Ministry of Defence

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Design and Airworthiness Requirements for Service Aircraft

Part 7: Rotorcraft

Supplement 6: Equipment (Subpart F)

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	LEAFLET 707				
	RADIO AND RADAR INSTALLATIONS				
1	**INTRODUCTION**				
	The requirements of this Leaflet apply unless specified otherwise, to all radio and radar installations forming part of the operational equipment of a rotorcraft.				
			A RADIO INSTALLATION comprises all those items of equipment necessary to communicate or receive information (e.g., speech, navigational data etc)., via the medium of electromagnetically radiated waves to/from a similar system with which it has no direct physical contact. A RADAR INSTALLATION comprises all those items of equipment necessary to radiate electromagnetic waves, and then to utilise the reflected, or automatically re-transmitted waves, to gain information concerning distant objects (e.g., range and relative position, topographical features,		

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			meteorological conditions etc).		
1.4	Installations shall be so planned that when utilising the appropriate rotorcraft power supplies and (even when subjected to the most severe rotorcraft environmental conditions envisaged), they will achieve optimum specified performance when used alone or when integrated into a larger system of installations.				
1.5	Installations shall have a proof factor of not less than 1.0 and an ultimate factor of not less than 1.33 on the loads arising in all conditions of flight specified for the rotorcraft as a whole.		(For the crash case see Leaflet 307).		
2	**AERIAL DESIGN**				
2.1	Aerials shall be designed having due regard to:				
2.1.1	Electrical Performance.	(i) Signal polarisation. (ii) Optimised radiation efficiency.			

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		(iii) The required radiation pattern coverage. (iv) Optimum energy transfer (i.e. , electrical matching) to associated rf feeders and equipment assemblies. (v) The effect on the above features, of any fitment required to affix the item to the airframe. (vi) The effect, on the electrical performance, of any additional protective dielectric cover or housing. (vii) Where individual aerials are used in pairs for 'homing' purposes they shall be accurately electrically matched, to close tolerances, over the whole of the frequency band in which they are to be used. Likewise, their connecting rf feeders are to be accurately matched before assembly on to the airframe. Consideration shall be given to out of band			

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		attenuation and cross polarisation performance.			
2.1.2	Mechanical Performance With Respect to Rotorcraft Permitted Aerodynamic Limitations.	(i) Minimised mass, and optimised mechanical integrity consistent with the intended application i.e., (a) to withstand maximum aerodynamic loads envisaged at the proposed airframe location (b) to have freedom from flutter and to withstand loads arising from the oscillatory behaviour of fixed or trailing wire elements. For whip aerials consideration shall be given to the need for flexible mountings. (c) to withstand damage due to vibration. (d) to suffer minimal damage due to impact e.g., through birdstrike, (see Leaflet 206), rough terrain etc. (e) the physical balance of moving components e.g.,			

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		scanner, under the influence of rotorcraft manoeuvre. (ii) Environmental effects including: (a) ice accretion (b) erosion through rain, hail, rotorcraft fluids.			
3	**AERIAL LOCATION ON AN AIRFRAME**				
3.1	Aerials shall be located having due regard to:				
3.1.1	Electrical Performance.	(i) Signal polarisation, (of special note where an aerial is mounted on a movable surface e.g., nosewheel door, cargo ramp etc). (ii) Required radiation pattern coverage, i.e., a site with a 'clear field of view' from which the radiated signal is not: (a) Obstructed by intervening airframe structure, or projections therefrom of significant electrical size,			

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		i.e., producing 'holes' in the patterns. (b) Distorted by electromagnetic wave re-radiation/ reflection from 'nearby' airframe components or projecting objects e.g., rotors, other aerials. (c) Obstructed/distorted by the movement of airframe components e.g., undercarriage, cargo ramp etc. (d) Obstructed/distorted by carriage and/or disposal of external stores e.g., weapons, fuel tanks etc. (iii) Electromagnetic interference (EMI) from other electronic sources including rf feeder cables, and power supplies within the rotorcraft or the radiation/induction of EMI onto other systems.			

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		(iv) Where communications with other aircraft are envisaged, minimisation of any deleterious effects due to multipath signal reflections from terrestrial sources.			
3.1.2	**Mechanical Constraints**				
3.1.2	(i) Mechanically deployed aerials (e.g., trailing wires, long 'whips' under the fuselage, and those in retractable housings etc)., shall be 'fail-safe' in order that no damage to the rotorcraft shall occur during any phase of deployment or retraction, or when the rotorcraft is taking off or landing.		(see also paras 4.1.7 and 4.1.8).		
3.1.2	(ii) No damage shall arise from the movement of adjacent airframe components. (iii) Where the aerial is fixed to a movable airframe component, its associated rf	(iv) Vulnerability to battle damage shall be minimised (see Leaflet 112). (xi) Access for maintenance purposes (i.e, fitting or removal of the			

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	feeder, and power supply leads where supplied, shall not be subject to undue stress during such movement. (v) In-flight detachment of the aerial through mechanical failure shall not cause significant damage to the rotorcraft, particularly the rotors. (vi) In-flight separation of accreted ice shall not cause damage to engines, or significant damage to the airframe or rotors. (vii) Freedom from contamination by aircraft fluids and water. (viii) Freedom from excessive heating (e.g., engine efflux). (ix) No hazard shall be presented to maintenance or ground handling personnel. Where such a possibility exists, adequate warnings shall be provided. (x) 'Hands/Feet Off'	aerial, attention to rf and power connections) shall be as simple as possible, to minimise rotorcraft 'down' times.			

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	warnings shall be prominently displayed wherever an aerial is likely to, present a hand or foothold to aircrew and maintenance or ground handling personnel.				
4	**AERIAL INSTALLATION ON AN AIRFRAME**				
4.1	The following requirements shall apply when installing aerials on to an airframe:				
4.1.1	A homogeneous conductive path, of dc resistance less than 5 milliohms, shall be maintained between the aerial mounting flange and that part of the airframe which forms an extension of the 'earth plane'. Where there is a mechanical discrepancy between the aerial mounting face and the rotorcraft structure, the aerial shall be assembled on to the airframe using a profiled packing piece interposed between aerial mounting and airframe. Such	Where possible, 'wet assembly' techniques shall be used, including release agents where necessary. This is essential to prevent moisture or fluid ingress from both inside and outside the rotorcraft from causing contamination of the aerial-to-structure interface, and to facilitate aerial removal (see para 3.1.2(xi)). However where the aerial requires a large earth plane, mating surfaces of metal skin joints may be treated with a suitable	Dissimilar metals in contact can cause corrosion due to galvanic action The requirements of Leaflet 407 are to be observed. See Leaflet 407/3 for additional information on galvanic action.		

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	packing shall have a minimal effect upon the required radiation performance of the aerial (see para 3.1.1). The packing piece shall be of material in compliance with BS 3G100 Part 2 Section 3 Sub Section 3.2 Table 2, and shall not increase the dc resistance between aerial and airframe earth to more than 5 milliohms.	conductive protective treatment. These joints shall receive suitable treatment after assembly. An approved sealant shall be used around the outside periphery of the aerial junction to the airframe and, in the case of lower fuselage aerials, to the inside junction also. The seal may be achieved with a gasket complying with the requirements of para 4.1.1.			
4.1.5	Fixed wire aerials shall have a device to maintain a constant tension and a weak link to ensure failure can be anticipated at a known point. The design shall consider the effect of having a free wire aerial as defined by the position of this weak link (see also para 3.1.2 (i)).				
4.1.6	Adequate drainage shall be provided in the vicinity of a				

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	belly mounted aerial so that accumulation of water or other liquids may be reduced to a minimum. Such aerials shall have liquid-proofed feeder cable mating connectors to prevent ingress of moisture.				
4.1.7	To achieve necessary clearances or reduce drag some aerial configurations may, according to application, be installed on a retractable mounting. Such a mounting shall be provided with the necessary interlocks and indications to ensure the assembly may only be extended, operated and retracted at the correct phase of flight.				
4.1.8	No single failure shall prevent the operation, retraction or extension of an aerial system where such failure could affect the safe handling of the rotorcraft.				29.1431 29.1431a

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4.1.9	Where an aerial is shared by two or more transmitters, appropriate interlocks shall be provided to prevent inadvertent simultaneous transmissions.				
5	**RADOMES AND AERIALS FAIRINGS**				
5.1	**MECHANICAL REQUIREMENTS**				
5.1.1	Radome shape will be constrained by the aerial application, and ideally will offer minimum aerodynamic drag.	Where a radome alters the original airframe profile, the significance of its aerodynamic effects shall be assessed through re-test of the rotorcraft's handling and performance characteristics.			
5.1.2	The radome shall be structurally sound, capable of withstanding the aerodynamic loads and be resistant to erosion by rain, hail, and to damage from debris when landing on 'rough' terrain.				
5.1.3	Where a radome fairing is located at the extremity of the airframe e.g., nose, tail,				

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	sponsons, it shall be fitted with lightning diverter strips either on the inside or outside of the radome. These must be electrically bonded to airframe earth (dc resistance of not more than 50 milliohms). The configuration, arrangement and material for the lightning diverter strips shall be adequate to provide the necessary protection against a direct lightning attachment and to conduct the ensuing lightning current to the airframe without damage to the radome.				
5.2	**ELECTRICAL REQUIREMENTS**				
5.2.1	Hence the radome shall be designed to provide maximum transmissivity, over the frequency range concerned, of radiation from the enclosed aerial.	In addition to structural integrity the material used in the construction and geometry of the radome shall provide a clear undistorted aerial view, with minimum reflection over the required	The electrical performance of the radome contributes to the performance of a total installed system.		

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		arcs of radio wave transmission.			
5.2.3	Where a mechanically scanning aerial causes high energy transmissions either as main beam or sidelobe to be directed inboard at the airframe or other equipment then radar absorbent material, appropriate to the frequency band in question, shall be used to protect those parts and to minimise reflection.				
6	**RADIO AND RADAR EQUIPMENTS**				
6.1	**LOCATION**				
6.1.1	Each unit shall be suitable for the environment in which it is located and shall be capable of normal operation to the maximum altitude to which the rotorcraft is designed.	Additional cooling or heating shall be provided where the installation or the radio manufacturer's specification dictates.			29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g
6.1.3	Units generating		(see DEF STAN 59-412).		

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	electromagnetic interference shall be located so as to minimise the effect on other systems. Similarly, interconnections between units that may generate electromagnetic interference shall be installed so as to minimise the effect.				
6.1.4	All equipment and cables shall be positioned where practical to avoid damage by acid, water, oil, fuel or other fluid or by the air crew or ground crew in the normal course of their duties.				
6.1.5	Cable connections to units shall not run adjacent to the rotorcraft's main power distribution feeders or other likely sources of interference. Where systems are duplicated the cable connections of the separate systems shall be kept well apart.				29.1307 29.1307 29.1307b
6.1.6	Control panels, indicators and selectors shall be located at				

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	crew stations to comply with the provisions and requirements of Leaflet 107.				
6.1.7	Units shall be located to minimise the effects of power supply voltage reduction and rf losses through excessively long cables/feeders.				
6.2	**MOUNTING**				
6.2.1	Where the vibration limits applicable to a radio or radar unit would not be satisfied by direct attachment to the airframe means of isolating the vibration shall be employed. However adequate electrical bonding, resistance not greater than 5 milliohms, shall be provided between the equipment and airframe earth.	Units, connectors, complete with their interconnections, feeders, etc., shall be installed as far as practicable so that they can be quickly and easily replaced when the rotorcraft is on the ground and also without the need to first remove other equipment. Units shall not be mounted on a rotorcraft component which is itself subject to a different periodic removal unless that component forms part of the same radio or radar installation.	(see also Leaflet 802)		29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g
6.2.2	Equipment mounted in quick release trays shall not be so		(see Leaflet 307).		

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	oriented that the equipments, if not properly secured, would be likely to impact an occupant or other equipments in the event of a crash landing.				
6.2.5	The removal of one component shall not loosen another component.				
6.3	**POWER SUPPLIES**				
6.3.1	Power supplies for rotorcraft installed radio and radar equipment shall conform to those specified in Leaflet 706.				
6.3.2	The distribution system for radio and radar power supplies and for equipment controlling radio and radar outputs shall be designed to minimise interruption or loss of service, and loss of facility, (where duplicated equipments are fitted) in the event of a failure occurring at a power source or in the distribution system itself.	Details of distribution, capacity, alternative or standby systems and special voltages (if applicable) shall be agreed with the Rotorcraft Project Director.			
6.3.3	Equipments requiring a				

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	continuous power supply shall be provided with a standby battery source, and a purpose converter if necessary.				
6.3.4	Equipments sensitive to phase alignment shall have a suitable power supply.				
6.3.5	Where alternative or standby power supplies are desirable the supply shall have the same integrity as the main system. The capacity of an alternative or standby power supply shall be adequate for the intended operation of the rotorcraft.				
6.4	**INTERCONNECTION**				
6.4.1	The installation of interconnecting electrical wires and cables shall be in accordance with Leaflet 706.	As a design aim cables shall be routed to avoid areas of elevated temperatures but where such routing is unavoidable, e.g., in engine bays and locations close to exhaust pipes, cables and connectors shall be constructed from components	Coaxial feeder cables require special attention to ensure that the dielectric is not deformed or crushed by the installation of retaining devices, e.g., clips, straps etc., and that the cable is not subjected in the installation or during installation to bends		

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		and materials having a suitable high temperature duty rating. Where practicable such cables shall be routed to provide adequate clearance from sharp angles or corners of equipment and structure.	having a radius less than that specified as the minimum bend radius.		
6.4.2	Where necessary, high voltage cables shall be provided with protection, in addition to the basic covering, to guard against mechanical damage.				
6.4.3	Cable connections to units, plug boards and bulkhead plugs shall be accessible, clearly identified and not capable of cross connection.				
6.4.5	Transmitter control circuits shall be interlocked to ensure that incompatible transmissions cannot operate simultaneously. Also where transmissions may adversely affect the operation of a				

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	working receiver, the operating crew shall be provided with a label or warning indication that the system is temporarily degraded during the period of transmission.				
6.5	**HIGH TENSION VOLTAGES**				
6.5.1	Installations operating at high voltages shall be adequately insulated.				
6.5.2	Where high voltage insulation is achieved by virtue of crew compartment or equipment pressurisation, means to isolate the power in the event of loss of pressure shall be provided. Equipment requiring such protection shall not be installed at the flight deck.				
6.6	**ELECTROMAGNETIC INTERFERENCE**				
6.6.1	The level of possible electromagnetic interference from a unit or its associated	An electromagnetic compatibility test schedule shall be prepared and agreed	(see also DEF STAN 59-41)		

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	wiring shall be compatible with other equipments fitted and those likely to be fitted and shall conform to the radiated emission limits specified in BS 3G100, or as agreed with the Rotorcraft Project Director .	with the Rotorcraft Project Director.			
6.7	**TEMPEST**				
6.7.1	Requirements for Tempest clearance shall be considered in conjunction with the Rotorcraft Project Director.				
7	**RADIO AND RADAR SYSTEM CONTROL**				
7.1	Crew members shall be provided with the necessary control of equipments and systems under their charge. The status of this control shall be positively and clearly confirmed to the crew members concerned in an unambiguous manner.	Conflicting systems and operations shall be provided with interlocks to the satisfaction of the Rotorcraft Project Director.			

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7.3	Elementary means of aircrew intercommunications, radio communications and radio or radar navigation shall be maintained in all situations, including a total generated power supply failure.				
8	**STATIC ELECTRICAL CHARGES**				
8.1	Adequate means for the dispersal of static electrical charges shall be provided.				29.610 29.610a 29.610b 29.610b1 29.610b2 29.610c 29.610c1 29.610c2 29.610d 29.610d1 29.610d2 29.610d3 29.610d4
9	**TESTING**				
		Flight and ground testing shall be in accordance with the Rotorcraft Specification or as agreed with the			

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		Rotorcraft Project Director.			
10	**SERVICING**				
10.1	Within any limitations which may be imposed by technical consideration and operational requirements of the equipment, radio and radar units shall be so installed that the servicing requirements of Part 8 are met.	When an electrical and/or air supply is required for ground testing a radio or radar installation, the connection for this shall be readily accessible and shall not necessarily require the ground testing equipment to be taken into the rotorcraft.			
	Sub-Leaflets				
	LEAFLET 707/0 RADIO AND RADAR INSTALLATIONS REFERENCE PAGE				
	LEAFLET 707/1 RADIO AND RADAR INSTALLATIONS THE INSTALLATION OF AIRBORNE SPEECH COMMUNICATIONS SYSTEMS				
	LEAFLET 707/2 RADIO AND RADAR INSTALLATIONS SERVICING				

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	LEAFLET 707/3 RADIO AND RADAR INSTALLATIONS AERIALS, ANTENNAE AND SCANNERS				
	LEAFLET 209				
	RADOMES				
1	**INTRODUCTION**				
	The general requirements for radomes are given in Leaflet 707 'Radio and Radar Installations'. These include, in para 5.1, specific requirements relating to aerodynamic and structural considerations, including, resistance to erosion, impact damage and lightning strike. It is accepted that good radome design will involve a trade-off between electrical and structural properties and the purpose here is to draw attention to the procedures that shall be followed in supporting any deviation from the structural standards that normally apply.				
2	**REQUIREMENTS**				
2.1	The structural requirements include those for static strength and stiffness, fatigue performance, impact from hail and resistance to bird impact and lightning strike.	In each design case where it is found to be impractical to achieve these standards, the reasons for compromise and the basis of the trade-off between structural and electrical properties shall be referred by the Design Authority, to the Rotorcraft Project Director for a concession before proceeding			29.305 29.305a 29.571 29.571a 29.631 29.631

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		with the design. This supporting evidence shall include a failure analysis, containing descriptions of failure modes and consequential effects, including those on flight aerodynamics and engine(s). For those design cases which result in a likelihood of structural failure of the radome, it shall be shown that the integrity of the rotorcraft is not impaired to an extent unacceptable to the Rotorcraft Project Director. It is recognised that a best compromise between structural and electrical properties may sometimes be achieved by designing for replacement rather than repair. In such instances the economic and maintenance implications shall be drawn to the attention of the Rotorcraft Project Director; normally for 'disposable-type' radomes the			

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		mean-time-between failures must not be less than 500 flying hours.			
	Sub-Leaflets				
	LEAFLET 209/0 RADOMES REFERENCE PAGE				
	LEAFLET 724				
	INSTRUMENT/DISPLAY INSTALLATIONS				
1	**INTRODUCTION**				
	This Leaflet states the requirements for the installation of rotorcraft instruments and displays. Note the term instruments or displays used throughout this document shall include associated remote sensors, ancillary equipment and fittings.				
2	**MECHANICAL REQUIREMENTS**				
2.1	The case type for a particular instrument/display shall, where practicable, be selected from the standard range specified in DEF STAN 66-26 (Part 1).				
2.2	Flanged cases are normally mounted from the front of the instrument panel. Mounting shall be by means of screws through the corner ears of the flange into fixed locknuts at				

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	the back of the panel. For flangeless cases suitable clamps in accordance with DEF STAN 53-96 (in preparation from STANAG 3492) shall be used around the periphery of the case. Quick release fasteners shall be considered for face-up horizontal, or nearly horizontal, panels. Long or heavy cases may require additional support at the rear of the panel.				
		Certain cases may be mounted from the rear of the panel. In these instances the fixing holes in the corner ears of the case shall be replaced by integral locking nuts, which shall have unified or metric threads.			
	A warning notice as defined in DEF STAN 66-26 (Part 1) para 4c shall be displayed to identify unified threads. A notice of similar dimensions				

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	as depicted in DEF STAN 05-13 Annex D Type 1 shall be displayed to identify metric threads.				
2.4	Positioning of instruments/displays in the rotorcraft shall be in accordance with the requirements of Leaflets 105, 106 and 107.				
2.5	**CONNECTIONS**				
2.5.1	Electrical (i) Connectors shall be selected as practicable from suitable types listed in DEF STAN 59-35 (Part 0) Certain circular connectors therein are approved specifically for airframe fit and avionics applications. The type or types selected shall be agreed with the Rotorcraft Project Director. (ii) The rotorcraft manufacturer shall ensure that adjacent connectors cannot be incorrectly mated on any one				

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	instrument or on adjacent instruments. (iii) Where free connectors are used there shall be a minimum 0.75 in (20mm) radial clearance between any two adjacent connectors. (iv) Where a flying lead with connector is used it shall be of sufficient length for the instrument to be withdrawn to clear the panel. The lead shall be securely stowed when the instrument is fitted. (v) Bonding shall meet the requirements of Leaflet 708.				
2.5.2	Air. Pitot and static connections shall be made in accordance with the requirements of Leaflet 716 and DEF STAN 66-27				
2.5.3	Hydraulic. Connections to hydraulic instruments and gauges shall be in accordance with Leaflet 704 and DEF STAN 66-27.				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
2.5.4	Pneumatic. Connections to pneumatic gauges and instruments shall be in accordance with Leaflet 703 and DEF STAN 66-27.				
2.6	**LIGHTING**				
2.6.1	Instrument and panel lighting shall meet the requirements of Leaflet 105, para 15.	The Rotorcraft Project Director shall define the requirements for Emissive Displays monochrome or multicolour.			29.1381 29.1381 29.1381a 29.1381b1 29.1381b2
2.6.3	Where Night Vision Goggles are to be used cockpit lighting shall comply with the compatibility requirements defined by the Rotorcraft Project Director.				
2.7	**INFORMATION PRESENTATION**				
2.7.1	The Presentation of Instrument Information shall meet the requirements of DEF STAN 66-26 (Part 5 and 6).	Pointer quantity information shall increase with clockwise movement of the pointer, from left to right on horizontal scales and from bottom to top on vertical scales. An exception can be made where round scales are			29.1543 29.1543 29.1543a 29.1543b 29.1545 29.1545a 29.1545b1 29.1545b2

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		mirrored (e.g., brake indicator); the left scale may have counter clockwise movement with increase in pointer quantity information.			29.1545b3 29.1545b4 29.1547 29.1547a 29.1547b 29.1547c 29.1547d 29.1549 29.1549 29.1549a 29.1549b 29.1549c 29.1549d 29.1549e 29.1551 29.1551 29.1553 29.1553
	The above principles of presentation shall apply to Electronically and/or Optically generated displays.	The requirements for Electrically and/or Optically generated displays will be stated in DEF STAN 66-28 (in preparation), but in the meantime will be defined by the Rotorcraft Project Director. They will include: (i) The location of			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		display information. (ii) General symbology for display flight and combat information.			
2.7.3	Units of displayed information shall be the same as the units of measurement applying in other aircrew instruments in the same rotorcraft.	Rotorcraft requirements for such units of measurement shall be stated by the Rotorcraft Project Director.			
2.7.4	The display shall be clearly readable in all lighting conditions.	Alternative fonts can be used[1].	Guidance in the testing of displays for this requirement is provided in Leaflet 724/1.		
3	**POWER SUPPLIES**				
3.3	Where a particular instrument/display adversely affects the characteristics of the power supplies to other equipment, the effects shall not exceed the Limits of BS 3G100, Part 3.		Primary power supplies are listed in Leaflet 706, Table 1. The characteristics of electrical power supplied to the terminals of airborne equipment are specified in BS 3G100, Part 3.		29.1353 29.1353a
3.4	Instrument/display/systems shall be capable of withstanding without damage the interruption and transients specified in BS 3G100, Part 3.				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
3.5	**IDENTIFICATION OF CONNECTING WIRES**				
3.5.1	Circuits and cable runs shall be identified in accordance with Leaflet 806, para 7.1.				
3.5.2	Instrument terminals shall be identified with letters A, B, C to define the phases of the ac supply.				
4	**ENVIRONMENTAL CHARACTERISTICS**				29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g
4.1	**VIBRATION**				
4.1.1	Instruments/displays shall be designed to operate under the vibration conditions which prevail in their particular allocated position in the rotorcraft.	Where the levels are appropriate compliance with para 4.1.1 shall be established by testing to BS 3G100, Part 2, Section 3, Subsection 3.1.			29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		Where the levels prescribed in para 4.1.2 are inappropriate then specific test levels shall be defined by the rotorcraft manufacturer.			29.1309b2 ii 29.1309g 29.1321f
4.2	**ACCELERATION**				
4.2.1	Normal Conditions. The instruments/displays shall continue to function during, and after the appropriate normal flight conditions specified by BS 3G100, Part 2, Section 3, Subsection 3.6 or the maximum conditions envisaged for the rotorcraft in flight manoeuvres.	This shall be demonstrated by appropriate tests with the instruments/displays mounted in a representative condition.			29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g
4.2.2	Angular Acceleration. This requirement is concerned with the Accident Data Recorder (ADR) and any instrument or piece of equipment which uses angular motion in any of its working parts and which				29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	supplies information to the pilot, or the ADR, during the period leading up to an accident or incident. Designers of such instruments shall determine from the rotorcraft manufacturer the likely severity of such angular acceleration and establish by calculation and by testing that the instrument/displays will continue to function during or after this acceleration, as appropriate.				ii 29.1309g
4.3	**TEMPERATURE AND PRESSURE**				
4.3.1	Instruments/displays shall function satisfactorily in the temperature and pressure conditions that prevail in their local environment throughout the operational range of the rotorcraft.	The instrument/display designer shall undertake the thermal analysis of the instruments/displays and inform the rotorcraft manufacturer of the heating/cooling requirements.			29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
4.3.2	The rotorcraft manufacturer shall provide heating/cooling systems, as appropriate, in accordance with Leaflet 101, para 5 and shall be responsible for the overall thermal management of the local environments.				
4.3.3	The thermal management of heating or cooling shall ensure that acceptable temperatures are maintained for correct functioning in all conditions of operation.				
4.3.4	Essential instruments/displays as defined by the Rotorcraft Project Director shall continue to function satisfactorily for an agreed period after a failure of any air conditioning system. Other instruments/displays shall fail "safe" in the event of a failure of the air conditioning systems.				
4.3.5	Instruments/displays whose				29.1323

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	operation is a function of dynamic pressure shall have been calibrated in accordance with BS G1992.				29.1323 29.1323a 29.1323b 29.1323b1 29.1323b2 29.1323b2i 29.1323b2ii 29.1323c 29.1323c1 29.1323c2 29.1323c2i 29.1323c2ii 29.1323d 29.1323e 29.1323f 29.1325 29.1325a 29.1325b 29.1325c 29.1325d 29.1325e 29.1325f 29.1325g 29.1325g1

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
					29.1325g2 29.1325h
4.4	**HUMIDITY**				
4.4.1	Instruments/displays shall be designed to function satisfactorily within the humidity limits of Leaflet 101, para 2.	Compliance shall be established by testing to the requirements of BS 3G100 Part 2, Section 3, Sub-section 3.7. Tropical exposure tests.			29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g
4.5	**DIRECT EXPOSURE TO SUNLIGHT**				
4.5.1	Instruments/displays likely to be exposed to direct sunlight shall not be degraded by such exposure. In particular materials and panel information markings shall not deteriorate or fade. Compliance shall be established by testing to DEF STAN 07-55 (Part 2), Section 2, Test B3. The rotorcraft manufacturer shall state the				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	severity and duration of such tests.				
4.5.2	The intensity of illumination of all instruments/displays shall be controlled in accordance with the requirements of Leaflet 105, paras 15.8 and 15.9.				
4.5.3	Electronically generated displays including Head Up (HUD's) and Multi-Function (MFD's) shall be clearly defined when superimposed against a background luminance to be defined by the Rotorcraft manufacturer/Project Director. See Leaflet 724/1.				
4.6	**DUST AND SAND**				
4.6.1	Leaflet 101, para 7 states the dust and sand proofing requirements for the rotorcraft.	The Rotorcraft Project Director shall state the tests required and the severity of the tests. The instruments/displays shall function satisfactorily during and after these tests. Whilst dust and sand proofing	DEF STAN 07-55 (Part 2) Section 4 specifies test methods for the ingress of dust and sand.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		of the rotorcraft fuselage may be a desirable aim there may be occasions when the proofing is insufficient or not possible.			
4.7	**FUNGAL CONTAMINATION**				
4.7.2	Use of materials that may support fungal growth shall be avoided. Instruments/displays shall not be damaged or deranged and shall continue to function in the presence of fungal growth.	The Rotorcraft Project Director shall state the tests required and the severity of the tests.	DEF STAN 00-29 provides particulars of fungal germination and growth on material. Methods of preventing or limiting fungal growth on material are also given. Tests. DEF STAN 07-55 (Part 2) Section 3 Test C1 specifies tests to determine the extent of fungal growth under short term exposure and assess the effect of a fungus growth on the functioning of the Instruments/Displays by longer exposure.		
4.8	**CONTAMINATION FROM FLUIDS**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
4.8.1	Instruments/displays and installations in certain parts of the rotorcraft may be subjected to contamination from fluids used in their particular location in the rotorcraft.	The Rotorcraft Project Director shall state the tests required and the severity of the tests.	BS 3G100, Part 2, Section 3, Sub-section 3.12 lists groups of fluids likely to be encountered in rotorcraft and details tests to be carried out on equipment. Only where items are likely to be contaminated by the fluid should contamination tests be carried out.		
4.9	**CHEMICAL ATTACK**				
		Should there be any likelihood of chemical attack within the rotorcraft then tests will be made. Procedures for tests are specified in DEF STAN 07-55 (Part 2), Section 3. The Rotorcraft Project Director shall state the tests required and the severity of the tests.	Information concerning chemical attack is provided by DEF STAN 00-50.		
4.10	**HANDLING TESTS**				
4.10.1	Instruments/displays shall be sufficiently robust to withstand handling and transit shocks.	The Rotorcraft Project Director shall state the tests required and the severity of the tests.	Test procedures for Bump (rough ride in the back of a four wheeled vehicle without packaging), bench handling		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			and topple tests are stated in DEF STAN 07-55 (Part 2) Section 1, Test A5 Bump Test A4 Drop and Topple Test A3 Shock.		
4.11	**ELECTROMAGNETIC COMPATIBILITY**				
		The Rotorcraft Project Director shall state the tests required and the severity of the tests. These will include testing of equipments, subsystems and systems of the rotorcraft.	Requirements applicable to the limitation of propagated electromagnetic energy whether radiated or conducted and to the limitation of susceptibility of equipments, installations and systems to such energy are stated in DEF STAN 59-41. Further information and requirements particular to rotorcraft are stated in AvP 118. Methods and conditions for testing are stated in DEF STAN 59-41 (Part 3) (and part 4 when published) and in BS 3G100 Part 4, Section 2.		
4.12	**EXPLOSIVE ATMOSPHERES**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
4.12.1	Instruments/displays which may come into contact with flammable vapours shall meet the requirements of Leaflet 712, para 6.				
4.13	**NUCLEAR HARDENING**				
	Consideration shall be given to nuclear hardening .		(Leaflet 717 is being revised)		
	REFERENCES				
	REFERENCES				
	Sub-Leaflets				
	LEAFLET 724/1 INSTRUMENT/DISPLAY INSTALLATIONS EXPOSURE TO SUNLIGHT				
	LEAFLET 725				
	AVIONIC EQUIPMENT INSTALLATIONS				
1	**INTRODUCTION**				

Reference	ASCC Air Std	STANAG	BS
1	-	3329	-
2	10/46	-	G199

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	This Leaflet states the requirements for the installation of the rotorcraft avionic equipment. Whenever possible, standard items shall be used throughout the installation in accordance with the requirements of Leaflet 706. In addition to the requirements of Leaflet 706, reference shall be made to the design requirements of DEF STAN 00-10. NOTE: The term equipment used throughout this document shall include remote sensors, ancillary equipment and fittings. Leaflet 725/2 gives guidance and advice on the transmission of data and inter-aircraft compatibility of data transfer.				
2	**PHYSICAL CHARACTERISTICS**				
2.1	**SIZE**				
2.1.1	Electronic Line Replaceable Items (LIRs) shall be hand manageable by one man.	Where possible standard items shall be used provided their use is consistent with efforts to minimise weight. Where non standard items are used they shall be designed to a minimum size and mass consistent with the specified performance, mechanical strength, reliability, maintainability and project economic philosophy.	(See Leaflet 804, para 6.3).		
2.2	**SHAPE**				
2.2.1	The Rotorcraft Designer/Project Director shall state the preferred equipment case design specification.	Where the shape of the equipment cannot be configured to a standard specification, due to lack of space, the particular envelope	Normally, cases will be rectangular hexahedral in shape and the content will be of modular construction. (Leaflet 725/3).		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		shape of the rotorcraft or ergonomic considerations, the limiting requirements shall be defined by the Rotorcraft Designer/Project Director.			
2.3	**PHYSICAL/MECHANICAL INTERFACE**				
2.3.1	Equipment shall be mounted to meet the crashlanding requirements of Leaflet 307, para 1.1 and the vibration requirements of para 6.1.1.				29.561b 29.561b1 29.561b2 29.561b3 29.561b3i 29.561b3ii 29.561b3iii 29.561b3iv 29.561b3v
2.3.2	Equipment shall be secured in place by means of hold-downs or quick release fasteners subject to meeting the requirements of para 2.3.1.				
2.3.3	Pitot and Static Connections shall be made in accordance with the requirements of				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Leaflet 716, and DEF STAN 66-27.				
	Equipment shall be designed to meet the requirements of Leaflet 100, para 7. (Incorrect Assembly).				
2.3.5	Moisture traps shall be avoided where practicable in accordance with DEF STAN 00-10.	Provision shall be made for drainage of moisture traps where these are unavoidable.			
2.3.6	Consideration shall be given to the capability to withstand secondary damage i.e., in the event of any form of failure of an equipment, interfacing equipments shall not incur damage.				
2.3.7	Interchangeability requirements shall be in accordance with DEF STAN 00-10.				
2.3.8	Elapsed Time Indicators (ETI) shall be fitted, when applicable, in all principal LRIs so that indications can be easily seen when equipment is fitted with				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	covers installed.				
2.4	**ELECTRICAL INTERFACE**				
2.4.1	Requirements for the electrical installations in rotorcraft are stated in Leaflet 706.	The types of connector to be used shall be specified by the Rotorcraft Project Director to meet the functional and environmental requirements of the rotorcraft.	For guidance see Leaflet 725/3.		
2.4.2	Where connectors are used on free cables from the rotorcraft or the equipment, means shall be provided to prevent mismating with similar adjacent connectors.				
2.4.3	Electrical Bonding shall meet the requirements of Leaflet 708.				
2.4.4	Where free connectors are used there shall be a minimum 20mm radial clearance between any two connectors when connected.				
2.4.5	Conformal coatings shall be avoided where possible but, if they are used they shall be non toxic and easy to remove				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	and replace.				
2.4.6	Volatile memories, if an essential part of the design, shall be provided with a means of data retention during power interruptions.		(see Leaflet 706, para 2.7.3 and Leaflet 725/3)		
3	**TESTABILITY AND BUILT IN TEST (BIT)**				
3.1	**TESTABILITY**				
			Testability is an essential element of equipment design. See DEF STAN 00-13.		
3.2	**BIT**				
3.2.1	The requirement for BIT will be stated in the Rotorcraft Specification or by the Rotorcraft Project Director as defined in Leaflet 800, para 9.	Among the items to be considered are: (i) Fault detection and location down to LRI or module level including inter LRI module connectors. (ii) Indication of fault status during system operation, in the air and on the ground. (iii) Recording of fault data during operation, in the air and on the ground, for			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		maintenance information. (iv) Provision for testing shall be so designed that any failure of the BIT shall not degrade the equipment operation or cause the equipment to shut down. (See DEF STAN 00-13). (v) The maximum reduction as a percentage of the Mean Time Between Failure (MTBF) due to the inclusion of BIT (see Leaflet 725/3). (vi) Minimising of the false alarm rate (see Leaflet 725/3). (vii) The probability rate of BIT detecting faults.			
3.3	**AUTOMATIC TEST EQUIPMENT (ATE)**				
		The installation shall facilitate the use of ATE where required by the Rotorcraft Specification or the Rotorcraft Project Director.	The use of ATE will depend on the maintenance philosophy adopted and the levels of testing envisaged.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
4	**A FAILURE MODE EFFECTS AND CRITICALITY ANALYSIS (FMECA)**				
4.1	When required by the Rotorcraft Project Director an FMECA shall be conducted to establish the effects of failure within the systems.	Where practical those items liable to failure, or critical in the function of the systems, shall be readily accessible and replaceable.			29.1309d 29.1309d1 29.1309d2 29.1309d3 29.1309d4
5	**POWER SUPPLIES**				
5.3	Where a particular equipment adversely affects the characteristics of the power supplies to other equipment, the effects shall not exceed the limits of BS 3G100, Part 3.		Primary power supplies are listed in Leaflet 706, Table 1. The characteristics of electrical power supplied to the terminals of airborne equipment are specified in BS 3G100, Part 3.		29.1353 29.1353a
5.4	Utilisation equipment/systems shall be capable of withstanding without damage the interruption and transients specified in BS 3G100, Part 3.				
5.5	**IDENTIFICATION OF CONNECTING WIRES**				
5.5.1	Circuits and cable runs shall				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	be identified in accordance with Leaflet 806, para 7.1.				
5.5.2	Equipment terminals shall be identified with letters A, B, C for the phasing of the ac supply.				
6	**ENVIRONMENTAL CHARACTERISTICS**				29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g
6.1	**VIBRATION**				
6.1.1	Equipments shall be designed to function under the vibration conditions which prevail in their particular position in the rotorcraft.	Where the levels are appropriate compliance with para 6.1.1 shall be established by testing to Leaflet 501, para 4. Where the levels prescribed in para 6.1.2 are inappropriate, then specific levels shall be defined by the rotorcraft manufacturer.			29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
6.2	**ACCELERATION**				
6.2.1	Normal Conditions. The equipment shall continue to function during and after the extreme conditions experienced by the rotorcraft in flight manoeuvres or in the absence of suitable information the appropriate normal flight conditions specified by BS 3G100, Part 2, Section 3, Subsection 3.6, Table 1.	This shall be demonstrated by appropriate tests with the equipment mounted in a representative condition.			29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2i 29.1309b2ii 29.1309g
6.2.2	Angular Acceleration. This requirement is concerned with any piece of equipment sensitive to angular acceleration. Designers of such equipment shall determine from the rotorcraft designer the likely severity of such angular acceleration and establish by calculation and by testing that the equipment will continue to function during and after this acceleration, as appropriate.				29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2i 29.1309b2ii 29.1309g

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
6.3	**TEMPERATURE AND PRESSURE**				
6.3.1	Equipment shall function satisfactorily in the temperature and pressure conditions which prevail in its local environment throughout the operational range of the rotorcraft.	The equipment designer shall undertake the thermal analysis of the equipment and inform the rotorcraft designer of the heating/cooling requirements.	(See Leaflet 725/1).		29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309g
6.3.2	The rotorcraft manufacturer shall provide heating/cooling systems, as appropriate, in accordance with Leaflet 101, para 5 and shall be responsible for the overall thermal management of the local environments.				
6.3.3	The thermal management of heating or cooling shall ensure that acceptable temperatures are maintained for correct functioning in all conditions of operation.				
6.3.4	Essential equipment as				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	defined by the Rotorcraft Project Director shall continue to function satisfactorily for an agreed period after a failure of any air conditioning systems. Other equipment shall fail "safe" in the event of a failure of the air conditioning systems.				
6.4	**HUMIDITY**				
6.4.1	Equipment shall be designed to function satisfactorily within the humidity limits of Leaflet 101, para 2.	Compliance shall be established by testing to the requirements of BS 3G100, Part 2, Section 3, Sub section 3.7, Tropical Exposure tests.			29.1309 29.1309a 29.1309b 29.1309b1 29.1309b2 29.1309b2i 29.1309b2ii 29.1309g
6.5	**DIRECT EXPOSURE TO SUNLIGHT**				
6.5.1	Equipment likely to be exposed to direct sunlight shall not be degraded by such exposure. In particular,	Compliance shall be established by testing to DEF STAN 07-55, Part 2 Section 2 Test B3. The rotorcraft			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	materials and panel information markings shall not deteriorate or fade.	manufacturer shall state the severity and duration of such tests.			
6.6	**EXPOSURE TO RAIN OR SALT SPRAY**				
6.6.1	Equipment mounted to the outside of the rotorcraft or in exposed parts such as engines or undercarriage shall function satisfactorily when subjected to rain or salt spray as appropriate.	Satisfactory functioning, shall be established by testing to BS 3G100, Part 2, Section 3, Sub section 3.11, Waterproofness Tests and Sub section 3.9, Salt Mist Test Severity 1.			
6.7	**DUST AND SAND**				
6.7.1	Leaflet 101, para 7 states the dust and sand proofing requirements for the rotorcraft.	Whilst dust and sand proofing of the rotorcraft fuselage is a desirable aim there may be occasions when the proofing is insufficient or not possible.	DEF STAN 07-55 (Part 2) Section 4 specifies test methods for the ingress of dust and sand. The Rotorcraft Project Director shall state the requirement for dust and sand tests and the severity. The equipment shall function satisfactorily during and after these tests.		
6.8	**FUNGAL CONTAMINATION**				
6.8.2	Use of materials that may support fungal growth shall	The Rotorcraft Project Director shall state the tests	DEF STAN 00-29 provides particulars of fungal		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	be avoided. Equipment shall not be damaged or deranged by and shall continue to function in the presence of fungal growth.	required and severity of the tests.	germination and growth on material. Methods of preventing or limiting fungal growth on materials is also given. DEF STAN 07-55, Part 2, Section 3, Test C1 specifies tests to determine the extent of fungal growth under short term exposure and assess the effect of fungal growth on the functioning of the equipment by longer exposure.		
6.9	**CONTAMINATION FROM FLUIDS**				
6.9.1	Equipment and installations shall continue to function when subjected to contamination from fluids used in their particular location in the rotorcraft.	Requirement for tests, their severity and the appropriate fluid shall be stated by the Rotorcraft Project Director.	BS 3G100, Part 2, Section 2, Sub section 3.12 lists groups of fluids and details tests to be carried out on equipment. Contamination tests should only be carried out on items which are likely to be contaminated by fluid.		
6.10	**CHEMICAL ATTACK**				
6.10.4	Contaminated equipment shall continue to function satisfactorily during the tests	Should there be any likelihood of chemical attack within the rotorcraft then the	Information concerning chemical attack is provided by DEF STAN 00-50. (See		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	of para 6.10.3.	Rotorcraft Project Director shall state the chemicals and the severity of tests to be carried out.	also new Leaflet 717 - JAC Paper No. 1178 in preparation). Procedures for tests are specified in DEF STAN 07-55 (Part 2) Section 3.		
6.11	**HANDLING TESTS**				
6.11.1	Equipment shall be sufficiently robust to withstand handling, and transit shocks.	Tests to be performed and the severity of the tests shall be specified by The Rotorcraft Project Director.	Test procedures for bump (rough ride in the back of a four wheeled vehicle without packaging) bench handling and topple tests are stated in DEF STAN 07-55, Part 2, Section 1, Test A5 Bump, Test A4 Drop and Topple, Test A3 Shock.		
6.12	**ELECTROMAGNETIC COMPATIBILITY**				
		Specific requirements and severity of tests shall be stated by the Rotorcraft Project Director. These will include testing of equipments, subsystems and systems of the rotorcraft.	Requirements applicable to the limitation of propagated electromagnetic energy whether radiated or conducted and to the limitation of susceptibility of equipments, installations and systems to such energy are stated in DEF STAN 59-41.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			Further information and requirements particular to rotorcraft are stated in AvP 118. Methods and conditions for testing are stated in DEF STAN 59-41 Part 3 (and Part 4 when published) and in BS 3G100 Part 4 Section 2. (See also Leaflet 1011).		
6.13	**EXPLOSIVE ATMOSPHERE**				
6.13.1	Equipment which may come into contact with flammable vapours shall be designed to meet the requirements of Leaflet 712, para 6.				
6.14	**NUCLEAR HARDENING**				
6.14.1	Consideration shall be given to requirements for nuclear hardening (see new Leaflet 717 - JAC Paper 1178 in preparation).	Specifically dose rates and EMP fields shall be included as choice of microprocessor is affected.			
6.15	**TEMPEST**				
6.15.1	Requirements for Tempest clearance shall be considered in conjunction with the				

