analysis. Compensating provisions should be identified to minimise the likelihood of occurrence of these failures. The safety assessment should also consider potential assembly or maintenance errors that cannot be readily detected during specified functional checks.

(b) The safety assessment should consider any specific design features which are subject to variability in manufacture or wear/degradation in service and which could have an appreciable effect on the *maximum period of operation following loss of lubrication*. Any features that may have a significant influence on the behaviour of the residual oil or the auxiliary lubrication system should be taken into account when determining the configuration of test articles.

(c) Identification of the *most severe failure mode* that results in the shortest duration of time in which the gearbox should be able to operate following the indication to the flight crew of a *normal-use lubrication system* failure. This should be used for simulating lubrication failure during the CS 29.927(c) loss of lubrication test.

(d) *Auxiliary lubrication system:* Where compliance with CS 29.927(c) is reliant upon the operation of an *auxiliary lubrication system*, sufficient independence between the *normal-use* and *auxiliary lubrication systems* should be substantiated. Common-cause failure analysis, including common-mode, particular-risk, and zonal safety analyses, should be performed. It should be established that no single failure or identified common-cause failure will prevent the operation of both the *normal-use* and the *auxiliary lubrication systems*, apart from any failures that are determined to be *extremely remote lubrication failures*. The effects of inadvertent operation of the *auxiliary lubrication system* should also be considered.

(e) Definitions

(1) *Lubrication System Failure:* in the context of CS 29.917(b), references to a failure of the lubrication system should be interpreted as any failure that results in a loss of pressure and an associated low oil pressure warning, within the duration of one flight.

(2) *Most severe failure mode*: the failure mode *of the normal use lubrication system* that results in the shortest duration of time in which the gearbox is expected to operate following an indication to the flight crew.

(3) *Normal-use lubrication system*: the lubrication system relied upon during normal operation.

(4) *Auxiliary lubrication system*: any lubrication system that is *independent* of the *normal-use lubrication system*.

(5) *Independent*: an *auxiliary lubrication system* should be able to function after a failure of the *normal-use lubrication system*. Failure modes which may result in the subsequent failure of both the *auxiliary and the normal-use lubrication systems* and which may prevent continued safe flight or safe landing should be shown to be *extremely remote lubrication failures*.

(6) *Extremely remote lubrication failure:* a lubrication failure where the likelihood of occurrence has been minimised, either by structural analysis in accordance with CS 29.571 or laboratory testing. Alternatively, service experience or other means can be used which indicate a level of reliability comparable with one failure per 10 million hours. Failure modes including failures of external pipes, fittings, coolers, or hoses, and any components that require periodic removal by maintainers, should not be considered *as extremely remote lubrication failures.*

(f) Determination of the *Most Severe Failure Mode*

(1) The objective of the loss of lubrication test is to demonstrate the operation of a rotor drive system gearbox following the *most severe failure mode* of the *normal-use lubrication system*. The determination of the *most severe failure mode* may not be immediately obvious, as leakage rates vary, and system performance following leaks from different areas varies as well. Thus, a careful analysis of the potential failure modes should be conducted, taking into account the effects of flight conditions if relevant.

(2) The starting point for the determination of the *most severe failure mode* should be an assessment of all the potential lubrication system failure modes. This should be accomplished as part of the CS 29.917(b) design assessment, and include leaks from any connections between components that are assembled together, such as threaded connections, hydraulic inserts, gaskets, seals, and packing (O-rings). Failure modes, such as failures of external lines, failures of component retention hardware and wall-through cracks that have not been substantiated for CS 29.307, CS 29.571 and CS 29.923(m) should also be considered. The determination that a failure is an *extremely remote lubrication failure*, when used to eliminate a potential failure mode from being considered as a candidate *most severe failure mode*, should be substantiated. Where leakage rates or the effect of failure modes cannot be easily determined, then a laboratory test should be conducted. Once the *most severe failure mode* has been determined, this should form the basis of the conditions for the start of the test.

(g) Use of an *auxiliary lubrication system*

Use of an *auxiliary lubrication system* may be an acceptable means of providing extended operating time after a loss of lubrication. The *auxiliary lubrication system* should be designed to provide sufficient independence from the *normal-use lubrication system*. Since the *auxiliary lubrication system* is by definition integral to the same gearbox as the *normal-use lubrication system*, it may be impractical for it to be completely independent. Therefore, designs should be conceived such that shared components or interfaces between the *normal-use* and *auxiliary lubrication systems* are minimised and comply with the design assessment provisions of CS 29.917(b). A failure of any common feature shared by both the *normal-use* and *auxiliary lubrication systems* that could result in the failure of both systems, and would consequently reduce the *maximum period of operation following loss of lubrication,* should be shown to be an *extremely remote lubrication failure*. If compliance with CS 29.927(c) is reliant on the functioning of an *auxiliary lubrication system*, then:

(1) in the unlikely event of a combined failure of both the *normal-use lubrication system* and the *auxiliary lubrication system*, the RFM emergency procedures should instruct the flight crew to 'Land immediately' unless testing representing this failure mode has been performed in order to substantiate that an increased duration is justified; and

(2) a means of verifying that the *auxiliary lubrication system* is functioning properly should be provided during normal operation of the rotorcraft on either a periodic, pre-flight or continual basis. Following failure of the normal use lube system and activation of an auxiliary lubrication system the flight crew should be alerted in the event of any system malfunction.

(h) Independence of the *auxiliary lubrication system*.

(1) In order to ensure that the *auxiliary lubrication system* is sufficiently independent:

(i) a failure of any pressurised portion of the *normal-use lubrication system* should not result in a subsequent failure of the *auxiliary lubrication system*;

(ii) common failure modes shown to defeat both the *normal-use* and the *auxiliary lubrication systems* should be shown to be *extremely remote lubrication* failures, unless it is demonstrated by testing conducted to comply with 29.927(c) that the failure mode does not compromise the *'Maximum period of operation following loss of lubrication'*; and

(iii) control systems, logic and health-reporting systems should not be shared; consideration should be given to the design process to ensure appropriate segregation of the control and warning systems in the system architecture.

(2) Methods which should be used to demonstrate that failure modes of common areas are *extremely remote* include:

(i) field experience of the exact design with an exact application;

(ii) field experience with a similar design/application with supporting test data to allow a comparison;

(iii) demonstration by test of extremely low leakage rates;

(iv) redundancy of design;

(v) structural substantiation with a high safety margin for elements of the lubrication systems assessed against CS 29.571; and

(vi) assessment of the potential dormant failure modes of the *auxiliary lubrication system,* and in order to minimise the risk of dormant failures, determination of the health of the *auxiliary lubrication system* prior to each flight.

<u>Create a new AMC 29.927 (amendment of AC 29.927) as follows:</u>

AMC 29.927 Additional tests

This AMC replaces item a. (Section 29.927(c)) of FAA AC 29.927 (Amendment 29-26).

(a) Explanation

(1) AMC 29.927 revises the rotor drive systems loss of lubrication test provisions for Category A rotorcraft, as defined in CS 29.927(c). This changes the related requirement to show a capability through testing of at least 36 minutes' duration. Additionally, minimum periods and load conditions are now defined directly in the provision. The failure condition to be

simulated is the *most severe loss of lubrication failure* mode of the *normal-use lubrication system*, which is defined in AMC 29.917. In addition, the term 'unless such failures are extremely remote' has been removed from the requirement. Assessment of the lubrication system reliability is now addressed under 29.917(b).

(2) CS 29.927(c) is intended to apply to pressurised lubrication systems, as the likelihood of loss of lubrication is significantly greater for gearboxes that use pressurised lubrication and external cooling. This is due to the increased complexity of the lubrication system, the external components that circulate oil outside the gearbox, and the resultant rapid leakages that may occur with a pressurised system. A pressurised lubrication system is more commonly used in the rotorcraft's main gearbox, but one may also be used in other rotor drive system gearboxes. The need for dedicated loss of lubrication testing for gearboxes using non-pressurised (splash) lubrication systems is determined by the design assessment carried out in accordance with 29.917(b).

(3) This provision is applicable to any pressurised lubrication gearbox that is necessary for continued safe flight or safe landing. Accordingly, this provision is not applicable to gearboxes that are not essential for continued safe flight or safe landing and which have a lubrication system which is *independent* of other essential gearboxes.

(4) The lubricating system has two primary functions. The first is to provide lubricating oil to contacting or rubbing surfaces to reduce the heat energy generated by friction. The second is to dissipate the heat energy generated by the friction of meshing gears and bearings, thus maintaining surface and component temperatures. Accordingly, a loss of lubrication leads to increased friction between components and increased component surface temperatures. With increased component surface temperatures, surface hardness may be lost, resulting in the inability of the component to carry or transmit loads appropriately. Thermal expansion in gearbox components may eventually lead to the mechanical failure of bearings, journals, gears, shafts, and clutches that are subjected to high loads and rotational speeds. A loss of lubrication may result from either internal or external failures.

(5) The intent of the rule change for Category A rotorcraft is to provide confidence in the continued flight capability of the rotorcraft, which should be of at least 30 minutes' duration after the loss of lubricant pressure in any single rotorcraft drive system gearbox, with the aim of optimising the eventual landing opportunities. In order to enable the crew to determine the safest action in the event of a loss of gearbox oil, the emergency procedures of the rotorcraft flight manual (RFM) should include instructions that define the maximum time period within which the rotorcraft should land. This AMC provides guidance for the completion of the loss of lubrication test and for how to demonstrate confidence in the margin of safety associated with the *maximum period of operation following loss of lubrication*, and associated period defined in the RFM emergency procedures. This margin of safety is intended to substantiate a period of operation that has been evaluated as likely to be safer than making a forced landing over hostile terrain.

(b) Procedures

(1) CS 29.927(c) prescribes a test that is intended to demonstrate that no hazardous failure or malfunction will occur within a defined period, and in a specified reduced-power condition, in the event of a significant failure of the rotor drive lubrication system. The failure of the lubrication system should not impair the ability of the crew to continue the safe operation of Category A rotorcraft for the defined period after an indication of the failure has been provided to the flight crew. For Category B rotorcraft, safe operation under autorotative conditions should be possible for a period of at least 15 minutes. For both Category A and B

rotorcraft, some damage to the rotor drive system components is acceptable after completion of the lubrication system testing. However, the condition of the components will influence the *maximum period of operation following loss of lubrication*.

(2) Since this is a test of the capability of the gearbox to operate with *residual oil* or oil supplied from an *auxiliary lubrication system*, the method for draining the oil and the operating conditions are also defined in the provision. The entry condition for the test should also be representative, and is defined in this AMC. For Category B rotorcraft, it is necessary to simulate an autorotation for a period of 15 minutes, followed by a minimum-power landing.

(c) Definitions

For the purposes of this test and the assessment of continued operation after a loss of lubrication, the following definitions apply:

(1) *Maximum period of operation following loss of lubrication*: The maximum period of time following a loss of oil pressure warning, within which the rotorcraft should land. The period stated in the associated RFM emergency procedures should not exceed the *maximum period of operation following loss of lubrication*.

(2) *Residual oil*: the oil present in the gearbox after experiencing the *most severe failure mode,* beginning at the time the pilot receives an indication of the failure. (Note: the amount of residual oil may decrease with time, and test conditions should take into account the possible effects of flight conditions where relevant. Also, when the lubrication system incorporates an *auxiliary lubrication system*, this will supplement the *residual oil* in the event of a failure of the *normal-use lubrication system*).

(d) Certification test configuration

Each gearbox lubricated by a pressurised system that is necessary for continued safe flight or safe landing should be tested. Deviations from the gearbox configuration being certified may be allowed where necessary for the installation of test instrumentation or equipment to facilitate simulation of the *most severe failure mode*. If any specific design features are identified in the safety assessment that may have a significant influence on the behaviour of the residual oil or the auxiliary lubrication system, they should be taken into account when determining the configuration of the test articles.

(e) Loss of lubrication test

(1) Category A rotorcraft

(i) Test entry condition: the test starting condition should be 100 % of the torque associated with all engines operative (AEO) maximum continuous power (MCP) and at the nominal speed for use with MCP. In addition, the torque necessary for the anti-torque function should be simulated for straight and level flight at the same flight conditions. The oil temperature should be stabilised at the maximum oil temperature limit for normal operation.

(ii) Draining of oil: once the oil temperature has stabilised at the maximum declared oil temperature limit for normal operation, the oil should be drained simulating the *most severe failure mode* of the *normal-use lubrication system*. The *most severe failure mode* should be determined by the failure analysis of CS 29.917(b). The location and rate of oil drainage should be representative of the mode being simulated and the drainage should continue throughout the test.

(iii) Depleted-oil run: upon illumination of the ‘low oil pressure’ warning or other indication, as required by CS 29.1305, continue to operate at AEO MCP and the nominal speed for use in this condition for 1 minute. Then, reduce the torque values to be greater than or equal to those necessary to sustain flight at the maximum gross weight and the most efficient flight conditions under standard atmospheric conditions (Vy). This condition should be maintained during the time determined necessary by the applicant to justify the *maximum period of operation following loss of lubrication* taking into account the applicable reduction factors. When determining the torque values to sustain flight at the maximum gross weight and the most efficient flight conditions (Vy), it should be assumed that the condition starts at 100 % maximum take-off weight (MTOW), and, thereafter, consideration for the fuel burn during the test is allowed.

(iv) Simulated landing: to complete the test, power should be applied to the gearbox for at least 45 seconds to simulate an out of ground effect (OGE) hover.