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	Rotorcraft Project Director.				
6.16	**REDUCTION OF VULNERABILITY TO BATTLE DAMAGE**				
			See Leaflet 112.		
6.17	**SAFETY CRITICAL SOFTWARE**				
			See Interim DEF STAN 00-31 for requirements, design, verification and validation of safety critical software. (See also Interim DEF STAN 00-55 when available).		
	Sub-Leaflets				
	LEAFLET 725/1 AVIONIC EQUIPMENT INSTALLATIONS THERMAL MANAGEMENT				
	LEAFLET 725/2 AVIONIC EQUIPMENT INSTALLATIONS DATA HIGHWAYS AND AIRCRAFT TO AIRCRAFT COMPATIBILITY				
	LEAFLET 725/3				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	AVIONIC EQUIPMENT INSTALLATIONS GENERAL AND INTERFACE REQUIREMENTS				
	LEAFLET 716				
	STATIC AND PITOT PRESSURE SYSTEMS				
1	**INTRODUCTION**				
	The requirements of this Leaflet govern the design of static and pitot pressure systems . (see Leaflet 711 para 2.5 for the protection of Air Data Sensors)				
2	**SYSTEM CONFIGURATION**				
2.1	Each rotorcraft shall have a minimum of either one pitot-static tube or a combination of pitot tube(s) and flush static vents, mounted such as to provide unambiguous indications of altitude and airspeed within the pressure error tolerances defined in para 3.3.				29.1303a 29.1323 29.1323 29.1323a 29.1325 29.1325e 29.1303 29.1303
	The static and pitot pressure system shall be designed to minimise moisture or dirt				29.1325 29.1325b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	ingression into the system.				
2.3	A duplicated static and pitot pressure system shall be provided for two independent Air Speed Indicator (ASI) Systems unless the Rotorcraft Specification calls for a single system. A duplex system shall not use a single data source.	In order to reduce lag, consideration shall be given to conversion of pressure to an electrical signal as close as possible to the pressure sensor.			
2.5	Where an altitude or airspeed indicating system requires an electrical supply for their operation, a secondary electrical source shall be available to permit continued operation in the event of failure of the primary or normal supply.				
3	**PRESSURE ERRORS**				
3.1	**GENERAL**				
3.1.1	In all flight conditions errors in the static and pitot system shall be kept to a minimum, but in any event they shall not exceed the tolerances specified at paras 3.2 and 3.3.		The errors quoted below are exclusive of instrumentation errors which are given in the appropriate instrumentation specification.		29.1323 29.1323 29.1323c 29.1323c1 29.1323c2 29.1323c2

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
					i 29.1323c2 ii 29.1323d 29.1325 29.1325f
3.2	**LAG ERRORS**				
3.2.1	The time interval, or lag, for 90% of a pressure change at the source to appear at the pilots primary ASI and altimeter shall not exceed 0.5 seconds at ground level.				
3.3	**PRESSURE ERROR TOLERANCE**				
3.3.1	When the rotorcraft is in level flight or descending on a flight path inclined at less than 10° to the horizontal, or in any other steady state flight condition (including turns and yawed flight, sidewards and rearwards flight), the pressure error shall not lead to an altitude reading differing from the correct altitude by more than				29.1325 29.1325f

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	30 ft				
3.3.2	When the rotorcraft is in level flight or descending on a flight path inclined at less than 10° to the horizontal, at an airspeed exceeding 30kt, the pressure error shall not lead to an airspeed reading differing from the correct speed by more than 5kt or 3%, whichever is the greater.				29.1323 29.1323 29.1323c 29.1323c1 29.1323c2 29.1323c2 i 29.1323c2 ii 29.1323d
3.3.3	The Vertical Speed Indicator (VSI) shall provide a constant indication of rate of climb and descent at all Equivalent Airspeeds (EAS) above 40kt. Small changes in rotorcraft pitch attitude or airspeed shall not affect the indication during an otherwise steady climb or descent. In transient flight conditions, including rapid entry to climbs or descents, the VSI shall indicate in the correct sense of the change without excessive hesitation.				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
3.3.4	The accuracy of the VSI shall be within ± 10% of the instrument reading at all rates of climb and descent below 4000 ft/min, and at airspeed in excess of 40kt EAS.		Ideally the error should be no worse than ± 5% of the true rate of change of pressure height.		
3.3.5	Changes in configuration that are permitted in normal flight (e.g., release of external stores, opening/closing of doors) shall not cause the airspeed to vary by more than ± 2kt or the altitude to vary by more than ± 15 ft. Changes in configuration that may occur in emergency situations (e.g., deployment of Flotation Gear) shall not generate airspeed and altitude pressure errors that prejudice rotorcraft safety.				
3.4	**AIRSPEED INDICATION**				
3.4.1	The ASI system shall provide consistent indicators of relative airspeed along the flight path during all normal manoeuvres required by the	These indicators should be available at above 20kt EAS and rates of climb/descent (ROC/D) of less than 200 ft/min; and above 40kt EAS			29.1323 29.1323 29.1323c 29.1323c1 29.1323c2

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	rotorcraft.	at ROC/D above 1000 ft/min. These requirements should be met at sideslip angles up to 20°.			29.1323c2 i 29.1323c2 ii 29.1323d
3.4.2	The minimum airspeed above which consistent indications are produced during acceleration from hover, and the minimum speed down to which consistent indications are produced during decelerations, shall be repeatable for all rotorcraft loadings and configurations.				
3.4.3	In all transient manoeuvres the airspeed indication should be available at airspeeds above 40kt EAS and shall be available at airspeeds in excess of 70kt EAS.		Entry to autorotative flight and recovery from steep pitch attitudes are defined as important transient manoeuvres in this context.		
4	**AERODYNAMIC REPEATABILITY**				
4.1	**PITOT AND PITOT-STATIC HEADS**				
4.1.1	The static pressure measurement when				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	referenced against a known standard shall not differ by more than ± 0.002qc, where qc is true dynamic pressure (impact pressure). The pitot pressure when referenced against a known standard shall not differ by more than ± 0.005qc (See Leaflet 716/2).				
5	**PITOT-STATIC SYSTEMS IN POWERED FLYING CONTROLS**				
5.1	Where the pitot-static pressure is monitored and signalled into the powered flying controls, the pitot-static system shall be regarded as part of the powered flying controls and shall meet the requirements of Leaflet 605, para 2.				
6	**PITOT-STATIC SOURCES UTILISED IN AUTOMATIC FLIGHT CONTROL SYSTEMS AND FOR MANUAL**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	BLIND FLYING				
6.1	The characteristics of the static and/or pitot sources, such as lag of the complete pressure system or its response to changes of altitude, shall not result in destabilising signals to any mode of automatic flight control system.				
7	**INSTALLATION OF PIPES**				
7.1	**GENERAL**				
7.1.1	All conditions within the design flight envelope of the rotorcraft shall be taken into account.	The aim shall be to ensure that the installation of pitot and static pipes, together with their components and supports, will be such that they are capable of withstanding throughout the life of the rotorcraft the worst effects of vibration, structural distortion and temperature likely to occur.			
7.2	**PRECAUTIONS AGAINST INCORRECT ASSEMBLY**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			(Ref Leaflet 100, para 7)		
7.2.2	All pipes shall be marked in accordance with the requirements of Leaflet 806.				
7.2.3	All pipes shall carry a supplementary identification marking P or S as appropriate complying with the requirements of BS 5M23.1987				
7.2.4	Pipe to pipe couplings and pipe connections to instruments and associated equipment shall be in accordance with AGS 3914 Pitot systems & AGS 3915 Static systems.	Where possible, joints in pipe lines shall be staggered.			
7.3	**PROTECTION FROM WATER**				
7.3.1	The installation of the pipe lines for the static and pitot systems shall be such as to minimise the entry or the accumulation of water.	In this connection pipes having an inside diameter less than 6.25mm (0.25 in) will not normally be acceptable.			
7.3.2	When a static vent is fitted, there shall be an immediate vertical rise of at least	When it is impracticable to have a continuous rise in the pipe lines from the static or			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	150mm in the pipe at the static vent inlet, wherever this is possible.	pitot pressure source to the instruments, accessible drain traps which are proof against leaks shall be fitted at the lowest points between each fall and rise in the pipe lines. The lowest points shall be determined when the rotorcraft is in the normal attitude on the ground.			
7.3.4	The capacity of the drain traps shall be kept to a minimum to limit the lag in the system but shall be sufficient to cater for the condensation arising as a result of one flight in the most critical case (for condensation) of the roles specified under the maximum humidity conditions of Leaflet 101.				
7.4	**PROTECTION FROM ENEMY ACTION**				
7.4.1	When two static vent systems and/or two pressure heads are fitted, the run of the pipe				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	lines shall be as far apart as possible, preferably on opposite sides of the fuselage.				
8	**INSTALLATION OF STATIC AND PITOT SOURCES**				
8.1	**PITOT-STATIC BOOM MOUNTING**				
8.1.1	Pitot and pitot-static probes shall be equipped with a positive means of alignment, to prevent incorrect installation. Consideration shall be given to marking probes, where appropriate, to indicate intended alignment. The probe(s) shall be securely mounted, with particular regard to birdstrike requirements.				
8.2	**PITOT-STATIC SYSTEM ANTI-ICING**				
8.2.1	The Pitot-Static system shall be capable of continuous operation in the icing environment defined in Leaflet 711/1 such that it will	Icing effects shall be considered at various angles of attack in the choice of location of flush static vents.			29.1325 29.1325c

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	still meet the requirements of para 3 in respect of pressure errors, and the system calibration shall not change by the equivalent of more than 0.5 kt IAS in airspeed or 5 ft in indicated altitude.				
8.2.2	Where a pitot or a pitot-static probe is mast mounted, any icing protection supplied to the mast shall be so connected that it will operate concurrently with the pitot or pitot-static probe anti-icing system.				
8.2.3	All electrically de-iced pitot and pitot-static systems shall be equipped with a monitor to detect heater failure. The monitor shall not degrade the reliability of the heater circuitry.				
8.3	**HOSES**				
8.3.1	Where flexible hoses are required they shall be in accordance with AGS 3914 for pitot lines and AGS 3915				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	for static lines.				
9	**STATIC VENTS**				
9.1	When the rotorcraft is in any steady flight condition, at zero sideslip, and the rotorcraft is subsequently yawed to a sideslip angle of 10o, the airspeed indicator shall not change by more than 2kt, and the altitude indication shall not change by more than 15 ft.				29.1325 29.1325b
9.2	When the static pressure is derived from static vents, these shall be fitted at corresponding positions on each side of the fuselage each being interconnected with the corresponding vent on the opposite side of the fuselage, and the instrument connection being taken from the mid-point of this interconnection.				
10	**PRESSURE SOURCES FOR EQUIPMENT**				
10.1	The pitot and static systems				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	supplying the pilot's primary instruments shall not be used for instruments or equipment which may be removed for servicing.				
11	**CALIBRATION FACILITIES**				
11.1	To facilitate calibration checks on instruments in situ, two-way test valves shall not be fitted in the pipe lines. These tests can instead, be carried out using the external static and pitot sources.				
12	**GROUND TESTS**				
12.1	**LEAKAGE TESTS**				
12.1.1	Tests shall be made on the piping system alone, by the method detailed in Leaflet 716/1, para 2, to detect any pressure drop.	The test must show no pressure drop from 69kPa (10 psi) after 10 minutes.			29.1325 29.1325d
12.1.2	Tests shall be made on the complete installation, by the method detailed in Leaflet 716/1, para 3, to measure the time for the altimeter reading to fall from 5,000 ft to 4,800				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	ft and the ASI reading to fall from 130kt to 125kt. In each case the time shall not be less than 3 minutes.				
	Sub-Leaflets				
	LEAFLET 716/1 STATIC AND PITOT PRESSURE SYSTEMS TESTS				
	LEAFLET 716/2 STATIC AND PITOT PRESSURE SYSTEMS AERODYNAMIC REPEATABILITY				
	LEAFLET 713				
	MAGNETIC COMPASS INSTALLATIONS				
1	**INTRODUCTION**				
	This Leaflet deals with the installation of magnetic compasses and states those requirements which shall be met to ensure the satisfactory operation of the compass.				
1.3	Where a remote indicating compass is provided as the primary heading reference, a direct indicating compass shall also be fitted for use as a standby.	Note: The term standby is taken to include both the normal and emergency uses of the standby compass.	There are 2 main types of compass in use: (i) the direct indicating compass, and (ii) the remote indicating compass. A lesser degree of accuracy		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			may be sufficient for a remote indicating compass which does not feed automatic direct reading equipment or for the direct indicating compass (whether this is the normal or standby compass), but reliability is still necessary. A high order of accuracy is required for a remote indicating compass which feeds ancillary equipment such as automatic direct reading instruments; this is particularly necessary for navigation computers which combine compass heading with Doppler information.		
2	**POSITION OF COMPASS**				
2.1	The direct indicating compass shall be installed so that it can be easily read from each pilot's seat position with a minimum of parallax error under all operating conditions of flight and on the ground.	In the case of bearing plates, repeaters or compasses, due regard shall be given to the arcs of vision specified for the particular rotorcraft.			
2.2	The position of any compass				

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	of the set heading type shall be such that each pilot can adjust the grid ring, clamping arm or set heading device without difficulty during flight.				
2.3	Adequate clearance shall be allowed around the compass bowl to ensure that the movement of the bowl inside the container is unrestricted.				
2.4	Sufficient space shall be provided, where appropriate, for the fitting of a deviation corrector (ie when an internal corrector has not been incorporated in the compass system).				
2.5	Easy access shall be provided to the deviation corrector to permit adjustments to be made. The movement of the corrector key shall not be restricted.				
2.6	The direct reading compass and the detector unit of a remote indicating compass	To this end, they shall be mounted in a position as remote as possible from	As a guide, the minimum safe distance of these materials from the detector units of		29.1327a 29.1327b

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	shall be mounted in such a position that at all times the installation complies with the deviation limits given in Table 2 (See also Para 6).	magnetic materials.	remote indicating compasses is 1.5 metres (5ft).		
3	**ALIGNMENT OF COMPASS AND CORRECTOR**				
3.1	A separate deviation corrector shall be provided when an internal unit has not been incorporated in the compass system.				
3.2	All direct indicating compasses, the detector units of remote indicating compasses, standards and correctors which are not already built into the compass shall be attached rigidly to the structure by means of their securing points so that in the normal flying attitude: (i) the locating plane of the unit is horizontal or vertical, according to the type	No 3 and No 4 correctors for P type compasses shall be mounted on the compass bracket with their fixing lugs towards the compass. The vertical centre lines of each compass and its corrector shall be coincident. The correctors should not be separated from the compass by more than 3 mm.			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	of unit concerned, and (ii) the vertical plane through the fore and aft line of the unit is parallel to the vertical plane through the fore and aft axis of the rotorcraft.				
4	**DEVIATION CARDS**				
4.1	Holders suitable for standard compass deviation cards shall be provided at positions agreed for each type of Rotorcraft.				
5	**INTER-COMPASS SAFE DISTANCES**				
5.1	The distances between the magnetic elements of compasses/detector units shall not be less than those shown in Table 1.				
6	**PERMISSIBLE LIMITS**				
6.1	The design of the structure and position of the equipment and electrical wiring in the vicinity of the compass and detector unit shall be such that the figures given in Table		Note: The following are likely to jeopardise this requirement: (i) ferro-magnetic bolts, nuts and washers in instrument coaming and		

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	2 are not exceeded.		windscreen arches, set at a distance from the magnetic element less than their safe distances, (ii) single pole DC wiring or loops in the cockpit area or near the detector unit, (iii) single pole DC wiring from engine driven generators or ground supply, especially if the ground supply point is positioned at a distance from and in a different horizontal plane from the engine driven generator, (iv) unscreened AC cable in the vicinity of the detector unit, (v) unscreened signal leads between detector and amplifier.		
6.2	In the case of components subjected to shock, such as undercarriage units, the limits specified shall refer to the component in the shock magnetised condition (See				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	para 9.1).				
6.3	A vertical corrector shall be fitted if the change in deviation due to movement of the Rotorcraft from ground to normal cruising attitude is 2° or more.				
7	**DIRECTIVE FORCE**				
7.1	When it is anticipated that the directive force at the compass position is likely to be impaired due to the presence of soft iron, tests shall be carried out to determine the co-efficient l (lambda).	This is especially important when it is likely that compass swinging techniques will be used where the whole swing will be carried out with the rotorcraft on one heading. If a low lambda is found, the acceptability or otherwise of the value should be established in conjunction with the Admiralty Compass Observatory.	(Lambda is the ratio of the mean value of the horizontal force at the compass position, as deduced from readings with the rotorcraft on a number of headings, to the horizontal force which would be experienced in the Earth's magnetic field alone at the same point).		
8	**DEMAGNETISATION**				
8.1	Components which have been subjected to strong magnetic fields, such as magnetic flaw detection tests or production operations involving the use of magnetic chucks, and	All drawings of such components shall be marked as follows: "De-magnetise, Compass test at "x" metres".	(See Leaflet 715/3 for the demagnetising methods that can be used)		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	which are liable to affect the compass shall, prior to assembly, be demagnetised .	Where "x" equals the distance from the compass the component will be when assembled in the Rotorcraft.			
9	**TESTED EQUIPMENT**				
9.1	All equipment shall be positioned outside its specified safe distance. The safe distance shall be determined in accordance with BS 3G.100: Part 2: Section 2.	If it is not possible to comply with the specific safe distances, the Rotorcraft Project Director shall be consulted.			
10	**COMPASS CALIBRATION**				
10.1	Provision shall be made for the accurate alignment of the Rotorcraft to: (i) one tenth of a degree on Rotorcraft fitted with "Doppler" navigation equipment, and (ii) one quarter of a degree on all other Rotorcraft.				29.1547a 29.1547b 29.1547c 29.1547d
10.4	Where removable sighting rods are used, they shall be in	Where possible, sighting rods shall be so arranged that			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	a form suitable for transportation by the Rotorcraft and shall be considered as ground servicing equipment.	sighting may be made from either ahead or astern of the Rotorcraft. It shall be possible to determine the verticality of the rods (in the athwartships plane) and also possible to lock the rods in the true vertical position. The fixed portion of the rods (ie, the part fixed to the Rotorcraft) shall be parallel to the Rotorcraft vertical datum in the athwartships plane. The points of suspension (eg, the line through the joints or pivots) of the movable parts of the rods shall be parallel to the horizontal flight datum (ie, that datum which is horizontal when the Rotorcraft is in a normal flying attitude). The rods shall be so designed that the one farther from the sighting device can be readily aligned to and is visible below the nearer rod when viewed from a height of 1.5 metres at a			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		distance of 25 metres from the nearer rod. (Rods of triangular cross-section, the further one pointed and the nearer one Vee-notched, will achieve this). The use of protruding equipment provided for other purposes (eg, wireless mast) or the use of paint marks on the structure is not acceptable for sighting purposes.			
11	**COMPASS ACCEPTANCE TESTS**				
11.1	A complete magnetic and electrical investigation of the compass installation on the general lines given in Leaflet 713/4 shall be made, in consultation with the Admiralty Compass Observatory, on the first prototype and the first fully equipped production rotorcraft.	The Rotorcraft supplied for navigation assessment purposes shall be checked on 2 occasions, separated by an interval of at least 20 hours flying time, to ensure that the compass deviations remain within the limits in Table 2.			
	TABLES				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	TABLE 1 **MINIMUM DISTANCES BETWEEN COMPASSES**				

	Minimum Distances between the centres of the instruments in metres (inches)			
Compass Type	**P11 with No 3 or 4 Corrector**	**P12 with No 3 or 4 Corrector**	**E2**	**Remote Indicating Detector Units**
P11 with No 3 or No 4 Corrector …	0.51 (20)			
P12 with No 3 or No 4 Corrector …	0.51 (20)	0.51 (20)	0.31 (12)	
E2 … … … …	0.51 (20)	0.51 (20)		
Remote Indicating Detector for Units …	1.02 (40)	1.02 (40)	0.61 (24)	0.41 (16)

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
					29.1327a 29.1327b

TABLE 2

PERMISSIBLE LIMITS OF COEFFICIENTS AND CHANGE IN DEVIATION OF COMPASSES

		Main Compass		
		Remote Indicating	Direct Indicating	Stand-by
(i)	Permanent magnetism of structure and equipments as given by uncorrected coefficients B and C (in a field of 18 microtesla 'h' and 43 microtesla 'z')	2°	10°	20°
(ii)	Induced magnetism as given by coefficients D and E	0.25°	1°	2°
(iii)	Operation of electrical equipment. Maximum deviation from:-			
	(a) Individual circuits	) 0.25°	(1°	2°
	(b) Any combination of circuits	)	(3°	5°
(iv)	Changes due to modification of the rotorcraft or equipment provided conditions (i) and (ii) are not exceeded:-			
	(a) Individual	) 0.25°	(1°	1°
	(b) Any combination of mods.	)	(3°	3°
(v)	Moving components when moving between limiting conditions. Change of deviation (see para 6.2)	0.25°	1°	2°
(vi)	Changes in magnetism of fixed structure subjected to intense shock. Change of deviation.	0.25°	1°	2°
(vii)	Change in deviation between ground and normal cruising position (see para 6.3)	0°	5°	5°
(viii)	Changes due to changing from engine running to engine off states. Change of deviation	0°	1°	2°
(ix)	Changes due to changing from external ground electrical supply to 'in flight' supply. Change of deviation	0°	1°	2°
(x)	Changes due to installation of role equipment eg ECM/RECCE pods (See Note 1)			
	(a) Individual items	) 0.25°	(1°	1°
	(b) Any combination of items	)	(3°	3°
(xi)	Changes due to fitting Armament and/or Guided Weapons (See Note 1)	) 0.25°)	(1° (3°	2° 5°
(xii)	Total Changes (sub-para. (iii) to (xi))	0.5°	5°	8°

Notes: 1 Equipments that are normally non-disposable shall meet the requirements of (x) and those that are normally disposable shall meet the requirements of (xi).

2 Any secondary compass which will be used for the completion of a mission in the event of the failure of the primary compass shall be subject to the 'Main Compass' requirements.

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Sub-Leaflets				
	LEAFLET 713/1 MAGNETIC COMPASS INSTALLATIONS EFFECT OF MAGNETIC STRUCTURE				
	LEAFLET 713/2 MAGNETIC COMPASS INSTALLATIONS EFFECT OF WIRING				
	LEAFLET 713/3 MAGNETIC COMPASS INSTALLATIONS DEMAGNETISATION				
	LEAFLET 713/4 MAGNETIC COMPASS INSTALLATIONS ACCEPTANCE OF TYPE TESTS				
	CHAPTER 706				
	ELECTRICAL INSTALLATIONS				
	NOTE: The Ministry of Defence requires the minimum use of Cadmium in its equipment. To this end, the use of Cadmium should be reviewed on a case by case basis with the IPTL and a suitable alternative used where appropriate.				
1	**INTRODUCTION**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	The requirements for this chapter apply to all electrical systems in aircraft. An electrical system comprises those electrical units and components which generate, distribute and control the supply of ac and/or dc electrical power for other systems. Characteristics of electrical generating and distributing and consumer units are given in Def Stan 00-35 & STANAG 3456. Leaflet 706/1 makes general recommendations concerning the design of electrical installations, and Leaflet 706/2 gives further information on the standard power supplies and their application to the installations. Leaflet 706/3 lists British Standards and Defence Standards which contain advice on accessories and components.				
2	**GENERAL REQUIREMENTS**				
2.2	All installations and systems shall function correctly under all conditions, on the ground, in flight and at the altitudes for which they are required to operate. In pressure cabin aircraft, any electrical equipment necessary to enable the aircraft to return to base safely in all weather conditions shall continue to function satisfactorily in the event of cabin pressure failure occurring at maximum distance from base. The maximum distance from base	The operating requirements will be stated in the Aircraft Specification.	*NOTE: a) Essential Services are those required for continued safe flight. b) Standby Services are those providing secondary alternatives to a primary system. c) Emergency Services are defined in SUBPART D Leaflet 105, para 11.3.		29.1309a

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	should be related to the maximum altitude at which the aircraft can operate in the unpressurized condition.				
2.3	The aircraft designer shall categorize all electrical services as either *Essential, Standby, or Emergency, as appropriate to the aircraft and the operational role specified. The Aircraft Project Director/specification will specify the reliability required in terms of failure probability for each of these categories. The designer shall prepare a safety assessment of the electrical system in accordance with the requirements of Chapter 117 (to be issued) using the reliability targets quoted in the specification/Leaflet 117/2 or as agreed with the Aircraft Project Director.				29.1309d 29.1309e 29.1309g 29.1351d2i 29.1351d2ii 29.1351d2iii
2.4	No failure condition of the				29.1309b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	electrical installation resulting from a single failure, a second failure or unrevealed dormant fault, or a combination thereof shall jeopardise: a) the safety of the aircraft, or its occupants in flight, taxying, take-off, landing, or on the ground b) the ability of the crew to escape from the aircraft c) the ability of the aircraft to return safely from a mission subsequent to such a failure.				29.1309b1 29.1309b2 29.1309b2 i 29.1309b2 ii 29.1309c
2.5	All electrical equipment, including wires and cables, shall be so installed as to: a) operate satisfactorily in the particular local environment having due regard to the possibility of that environment becoming more adverse as a result of a failure or battle damage b) minimize the	d) be easily accessible for inspection and servicing e) have minimum vulnerability, to battle damage	SUBPART D Leaflet 712 SUBPART G Leaflet 101 & 806 para 8 Section 3 Leaflet 112		29.1309a 29.1309b1 29.1351b2 29.1351b5 29.1351d1 i 29.1353a

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	secondary effects of primary failure (however caused) c) remain unaffected by moisture and liquids liable to come in contact with it f) minimize the risk of fire or explosion from inflammable liquids and gases and from electrically initiated explosive devices, both in flight and during ground operations g) minimize the risk of electrical shock or injury to personnel, e.g., from exposed live conductive parts, fire, toxic fumes etc. Exposed live parts of systems and equipment shall be mechanically protected so that the probability of short circuits and earth faults is remote h) minimize the risk of accidental damage by the crew and ground personnel j) be marked so as to				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	make identification possible under all conditions of servicing .				
2.6	The changeover from external to internal power supply shall be automatic when the aircraft generator(s) come "on line", except where the two supplies can be safely operated in parallel.				29.1351b1
2.7	Where load shedding occurs under conditions of engine or generator failure, provision shall be made for retaining those services, including the essential services defined in Leaflet 712/1 para 2.16, necessary for the time stated in the aircraft specification. .		see para 3.3, SUBPART A Leaflet 100 para 9.2 SUBPART B Leaflet 600 para 5		29.1309e 29.1351b 29.1351b5 29.1351b6
2.7.1	After Total Generator Failure. Power supplies for the following services shall be available to enable continued controlled flight and emergency landing to operate for the period defined in the aircraft specification:		SUBPART A Leaflet 100, para 18		29.1309e 29.1331 29.1331 29.1331a1 29.1331a2 29.1351b6 29.1351d2 i

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	a) primary flight controls (when electrically actuated) b) power plant controls (when electrically actuated) c) stability augmentation systems (when these are critical to flight safety) d) one indicator each displaying aircraft attitude, airspeed and altitude, including operation of the relevant pitot-static de-ice and instrument lights e) one radio communication equipment and minimum internal communication equipment f) one navigation aid g) re-excitation of an inoperative generator h) re-start of an inoperative engine j) jettison of stores k) escape system(s) l) minimum instrumentation displayed, and continued fuel supply m) environmental control				29.1351d2 iii

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	system.				
2.7.2	After Single Generator Failure of a Multiple Generator System. Power supplies for the following services shall be available in addition to those listed in para 2.7.1 to allow completion of the aircraft sortie: a) fuel management b) where navigation, communication or instrument systems are duplicated, only one of each system may become inoperative c) any service essential for the completion of the operational role (see para 3.3.2).				29.1331 29.1331 29.1331a1 29.1331a2 29.1351d2 i 29.1355b
2.7.3	Continuous Supply. Power supply for the following shall be available at all times independent of any aircraft master switch or load shed arrangements other than battery contactors:		*NOTE: If these systems are fitted then their continuous power supply must be provided by additional batteries charged from the aircraft main bus bars. SUBPART A Leaflet 100		29.812e 29.812f 29.1351d2 i 29.1457d 29.1457d1

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	a) fire extinguishers and detection b) *emergency lighting c) *systems having volatile memory (when electrically activated) d) primary flight controls e) crew intercommunication (when appropriate) f) escape means g) ADR and CVR		para 9.2. SUBPART A Leaflet 100, paras 21 and 22		
2.8	Emergency escape illumination shall be provided independent of normal power sources SUBPART A Leaflet 102, para 3.1 (d)).				29.812a 29.812a1 29.812e 29.812f
2.9	Means of isolating electrical supplies shall comply with para 8.				29.863 29.863a 29.863b 29.863b3 29.863b4
3	**POWER SUPPLIES**				
3,1	**GENERAL**				
3.1.1	The power supplies shall be selected from those listed in Table 1 and shall meet the	The nominal voltage and nominal frequency at the bus bars shall be as specified in	NOTE : Where there is a requirement for a different power supply to those listed		29.1351b 29.1351b3

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	requirements of BS 3G100 Part 3[1].	Table 1. All consumer equipment shall be suitable for operating on a power supply conforming to the requirements of BS 3G100 or superseding Defence Standard.	in Table 1 and Table 2 - approval must be obtained from the Aircraft Design Authority and agreed with the MOD Project Director.		
3.1.2	For installed aircraft electrical systems, transient voltage spikes shall not exceed the limits for equipment exported spikes given in DEF STAN 59-41, Part 3, test method DCE03.				29.1351b3 29.1351b4
3.1.3	All generators shall be self exciting.				
3.1.4	The electrical installation shall be capable of being functioned from a ground supply whose characteristics conform to those specified in BS G219				29.1351b1 29.1351c
3.1.5	Means shall be provided to give immediate warning of the failure, or deterioration beyond trip limits of voltage or frequency , of power		(see Leaflet 107, para 12.1) (see Leaflet 706/2)		29.1309c

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	supplies to the bus bars from each source of electrical power. The warning shall identify the particular source affected and shall not itself be rendered inoperative by any single failure of the power system.				
3.2	**SYSTEM CAPACITY (NORMAL)**				
3.2.1	The generating capacity shall be adequate to meet the largest transient peak loads which can occur with the aircraft fulfilling its operational roles, including taxying, take-off and landing and shall meet the failure conditions considered in para 2.	With throttles set at approach r.p.m. there shall be sufficient generated power to provide full operational facilities when descending at minimum speed from maximum attainable altitude to ground level. When a constant speed drive is fitted, there shall be sufficient generated power to provide full operational facilities if the engine power is set at 'flight idle'. With the necessary engines running at a speed			29.1309a 29.1309e 29.1309e1 29.1309e2 29.1309e3 29.1309e3 i 29.1309e3 ii 29.1351a 29.1351a1 29.1351a2

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		approximately 20% above minimum ground idling speed, it shall be possible, without discharging batteries, to exercise and check on the ground all electrical equipment installed in the aircraft.Generating capacity shall not rely on assistance from storage batteries, except that peak demands of short duration may be proposed by the Aircraft Design Authority for consideration by the MOD Project Director.			
3.2.2	The generating capacity shall be at least 50 per cent greater than the maximum continuous demand.	This estimate shall be based on the fully equipped aircraft as at the date of the Final Conference or earlier as agreed with Aircraft Project Director.	(see also Leaflet 706/2, para 3).		
3.3	**SYSTEM CAPACITY (EMERGENCY)**				
3.3.1	Sufficient power shall be available to retain those electrical services necessary, for operating the aircraft for	In the event of main generator failure alternative supplies shall be provided from either:	The Aircraft Specification will state whether the aircraft is required to complete the mission without the loss of		29.1351d 29.1351d1 29.1351d1 i

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the endurance period stated in the Aircraft Specification.	a) the main battery b) a standby battery carried solely for the purposes of emergency power c) a standby generator powered either by an emergency ram air turbine, or an auxiliary power unit capable of starting and operating in flight.	services after the failure of a particular supply channel. (see also Leaflet 100, para 9)		29.1351d1 ii 29.1351d2 29.1351d2 i 29.1351d2 ii 29.1351d2 iii
3.3.4	Where batteries are installed the duration of operation when supplying emergency loads shall be determined and shall be declared for inclusion in Air Publications .		(see also paras 2.4 and 7.2.1)		
4	**GENERATOR SYSTEMS**				
4.1	**GENERAL**				
4.1.1	Each generator system shall provide an output conforming to the supply characteristics required by BS3G100 or superseding Defence Standard (see Table 1) and shall be capable of withstanding the transient condition specified in				29.1351b 29.1351b3

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	BS3G100 Part 3.				
4.1.2	Self exciting generators are required, but additional instantaneous excitation shall be provided to overcome a possible emergency situation.				
4.1.3	Provision shall be made to limit the input torque to a generator unless means to disconnect the drive is provided.				
4.2	**INSTRUMENTATION**				
4.2.1	Means shall be provided to monitor the voltage and load provided by each generator, and in addition a frequency meter shall be provided for ac systems.				29.1351b6
4.2.2	Warning lights shall be provided to indicate whenever a generator output is disconnected from the distribution system.	This warning shall be repeated in a central or master warning system (where fitted).			29.1309c
4.2.3	Warning and control systems shall not be reliant on the power supply they monitor.				
4.3	**LOAD SHARING**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
4.3.2	Ac frequency wild generators shall not be operated in parallel unless their output is rectified.				
4.3.3	The capacities of generators operating in parallel shall be selected in accordance with para 3.	Provided regulation circuits ensure the total load is evenly divided: a) similar dc generators may be operated in parallel b) similar ac constant frequency generators may be operated in parallel.			29.1355b
4.4	**GENERATOR CONTROL AND PROTECTION**				
4.4.1	Each generator installation shall have its own segregated control and indication system. Separate or switch selected instruments may be installed.				29.1351b1
4.4.2	Control shall provide for interruption of the generator output and separate interruption of the generator excitation.				29.1351b5
4.4.3	Each generator shall be protected from overload and fault conditions. Ac	The response of a particular system shall be adequate to safeguard the equipment but			29.1357b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	generators shall be protected from excessive imbalance of the load.	shall not be so sensitive as to give nuisance disconnections.			
4.5	**GROUND CURRENT EFFECTS**				
4.5.2	Main connections to ground shall be adequate for the conduction of any current, including possible fault currents, which it may be necessary to carry.	The metallic airframe is used normally as the ground conductor for: a) the negative or return in a 28V dc system b) the neutral in a 115V ac single phase system c) the star point in a 200/115V ac 3 phase system. Where a metallic airframe is not used special bonding conductors shall be installed .	(see Leaflet 708)		29.610d1 29.610d3
4.5.3	Main connections to ground shall be located such that high circulating currents do not exist in the vicinity of compass detectors or directionally sensitive radio aerials.				
4.5.4	Where special ground bonding conductors are used these are considered in a				29.610d4

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	similar manner to cables carrying high currents. Electromagnetically sensitive equipments shall be located remote from these installations.				
4.6	**COOLING**				
4.6.1	Adequate ventilation and cooling shall be provided to meet all possible operating conditions.				29.1309g
5	**CIRCUIT**				
5.1	**BASIC REQUIREMENT**				
5.1.1	The aim shall be to ensure that the installation of cables, bus bars, electrical components and their supports and insulation will be such that they are capable of withstanding throughout the life of the aircraft the worst effects of vibration.	All conditions likely to be encountered on the ground and up to the design flight envelope shall be taken into account (in particular the effects of vibration and environmental conditions such as gun firing effects, severe wind and moisture prone areas, high temperatures, condensation, fuel contamination, hydraulic oil contamination and de-icing fluids).	Consideration as required by DEF STAN 00-40 shall be given to reliability and maintainability. The guidance on reliability and maintainability procedures and practice given in DEF STAN 00-40 shall be followed where practicable.		29.1309a 29.1309g 29.1353b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
5.2	**CIRCUIT CONTROL**				
5.2.1	All switching of electrical circuits shall be as shown in Table 1.				
5.3	**CIRCUIT PROTECTION**				
5.3.1	Each electrical circuit and distribution feeder shall be automatically protected against short circuits (see also Table 1). When safety considerations so dictate, similar protection shall also be made against overload.	Electronic Circuit Protection devices that can be reset whilst in flight manually or automatically should be limited to 3 or less circuit resets for essential loads. The circuit protection device should be inhibited from attempting to reset if short circuit or overload conditions persist.	NOTE: This requirement does not apply to heavy duty circuits for direct electrical starting of engines.		29.1357a
5.3.2	When circuit breakers are used they shall be of such design that although the external operating mechanism may be held closed, the tripping device when carrying overload current will open the circuit.				29.1357c
5.3.3	Where protective devices are used in series, their characteristics shall be		(see also Leaflet 706/1, para 3)		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	compatible .				
5.3.4	The characteristics of devices used to limit current, voltage or frequency in any one circuit shall be compatible with each other and their effective operation shall not be prevented by any power supply deviations which may occur.				
5.3.5	Protective devices shall be disposed in groups, physically protected to decrease vulnerability, and shall be installed as near to the bus bar or appropriate distribution point as possible. Such devices and their controls shall be accessible and easily identified. A statement of the nominal rating of each fuse shall be provided in the vicinity of the fuse. Where neon lamps are used as fuse indicators, they shall adjoin the fuse monitored.	In certain circuits, as agreed with the Aircraft Project Director it will be necessary for a circuit breaker or fuse to be under the control of a particular crew member. In such circuits the full circuit protection of para 5.3.1 shall also be provided. Circuit breakers shall not normally be used as ON/OFF switches.			29.1357d

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
5.3.7	Provision shall be made for carrying as spares at least 5 per cent and a minimum of 1 of each type of fuse of the ratings installed. They shall be located at the appropriate station in the aircraft. Fuse stowages shall be provided with means for identifying the fuse rating. Unused fuse holders shall be fitted with dummy fuses.				29.1357f
5.4	**SPARE CIRCUITS**				
5.4.1	For new aircraft, allowance shall be made for a minimum of ten percent increase in the number of main cable runs, connectors, circuit breakers and fuse holders above those in use at the time of the Final Conference, or earlier as agreed with the Aircraft Project Director, and sufficient space be left in junction boxes and control panels for such increases (for updates to existing aircraft a				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	five percent increase is acceptable).				
5.5	**GROUNDING OF CIRCUITS**				
5.5.1	When single pole wiring is used, the airframe shall be capable of carrying the electrical load of grounded equipment between the local ground points and the main ground points with a voltage drop not exceeding 0.5 volt.		This is of particular importance for the airframe path between the ground point of each power source, i.e., Generator, TRU, or battery, and that of its associated voltage regulator.		
5.5.2	Grounding attachments shall be so secured to the airframe that during their operational use there will be no risk of the attachment loosening.				
5.5.3	The grounding attachments to the airframe shall be protected to prevent corrosion at the joint.				
5.5.4	Failure of a grounding cable or attachment shall not adversely affect more than one circuit or more than one part of a multiple circuit, nor shall it cause the inadvertent		(see Leaflet 706/1, para 2.1.3)		