(v) Test conditions: for (i) to (iv) above, the input and output shaft torques should be reacted appropriately and the corresponding input and output shaft loads should be applied. As the efficiency of the gearbox may change during the test, the input loads may need to be adjusted in order to maintain the correct output shaft torque during the test. The vertical load of the main gearbox should be applied at the mast, and should be equal to the maximum gross weight of the rotorcraft at 1 g.

(vi) This test may be conducted on a representative bench test rig. The test should be performed with all the accessory loads represented by a load associated with normal cruise conditions. The test should not be performed with an ambient temperature in the test cell lower than ISA conditions. No additional ventilation that could reduce the gearbox temperature should be used which could result in temperatures which are lower than those which are likely to be experienced on the helicopter operating at ISA conditions.

(vii) A successful demonstration may involve limited damage to the rotor drive system; however, the gearbox should continue to transmit the necessary torque to the output shafts throughout the duration of the test. The loss of drive to accessories that are necessary for continued safe flight or safe landing should constitute a test failure.

(2) Category B rotorcraft

(i) The provisions for Category A apply, except that the rotor drive system need only perform a depleted-oil run for 15 minutes operating at a torque and speed to simulate autorotative conditions.

(ii) A successful demonstration may involve limited damage to the rotor drive system provided that it is established that the autorotative capabilities of the rotorcraft would not be significantly impaired. If compliance with Category A provisions is demonstrated, Category B provisions will be considered to have been met.

(3) The test parameters described in (e)(1) above have been chosen to represent an occurrence of loss of oil in flight, namely a reaction/transition period for the crew to be able to reduce power, followed by an extended period at reduced power for continued flight at Vy. When determining the torque necessary for the reduced-power segment of this test, an international standard atmosphere (ISA) sea level condition is considered to be acceptable.

(4) Should the applicant wish to establish a positive safety margin for a Category A rotorcraft for a *maximum period of operation following loss of lubrication* longer than 30 minutes, it will be necessary to extend the test duration representing flight at Vy, described in (e)(1)(iii) above.

(f) Determination of the *maximum period of operation following loss of lubrication*

In order to enable the flight crew to determine the safest action in the event of a loss of gearbox oil, the RFM emergency procedures should include instructions defining the maximum period of time, for each gearbox subject to 29.927(c), within which the rotorcraft should land. This period starts at the low pressure warning. Specific instructions can be prescribed by the applicant as an alternative to, or in addition to, defining the maximum *period of operation following loss of lubrication*, in order to maintain a continued safe flight and safe landing capability. The flight time allowance listed in the RFM should be based on the OEM's determination of what is appropriate, using guidance from the available test data, but it should be no greater than what is substantiated per the acceptable means of compliance (AMC) prescribed below. Accordingly, it is necessary to demonstrate reasonable confidence in the ability of the gearbox to continue operation enabling safe flight and safe landing after experiencing a loss of oil or a lubrication failure. (f)(1) to (f)(4) below describe acceptable means of compliance (AMC) to demonstrate this level of confidence, for a specified period at given operating conditions. This AMC explains how the test duration, the number of tests, the condition of the gearbox components upon completion of the tests, and the behaviour of the gearbox during these tests may be combined to establish a positive safety margin when determining the *maximum period of operation following loss of lubrication*.

(1) Certification test duration

The duration of the loss of lubrication certification test, as defined in (e) above, should be used as the starting point for the determination of the *maximum period of operation following loss of lubrication* and should be reduced as described in the following paragraphs as appropriate. The start of the test is considered to be the time at which the lubrication failure is indicated to the pilot.

(2) Reduction factor

In order to substantiate the *maximum period of operation following loss of lubrication*, a suitable reduction factor should be applied to correlate the test duration with the *maximum period of operation following loss of lubrication*. Suitable reduction factors should be used as follows:

(i) 0.6 where the certification test has no supporting data to provide understanding of the gearbox behaviour and confidence in the repeatability of the certification test data.

(ii) 0.8 where the certification test is corroborated by one representative full-scale test (certification or development test). The corroborating test results should show consistency of the temperature history, and demonstrate good correlation with the certification test.

(iii) 0.9 where the certification test is corroborated by two or more representative full-scale tests (certification or development tests) or by one representative full scale and one or more modular tests, historical data, or simulation results. The corroborating data should show consistency of the temperature history, and demonstrate good correlation with the certification test. In addition the behaviour of the limiting design characteristics is established and supported by repeatable test data.

Note: Specific testing, simulation or representative development test data from other programmes are examples of data that can be used to support the application of this Kr factor.

(iv) When two or more tests are submitted to show compliance with this provision, the test of shortest duration will be considered to be the certification test and should be used as the basis for demonstrating the *maximum period of operation following loss of lubrication*. If excessive variation is experienced between tests, it should be investigated and explained.

(v) The intent of using data from multiple tests is that the parts replaced between tests are those that potentially limit the performance of the gearbox when operating under *residual oil* or oil supplied from an *auxiliary lubrication system*. Where particular design characteristics are known to be critical to *residual oil* performance, parts should be selected at the most severe end of the tolerance range of the dimensions/specifications impacting these characteristics. Additionally, the objective of multiple tests is to evaluate the consistency between tests (using different gearbox components). When using multiple (full scale or modular) test results to corroborate the certification test duration and, thus, support the determination of the maximum period of operation following loss of lubrication, the criteria for the reconciliation between the corroborating test data and an official certification test should include:

a. the test conditions, i.e. loads, entry point and test profile, should be duplicated on the development test as for the official test, and any deviations should be substantiated;

b. the representativeness of parts should be demonstrated and documented;

c. the test equipment and instrumentation should be qualified and calibrated;

d. the correlation between development and official test should be demonstrated by absolute temperatures and temperature rates of change; and

e. in addition for modular tests, the lubrication conditions should be conservatively simulated to avoid that the isolated module benefits from secondary lubrication from the boundaries of the module, which may not be representative of the module conditions in a full test.

(vi) When determining the appropriate reduction factor, consideration should be given to any factors that may reflect the health or stability of gearbox components during the test(s). These factors are addressed below and include: temperature history, maximum temperatures achieved with respect to physical limitations of the material, simulation results, and the time difference between the demonstrated duration up to a test failure and the duration of the certification test.

a. Temperature rate of change during test. Gearboxes operating after loss of lubrication sometimes exhibit portions of the test where the thermal response is either stable (approaching to zero rate of change) or meta-stable (with a ‘small’ rate of change). It is considered that confidence in the behaviour of the gearbox may be greater for a maximum absolute temperature measured under these conditions in the context of the certification test or an official test. Portions of the test that exhibit a larger temperature rate of change should be investigated and substantiated.

b. Maximum temperature reached during test. Similarly to the rate of temperature change, general experience from 'total loss of lubrication' tests performed has shown that successful tests do not exceed certain values of temperature measured at critical locations of the gearbox. The applicant should record temperature measurements from critical points of the gearbox or at related locations in order to compare with previous experience. This data should be used to validate analysis models and to support the application of a high Kr value when determining the maximum period of operation following loss of lubrication.

c. Models/simulations. Numerical simulation of loss of lubrication conditions is not considered sufficient to demonstrate confidence in absolute temperature values achieved during the certification test, when applied to the prediction of the *maximum period of operation following loss of lubrication*. However, it may be possible to apply numerical simulation (0-3 dimensional) to extrapolate test results to other boundary or entry conditions.

d. Extended operation. The applicant is encouraged to perform tests in order to evaluate the time difference between the point at which the certification test was concluded and the likely time of gearbox failure (if the certification test had continued). Of equal importance is the identification of the gearbox design features which are most likely to initiate gearbox failure in the event of extended operation after loss of lubrication.

Note: if, at the completion of the certification test landing simulation phase, the gearbox continues to transmit the necessary torque, it is acceptable to consider that the classification of component condition is Class 3 and can thus be considered a valid certification test result. Further component degradation resulting from continued running of the same test will not invalidate this result with respect to compliance with this requirement. Should an extended test be completed with a successful second landing simulation, the total duration can be considered applicable to the certification test result.

(3) Fixed time penalty.

Based on the condition of components necessary for continued safe flight or landing at the end of the certification test a fixed time penalty should be applied in accordance with the definitions below. This fixed time penalty should be 2 minutes for CLASS 1 ('Good' condition), 5 minutes for CLASS 2 ('Fair' condition), and 10 minutes for CLASS 3 ('Imminent failure' condition) with the CLASS defined based upon the following criteria.

CLASS 0 — Intact/serviceable

Parts in new condition. It is impractical to expect components to be in this condition after the test, but this classification is stated for reference only.

CLASS 1 — Good

- Parts are still well oil-wetted with little or no discolouration (light yellow to light/local blue).
- Local moderate scuffing of gear teeth and/or local moderate scorings on bearing-active surfaces is present.
- Hardened surfaces (gear teeth and bearing-active surfaces) may show slight/local reduction in hardness (maximum 2 points on the Rockwell C Hardness (HRC) scale).
- Normally, operation in these conditions should not significantly alter the vibration and noise signatures of the gearbox during test.
- Gearbox still transmits the required torque and rotates smoothly.

CLASS 2 — Fair

- Parts are almost completely dry, little *residual oil* in localised areas.
- Dark blue to brown discolouration is present, showing signs of uniform wear.
- Coatings such as silver plating are still visible but may be worn out locally or discoloured.
- Heavy localised scuffing on gear teeth as well wear on active surfaces of gear teeth are visible.
- Surface hardness may have been reduced more significantly (up to a maximum of 4 points on the HRC scale).
- Normally, operation in these conditions could cause moderate changes to the vibration and noise signatures of the gearbox during test.
- Gearbox still transmits the required torque.

CLASS 3 — Imminent failure

- Parts show evidence of plastic deformation or melting in local areas due to high temperatures.
- Macroscopic wear of some of the rolling elements of bearings and gear teeth, with appreciable alteration of dimensions and associated increases in clearances and play.
- Bearing cages are worn or with incipient breakage.
- Normally, operation in these conditions causes significant and audible changes to the vibration and noise signatures of the gearbox during test.
- The gearbox still transmits the required torque and is still capable of rotating immediately after test (after it has cooled down, it may be more difficult to rotate).

CLASS 4 — Failed

In this case, there is a complete and gross plastic deformation of parts, and bearing balls and rollers are melted. Parts in this conditions mean that the test specimen has failed, hence, this classification is also provided for reference only.

(4) Calculation of the maximum period of operation following loss of lubrication

Application of the factors described in (2) and (3) above can be represented by the following formula:

Td = (Kr x Tc) – Tp

where:

— Td is the Maximum Period of Operation Following Loss of Lubrication, for which confidence has been established and which is to be used as the basis for the period stated in the RFM emergency procedures. This period should not exceed Td;

— Kr is the confidence/reliability reduction factor defined in (2) above;

— Tc is the duration of the certification test (from low-pressure indication to end of test); and

— Tp is a fixed-time penalty to account for condition at the end of the test, as defined in (3) above.

(5) Secondary indication

Another possible means to increase confidence in the ability of the gearbox to continue to operate safely after suffering a loss of lubrication is to provide a secondary indication, which may indicate when the most critical mode of degradation has progressed to a level where gearbox functional failure may be imminent. If such a design feature is selected, the following considerations are necessary:

(i) evidence should be available, preferably from multiple tests, to provide confidence that the failure mode being monitored is always the most critical failure mode after a loss of lubrication, and that the rate of degradation up to the point of failure is understood;

(ii) if the oil pressure is normal, inhibition of the warning to the flight crew may be considered in order to reduce the likelihood of a false warning resulting in an instruction to 'land immediately'; and

(iii) the availability/reliability of the warning should be justified; it should be possible to test the correct functioning of the sensor or warning during pre-flight/start-up checks or during routine maintenance.

(iv) noise and/or vibration detected by the crew should not be considered to be reliable secondary indications on their own.

Create a new AMC 29.1411 as follows:

AMC 29.1411 Safety equipment — General

This AMC replaces FAA AC 29.1411.

(a) Explanation

CS-29 Amendment 5 introduced changes related to ditching and associated equipment. In particular, it defined a standard set of terminology, it simplified CS 29.1411 in line with it being a general certification specification for safety equipment, reorganised CS 29.1415 specifically for ditching equipment, and created a new CS 29.1470 on the installation and carriage of emergency locator transmitters (ELTs). All requirements relating to life raft installations are now co-located in CS 29.1415.

(1) The safety equipment should be accessible and appropriately stowed, and it should be ensured that:

(i) locations for stowage of all required safety equipment have been provided;

(ii) safety equipment is readily accessible to both crew members and passengers, as appropriate, during any reasonably probable emergency situation;

(iii) stowage locations for all required safety equipment will adequately protect such equipment from inadvertent damage during normal operations; and

(iv) safety equipment stowage provisions will protect the equipment from damage during emergency landings when subjected to the inertia loads specified in CS 29.561.

(b) Procedures

(1) A cockpit evaluation should be conducted to demonstrate that all required emergency equipment to be used by the flight crew will be readily accessible during any foreseeable emergency situation. This evaluation should include, for example, emergency flotation equipment actuation devices, remote life raft releases, door jettison handles, handheld fire extinguishers, and protective breathing equipment.

(2) Stowage provisions for safety equipment shown to be compatible with the vehicle configuration presented for certification should be provided and identified so that:

(i) equipment is readily accessible regardless of the operational configuration;

(ii) stowed equipment is free from inadvertent damage from passengers and handling; and

(iii) stowed equipment is adequately restrained to withstand the inertia forces specified in CS 29.561(b)(3) without sustaining damage.

(3) For rotorcraft required to have an emergency descent slide or rope according to CS 29.809(f), the stowage provisions for these devices should be located at the exits where those devices are intended to be used.