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	operation of any circuit. No more than four wires shall be connected to a single ground stud provided the effect of failure of the stud is no more severe than the associated supply protection or control device going open circuit.				
5.5.5	When terminal block connections are used for grounding groups of cables the common ground shall be connected to the airframe by at least two cables and two separate grounding points, each capable of carrying the full ground current of all equipments connected to the block with a voltage drop not exceeding 0.1 volt.		(see also para 5.5.8) NOTE : Modern earthing modules have built in earthing feet which dispenses the need for earthing cables.		
5.5.6	Ground points shall be clearly identified and readily accessible to servicing personnel .		(see Leaflet 806)		
5.5.7	The grounding of all electrical panels, chassis equipment and wiring				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	components shall be such that under any fault condition the protection device shall operate and the sustained voltage developed between exposed metal and the aircraft structure shall not exceed a maximum of 50 V ac and 120 V dc (including ripple).				
5.5.8	Grounding terminations of ac and dc systems or systems having different voltage supplies shall not have a point of common mode failure and shall not be connected to a common stud, bolt or other connection.				
6	**INSTALLATION**				
6.1	**GENERAL**				
6.1.1	All electrical equipment shall comply with BS3G100 or superseding Def Standard.				
6.1.2	All electrical equipment shall be adequately attached to airframe, sub assembly or power plant unit. Neither the items of equipment nor their				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	immediate casings shall be subject to, or assist in the carriage of structural loads existing in the assembly to which it is attached.				
6.1.3	All installations shall comply with the requirements for Electromagnetic Compatibility contained in DEF STAN 59-411.				
6.1.4	Interconnecting electrical wiring shall be installed using components, (e.g., terminal posts, terminal blocks, terminal junction modules or electrical connectors) and methods of support (e.g., cable ducts, conduit, open looms in conjunction with cable ties and cleats) that meet with specifications approved by the Aircraft Design Authority and agreed with the MOD Project Director.				
6.1.5	Wiring of a type appropriate to the electrical load, duty		(See also Leaflet 706 para 6.6, Leaflet 712 para 6.6.4		29.1301 29.1301

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	and environment shall be used.		and DEF STAN 61-12)[2].		29.1301a 29.1309a
6.1.6	The choice of termination shall be determined by the duty and environment envisaged. Components featuring crimped cable ends are preferred .	Where necessary cables, connections and terminations shall be provided with additional protection.			
6.1.7	The cable and type of termination shall be selected and approved by the Aircraft Design Authority and agreed with the MOD Project Director.				
6.2	**TERMINAL POSTS**				
6.2.1	Terminal posts shall be adequately supported in an insulator suitable for the environment. Terminal posts shall be sized appropriately for the circuit rating.	The terminal post manufacturer's recommended electrical and physical stud loading shall not be exceeded.			
6.3	**TERMINAL BLOCKS**				
6.3.1	Only approved assemblies of appropriate rating shall be installed.	The manufacturers' recommended configurations shall be followed. Terminal blocks shall be selected appropriate to the circuit			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		rating.			
6.4	**ELECTRICAL CONNECTORS**				
6.4.1	Circular electrical connectors shall be selected from the types listed in DEF STAN 59-35 (Part 0), Section B, Table C-1 which are approved for airframe-fit and avionics applications. Limitations of use shall be noted, e.g., unsuitability for blind mating etc.	The type of connector selected shall be agreed with the Aircraft Project Director.			
6.4.2	Cable-clamping accessories shall be used to provide proper restraint for wire and cables.		Straight and angled outlets are available for each type of airframe connector.		
6.4.3	The applications of mated pairs of connectors shall be such that in the event of separation, only female (socket) contacts shall be connected to the live supply. Unmated connectors shall be fitted with protective covers.				
6.5	**INTERCONNECT WIRING**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
6.5.1	When installed, all electrical wires shall be adequately restrained with approved devices appropriately applied. Electrical wires shall be held clear of moving mechanical parts.				29.1353b
6.5.2	All electrical wires shall be clearly identified either by code, legend, or colour or combination thereof. Each wire of a multicore cable shall be identified.		SUBPART G Leaflet 806.		
6.5.3	All wires and cables shall be installed so as to minimise the probability of inadvertent operation or malfunction of equipment resulting from: a) resistive voltage components and/or fast flux coupling generated by the application of the lightning test waveforms defined in the UK AEA Culham Laboratories Report CLM-R-163 (see Leaflet 708/3 and DEF STAN 59-113)				29.1309a 29.1309b 29.1309h

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	b) coupling with electromagnetic fields to the levels defined in Naval Weapons Specification (NWS) 1006 Annex A and BS 3G100 or superseding Defence Standard.				
6.5.4	All wires and cables associated with fire warning and fire extinguishing equipment shall be so routed that the probability of damage resulting from the break up of a high energy rotor, the rupture of a high energy storage container, or a crash landing is reduced to a minimum.		(see Leaflet 712 and Leaflet 100, para 24).		29.1353a
6.5.5	At distribution boxes (panels) the sections carrying voltages exceeding a nominal 28 volt shall be separated from sections carrying voltages not exceeding 28 volt. High voltage sections shall be clearly marked with the highest effective voltage				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	value found in that section. Lids (covers) of the distribution boxes (panels) shall also be clearly marked with the voltage values and shall be so designed that they cannot be replaced on the wrong box.				
6.5.6	All external terminals of electrical equipment shall be locked by methods to be agreed with the Aircraft Project Director.		(see also Leaflet 706/1, para 5.3)		
6.5.7	In-line splices shall not normally be used; when their use in general airframe wiring is unavoidable, the agreement of the Aircraft Project Director shall be obtained.	The location of these splices shall be clearly defined in the aircraft drawings and I.A.W. MAP RA4552			
6.5.8	The outer conductor of a screened cable shall be terminated with a suitable RFI backfitting.	Should this not be possible, cable screens may be terminated by a short flying lead of adequate cross section provided it is not grounded within any equipment case.			
6.5.9	Where conduit is installed adequate drainage shall be				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	provided.				
6.5.10	Wiring between terminal blocks or connectors and an airframe grounding stud shall be clearly marked as a 'Ground' connection.				
6.5.11	Wiring harness power density criteria shall be as specified in US MIL-W-5088L para 3.8.8-1.1.				
6.5.12	Compatibility between circuit breaker time/current characteristics, cable ampere rating characteristics and load characteristics shall be as specified in US MIL-W-5088L, para 6.7.				
6.6	**SELECTION OF INTERCONNECT WIRING**				
6.6.1	For national programmes, general purpose aircraft wires and cables are to be qualified to DEF STAN 61-12 Part 33 or an equivalent Specification demonstrated to fulfill these requirements as a minimum.	On international projects, the technical basis of national Specifications should be applied.	See also Leaflet 706/1 para 4.1.14		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
6.6.2	Wires and cables shall have a demonstrated resistance to arc tracking as defined in Defence Standard 61-12 Part 33.				
6.6.3	Wires and cables which employ an outer sheath, commonly known as a topcoat, in their construction are to have proven topcoat durability, by compliance with test procedures defined in DEF STAN 61-12 Part 33 or an equivalent Procedure demonstrated to fulfill these requirements as a minimum.		It should be noted that wires and cables compliant with these requirements may contain polyimide (commonly referred to under the trade name Kapton) in the construction of their insulation. See also leaflet 706/1 para 4.1.14.		
7	**BATTERIES**				
7.1	**CONTROL (see also Chapter 107, Table 6, Item 2)**				
7.1.1	Each battery shall be capable of isolation from the aircraft electrical system except those services required in an emergency and specified in the aircraft specification.		A warning should be provided in the Pilot's Notes, that in the event of a total loss of generated power, the battery must be connected to its appropriate bus bar regardless of an overheat		29.1353c6 iii

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			condition being indicated.		
7.1.2	The battery shall be designed to withstand thermal runaway without failure of the case structure or leakage of electrolyte. The battery installation shall be designed to minimise damage to the airframe from battery electrolyte in the event of a cell or battery case failure from any cause.				29.1353c3 29.1353c4 29.1353c6 29.1353c6 ii
7.2	**CAPACITY**				
7.2.1	The capacities of all batteries installed in the aircraft and their duration appropriate to their maximum loads shall be agreed with the Aircraft Project Director .		(see also para 3.3) It is Service policy to use batteries until they give 80 per cent of specified capacity.		
7.3	**INSTALLATION**				
7.3.1	Batteries shall be so installed that they are adequately protected from extremes of heat and cold during flight .	The design of the battery stowages shall permit rapid removal and replacement of batteries without hazard and the need for special ground equipment under all climatic conditions.	(see also para 9.1)		29.1353c1 29.1353c1 iii

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
7.3.2	Unless, of the sealed type, batteries shall be enclosed in compartments vented to atmosphere and, for batteries requiring assisted ventilation, suitable venting provision made. The installation shall be such as to minimise the risk of explosion or of corrosion of the aircraft or its equipment.	The ventilation shall be adequate during all conditions of flight, whilst taxying and during servicing and shall allow for all conditions of battery malfunction .	(see also Leaflet 407, para 22)		29.1353c3 29.1353c4
7.3.4	Stowage shall be provided for the battery connectors when they are of such type that when free they might cause a short circuit to the airframe.				
7.3.5	When a separate emergency battery is provided for the operation of certain vital services, the installation shall be engineered to the same standard as the main electrical installation.				
7.3.6	Metal-cased batteries shall be electrically insulated from airframe structure. Where bonding to earth of the case is				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	necessary, the connection shall be made through a fusible element. An appropriate dormant failure check shall be devised.				
7.4	**CHARGING**				
7.4.3	Means shall be provided to minimise the risk of overcharging or overheating of batteries.	Provision shall be made for the use of suitable equipment for cooling the battery and/or charge control system, and ventilating the battery and/or battery compartment.	The need for a charge control system and the provision of a warning that the battery is not being charged shall be considered.		29.1353c1 29.1353c1 i 29.1353c1 ii 29.1353c1 iii 29.1353c6 i
7.4.4	Nickel-Cadmium batteries used for engine or Auxiliary Power Unit (APU) and/or as part of the main power supply shall have: a) an automatic charge control system to meet the requirements of para 7.1.2 and/or b) an overheat warning system at the flight crew station together with a means				29.1353c5 29.1353c6 29.1353c6 i 29.1353c6 ii 29.1353c6 iii

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	of disconnecting the battery from its charging source in the event of an over temperature condition.				
8	**FIRE PRECAUTIONS**				
8.1	Means shall be provided to disconnect electrical power supplies not essential to post crash conditions. If automatic disconnection of power supplies and automatic activation of the fire extinguisher systems are required, these will be stated in the Aircraft Specification and shall be discussed with the Aircraft Project Director.		(see also Leaflet 712)		29.863a 29.863b 29.863b3
8.3	These circuits shall be left connected to a battery and shall be protected so that the risk of their causing a fire under these conditions is a minimum .	The systems which are required during or after a crash shall include: a) means of escape b) fuel Shut Off valves c) fire extinguishing systems d) communication (e) emergency escape/evacuation	(see para 8-1)		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		illumination (See Leaflet 102 para 3).			
8.4	Electrical cables, terminals and equipment in designated fire zones, that are used during emergency procedures, shall be at least fire resistant .				29.1359b
8.5	Main power cables (including generator cables) in the fuselage shall be designed to allow a reasonable degree of deformation and stretching without failure and must: a) be isolated from flammable fluid lines, or b) be shrouded by means of electrically insulated flexible conduit, or equivalent, which is in addition to the normal cable insulation.				29.952f 29.1359a
8.6	Insulated electrical wire and cable installed in any region of the aircraft shall comply with the flammability requirements in BS G212,				29.1359c

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	para 2.28A Flammability Test Method 3.				
9	**TEMPERATURE LIMITATIONS**				
9.1	The design of the electrical system shall be such that the specified temperature limits of the component parts are not exceeded.		The possibility of the components' environment becoming overheated due to the failure of another adjacent system shall be considered at the design stage (see Leaflet 712, para 10-6).		29.1353a
10	**GROUND CHECKING AND SERVICING**				
10.1	The electrical system shall include a means for connection to the external power supply system for either servicing, pre-engine start drills, or engine starting .				29.1351c
	Ac and/or dc ground power receptacles shall be fitted to comply with BS G173.	They shall be mounted at a suitable angle to reduce to a minimum the effect of the weight of the ground trailer cables and shall be located so that ground crew may safely connect or disconnect ground supply, when engines are	(see also Leaflet 802, para 1-7)		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		running, flight control surfaces are being moved and/or wings are spread or folded. When two or more connectors are fitted, the spacing between each shall be of such as to prevent the possibility of fouling by the mating connectors or their associated cables.[3]			
10.2	Facilities shall be provided for checking the performance of primary and secondary power supply circuits, including dormant circuits, by means of built-in or external test equipment, without disturbing the internal or external wiring of, the equipment.		(see also Leaflet 706/1, para 10)		
10.3	Provision shall be made in the aircraft installation for power supply socket outlets.	The number, type and location of such socket outlets shall be agreed with the Aircraft Project Director.			
10.4	Servicing ground bolts in accordance with SBAC Drawings RS 682 or				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	equivalent shall be provided.[4]				
11	**TESTS**				
11.1	The electrical system shall be subjected to functional tests on the working rig required by MRP 5204	The functioning of the system in the aircraft shall be demonstrated to the satisfaction of the Aircraft Project Director. The electrical rig shall simulate every significant aspect of the total electrical system. It shall be constructed at the design stage, and tests shall be conducted to demonstrate that the system proposed satisfies the design requirements of this chapter and the appropriate requirements of MRP 5204	(see Leaflet 1003)		29.1363a 29.1363a1 29.1363a2 29.1363a3
11.3	Where an electrical power supply is software controlled the flight safety critical aspects of the software must be verified/validated to the satisfaction of the Aircraft Project Director.				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
12	**CROSS REFERENCE**				
			A number of requirements directly related to the electrical installation appear elsewhere in this publication and these are listed in the Alphabetical Index. In addition, certain general requirements apply when electrical actuation is chosen for special tasks and it is the designer's responsibility to ensure compliance with all such requirements.		
13	**ACCESSORIES AND COMPONENTS**				
			See Leaflet 706/3.		
	REFERENCES				
	REFERENCES				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	TABLES				
	TABLE 1 **PRIMARY POWER SUPPLIES** (Characteristics shall be in accordance with BS 3G100 Part 3)				

Reference	ASCC Air Standard	STANAG
1	25/20	3456
2	-	3317
3	25/18	3302
4	25/19	3303
5	25/25	3632

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.

NOMINAL VOLTAGE AT BUS BAR	NOMINAL FREQUENCY (Hz)	TRANSMISSION SYSTEM	SWITCHING DISTRIBUTION CIRCUITS	PROTECTION OF DISTRIBUTION CIRCUITS
28V dc		SINGLE LINE AND NEGATIVE GROUND	IN POSITIVE LINE (SEE ALSO NOTE 3)	IN POSITIVE LINE
115/200V 3 PHASE ac	500 (CONSTANT)	THREE LINES - NEUTRAL POINTS GROUNDED AT GENERATORS	IN ALL THREE LINES	IN ALL THREE LINES
115/200V 3 PHASE ac	400 (VARIABLE)			

NOTES:

1 The only ground supplies available will be 28 V dc and 115/200 V ac 400 Hz.

2 In certain circuits it may be desirable to use negative switching e.g., use of solid state switches. A fail-safe circuit shall be achieved.

3 The 115 volt supply is angle phase derived from the primary 3 phase supply and connected between line and neutral; switching and protection to be in the line.

4 For turbo-propeller aircraft with electrical propeller anti-icing, the neutral for this circuit should be grounded through a high impedance.

5 When it is essential to use existing equipment requiring alternating current of different voltages and frequencies from those given in Table 1, the approval of the Aircraft Project Director is required.

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	TABLE 2 **SECONDARY POWER SUPPLIES**				
	Sub-Leaflets				
	LEAFLET 706/0 ELECTRICAL INSTALLATIONS REFERENCE PAGE				
	LEAFLET 706/1 ELECTRICAL INSTALLATIONS GENERAL				

AC	115V SINGLE PHASE 400 Hz 115V THREE PHASE 400 Hz 26V SINGLE PHASE 400 Hz 5V SINGLE PHASE 400 Hz
DC	270V dc 28V dc 14V dc 5V dc

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	RECOMMENDATIONS				
	LEAFLET 706/2 ELECTRICAL INSTALLATIONS POWER SUPPLIES				
	LEAFLET 706/3 ELECTRICAL INSTALLATIONS ACCESSORIES AND COMPONENTS				
	LEAFLET 1003				
	ELECTRICAL SYSTEMS				
1	**OBJECT**				
	The object of the tests of this Leaflet is to demonstrate that the electrical system installed in the Rotorcraft is suitable for Service use, in particular that: (i) The system can be used satisfactorily on the ground with the use of approved sources of electrical power. (ii) Electrical power can be satisfactorily generated on-board the Rotorcraft and utilised to operate actuators, motors and other electrical power dependent equipment, both on the ground and in flight throughout the specified flight envelope, and to satisfy all operational and environmental requirements.				
2	**RELEVANT DESIGN REQUIREMENTS**				
			DEF STAN 00-970 Volume 1 Leaflet 706		
3	**APPLICABILITY**				
3.1	The tests described in this		The tests are also applicable		29.1363a

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Leaflet are applicable to all new electrical systems in Rotorcraft, and shall be conducted on systems which are fully representative of the final service standard and where the system(s) interfaces with others, they shall also be representative of the service standard.		to electrical systems which are modified to the extent that results of tests are likely to differ from results achieved prior to the modification. The need for further testing must also be considered where modifications are made to other aircraft systems which affect the operation or performance of the electrical system.		29.1363a1 29.1363a2 29.1363a3 29.1363b
4	**TEST PHILOSOPHY**				
	The Rotorcraft constructor shall satisfy himself that sufficient evidence of satisfactory operation and performance has been provided by the supplier. Rig testing will then be undertaken by the Rotorcraft constructor to evaluate the operation and performance of the collective equipments when installed in the electrical system, in order to confirm that the individual		The test philosophy assumes that the electrical system clearance activity is divided in specific areas of activity, namely, supplier tests, system rig tests, aircraft pre-flight tests and finally ground/flight trials. This type of approach is particularly beneficial for new electrical systems where it is essential that comprehensive rig testing of the fully configured electrical		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	components of the system are correctly related with one another and perform the required duty for which they are employed.		system is conducted prior to assessment on the aircraft. In principle, an electrical rig installation which is fully representative of the aircraft installation will enable a large proportion of the system clearance testing to be conducted without the need for extensive ground testing on the aircraft. The individual components or subsystems which make up the electrical system will have been fully tested by the equipment supplier and compliance with the Requirement Specification will have been adequately demonstrated and reported in the applicable type approval documentation.		
	Similarly, any tests which cannot be representatively carried out during the rig testing phase shall be conducted during aircraft pre-		Following an extensive rig test programme, sufficient testing will normally have been completed to enable a 'system operating' release to		29.1363b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	flight testing, ground or flight trials as applicable.		be given to operate the system under aircraft ground running conditions. Therefore, the aircraft ground tests will normally be limited to confirming the system control and indications, general busbar power supply integrity, demonstration of, and recovery from simulated power supply failures and a more thorough assessment of any of the system interfaces which have not been fully investigated during rig testing.		
	Finally, the system will be assessed during a period of aircraft ground and flight trials at which time the system assessment will be conducted under ground and flight conditions representative of the Service role of the Rotorcraft. and shall cover the whole of the operational flight envelope				29.1309g

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	and environmental conditions defined in the Rotorcraft Specification.				
5	**GENERAL TEST CONDITIONS AND REQUIREMENTS**				
	Ground and flight conditions shall be representative of the Service role of the Rotorcraft and shall cover the whole of the operational flight envelope and the environmental conditions defined in the Rotorcraft Specification.				29.1363b
5.2	The electrical systems of the aeroplane under test are to be fully representative of the production standard and functioning. The Rotorcraft systems and equipment which interface with the electrical systems in such a way as to be likely to interact are also to be fully representative of the production standard.	Where for any reason this is difficult to achieve then agreement shall be obtained from the Rotorcraft Project Director before proceeding with the tests.			
	For new electrical systems it	In particular the following	For "mid term up-dates" and		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	is essential that comprehensive rig testing of a fully configured system has been completed and satisfactory operating characteristics established, prior to the commencement of testing.	shall be taken into account: (i) The evidence from preliminary ground rig testing, including operating extremes of transmission/rotor rpm, from minimum up to maximum transient conditions. Where multiple generation systems have common interfaces then the interaction of systems one with the other shall be considered. (ii) The standard of the electrical system(s) and components and their suitability for the tests proposed.	modifications generally to electrical systems where the original ground test rig installation is no longer available and provision of a new rig is deemed to be uneconomic, Rotorcraft ground tests assume additional importance and particular care must be given to the planning and execution of them to establish the necessary level of confidence in the system(s) required for initial flight tests.		
5.5	The Electro-Magnetic Compatibility (EMC) characteristics shall be considered before flight trials are undertaken. Continued assessment will be an activity which cannot be separated from Electrical				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	System Tests and is covered in Leaflet 1011.				
5.6	The standard of instrumentation employed shall be such that parameters of interest can be measured simultaneously with sufficient accuracy to enable the electrical system characteristics to be established in accordance with the applicable electrical specification’ The standard of data processing equipment shall be selected to meet the same objective and evidence of calibration traceable to national standards provided where necessary.				
5.7	Aircraft tests may be conducted at any convenient loading and centre-of-gravity position, provided that this does not result in the achievable flight envelope being more restrictive than				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the maximum envelope as defined by the Rotorcraft Specification or, if not so defined, as envisaged by the Service user, taking into account limitations imposed by the carriage of external stores or other loads (i.e. maximum normal acceleration, attitude, speed, etc.).				
5.8	On Rotorcraft powered by a single engine, external stores or other loads must not be carried on any test which may result in, or require the engine to be shut down, unless the store or load is specifically required for the trial.				
6	**ELECTRICAL RIG TESTS**				
			In general terms Electrical rig tests enable the satisfactory collective performance of equipment, which comprise the system, to be established under simulated ground and		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			flight operating conditions. This will normally be achieved early in an aircraft development programme, substantiating the Design philosophy thereby enabling a high level of confidence to be established prior to flight trials taking place.		
6.1	**Rig Facilities**				
			The provision of suitable electrical rig test facilities will enable a large proportion of the overall test programme to be conducted prior to aircraft ground and flight trials. Wherever possible, the electrical system installation on the rig should be fully representative of the aircraft installation, ideally built to aircraft standard drawings, employing aircraft standard components and connected using correct aircraft cable type, gauge, length and routing.		29.1363 29.1363a 29.1363a1 29.1363a2 29.1363a3

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			Where physical constraints render this approach impractical, every effort should be made to reproduce the equivalent aircraft cable impedance between components. Generator drive rig facilities should enable the full range of generator functions, load and speed characteristics to be represented.		
	Aircraft system interfaces which cannot be fully represented (for example, aircraft computer based control and display systems) shall be simulated to enable the electrical system warning and status information to be suitably represented.				
	Critical aircraft loads which may impact on the performance of the electrical system shall be evaluated on the rig.	Aircraft electrical loads may be simulated by the connection of resistive, inductive and capacitive load banks to the electrical system to enable assessments to be			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		undertaken over the full load conditions (including overload) of the aircraft.			
6.2	**Rig Tests**				
			Following commissioning, initial rig tests should demonstrate that the design philosophy has been achieved and that the means of selection, control and indication have been implemented correctly. An in-depth study of the operation of the system may then be conducted to assess the following aspects: (a) Switching control logic and indication of AC generator, inverter and external power supplies as applicable. (b) Switching control logic and indication of DC generator, TRU battery and external power supplies as applicable. (c) Regulation		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			characteristics of AC/DC generators over available speed/load range including limited overload conditions. (d) System load/volt drop characteristics. (e) Power supply load sharing capabilities (where applicable). (f) Battery charging characteristics. (g) GCU operation including fault testing. (h) Distribution system and direct fault testing. (i) Simulated system failures and recovery action. (j) General power supply quality checks. (k) Equipment thermal assessment. (l) Generator cooling medium characteristics. (m) Power supply interrupts and voltage disturbances arising from system control and load switching.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
7	**AIRCRAFT PRE-FLIGHT TESTING**				
7.2	Any of the activities detailed under ‘rig testing’ which cannot be completed successfully shall be demonstrated on the aircraft during the ground or flight test phase as necessary.	During the test period measurements of the steady state. AC and DC busbar voltage shall be made at selected load conditions. In addition, suitable recording shall be made of AC and DC busbar voltage disturbances caused by system control operations, load switching, generator speed transients and failure simulations.	This phase of testing will normally be conducted following hangar clearance of the system by means of the relevant Acceptance Test Procedure, which enables clearance of the installation to be undertaken prior to aircraft operating conditions being established.		
7.3	The evidence of an extensive rig test programme will reduce the pre-flight testing phase to one of a confirmatory nature during which the following shall be demonstrated: (i) The transition from external to internal supplies and vice versa is carried out in a satisfactory manner; (ii) confirmation of				29.1351 29.1351b 29.1351b3 29.1351b4 29.1351c

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	system control and switching logic; (iii) confirmation of acceptable busbar voltage levels under max/min extremes of electrical load; (iv) primary power system failures and establishment of secondary or emergency power sources as applicable; (v) assessment of aircraft services due to loss of busbar supplies; (vi) assessment of electrical system advisory, cautionary and warning indications;				
8	**AIRCRAFT GROUND AND FLIGHT TRIALS**				
8.1	Satisfactory systems(s) operation shall be demonstrated over the full flight envelope and manoeuvre range of the rotorcraft.	Generally the objective is to confirm the results of rig and ground testing and to explore operating regimes and duty cycles that are fully representative of the service role. It is particularly important that the extremes of			29.1351 29.1351a 29.1351a1 29.1351a2 29.1351b 29.1351b1 29.1351b2 29.1351b3

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		aerodynamic and acceleration loads, including zero and negative "g" (where applicable) are experienced. In particular checks and measurements shall be made as follows: (i) Temperatures of generators, TRUs, batteries, battery charging equipment and other temperature sensitive items which may be affected by recirculation of exhaust gases and/or cooling air during prolonged hover, sideways and rearwards flight (including the need to hover other than head into wind). (ii) Effect of vibration and shock (including that which might arise from gun firing or the firing of air launched missile booster rockets, etc.) on the performance and functioning of contractors, constant speed drives and other mechanical systems and devices.			29.1351b4 29.1351b6 29.1351d 29.1351d2 i 29.1351d2 ii 29.1351d2 iii 29.1353c 29.1353c1 29.1353c1 i 29.1353c1 ii 29.1353c1 iii 29.1353c2 29.1353c6 29.1353c6 i 29.1353c6 ii 29.1353c6 iii 29.1355b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		(iii) Extending the range of system operation and loading beyond that achievable during ground testing. This may include short-term overload conditions (above maximum continuous rating where required) and use of emergency generator(s) which can only be operated in flight such as those driven by ram air turbines (if applicable). (v) Checks shall be made to ensure that adequate and correct indication of system(s) or equipment failure or malfunction takes place and that reversionary or emergency functions are available as required. (vi) Confirmation of the power supply quality and integrity shall be established over the full flight envelope and Service role conditions to ensure that the requirements			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		of the applicable standards and specifications have been met. (vii) Checks shall be made on charging characteristics of the rotorcraft to establish that the capacity of charged batteries is adequate to support essential services for required duration following total primary electrical power failure. (viii) Following a battery cold soak to minimum environment temperature, engine or APU starting shall be demonstrated in accordance with the Rotorcraft Specification. (ix) The system(s) operate(s) satisfactorily after cold and hot soaks of the rotorcraft, in the inoperative condition, at the extremes of the environmental range as required by the Rotorcraft Specification. (x) Verification of			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		emergency power supply operation and adequacy of procedures under in flight conditions.			
(iv)	(iv) Failure simulations shall be explored to the extent that is considered acceptable and necessary in flight tests.				29.1355b 29.1363a3
	LEAFLET 110				
	NAVIGATION AND ANTI-COLLISION LIGHTS				
1	**INTRODUCTION**				
	This Leaflet contains requirements for rotorcraft navigation and anti- collision lights based on an international agreement within NAT01.				
1.2	All military rotorcraft shall be provided with navigation light systems which will provide illumination completely around the normal plan of flight of the rotorcraft.	The navigation light system shall include anti-collision lights as well as the side and tail lights or their equivalent unless otherwise agreed with the Rotorcraft Project Director.	The coloured side and white tail lights or their equivalent, provide direction of flight information to pilots of other aircraft in the vicinity. The anti-collision light system provides a signal which generally permits rotorcraft to be seen at greater distances than rotorcraft provided only with the side and tail lights.		29.1401a 29.1401a1 29.1401a2
2	**ANTI-COLLISION LIGHT**				

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	SYSTEM				
2.1	**LOCATION**				
2.1.1	The anti-collision light(s) shall be located so that the emitted light shall not be detrimental to the crews' vision and will not detract from the conspicuity of the navigation lights.				29.1401a1
2.2	**COLOUR**				
2.2.1	Red and/or Aviation White (while operating).				29.1401d
2.3	**FIELD OF COVERAGE**				
2.3.1	The system shall consist of such lights as will afford coverage of all areas around the rotorcraft.	The field of coverage shall extend in all directions within 30° above and 30° below the horizontal plane of the rotorcraft, except that obstructed visibility totalling not more than 0.03 steradian shall be permissible within a solid angle of 0.15 steradian centred about the longitudinal axis in the rearward direction.			29.1401b
2.4	**FLASHING CHARACTERISTICS**				
2.4.1	The arrangement of the	The flash frequency for any			29.1401c

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	system, such as the number of light sources, beam width, speed of rotation, etc., shall be such as to give an optimum flash frequency of 90 cycles per minute.	single light source shall not be less than 40 cycles per minute. The flash frequency shall not be more than 100 cycles per minute except when the system includes overlaps created by more than one light source. In overlaps, the effective flash frequency shall not exceed 180 cycles per minute. The effective flash frequency is to be established as that frequency at which the rotorcraft's complete anti-collision light system is observed from a reasonable distance.			
2.5	**LIGHT INTENSITY**				
2.5.1	The minimum effective intensities in all vertical planes, measured with the red filter, shall be in accordance with Table 1.	If a higher intensity is desired, a colourless glass may be used. In this case, the value of the effective intensity of the white light must be at least four (4) times higher than the minimum intensity of the red light (Table 1). The following	I_e = effective intensity (candelas),and is the maximised value of the righthand side of this equation. I_t = instantaneous intensity as a function		29.1401e 29.1401e 29.1401e 29.1401e 29.1401e 29.1401e 29.1401f 29.1401e 29.1401f

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		relation shall be assumed: where $I_e = \frac{\int_{t_1}^{t_2}}{0.2 +}$	of time. $t_2 - t_1$ = flash duration (seconds). Note: The maximum value of Ie is obtained when t2 and t1 are so chosen that the effective intensity is equal to the instantaneous intensity at t2 and t1.		

TABLE 1
MINIMUM EFFECTIVE INTENSITIES FOR ANTI-COLLISION LIGHTS

Angle Above and Below Horizontal Plane	Effective Intensity Ie (Candelas)	
	Imin < 0.30 Imax	Imin > 0.30 Imax
0° to 5°	100	
5° to 10°	60	See sub-para 2.6
10° to 20°	20	
20° to 30°	10	

Imin = minimum intensity during "OFF" period.
Imax = maximum intensity during 'ON" period.

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Note: It is desirable to increase the angle above and below the horizontal plane to 60°. Between 20° and 60° the minimum effective intensity shall be 10 candelas.				
2.6	**FLASH FREQUENCY v EFFECTIVE INTENSITY**				
2.6.1	The rise and decay characteristic of high current lamps flashed by electrical means are such that the intensity may not decay during, the "OFF" period to an acceptable level of less than 0.30 times the peak intensity. In such cases the flash frequency may be reduced to obtain an adequate decay provided that the effective light intensity (see para 2.5 above) is increased by twice the percentage of flash frequency reduction below 90 cycles per minute.		As an example, if the flash frequency is 45 cycles per minute (a decrease from 90 cycles per minute of 5O percent), the effective intensity requirements of para 2.5 shall be increased by 100 percent.		
3	**NAVIGATION LIGHT SYSTEM**				
3.1	**WING LIGHTS (SIDE EXTREMITY LIGHTS)**				
3.1.1	Location - The side lights	Such lights may be installed			29.1385a

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	shall be spaced laterally and as far apart as practicable on the fuselage.	on other than the fuselage as agreed with the Rotorcraft Project Director. Supplementary lights may be installed in any location as necessary to meet minimum light distribution requirements. Each light as installed shall show unbroken light in accordance with Figs.1 and 2.			29.1385b
3.1.2	Colour - The side lights shall be Aviation Red for the left side and Aviation Green for the right side.				29.1385b
3.1.3	Candlepower - Candlepower requirements shall be as shown in Figs.1 and 2.				29.1387 29.1387a 29.1387b 29.1387c 29.1387d 29.1387e 29.1389 29.1389a 29.1389b 29.1389b1 29.1389b2 29.1389b3

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
					29.1391 29.1391 29.1391
3.2	**TAIL LIGHTS (AFT EXTREMITY LIGHTS)**				
3.2.1	Location - The tail light shall be located as near as practicable to the rear extremity of the fuselage.	Supplementary lights may be installed if necessary to meet the minimum distribution requirements of Figs.1 and 2.			29.1385c
3.2.2	Colour - Aviation White.				29.1385c
3.2.3	Candlepower - The candlepower requirements shall be as shown in Figs.1 and 2.				29.1387 29.1387a 29.1387b 29.1387c 29.1387d 29.1387e 29.1389 29.1389a 29.1389b 29.1389b1 29.1389b2 29.1389b3 29.1393 29.1393 29.1393
3.3	Rotorcraft not provided with anti-collision lights shall be				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	furnished with flashing navigation lights. The flash rate for the navigation lights shall be 85 + 15 flashes per minute with an "on" to "off" ratio of between 3:1 and 1.857:1. The complete system, side and tail lights, shall be flashed simultaneously.				
3.4	Naval rotorcraft shall be fitted with flashing navigation lights controlled by a FLASHING/OFF/STEADY switch and by a BRIGHT/DIM switch. They shall, where possible, be fitted with a flashing white light(s) visible in all directions and be capable of independent operation.				
4	**COLOURS**				
4.1	Chromaticity - Colours reference in this document shall have the applicable International Commission on	(i) Aviation Red: y is not greater than 0.335, z is not greater than 0.020.	(see also Fig.3)		29.1397 29.1397 29.1397a 29.1401d

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Illumination (CIE) chromaticity co-ordinates as follows :	(ii) Aviation Green: x is not greater than 0.440 - 0.320y, x is not greater than y - 0.170, y is not less than 0.390 - 0.170x. (iii) Aviation White: x is not less than 0.300, x is not greater than 0.540, y- yo is not numerically greater than 0.01. yo is the y co-ordinate of the Plankian radiator for which "xo = x". (iv) Red for Anti-collision Lights: y is not greater than 0.350, z is not greater than 0.020.r			29.1397c 29.1397c 29.1397c 29.1397c 29.1397c 29.1397a 29.1397a 29.1397b 29.1397b 29.1397b 29.1397b
4.2	Colour Limits - Fig.3 graphically represents limit co-ordinates of Aviation colours.				
	REFERENCES				
	REFERENCES Reference 1 / ASCC Air Standard - / STANAG 3153				

Reference	ASCC Air Standard	STANAG
1	-	3153

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	FIGURES				

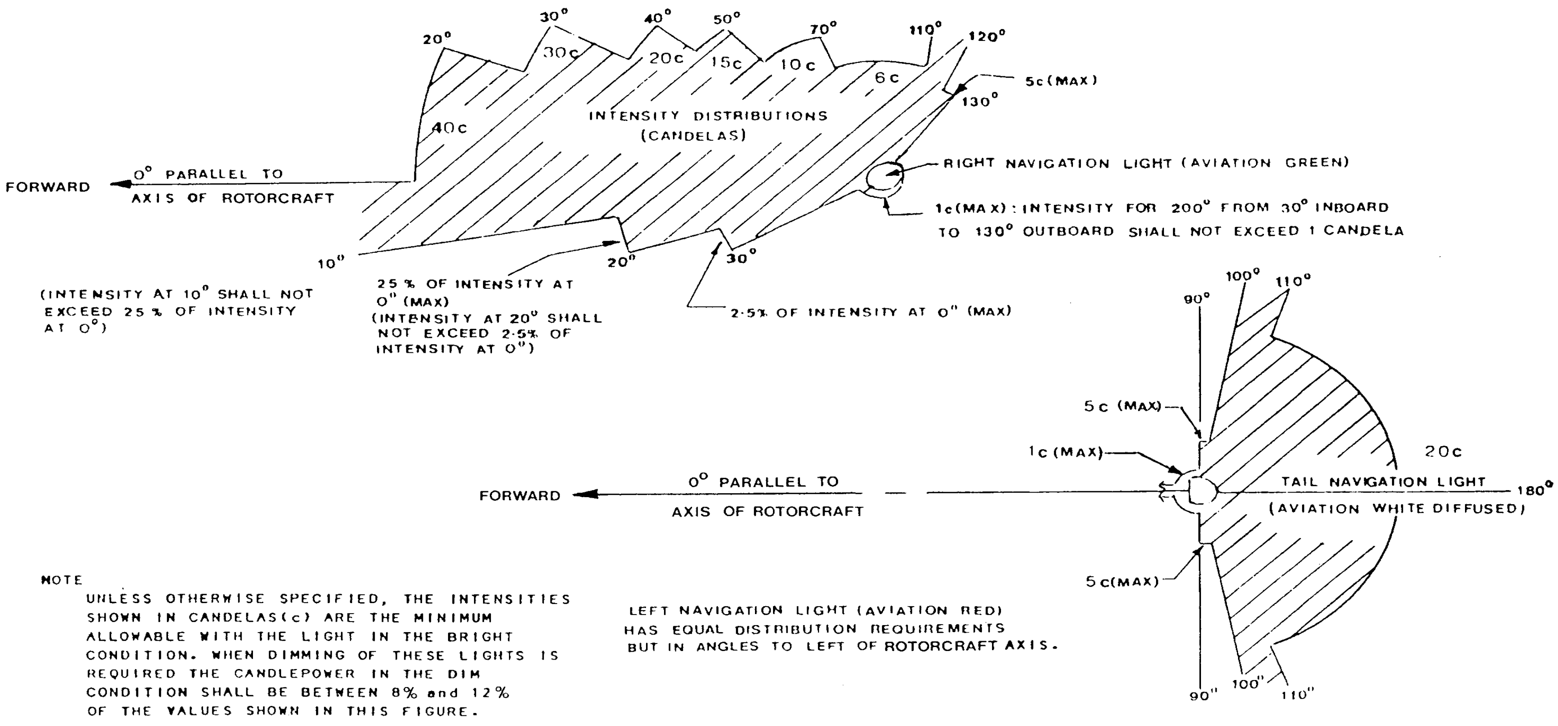
Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
					

FIG.1 INTENSITY DISTRIBUTIONS IN THE HORIZONTAL PLANES, THROUGH THE CENTRES OF THE LIGHTS

<table>
<tr><th>Para No</th><th>DS970 Pt7 Requirement</th><th>DS970 Pt7 Acceptable Means of Compliance</th><th>DS970 Pt7 Guidance</th><th>DS970 Pt7 Policy, Notes, and References</th><th>CS-29 Para No.</th></tr>
<tr><td></td><td colspan="4">