Create a new AMC 29.1415 as follows:

AMC 29.1415 Ditching equipment

This AMC replaces FAA AC 29.1415.

(a) Explanation

(1) Additional safety equipment is not required for all rotorcraft overwater operations. However, if such equipment is required by the applicable operating rule, the equipment supplied should satisfy this AMC.

NOTE: Although the term ‘ditching’ is most commonly associated with the design standards related to CS 29.801 (ditching approval), a rotorcraft equipped to the less demanding requirements of CS 29.802 (emergency flotation approval), when performing an emergency landing on to water, would nevertheless be commonly described as carrying out the process of ditching. The term ‘ditching equipment’ is therefore to be considered to apply to any safety equipment required by operational rule for operation over water.

It is a frequent practice for the rotorcraft manufacturer to provide the substantiation for only those portions of the ditching requirements relating to rotorcraft flotation and emergency exits. Completion of the ditching certification to include the safety equipment installation and stowage provisions is then left to the affected operator so that those aspects can best be adapted to the selected cabin interior. In such cases, the ‘Limitations’ section of the rotorcraft flight manual (RFM) should identify the substantiations yet to be provided in order to justify the full certification with ditching provisions. The modifier performing these final installations is then concerned directly with the details of this AMC. Any issues arising from aspects of the basic rotorcraft flotation and emergency exits certification that are not compatible with the modifier’s proposed safety equipment provisions should be resolved between the type certificate (TC) holder and the modifier prior to the certifying authority’s certification with ditching provisions (see AMC 29.801(b)(16) and AMC 29.1415(a)(3)).

(2) Compliance with the requirements of CS 29.801 for rotorcraft ditching requires compliance with the safety equipment stowage requirements and ditching equipment requirements of CS 29.1411 and CS 29.1415, respectively.

(i) Ditching equipment installed to complete ditching certification, or required by the applicable operating rule, should be compatible with the basic rotorcraft configuration presented for ditching certification. It is satisfactory if the ditching equipment is not incorporated at the time of the original rotorcraft type certification provided that suitable information is included in the 'Limitations' section of the rotorcraft flight manual (RFM) to identify the extent of ditching certification not yet completed.

(ii) When ditching equipment is being installed by a person other than the applicant who provided the rotorcraft flotation system and emergency exits, special care should be taken to avoid degrading the functioning of those items, and to make the ditching equipment compatible with them (see AMC 29.801(a)(10) and AMC 29.1411(a)(2)).

(b) Procedures

All ditching equipment, including life rafts, life preservers, immersion suits, emergency breathing systems etc., should be of an approved type. Life rafts should be chosen to be suitable for use in all sea conditions covered by the certification with ditching provisions.

(1) Life rafts

(i) Life rafts are rated during their certification according to the number of people that can be carried under normal conditions and the number that can be accommodated in an overload condition. Only the normal rating may be used in relation to the number of occupants permitted to fly in the rotorcraft.

(ii) The life rafts should deploy on opposite sides of the rotorcraft in order to minimise the probability that all may be damaged during water entry/impact, and to provide the maximum likelihood that at least half of those provided will be useable in any wind condition.

(iii) Successful deployment of life raft installations should be demonstrated in all representative conditions. Testing should be performed, including underwater deployment, if applicable, to demonstrate that life rafts sufficient to accommodate all rotorcraft occupants, without exceeding the rated capacity of any life raft, will deploy reliably with the rotorcraft in any reasonably foreseeable floating attitude, including capsized. It should also be substantiated that reliable deployment will not be compromised by inertial effects from the rolling/pitching/heaving of the rotorcraft in the sea conditions chosen for the demonstration of compliance with the flotation/trim requirements of CS 29.801(e), or by intermittent submerging of the stowed raft location (if applicable) and the effects of wind. This substantiation should also consider all reasonably foreseeable rotorcraft floating attitudes, including capsized. Reasonably foreseeable floating attitudes are considered to be, as a minimum, upright, with and without loss of the critical emergency flotation system (EFS) compartment, and capsized, also with and without loss of the critical EFS compartment. Consideration should also be given towards maximising, where practicable, the likelihood of life raft deployment for other cases of EFS damage.

(iv) Rotorcraft fuselage attachments for the life raft retaining lines should be provided.

(A) Each life raft should be equipped with two retaining lines to be used for securing the life raft to the rotorcraft. The short retaining line should be of such a length as to hold the raft at a point next to an upright floating rotorcraft such that the occupants can enter the life raft directly without entering the water. If the design of the rotorcraft is such that the flight crew cannot enter the passenger cabin, it is acceptable that they would need to take a more indirect route when boarding the life raft. After life raft boarding is completed, the short retaining line may be cut and the life raft then remain attached to the rotorcraft by means of the long retaining line.

(B) Attachments on the rotorcraft for the retaining lines should not be susceptible to damage when the rotorcraft is subjected to the maximum water entry loads established by CS 29.563.

(C) Attachments on the rotorcraft for the retaining lines should be structurally adequate to restrain a fully loaded life raft.

(D) Life rafts should be attached to the rotorcraft by the required retaining lines after deployment without further action from the crew or passengers.

(E) It should be verified that the length of the long retaining line will not result in the life raft taking up a position which could create a potential puncture risk or hazard to the occupants, such as directly under the tail boom, tail rotor or main rotor disc.

(v) Life raft stowage provisions should be sufficient to accommodate rafts for the maximum number of occupants for which certification for ditching is requested by the applicant.

(vi) Life raft activation

The following should be provided for each life raft:

(A) primary activation: manual activation control(s), readily accessible to each pilot on the flight deck whilst seated;

(B) secondary activation: activation control(s) accessible from the passenger cabin with the rotorcraft in the upright or capsized position; if any control is located within the cabin, it should be protected from inadvertent operation; and

(C) tertiary activation: activation control(s) accessible to a person in the water, with the rotorcraft in any foreseeable floating attitude, including capsized.

It is acceptable for two of these manual activation functions to be incorporated into one control.

Automatic life raft activation is not prohibited (e.g. it could be triggered by water immersion). However, such a capability should be provided in addition to the above manual activation controls, not instead of them, and issues such as inadvertent deployment in flight and the potential for damage from turning rotors during deployment on the water should be mitigated.

Placards should be installed, of appropriate size, number and location, to highlight the location of each of the above life raft activation controls. All reasonably foreseeable rotorcraft floating attitudes should be considered.

(vii) Protection of life rafts from damage

Service experience has shown that following deployment, life rafts are susceptible to damage while in the water adjacent to the rotorcraft due to projections on the exterior of the rotorcraft such as antennas, overboard vents, unprotected split pin tails, guttering, etc. and any projections sharper than a three dimensional right angled corner. Projections likely to cause damage to a deployed life raft should be avoided by design, or suitably protected to minimise the likelihood of their causing damage to a deployed life raft. In general, projections on the exterior surface of the helicopter, that are located in a zone delineated by boundaries that are 1.22 m (4 ft) above and 0.61 m (2 ft) below the established static water line should be assessed. Relevant maintenance information should also provide procedures for maintaining such protection for rotorcraft equipped with life rafts. Furthermore, due account should be taken of the likely damage that may occur (e.g. disintegration of carbon-fibre panels or structure) during water entry and its potential hazard to deployed life rafts.

(2) Life preservers.

No provision for the stowage of life preservers is necessary if the applicable operating rule mandates the need for constant-wear life preservers.

(3) Emergency signalling equipment

Emergency signalling equipment required by the applicable operating rule should be free from hazards in its operation, and operable using either bare or gloved hands. Required signalling equipment should be easily accessible to the passengers or crew and located near a ditching emergency exit or included in the survival equipment attached to the life rafts.

Create a new AMC 29.1470 as follows:

AMC 29.1470 Emergency locator transmitters (ELTs)

(a) Explanation

The purpose of this AMC is to provide specific guidance for compliance with CS 29.1301, CS 29.1309, CS 29.1470, CS 29.1529 and CS 29.1581 regarding emergency locator transmitters (ELT) and their installation.

An ELT is considered to be a passive and dormant device whose status is unknown until it is required to perform its intended function. As such, its performance is highly dependent on proper installation and post-installation testing.

(b) References

Further guidance on this subject can be found in the following references:

(1) ETSO-C126b 406 and 121.5 MHZ Emergency Locator Transmitter;

(2) ETSO-C126b 406 MHz Emergency Locator Transmitter;

(3) FAA TSO-C126b 406 MHz Emergency Locator Transmitter (ELT);

(4) EUROCAE ED-62A MOPS for aircraft emergency locator transmitters (406 MHz and 121.5 MHz (optional 243 MHz));

(5) RTCA DO-182 Emergency Locator Transmitter (ELT) Equipment Installation and Performance; and

(6) RTCA DO-204A Minimum Operational Performance Standards for 406 MHz Emergency Locator Transmitters (ELTs).

(c) Definitions

(1) ELT (AF): an ELT (automatic fixed) is intended to be permanently attached to the rotorcraft before and after a crash, is automatically activated by the shock of the crash, and is designed to aid search and rescue (SAR) teams in locating a crash site.

(2) ELT (AP): an ELT (automatic portable) is intended to be rigidly attached to the rotorcraft before a crash and is automatically activated by the shock of the crash, but is readily removable from the rotorcraft after a crash. It functions as an ELT (AF) during the crash sequence. If the ELT does not employ an integral antenna, the rotorcraft-mounted antenna may be disconnected and an auxiliary antenna (stowed in the ELT case) connected in its place. The ELT can be tethered to a survivor or a life raft. This type of ELT is intended to assist SAR teams in locating the crash site or survivor(s).

(3) ELT (S): an ELT (survival) should survive the crash forces, be capable of transmitting a signal, and have an aural or visual indication (or both) that power is on. Activation of an ELT (S) usually occurs by manual means but automatic activation (e.g. activation by water) may also apply.

(i) ELT (S) Class A (buoyant): this type of ELT is intended to be removed from the rotorcraft, deployed and activated by survivors of a crash. It can be tethered to a life raft or a survivor. The equipment should be buoyant and it should be designed to operate when floating in fresh or salt water, and should be self-righting to establish the antenna in its nominal position in calm conditions.

(ii) ELT (S) Class B (non-buoyant): this type of ELT should be integral to a buoyant device in the rotorcraft, deployed and activated by the survivors of a crash.

(4) ELT (AD) or automatically deployable emergency locator transmitter (ADELT): this type of automatically deployable ELT is intended to be rigidly attached to the rotorcraft before a crash and automatically deployed after the crash sensor determines that a crash has occurred or after activation by a hydrostatic sensor. This type of ELT should float in water and is intended to aid SAR teams in locating the crash site.

(5) A crash acceleration sensor (CAS) is a device that detects an acceleration and initiates the transmission of emergency signals when the acceleration exceeds a predefined threshold (Gth). It is also often referred to as a ‘g switch’.

(d) Procedures

(1) Installation aspects of ELTs

The installation of the equipment should be designed in accordance with the ELT manufacturer’s instructions.

(i) Installation of the ELT transmitter unit and crash acceleration sensors

The location of the ELT should be chosen to minimise the potential for inadvertent activation or damage by impact, fire, or contact with passengers, baggage or cargo.

The ELT transmitter unit should ideally be mounted on primary rotorcraft load-carrying structures such as trusses, bulkheads, longerons, spars, or floor beams (not rotorcraft skin). Alternatively, the structure should meet the requirements of the test specified in 6.1.8 of ED-62A. For convenience, the requirements of this test are reproduced here, as follows:

‘The mounts shall have a maximum static local deflection no greater than 2.5 mm when a force of 450 Newtons (100 lbf) is applied to the mount in the most flexible direction. Deflection measurements shall be made with reference to another part of the airframe not less than 0.3 m or more than 1.0 m from the mounting location.’

However, this does not apply to an ELT (S), which should be installed or stowed in a location that is conspicuously marked and readily accessible, or should be integral to a buoyant device such as a life raft, depending on whether it is of Class A or B.

A poorly designed crash acceleration sensor installation can be a source of problems such as nuisance triggers, failures to trigger and failures to deploy.

Nuisance triggers can occur when the crash acceleration sensor does not work as expected or is installed in a way that exposes it to shocks or vibration levels outside those assumed during equipment qualification. This can also occur as a result of improper handling and installation practices.

A failure to trigger can occur when an operational ELT is installed such that the crash sensor is prevented from sensing the relevant crash accelerations.

Particular attention should be paid to the installation orientation of the crash acceleration sensor. If the equipment contains a crash sensor with particular installation orientation needs, the part of the equipment containing the crash sensor will be clearly marked by the ELT manufacturer to indicate the correct installation orientation(s).

The design of the installation should follow the instructions contained in the installation manual provided by the equipment manufacturer. In the absence of an installation manual, in general, in the case of a helicopter installation, if the equipment has been designed to be installed on fixed-wing aircraft, it may nevertheless be acceptable for a rotorcraft application. In such cases, guidance should be sought from the equipment manufacturer. This has typically resulted in a recommendation to install the ELT with a different orientation, e.g. of 45 degrees with respect to the main longitudinal axis (versus zero degrees for a fixed wing application). This may help the sensor to detect forces in directions other than the main longitudinal axis, since, during a helicopter crash, the direction of the impact may differ appreciably from the main aircraft axis. However, some ELTs are designed specifically for helicopters or designed to sense forces in several axes.

(ii) Use of hook and loop style fasteners

In several recent aircraft accidents, ELTs mounted with hook and loop style fasteners, commonly known by the brand name Velcro®, have detached from their aircraft mountings. The separation of the ELT from its mount could cause the antenna connection to be severed, rendering the ELT ineffective.