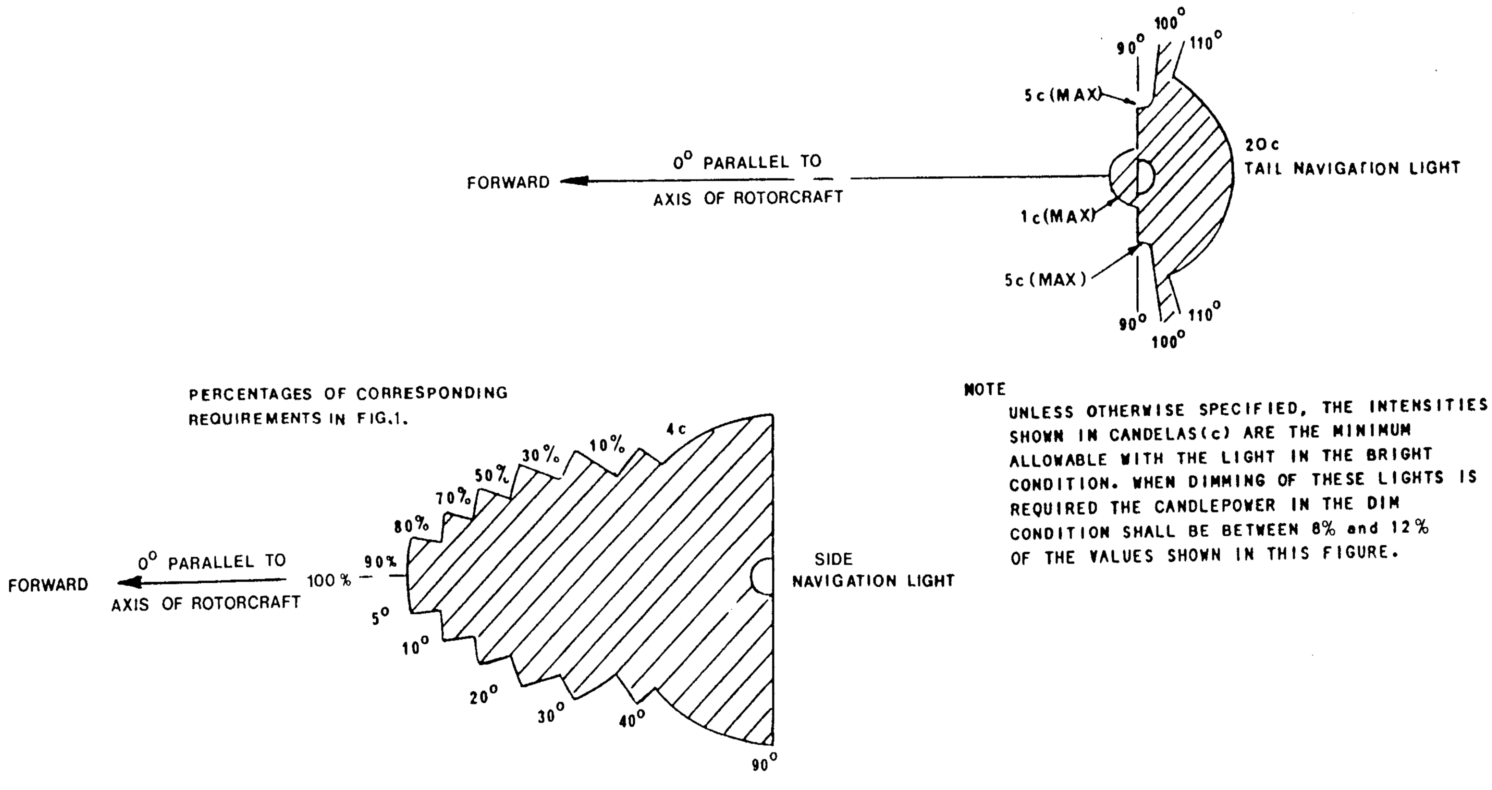


FIG.2 INTENSITY DISTRIBUTIONS IN THE VERTICAL PLANES THROUGH THE CENTRES OF THE LIGHTS

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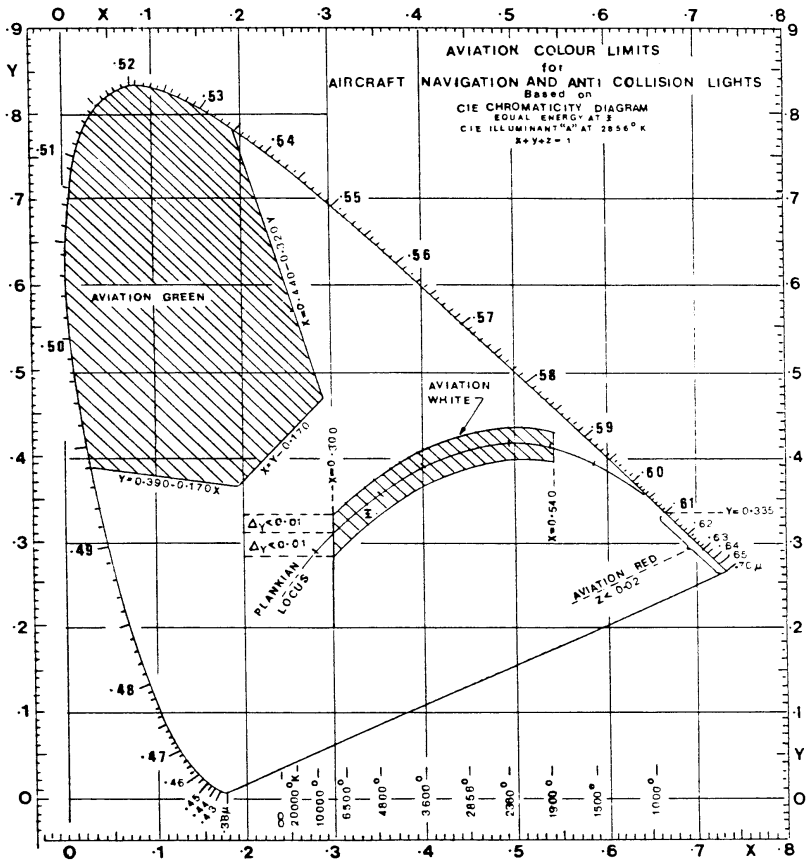
Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	 FIG. 3 CIE CHROMATICITY DIAGRAM SHOWING AVIATION COLOUR LIMITS				
	LEAFLET 721				
	EMERGENCY LIFERAFT				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	INSTALLATIONS				
1	**INTRODUCTION** The requirements of this Leaflet apply to the installation of multi-seat emergency liferafts.				
2	**BASIC REQUIREMENTS**				
2.1	Materials, components, standard parts, processes, corrosion protection and design features, shall comply with the provisions of Leaflet 801.	Unless otherwise specified, the materials and components used in the construction of the release systems for the ejection of the liferafts from the rotorcraft shall be selected such that the effect of elapsed time from manufacture either in equipment being stored, on the shelf, or on the rotorcraft, will have no detrimental effects upon successful operation of the system.			
2.2	The location of liferafts and their methods of release shall be suitably chosen in relation to the ditching and flotation characteristics of the rotorcraft, the escape facilities of the rotorcraft, and the disposition of the occupants. Under no circumstances shall the		Heat is very detrimental to rubber and can be dangerous to a charged gas cylinder.		29.1411 29.1411a 29.1411b 29.1411b1 29.1411b2

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	compartment opening be below the estimated water line of the ditched rotorcraft. The structural strength of the area shall be capable of withstanding an emergency ditching without collapsing or damaging the compartment. Furthermore, the compartment shall not be located in an engine necelle, nor close to hot areas such as jet pipes or exhaust pipes.				
2.3	Every effort shall be made to ensure that the location of the compartment in relation to the slip stream and downdraft of the rotorcraft and the location of the rotors, aerials and stabilizers shall be such that, not withstanding para 2.8, no part of the rotorcraft critical to continued safe flight shall be damaged or fouled by the compartment cover, liferaft, or by any component of the liferaft in				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the event of a release system malfunction causing an inadvertent operation of the release system during flight.				
2.4	Liferaft installations shall be designed so as to ensure that the liferaft, together with any equipment, provisions, etc., which are required to be carried, will be serviceable when needed and that, so far as is practical, the installations will not be damaged by any defect likely to necessitate an Emergency Alighting on water (eg engine fire or fuel leakage) or by any damage liable to occur during such an alighting.				
2.5	Following the operation of the releases provided, the liferaft and all equipment stowed with it shall be ejected from its compartment in such a way that the liferaft is launched the right way up (unless it is of the reversible	The installations shall be so arranged that the necessary action for launching any liferaft is not likely to be either an undue hindrance to or unduly hindered by, the occupants vacating the rotorcraft.			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	type) with its equipment within it secured in a position which will enable the crew to board it with the least possible risk of getting wet. The liferaft shall be attached to the rotorcraft by a line. This attachment, however, shall be incapable of submerging or capsizing the loaded liferaft when the rotorcraft sinks.				
2.6	The correct operation of the liferaft installation shall not be prevented by the formation of ice.				
2.7	It shall be impossible to complete the installation unless all components have been correctly and securely fitted, and all safety devices used for transit purposes, etc., removed.				
2.8	The stowage of all liferafts shall be such that the probability of unintentional inflation or release is not				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	greater than Extremely Remote, unless it can be shown that such inflation or release will not hazard the rotorcraft.				
3	**LIFERAFT COMPARTMENT**				
3.1	Each liferaft and its associated inflation and survival equipment shall be installed in a pre-packed pan. The pan shall provide positive location for inflation cylinders and any other articles which might otherwise shift and damage or disarrange the liferaft or the release of operating mechanism. Similarly the operating mechanism for the release of the liferaft from the rotorcraft shall be installed as a self-contained unit.	The liferaft pre-packed pan and the release operating mechanism unit shall be capable of being removed from or fitted to the rotorcraft quickly and easily and without the use of special tools. It shall be possible to remove either item independently and without disturbing the other.			
3.3	The liferaft stowage compartment and its pre-packed pan, its operating mechanism and its cover,				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	shall be free from all sharp corners, edges or projections, which might trap or damage the liferaft either while stowed or during inflation.				
3.4	A cover shall be provided so arranged that under all possible flight conditions it will be held firmly shut by the cover locks with no possibility of even partial opening of its edges. The security of the locks shall be readily ascertainable by visual inspection when the rotorcraft is on the ground.	The stowage compartment shall be substantially weathertight and yet designed to drain completely in both ground and flight attitudes.			
3.6	Provision shall be made to prevent any excessive build up of pressure within the liferaft stowage due to air or due to high temperature discharge or seepage of the gas cylinder.				
3.7	The stowage of all liferafts (including valise-types) shall be such that the liferafts will not be disturbed except for				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	inspection purposes and, under normal conditions, will not be liable to damage by passengers or by the loading or unloading of freight.				
3.8	Stowages shall be such as to prevent damage to or deterioration of the liferaft package due to spillage of or contact with any likely contaminants, including deleterious quantities of water.	The total volume of the compartment shall be 10 percent greater than the full volume of the equipment which it is to contain. With the full equipment installed only light hand pressure shall be required to close and lock the lid correctly.			
4	**RELEASE**				
4.1	Two independent liferaft release systems shall be provided, one operating automatically when the rotorcraft has ditched and the other one manually. Such manual release shall function even if the automatic control fails to function.	The release systems shall be capable of operating satisfactorily in all climates, when subject to any ambient atmospheric temperature between 70 degrees Centigrade (158 degrees Fahrenheit) and minus 54 degrees Centigrade (minus 65 degrees Fahrenheit).			
4.2	The automatic release system	The release system shall not			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	shall operate so that there is no danger of the liferaft inflating prematurely and being lost.	be activated by electromagnetic radiation, oil leakage, washing down, condensation, flight and gunfire vibration, take-off, landing, change in altitude nor by the retardation effects of ditching or crashlanding. In addition the automatic release system shall have its own source of power so that it will function in the event of failure of the primary rotorcraft electrical system.			
4.3	The entire mechanism of the manual and automatic systems, when operated by any method, shall not foul upon operation and shall automatically and completely disconnect the release connections, after the compartment cover has released and the gas filled cylinder on the stowed liferaft has been actuated. The compartment cover or any	The system shall be installed in accordance with the provisions of Leaflet 100, para 9.			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	component of the manual or automatic release systems shall not interfere with the ejection of the liferaft or with the liferaft once it has been ejected.				
4.5	The manual release system shall consist of local and remote release handles which shall be connected, by suitable means to the compartment cover locking device and to the liferaft pull cable. A pull on any release handle shall simultaneously release the compartment cover, actuate the gas filled cylinder on the stowed liferaft, thereby inflating the raft, and eject the liferaft.	The local and remote manual release handles may be connected in series and shall be identified and protected so that they cannot be confused with the other controls or operated inadvertently. Jamming of the remote control shall not prevent functioning of the manual release. Release handles shall be provided as follows:- (i) Adjacent to the ditching exit and easily accessible to a person, both immediately before and after passing through the exit. (ii) Adjacent to the liferaft stowage and capable of being operated by a person standings on the ditched			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		rotorcraft. (iii) Capable of being operated by a person in the sea in the vicinity of the escape hatch unless (i) or (ii) meets this requirement. (iv) There shall be at least one convenient release means inside the rotorcraft by which all remotely controlled liferafts can be released. In addition, release means on the outside of the rotorcraft and accessible to survivors in the water shall be provided. (v) Release systems shall be safeguarded against spontaneous or inadvertent operation in any condition of flight, and shall be so designed that it is impossible to operate the release partially and return the control to its normal position, without it being obvious that the release has been partially operated.			
4.6	It shall be possible to easily				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	remove the liferaft from its stowage manually without the use of tools and then to inflate the liferaft by means of the bellows which are provided.				
4.7	The position of the release handles shall be marked in accordance with the appropriate identification requirements (see Leaflet 103 para 4) and easy identification in total darkness is essential. It shall also be borne in mind that the Rotorcraft may even be inverted after ditching, and the occupants disorientated. The pull required to operate any of the liferaft releases shall not exceed 135 N under the most adverse conditions.				29.1561 29.1561d
4.8	A liferaft released by remote control shall be attached to the rotorcraft by its line. This line, however, shall be incapable of submerging or	The effects of wind on the raft with any inflatable canopies erected should be taken into account when deciding the breaking			29.1415 29.1415b 29.1415b2

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	capsizing the liferaft if the rotorcraft sinks with the line still attached.	strength and length of the line. Consideration shall also be given to the load involved if it is intended to tow the liferaft.			
4.9	After launching it shall be possible to hold liferafts in such a position that the likelihood of the occupants of the rotorcraft being immersed while boarding them is reduced to a minimum.				
5	**STRENGTH**				
5.1	The liferaft installation shall comply with the strength requirements for the rotorcraft as a whole, including those for, crashlanding and in particular, the loads resulting from inertia, preloading, internal and external aerodynamic forces and pressure.	Altitude loading due to residual air in the liferaft shall be considered.			
6	**INFLATION CYLINDER HIGH TEMPERATURE DISCHARGE**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	INDICATOR				
6.1	An indicator shall show if the liferaft inflation cylinder has discharged itself to atmosphere.	This unit shall normally be situated in the cover of the liferaft stowage but if the indicator would not be readily seen in that position it can be fitted in some position slightly remote from the liferaft stowage. Consideration shall be given to displaying a warning indicator in the flight deck console.			
7	**LIFERAFTS STOWED IN VALISES**				
7.1	In particular circumstances on transport rotorcraft, liferafts stowed in valises may be accepted in addition to or in lieu of the pre-packed stowage type of installation. In such cases the liferaft valise shall be stowed in a designated compartment so as to be readily accessible after ditching and a suitably placed anchorage shall be provided				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	for the static line. This line shall be incapable of submerging or capsizing the loaded liferaft when the rotorcraft sinks.				
7.2	Internal liferaft stowages shall be so arranged that adequate space is available for access to and easy manipulation of the liferaft package prior to launching.				
7.3	When launching is by hand, the necessary actions shall be within the capacity of an untrained person of average strength, and shall not require exceptional agility or skill. This is to cover the use of rotorcraft in the transport role.				
7.4	The overall dimensions of the liferaft package shall be such that it can be easily passed through any emergency exit likely to be used for launching.				
7.5	A suitable line which can be				29.1415

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	attached to the rotorcraft prior to launching is assumed to be provided as part of the liferaft.				29.1415b2
8	**ENGINEERING DATA**				
		Engineering drawings and other data required by the detail specification for a particular rotorcraft shall include the following:- (i) Location of all the liferaft compartments in the rotorcraft. (ii) Design of the cover and locking device. (iii) Provisions for the removal of the compartment cover for inspection of the liferaft and equipment without operating the rotorcraft release systems and the stowed liferaft's inflation system. (iv) Design of the local and remote manual release systems and the force and amount of travel required to			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		operate each manual release. (v) Design of the basic components of the automatic release system. (vi) Description of any electrical installation. (vii) Signs or labels detailing operating and servicing instructions and warnings. (viii) Internal volume of each liferaft compartment.			
9	**GROUND TESTS**				
		The Contractor shall demonstrate by ground tests that:- (i) The pre-packed container and release mechanism unit can be fitted in accordance with para 3.2. (ii) The stowage cover can be locked safely in position using only light hand pressure and, (iii) The liferaft inflates correctly and unless it is of the reversible type launches			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		the right way up on operation of any of the automatic or manual releases.			
	Sub-Leaflets				
	LEAFLET 721/0 EMERGENCY LIFERAFT INSTALLATIONS REFERENCE PAGE				
	LEAFLET 721/1 EMERGENCY LIFERAFT INSTALLATIONS GENERAL RECOMMENDATIONS				
	LEAFLET 711				
	ICE PROTECTION				
1	**INTRODUCTION**				
	This Leaflet applies to all rotorcraft irrespective of the extent of ice protection provided, which are required by the Rotorcraft Specification to enter, or operate in, icing conditions. This Leaflet contains the requirements for protecting rotorcraft against the accretion of ice, snow and slush. The atmospheric conditions in which ice accretion may occur, and their probable extent, are defined in Leaflet 711/2. If the Rotorcraft Specification requires operation at altitudes above 3000 m the appropriate icing standards shall be as defined therein. Although general requirements for engine ice protection are defined elsewhere (for example, in DEF STAN 00-971), requirements for engine and auxiliary air intake ice protection are contained in this Leaflet.				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
2	**OPERATIONAL REQUIREMENTS**				
2.1	The rotorcraft shall be capable of meeting the Service operational roles for the durations stipulated in the Rotorcraft Specification under the following conditions: (i) the Continuous Maximum icing conditions, (ii) the Periodic Maximum icing conditions, (iii) the Mixed icing conditions, continuous, (iv) the Mixed icing conditions, periodic, (v) falling snow, continuous, (vi) falling snow, periodic, (vii) blowing or recirculating snow, (viii) freezing fog, (ix) freezing rain/drizzle, (x) any additional conditions stipulated in the Rotorcraft Specification.	In order to satisfy the requirements of this Leaflet it shall be shown that, when the rotorcraft is operated in the stipulated conditions and for the required durations, there will be no hazard to the rotorcraft or its crew, and no unacceptable degradation in:- (i) the performance of the rotorcraft or its systems, (ii) the handling qualities of the rotorcraft, (iii) the performance of weapon systems carried in or on the rotorcraft. Note: Any degradation would be unacceptable if it resulted in the rotorcraft or its systems being unable to meet the requirements of the Rotorcraft Specification appropriate to flight in ice-forming conditions.	Notes: (1) See Leaflet 711/2 for the definition of conditions (i) to (ix). (2) Condition (x) might include, for example, operation from or onto runways contaminated with ice, snow (both lying and hard-packed), slush or standing water.		29.1419 29.1419a 29.1419b C29.1 C29.1a C29.1b C29.1Fig1 C29.1Fig1 C29.1Fig1 C29.1Fig1 C29.1Fig2 C29.1Fig2 C29.1Fig2 C29.1Fig2 C29.1Fig3 C29.1Fig3 C29.1Fig3 C29.1Fig3 C29.1Fig4 C29.1Fig4 C29.1Fig4 C29.1Fig4 C29.1Fig5 C29.1Fig5 C29.1Fig5

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
					C29.1Fig5 C29.1Fig6 C29.1Fig6 C29.1Fig6 C29.1Fig6
2.3	The flight envelope for flight in icing conditions shall not produce loads in the mechanical systems of the rotorcraft that exceed the design loads at Vne under non-icing conditions. An allowance may be required in the fatigue spectrum for the manoeuvre envelope to cater for flight in icing conditions, and the Design Authority shall evaluate the effects of icing on the flight manoeuvre loads. Any limitations in the flight envelope for flight in icing conditions shall not be more restrictive than permitted by the Rotorcraft Specification.				
3	**ICE PROTECTION SYSTEMS**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
3.1	**BASIC SYSTEM TYPES**				
			The two basic types of ice protection systems are: (i) Anti-Icing: Systems used to prevent the formation of ice on critical parts of the rotorcraft surface. This is usually achieved by the continuous heating of the relevant parts, but use can also be made of freezing point depressant fluids in certain applications. (ii) De-Icing: Systems used to periodically remove the ice from parts of the rotorcraft surface, before it reaches a size that could cause an unacceptable degradation of rotorcraft or system performance, or hazard the rotorcraft during shedding. Anti-icing and de-icing systems can be used in combination.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
3.2	**ICE PROTECTION METHODS**				
			A brief description of the various means of ice protection is given in Leaflet 711/3.		
4	**SYSTEM REQUIREMENTS - GENERAL**				
4.2	The system shall be designed so far as is reasonable to provide symmetric protection of dynamic systems, eg rotors, in order that the problems associated with asymmetric ice accretion and/or shedding may be avoided. In designing to achieve this objective the effects of possible system failures shall be considered (see para 4.5).	The protection system shall be capable of satisfactory operation throughout the rotorcraft flight envelope, unless otherwise stated in the Rotorcraft Specification. The Design Authority must show that the protection system meets the Rotorcraft Specification by means of some combination of modelling, rig and tunnel testing, and flight tests in natural or simulated icing conditions. (See para 9 and Leaflet 1006). Where computer models or simulated icing conditions are	Note: This is of particular importance in respect of main rotors where the asymmetric accretion or shedding of ice must not result in unacceptable levels of vibration or excessive structural stresses.		29.1419 29.1525 29.1525

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		used to prove compliance, they must be supported by substantiation and/or validation evidence. The manufacturer shall show, by analysis or test, that the performance of the ice protection system(s) will not be degraded to an unacceptable extent over the required life and predicted usage of the rotorcraft.			
4.3	Notwithstanding the formation of ice, the rotorcraft services and auxiliary equipment, (e.g undercarriage, aerodynamic control surfaces, generators, rotor droop stops, pitch change links and flight instruments) that are required for safe flight, emergency operation, and landing, shall continue to function satisfactorily.				
4.4	Ice protection power requirements shall be kept to				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the minimum necessary to achieve the required level of protection.				
4.5	Back-up systems/power sources must be provided where failure of the protection system could lead to unacceptable flight safety problems or operating restrictions. On multi-engined rotorcraft where protection is provided by the engine, alternative sources must be provided to cater for the effect of engine failure.				
4.6	Ice protection systems shall not introduce secondary ice accretion (run-back) unless it can be shown to be of no consequence. Specific attention shall be paid to the effect of runback on the rotor blades as this may cause a loss of aerodynamic performance or a degradation of the dynamics of the rotor due to the aft movement of				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the blade c.g.				
4.7	When a de-icing system is used, the ice accretion formed during the de-icing off-time must not produce unacceptable rotorcraft or system performance degradation.				
4.8	The ice protection systems, whether functioning or not, shall not: (i) cause corrosion or deterioration of any part of the structure, or associated and adjacent systems, (ii) cause unacceptable levels of vibration, loss of control power, or excessive structural stresses due to ice accretion on, or shedding from, the main or tail rotors.				
4.9	The ice protection systems shall be so designed that toxic fluids or vapours can not enter the cabin in normal flight, or as a result of enemy action, to the extent required				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	by the Rotorcraft Specification.				
4.10	Ice protection systems for engine intakes, pilots' windscreens, air data probes and any other system requiring protection prior to take-off shall be designed for operation during start-up, manoeuvring on or near the ground and take-off as well as in flight.				
5	**ICE PROTECTION COVERAGE**				
5.4	The design of the rotorcraft and its systems, inclusive of protective systems such as debris guards, shall be such that the probability of damage from any ice or slush shed from unprotected or de-iced areas of the rotorcraft is minimised. In addition, such shed ice or slush shall not hazard the rotorcraft occupants, nor - so far as is within the control of the	In determining the extent of ice protection coverage and the degree of protection (eg heat per unit area) required, the designer shall consider droplet trajectories and hence rate of water droplet impingement under all critical combinations of airspeed, altitude, ambient temperature, liquid water (or ice crystal) content, and water droplet size. For any but the	In determining the areas requiring protection the designer shall give particular consideration to the following: (i) rotors, rotor hubs, associated control linkages, and blade-limiting stops, (ii) aerofoil surfaces, (iii) moving surfaces, (iv) engine and auxiliary intakes,		29.773 29.773b 29.773b1 29.773b1ii 29.951 29.951c 29.975 29.975a 29.975a1 29.975b 29.975b1 29.1093 29.1093a

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	system designer - cause hazard to ground personnel.	simplest shapes mathematical modelling and/or rig testing may be required to provide quantitative results. The extent of ice protection coverage shall also take account of the predicted effects of the maximum likely ice accretion on the unprotected areas.	(v) pitot and static heads and masts, (vi) aerials, sensors and radomes, (vii) weapons and weapon carriers, (viii) transparencies, (ix) vents and drains, (x) other items as specified. Note: For most shapes and ambient conditions there is a worst or least favourable speed which results in the worst accretion rate or greatest heat flux required. This speed is not normally either the lowest or the highest speed of which the rotorcraft is capable.		29.1093a1 29.1093a2 29.1093a3 29.1093a4 29.1093b 29.1093b1 29.1093b1 i 29.1093b1 ii 29.1093b2 29.1093c 29.1323 29.1323 29.1323f 29.1325 29.1325c 29.1419 29.1419a 29.1419b
6	**ROTORCRAFT ICE PROTECTION**				
6.1	**GENERAL**				
6.1.1	The design features of the rotorcraft shall be such as to				

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	minimise the hazards of flight in ice forming conditions. Surface discontinuities and excrescences shall be avoided if possible.				
6.2	**ROTORS**				
6.2.1	Excessive ice accretion on rotors shall be prevented, unless it can be shown by rotor icing tests that, in the meteorological conditions of para 2.1: (i) the rotors and their associated control linkages operate satisfactorily, (ii) loss of lift or directional control, resulting from ice accretion, is within acceptable limits, (iii) vibration levels and structural stresses resulting from accretion or shedding of ice are within acceptable limits, and (iv) there is no hazard to the rotorcraft or its systems,	Rotor ice protection may be continuous, cyclic, or a combination of both in order to meet the requirements of the Rotorcraft Specification. Operation of the ice protection system shall be accomplished either automatically or manually (as specified) unless a continuous system is provided. Irrespective of the type of system installed, continuous operation of the ice control system in flight shall not damage or affect the life of the rotor or the system unless the design of the system is such that it cannot operate manually in conditions where damage would result (see	If ice accretion is to be prevented, then protection may need to be provided for the rotor hubs, associated controls, and blade limiting stops, as well as for the blades		29.1419 29.1419a 29.1419b 29.1419c 29.1419c1 29.1419c2 29.1419c3 29.1419d 29.1419e

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	its occupants, or - so far as can reasonably be prevented - to ground personnel due to ice shed from the rotors.	para. 7.1 (iv)). Indication of the operation of the ice control system, and of any failure to operate, shall be provided in accordance with the Rotorcraft Specification.			
6.2.4	The airframe, and the rotors themselves, shall be protected against unacceptable damage by ice thrown from the rotors.				
6.3	**AEROFOIL SURFACES**				
			Aerofoil surfaces (such as vertical and horizontal stabilizers, stub wings, faired sponsons etc.) may require some degree of ice protection in order to meet the requirements of para. 2. The Design Authority shall give due attention to the effects that such protection may have on the operational performance of the rotorcraft.		
6.4	**ENGINE AND AUXILIARY AIR INTAKES**				
6.4.1	Engine air intakes, and any	Debris guards and grilles or	Note: The engine air intake		29.1091

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	components such as sensor probes which may be located within or in close proximity to the induced airflow, shall be protected against the accumulation of ice in such quantity as to interfere with the performance or safe running of the engine, or which, upon separation, could cause damage to the engine or the airframe.	screens fitted to engine or auxiliary intakes shall be designed or protected against blockage by ice, snow or slush which could result in abnormal engine or system operation, or an unacceptable engine performance degradation. They shall also be designed to minimise the hazard to engines, airframe or rotorcraft systems due to ice shed from them. Appropriate advice and procedures shall be included in the rotorcraft operating and maintenance instructions to avoid damage so caused.	is assumed to begin at the upstream end of the duct traversed by the air which eventually passes into the engine, and to include the whole of such duct.		29.1091e 29.1093 29.1093a 29.1093a1 29.1093a2 29.1093a3 29.1093a4 29.1093b 29.1093b1 29.1093b1 i 29.1093b1 ii 29.1093b2 29.1093c
6.4.2	Air intakes shall be protected against the ingestion of ice, compacted snow and slush shed from the airframe or the rotors, or picked up from the ground, of a quantity sufficient to cause engine damage or malfunction. They shall also be protected against				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	clear air icing when flying in clouds containing ice crystals. (See Leaflet 711/2, Conditions III and IV.)				
6.4.3	The adhesion of ice to any part of the interior of the engine intake shall be completely prevented under the conditions specified in para 2.1 unless tests have shown that the engine can safely accept such ice as might form in the air intake and subsequently be ingested, and there is no significant deterioration in engine performance.				
6.4.4	The engine intake anti-icing system shall be designed, as far as is reasonably possible, to "fail-safe"; that is to say, to remain in or revert to the anti-icing mode in the event of a partial system failure, with the system selected on. Continuous operation of the anti-icing system throughout				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the operational envelope of the rotorcraft shall not damage or affect the life of the engine or the system.				
6.4.5	Auxiliary air intakes and their associated components shall be protected against ice accretion (and any subsequent shedding) which could cause damage to, or unacceptable loss of efficiency of, any rotorcraft system.				
6.5	**AIR DATA SENSORS**				
6.5.1	Pitot, Static, and other similar air data sensors shall be protected against ice accretion unless it can be shown that such accretion will not cause a hazard, or result in an unacceptable loss of performance of the sensor, its associated systems, or any other part of the rotorcraft.				29.1323 29.1323 29.1323f 29.1325 29.1325c
6.5.2	Where protection is required, it should be automatically selected, unless otherwise stated in the Rotorcraft				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Specification. The pilot shall be given a cautionary warning (see Leaflet 107 para 14.3) of the failure of any air data sensor heating system.				
6.6	**RADOMES**				
6.6.2	When siting radomes, account shall be taken of the possibility of damage being caused by ice shed from the rotors and from other parts of the airframe on the radome, and from the radome itself on other parts of the rotorcraft.		Even though radomes are manufactured from low thermal conductivity materials, such structures, depending on shape and position, readily accrete ice and slush. Account shall be taken of the possible effects of ice and slush build-up which may attenuate the radar signal, and may also degrade rotorcraft performance and handling.		
6.7	**WEAPONS AND WEAPON CARRIERS**				
6.7.1	Weapons (system, sights, stores, pods, guns etc.) whilst being carried by rotorcraft in icing or snow, must not be adversely affected by accretions during use,				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	deployment or jettison, unless the weapon or rotorcraft specification permits otherwise. Furthermore, ice accretion on such systems must not hazard the rotorcraft during use of the weapon system.				
6.8	**TRANSPARENCIES**				
6.8.1	Adequate areas of the transparencies used by the crew for the safe and effective operation of the rotorcraft in its designated role shall be maintained free of ice, snow and slush.	The ice protection system shall be capable of correct operation during engine warm-up, ground manoeuvring, hover, take-off and landing, as well as throughout the normal flight envelope of the rotorcraft.	(See also Leaflet 104, para. 5.1)		29.773 29.773b 29.773b1 29.773b1ii
6.8.3	Redundant systems shall be provided if the failure of a single system would result in an inability to comply with para 6.8.1.	The ice protection system shall be tested to demonstrate compliance with para. 6.8.1 without causing overheating or other detrimental effects on the transparency. (See Leaflet 715.)			29.773 29.773b 29.773b1 29.773b1ii
6.9	**VENTS AND DRAINS**				
6.9.1	Airframe and systems vents and drains shall be designed				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	or protected against blockage by ice, snow and slush.				
6.9.2	Water systems (where installed) shall be so designed that the waste water is either collected and retained in the rotorcraft, or is discharged in such a way as to prevent it eventually falling from the rotorcraft in the form of lumps of ice.		(See also Leaflet 711/1)		
7	**ICE PROTECTION SYSTEM CONTROLS AND INDICATORS**				
7.2	The following indications shall be provided to the pilot: (i) accurate indication of the onset of icing (see para 7.3 (v)), unless otherwise stated in the Rotorcraft Specification, (ii) confirmation that the protection systems are operating, (iii) system failure indication,	All ice protection systems should, unless otherwise stipulated in the Rotorcraft Specification: (i) operate automatically when ice begins to form (see para. 7.3(v)) (ii) automatically cease to operate as soon as it is no longer required, (iii) be capable of being switched on-off manually to	Ice detectors shall: (i) provide an accurate indication of ice build-up or impending ice formation (depending on whether they are of the accretion or inferential type) over the full range of temperatures and associated conditions required by the Rotorcraft Specification unless otherwise specified therein,		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	(iv) indication of overheating if the construction of the component is such, (e.g. by bonding process), that overheating would be a serious hazard, (v) indication of the severity of the icing conditions, unless this is shown to be unnecessary or impractical.	override the automatic control (see Leaflet 107, Table 3, Item 2, for location of manual controls), andAll ice protection systems (iv) be capable of operation throughout the flight envelope of the rotorcraft without causing damage, or, alternatively, be so designed that it cannot operate automatically in conditions when damage would result. (In such cases, the pilot shall be given warning that, if the system is operated manually, damage will result.), and, (v) incorporate back-up systems where flight safety may be impaired by the failure of primary systems.	(ii) be located so as to give an accurate indication in all phases of flight and associated rotorcraft configurations, (iii) if they project into the airstream, present the least obstruction to airflow and be constructed to withstand damage from the impact of ice or slush shed from the rotors or other parts of the airframe, (iv) in the case of accretion type detector probes, be positioned with due regard to the probable trajectories of ice shed from them in order to obviate damage to engines, or other systems or components, and (v) have a response time such that the safety of the Rotorcraft, and the correct functioning of its engines and systems, are not jeopardised due to ice accretion. Ice detectors, and temperature		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			or thermostat probes if used, shall be designed for minimum thermal lag.		
8	**DESIGN AND CONSTRUCTION**				
8.1	The ice protection system shall conform to the applicable requirements for equipment for use in aircraft. See DEF STAN 00-35 "Environmental Handbook for Defence Materiel".		The system shall be designed with due regard to: (i) reliability, (ii) availability, (iii) maintainability (including inspection and servicing, see Leaflet 800), and (iv) testability, and shall be shown to meet the requirements of the Rotorcraft Specification in these respects.		
8.2	The protection system and its installation in the airframe shall meet the relevant static strength and fatigue damage tolerance requirements of Leaflets 200 and 201, in addition to any life requirements contained in the Rotorcraft Specification.				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
8.3	All electrical installations shall be designed in accordance with Leaflet 706.				
8.4	Materials used must not be adversely affected by the de-icing or anti-icing medium.				
8.5	Temperature limiting devices, insulation, or other methods shall be used, as necessary, to prevent any system or component of the Rotorcraft from exceeding any of the following: (i) a surface temperature of 70°C, or that which would be hazardous to the occupants, (ii) its design temperature limitations, (iii) the self-ignition temperature of any flammable material (solid or liquid) to which it may be exposed either normally or accidentally, including during ground handling and maintenance.				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
8.6	Any insulation which is not naturally impervious to combustible fluids and which is used in areas where combustible fluids are present shall be covered and sealed with abrasion and fluid resistant covering.				
8.8	If ground checking requires the use of external supplies or test equipment, then suitable test connection facilities shall be provided within the system.				
8.9	The internal diameter of any filling orifice shall not be less than 44mm[1].				
9	**TESTING**				
9.2	Testing shall be performed in accordance with the provisions of Leaflet 1006.	The Design Authority shall show by ground and flight tests that the requirements of this Leaflet are complied with, and in particular that: (i) sufficient ice protection is provided for the icing conditions and	Where flight testing of untried systems or applications may involve some risk, consideration shall be given to first conducting ground tests on representative test specimens using rigs, icing tunnels or other suitable facilities.		29.1419 29.1419c 29.1419c1 29.1419c2 29.1419c3

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		durations required by the specification, (ii) the ice detector will detect, and respond rapidly to, icing conditions, (iii) the automatic controls function satisfactorily when flying into and out of icing conditions, (iv) automatic system operation does not occur in conditions where this might hazard the Rotorcraft or system, and (v) significant failures of the protection system are indicated to the pilot and any back-up systems operate satisfactorily at such times.			
9.4	The ice protection systems under compliance test shall be representative of the standard to be used on production Rotorcraft.				
9.5	With the ice protection system installed and working, the handling and performance				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	requirements of Part 6 must be complied with.				
	The test schedule shall be so drafted, and suitable instrumentation provided, as to ensure (by calculation on the basis of the tests that are performed) that the Rotorcraft and its ice protection systems will also meet the requirements of the Rotorcraft Specification under those conditions which may not be available during the designated test period.				
10	**CROSS REFERENCES TO OTHER LEAFLETS**				
	A number of requirements directly applicable to ice protection appear elsewhere in this publication and the most important of these are listed below. (See also the Alphabetical Index.)				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.

Leaflet	Subject
100	General Requirements.
101	Operation in various Climatic Conditions.
104	View and Clear Vision.
105	Crew Stations - General Requirements.
107	Pilot's Cockpit - Controls and Instruments.
200	Static Strength and Deformation.
201	Fatigue.
400	General Design Data.
407	Precautions against Corrosion and Deterioration.
700	Propulsion System Installations.
706	Electrical Installations.
716	Static and Pitot Pressure Systems.
724	Instrument/Display Installations.
800	General Maintenance Requirements.
1006	Ice Protection Systems.

REFERENCES

REFERENCES

Reference	ASCC Air Standard	STANAG
1	25/11	3212

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Sub-Leaflets				
	LEAFLET 711/1 ICE PROTECTION PRECAUTIONS TO PREVENT WASTE WATER LEAVING ROTORCRAFT AS ICE				
	LEAFLET 711/2 ICE PROTECTION ICING CONDITIONS				
	LEAFLET 711/3 ICE PROTECTION ICE PROTECTION SYSTEMS				
	LEAFLET 1006				
	ICE PROTECTION SYSTEMS				
	GENERAL FLIGHT TEST REQUIREMENTS				
1	**OBJECT**				
	The object of the tests of this Leaflet is to demonstrate, to the maximum extent practical, that any ice-protection systems installed on the Rotorcraft will protect it in all the icing, snow and mixed conditions as laid down in the Rotorcraft Specification.				
1.2			Where the evidence gathered during flight test does not correspond precisely to the		29.1419b 29.1419c 29.1419c1

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			range of conditions specified, best use shall be made of modelling, analysis and rig tests to predict the system capability in the specified conditions. The object of this further analysis is to satisfy the Rotorcraft Project Director that, when the results of such analysis are taken in combination with the flight test evidence, there is confidence that the ice protection systems will provide protection throughout the range of required conditions. If the combination of flight tests and other data is insufficient to fulfil this objective, a recommendation for a limited CA release will be defined based upon the available evidence. The extension of this release will depend upon further flight tests and in-service experience.		29.1419c2 29.1419c3

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			There will be an initial phase of testing during which the rotorcraft's basic capability for flight in icing is assessed, with particular emphasis being placed on establishing the adequacy of anti-icing and de-icing in relation to vulnerable areas. From this may arise a requirement for some secondary protection (eg aerials, areas outside the designed intake coverage, etc). Tests will confirm the integration of protection system with the rotors, airframe and other systems. Testing does not cover general clearance/handling in icing conditions, whether or not the rotorcraft is fitted with ice protection systems. These aspects of testing will be covered by (an amendment to) Part 9. Testing must, however, cover the consequences, or		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			effectiveness, of ice protection systems failure or degraded mode operation.		
2	**RELEVANT DESIGN REQUIREMENTS**				
			DEF STAN 00-970 Volume 2 Leaflets 101, 703, 705 to 708, 710 to 713, 715 to 718, 800, 806.		
3	**APPLICABILITY**				
3.1	The tests in this Leaflet must conclude with assessment on a rotorcraft with an ice protection system representative to the Service standard with all relevant ice protection systems operative, i.e. engine air intakes, rotor anti/de-icing, etc.		Protected areas and areas requiring specific assessment regardless of protection may include:- a) Aerofoils - including rotor blades, wings, stabilisers, etc which may be part of a particular rotorcraft type, ie compound helicopter, tilt rotor/wing. b) Propellers, rotor heads and associated mechanisms. c) Moving surfaces, ie slats, flaps, controls, trim tabs, undercarriage and weapon bay doors. d) Engine, auxiliary and		29.1419e

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			cooling intakes and exhausts. e) Air data system and associated sensors including pitot and static heads/ports and masts. f) External protuberances such as aerials, external sensors and wire-strike protection cutters. g) Weapons and weapon carriers/launchers. h) Transparencies, including those of weapon sensors and sighting systems. j) Vents and drains. k) Other specialised items not covered by the above, including any external role(s) equipment such as underslung or external load equipment. The two basic types of active ice protection systems are as follows:- a) Anti-icing: Systems used to prevent formation of ice on part of the surface of a rotorcraft, usually achieved		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			through continuous and/or rapid cyclic heating of the relevant part of the rotorcraft surface, but can be based on the use of freezing point depressant fluids/pastes in certain limited applications. b) De-icing: Systems used to periodically remove ice from part of the surface of a rotorcraft, before it reaches the point where it would cause rapid and unacceptable degradation of the rotorcraft and/or system(s) functioning/performance or would hazard the rotorcraft during shedding.		
4	**EQUIPMENT**				
4.1	**INSTRUMENTATION**				
4.1.2	All normal flying and general instruments shall be fitted and serviceable for the tests of this Leaflet. In particular the instruments and their standard of calibration shall be such that the crew can	Obtaining, installing and calibrating these instruments, shall be the responsibility of the contractor in accordance with the requirements of Def Stan 05-123 Leaflet 240.	Instrumentation will, to some extent, depend upon the assessment of risk related to flying the particular rotorcraft in icing conditions. This will be based upon calculation, modelling and rig tests (icing		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	monitor all critical aircraft and atmospheric parameters. Special test instrumentation shall be provided where the standard cockpit flight instruments are considered inadequate for this purpose, eg OAT, Liquid Water Content (LWC), rotor control loads/stresses, etc.		tunnel, etc.), previous experience with the rotorcraft and the extent of the icing envelope to be investigated. Many of the parameters required for these tests are common with those of Part 9 and of several Leaflets of Part 10. [Refer particularly to Leaflets 1001, 1003, 10015 and 1016, also to the relevant accompanying leaflets]. The instrumentation specific to this Leaflet is discussed in detail in Leaflet 1006/1.		
4.1.3	Icing on main and tail rotor blades can result in significant and rapid increases in rotor head/blade stresses and control loads. It is important that the instrumentation includes appropriate load monitoring in all critical areas and that on-board visual indicators are provided. Whilst telemetry may be employed, if				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	available, to reduce the number of channels in need of monitoring by aircrew on the test vehicle, the most critical parameters must still be available for continuous monitoring by aircrew in the event of loss of telemetry during critical phases of the test programme.				
4.1.4	The effects of icing, ice/slush/snow ingestion or intake blockage upon engine behaviour is an area which may become evident in the form of torque instability, and/or mismatching in the event of multi engineered vehicles, so that appropriate supplementary engine instrumentation shall be considered.	NOTE: Every effort shall be made during the design phase of the instrumentation to ensure that the sensors and other external instrumentation such as cameras and their mountings are unlikely to introduce an extra element of hazard into the trials or to appreciably modify the basic Rotorcraft ice accretion characteristics. Where possible, these problems should be investigated using icing simulation methods prior to commencement of trials and, in extreme cases,			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		simulated shedding techniques may be used such as wax block methods (see para 6.5) to determine the degree of extra hazard introduced. Where the accretion of ice cannot otherwise be prevented then either heating or chemical anti/de-icing should be considered to ensure that no restriction upon trials flight is introduced.			
4.2	**VISUALISATION**				
4.2.2	Wherever possible, visual monitoring of the accumulation of snow/ice in all critical areas shall be provided together with video or cine-recording where warranted. Where visual monitoring is not practical, flight trials must be restricted to accommodate possible hazards with a progressive expansion of activities subject to regular satisfactory		The use of rotor/engine intake visualisation is considered important and essential to the understanding of the variable characteristics of the ice accretion which will be encountered in natural icing conditions. To achieve this, it will be necessary to make every effort to ensure all potentially hazardous accretions of ice/slush or snow are retained		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	post flight inspections.		by the airframe until visual inspection can be accomplished.		
4.2.3	Where rotor head and other limitations permit, camera(s) shall be mounted to record the build-up, shedding and run-back of ice on upper and/or lower surfaces of main rotor blades.	These may be configured to view all blades simultaneously or singly, and shall have a means of correlating data with other on-board monitoring systems. These cameras shall be subject to development testing to ensure that they do not add to the hazards of the trial by aggravating the overall vibration levels, the airframe/rotor stresses and loads or to the rotor-head icing. They shall also be subject to EMC investigation, both as to possible cause and effect.			
4.2.4	Prevailing ambient atmospheric conditions shall be recorded (the relevant list should include outside air temperature, liquid water content, droplet size, snow				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	severity and altitude).				
4.2.5	An ice accretion meter should be provided for the pilot to enable identification of the onset of airframe icing, ice type and amount.	If a calibrated Vernier Accretion Meter is not practical on the aircraft type, an appropriate part of the airframe shall be identified for this purpose. Consideration shall be given to the clearance of the meter once it has accreted the maximum it is capable of measuring.			
5	**LOADING**				
5.1	The tests must be made over a range of loading and centre-of-gravity positions to ensure that the achievable flight envelope is not significantly more restrictive than the maximum envelope for which release is sought taking into account the limitations imposed by the carriage of external stores or other loads, ie maximum normal acceleration, attitude, speed, etc.	On rotorcraft powered by a single engine, external loads should not be carried if the tests may either result in or require the engine to be shut down in flight, unless the load is specifically required for the trial .			29.21 29.21 29.21a 29.21b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
6.	**GENERAL TEST CONDITIONS AND REQUIREMENTS**				
6.1	The service operational requirements need to be clearly defined in terms of, severity of snow and icing encounters to be considered, the duration of any and each icing encounter and the number of icing encounters per flight.	The level of acceptable rotorcraft or system performance degradation shall be specified in the requirement.			
6.2	The ice protection systems under test shall be representative of the production standard rotorcraft. Ground and flight conditions shall be representative of the Service role of the rotorcraft and the range of climatic conditions for which clearance is required.	In areas where the likelihood of large accretions is judged as high, shedding tests may be necessary before the aircraft is exposed to significant levels of ice accretion. Such tests, possibly using wax blocks, can identify the probability of ice shedding and impacting vulnerable areas.	Icing trials with a hitherto untried rotorcraft have to be approached with the understanding that it is a high risk area. The choice of icing trials venue must be made carefully to ensure that the following important factors are taken into account:- a) The best probability of icing or snow conditions at the temperatures and severities required. b) Good servicing facilities including heated		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			hangarage to ensure fast turn around between icing sorties and safe, efficient maintenance in a hostile environment. c) Effective logistic support for rotorcraft and trials equipment spares and for personnel. d) Good air traffic facilities with an efficient meteorological service, radar cover and safety services and ideally a dedicated area for icing encounters. e) Safe, uncluttered terrain against the possibility of a forced landing. f) Line features, e.g railways or roads, (ideally connecting with the airfield) to give good visual cues and enable safe snow flying to take place. g) Flat terrain to increase the probability of non-icing air between the icing level and ground.		