Inconsistent installation and reinstallation practices can lead to the hook and loop style fastener not having the necessary strength to perform its intended function. Furthermore, the retention capability of the hook and loop style fastener may degrade over time, due to wear and environmental factors such as vibration, temperature, or contamination. The safety concern about these attachments increases when the ELT manufacturer's instructions for continued airworthiness (ICA) do not contain specific instructions for regularly inspecting the hook and loop style fasteners, or a replacement interval (e.g. Velcro life limit). This concern applies, regardless of how the hook and loop style fastener is installed in the aircraft.

Separation of ELTs has occurred, even though the associated hook and loop style fastener design was tested during initial European Technical Standard Order (ETSO) compliance verification against crash shock requirements.

Therefore, it is recommended that when designing an ELT installation, the ELT manufacturer's ICA is reviewed and it is ensured that the ICA for the rotorcraft (or the modification, as applicable) appropriately addresses the in-service handling of hook and loop style fasteners.

It is to be noted that ETSO/TSO-C126b states that the use of hook and loop fasteners is not an acceptable means of attachment for automatic fixed (AF) and automatic portable (AP) ELTs.

(iii) ELT antenna installation

This section does not apply to the ELT (S) or ELT (AD) types of ELT.

The most recurrent issue found during accident investigations concerning ELTs is the detachment of the antenna (coaxial cable), causing the transmission of the ELT unit to be completely ineffective.

Chapter 6 of ED-62A addresses the installation of an external antenna and provides guidance, in particular, on:

(A) the location of the antenna;

(B) the position of the antenna relative to the ELT transmission unit;

(C) the characteristics of coaxial-cables; and

(D) the installation of coaxial-cables.

Any ELT antenna should be located away from other antennas to avoid disruption of the antenna radiation patterns. In any case, during installation of the antenna, it should be ensured that the antenna has a free line of sight to the orbiting COSPAS-SARSAT satellites at most times when the aircraft is in the normal flight attitude.

Ideally, for the 121.5 MHz ELT antenna, a separation of 2.5 metres from antennas receiving very high frequency (VHF) communications and navigation data is sufficient to minimise unwanted interference. The 406 MHz ELT antenna should be positioned at least 0.8 metres from antennas receiving VHF communications and navigation data to minimise interference.

External antennas which have been shown to be compatible with a particular ELT will either be part of the ETSO/TSO-approved ELT or will be identified in the ELT manufacturer's installation instructions. Recommended methods for installing antennas are outlined in FAA AC 43.13-2B.

The antenna should be mounted as close to the respective ELT as practicable. Provision should be taken to protect coaxial cables from disconnection or from being cut. Therefore, installation of the external antenna close to the ELT unit is recommended. Coaxial cables connecting the antenna to the ELT unit should not cross rotorcraft production breaks.

In the case of an external antenna installation, ED-62A recommends that its mounting surface should be able to withstand a static load equal to 100 times the antenna's weight applied at the antenna mounting base along the longitudinal axis of the rotorcraft. This strength can be substantiated by either test or conservative analysis.

If the antenna is installed within a fin cap, the fin cap should be made of an RF-transparent material that will not severely attenuate the radiated transmission or adversely affect the antenna radiation pattern shape.

In the case of an internal antenna location, the antenna should be installed as close to the ELT unit as practicable, insulated from metal window casings and restrained from movement within the cabin area. The antenna should be located such that its vertical extension is exposed to an RF-transparent window. The antenna's proximity to the vertical sides of the window and to the window pane and casing as well as the minimum acceptable window dimensions should be in accordance with the equipment manufacturer's instructions.

The voltage standing wave ratio (VSWR) of the installed external antenna should be checked at all working frequencies, according to the test equipment manufacturer's recommendations, during the first certification exercise for installation on a particular rotorcraft type.

Coaxial cables between the antenna and the ELT unit should be provided on each end with an RF connector that is suitable for the vibration environment of the particular installation application. When the coaxial cable is installed and the connectors mated, each end should have some slack in the cable, and the cable should be secured to rotorcraft structures for support and protection.

In order to withstand exposure to fire or flames, the use of fire-resistant coaxial cables or the use of fire sleeves compliant to SAE AS1072 is recommended.

(2) Deployment aspects of ELTs

Automatically deployable emergency locator transmitters (ADELTs) have particularities in their designs and installations that need to be addressed independently of the general recommendations.

The location of an ADELT and its manner of installation should minimise the risk of injury to persons or damage to the rotorcraft in the event of its inadvertent deployment. The means to manually deploy the ADELT should be located in the cockpit, and be guarded, such that the risk of inadvertent manual deployment is minimised.

Automatically deployable ELTs should be located so as to minimise any damage to the structure and surfaces of the rotorcraft during their deployment. The deployment trajectory of the ELT should be demonstrated to be clear of interference from the airframe or any other parts of the rotorcraft, or from the rotor in the case of helicopters. The installation should not compromise the operation of emergency exits or of any other safety features.

In some helicopters, where an ADELT is installed aft of the transport joint in the tail boom, any disruption of the tail rotor drive shaft has the potential to disrupt or disconnect the ADELT wiring. From accident investigations, it can be seen that if a tail boom becomes detached, an ADELT that is installed there, aft of the transport joint, will also become detached before signals from sensors that trigger its deployment can be received.

Therefore, it is recommended to install the ADELT forward of the transport joint of the tail boom. Alternatively, it should be assured that ELT system operation will not be impacted by the detachment of the structural part on which it is installed.

The hydrostatic sensor used for automatic deployment should be installed in a location shown to be immersed in water within a short time following a ditching or water impact, but not subject to water exposure in the expected rotorcraft operations. This assessment should include the most probable rotorcraft attitude when crashed, i.e. its capability to keep an upright position after a ditching or a crash into water.

The installation supporting the deployment feature should be demonstrated to be robust to immersion. Assuming a crash over water or a ditching, water may immerse not only the beacon and the hydrostatic sensor, which is designed for this, but also any electronic component, wires and the source of power used for the deployment.

(3) Additional considerations

(i) Human factors (HF)

The ELT controls should be designed and installed so that they are not activated unintentionally. These considerations should address the control panel locations, which should be clear from normal flight crew movements when getting into and out of the cockpit and when operating the rotorcraft, and the control itself. The means for manually activating the ELT should be guarded in order to avoid unintentional activation.

(ii) The rotorcraft flight manual (RFM) should document the operation of the ELT, and in particular, any feature specific to the installed model.

(iii) Batteries

An ELT operates using its own power source. The ELT manufacturer indicates the useful life and expiration date of the batteries by means of a dedicated label. The installation of the ELT should be such that the label indicating the battery expiration date is clearly visible without requiring the removal of the ELT or other LRU from the rotorcraft.