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6.3	In particular, the following shall be taken into account prior to testing:- a) The evidence from ground rig tests, together with any previous experience of operation with similar equipment or installations. b) The protection systems manufacturers limitations on the equipment under test and evidence from any previous experience with the rotorcraft in icing conditions with or without protection c) Test evidence from the Engine manufacturer as to the engine's liquid water, snow and ice ingestion tolerance and ice protection system qualification. d) The various snow and icing conditions to be examined, including blown, recirculating snow and freezing rain/drizzle. e) The status and				29.1093b1 29.1093b1i 29.1093b1ii 29.1305a17 29.1419a 29.1419b 29.1419c B29.8b1

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	condition of any ice protection system including failure and degraded modes where appropriate. f) The need to test different configurations of other aircraft systems that may affect the ability of the aircraft to operate in snow or icing e.g. Environmental Control System ON/OFF				
6.4	Datum engine and aircraft performance and stress/load measurements shall be undertaken, on the fully equipped trials rotorcraft, out of icing conditions, and should be completed and assessed in advance of any icing sortie.				
7	**GROUND TESTS**				
7.1	Validation of qualification evidence of windscreen services shall be provided by cold soak ground tests where the windscreen and cockpit transparencies have been				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	allowed to mist up or ice over, followed by operation of:- a) Normal windscreen/transparency demist/ice protection systems to assess the adequacy of clear vision throughout the pre-take off period. b) Engine(s) and/or APU operating in accessory drive (where appropriate), air conditioning to maximum heat setting and windscreen/transparency heat to maximum boost to assess adequacy of clear vision for take off and hover. c) Any standby demist/de-ice system which may be fitted.				
7.2	Engine and APU (where appropriate) running should be carried out over the widest range of power possible on the ground to establish any condition at which the onset		Consideration must be shown to be given to the validation of the qualification by means of test evidence gathered from full scale aircraft tests over the range of conditions		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	of intake icing may occur for any intake configuration for which release is sought. All configurations of engine air intake shall be qualified by evidence gained using appropriate wind tunnel icing facilities or an equivalent simulation.		required by the Rotorcraft Specification. This is of particular importance in conditions for which accurate simulations are not available. Note that under some conditions this could be at ambient temperatures as high as +50C. These tests shall also establish lower temperature ground running procedures for Service use and any necessary operational restrictions.		
7.3	Taxying and ground running operations should be assessed to determine the extent of airframe and/or rotor contamination from the effects of spray/slush thrown up from the ground by wheels (if fitted) and rotor down wash. The assessment should encompass both take off and landing configurations if different.	Consideration shall then be given to the possible effects of the resultant spray/slush freezing and causing interference with normal operation of undercarriage, undercarriage doors, adjustable control surfaces and flying controls or other systems during and after take off.	A preliminary assessment of the effects of recirculating snow on engines, rotors and pilot/crew vision may also be made during this phase of testing.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
7.4	Following operation of ice protection systems there shall be a post-flight assessment of the extent of run-back of melted snow/ice on rotor blades, engines, flying controls and control surfaces where subsequent refreezing could occur to the detriment of their performance.		It must be remembered that similar hazards may occur, particularly as a result of flight in precipitating and recirculating snow, due to snow melt-water draining from the aircraft drains, bays and panels. Particular attention must be paid to resultant effects upon flush-fitted vents such as employed for fuel and air data systems.		
	Where the ice protection system has built-in-test equipment (BITE) then the performance of this equipment should be assessed against the known status of the protection system throughout the tests.				
7.6	The design of the ice protection systems should be such as to preclude potentially damaging effects in the event of deliberate or inadvertent operation outside the range of the design	However, where system operation is controlled only by pilot action and no other protection or restriction is applied, tests may be necessary to establish the effect on the airframe			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	envelope.	structure, rotors and other systems resulting from such circumstances. These tests shall, where the design of the Rotorcraft electrical or protection systems permit and an argument of possible effect can be sustained, be undertaken both with and without engines/rotors running as applicable.			
7.7	In order to minimise risk during subsequent flight testing, consideration shall be given to conducting a series of tests on the ground using appropriate wind tunnel icing facilities or an equivalent simulation.		Aspects that might usefully be addressed are:- a) The ability of the ice detector(s) to detect icing conditions and its (their) response time to those conditions. b) Functioning of pitot/static head and mast heaters under icing conditions. c) Operation of low airspeed sensing systems and heating (where provided) under icing conditions. d) Functioning of the ice		29.1419a 29.1419b 29.1419c 29.1419c1 29.1419c2 29.1419c3 29.1419d 29.1419e

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			protection systems of the rotor(s) under normal and partial failure conditions. e) Functioning of engine and APU intake ice protection systems. f) Ice shedding from unprotected parts of rotors, airframe and intakes to assess the possibility of significant quantities of ice being ingested by engine(s)/APU and general FOD risk to the rotorcraft. g) The effects of ice accretion on primary and secondary flying controls. h) Assessment of clear vision for the pilot(s) over the specified operational envelope of the rotorcraft. j) Assessment of the effects on rescue winch(es), MAD winches, weapon carrier installations, etc and the effect this has on operation and jettison capability.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			k) Initial assessment of the possible effects of frozen slush on the operation of undercarriage and undercarriage/weapon bay doors. m) An assessment of the effects of ice or snow blocking engine or APU screens, fuel system vents, cooling air ducts, etc. Such an assessment should include the effects on the mechanical integrity of the screens		
8	**FLIGHT TESTS**				
(b)		Aspects to be addressed in the initial phase should encompass: a) Establishment of electrical power demands and adverse effects of operation of ice detection and protection systems on airframe, rotor and other systems by operation in a range of conditions including clear air at temperatures from	Flight in icing conditions with an untried rotorcraft and/or ice protection system(s) is an area to be approached with extreme caution with appropriately restricted initial sorties into icing conditions and progressing slowly to a less restrictive envelope. (see Leaflet 1006/2 for notes on Flight Safety aspects of these		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		+50C down to -100C and progressively colder. b) Establish by flight in a range of conditions, the correct functioning of ice detection systems (if fitted) and the relationship with airframe ice build up. Observation shall be maintained to establish all cues that the rotorcraft has entered icing conditions, eg; ice formation on unheated areas of windscreen/transparencies, windscreen wipers (where fitted) and/or structure in the immediate view of pilot/crew. c) The extent of ice formation on the intake protection systems along with the associated effects of intake blockage on engine operation. Having established a degree of confidence in the basic capabilities of the aircraft systems and any areas of the	trials). The extent and scope of test in natural snow and ice conditions will depend upon the rotorcraft configuration and required operational envelope sought. The level of test necessary to substantiate qualification evidence previously gained by rig testing of specific ice protection system and components may also vary and the following specific areas of investigation may thus be reviewed on merit subject to agreement with the Rotorcraft Project Director. The gathering of meteorological data throughout all icing encounters, especially OAT, liquid water content, droplet size and ice accretion is essential to the support of the qualification and		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		airframe that may result in restrictive or limited activities, testing should then be extended progressively to cover the following:- a) Flight in icing conditions to substantiate the performance of all ice protection fitted including engine air intakes, rotors and general airframe icing. b) Flight in precipitating and recirculating snow. c) To demonstrate that adequate pilot/crew vision is maintained under all required operational conditions by use of available transparency demisting/ice protection and other windscreen services. d) The effects of relevant partial and total system failures including, if required, cautious assessment of the unprotected rotorcraft. This shall include an assessment of the effects of load shedding following an electrical	substantiation programme and a critical aid in the evaluation of any possible limiting conditions and interpretation of data gathered throughout the trials.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		generation system failure if relevant to continued operation in icing conditions. Note that basic electrical ice protection systems are considered to be essential services in terms of the electrical system power capacity (Leaflet 711 para 2.8) if the functioning of the Ice Protection system, is a prerequisite to the performance of the Operational Role of the Rotorcraft (Leaflet 706 para 2.7.2 iii). e) The effects of icing on the operation of any sensors critical to the operational role of the Rotorcraft, eg Pitot-static heads/ports, low airspeed sensing system, etc. f) Assessment of mechanical side effects arising from icing, eg run-back from heated surfaces restricting sliding panels, movable controls or items			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		such as blade stops on rotor heads. g) Effects of the accumulation of ice/snow/slush on equipment air cooling intakes and exhausts and ancillary vents and drains such as employed on fuel systems. h) Rates, position and significance of any ice accretion and effect on rotorcraft. It must be noted that the level of significance of any ice accretion will vary dependent upon rotorcraft and configuration and the location of accretion. j) Operation on, from or to ice and snow covered surfaces including ground and hover taxying, rotor engagement and use of deck-lock or haul-down equipment (where appropriate). k) An assessment of the effect on Rotorcraft performance of the operation			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		of ice protection systems, eg net effects upon available engine power (both direct and in-direct), airframe and rotor drag effects, and the significance of any failures in terms of comparative data as derived by testing outlined in (iv) of this paragraph.			
	Sub-Leaflets				
	LEAFLET 1006/1 ICE PROTECTION SYSTEMS GENERAL FLIGHT TEST REQUIREMENTS				
	LEAFLET 1006/2 ICE PROTECTION SYSTEMS GENERAL FLIGHT TEST REQUIREMENTS		**LEAFLET 1006/2**		
	LEAFLET 1011				
	ELECTROMAGNETIC COMPATIBILITY OF SAFETY CRITICAL SYSTEMS				
1	**OBJECT**				
	The object of the tests of this Leaflet is to demonstrate that the electronic/electrical systems of the rotorcraft which are				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	safety critical operate satisfactorily and with an adequate margin of safety (as defined by the Main Contractor and agreed by Project Office on advice from EMC specialists) in: (i) The electromagnetic environment generated by the rotorcraft (systems of the rotorcraft are self compatible), and (ii) The external electromagnetic environment corresponding to the operational requirement.				
2	**RELEVANT DESIGN REQUIREMENTS**				
2.1	The documents must include the agreed statement defining the limits of satisfactory operation, criteria against which satisfactory operation shall be judged, methods of monitoring and limits of responsibility of Contractor and Project Office. The documents must also contain agreed statements concerning the levels of electrical transients on power, signal and/or control leads .		EMC Control Document/Portfolio/Design Guide written by the main contractor for the specific project as agreed by DAES, (for non-armament aspects) or DA Arm (for air armament and air armament control aspects) Project Office and the test authority (usually A&AEE/Engineering Division/Armament Division); external environment as defined in NWS 6 or as agreed in the Contract; EMC qualification test requirements for the installed equipment to RAE Tech Memo FS(F) 510 and Ordnance Board Proceeding (41273) "Principles of Design		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			and Use for Electrical Circuits Incorporating Explosive Components". (see also Leaflet 1003).		
3	**APPLICABILITY**				
			The rotorcraft tests described in this Leaflet are applicable to all new electronic/electrical safety critical systems of rotorcraft and all such systems where modifications have been made which are likely to affect the results of the tests unless otherwise stated. A safety critical system is defined as a system (or one of a collection of systems) of the rotorcraft in which a disturbance (or combination of disturbances) could result in a direct hazard to the rotorcraft, aircrew, people or property on the ground.		
4	**EQUIPMENT**				
		The basic equipment required for these tests is:	Note: The standard of instrumentation and installed		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		(i) Source(s) of electromagnetic fields. (ii) Antennae/receivers to measure strength of electromagnetic fields . (iii) Current/voltage probes for injecting and measuring interference induced during trials and fibre optic instrumentation for signal transmission. (iv) Such instrumentation as is necessary to indicate system malfunction/ degradation of performance.	test equipment in the test rotorcraft must be such that it does not affect the rotorcraft's electromagnetic compatibility.		
5	**GENERAL TEST CONDITIONS AND REQUIREMENTS**				
5.1	All electrical/electronic systems are to be fully representative of the production rotorcraft and working. No additional wiring to rotorcraft or to stores is to be present except that required for the trial. (See also Note, para 4).	Soundly based information on the likely EMC characteristics of the systems under test is an important pre-requisite to effective testing of the rotorcraft and this shall be obtained by the main contractor. The information shall be acquired during			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		Qualification and Rig Testing or by special tests agreed with the Test Authority. The information shall be presented in the form of a malfunction signature (in a form in which measurements on rotorcraft can be related) showing the minimum voltages/currents/field strengths required to prevent satisfactory operation or to cause a malfunction as a function of frequencies as agreed between the Contractor and the Test Authority. Particular susceptibilities at certain frequencies are to be clearly identified together with levels at which malfunction/unacceptable degradation of performance occurs. Such information should be available in the EMC portfolio compiled through pursuance of the EMC Control Plan for the			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		systems under test. In order to ensure the relevance of the data, care shall be taken to ensure that the tests used to generate the malfunction signature are made under conditions which are as representative of the final installation as is practicable to achieve. These conditions shall be agreed between the Main Contractor, Rotorcraft Project Director and the Test Authority.			
6	**TEST DETAILS**				
		Each system to be tested shall be exercised through or in all (or at least most) susceptible modes while the other rotorcraft systems are brought into operation and any effect of operation, including effects of electrical transients, noted and where practical and sensible the emission from intentional transmitters e.g. VHF radio should be			29.1431a 29.1431b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		enhanced in power) as agreed in the EMC Portfolio. Subsequently, the systems are to be exercised while the rotorcraft is illuminated from a source (or range of sources) representative of the required external electromagnetic environment. If there are limitations to the extent to which the required external environment can be generated, for example with respect to frequency, power or orientation in relation to the axes of the rotorcraft then additional tests should be considered using substitutional techniques such as direct voltage or current injection.			
6.2	Induced interference is to be continuously monitored during the trial together with performance of the systems under test.	Serious loss or degradation of performance is likely to take the form of either an unwanted output or as a failure to respond to a wanted signal. Because the former is			

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		easier to detect and because the mechanisms generating the two forms of degradation are similar, the interferences shall be modulated at a frequency which is within the operating bandwidth of the system under examination.			
6.3	Where the test is completed without system malfunction or serious degradation of performance occurring, the margin of safety is to be established by comparison of the induced interference recorded from the test with the malfunction signature established previously (see para 5.2). In the case of armament systems, the margin of safety to be applied shall be in accordance with Ordnance Board Proceeding (41273).				
	LEAFLET 704				
	HYDRAULIC SYSTEMS				
1	**INTRODUCTION**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			The requirements of this Leaflet apply to all hydraulic systems. A hydraulic system comprises a source of hydraulic power, distribution lines and components, control devices, actuating units, accumulators, fluid reservoirs, and filters.		
2	**HYDRAULIC SYSTEM TYPES**				
2.1	**PRIMARY SYSTEMS**				
			Hydraulic systems which are dedicated to functions that are essential to flight safety (e.g., primary flight controls).		
2.2	**UTILITY SYSTEMS**				
			Hydraulic systems which serve functions which are not essential to flight safety (to be agreed with the Rotorcraft Project Director).		
3	**HYDRAULIC SYSTEM PRESSURE/TEMPERATURE CLASSIFICATION (REF BS M51-ISO 6771)**				

<table>
<tr><th>Para No</th><th>DS970 Pt7 Requirement</th><th>DS970 Pt7 Acceptable Means of Compliance</th><th>DS970 Pt7 Guidance</th><th>DS970 Pt7 Policy, Notes, and References</th><th>CS-29 Para No.</th></tr>
<tr><td></td><td colspan="4">
<table>
<tr><th colspan="2">NOMINAL PRESSURE CLASSIFICATIONS NOMINAL SYSTEM PRESSURES (Pw) SHALL BE CLASSIFIED AS FOLLOWS:</th><th></th><th colspan="2">TEMPERATURE TYPES SYSTEM OPERATING TEMPERATURE RANGES SHALL BE CLASSIFIED AS FOLLOWS:</th></tr>
<tr><th>CLASS</th><th>PRESSURE</th><th></th><th>TYPE</th><th>TEMPERATURE RANGE</th></tr>
<tr><td>A</td><td>4000 kPa (40 bar)</td><td></td><td>I</td><td>-55 to 70°C</td></tr>
<tr><td>B</td><td>10500 kPa (105 bar)</td><td></td><td>II</td><td>-55 to 135°C</td></tr>
<tr><td>C</td><td>16000 kPa (160 bar)</td><td></td><td>III</td><td>-55 to 200°C</td></tr>
<tr><td>D</td><td>21000 kPa (210 bar)</td><td></td><td>IV</td><td>-55 40 320°C</td></tr>
<tr><td>E</td><td>28000 kPa (280 bar)</td><td></td><td>V</td><td>-55 to 400°C</td></tr>
<tr><td>F</td><td>40000 kPa (400 bar)</td><td></td><td>VI</td><td>-55 to 650°C</td></tr>
<tr><td>G</td><td>50000 kPa (500 bar)</td><td></td><td></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>4</td><td>HYDRAULIC FLUID</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4.2</td><td>All materials in contact with the fluid and in particular elastomeric sealing materials, shall be compatible with the hydraulic fluid over the temperature range, functional, service and storage conditions to which the hydraulic system will be exposed.</td><td></td><td>The type of hydraulic fluid to be used in the system will be stated in the rotorcraft specification. (see Leaflet 704/0).</td><td></td><td></td></tr>
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Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
5	**DEFINITIONS**				
			Pw - The nominal system supply working pressure within its design tolerance, see para 6.1. Pr - The relief pressure is the maximum pressure permitted by any pressure relief means provided in compliance with para 8.1.6 within its design tolerance. Pd - The design pressure for any component or part of the system. This includes the working pressure (Pw) plus the effect of any intensification of pressure during operation, or from external loading, and from transient peak pressures that may occur. See para 8.1.3. and 8.14.		
6	**HYDRAULIC POWER SUPPLY**				
6.1	Means shall be provided to maintain the pressure in any part of the system without	The design aim shall be to maintain the steady state system pressure at Pw ± 10%.	Also see para 5.1 and 8.1.4.		29.1435a4

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	excessive fluctuations during normal operation of any service. These means shall ensure that, under any possible condition of operation, the maximum pressures never exceed the proof pressure and the minimum pressures never become less than that necessary for efficient operation.				
6.2	The power output from the power supply, including the accumulator(s) shall be sufficient to allow all services to satisfy their respective operating requirements.				
6.3	The requirements of paras 6.1 and 6.2 shall be met when the services are operated singly and also when the most adverse combination of services likely to be operated during operational flying is used (e.g., under approach conditions), including engine				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	out conditions on multi engined rotorcraft.				
7	**FLUID CAPACITY AND RESERVOIRS**				
7.1	Provision shall be made in the reservoir for a minimum reserve of fluid equal to at least 25 per cent of the fluid between the maximum and minimum levels (or 1.0 litre if this is greater).	This reserve shall be available when the fluid is at its minimum level and the rotorcraft is in the most adverse attitude, corresponding to that combination of services which produces the minimum level.	Note: This does not apply to completely self contained power units.		
7.2	The system shall be designed to minimise possible changes in reservoir fluid level when operating, and the reservoir capacity shall be such that, in normal conditions, it can accept all the returning fluid without spillage or over pressurisation.				
7.3	Reservoirs shall provide adequate head of fluid for the hydraulic pump, or be pressurised to meet the hydraulic pump requirements				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	at system start up and at all operating conditions and altitudes. Pressurised reservoirs shall have a maximum pressure control device to prevent over pressurisation. Bootstrap type reservoirs shall have the equivalent low pressure relief setting slightly higher than the HP system relief pressure to avoid transient functioning of the reservoir relief valve. Non pressurised reservoirs shall also have a maximum pressure control, and a minimum pressure control shall be considered to prevent collapse of the reservoir or system cavitation.				
7.4	Reservoirs shall be either self bleeding of air during filling and changes in fluid level, or a manually operated bleed valve shall be fitted.	This valve is important when manual filling is required as provision must be made for the reservoir to depressurise safely before removal of the filler cap. The return flow to the reservoir must be so			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		arranged that the pump suction does not directly receive the returning fluid and any fluid aeration is reduced to a minimum.			
8	**SYSTEM OPERATING REQUIREMENTS**				
8.1	**PRESSURE AND FLOW CHARACTERISTICS**				
8.1.1	Consideration shall be given to pressure losses in hydraulic lines and units due to flow. The hydraulic pipe sizes selected shall take into account hydraulic losses due to pressure and flow rates and the shape of the pipe.				
8.1.2	The actual working pressures available at hydraulic units shall be used for operational performance calculations.		See para 15 for strength requirements.		
8.1,4	Transient peak pressures that may occur during operation of any service in the system shall not exceed the nominal system pressure (1.0 Pw) by more than 20 per cent (1.2	In special cases where this cannot be achieved, due allowance shall be made for the surge pressures in the strength of the system (see para 15).	Account shall be taken during design, of any intensification of pressure that could occur in the system under operational conditions of loading (e.g., that caused		29.1435 29.1435a1 29.1435a4

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Pw max).		under certain circumstances by the difference in area between the two sides of an actuator piston or where the load assists the actuator pressure).		
8.1.6	Pressure relief provision shall be made for preventing the steady pressure in any part of the system from exceeding, from any cause including thermal expansion of the fluid and excessive external loads, the pressure Pr, where Pr is the relief pressure for that part of the system fixed at a value which allows a reasonable margin above Pw (usually Pr = 1.33 Pw approximately but in some systems a higher relief pressure may be necessary). The pressure relief provision shall also protect the system during ground testing with external hydraulic power applied.		Return line back pressures which can occur in the system from reservoir pressurisation, or operational conditions shall be considered in the design of hydraulic units and transmission lines. In particular the effect which this may have on performance of hydraulic valves, actuators, wheel brakes and mechanical locks that are hydraulically actuated. Consideration shall be given to the effect of local heating of fluid due to high pressure leakage and to possible electrokinetic damage.		29.1435a4

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
8.2	**TEMPERATURE**				
8.2.1	The hydraulic system shall be designed so that the hydraulic fluid and sealing materials in any part of the system do not exceed their temperature limitations under the most severe conditions of normal flight or on the ground. Local heating due to any cause, including increased flow through worn components, shall not cause excessive friction or seizure.	The cumulative damage which may be caused to elastomeric sealing materials or flexible pipes, that may have to operate at their extremes of temperature for considerable periods, shall be considered when selecting materials.			
8.2.3	When electrical or electronic controls are used integrally with hydraulic components and units in the system the combined effect of hydraulic heating with fluid temperatures shall be considered (e.g., wet solenoids) and also any fire hazard.				
8.3	**BLEEDING**				
		The design aim shall be that systems are self bleeding, but			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		where this is not possible, bleed screws in components shall be provided for the removal of trapped air, and if necessary in the piping system. Disconnection or slackening of the pipelines for bleeding is prohibited unless agreed by the Rotorcraft Project Director.			
8.4	**INDICATION AND INSTRUMENTATION .**				
8.4.1	Pressure indication shall be provided in the cockpit to show the pressure available from the hydraulic system and to give indication of the failure of any system. On rotorcraft with more than one system the indication shall show the pressure available in each system.	Cockpit or pressure cabin indication shall be provided by the use of remote indication type gauges to avoid locating fluid or gas transmission lines in these areas (see para 13.5). Alternatively indication may be by electronic means when the Rotorcraft Specification includes the use of data bus electronic transmission systems.	When two pumps feed into one system consideration shall be given to the need for providing flow and/or pressure indication for each pump. **(see also Leaflet 107)**		29.1435a3
8.4.4	Pressure indication for accumulator gas charge				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	pressure shall be installed so that it can be easily seen when servicing the rotorcraft.				
8.4.5	Where mechanical pressure gauges are used in other rotorcraft locations, with the agreement of the Rotorcraft Project Director, they shall be installed so that failure of the gauge cannot cause serious loss of hydraulic fluid or gas.		Additional instrumentation to satisfy particular requirements for monitoring or indication of the condition of the hydraulic system (e.g., reservoir fluid level, low pressure warnings or BIT) will be stated in the Rotorcraft Specification and agreed with the Rotorcraft Project Director.		
8.5	**REPLENISHMENT**				
8.5.1	Replenishment points of hydraulic reservoirs shall be readily accessible and there shall be a simple means of determining the fluid level from the replenishment point without the use of external equipment. Fluid used for replenishment shall be filtered to the required standard for the system, and pass through a rotorcraft	When gravity filling is required the internal diameter of the filling orifice shall not be less than 38mm (Ref 1) and the reservoir replenishment inlets shall contain strainers to prevent the ingress of foreign bodies when the filler cap is removed.			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	system, filter.				
8.5.3	Means shall be provided for draining away clear of the rotorcraft any fluid spilled at the filling points.				
8.6	**GROUND TESTING**				
8.6.1	External Test connections from which all services can be operated by external ground servicing equipment shall be provided.	These shall be of the self sealing type. Test connections must give easy access to, and be of adequate strength to accept the load from the ground equipment hoses. On small simple rotorcraft and when agreed with the Rotorcraft Project Director a hand pump which is part of the rotorcraft system can be used for ground testing.			
8.6.2	Where two or more pumps feed on a system, means shall be provided for checking all pumps on the ground before take off.				
8.6.3	Where more than one hydraulic system is connected to a hydraulic sub circuit it		Care shall be taken to avoid possible damage to, or cavitation in, any unit due to		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	shall be possible to check the functioning of the hydraulic circuit using each hydraulic system separately.		single system working e.g., hydraulic motors with a common drive shaft where one may act as a pump in an unpressurised condition, or cavitation in the unpressurised portion of a tandem powered flight control.		
8.7	**INTERNAL PROTECTION**				
8.7.1	Internal corrosion and fretting shall be considered when designing the hydraulic system and its components and protection provided where possible.		Some hydraulic fluids are hygroscopic and additional water may be induced due to condensation in reservoirs. Also, other contaminants are possible, therefore, the ability to drain is necessary and suitable drain points shall be provided.		29.1435a5
8.8	**FUNCTIONING**				
8.8.1	The system shall comply with the requirements of Leaflet 100, paras 8 and 9.				29.1301 29.1301 29.1301a 29.1301c 29.1301d
9	**FILTRATION**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
9.1	**FILTRATION STANDARDS**				
9.1.1	Filters shall be provided to filter all the circulating fluid in the system and shall be such as to maintain contamination levels of the system below the level of the class (as specified in DEF STAN 05-42) agreed between the Designer and the Rotorcraft Project Director.	When ground servicing rigs are connected to the rotorcraft hydraulic system(s) the filtration standard of the rotorcraft system must not be degraded by circulation of fluid through the ground rig.	Sub circuits may require a different filtration standard to that required for the main system.		29.1435a5
9.2	**FILTER TYPES AND LOCATIONS**				
9.2.1	General. Filters of the type specified shall be provided in the locations in the following paras as a minimum requirement.	Additional filter locations shall be provided if required by the Rotorcraft Project Director, or if required to protect critical components such as powered flight controls.			
9.2.2	Pump Circuit (i) Pressure Line. A non bypass type filter shall be installed in each system pressure line, and so located that all fluid from the		Separate PCD filters shall normally be of the bypass type, but may be of the non bypass type with differential indicator if the proof pressure of the pump case and the		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	pump(s) and ground rigs will be filtered prior to reaching system components which are sensitive to contamination. In multi pump systems each pump shall have a separate filter installed with no system components between the pump and the filter. (ii) Pump Case Drain Circuit (PCD) Pump case drain flows shall be filtered using either a separate pump case drain (PCD) filter or combined LP/PCD filter. (iii) Pump Suction Circuit. Suction filters (filters between the system reservoir and pump inlet) shall not be used unless specifically agreed with the Rotorcraft Project Director.		PCD filter is high enough to withstand the pressure arising from a blocked PCD filter up to full system pressure.		
9.2.3	Hydraulic Sub Circuits. Screen type filter elements to protect against contaminate particles in both flow directions shall be fitted	Other hydraulic units (e.g., sequence valves) may also require filter screens in both flow directions if the unit controls a critical function.			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	adjacent to the orifices in components or hydraulic lines where these are 1.75mm or less in diameter, or the equivalent cross section area. The total area of the screen must ensure that it does not itself cause a blockage.	Powered flying control valve blocks should also be fitted with a suitable filter or filter screen.			
9.2.4	Return Line Circuits. A bypass type filter shall be installed in each system low pressure (LP) (return) line downstream of all system components. All fluid in the low pressure circuits (including reservoir replenishment fluid) shall pass through the low pressure filter prior to entering the system reservoir.	Consideration shall be given to providing a filter with a rated flow well above the return line flow under maximum operating conditions to minimise bypass operation. Special consideration must be given to prevent unacceptable back pressures generated by return line filters in return lines from wheel-brakes. The solution to be agreed with the Rotorcraft Project Director.			
9.3	**FILTER ELEMENTS**				
9.3.1	All filter elements other than the screen type called for in para 9 shall be of the disposable 'depth' type. The	Filters shall be positioned to give easy access for element change in minimum time, with suitable provision for the			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	pressure line filter elements including screen type elements shall have a burst strength above the nominal system working pressure for both normal and reverse flow directions (see para 15).	removal and replacement of the filter elements, and to prevent fluid spillage and limit the ingress of air.			
9.4	**DIFFERENTIAL PRESSURE AND INDICATORS**				
9.4.1	All non by pass type filters shall be equipped with differential pressure indicators, and it is preferred that these indicators shall be fitted to all filters.	The differential pressure indicator shall signal when an element change is required and shall be clearly visible to the ground crew during routine inspections. Provision shall be made to prevent spurious indications occurring due to extreme conditions (e.g., external contamination). Where indicators are not fitted filter elements must be changed on a periodic rather than an 'on condition' basis.			
9.5	**FLUID SAMPLING POINTS**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		DEF STAN 05-43 gives guidance on fluid sampling and the type of sampling valve shall be agreed with the Rotorcraft Project Director.	The requirement for fluid sampling points will be stated in the rotorcraft specification.		
10	**HYDRAULIC PIPELINES AND COUPLINGS**				
10.1	**RIGID PIPES**				
10.1.1	The hydraulic tubing shall be in accordance with DEF STAN 47-25 unless otherwise agreed with the Rotorcraft Project Director.				
10.2	**INSTALLATION OF RIGID PIPES**				
10.2.1	All conditions up to the limits of the design flight envelope of the rotorcraft shall be taken into account.	The aim shall be to ensure that the installation of hydraulic rigid pipes, together with their components and supports, will be such that they are capable of withstanding throughout the life of the rotorcraft the worst effects of vibration, structural distortion, malhandling and temperatures likely to occur.	In addition the rigid pipes shall be so installed that they are unlikely to be used as hand or foot holds.		29.1435a1
10.2.2	The material of the pipe	The need for electrical	See Leaflet 407 for protection		29.1435a5

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	supports, clips and fairleads in contact with the pipe, shall be such that it does not cause damage to the pipe through chaffing when subjected to vibration, expansion and contraction.	bonding shall be considered.	against corrosion.		
10.2.3	Provision shall also be made in the construction of the supports or in the layout of the pipes to permit changes in pipe length induced by expansion or contraction resulting from changes in temperature, flight or ground loads, actuator movement or hydraulic pressure. All pipes shall be adequately supported. Outrigged clipping with distance tubing and spacing bobbins shall not be used.				29.1435a6
10.2.4	The following minimum clearances shall be maintained: (i) between pipe lines and between pipelines and	The clearances of para 10.2.4 shall not be achieved by the insertion of packing materials which will be subject to deformation or deterioration			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	adjacent rigid structures or fixed components - 6.0mm. (ii) between pipelines and structure where pipes are held by a fairlead on to the structure or a support bracket - 3.0mm. (This dimension can only be permitted if the structural part does not extend more than 25.0mm beyond the fairlead). (iii) between pipelines and moving rigid parts, e.g., control rods, etc., - 13.0mm under the most adverse conditions, and (iv) between pipelines and control cables or other flexible moving parts - 25.0mm under the most adverse conditions.	which will ultimately appreciably reduce the clearance. Any cases of difficulty in complying with this requirement shall be referred to the Rotorcraft Project Director for consideration at an early stage in the design.			
10.2.6	Where components and units, such as non return valves, restrictors etc., are not provided with integral mountings and are coupled directly into pipelines,				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	provision shall be made for the pipes to be supported as close as practicable on each side of the component.				
10.2.7	Adequate spanner access to all hydraulic pipe unions, connections and couplings shall be provided. Torque loading shall be specified where necessary. It shall be possible to change a pipe, component or unit with the minimum of disturbance, and if necessary adjustment shall be provided to achieve this requirement.				
10.2.8	Pipe identification shall be in accordance with Leaflet 806, para 5.				
10.3	**PIPE COUPLINGS**				
10.3.1	All pipe couplings shall be in accordance with DEF STAN 47-25 unless otherwise agreed with the Rotorcraft Project Director.				
10.3.2	The pressure line and return line pipe coupling sizes at	Direction of flow where this is important, e.g., non return			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	each junction shall be different and so arranged that there is no possibility of incorrect assembly.	valves, shall be clearly marked on the unit, but in addition different size and connections is preferred, or male and female configuration.			
10.4	**FLEXIBLE PIPES/HOSES**				
10.4.1	All flexible hoses shall conform to DEF STAN 47-12. The hose assemblies shall not be subjected to torsional deflections (twisting) when installed, or during functioning and operation of the system. The support of a flexible hose shall not cause deflection or relative motion with its associated rigid pipe.	Coiled rigid tubing may be used if required to connect the hydraulic lines of moving components or units to the airframe connections, providing the movement is relatively small, and adequate qualification testing has been completed to prove the design to a standard acceptable to the Rotorcraft Project Director. Other forms of flexible connections in hydraulic circuits, such as swivel couplings, sliding sleeves, ball joints etc., may be used if required, providing approval testing has been completed to a standard acceptable to the	The minimum hose bend ratio is a function of hose size and type; it will be stated in the applicable hose specification.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		Rotorcraft Project Director. Unless otherwise agreed (see para 10.3.1), the end fittings shall be in accordance with DEF STAN 47-22.			
10.4.2	Hoses shall be installed so that chaffing with adjacent parts does not occur and where necessary they shall be suitably protected. Any hose elongation and contraction under pressure shall not cause straining of the end fittings, or binding and chaffing of the hose.				29.1435a5 29.1435a6
10.4.5	The installation of all types of flexible pipes and hoses shall be such that cross coupling between pipes or hoses cannot occur.				
11	**BONDING**				
11.1	The hydraulic system units and components, also the pipelines, shall be electrically bonded to the airframe in accordance with the requirements of Leaflet 708.				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
12	**ELECTRICAL AND ELECTRONIC UNITS AND COMPONENTS**				
12.2	The electrical or electronic components must be compatible with the associated systems.	The hydraulic unit shall be tested and approved complete with the electrical or electronic components. Where electrical or electronic controls, switches, transducers, potentiometers, differential transformers, solenoids, or motors etc., are built in or form part of a hydraulic unit, their requirements will be included in the specification for the hydraulic unit. They should be items approved as individual components. Where this is not possible they may be qualified and approved with the hydraulic unit, providing the testing satisfied both the hydraulic and electrical requirements. (see also Leaflet 706 and 708).			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
12.3	EMC requirements, when applicable, shall be satisfied in accordance with the requirements of DEF STAN 59-41 and Leaflet 1011				
13	**FAILURE MODE AND EFFECT ANALYSIS**				
13.1	On completion of the initial design of the hydraulic system a failure mode and effect analysis shall be prepared.	This will identify the degree of hazard or emergency which can occur as a consequence of the design or failure of any component or detail part in the system. This shall be updated as changes to the system occur.			29.1309 29.1309a 29.1309b 29.1309b1
13.2	Primary hydraulic systems and any critical circuits served by utility systems must have an emergency standby system. Malfunction or failure of any part of a hydraulic system shall not leave the rotorcraft in a hazardous flight condition. See Leaflet 100, para 9.1.	The extent of the emergency system and the method of engagement/disengagement shall be agreed with the Rotorcraft Project Director.			
13.3	Where more than one				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	hydraulic system is installed in the rotorcraft, the transfer of fluid between systems shall be prevented, as shall any pressure or flow change due to the interaction of the systems at any hydraulic component. It shall not be possible for the failure or malfunction of one system to cause the failure or malfunction of the other system due to interaction at any point including the reservoir and return lines.				
13.4	Where two or more sub circuits are pressurised by a common pressure source, one of which is essential to flight operation and the other is not essential, suitable priority circuit isolation shall be included to prevent a failure in the non essential circuit affecting the essential circuit.				
13.5	The location of high pressure fluid components and				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	transmission lines in the cockpit or pressure cabins shall be avoided or contained in sealed conduits drained out of the inhabited area.				
13.6	**REDUCTION IN VULNERABILITY TO BATTLE DAMAGE (Leaflet 112)**				
13.6.1	Reduction of vulnerability to battle damage shall be in accordance with the aims and requirements of Leaflet 112. (See para 15.2 for vulnerability test on gas/oil accumulators).	Pipes shall be designed to function despite structural distortion caused by the effects of Defined or Specified threats in Leaflet 112.			
13.7	**FIRE PRECAUTIONS**				
13.7.1	Fire precautions shall be in accordance with Leaflet 712 to minimise the inherent fire risk in hydraulic systems.				29.1435c
14	**HYDRAULIC SYSTEM FUNCTIONING AND TESTING**				
14.1	**TEST PLAN**				
14.1.1	A test plan shall give full details of all testing proposed	This shall be agreed with the Rotorcraft Project Director in			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	including information on the components, units or systems to be used to demonstrate compliance with the requirements.	conjunction with Airworthiness Division RAE Farnborough.			
14.2	**FUNCTIONING TEST RIG**				
14.2.1	The satisfactory operation of the complete hydraulic system(s) shall be demonstrated on a functional mockup of the system(s).	This shall show that the system adequately satisfies the rotorcraft operation requirements, including the most critical cases, with all reasonably foreseeable combinations of loading and failure cases. Suitable instrumentation shall be included to measure critical parameters such as load, speed of operation, temperature, pressure surges, flow rates where critical, fluid contamination etc.	(Leaflet 704/1).		
15	**STRENGTH, FATIGUE, ENVIRONMENTAL, VIBRATION AND ENDURANCE REQUIRMENTS**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
15.1	**STRENGTH REQUIREMENTS**				
15.1.1	The strength of each part is defined in terms of pressure Pw, Pr and Pd defined in para 5. This applies equally to parts subjected to internal pressure, and those subjected to suction pressure which may cause the collapse of parts.	The criteria defined for Pw, Pr and Pd also applies to those components exclusively used in low pressure hydraulic systems.			
15.1.2	Components (ii) All hydraulic components shall be able to withstand: (a) A design proof pressure not less than 1.5 Pw, 1.33 Pd or 1.125 Pr whichever is the greater, without permanent distortion or leakage. (b) An ultimate pressure not less than 2.0 Pw, 1.75 Pd or 1.5 Pr whichever is the greater, without fracture or bursting. Together with, in each case,	(iii) When a hydraulic component forms part of a mechanism which has to withstand externally applied loads during flight, take-off or landings, the required proof and ultimate factors shall be realised in the current strength cases for the mechanism when the most adverse effects of pressure which can occur at the same time are included in the loading conditions.	(i) A hydraulic component is defined as any separate unit which is connected by the piping or hoses within the hydraulic system. Components include all classes of valves, hydraulic actuators, accumulators, manifold blocks, hydro-mechanical devices, filters etc. The strength requirements for reservoirs are detailed in para 15.1.4.		29.1435b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the most adverse loads, similarly factored that can occur at the same time from the operation of any service or from flight, landing or take-off conditions.				
15.1.3	Pipes and Pipe Couplings (i) Rigid pipes and couplings shall be able to withstand: (a) A design proof pressure not less than 1.5 Pw, 1.33 Pd or 1.125 Pr whichever is the greater, without leakage or permanent distortion greater than that permitted by the material specification at the specification pressure. (b) An ultimate pressure not less than 3.0 Pw, 2.66 Pd or 2.25 Pr whichever is the greater, without fracture or bursting. (ii) All flexible pipes shall be able to withstand: a) flexible hoses,	In the case of rigid pipes subjected to return line pressures only, the proof pressure may be 0.75 Pw (the Nominal system supply pressure) with an ultimate pressure of 1.5 Pw or a proof pressure of 1.5 times maximum return line pressure with an ultimate pressure of 3.0 times maximum return line pressure, whichever is the greater.			29.1435b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the design proof and ultimate pressures defined in DEF STAN 47-12 for the appropriate Type. b) coiled rigid tubing and other forms of flexible connection as defined in paras 10.4.2 and 10.4.3, the proof and ultimate pressures in para 15.1.3.				
15.1.4	Reservoirs (i) The reservoir shall have proof and ultimate factors not less than 1.125 and 1.5 respectively on the most adverse loads than can occur at the same time or separately under all conditions of flight. This requirement shall be met at all fluid levels in the reservoir from empty to full. (ii) Reservoirs shall have proof and ultimate factors not less than 1.5 and 2.0 respectively on the maximum working reservoir differential				29.1435b