(4) Maintenance and inspection aspects

This Chapter provides guidance for the applicant to produce ICA related to ELT systems. The guidance is based on Chapter 7 of ED-62A.

(i) The ICA should explicitly mention that:

(A) The self-test function should be performed according to the manufacturer’s recommendation but no less than once every 6 months. Regulation at the place of operation should be considered when performing self-tests, as national aviation authorities (NAAs) may have established specific procedures to perform self-tests.

(B) As a minimum, a periodic inspection should occur at every battery replacement unless an inspection is required more frequently by the airworthiness authorities or the manufacturer.

(ii) Each inspection should include:

(A) the removal of all interconnections to the ELT antenna, and inspection of the cables and terminals;

(B) the removal of the ELT unit, and inspection of the mounting;

(C) access to the battery to check that there is no corrosion;

(D) a check of all the sensors as recommended by Chapter 7.6 of ED-62A — Periodic inspection; and

(E) measurement of the transmission frequencies and the power output.

(5) Rotorcraft flight manual/flight manual supplement (RFM/RFMS)

The rotorcraft flight manual (RFM) or supplement (RFMS), as appropriate, should contain all the pertinent information related to the operation of the ELT, including the use of the remote control panel in the cockpit. If there are any limitations on its use, these should be declared in the ‘Limitations’ section.

Detailed instructions for pre-flight and post-flight checks should be provided. As a pre-flight check, the ELT remote control should be checked to ensure that it is in the armed position. Post-flight, the ELT should be checked to ensure that it does not transmit, by activating the indicator on the remote control or monitoring 121.5 MHz.

Information on the location and deactivation of ELTs should also be provided. Indeed, accident investigations have shown that following aircraft ground impact, the remote control switch on the instrument panel may become inoperative, and extensive fuselage disruption may render the localisation of, and the access to, the ELT unit difficult. As a consequence, in the absence of information available to the accident investigators and first responders, this has led to situations where the ELT transmitted for a long time before being shut down, thus blocking the SAR channel for an extended time period. It is therefore recommended that information explaining how to disarm or shut down the ELT after an accident, including when the remote control switch is inoperative, should be included.

Create a new AMC 29.1555 as follows:

AMC 29.1555 Control markings

This AMC supplements FAA AC 29.1555.

(a) Explanation

CS-29 Amendment 5 introduced the need to mark emergency controls for use following a ditching or water impact with black and yellow stripes, instead of red, to make them more conspicuous when viewed underwater.

(b) Procedures

(1) Any emergency control that may be required to be operated underwater (e.g. an emergency flotation system deployment switch, a life raft deployment switch or handle) should be coloured with black and yellow stripes.

(2) Black and yellow markings should consist of at least two bands of each colour of approximately equal widths.

Create a new AMC 29.1561 as follows:

AMC 29.1561 Safety Equipment

This AMC supplements FAA AC 29.1561.

(a) Explanation

CS 29.1561 requires each safety equipment control that can be operated by a crew member or passenger to be plainly marked to identify its function and method of operation. (Note that the marking of safety equipment controls located within the cockpit and intended for use by the flight crew is addressed in CS 29.1555.)

In addition, a location marking for each item of stowed safety equipment should be provided that identifies the contents and how to remove them. All safety equipment, including ditching and survival equipment, should be clearly identifiable and provided with operating instructions. Markings and placards should be conspicuous and durable as per CS 29.1541. Both passengers and crew should be able to easily identify and then use the safety equipment.

(b) Procedures

(1) Release devices such as levers or latch handles for life rafts and other safety equipment should be plainly marked to identify their function and method of operation. Stencils, permanent decals, placards, or other permanent labels or instructions may be used.

(2) Lockers, compartments, or pouches used to contain safety equipment such as life preservers, etc., should be marked to identify the equipment therein and to also identify, if not obvious, the method or means of accessing or releasing the equipment.

(3) Safety equipment should be labelled and provided with operating-instructions for its use or operation.

(4) Locating signs for safety equipment should be legible in daylight from the furthest seated point in the cabin or recognisable from a distance equal to the width of the cabin. Letters, 2.5 cm (1 in) high, should be acceptable to satisfy the recommendation. Operating instructions should be legible from a distance of 76 cm (30 in). These recommendations are based on the exit requirements of CS 29.811(b) and (e)(1).

(5) As prescribed, each life raft and its installed equipment should be provided with clear operating instruction markings that cannot be easily erased or disfigured and are readable at low levels of illumination.

(6) Easily recognised or identified and easily accessible safety equipment located in sight of the occupants, such as a passenger compartment fire extinguisher that all passengers can see, may not require locating signs, stencils, or decals. However, operating instructions are required.

Create a new AMC 29.1585 as follows:

AMC 29.1585 Operating Procedures

CS 29.927(c) provides guidance for the completion of testing to simulate a loss of lubrication and on how to demonstrate confidence in the margin of safety associated with the *maximum period of operation following loss of lubrication*. This margin of safety is intended to substantiate a period of operation that has been evaluated as likely to be safer than making a forced landing over hostile terrain. Accordingly, the need to 'Land as Soon as Possible', which may include ditching where circumstances permit, should be reflected in the associated RFM emergency procedures. This can be supplemented with 'Land Immediately' in the event of additional conditions to that of low oil pressure being present.

Emergency procedures should identify the need to minimise the power that is used for yaw and accessories following a loss of oil pressure warning.

Create a new AMC 29.1587(c) as follows:

AMC 29.1587(c) Performance Information

This AMC supplements FAA AC 29.1587, AC 29.1587A and AC 29.1587B.

a. Explanation

The rotorcraft flight manual (RFM) is an important element in the certification process of the rotorcraft for approval with ditching or emergency flotation provisions. The material may be presented in the form of a supplement or a revision to the basic manual. This material should include:

(1) A statement in the 'Limitations' section stating that the rotorcraft is approved for ditching or emergency flotation, as appropriate.

If certification with ditching provisions is obtained in a segmented fashion (i.e. one applicant performing the safety equipment installation and operations portion and another designing and substantiating the safety equipment's performance and deployment facilities), the RFM limitations should state that the ditching provisions are not approved until all the segments are completed. The outstanding ditching provisions for a complete certification should be identified in the 'Limitations' section.

(2) Procedures and limitations for the inflation of a flotation device.

(3) A statement in the performance information section of the RFM, identifying the substantiated sea conditions and any other pertinent information. If substantiation was performed using the default North Sea wave climate (JONSWAP), the maximum substantiated significant wave height (H_s)–should be stated. If extended testing was performed in accordance with the AMC to 29.801(e) and 29.802(c) to demonstrate that the target level of capsize probability can be reached without any operational limitations, this should also be stated. If substantiation was performed for other sea conditions, the maximum substantiated significant wave height (H_s) and the limits of the geographical area represented should be stated.

(4) Recommended rotorcraft water entry attitude and speed.

(5) Procedures for the use of safety equipment.

(6) Egress and life raft entry procedures.