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	pressure, or 1.15 and 1.5 times the maximum reservoir relief pressure, whichever is the greater.				
15.2	**STRENGTH TESTS**				
15.2.1	General - Hydraulic Equipment. Using the units allocated for qualification testing in the test plan, all hydraulic equipment shall be tested to establish compliance with the requirements of para 15.1. The equipment is defined as follows: (i) Components in para 15.1.2. (ii) Pipes and pipe couplings in para 15.1.3. (iii) Reservoirs in para 15.1.4.	The tests shall demonstrate that there is no permanent distortion or leakage at proof conditions. In the case of hydraulic components where the shape of the component is such that reliable calculations of ultimate strength can be made, tests to ultimate pressure need not be carried out. Gas/oil hydraulic accumulators shall also be tested to the requirements of Leaflet 719, para 5.8.			
15.2.2	Prototype System. The prototype system shall be tested to show that no leaks occur at a pressure of 1.33 Pw.		For the purpose of this test valves in components shall be adjusted where necessary to obtain this pressure.		
15.2.3	Production Tests (i) General - Hydraulic				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Equipment. The drawings and/or production test procedures of all hydraulic components, units, pipe and coupling assemblies and reservoirs shall specify a test pressure equal to: (a) 1.33 Pw, Pd or Pr, whichever is the greater for 3 minutes, for hydraulic components, units and pipe and pipe coupling assemblies. (see paras 5.1 and 7.1.6). (b) 1.0 Pw or Pr whichever is the greater for 3 minutes, for hydraulic reservoirs. (see para 15.14). (c) Pipe and pipe coupling assemblies which are subjected to return line pressures only, may be tested to 0.75 (Pw or Pr) whichever is the greater, or 1.33 times maximum return line pressure; pressures to be held for 3 minutes. (see paras 5.1 and 8.1.6). and shall state that no leakage				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	or permanent distortion is to occur when the test pressure is applied. (ii) Complete Rotorcraft - Hydraulic Systems. The drawings and/or production test procedures for the complete hydraulic system shall specify a test pressure equal to 1.0 Pw (see para 5.1 and 6.1) for 3 minutes and shall state that no leakage is to occur when the pressure is applied.				
15.3	**FATIGUE REQUIREMENTS**				
15.3.1	The safe fatigue life of each hydraulic component, hydraulic unit, pipe and pipe coupling assemblies, flexible pipes, reservoirs, filters etc., shall be at least equal to the specified life of the rotorcraft. Any deviation shall be agreed with the Rotorcraft Project Director in conjunction with Airworthiness Division RAE.	The fatigue life of all Grade 'A' parts (see Leaflet 400) shall be demonstrated by a fatigue test to an agreed spectrum and appropriate safety factors, with exceptions as defined in para 15.4.2.	The requirements for fatigue life determination are given in Leaflet 201, and advisory material is contained in Leaflet 201 supporting leaflets and Leaflet 704/2.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
15.4	**FATIGUE TESTS**				
15.4.1	General - Hydraulic Equipment. Using the units allocated for fatigue testing, it shall be demonstrated by a fatigue test to an agreed spectrum, suitably factored, that the specified fatigue life of each component is achieved.	Existing Equipment and Standard Parts. Further fatigue tests may not be required on components such as hydraulic pumps, motors, existing equipment and standard parts, for which a separate type test and test evidence is available. The existing test reports shall be compared with the fatigue requirements for the particular project and presented for approval by the Rotorcraft Project Director in conjunction with Airworthiness Division RAE. The endurance test in para 15.6.1 may be used as part of the fatigue test providing all conditions are satisfied. The whole fatigue test must be completed on the same component, and the test factors in Leaflet 201 achieved.	Leaflet 704/2 provides information on the fatigue testing of hydraulic components. The factors to be used are given in Leaflet 201.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
15.5	**ENVIRONMENTAL AND VIBRATION REQUIREMENTS**				
15.5.1	The complete hydraulic system, including lines and components shall be designed to withstand the effects of vibration, pump pulsation and shock loads encountered during the service operation of the rotorcraft.		General Requirements. Information on the general working ambient temperatures for the system is given in para 3. More general information will be contained in the Rotorcraft Specification and in BS3G100 for environmental conditions and BS3G100 Sub Section 3.1 for vibration. The appropriate requirements and tests will be included in the separate specification for hydraulic equipment.		
15.5.2	Environmental Tests. New designs of hydraulic equipment shall be tested to establish compliance with the environmental conditions.	For all cases if there is close similarity to other components already tested and in service, the evidence shall be considered and if appropriate submitted for agreement by the Rotorcraft Project Director in lieu of further testing.			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
15.5.3	Vibration Tests. Using the units allocated for qualification testing in the test plan, all hydraulic equipment (components and units etc.,) shall be tested to establish compliance with the vibration requirements.	An exception may be acceptable if there is close similarity in all respects with components already tested. The test evidence shall be considered and if appropriate submitted for agreement by the Rotorcraft Project Director in lieu of further testing.			
15.6	**ENDURANCE REQUIREMENTS**				
15.6.1	General Requirements. When preparing the separate specifications for hydraulic equipment, consideration shall be given to the need to demonstrate by endurance testing that the maintenance requirements of DEF STAN 00-970 Part 8 will be achieved.	The required duty cycle, loads and number of cycles to be achieved will be included in the equipment specification with any temperature or other conditions. A suitable factor on the actual duty cycle is required, and normally for a separate endurance test to demonstrate maintenance requirements only, a factor of 2.0 is recommended. This shall be agreed with the Rotorcraft Project Director.	Endurance Tests. Endurance tests may be carried out on units allocated for qualification testing as a separate test, but if convenient, and all conditions are satisfied, the tests may be carried out as part of the tests of the functioning test rig required in para 14.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		However, if it is proposed to use the Endurance Test as part of the Fatigue Test, the test factors given in Leaflet 201 must be achieved on parts subject to fatigue life control. See para 15.4.1.			
16	**SYSTEM MAINTENANCE**				
16.1	**MAINTENANCE**				
			(See Part 8)		
16.2	**HEALTH MONITORING**				
		Health monitoring procedures shall be considered for the hydraulic circuits and sub circuits, to enable the Service to have early warning of possible failures. This may include built in test equipment or external ground services diagnostic equipment, as required by the Rotorcraft Specification. Technical data shall be provided on the principal performance parameters of the hydraulic system and its individual units, for the as			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		new and maximum worn conditions (e.g., pressure, flow, leakage etc., as appropriate). This information will assist the User Service in assessing the airworthiness of the system and its units.			
16.3	Marking of hydraulic components shall be in accordance with DEF STAN 16-21.				
17	**CROSS REFERENCES**				
	A number of requirements directly related to the hydraulic system appear elsewhere in this publication and these are listed in the Alphabetical Index. In addition certain general requirements apply when hydraulic actuation is chosen for special tasks and it is the designer's responsibility to ensure compliance with all such requirements. Some of the more important requirements in both these categories are listed in Table 1. TABLE 1 **LIST OF OTHER IMPORTANT REQUIREMENTS**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.

Leaflet	Paragraph	Subject
100	2	Use of standard equipment
	6.2	Component tests
	7	Prevention of incorrect assembly
	8	Conditions of operation
	9	Power operated systems
	9.1	Independence of services
	9.2	Provision of power for use in an emergency
101	1	Climatic conditions
107	14.2	Warning of main hydraulic power failure
	10	Powered flying controls - tests
306		Undercarriages - retraction and lowering
310	-	Wheel tyres, brakes and braking systems
407	-	Precautions against corrosion
605	-	Power operated flying controls - safety precautions
712	-	Fire Precautions
800	-	Maintenance
806	4 and 5	Marking of filling points and pipe lines
1004	-	Flight tests - hydraulic systems

Leaflet	Paragraph	Subject
206/5 (VOL 1)	-	Fatigue tests on hydraulic powered flying controls

ASSOCIATED INTERNATIONAL AEROSPACE REFERENCES

ISO 6771 Aerospace Construction - Fluid systems and components - Pressure and temperature classification.

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	ASSOCIATED USA AEROSPACE REFERENCES MIL-H-5440G - Hydraulic Systems Aircraft Types I and II, Design and Installation Requirements for MIL-H-8775D - Hydraulic System Components, Aircraft and Missiles, General Specification for MIL-A-5503D - Actuators, Aeronautical Linear Utility, Hydraulic, General Specification for MIL-A-5498C - Accumulators Aircraft Hydropneumatic Pressure MIL-F-8815 - Filter and Filter Element, Fluid Pressure Hydraulic Line, 15 Micron Absolute and 5 Micron Absolute Type II System, General Specification for				
	REFERENCES				
	REFERENCES				
	Sub-Leaflets				
	LEAFLET 704/0 HYDRAULIC SYSTEMS REFERENCE PAGE				
	LEAFLET 704/1 HYDRAULIC SYSTEMS FUNCTIONAL TESTING				
	LEAFLET 704/2 HYDRAULIC SYSTEMS FATIGUE TESTING OF				

Reference	ASCC Air Standard	STANAG	British Standard
1	25/11	3212	C13

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	HYDRAULIC COMPONENTS				
	LEAFLET 1004				
	HYDRAULIC SYSTEMS				
1	**OBJECT** The object of the tests of this Leaflet is to demonstrate that the hydraulic system(s) installed in the rotorcraft is suitable for Service use, in particular that:- (i) The various actuators, motors and other components of the system can be satisfactorily operated on the ground using approved sources of hydraulic power; and (ii) Hydraulic power can be satisfactorily generated on-board the rotorcraft and utilised to operate the actuators, motors and other units of the system both on the ground and in flight throughout the specified flight envelope and to satisfy all operational and environmental requirements. AC29				
2	**RELEVANT DESIGN REQUIREMENTS**				
			DEF STAN 00-970 Volume 2 Leaflet 100, 101 and 704.		
3	**APPLICABILITY**				
3.1			The need for further testing shall also be considered where modifications are made to systems which interface with the hydraulic system(s). Of particular concern are those affecting loading on actuators and motors, changes to flow demands and		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			directions and heat transfer to the hydraulic fluid. Changes to systems which involve altering fluid volumes or column lengths shall be investigated to ensure freedom from hydraulic resonance whether excited by pump or load characteristics. Tests on Alighting Gear and Powered Flying Controls are not included except in so far as they affect the hydraulic system as a whole, as tests on these systems are covered by Leaflets 1008 and 1010 respectively.		
4	**INSTRUMENTATION**				
4.1	The standard of instrumentation shall be such that a continuous recording can be obtained of flight conditions (e.g., IAS, Altitude, OAT, Rotorcraft attitudes) and hydraulic system conditions (e.g., pressures, including		The suggested parameters to be recorded to meet the requirements of this Leaflet are detailed in Leaflet 1004/1.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	transients and pulsations; displacements, temperatures, fluid flow rates and vibration) during both ground and flight tests.				
5	**LOADING**				
5.2	The tests may be made at any convenient loading and centre-of-gravity position, provided that this does not result in the achievable flight envelope being more restrictive than the maximum envelope as defined by the Rotorcraft Specification or, if not so defined, as envisaged by the Service user, taking into account, limitations imposed by the carriage of external stores or other loads, i.e. maximum normal acceleration, attitude, speed etc.	On rotorcraft powered by a single engine, external stores or other loads must not be carried on any test which may result in, or require the engine to be shut down, unless the store or load is specifically required for the trial (e.g., the effect of rocket/missile launch or gun firing on engine behaviour).			
6	**GENERAL TEST CONDITIONS**				
6.2	Ground and flight conditions shall be representative of the	For new hydraulic systems it is essential that			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Service roles for the rotorcraft and shall cover the whole of the operational flight envelope and the environmental conditions defined in the Rotorcraft Specification.	comprehensive rig testing of a fully configured and representative system has been completed and satisfactory characteristics established prior to commencement of the tests which are subject of this Leaflet. In particular the following shall be taken into account:- (i) The evidence from preliminary ground rig testing, including any tendency towards hydraulic resonance up to at least the maximum possible pump pulsation frequencies (i.e. including transient overspeed conditions) and the possibility of large transient sub-systems. Where multiple hydraulic systems have common interfaces then the effects of operation of systems one upon the other shall be considered. (ii) The standard of the			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		hydraulic system(s) and components and their suitability for the tests proposed (iii) Natural frequency (rapping tests) on major components and pipe runs.			
7	**GROUND TESTS**				
7.1	Tests shall be conducted on the systems utilising:- (i) External hydraulic supply(ies) as appropriate to the rotorcraft. (ii) All on-board hydraulic power sources, i.e. main supplies (primary, secondary and utility if so designated), auxiliary and emergency supplies (where applicable) throughout the range of system operating configurations provided, for which testing on the ground is practicable.	Generally it shall be established that system(s) can be operated in accordance with the requirements laid down in the Rotorcraft Specification and as previously demonstrated on the ground rig. In particular it shall be demonstrated that:- (i) Means for selection, control and monitoring of systems (including coupling and decoupling in the case of external supplies) is satisfactory. (ii) The accessibility of all components is satisfactory with respect to bleeding and replenishing of reservoir			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		fluid, replacement of filter elements and checks necessary to establish the state of the system(s). (iii) Operation of the combination of actuators, motors, etc., which is most demanding in terms of flow requirement (within the range of normal or emergency utilisation) does not result in the pressures at any point in the system(s) falling below the minimum acceptable (for the particular system configuration) and that the time/rate of operation of each actuator, motor, etc., is in accordance with specification requirements. (iv) Each actuator, motor, etc., operates satisfactorily when selected and only when selected and there is no detrimental interaction between actuators. The actuators shall operate smoothly and without			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		hesitation or instability over full operating ranges. Tests as follows shall be carried out to ensure that the systems environmental and duty cycle requirements are capable of being met:- (i) At zero loading of the system, i.e., with no actuators, motors, etc., operating, the steady state pressures, fluid and component temperatures do not exceed the maximum and minima permitted and the system(s) operate(s) with no evidence of instability or extreme pressure fluctuations. (ii) Ascertain that prolonged application of wheel brakes during taxying does not cause local fluid temperatures to exceed limitations nor pressures to go outside the range necessary for satisfactory operation (iii) Ascertain that the			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		normal or emergency operation of rotor brake does not cause fluid temperature to exceed limitations nor the pressure to go outside the range necessary for satisfactory operation. (iv) The system(s) operate(s) satisfactorily after cold and hot soaks of the rotorcraft in the inoperative condition, at the extremes of the environmental range as detailed in the Rotorcraft Specification. (v) System(s), drains and vents shall be observed to ensure that excessive loss of fluid does not take place at environmental or duty cycle extremes. Tests shall be carried out to demonstrate that:- (i) Such failures as can be readily represented; i.e., partial, single, multi-engined or APU failures or shutdowns (where applicable) result in			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		correct warning indication, automatic changeover to standby or emergency power (where applicable) and continuing satisfactory operation of system(s) (or specified part(s) of system(s)) in accordance with requirements. (ii) When gas blow down systems are used for emergency power in the hydraulic system for lowering of the alighting gear, flaps or other devices, that the gas can be vented from the system(s) after use, and the hydraulic system(s) readily restored to normal configuration.			
8	**FLIGHT TESTS**				
8.1	Satisfactory system(s) operation shall be demonstrated over the full flight envelope and manoeuvre range of the rotorcraft.	Generally the objective is to confirm the results of rig and ground testing and to explore operating regimes and duty cycles that cannot readily be produced on the ground. It is of particular importance that	Note: Much of the flight testing of this Leaflet can be readily carried out in association with the tests required by Leaflets 1008, 1010, 1016 and 1017 and those required by Part 9		29.1435a3 29.1435a4 29.1435a5

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		the extremes of aerodynamic and acceleration loads, including zero and negative "g" (where applicable) are experienced. Particular checks and measurements shall be made as follows:- (i) Pressure throughout the system(s) including transients to ensure that the margins between supply pressures and actuator, motor, etc., requirements are adequate. (ii) Temperatures throughout the system, particularly of components which may be affected by recirculation of exhaust gases or cooling air during prolonged hover, sideways and rearwards flight (including need to hover other than head into wind). (iii) Vibration (whether mechanically impressed or system excited) throughout the system(s) or evidence of	(Handling).		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		any form of hydraulic instability.			
8.2	Failure simulations shall be explored to the extent that it is considered acceptable and necessary in flight tests.	The tests of para 8.2 and 8.3 shall include the operation of all hydraulic accessory equipment and an assessment of effects of such system failure on these items shall be made, together with the possible adverse effect(s) on the main system of any individual equipment failures.			
8.3	Checks shall be made to ensure that adequate and correct indication of system(s) or equipment failure or malfunction takes place and that reversionary or emergency functions are available as required.				29.1435a3
8.4	On completion of a flight test and after engine/APU shut down and rotor stop, hydraulic system(s) are to be checked as follows:- (i) Reservoir fluid levels are correct, and in multi-				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	system installations there has been no fluid transfer between systems. (ii) That there has been no unacceptable loss of fluid from the system(s) nor any component or accessory leakage (either seals, couplings, etc.,) or excessive venting of fluid. (iii) Any depressurisation method operates satisfactorily and after despressurisation of the system(s) that the initial gas charge of all accumulators is satisfactory.				
	Sub-Leaflets				
	LEAFLET 1004/1 HYDRAULIC SYSTEMS TEST INSTRUMENTATION PARAMETERS				
	LEAFLET 703				
	PNEUMATIC SYSTEMS				
1	**INTRODUCTION**				
1.1	The requirements of this	The requirements apply to all	The applicable		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Leaflet apply to all pneumatic systems in Rotorcraft both static (low mass flow) systems used for power transmission and dynamic (high mass flow - total loss) systems used mostly for environmental control. Alternative requirements are given where necessary.	components of the pneumatic system but the requirements of Leaflet 719 (Pressurised Gas Storage Vessels) may also apply to some. Any component, or part of the system, or combination of these, having a medium or high energy rating (see Leaflet 719/1) shall meet the relevant requirements of Leaflet 719.	temperature/altitude requirements will be found in Leaflet 101 or the Rotorcraft specification. See Leaflet 703/1 for recommendations about the protection of Pneumatic Systems against the ingress of foreign matter. See Leaflet 703/2 for recommendations on how to reduce the explosion hazard. See Leaflet 703/3 for recommendations about Hoses. See Leaflet 703/4 for recommendations about Tubing. See Leaflet 703/5 for recommendations about V-Flange Couplings See MIL-SPEC Mil-P-5518 for further background information and equivalent American requirements.		
2	**GENERAL**				
2.1	The capacity and output of				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the storage vessel(s) and/or compressor(s) shall be sufficient to operate all normal services which may need to be used simultaneously and all combinations of normal and emergency services which could reasonably be expected to be needed at the same time, against the appropriate external loads.				
2.2	All pneumatically operated services, which are essential to safety in flight or landing shall be provided with an alternative source of power, not necessarily pneumatic, for use in an emergency. Emergency systems shall be completely independent of the main systems up to, but not necessarily including, the actuator. Any part of either system which is also part of the power plant shall comply with power plant design		(see Leaflet 700)		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	requirements .				
2.3	The system shall be so designed and installed as to ensure its satisfactory functioning under all expected conditions.	Consideration shall be given to the effect of the ambient temperatures to which the various components may be subjected (see para 3) and to other environmental effects, such as vibration, abrasion, corrosion and mechanical damage in service.			
2.5	When two sub-systems are powered by a common source, and one is essential to safety in flight and the other is essential to safety in landing each shall have an emergency system (para 2.2) and, a vulnerability analysis shall be done to show whether the two systems should be fully isolated.		(Leaflet 112)		
2.6	Any part of the system that would be adversely affected by foreign matter, or oil or water contamination, shall be adequately protected by filters or other devices which,		(see Leaflet 703/1)		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	if they require routine servicing, shall be readily accessible .				
2.7	Where differential motion or vibration exists between any two points in a pneumatic line compensation shall be provided by the use of flexible connections or other suitable devices.				
2.8	Adequate indication of system and sub-system condition shall be provided to the crew to ensure safety in flight and landing and to ensure that correct action can be taken in the event of any malfunction.				
2.9	External test connections from which all services can be recharged and tested for correct operation while the rotorcraft is on the ground, shall be provided. These connections shall be readily accessible and incapable of incorrect assembly.		(see Leaflet 100 para 7)		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	Adequate charging pressure and temperature data shall be placarded on the structure near the connections.				
3	**TEMPERATURE EFFECTS**				
3.1	Blockage caused by freezing shall not occur on the ground or in the air.	Where necessary drains shall be provided at low points in the system to permit removal of condensation. Where necessary anti-freeze and/or pressure relief devices shall be provided.			
3.3	Provision shall be made, where necessary, to cool the compressors, under all conditions of flight and ground operation, such that the design life and reliability targets are met.				
3.4	Pressure limiting devices shall not be installed where they are liable to freeze up. If their design is such that they are liable to be adversely affected by heat they shall not be fitted in positions where	Consideration shall be given to relative expansion and contraction between the system components and the airframe.	See Leaflets 703/3 and 703/4.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	their operating temperature, either on the ground or in flight is expected to be high.				
4	**SAFETY AND VULNERABILITY**				
4.1	The system shall be designed to comply with the requirements of Leaflet 100 para 9. 1 and of Leaflet 112.				
4.2	When duplicate lines are provided they shall be so located as to minimise the probability of both being damaged by a single threat effect (see Leaflet 112), tyre burst, non-containment of an internal engine failure, local structural failure or other hazardous event.				
4.3	As far as possible all components shall be so installed that their bursting would not be likely to cause catastrophic failure of any part of the rotorcraft or any injury to any occupant.				
4.4	No component which would				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	be liable to explode if subject to a fuel fire shall be mounted within an engine bay or other designated fire zone.				
4.5	Means shall be provided (e.g., valves, fuses), as far as practical, to isolate ruptured circuits and prevent complete loss of power in both the normal and emergency systems.				
4.6	Shuttle valves shall not be used in installations in which a force balance can be obtained on both inlet ports simultaneously which may cause the shuttle valve to restrict flow from the outlet port. Where shuttle valves are necessary to connect an actuating cylinder with the normal and emergency systems, the shuttle valve unit shall be built into, or attached to, the appropriate cylinder head.				
5	**DEFINITIONS**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			Pw. The normal working pressure for which a particular part of the system is designed, and which must not be less than the minimum pressure necessary for efficient functioning of that part of the system. Pr. The relief pressure associated with a particular part of the system and fixed at a value which allows a reasonable margin above Pw. A value of 1.33 Pw is implied by the strength requirements of this Leaflet and covers the effects of variability in maximum delivery pressure in service (nominally 10%), supply control failure, ingress of foreign matter, filter blockage (Leaflet 703/1), and temperature changes but not transients. In some projects a value of Pr greater than 1.33 Pw may be necessary to prevent excessive loss of gas from the system following a		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			cold soak at altitude and a rapid descent to ground level in a high temperature. TPA (Transient Pressure Allowance). The pressure allowance above Pr for short duration increases in pressure, arising from solenoid operation or similar causes, which do not last long, enough to cause the relief valve to crack. The allowance should be based on experimental evidence if available. If no relevant evidence is available the allowance should not be less than 50% of Pr. P_c. The maximum permissible charging pressure at 20°C for which the system is designed. R. Design Pressure Ratio. The ratio of pressure at the maximum design temperature to the pressure at 20°C, obtainable from standard tables for the gas used.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			P_d. The design pressure for a component or part of the system. For static systems Pd = Pr + TPA For dynamic systems Pd = (P_c x R) + TPA or P_d = PW + TPA as appropriate.		
6	**PRESSURES**				
6.2	The pneumatic power supply shall incorporate, or work in conjunction with, pressure regulating devices such that within their design tolerances the pressure supplied to any part of the system, both during and on completion of the normal operation of any service, is not greater than Pw.	The system may be designed to operate at any pressure(s) consistent with the particular needs of the services operated.			
6.3	Means shall be provided, which within their design tolerances, will prevent the pressure in any part of the system exceeding the relevant Pr, both during normal operation and during ground				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	charging.				
6.4	The system shall be so designed that the intended functioning of the components will not be adversely affected by the highest back pressure resulting from operation of any part of the system.	Transient pressures shall be damped wherever possible. Any residual transients, shall be included in the fatigue analysis for the parts affected.			
7	**STRENGTH**				
7.1	The strength of each part is defined in terms of its design pressure P_d as defined in para 5.6.				
7.2	**COMPONENTS**				
7.2.1	All pneumatic components shall be designed to withstand, at most adverse working temperature: (i) without leakage (but see para 7.4 below) or permanent distortion, a design proof pressure not less than $1.125P_d$. (ii) without fracture or bursting, an ultimate pressure not less than $1.5P_d$.	When a pneumatic component forms part of a mechanism which has to withstand externally applied loads during flight, take-off or landing, the required proof and ultimate factors shall be realised in the current strength cases when the most adverse effects of pressure and acceleration which can occur at the same time are			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	together with, in each case, the most adverse loads, similarly factored, that can occur at the same time from the operation of any service or from flight, take-off or landing.	included in the loading conditions.			
7.3	**PIPES AND PIPE COUPLINGS**				
7.3.1	All pipes and pipe couplings shall be designed to be capable of withstanding at most adverse working temperature, without leakage (but see para 7.4 below) or permanent distortion, a proof pressure of 1.125Pd and without fracture or bursting an ultimate pressure of 2.25Pd.		(See Leaflet 703/5 for recommendations about V-Flange Couplings)		
7.4	**LEAKAGE AND DISTORTION**				
	In addition to the conditions of Leaflet 200, para 4.3 such leakage or distortion as might directly prevent the operation of any part or would in the	On the other hand, in dynamic systems, (see para 1.1 above) some leakage may be permitted from joints, and from some components. The			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	course of one flight be likely to render the system inoperative, shall be regarded as a failure.	standard shall be agreed with the Rotorcraft Project Director.			
7.5	**FATIGUE**				
7.5.1	Where any part of the system is subject to fluctuating or repeated external or internal loads, due allowance shall be made for fatigue.	The effects of variability of compressor delivery pressure and of transient pressure changes shall be included.	(See Leaflet 201).		
8	**STRENGTH TESTS**				
8.1	**SAFETY PRECAUTIONS**				
		Where it is considered that tests at high temperature are too hazardous, an additional test factor shall be applied to the required pressure.	For safety reasons pressure tests on pneumatic components shall first be done hydraulically. The hydraulic fluid used shall be such that it will not cause damage to, or deterioration of, any part of the system with which it will come into contact.		
8.2	**STATIC TESTS - COMPONENTS**				
8.2.1	Prototypes of all pneumatic components shall be tested to establish compliance with the	In cases where the shape of the component is such that reliable calculations of			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	requirements of para 7.2.	ultimate strength can be made, and if failure is unlikely to cause damage additional to that caused by the loss of pneumatic pressure, tests to ultimate conditions need not be made unless called for. But see also para 1.2.			
8.3	**STATIC TESTS - PIPES AND COUPLINGS**				
8.3.1	Prototype pipe couplings in conjunction with the appropriate piping shall be tested to establish compliance with the requirements of para 7.3.		But see also para 1.2.		
8.4	**PROTOTYPE SYSTEM TESTS**				
8.4.1	The prototype system shall be tested at a pressure of P_d to show that functional and leakage requirements have been met.	For the purpose of these tests, valves in components shall be adjusted where necessary to obtain correct local pressure.			
8.4.2	The test of 8.4.1 shall be continued to $1.125P_d$ without deformation of any part of the	Clearance between parts of the system and the structure must be adequate and there			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	system that would prevent it from performing its intended function.	shall be no permanent detrimental deformation. Such leakage as occurs shall meet the requirements of para 7.4.			
8.5	**FATIGUE TESTS**				
8.5.1	Each pneumatic component, pipe or coupling, shall have a safe life at least equal to the specified life of the rotorcraft unless otherwise agreed.	This shall be demonstrated by fatigue tests which shall be on lines similar to those of Leaflet 704/2 for hydraulic systems. Where possible these tests should be integrated with the Endurance and Environmental tests of para 9 to improve simulation of true service conditions.	Fatigue tests may not be required on components such as compressors for which a separate type test schedule is specified, nor on some components, such as certain items in an emergency circuit which are not subject to pressure applications during normal flying.		
9	**FUNCTIONING, ENDURANCE AND ENVIRONMENTAL TESTS**				
9.1	The satisfactory operation of the complete pneumatic system shall be demonstrated on a prototype or development rotorcraft or on a representative ground rig of the system, or appropriate	Tests shall be included to demonstrate compliance with paras 6.2, 6.3 and 6.4, and also to show that, at all operating temperatures, oil, water or other impurities in the system do not adversely			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	sub-systems, to a schedule agreed with the Rotorcraft Project Director.	affect the operation of the system including the functioning of the relief valves (see para 2.6). Consideration shall be given to the possibility of ice formation.			
9.2	The functioning tests shall include simulation of pneumatic system failure conditions.	The tests should also include relevant flight loads, ground loads and pneumatic system working loads, relief loads, limit loads, and transient pressures expected during normal operation. Vibration loads and loads caused by temperature effects may be included where relevant subject to the agreement of the Rotorcraft Project Director.			
9.3	Endurance tests shall simulate the repeated complete flights that could be expected to occur in service. Elements which fail during the tests shall be modified in order to have the design				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	deficiency corrected and where necessary must be sufficiently retested.				
9.4	Tests simulating operating and environmental conditions shall be done on elements and appropriate portions of the pneumatic system to the extent necessary to evaluate the environmental effects.				
10	**PRODUCTION TESTS**				
10.1	The drawings of all pneumatic components and pipe coupling assemblies shall specify a test pressure equal to Pr for the relevant part of the system, and shall state that all parts shall function correctly, that no permanent distortion shall occur when the test pressure is applied, and that the leakage requirements of paras 7.2, 7.3 and 7.4 shall be met.				
10.2	The drawings of the complete system shall specify a test pressure Pw or Pc as				

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	appropriate for the main high pressure part of the system and shall state that the system shall function correctly, and that such leakage as occurs when this pressure is applied shall meet the requirements of para 7.4. The resulting pressures in the low-pressure sections of the system, with the pressure reducing valves correctly set, will be considered to be the proof test pressure for these portions of the system.				
	Sub-Leaflets				
	LEAFLET 703/0 PNEUMATIC SYSTEMS REFERENCE PAGE				
	LEAFLET 703/1 PNEUMATIC SYSTEMS PROTECTION AGAINST THE INGRESS OF FOREIGN MATTER				
	LEAFLET 703/2 PNEUMATIC SYSTEMS EXPLOSION HAZARD				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	LEAFLET 703/3 PNEUMATIC SYSTEMS HOSES				
	LEAFLET 703/4 PNEUMATIC SYSTEMS TUBING				
	LEAFLET 703/5 PNEUMATIC SYSTEMS V-FLANGE COUPLINGS				
	LEAFLET 719				
	PRESSURISED GAS STORAGE VESSELS				
1	**INTRODUCTION**				
	This Leaflet applies to all pressurised gas storage vessels, made from metallic materials, for installation in rotorcraft and in equipment installed in rotorcraft. The requirements shall be read in conjunction with the appropriate parts of Leaflet 703 for pneumatic systems.				
	This Leaflet states essential design and test requirements. Conditions of service use (particularly service life and permissible charging pressures) shall be determined by the designer and agreed with the Rotorcraft Project Director taking into account the design requirements and the results of all tests. This Leaflet provides: (i) the basic design requirements for pressurised gas storage vessels, (ii) the approval tests to be applied to verify the design and to establish a production standard, (iii) the mandatory tests to be applied to production vessels, (iv) the information to be marked on the vessel and on the drawing.				
2	**CLASSIFICATION**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
2.1	The requirements apply to five distinct types of vessel, depending on design and purpose as follows:	Any particular vessel may be designed to meet the requirements of more than one type. Such vessels shall meet the requirements for both types.	Type 1 Vessels charged by a ground rig before flight and not re-charged in flight and not having a pressure relief valve on the vessel or in the system. But see para 4.3. Type 2 Vessels charged by a compressor on the rotorcraft, whether initially charged by a ground rig or not, in a system having pressure regulating and pressure relief devices in accordance with Leaflet 703 paras 2 and 3. Type 3 As Type 2, but having a solenoid or other component in the system which can cause transient pressures higher than the relief valve relief pressure. Type 4 Vessels fitted uncharged, not having a relief valve, in a system charged by a cartridge or similar gas source. But see para 4.3.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			Type 5 Vessels charged and fitted in equipment which may be stowed in the rotorcraft or carried by the crew or other occupants, fitted with a piercing disc which may also act as a burst disc where necessary, discharged only in emergency and during refurbishing.		
3	**DEFINITIONS**				
			DESIGN PRESSURE (Pd). The maximum pressure expected to arise in service from all causes (All types) (See paras 4.6 and 4.7 below). DESIGN CHARGING PRESSURE (Pc). The maximum permissible charging pressure at 20°C, for which the vessel is designed. (Types 1 and 5). DESIGN PRESSURE RATIO (R). The ratio of the		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			pressure at maximum design temperature to the pressure at 20°C, obtainable from standard tables for the gas concerned. The temperature used to determine this ratio shall include an allowance for any local rise in temperature during normal operations caused by the position of the vessel in the Rotorcraft. (Type 1). WORKING PRESSURE (Pw). The maximum normal working pressure for the relevant part of the system as defined in Leaflet 703 para 2.1 (Types 2, 3 and 4). RELIEF PRESSURE (Pr). The maximum pressure at which the pressure limiting device, as defined in Leaflet 703 para 3.1, operates. A value of 1.33 Pw is implied by the requirements of Leaflet 703 and covers the effects of variability in maximum delivery pressure		

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			(nominally 10%), ingress of foreign matter, filter blockage (Leaflet 703/1), and temperature changes. In some rotorcraft a value greater than 1.33 Pw may be necessary to prevent excessive loss of air from the system following cold soak at altitude and rapid descent to ground level in a high temperature. (Types 2 and 3). BURST DISC FAILURE PRESSURE (Pb). See para 4.3. The maximum pressure at which the burst disc is expected to operate including an allowance (normally 20% above nominal) for variability. A recommended value is 1.5 Pd. (Types 1, 4 and 5). MOUNTING STRESS ALLOWANCE (MSA). The allowance required to take account of clamping and inertia forces and of their reactions. The value is to be		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			agreed with the system designer for the Rotorcraft. For strapped vessels the allowance should be the pressure stress equivalent to the maximum local acceleration in the worst flight manoeuvre. For vessels mounted on bosses the local stress caused by this acceleration may be applied separately. TRANSIENT PRESSURE ALLOWANCE (TPA). The pressure allowance above Pr for short duration transient increases in pressure arising from solenoid operation in some systems and from explosive forces in others. The allowance should be based on relevant experimental evidence, if available. It should be not less than 50% of Pr (Type 3) or 50% of Pw (Type 4) if no relevant evidence is available. SAFE LIFE. The maximum		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			number of inflations (See para 3.10) permitted during the Service Life of the vessel. The safe life will be stated in the appropriate specification and shall be not less than the equivalent of 10 years service use unless otherwise agreed with the Rotorcraft Project Director. INFLATION. In service, an inflation will be deemed to have taken place when, on charging the vessel, the pressure passes through a level of 80% of Pc for Type 1 vessels, once per engine start or per flight for Types 2 and 3 vessels and once per usage for Type 4 and 5 vessels. In tests, a cycle is an inflation from zero to Pd to zero except in some Type 2 and 3 vessels (para 5.5.2). LIMIT OF EXPANSION. The time at which, during a pressure test, the rate of change of volume drops to		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			zero.		
4	**DESIGN REQUIREMENTS**				
4.1	The design of all Pressurised Gas Storage Vessels shall be such that the finished vessel, including its protective coating: (i) passes the proof, fatigue, and ultimate strength tests of para 5 appropriate to the type, (ii) passes the vulnerability tests appropriate to the design energy capacity.	The design of all Pressurised Gas Storage Vessels should also, so far as it is possible to determine in advance: (i) meet the strength and life requirements in the environmental conditions, such as temperature, humidity, vibration, shock and acceleration, to which it may be subjected in service, (ii) not be affected detrimentally by any gases or liquids that may come into contact with it during normal use, (iii) not introduce contaminants into the gas contained in it beyond the level permitted by the appropriate gas specifications.	See Leaflet 719/1.		
4.3	A pressure relief device		(See Leaflet 719/1)		29.1199

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	known as a burst disc shall be fitted to all Type 1, 4 and 5 vessels: (i) having a high energy rating , (ii) having a medium energy rating located where they could cause injury to personnel in a crash.				29.1199a
4.4	The burst disc shall be designed to release the pressure in a controlled manner as far as is possible.				
4.5	Manufacturing processes for vessels used for type approval tests shall be adequately defined and all subsequent production shall be to this defined standard.	Proposed departures from this standard shall be referred to the Rotorcraft Project Director.			
4.6	The design of vessels shall be based on: (i) the Design Pressure (Pd), (ii) the Safe Life required.	The design pressure (Pd) shall be not less than: (i) Type 1 (Pc x R) + MSA, (ii) Type 2 Pr + MSA, (iii) Type 3 Pr + TPA + MSA,			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		(iv) Type 4 Pw + MSA + TPA, (v) Type 5 (Pc x R) + MSA.			
4.8	All vessels shall be designed to withstand without leakage or distortion a proof pressure of: (i) 1.5 Pd where Pd is derived from Pw or Pc (ii) 1.125 Pd where Pd is derived from Pr	For high and medium energy vessels irrespective of the results of the vulnerability test (See para 5.8) and the allowance made for MSA (See para 3.7) consideration shall be given to the case where a bullet or fragment makes a hole in the vessel and releases the energy. Possible effects on the vulnerability of structure and systems shall be considered and included in the Vulnerability Analysis of Leaflet 112.	(See Leaflet 719/1)		
4.9	All vessels shall also be designed to withstand without fracture or bursting an ultimate pressure of: (i) 2.0 Pd where Pd is				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	derived from Pw or Pc (ii) 1.5 Pd where Pd is derived from Pr				
4.10	Where it is proposed to fill the vessel with a liquefiable gas, the filling ratio shall be such that, in all conditions within the environmental envelope, the vessel cannot be full of liquid.				
5	**TYPE APPROVAL TESTS**				
5.1	**SAFETY**				
		Tests will normally be done in the local ambient temperature but see para 5.8.2.	These tests are hazardous. Attention is drawn to the need for precautions in accordance with the Health and Safety at Work Acts.		
5.2	**NUMBER OF VESSELS**				
5.2.1	All vessels used for type approval tests shall be individually numbered and each initially subjected to the proof test of para 5.4.	Eighteen vessels shall be provisioned for the tests and allocated as follows: (i) Nos 1 to 6 for the tests of para 5.5, (ii) Nos 7 to 12 for the tests of paras 5.6 and 5.7, (iii) Nos 13 to 18 for the			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		tests of para 5.8.			
5.2.3	For any one vessel of a group of six that fails one of the following tests, a further two shall be successfully tested, unless the failure indicates the need for redesign, when the procedure must be started again				
5.3	**PHYSICAL CONDITION**				
5.3.1	All vessels used for type approval tests shall be fully representative of subsequent production (See also para 7).				
5.3.2	All vessels shall be complete with all permanent end fittings and representative labels.	They shall be marked with all incised or embossed production marks of DEF STAN 81-24. Hardness marks shall be to the same standard as on production vessels. No pressure greater than Pd shall have been previously applied to them.			
5.3.3	In order to check subsequent performance, the mass, dimensions, and internal volume of each vessel shall				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	be recorded before the commencement of tests.				
5.3.4	Where a burst disc is provided it shall be blanked-off in a manner which will not invalidate the test results.				
5.4	**PROOF TEST**				
5.4.1	Each of the vessels used in a type approval test shall first be subjected hydraulically to the proof pressure (para 4.8) for long enough to verify by the volume measuring apparatus that the limit of expansion has been reached or for 30 seconds, whichever is the greater.	The method of test and the results shall be in accordance with BS 5045 Part 1. Where the vessel is subsequently to be filled with oxygen the hydraulic fluid used for this test must be non-toxic and sufficiently volatile to be easily removed.			
5.5	**FATIGUE TEST**				
5.5.1	The vessels numbered 1 to 6 shall be subjected to pressure cycles (see para 3.10) applied hydraulically from atmospheric pressure to Pd. Failure shall be deemed to have taken place as soon as cylinder leakage is detectable.	If variations of test pressure are considered desirable either: (i) to represent variations in working or charging pressure, or (ii) because Pr is greater than 1.33 Pw and is not reached every flight,			

<table>
<tr><th>Para No</th><th>DS970 Pt7 Requirement</th><th>DS970 Pt7 Acceptable Means of Compliance</th><th>DS970 Pt7 Guidance</th><th>DS970 Pt7 Policy, Notes, and References</th><th>CS-29 Para No.</th></tr>
<tr><td></td><td></td><td>then a spectrum more representative of service conditions may be used subject to the agreement of the Rotorcraft designer.

The test pressure and number of cycles shall be recorded. The results shall be interpreted according to the requirement of para 4.11, above.</td><td></td><td></td><td></td></tr>
<tr><td>5.5.3</td><td colspan="4">The geometric mean life of the fatigue tests shall be F times the required life where F is given by the following table and v is the sample coefficient of variation of the logarithm of the life of each specimen.

<table><tr><td>v</td><td>0.02</td><td>0.025</td><td>0.03</td><td>0.035</td><td>0.04</td><td>0.045</td><td>0.05</td></tr><tr><td>F</td><td>2.8</td><td>3.8</td><td>5.4</td><td>7.5</td><td>10.5</td><td>14.3</td><td>20.0</td></tr></table>
Intermediate results may be interpolated.
See Leaflet 719/2.

Note that F=2.8 for all values of v up to 0.02.</td><td></td></tr>
<tr><td>5.6</td><td>VIBRATION, SHOCK, ACCELERATION, CLIMATIC AND AGEING TESTS</td><td></td><td></td><td></td><td></td></tr>
</table>

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
5.6.2	They shall withstand these tests without failure or leakage.	If agreed by the Rotorcraft Project Director, some of these tests may be combined with the fatigue tests of para 5.5 to produce a more realistic representation of service conditions. After the proof test of para 5.4 the vessels numbered 7 to 12 shall first be subjected to one safe life of the fatigue test of para 5.5 without leakage or failure. The vessels shall then be subjected, whilst pressurised pneumatically to Pc (Type 1) Pw (Types 2 and 3), or 10% of Pw (Type 4), as appropriate, and mounted in a representative fashion, to tests to a schedule (based on BS 2G100, BS 3G100, DEF STAN 07-55 and Leaflet 101) agreed with the Rotorcraft Project Director.			
5.7	**ULTIMATE AND BURST**				

<table>
<tr><th>Para No</th><th>DS970 Pt7 Requirement</th><th>DS970 Pt7 Acceptable Means of Compliance</th><th>DS970 Pt7 Guidance</th><th>DS970 Pt7 Policy, Notes, and References</th><th>CS-29 Para No.</th></tr>
<tr><td></td><td>TESTS</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5.7.3</td><td colspan="4">The arithmetic mean and standard deviation, and hence the co-efficient of variation (v), of the burst test results shall be calculated. The ratio of the mean to the design ultimate pressure shall not be less than F as shown in the table below. Intermediate results may be interpolated.
<table><tr><td>v</td><td>0.02</td><td>0.03</td><td>0.04</td><td>0.05</td><td>0.06</td><td>0.07</td><td>0.08</td></tr><tr><td>F</td><td>1.05</td><td>1.06</td><td>1.09</td><td>1.12</td><td>1.16</td><td>1.20</td><td>1.25</td></tr></table>
The vessels numbered 7 to 12 shall, following the tests at para 5.6 above, be submitted hydraulically to the ultimate pressure for a period of two minutes without fracture or bursting. The pressure shall not vary during this time.
The pressure shall then be increased steadily in increments and the value at which fracture or bursting occurs shall be recorded.
See Leaflet 731/2 para 3.</td><td></td></tr>
<tr><td>5.7.4</td><td>If a co-efficient of variation greater than 0.08 is obtained this indicates a need for redesign or improved manufacturing practices.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5.8</td><td>VULNERABILITY TEST</td><td></td><td></td><td></td><td></td></tr>
<tr><td>5.8.4</td><td>There shall be no fragmentation of the vessels and they shall not sustain combustion.</td><td>The preferred vulnerability test is the 'Cuboid Test' described below and in Leaflet 719/1. This test shall be done on vessels Nos 13 to 18, by an MOD Approved</td><td>Each vessel shall be charged with the appropriate gas to a pressure not less than Pd. For liquefiable gases this shall be done by charging the vessel with the appropriate mass and</td><td></td><td></td></tr>
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Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		authority, after they have passed the proof test of para 5.4. Exceptionally, the Rotorcraft Project Director may authorize the 'Gunfire Test' described in Leaflet 719/3 as an alternative test for gas vessels and that described in Leaflet 719/4 for gas/oil vessels, provided that in the case of cylinders less than 64mm dia., the Vulnerability Analysis of Leaflet 112, para 4 shows this does not increase the overall vulnerability unacceptably.	raising the temperature. For permanent gases this may be done at ambient temperature by pressurising the vessel. Each vessel shall then be attacked, at a striking velocity of 1830 m/s ± 3%, with a 7g cuboid silver steel fragment (BS 1407) hardened and tempered to between 300 and 350 Vickers Hardness Number. All strikes shall be at approximately the centre of the vessel and normal to the surface.		
5.9	**REDUCED TYPE APPROVAL TESTING**				
5.9.1	A reduced level of testing for type approval may be agreed with the Rotorcraft Project Director, provided that there is sufficient relevant test evidence available for similar types of vessels and the				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	vulnerability requirements of Leaflet No.719/1 are not reduced.				
5.10	**RECORD OF TYPE APPROVAL, TESTS**				
5.10.1	The results of all tests shall be submitted to the Rotorcraft Project Director.	A record shall be made, in accordance with DEF STAN 05-123, of the satisfactory completion of the type approval test and the modification standard at which the tests were made. This should include relevant details of Pd, Pc, Pr and Pw, all test failures including fatigue, inflation limitations, and the safe life of the vessel.			
5.11	**DISPOSAL**				
5.11.1	When all tests and investigations are complete and the results have been accepted by the Rotorcraft Project Director, the vessels used in Type Approval Tests shall be destroyed in accordance with BS 5430.				
6	**PRODUCTION TESTS**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
6.1	**PRODUCTION PROVING TEST**				
6.1.1	Each production vessel shall be subject to a proof test as described in para 5.4.		Provided that there are no differences between the type test vessel and the production vessels, in design and manufacturing processes, this is the only test applicable to the first 100 production vessels.		
6.2	**PRODUCTION FATIGUE TESTS**				
6.2.1	Six of the second hundred vessels, selected at random, having already passed the proving test of para 5.4, shall be subject to the fatigue test of para 5.5.	The results shall be interpreted according to the requirement of para 4.10, and the batch or production run shall be accepted or rejected accordingly.			
6.2.2	From each subsequent batch or production run of 100, 6 shall be similarly tested and the batch or production run similarly accepted or rejected.	If a batch of less than a hundred is made, six shall nevertheless be tested. These will clear further production up to a hundred provided there are no changes. Where more than a hundred are made in one batch			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		without varying the manufacturing conditions in any way the sample size (n) may be determined by the formula: n = N/100 + Ö N/2 Where N is the batch size. (Round up or down to nearest integer). Where the fatigue life is estimated by the results of the type approval tests, extended if necessary for the purpose, is assessed as being infinite or very large compared to the service requirement, as in the case of vessels discharged only in emergency and during refurbishing, the production fatigue test requirements may be waived if agreed by the Rotorcraft Project Director.			
6.3	**MARKING**				
6.3.1	All vessels shall be clearly marked in accordance with DEF STAN 81-24.	The date of manufacture shall be taken as the date of the proof test.			

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
6.4	**ACCURACY**				
6.4.1	Particular care shall be taken to ensure the accuracy of all measuring equipment and methods to avoid overstressing the vessels. After production testing, the vessels shall be adequately dried and cleaned before further use.				
6.5	**DISPOSAL**				
6.5.1	When all tests and investigations are complete and the results have been accepted by the Rotorcraft Project Director, the vessels used for the fatigue tests shall be destroyed in accordance with BS 5430.				
7	**CHANGES**				
7.1	**MODIFICATION**				
7.1.1	If any change is made to the design or the method of manufacture which could affect any of the properties tested or any of the requirements of Para 4, the				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	relevant type approval tests shall be repeated.				
7.2	**CHANGE OF MANUFACTURER**				
7.2.1	If it is proposed to change the manufacturer but not the design or methods of manufacture, it may be necessary to repeat some of the type approval tests to validate the new source of supply.	Any such proposal shall be discussed with the Rotorcraft Project Director and tests to an agreed programme shall be done.			
7.3	**DERATING**				
7.3.1	Where a vessel is supplied for use in a derated condition (that is when the original design pressure (Pd) is larger than would be necessary for the purpose for which the vessel is now to be used) all production tests shall be based on the original Pd whether or not the vessel is fitted with a new pressure relief valve or burst disc having a lower rating.				
	Sub-Leaflets				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	LEAFLET 719/1 PRESSURISED GAS STORAGE VESSELS DEFINITION OF ENERGY LEVELS FOR VULNERABILITY TEST REQUIREMENTS				
	LEAFLET 719/2 PRESSURISED GAS STORAGE VESSELS FATIGUE AND STATIC TEST EXAMPLES				
	LEAFLET 719/3 PRESSURISED GAS STORAGE VESSELS FRAGMENTATION TEST REQUIREMENTS				
	LEAFLET 719/4 PRESSURISED GAS STORAGE VESSELS FRAGMENTATION TEST REQUIREMENTS FOR GAS/OIL HYDRAULIC ACCUMULATORS				
	LEAFLET 727				
	HEALTH AND USAGE MONITORING SYSTEMS				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
1	**INTRODUCTION**				
	The purpose of health and usage monitoring (HUM) is to improve flight safety, rotorcraft availability, maintainability, the ability to complete a mission, and to reduce life cycle costs. System functions include the diagnosis of development faults, measurement of damaging loads, and performance monitoring. The system provides in-flight indications restricted to events likely to result in mission failure. After-flight indications are provided of the rotorcraft's fitness to fly and of servicing actions necessitated by component degradation. Information of use in maintenance planning is output via a data transfer device for analysis in a ground station. The HUM system provides additional support to mission effectiveness during wartime operations by reduced reliance upon subjective inflight assessment of battle damage, and by improved diagnosis of damage repair requirements.				
			In order to fully utilise the benefits of Health and Usage Monitoring the outputs from the system should be fully integrated with the maintenance philosophy of the rotorcraft. Functionally, in this Leaflet HUM is considered separately from other rotorcraft systems. However, many of the parameters which are required for such a system are necessarily provided for other functions, and on-aircraft HUM system		

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			indications may make use of existing aircrew display facilities. As a result of this interaction, the HUM system will generally constitute an integrated component of the total rotorcraft avionics system, although stand-alone HUM systems (or sub-systems) are not necessarily excluded. This Leaflet sets out the requirements for the functional design and testing of the system. Equipments provisioned shall also comply with the requirements of the Basic Design, Manufacture, and Testing of Avionics system (DEF STAN 00-10), and with Avionic Equipment Installations (Leaflet 725). Software shall comply with the requirements for 'essential' software in interim DEF STAN 00-31 (The Development of Safety Critical Software for		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			Airborne Systems). The HUM system encompasses health monitoring, usage monitoring, status monitoring and other functions. The definition of terms used is given in Leaflet 727/1 together with a functional block diagram showing interrelationships. The status of BCAR requirements for health and usage monitoring is indicated in Leaflet 727/3.		
2	**SCOPE**				
2.1	The scope of HUM system provisions shall be agreed with the Rotorcraft Project Director. This will include such issues as the extent of integration of the HUM system with other rotorcraft systems and the interfaces with these systems (e.g., avionics equipment and engines).		Whilst HUM relating to installation aspects of engines and APUs is included within the scope of this Leaflet, HUM relating to engine components falls within the scope of the DEF STAN 00-971 (General Specification for Aircraft Gas Turbine Engines). It is essential that integration of the engine		

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			monitoring functions is considered during the design and development of the rotorcraft HUM system, either in terms of providing an interface with HUM facilities furnished with the engine, or by incorporation of the engine monitoring functions within the rotorcraft HUM facilities.		
3	**DESIGN AIMS**				
			The design aims of a Health and Usage Monitoring (HUM) System are to: (i) Minimise the possibility of catastrophic accidents though: (a) improved in-flight indications of serious degradation or failure or wear of flight-critical systems (b) improved post-flight indications of trends of serious degradation of flight-critical systems.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			(c) replacement of assumptions concerning fatigue usage with actual load measurements in service. (ii) Assist the completion of the mission in the event of degradation of flightcritical systems, in peacetime and in wartime, through improved diagnostic information to the pilot. (iii) Minimise front line maintenance time through accurate identification of faulty components, and speed battle damage repair. (iv) Enhance rotorcraft availability through improved warning of incipient failures and pre-scheduling of component retirements on the basis of actual usage. (v) Reduce life cycle costs through reduced accidents, and minimised scheduled maintenance and supporting procedures (e.g., TBO extension), and potentially by		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			retiring components on the basis of actual usage and condition. (vi) Minimise exposure to damaging flight condition by providing appropriate cockpit displays.		
4	**IMPLEMENTATION**				
4.1	Health and usage monitoring requirements shall be considered at all stages in the design and development of the rotorcraft and its installations, including the feasibility studies, during which a weight and installation allowance shall be made for the system.				
4.2	A development plan shall be defined which permits caution and rejection criteria to be established.				
4.3	Installations for flight safety is dependent upon health or usage monitoring shall be designed to ensure the effectiveness and practicality				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	of monitoring, particularly in respect of sensor installations. The integrity of the monitored installation shall not be compromised by the monitoring provisions.				
4.4	Consideration shall be given to the need for duplications of health and usage monitoring equipments and data transmission links to ensure a high level of system integrity, in safety critical areas.				
4.5	The system shall function throughout the period between rotorcraft electrical power on to power off including for those periods of maintenance which influence monitored component lives. The system need not function during power on for other maintenance actions. The system shall be treated as an essential system, and sufficient non-volatile memory to satisfy all data				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	recording requirements shall be provided and be compatible with the pattern of operation of the rotorcraft.				
4.6	Should data acquisition or processing be interrupted or aborted at any time the incidence and duration shall be flagged in post-flight data displays so that usage data can be modified by contingency allowances.				
4.7	Monitoring provisions, both hardware and software, required for wartime operations shall be installed and validated concurrently with peacetime provisions and shall be capable of rapid implementation.				
4.8	In specifying requirements for sensors and associated signal conditioning attention shall be paid both to the functional requirements (e.g., frequency range required for gearbox accelerometers) and				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the environmental conditions, using measured data from previous rotorcraft components where appropriate. Particular attention shall be paid to the vibration, EMC, temperature, and the maintenance environment.				
4.9	Wherever practicable sensors provided for other systems such as engine control systems and accident data recorders shall be used, but in a non-intrusive manner by the Health and Usage Monitoring system.				
4.10	Wherever possible monitoring systems provided with government furnished equipment (GFE) such as engines and avionics equipment shall be integrated with the Health and Usage Monitoring system in accordance with para 2.				
4.11	Specifications for sub-				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	contracted systems shall include HUM requirements in accordance with this Leaflet.				
4.12	Where Accident Data Recorders are to be installed in the rotorcraft, consideration shall be given to the most effective means of combining functions that can have commonality with the Health and Usage Monitoring System.				
4.13	Data to be transferred between the rotorcraft and the ground station shall be specified at an early stage by the Design Authority and agreed by the Rotorcraft Project Director so that the Services may determine maintenance policies and ground analysis requirements.				
4.13.1	Data transfer times shall be less than normal refuelling times, and shall not interfere with the operational requirement of the rotorcraft.				

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4.13.2	Data ports shall comply with the requirements of DEF STAN 00-13 (Avionic Data Transmission Interface Systems).				
4.13.3	Data transferred is to be fully annotated with time of day, date, and full identification of the parameter being monitored.				
4.14	**DATA SAMPLING AND PROCESSING**				
4.14.1	Sampling and processing intervals for health monitoring data shall be compatible with predicted or demonstrated damage propagation rates.				
4.14.2	Sampling and processing intervals for usage monitoring data shall be at a rate sufficient to permit the detection of all peak values of monitored parameters.				
4.14.3	Data sampling requirements for all monitoring functions shall not require special				

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	flights or damaging flight conditions.				
4.15	**SYSTEM RELIABILITY**				
4.15.1	The Design Authority shall indicate those areas in which the HUM system is contributing to the safety of the rotorcraft, and shall give an assessment of the likelihood of the mature HUM system detecting failure and giving spurious indications in those areas.				
5	**BASIC SYSTEMS ELEMENTS**				
5.1	**DATA DISPLAY**				
5.1.1	The system shall provide to the pilot warnings and cautions, and advisories, relating to the functional status of flight critical systems .	Advisories shall be displayed during ground operations but may be suppressed for flight where appropriate. The extent of coverage of flight critical systems shall be agreed with the Rotorcraft Project Director.	(see Leaflet 105)		
5.2	**DATA PROCESSING AND STORAGE**				
5.2.1	The system shall provide, at				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	the completion of each flight, structured indications of rotorcraft serviceability and system unserviceabilities as appropriate. The system shall detail adjustments, replenishments and installation replacements that are essential before the next flight. The system shall also detail maintenance actions which are essential before a period of time or number of operations to be agreed with the Rotorcraft Project Director.				
5.2.2	The HUM system will need both working and archive storage. Where the system is integrated with other avionics systems parts of this storage may be shared.	The following aspects shall be considered: (i) The size of the working memory and the extent of provision of spare capacity for subsequent enhancements. (ii) The size of the memory for archive storage. (iii) The length of time for which the archive storage will retain valid data in the			

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		absence of rotorcraft power. (iv) A strategy to be adopted in the even that the archive store becomes full, to ensure retention of the most important information. (This could occur if maintenance information could not be downloaded within the time scale assumed at the stage			
5.3	**DATA TRANSFER**				
5.3.1	The system shall have provisions for transferring data between the rotorcraft and the operator's ground station with minimum risk of data loss or corruption. Telemetering of data is not to be considered unless required by Rotorcraft Project Director.	Data transfer may be accompanied by transfer of a physical medium or through a communication channel. For the former, robustness and reliability shall be considered. For the latter, data transfer times shall be optimized whilst retaining data integrity. In both cases, a procedure for checking the validity of the transferred data and a strategy to be adopted in the event of data corruption shall be included.			
5.3.3	Where practicable, provision				

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	shall be made to download maintenance data independently from any security classified operational data.				
			Background information relating to system elements is given in Leaflet 727/2.		
6	**MONITORING FUNCTIONS**				
6.1	**DEFINITION**				
			The definitions of monitoring, and the functions to be considered are given in Leaflet 727/1.		
6.2	**EXTENT OF COVERAGE**				
6.2.1	The systems to be monitored, and the functions to be provided shall be agreed with the Rotorcraft Project Director.				
6.2.2	Status Monitoring. Systems and installations for which indications of failure status and identification shall be considered shall include fuel systems, propulsion systems,				

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	transmission systems, main and auxiliary rotor systems, flight control systems, missions systems, and critical parts of the structure such as installation attachments.				
6.2.3	Health Monitoring. In selecting health monitoring functions, consideration shall be given to: (i) Deterioration of Grade A parts, however their service lives are substantiated. (ii)All components involved in the phase separation of rotors where lack of such separation would result in catastrophic failure.				
6.2.4	Usage Monitoring. In selecting usage monitoring functions, consideration shall be given to: (i) The incidence and effect of operational hazards, abnormal loads, manoeuvres, or duty cycles. (ii) Retirement of				

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	components on the basis of measured load history or other parameters determining cumulative damage. (iii) Components potentially life-limited through the application of load scatter factors in design or substantiation, which have not had such factors applied.				
6.3	**TECHNIQUES - GENERAL REQUIREMENTS**				
6.3.1	The Design Authority shall inform the Rotorcraft Project Director of the details of the monitoring techniques and algorithms to be used.	Techniques selected shall be practicable and effective, and substantiated by relevant experience, sound design and test philosophies, and engineering judgment. Techniques selected shall be amendable to the application of simple caution and rejection criteria. The implementation of algorithms shall be such that adjustment of caution and rejection criteria can be made in	Background information on preferred techniques is given in Leaflet 727/3.		

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		service, by simple menu and keyboard inputs. Adjustments requiring new software, firmware or hardware changes are to be avoided. Means shall be provided by the Design Authority to ensure that unauthorised modification of these criteria does not occur.			
7	**TESTING**				
7.1	In all rig and flight tests of components for which monitoring functions are specified, action shall be taken to employ the definitive monitoring techniques intended for the rotorcraft HUM system, where practicable, and to use the results to further the development of the HUM system.		Test requirements covering the components of the Health and Usage Monitoring system are detailed in Leaflet 725/4 (Avionics Systems). Background information on the testing of HUM algorithms is given in Leaflet 727/4.		
8	**COMPLIANCE**				
8.1	It shall be demonstrated to the satisfaction of the Rotorcraft Project Director		Information on demonstration of compliance is provided in Leaflet 727/5.		

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	that the requirements of this Leaflet have been met.				
	Sub-Leaflets				
	LEAFLET 727/1 HEALTH AND USAGE MONITORING SYSTEMS DEFINITION OF TERMS				
	LEAFLET 727/2 HEALTH AND USAGE MONITORING SYSTEMS SYSTEM COMPONENTS				
	LEAFLET 727/3 HEALTH AND USAGE MONITORING SYSTEMS RECOMMENDED TECHNIQUES				
	LEAFLET 727/4 HEALTH AND USAGE MONITORING SYSTEMS DEVELOPMENT AND VALIDATION TESTING				
	LEAFLET 727/5 HEALTH AND USAGE MONITORING SYSTEMS DEMONSTRATION OF COMPLIANCE				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	LEAFLET 723				
	RESCUE HOIST AND SONAR HOIST INSTALLATIONS				
1	**INTRODUCTION** This Leaflet states the design requirements for the installation of Sonar and Rescue hoist equipment in all rotorcraft. Sonar and Rescue Hoist equipment for the purpose of these requirements, comprise the Sonar and Rescue hoist installations associated hydraulic and electrical circuits and components concerned with powering, controlling, and monitoring the equipment to ensure safe rotorcraft operation.				
	If an auxiliary structure is provided and this is detachable, the requirements apply to the auxiliary structure and its attachments to the rotorcraft. Existing, in-service equipment shall be utilised wherever possible provided the system performance is not prejudiced.				
2	**STRENGTH**				
2.1	The rotorcraft as a whole and that part of the load suspension system associated with the rotorcraft shall have proof and ultimate factors of not less than 1.5 and 2.0 respectively on the heaviest load to be carried.	The factored forces of para 2.1 shall be assumed to be applied to the rotorcraft in any direction within a cone of semi-angle 30° having its apex at the suspension point on the rotorcraft and its axis normal to the rotorcraft horizontal axis.			29.865 29.865a 29.865a1 29.865a2
2.3	The effects of dynamic, aerodynamic and turbulence				29.865a

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	excitations on both the load and the rotorcraft shall be considered with respect to strength, stability, controllability and handling of the rotorcraft.				
3	**FATIGUE**				
3.1	The fatigue life of those parts of the rotorcraft structure subjected only to the forces arising from the carriage of rescue and/or sonar hoist loads and of the removable auxiliary structure, if provided, shall be established in accordance with the requirements of Leaflet 201, to a load spectrum to be agreed with the Rotorcraft Project Director (in conjunction with the Airworthiness Division, R.A.E.)	When formulating fatigue spectra for other parts of the rotorcraft, the effects of carriage of rescue and/or sonar hoist loads shall be taken into account to the extent agreed with the Rotorcraft Project Director (in conjunction with Airworthiness Division, R.A.E.). The fatigue life of the fixed parts shall be at least equal to the specified life of other parts of the rotorcraft structure. The fatigue life of the removable auxiliary structure, if provided, shall be agreed with the Rotorcraft Project Director (in			29.865 29.865f

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
		conjunction with Airworthiness Division, R.A.E.).			
4	**ENVIRONMENTAL**				
4.1	The rescue and/or sonar hoist installations shall satisfy the environmental requirements for the rotorcraft stated in the Rotorcraft Specification or agreed with the Rotorcraft Project Director.				
4.2	Provision shall be made to minimise the ingress of water, particularly from sonar hoists. Any provision to contain ingressed water shall be provided with adequate drainage.		(see Leaflet 711/3).		
5	**INSTALLATION**				
5.1	The layout of the completed installation shall be such that no part of the installation, loading apparatus or equipment will foul any other part of the installation, loading apparatus, equipment or the rotorcraft structure	In the case of ship-borne rotorcraft these requirements shall be met under the conditions for securing of naval rotorcraft given in Leaflet 309, with the rotorcraft heading in any direction.			

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	under the normal conditions of loading, operation or unloading.				
5.2	The position of the rescue and/or sonar hoist installation for any of the specified combinations shall be chosen to minimise undesirable rotorcraft trim changes during operation and loading.				
5.3	When the rotorcraft has folding components (e.g., rotor, fuselage, tail) it shall be possible to fold and spread these components with rescue and/or sonar hoist(s) fitted.				
5.4	It shall be possible to load and install the rescue and/or sonar hoist(s) with the folding components folded.				
5.5	Adequate clearance shall be provided for the loading and unloading of equipment with the rotorcraft at maximum all up weight and its alighting gear compressed and tyres deflated in the most adverse		Allowance for uneven surface conditions shall be made.		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	manner.				
5.6	Adequate ground clearance between rescue and sonar hoist installations to cater for rotorcraft landings in the most adverse conditions shall be provided.				
5.7	Adequate escape routes for occupants shall be provided with sonar and/or rescue hoists installed.				
6	**ACCESSIBILITY**				
6.1	The layout of the complete installation shall be such that it is possible to carry out easily and quickly all necessary equipment fits.				
6.2	All parts of the installation requiring inspection and servicing shall be readily accessible.				
6.3	It shall be possible to carry out all servicing and inspection wearing the appropriate protective clothing.				
7	**EMERGENCY**				

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	OPERATION				
7.1	Means shall be provided for emergency jettison of rescue and sonar hoist cables.				
7.2	Control of emergency jettison shall be available to both pilot and equipment operator.				
7.3	All switches for control of emergency jettison shall be guarded.		(see also Leaflet 105, para 11.5).		
7.4	It shall be possible to operate the jettison circuits correctly despite a complete failure of the normal generating system.				
7.5	Jettison systems shall be so engineered that no single functional failure can cause inadvertent cable jettison or prevent cable jettison when required.				
8	**CONTROL HANDLE AND CONTROL COLUMN ELECTRICAL CIRCUITS**				
8.1	Rescue and sonar hoist cable jettison electrical circuits in control handles and control columns shall be designed		The close proximity of standing and switched voltages for rescue and/or sonar hoist and non-hoist		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
	and manufactured to prevent faults leading to inadvertent jettison.		services in these locations, makes it necessary to ensure that the hoist circuits are properly segregated from all other services.		
9	**COMMUNICATIONS**				
9.1	Intercommunication shall be provided between the crew members and pilot(s).				
10	**COMPLIANCE WITH OTHER DEF STAN 00-970 VOLUME 2 LEAFLETS**				
10.1	Rotorcraft rescue and/or sonar hoist(s) installations shall comply with the requirements of the following Leaflets as appropriate.		Leaflet 704 - Hydraulically powered hoists and hoist systems. Leaflet 706 - Electrically powered hoists and hoist systems. Leaflet 703 - Pneumatically powered hoists and hoist systems. Leaflet 718 - Explosive devices. Leaflet 708 - Bonding and screening. Leaflet 711 - Ice protection, in particular para 2.3.2, 2.6.1		

Para No	DS970 Pt7 Requirement	DS970 Pt7 Acceptable Means of Compliance	DS970 Pt7 Guidance	DS970 Pt7 Policy, Notes, and References	CS-29 Para No.
			and Leaflet 711/3. Leaflet 714 - Role equipment installation, particularly paras 2.1.3, 2.4, 2.8, 2.9, 3.6 and 3.8. Leaflet 722 - Folding hoist installations. Leaflet 105 - Layout of crew stations.		
11	**TESTING**				
11.2	Flight testing shall be in accordance with Leaflet 1017.	Consideration shall be given to the need for model tests, and proposals shall be agreed with the Rotorcraft Project Director.			
	LEAFLET 726				
	Not issued				
	LEAFLET 728				
	Software				
	Not Issued Refer DStan 00-970 Pt 13 Clause 1.7				
	LEAFLET 729				
	Safety Related Software				
	Not IssuedRefer DStan 00-970 Pt 13 Clause 1.7				

LEAFLET 704/0

HYDRAULIC SYSTEMS

REFERENCE PAGE

Scientific and Technical Memoranda

16/62	..	..	Fatigue and hydraulic tubing

RAE Technical Notes

Mech Eng 365	..	..	The manipulation, strength and fatigue properties of titanium tubing for aircraft hydraulic systems
Chem 1108	..	..	The cubical coefficients of expansion of rubbers used in hydraulic and pneumatic systems
Chem 1118	..	..	The compounding of natural and synthetic rubber to control the cubical coefficients of expansion
Chem 1132	..	..	The swelling of natural and synthetic rubber in experimental hydraulic fluids

British Standards

C9	..	..	Specification for coupling dimensions for high pressure air charging valves for aircraft
C13	..	..	Sizes and gravity filling orifices on aircraft
M24	..	..	Graphical symbols for aircraft hydraulic and pneumatic systems
M51 (ISO 6771)	..	..	Temperature and pressure classifications
M52 (ISO 6772)	..	..	Impulse testing of hydraulic hose, tubing and fittings
M53 (ISO 6773)	..	..	Thermal shock testing of pipes and fittings for fluid systems
M55 (ISO 7257)	..	..	Rotary flexure testing of hydraulic tubing joints and fittings
M60 (ISO 7169)	..	..	General specification for separable tube fittings for fluid systems
3G100	..	..	Specification for general requirements for equipment in use in aircraft
6275 Part 1	..	..	Hydraulic fluid power filter elements: multipass method of evaluating filter performance

Defence Standards

00-40	..	..	Achievements of reliability and maintainability
00-41	..	..	MOD practices and procedures for reliability and maintainability
01-5	..	..	Fuels, lubricants and associated products
05-42	..	..	Particulate contamination classes for fluids in hydraulic systems
05-43	..	..	Standard procedures for taking samples of hydraulic fluids for evaluation of particle contamination
05-56	..	..	Graphical symbols for aircraft hydraulic and pneumatic systems
05-123	..	..	Technical procedures for the procurement of aircraft, weapons and electronic systems
16-6	..	..	Charging valve for aircraft liquid spring undercarriage units
16-21	..	..	Marking of aircraft hydraulic components
16-26	..	..	Charging valves for aircraft high pressure nitrogen and hydraulic fluid systems
17-5	..	..	Aircraft hydraulic system ground support equipment used for international cross-servicing purposes
47-12	..	..	PTFE hoses for medium and high pressure fluid systems
47-22	..	..	End fittings for flexible hose assemblies for aircraft - metric
47-25	..	..	Pipelines and pipe couplings for aircraft fluid systems - metric

LEAFLET 703/5

PNEUMATIC SYSTEMS

V-FLANGE COUPLINGS

1 INTRODUCTION

1.1 This leaflet draws upon in-Service experience to outline the factors that should be considered when designing aircraft systems which incorporate V-Flange couplings.

1.2 V-Flange couplings are used widely in aircraft pneumatic and fuel systems. They are most commonly used within bleed air and environmental control systems and provide a strong, lightweight alternative to heavy bolted flange joints.

1.3 In-Service experience has shown that the most significant factors in failures of V-Flange couplings in aircraft systems are mal-alignment of rigid pipe flange mating faces and failure to seat the coupling correctly over the mating faces.

2 PIPE FLANGE ALIGNMENT

2.1 The designer should consider the alignment of the pipe mating faces, particularly where tolerances can build up through the system, to ensure force does not have to be applied to one or both pipe mating flanges to align them to allow the coupling to be fitted.

3 COUPLING ACCESS

3.1 The designer should consider maintainability of couplings including provision of adequate access for fitting and removal. Where inadequate space is available consideration should be given to the installation of overheat detectors.

4 COUPLING MARKINGS

4.1 Coupling markings should be in accordance with Leaflet 404 of this document and should not include clamp nut torque figures.

LEAFLET 703/4

PNEUMATIC SYSTEMS

TUBING

1 MATERIALS

1.1 Only corrosion-resistant steel tubing should be used in pressure lines and for all tubing mounted on shock struts. Proposals to use alternative materials should be discussed with the Project Director.

2 SYSTEM TUBING CORROSION PROTECTION

2.1 Aluminium-alloy tubing in exposed areas such as landing gear wheel wells and missile bays, should be protected against corrosion, particularly under the sleeve and nut couplings.

3 DESIGNED MOTION IN TUBING

3.1 Looped or straight aluminium-alloy tubing should not be used between connections where there is designed relative motion. Relative motion is allowable between the ends of steel tubing if the combined calculated stress resulting from Bourdon effect, torsion, tension, and compression, as applicable, due to the relative motion, is less than 10 per cent of the ultimate strength of the tubing and vibration of the tubing mass does not have a detrimental effect. Endurance tests of such installations may be required at the option of the Project Director.

4 STRAIGHT TUBE LINES

4.1 The use of straight tube lines installed between two rigid connections should be avoided wherever possible. Where such straight lines are necessary, provision should be made in the mounting of the units or rigid connections to ensure that no excessive strains will be applied to the tubing and fittings. Semiloops may be provided in the tubing, as necessary, to ensure proper alignment on installation and to take care of vibratory motion.

5 TUBING IDENTIFICATION

5.1 All pneumatic lines should be permanently marked in accordance with Leaflet 806, para 5, and BS M23. A sufficient number of pneumatic lines should be marked in conspicuous locations throughout the rotorcraft so that each run of line may be traced. This marking should indicate the unit operated and the direction of flow. These markings should be repeated as often as necessary, particularly on lines entering and emerging from closed compartments.

6 LOCATION OF PNEUMATIC TUBING

6.1 Insofar as practicable, pneumatic lines should not be installed in the cockpit or cabin and should be remote from crew stations. All tubing should be so installed that accumulated moisture will drain to the reservoirs or to specially provided drain points.

7 MISCELLANEOUS

7.1 Provision should be made in clamp location to provide for change in tubing length due to contraction and expansion. Removal and replacement of tubing should be possible without removal of components.

LEAFLET 703/3

PNEUMATIC SYSTEMS

HOSES

1 JOINT TYPES

1.1 Preferably, where there is relative motion between two connections, hoses should be used. However when design conditions permit, swivel joints or flexible steel lines may be used, subject to the approval of the Project Director.

2 INSTALLATION

2.1 Hoses should be so installed that they will not be subject to torsion under any condition of operation; and there should be no tendency for their connecting fittings to loosen.

3 HOSE SUPPORT

3.1 The support of a flexible line should be such that it will never tend to cause deflection of the rigid lines under any possible relative motion that may occur. Flexible hose between two rigid connections may have excessive motion restrained where necessary, but should never be rigidly supported, as by a tight clamp around the flexible hose.

4 HOSE BEND RADII

4.1 The minimum radius of bend of hose assemblies will be a function of hose size and flexing range to which the hose installation will be subjected, and will be specified by the designer.

5 HOSE PROTECTION

5.1 Hoses should be suitably protected against chafing wherever this is expected to occur.

6 PROVISION FOR HOSE ELONGATION AND CONTRACTION

6.1 Hose assemblies should be so selected and installed that elongation and contraction under pressure, within the hose specification limits, will not be detrimental to the installation either by causing strain on the end fittings or by binding or chafing of the hose.

LEAFLET 703/2

PNEUMATIC SYSTEMS

EXPLOSION HAZARD

1 Under certain conditions of pressure and temperature, the combination of air with lubricant combustible materials may cause damaging ignitions and explosions. The designer should attempt to so design and install the system that:

(i) The pressure and temperature conditions are not inductive to combustion or explosion.

(ii) Percentages of lubricant and combustible materials tending to cause or sustain combustion are controlled and held to a minimum.

(iii) Large cavities, in which high energy combustions or explosions could occur, are avoided as much as possible. See also Leaflet 719.

(iv) Excessively high compression ratios, and resulting temperature peaks, are avoided, particularly in the compressor, if one is used; and pressure or temperature responsive devices are used to temporarily suspend the compressor activity whenever there is a danger of approaching dangerous temperatures.

(v) Lubricating oils or greases which are (basically or because of additives) prone to induce combustions or explosions are avoided.

(vi) All materials used in the system are chosen after taking into consideration their merits in not sustaining combustion or enhancing explosion; and in not wearing out, eroding, or weakening in service in a manner that might cause substantial weakening of any part of the system.

2 Where the possibility of combustion or explosion cannot be precluded, all steps should be taken to minimise the effects of combustion or explosion on personnel and equipment, such steps may include flame arresters and blowout disks.

LEAFLET 703/1

PNEUMATIC SYSTEMS

PROTECTION AGAINST THE INGRESS OF FOREIGN MATTER

1 INTRODUCTION

1.1 This leaflet describes the possible sources of contamination of pneumatic systems which should be taken into account when complying with the requirements of Leaflet 703, para 2.6.

1.2 In servo systems where close tolerances between working parts are critical, protection by filters or other devices is essential. In other systems, however, where large air flows occur, fine filtration may not be necessary.

2 FLUID CONTAMINATION

2.1 Oil may enter a pneumatic system:

(i) When the normal air supply is via a tapping from the rotorcraft engine compressor, the working parts of which are oil lubricated, and

(ii) During ground checks and/or testing in cases where an external air supply is used, particularly if the ground support equipment concerned incorporates an engine-driven compressor, and more so if the servicing of the ground support equipment is suspect, i.e., away from a fixed, properly supervised base, or in the field.

2.2 Water may enter a pneumatic system during ground checks and/or testing under the conditions of para 2.1 (ii) above and also possibly when workshop high pressure air supply is used.

3 SOLID FOREIGN MATTER

3.1 Solid foreign matter may enter a pneumatic system:

(i) By being ingested into the rotorcraft engine compressor thereafter passing by way of the tapping into the pneumatic system.

(ii) Through external connections used during ground servicing and/or testing. This can occur when using ground support equipment in circumstances similar to those referred to in para 2.1(ii) above. It can also occur through breakdown of the internal surfaces of ground support equipment, e.g., due to flaking or rusting of the pipelines of workshop high pressure air supply pipelines.

4 FILTER BLOCKAGE

4.1 Filters used to guard against contamination may, depending on the type of contamination, be liable to complete blockage, or to restriction such that the performance of the system is affected. Suitable relief and by-pass arrangements should, therefore, be included to meet this eventuality.

4.2 Alternatively a clogging indicator to ensure timely changing of the filter may be provided if agreed with the Project Director.

4.3 In either case suitable instructions must be included in the servicing handbook.

5 DEHYDRATORS

5.1 Dehydrators may be used where necessary to remove moisture introduced by the compressor(s). They may also be used to remove all but traces of compressor lubricating oil.

LEAFLET 703/0

PNEUMATIC SYSTEMS

REFERENCE PAGE

RAE Technical Notes

SME 377	Flow of high pressure air in small pipes.
Chem 1108	The cubical coefficients of expansion of rubbers used in hydraulic and pneumatic systems.
Chem 1118	The compounding of natural and synthetic rubber to control the cubical coefficients of expansion

R.A.E. Specifications

AD 139	Rams, pneumatic

British Standards Specifications

C 9	Coupling dimensions for high pressure air charging valves for aeroplanes
C18	V-Flange couplings for aircraft piping and ducting - metric series.
M23	Specification for an identification scheme for pipelines
M48	Dimensions of elastomeric toroidal sealing rings for aerospace use - inch series
2917	Specification for graphical symbols used on diagrams for fluid power systems and components

Defence Standards

05-56	Graphical symbols for aircraft hydraulic and pneumatic systems.
16-7	Compressed non-breathing air characteristics, supply pressure and hoses for aircraft systems.
16-26	Charging valves for aircraft high pressure nitrogen and hydraulic fluid systems
47-12	Polytetrafluoroethylene (PTFE) hose assemblies for medium and high pressure fluid systems in aeroplanes.
47-22	End fittings for flexible hose assemblies for aeroplanes -

metric.

47-25	Pipelines and pipe couplings for aeroplane fluid systems (metric).
53-68	V-Flange couplings for Aircraft piping and ducting (metric).
81-24	Identification marking of cylinders, compressed gases

American Mil-Specs

MIL-P-5518	Pneumatic systems, Aircraft, Design, Installation and Data Requirements for.

LEAFLET 704/1

HYDRAULIC SYSTEMS

FUNCTIONAL TESTING

1 INTRODUCTION

1.1 The purpose of this Leaflet is to recommend a schedule of tests to be made on a functional mock-up of the hydraulic system in order to establish that the requirements of Leaflet 704 are satisfied. These tests are to check the operation of the hydraulic system as a whole and do not include tests on individual services such as undercarriage raising and lowering, bomb door opening, operation of powered flying controls, etc.

1.2 Provision by the contractor of a functional mock-up is called for in DEF STAN 05-123 (Technical Procedures for the Procurement of Aircraft, Weapon and Electronic Systems) Leaflet 230. Further details necessary for the required tests are given in this Leaflet.

2 FUNCTIONAL MOCK-UP

2.1 The mock-up should represent the complete Hydraulic System including all emergency systems both physically and functionally as far as is practical. Where possible simulation of environmental extremes should be considered. It should be a replica in all details such as lengths of pipe lines and general disposition and types of components. Each service should be loaded by some means which simulated as far as possible the flight loading conditions. Pressure pickups required by Leaflet 704, should be fitted at all points where surge pressures are likely to develop and temperatures should be measured at critical points in the system.

2.2 If an unpressurised reservoir, or a pressurised reservoir in which the fluid level can be affected by attitude, is used in the system means should be provided for tilting the hydraulic reservoir and suction pipe about an appropriate axis so that the fluid level at any rotorcraft attitude or acceleration can be simulated. Hydraulic pumps should be driven by a power source which can be regulated so that all engine power conditions from idling to maximum power can be simulated.

3 TEST SCHEDULE

3.1 HYDRAULIC POWER SUPPLY

3.1.1 With the power supply operating at maximum engine conditions and with no services operating check that the steady pressure does not exceed the maximum working pressure requirements defined in Leaflet 704, para 6.1 in any part of the system.

3.1.2 With the power supply operating at the appropriate conditions select simultaneously all services that could be needed in any flight condition and determine the most adverse combination of services likely to be used in operational flying. Check that the times of operation with this combination of services satisfy the operating requirement for each service.

3.1.3 Simulate failure of the mechanism which off-loads the pumps and show that with pumps working at full capacity with no services operating, the pressure in the system does not exceed the relief pressure, P_r.

3.2 SURGE PRESSURE

3.2.1 Explore the complete system for surge pressures and examine the interaction of one circuit with another. Check that under all likely conditions of operation the requirement of Leaflet 704, para 8.1 is satisfied. Any surge pressure which cannot be eliminated by design modification should be recorded so that account can be taken of it in the strength calculations in accordance with the requirements of Leaflet 704.

3.3 TEMPERATURES

3.3.1 In the tests of para 3.1 check the functioning of each service or combination of services as far as practicable throughout its appropriate ambient temperature range as required by Leaflet 101. Check that the temperature limitations of fluid and sealing materials are not exceeded under the most severe operational conditions of temperature and horsepower output.

3.4 INDEPENDENCE OF SERVICES (see Leaflet 100, para 9)

3.4.1 Simulate singly, various likely failures, including leakage of fluid in each service in turn and each time check the operation of the corresponding emergency system. Each time check that all other vital services, as required by Leaflet 100, para 9, can be operated and satisfy their respective operating requirements.

3.5 RESERVOIR CAPACITY

3.5.1 Select the combination of services corresponding to the fluid at minimum level and if applicable with the reservoir positioned to simulate the most adverse attitude and acceleration appropriate to that combination of services, check that the fluid level satisfied the requirement of Leaflet 704, para 7. When simulating forward acceleration with any reservoir in which the fluid level can be affected by attitude the reservoir should be tilted so that the fluid level is equal to that which would be produced by the acceleration. The effect of accelerated take-off, when applicable, should be taken into account.

3.5.2 With the power supply operating at the most adverse conditions and with fluid topped up to the correct level operate those services or possible combinations of services which produce the maximum inflow to the reservoir and check that the reservoir relief valve or vent will operate satisfactorily, if required, and that the pressure in the reservoir does not exceed the design pressure. These tests should include the operation of emergency systems after a primary system failure.

3.6 NEGATIVE G CASE

3.6.1 Invert the reservoir if applicable and check that detrimental aeration of the fluid is not caused when the pump is running at all speeds from idling to maximum conditions. In systems in which powered flying controls are incorporated, no aeration should occur and full control should be maintained under negative g conditions for a period longer than the endurance of the engines for the particular installation, such that, after the engines have stopped, normal attitude can be regained from the most adverse g conditions, and engines restarted. When no special provision for negative g is made in the engine installation a period of 10 seconds should be assumed or a lesser period as agreed with the Rotorcraft Project Director.

LEAFLET 713/0

MAGNETIC COMPASS INSTALLATIONS

REFERENCE PAGE

A & AEE Reports

Res/175/1	..	..	Lightning: Its effect upon compass deviation in aircraft
Res/175/3	..	..	Changes during flight of deviation due to fuselages, etc

RAE Technical Memoranda

LAP363	..	..	The magnetising effects of field strength variation on Gyro Magnetic Compass Mk 4 detector units

Air Publications

AP 3456D, Part 2	..	..	Heading and Alignment Instruments
AP 112B.	..	..	This series describes specific compass types

British Standards

2G 100	..	..	General Requirements for Aircraft Electrical Equipment and Indicating Instruments
3G 100	..	..	General Requirements for Equipment in Aircraft
			(2G.100 is progressively being superseded by 3G 100)

LEAFLET 711/3

ICE PROTECTION

ICE PROTECTION SYSTEMS

1 GENERAL

1.1 The design or selection of ice protection systems requires consideration of the following:

(i) The Design Icing Conditions in which the Rotorcraft is required to be capable of meeting its Service operational requirements stated in the Rotorcraft Specification,

(ii) The areas over which ice accretion can occur, and the effects of ice accretion on Rotorcraft or systems performance,

(iii) The rate at which ice accretion can occur, and the possible damage or hazards from shed ice.

1.2 The Design Icing Conditions are defined in Leaflet 711/2. The Rotorcraft Specification will stipulate which of the conditions shall be met, and for what durations.

2 AREA OF ICE ACCRETION

2.1 The area over which ice can accrete on an object is determined by:

(i) its shape, size and disposition relative to the airflow,

(ii) its surface temperature when exposed to the icing condition, and

(iii) the water droplet or ice crystal size and air velocity.

2.2 The shape of the ice accretion is largely a function of icing surface temperature and freezing fraction. These are complex functions of the parameters (i) and (iii) above, and of liquid/solid water concentration, ambient pressure, temperature and relative humidity. A concise relationship between accretion shape and surface temperature and freezing fraction has not been established. In general a freezing fraction of unity and low icing surface temperature gives a sharp pointed rime ice growth. As temperature rises to zero the ice type changes to glaze ice and the accretion shape changes with decrease in freezing fraction through arrowhead, blunt arrowhead and mushroom to double or single horned at low freezing fraction.

2.3 For fixed aerofoil surfaces the area and chordwise limits can be calculated using suitable computer programs, (see for example Reference 11). Further relevant information is contained in References 1 to 10 inclusive.

2.4 While a comprehensive theoretical treatment of main rotor ice accretion is still not possible, research to date suggests that computer programs developed for fixed-wing applications (e.g. References 10 or 11) may be used with reasonable confidence to assess the likely rate, shape, and both spanwise and chordwise extents of ice accretion. Photographic evidence gathered during flight tests in natural icing conditions has confirmed a variation in ice type and profile along the rotor due to the spanwise velocity gradient. Results from tests on aerofoils in icing wind tunnels confirm that cyclic variations in pitch increase the limits of droplet impact but do not significantly effect the size or the profile of the ice, when compared to an equivalent accretion on a static aerofoil set at the mean incidence. Cyclic variations in airspeed are predicted to have a small effect on the threshold for rime, glaze, and beak type ice accretion, but this remains to be confirmed by flight tests. On the knowledge available to date it is therefore recommended that evaluation of ice accretion limits at a given spanwise station be made for both the advancing and the retreating blade in forward flight and for the hover condition. For the evaluation of the ice accretion profile and size the use of the local mean blade incidence and airspeed is recommended.

3 RATE OF ICE ACCRETION

3.1 The rate at which ice may form on a surface is determined by:

(i) the shape, size and disposition of the surface relative to the airflow,

(ii) the water droplet or ice crystal size,

(iii) the airspeed, ambient air temperature and pressure,

(iv) the amount of water blown off,

(v) the liquid water or ice crystal content,

(vi) the surface freezing fraction (which depends on the balance of the heat transfer from the surface).

Items (i) to (iv) control the surface water catch efficiency, which with item (v) determines the total rate of catch of water/ice. Item (vi) determines how much of the collected water/ice freezes.

3.2 The rate of catch of water drops on aerofoil sections can be calculated using computer programs. In the absence of a suitable program the methods of Reference 1 may be used. An allowance should be made for the water which blows off and therefore does not require evaporation, and for kinetic heating. The kinetic temperature rise should be taken as half the value assumed for dry air conditions. The rate of catch of droplets on a radome may be assumed to be equal to that of a sphere with the same frontal area.

4 NOTES OF ICE PROTECTION SYSTEMS

4.1 GENERAL

4.1.1 Ice protection systems can be either of two types:

(i) Anti-icing Systems, where the surface is maintained free from ice accretion at all times, or

(ii) De-icing Systems, where accretion is allowed to occur and is periodically removed before its effects, and those of the shed ice, are hazardous.

4.1.2 Since there may be operational penalties associated with the provision of ice protection systems, and also with flight in icing conditions even when protection systems are fitted, it is essential that the requirements of the Rotorcraft Specification are carefully examined at an early stage in the design.

4.2 ANTI-ICING SYSTEMS

4.2.1 Anti-icing can be achieved by continuous heating, employing either electrical or hot air systems, or by the use of freezing point depressant fluids.

4.2.2 If a continuous heating method is employed, either an adequate surface should be maintained above 0°C, so that freezing of any run-back water which might cause a hazard is prevented or sufficient heat should be applied to the wetted area to evaporate all impinging water not blown off. Computer programs have been developed to perform these calculations (References 12 and 13). In the absence of a suitable program the heat required may be calculated by the methods given in References 2 and 6. The amount of heat should be evaluated for the droplet sizes given in Table 2 of Leaflet 711/2 with due allowance for the latent heat of fusion of ice for the mixed and snow conditions.

4.2.3 When methods employing freezing point depressants only are used as anti-icing systems, the quantity of fluid required to depress the freezing point below the local temperature of the surface should be calculated. The amount of fluid applied should be 1.25 times the calculated quantity for local variations both in the mixing process and in distribution (see Reference 7). The pumps should be duplicated, each capable of providing the full requirements. Allowance should also be made for the mixed conditions of Table 1 of Leaflet 711/2, and for the effects of the fluid when flying in snow.

Note: The use of fluid anti-icing systems may be ineffective in certain snow conditions; their use can aggravate and increase unwanted slush and ice accretions.

4.3 DE-ICING SYSTEMS

4.3.1 De-icing can be achieved by the application of heat through electrical or hot air systems to weaken the bond between the ice and the surface, by the use of freezing point depressant fluids, by mechanical means or by the use of low adhesion (ice-phobic) coatings or pastes.

4.3.2 If a heating method is employed, care should be exercised in the selection of heating power and duration to ensure that free water on the surface, after shedding of the ice, does not result in an unacceptable amount of run-back icing on unprotected parts of the surface. Methods of calculating heating requirements are given in Reference 7.

4.3.3 If eletro-impuse methods are used to provide de-ice protection, the airworthiness of the resulting structure must be fully substantiated.

REFERENCES

To assist the design of ice protection systems, the following references may be consulted:

Ref No	Author	Title
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2	Hardy J K	Protection of aircraft against ice. RAE Report SME 3380, 1946.
3	Brun A E	Icing problems and recommended solutions. Agardograph 16, November 1957.
4	Dorsch R G Brun R L Gregg J L	Impingement of water droplets on an ellipsoid with fineness ratio 5. NACA TN 3099, 1954.
5	Coles W C	Icing limit and wet-surface temperature variation for two airfoil shapes under simulated high speed flight conditions. NACA TN 3396, 1955.
6	Bowden D T et al	Engineering summary of airframe icing technical data. FAA Tech Report ADS-4 1964.
7	Messinger B L	Equilibrium temperature of an unheated surface as a function of airspeed. J Ae Sc January 1953 Vol 20 No 1.
8	Cansdale J T	Calculation of surface temperature and ice accretion rate in a mixed water droplet - ice crystal cloud. RAE Technical Report TR 77090, 1977.
9	Cansdale J T Gent R W	Ice accretion on aerofoils in 2-dimensional compressible flow - a mathematical model. RAE Technical report TR 82128, 1982.
10	Gent R W	Calculation of water droplet trajectories about an aerofoil in steady, 2-dimensional, compressible flow. RAE Technical Report TR 84060, 1984.
11	Gent R W	TRAJICE2 - A combined droplet trajectory and ice accretion prediction program for aerofoils. RAE Technical Report, 1990.
12	Gent R W	HRB1D - A computer program for the design and assessment of electrothermal rotor de-icing systems. RAE Technical Report TR 87047, 1987.
13	Gent R W	HRB2D - A computer program for the detailed assessment of electrothermal rotor protection systems. RAE Technical Report TR.

LEAFLET 711/2

ICE PROTECTION

ICING CONDITIONS

1 GENERAL

1.1 The design atmospheric icing conditions are defined in this leaflet.

1.2 These conditions represent standards which a Rotorcraft and its equipment may be required to meet in order to ensure the ability to fulfil the Service operational requirements stated in the Rotorcraft Specification in inclement weather.

1.3 The extent to which these conditions are applicable to any particular Rotorcraft or operational role fit will be stipulated in the Rotorcraft Specification.

1.4 The design atmospheric icing conditions in Table 1 extend up to 3000m altitude to cover the normal operational altitude range of Rotorcraft. Where Rotorcraft are required to operate at higher altitudes, the associated design atmospheric icing conditions shall be stipulated in the Rotorcraft Specification.

1.5 These design conditions have been based on statistical analyses of thousands of observations obtained over several decades in many geographic regions.

1.6 In natural icing the conditions experienced are unlikely to correspond precisely to any one of these design conditions; indeed, natural icing conditions may well be mixed, and may change rapidly in a short distance (or time).

2 METEOROLOGICAL FACTORS INFLUENCING ICING

2.1 Atmospheric icing is a complex phenomenon influenced by many interdependent factors. The more significant of these are as follows.

2.2 Ambient Temperature: Icing can occur at ambient temperatures between -40°C (-80 in ice crystal cloud) and +5°C or above. At positive ambient temperatures icing can occur in engine air intakes, carburettor venturis, and other places where the air experiences adiabatic cooling due to expansion of the airflow.

2.3 Liquid Water Content: The design icing conditions specify liquid water content (LWC) from 0.2 to 1.5 g/m^3. The higher concentrations are associated with the higher temperatures within the icing range. The liquid water content in layer (stratiform) cloud seldom exceeds 1 g/m^3, whereas much higher concentrations can occur in convective (cumuliform) cloud. However, convective cloud is normally much more limited in horizontal extent than layer cloud.

2.4 Ice Crystal Content: Clouds containing ice crystals can occur at temperatures from 0°C down to -80°C, and at altitudes up to 18000 m. At temperatures down to, and possibly below, -20°C (but no lower than -40°C) the ice crystals usually occur in combination with supercooled water. At lower ambient temperatures ice crystals and snow will not normally adhere to a cold surface. However, in ice crystal cloud, accumulation of slush can occur even on heated surfaces such as turbine engine air intakes, and on pitot heads and other sensor probes. Furthermore, the use of anti-icing fluids in ice crystal cloud and snow may cause unwanted accretions.

2.5 Droplet Size: The median volume diameter droplet size is a function of the icing condition. Reference to Table 1 shows a range of 10 microns (in freezing fog) to 1500 microns (in freezing rain). Within each condition the droplets are assumed to be distributed in size about the median diameter. The distribution is defined in Table 2. Water droplet and ice crystal size has a marked influence on both the extent and the severity of ice accretion on a body (see para 3.5). In calculating accretion characteristics it is recommended that, in addition to using the distribution defined in Table 2, the analysis should also be performed assuming a constant droplet diameter (equal to the median volume diameter appropriate to the Condition).

2.6 Pressure Altitude: The altitude ranges in which icing can occur depend considerably on the condition. For example, freezing fog often extends no higher than 15m (50 ft) above ground level, and seldom above 100m. However the severe icing associated with the Periodic Maximum Condition (normally associated with cumuliform cloud) is most likely to be experienced above 1200m.

3 THE INFLUENCE OF ICING CONDITIONS ON ICE ACCRETION CHARACTERISTICS

3.1 The distribution, and the type, of ice accretion is strongly dependent on air temperature, but is also influenced by the following factors:

(i) the shape, size, and attitude relative to the airflow of the accreting body,

(ii) the surface temperature of the body and its thermal conductivity if in contact with a source of heat or cold,

(iii) the liquid water or ice crystal content,

(iv) the size of the water droplets, and the airspeed,

(v) the atmospheric pressure at the altitude the rotorcraft is flying.

3.2 At the lowest temperatures in the icing range the supercooled water freezes on impact on a cold surface, normally in a narrow band centred on the stagnation point, to form rime ice. This is usually white, opaque and relatively streamlined in profile when small, but can become sharply pointed when large.

3.3 At the highest temperatures in the icing range, close to 0°C, the supercooled water does not freeze immediately on impact but runs back, losing heat by evaporation, conduction, and convective cooling until ice forms. This is glaze ice which may be smooth and fairly transparent. Since the runback of the impinging water occurs on both sides of the stagnation point, the ice formation grows as two horns which may be separated by a relatively ice-free area. Because of the high subsonic Mach number conditions existing on the outboard section of the rotor, it is possible for ice to grow only in the low pressure region close to the leading edge on the upper surface. Such accretion has been termed beak ice, and resembles a slushy ridge of ice which self-sheds. This accretion is thought to be specific to helicopter rotors. While it rarely grows to a large size (usually less than 2% chord) its effect on the rotor lift and drag characteristics cannot be neglected.

3.4 At intermediate temperatures in the icing range the extent and type of ice accretion lie between those described in paras 3.2 and 3.3. The ice may take on an arrowhead or a mushroom shape, and the ice texture may range from rime through cloudy ice to glaze, depending on the temperature.

3.5 Since there is a spanwise velocity gradient along the blade of a rotor, it is possible for rime, glaze and beak ice to exist on the same rotor. Rime ice will tend to form at inboard stations followed by glaze ice, with beak ice forming at outboard stations. The spanwise extent of these accretions will vary with the icing conditions, but particularly with ambient temperature and, in the case of glaze ice, with LWC.

3.6 The combined influences of body shape and size, liquid water content, water droplet diameter, and airspeed determine the rate at which supercooled water impacts with the surface, and the extent of the impact area. The larger the water droplets, the smaller the body, and the higher the airspeed - the greater the 'rate of catch' per unit frontal area, and thus the greater the rate of ice accretion if the air and surface temperatures are sufficiently low.

Note: Great caution should be exercised in extrapolating ice accretion rate data, whether obtained from calculation or by test. The very process of accreting ice modifies the profile of the accreting body. This alters the rate of catch, as well as changing such factors as the rate of convective cooling due to flow acceleration around rapid changes of profile. These factors modify the subsequent rate of ice accretion, sometimes resulting in an accelerating rate of ice accumulation.

4 RELATIONSHIP BETWEEN ICING SEVERITY STANDARDS

4.1 There is no simple or precise relationship between the design icing conditions defined in this leaflet and the Meteorological Office forecasters' terminology, viz. "light", "moderate" and "severe".

4.2 Reference to Table 1 shows that the LWCs appropriate to the Continuous Maximum and Periodic Maximum design icing conditions are functions of OAT and altitude. For the Continuous Maximum condition LWC ranges from 0.9 g/m^3 at +5°C to 0.2 at -30°C, whereas the Periodic Maximum LWCs range from 1.35 at +5°C to 0.3 at -30°C.

4.3 As a rough guide the Meteorological Office forecasters' "light icing" covers LWCs up to approximately 0.5 g/m^3, "moderate icing" covers LWCs from 0.5 to 1.0, and "severe icing" from 1.0 to 4.0 g/m^3.

Note: The US Army definitions are similar, viz.:

TRACE:	0	to 0.05 g/m^3
LIGHT:	0.05	to 0.5 g/m^3
MODERATE:	0.5	to 1.0 g/m^3
HEAVY:	1.0	to 2.0 g/m^3

5 AMPLIFICATION OF DESIGN ATMOSPHERIC CONDITIONS

5.1 The design atmospheric icing conditions are defined in Table 1 of this Leaflet. The amplification which follows is provided to assist the design of ice protection systems.

5.2 SUPERCOOLED WATER DROPLET CONDITIONS I AND II

5.2.1 In establishing the design icing conditions for Rotorcraft in the 0 - 3000m altitude range, it was clear that both the Instantaneous Maximum and the Intermittent Maximum Conditions used for aeroplanes were not relevant as they applied above 3000m. The validity of the Continuous Maximum was also questioned, as it was based on data covering a wider altitude band than was appropriate for Rotorcraft.

5.2.2 Re-examination of the original data (References 1 to 4), excluding those for altitudes above 3000m, and the inclusion of some additional data (see References 5 to 9), confirmed the applicability of the Continuous Maximum Condition to altitudes below 3000m. It was noted that periodic encounters with more severe LWC values had also been recorded. These formed the basis for Condition II - Periodic Maximum Icing where they were set at 1.5 times the LWC for the Continuous Maximum Icing Condition, but with the horizontal extent reduced to 6 km in every 100 km of Condition I.

5.3 MIXED CONDITIONS III AND IV

5.3.1 Icing trials have clearly demonstrated that mixed snow, or ice crystal, and water droplet conditions are encountered in the 0 - 3000m altitude range, and can have hazardous consequences. The frequency of these encounters, their horizontal extents, total water content, solid/liquid ratio and solid particle size have not been fully determined. The values presented in Table 1 for Conditions III and IV are based on reasoned judgement and will be reviewed in the light of future data.

5.3.2 Due to the wide range in shape and size of ice crystals and snowflakes, a unique size cannot be specified. In estimating impingement limits both large and small crystals should be considered. The relationship between mass (m), in milligrams, and maximum linear dimension (d) in millimetres, may be assumed to be $m = 0.010d^2$ for powder snow, and $m = 0.004d^2$ for plane dendrites in the range $1<d<5$ millimetres.

5.4 SNOW CONDITIONS V TO VII

5.4.1 Two snow conditions are defined: falling snow, and recirculating snow generated by hovering flight in ground effect over loose lying snow.

5.4.2 The water content for recirculating snow is based on References 10 and 11 together with other unpublished data, but no data is available on particle size (see para 5.3.2).

5.4.3 The water content for recirculating snow is based mainly on visual assessment and may be an underestimate. However, the recommended value of 1.5 g/m^3 is likely to last only for a minute or less until the loose snow has blown away, unless the Rotorcraft is moving slowly in ground effect over loose snow (which is not a recommended manoeuvre).

5.4.4 In designing ice protection systems it should be noted that snow can form slush on, or downstream of, heated surfaces. The additional heating requirements for anti-icing systems due to the latent heat of the snow should be considered.

5.5 FREEZING FOG CONDITION VIII

5.5.1 The values of 10 and 20 microns quoted for droplet size are for radiation fog and advection fog respectively. Both conditions should be considered in ice protection system design.

5.6 FREEZING RAIN/DRIZZLE CONDITION IX

5.6.1 The condition of freezing rain is based on a rainfall rate of 4 mm/hr and covers the temperature range 0 to -10° with 1.5 mm raindrops. The freezing drizzle condition covers the range +5 to -15°C with LWC decreasing linearly with temperature from 0.3 g/m^3 at +5°C to zero at -15°C. The droplet size is assumed to be 0.2 mm (200 microns).

REFERENCES

Ref	Author	Title etc.
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2	P T Hacker R G Dorsch	A summary of meteorological conditions associated with aircraft icing and a proposed method of selecting design criteria for ice protection equipment. NACA Tech Note 2569, 1951.
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7	F S Atkinson	A report on icing trials with the S61N, January/April 1971. BEAH/ENG/TD/R/113, February 1972.
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9	A Wilson C J Green	Wessex Mk 5, XT 762 and 768. Icing Trials in Canada during winter 1972/73. AAEE Interim Report, 1973.
10	J R Stallabras	Preliminary measurements of Snow Concentration. NRC Report LTR-LT-42, 1972.
11	R N Hardy	Rates of fall of snow, mixed precipitation and freezing rain. Met Office Investigation Division TN9, 1974.

TABLE 1

DEFINITION OF DESIGN ICING CONDITIONS

Condition	Air temp °C	Water content g/m^3	Horizontal extent km	Droplet median volume dia. microns	Altitude Range $mx10^3$	Notes
I Continuous Maximum Icing	+5 0 -10 -20 -30	0.90 0.80 0.60 0.30 0.20	Continuous	20	0 - 3	1, 2
II Periodic Maximum Icing	+5 0 -10 -20 -30	1.35 1.20 0.90 0.45 0.30	6 km every 100 km of Condition I	20	0 - 3	1,3,4

continued

TABLE 1 (Cont.)

DEFINITION OF DESIGN ICING CONDITIONS

Condition	Air temp °C	Water content g/m^3	Horizontal extent km	Droplet median volume dia. microns	Altitude Range $mx10^3$	Notes
III Mixed Conditions Continuous	0 -10 -20 -30	(0.20) LWC (0.60) Ice (0.25) LWC (0.45) Ice (0.10) LWC (0.20) Ice 0.20 Ice	Continuous		0 - 3	1,5,6
IV Mixed Conditions Periodic	0 -10 -20 -30	(0.30) :WC (0.90) Ice (0.20) LWC (0.70) Ice (0.15) LWC (0.30) Ice 0.30 Ice	6 km every 100 km of Condition III.		0 - 3	1,3,5

continued

TABLE 1(Cont.)

DEFINITION OF DESIGN ICING CONDITIONS

Condition	Air temp °C	Water content g/m^3	Horizontal extent km	Droplet median volume dia. microns	Altitude Range $mx10^3$	Notes
V Falling Snow Continuous	+3 to -30	0.8	Continuous		0 - 3	7
VI Falling Snow Periodic	+3 to -30	1.5	8 km every 100 km of Condition V		0 - 3	3,7
VII Blowing or Recirculat-ing snow	0 to -30	1.5			Hover, and manoeuvre on or near the ground	3
VIII Freezing fog	0 to -30	0.3		10 to 20	0 - 15m AGL.	3
IX Freezing Rain/ Drizzle	+5 to -15 0 to -10	0.3 at 0°C to 0 at -15°C 0.3	100km	200 1500	0 - 3 0 - 3	3,8

<u>Notes</u>

1. At altitudes below 1200 m (4000 ft), water content is assumed to decrease linearly with decreasing altitude to zero at sea level, except that below 300m (1000 ft) the content for 300 m (1000 ft) applies.

2. In determining the limits of the impingement area, droplet sizes up to 30 microns shall be considered.

3. The Rotorcraft Specification will define the durations for which protection is required against Conditions II, IV, and VI to IX inclusive.

4. In determining the limits of the impingement area, droplet sizes up to 40 microns shall be considered.

5. In the temperature range 0 to -20°C the ice crystals are likely to be mixed with water droplets (with a maximum diameter of 2 mm) up to a content of 1 g/m^3 or half the total content, whichever is the lesser, the total content remaining numerically the same. Below -20°C all the water present may be assumed to be in the form of ice crystals.

6. When the horizontal extent is shown as 'continuous' it is acceptable to show that the rotorcraft functions satisfactorily for the normal endurance of the rotorcraft, or until an equilibrium state has been achieved, or as otherwise stipulated in the Rotorcraft Specification.

7. See Figure 1 - Empirical Relationship between Snow Concentration and Observed Visibility - for a guide to the severity of snow conditions.

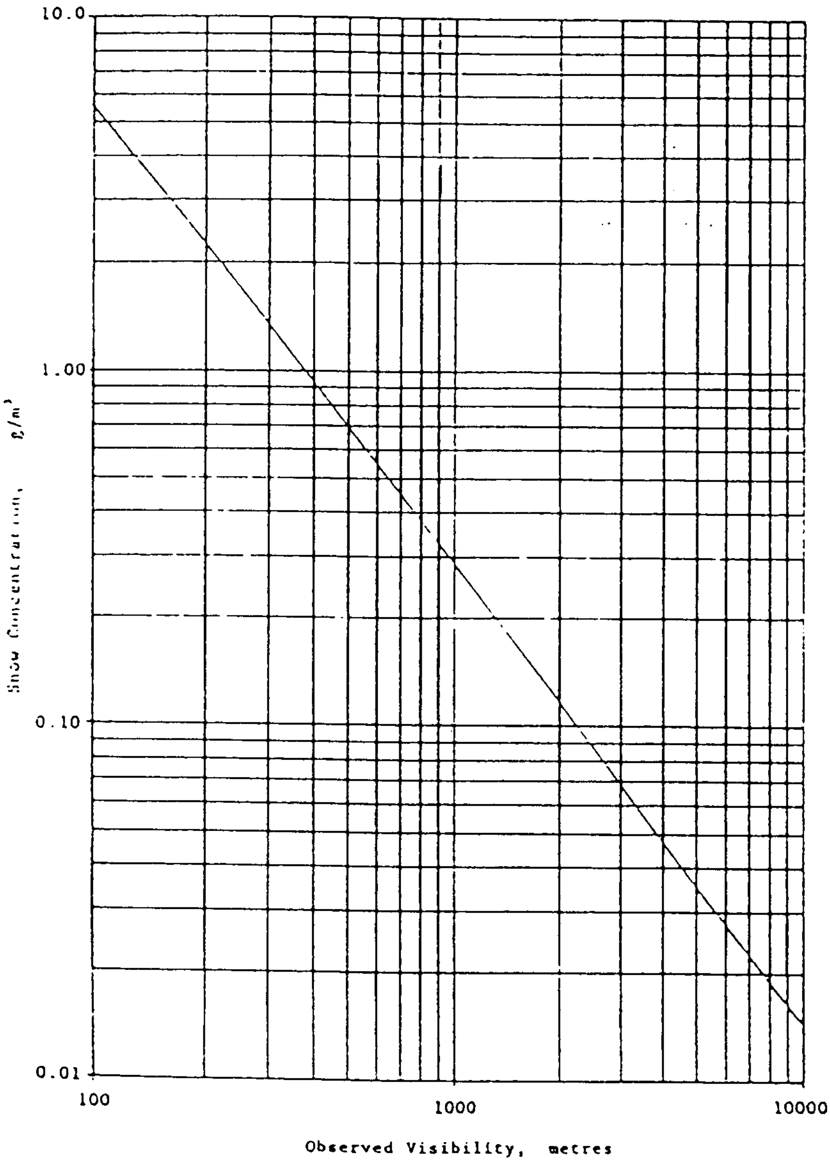
8. At air temperatures above 0°C the water content at 0°C shall be assumed to apply.

TABLE 2

RANGE OF DROPLET SIZES

% by weight of total water content contained in droplets of diameter d_F	3	8	20	30	20	10	5	4
Droplet diameter ratio, - d_F/d_V	0.27	0.55	0.83	1.10	1.39	1.67	1.95	2.22

Note: The droplet sizes quoted in Table 1 are the volume median diameters (d_V) for the distribution shown in Table 2; d_F is the particular droplet diameter under consideration.



NOTES:

1. Falling Snow

The snow severity definitions used within CA Release Limitations are as follows:

<u>Severity .. Visibility</u>

TRACE SNOW > 2000m
LIGHT 1200 to 2000m
MODERATE 400 to 1200m
HEAVY less than 400m

2. Recirculating Snow

HEAVY RECIRCULATION - reduction in visibility such that objects outside the recirculating snow cloud produced by the rotorcraft are obscured or can not be recognised by the pilot.

LIGHT RECIRCULATION - visibility may be impaired but objects outside the recirculating snow cloud can be recognised by the pilot.

Fig 1 Empirical Relationship between Snow Concentration and Observed Visibility

LEAFLET 711/1

ICE PROTECTION

PRECAUTIONS TO PREVENT WASTE WATER LEAVING ROTORCRAFT AS ICE

1 INTRODUCTION

1.1 Investigation into dangerous falls of ice from certain aircraft in flight has led to the conclusion that, in many instances, the ice was formed by the discharge of waste water on to the cold airframe structure; the ice then became detached in lumps when the aircraft entered warmer air.

1.2 It is, therefore, required for Rotorcraft which have waste water systems installed that waste water shall not be so discharged as to leave the Rotorcraft in the form of lumps of ice of such a size as to cause a hazard. This Leaflet gives recommendations for compliance with this requirement.

2 COLLECTION OF WASTE WATER

2.1 The surest way of meeting the requirements is to collect all waste water (by use of a soil tank, if necessary) and retain it in the Rotorcraft.

3 DISCHARGE OF WASTE WATER IN FLIGHT

3.1 Where the method of para 2.1 is not adopted, the waste water should be prevented from freezing in the outlet pipe and should be discharged clear of the Rotorcraft in such a manner that impingement of the waste water on any part of the Rotorcraft downstream of the outlet cannot occur.

3.2 The chances of ice forming on the airframe structure will be further reduced if the waste water is discharged in large amounts infrequently rather than in small amounts frequently. Hence it is desirable to store, at a suitable temperature, as much waste water as feasible and then to discharge it quickly.

4 RECOMMENDATIONS FOR DESIGN OF WASTE WATER OUTLETS

4.1 The water drain mast should either be heated to provide de-icing, or manufactured of low thermal conductivity materials if not de-iced.

4.2 The outlet pipes should cause the least possible interference with the air flow and should be long enough to clear the boundary layer (see also para 3.1).

5 FLIGHT TESTS

5.1 Where it is doubtful whether waste water discharged in flight will be carried clear of the Rotorcraft, flight tests should be made with whitewash on the Rotorcraft surfaces near to, and downstream of, the outlet and colour dye in the water.

LEAFLET 711/0

ICE PROTECTION

REFERENCE PAGE

MOD Specifications

DTD/RDI 3961	Windscreen de-icing pumps.

RAE Reports

SME 3380	Protection of aircraft against ice.
Mech Eng 2	Kinetic temperature of propeller blades in conditions of icing.
Mech Eng	Design of heat exchangers.
TR 77090	Calculation of surface temperatures and ice accretion rate in a mixed water droplet/ice crystal cloud.
Memo MAT/ST 1004	An investigation into the anti-icing of a heated cylinder in mixed conditions.
TR 82128	Ice accretion on aerofoils in 2-dimensional compressible flow - a mathematical model.
TR 84060	Calculation of water droplet trajectories about an aerofoil in steady 2-dimensional compressible flow.
TR 87013	Measurement of drag increase due to ice accretion on aerofoils of NACA 0012 and RAE 9645 section.
TR 88052	HOVACC - An aerofoil ice accretion predicition program for steady, two-dimensional, compressible flow conditions.
TR 90054	TRAJICE2 - A combined droplet trajectory and ice accretion prediction program for aerofoils.

RAE Technical Notes

Eng 124	Ice guards on engine air induction systems.
Mech Eng 12	Icing tests on engine air induction systems.
Mech Eng 19	Provision of heat on aircraft for protection against ice and for cabin heating.
Mech Eng 57	The maintenance of clear vision through aircraft transparencies.
Mech Eng 58	Tests of water spraying for simulating icing conditions ahead of a turbine engine in flight.

Mech Eng 62	The problem of icing as it affects modern military aircraft.
Mech Eng 203	Impingement of water droplets on aerofoils.
Mech Eng 283	The analysis of measurements of free ice and ice-water concentrations in the atmosphere in the equatorial zone (Tables 1 - 6).

NGTE Memorandum

M 106	The anti-icing of compressor blades by surface heating - Part 1 - Stator blades.

ARC Report

R & M 2805	Evaporation of drops of liquid (formerly RAE Report Mech Eng 1).

RAeS Journal

August, 1959	Water and ice in the atmosphere.

AGARD

AGARD 16	Icing problems and recommended solutions.
AGARD AR127	Aircraft icing.
AGARD AR223	Rotorcraft icing - progress and potential
AGARD CPP236	Icing tests for aircraft engines.

Defence Standards

00-35	Environmental handbook for defence materiel
00-971	General Specification for aircraft gas turbine engines.
01-5	Fuels, lubricants, and associated products.

Note: The following US reports contain useful bibliographies on the subject of aircraft icing and ice protection:

(i) Advisory Circular AC 20-73, Aircraft Ice Protection, (Appendices 1 and 2). FAA, 1971.

(ii) NASA TM 81651, Selected Bibliography of NACA - NASA aircraft icing publications.

(iii) Society of Automotive Engineer (SAE) Aerospace Information Report (AIR) 4015, Icing technology bibliography.

LEAFLET 707/3

RADIO AND RADAR INSTALLATIONS

AERIALS, ANTENNAE AND SCANNERS

1 INTRODUCTION

1.1 This Leaflet makes general recommendations regarding the manner in which aerials are located on airframes.

1.2 An aerial is a means of coupling electromagnetic radiations external to the rotorcraft with the equipment carried within the rotorcraft.

1.3 Transmitting aerials may handle considerable power. The requirements in the Leaflet are to ensure that an efficient aerial installation is produced and that energy is not wasted in coupling losses. The manufacturers' recommendations regarding matching of feeder cables should be followed.

1.4 Each aerial system will have a characteristic polar plot which may be modified by its installation in an airframe or by adjacent aerial systems. The Rotorcraft Project Director will determine if the polar performance of an aerial system needs to be demonstrated. Acceptable demonstration may involve ground tests, airborne tests or tests with models.

2 FIXED AERIALS

2.1 OMNI-DIRECTIONAL AERIALS

2.1.1 In general, communication aerials are omni-directional and may take the form of wire, probe, whip, blade or notch according to operating frequency.

2.1.2 Various manufacturers group stages of radio equipment in differing packages, but in all cases it is necessary to establish a high quality RF bond between the ground plane (usually airframe) and the RF output stage in the case of a transmitter, or the preamplifier of a receiver.

2.1.3 With MF and HF systems, separate aerial coupler units are usually fitted. These should be located as close as possible to the active aerial element. Long feeders within the rotorcraft are not desirable and provide the possibility of coupled interference with other rotorcraft systems. Special tuning units are required in connection with notch aerials involving close liaison between the airframe and radio equipment manufacturers.

2.1.4 Aerials mounted in a prominent position susceptible to lightning strike should have a low d.c. resistance path to airframe so as to protect the radio or radar equipment.

2.1.5 Where the low resistance path is not inherent in the aerial design (such as folded dipole) then means to provide lightning strike diversion (e.g., a glass enclosed spark gap) should be provided. A high resistance short to dissipate static is also necessary.

2.2 DIRECTIONAL AERIALS

2.2.1 Directional aerials may be either a purpose built assembly installed as a unit, or a combination of fixed aerials to give a directional effect.

2.2.2 Directional aerials should be located and orientated so as to look away from the airframe and not across it e.g., radio altimeter aerials will look vertically downwards from the underside.

2.2.3 Directional aerials intended to identify azimuth bearing of a signal relative to airframe should be located as near to the electrical centre as practical. Such aerials will exhibit quadrantal error characteristics. The limits of quadrantal error will be set by the Rotorcraft Project Director according to the application.

3 SCANNING AERIALS

3.1 There may be a need to scan highly directional aerials in order to find a signal. This will apply to aerials which are most sensitive to received signals within a small solid angle subtended at the aerial. Scanning may be accomplished electrically or by physically moving the aerial system.

3.2 ELECTRICAL SCANNING

3.2.1 Electrical scanning is usually achieved within a packaged electronic unit. The active aerial face is normally protected with a dielectric panel suitable for mounting external to or flush with the rotorcraft's skin. The 'viewing' angles of the device must be ascertained from the manufacturer and the unit installed where these arcs are not obstructed.

3.3 MECHANICAL SCANNING

3.3.1 Depending on the application aerials may move in one, two or three axes. Each axis may have full or restricted movement.

3.3.2 Control of the movement may be simple on/off selection of scan or servo controlled alignment permitting a crew member or other system on board to direct the aerial precisely.

3.3.3 By virtue of their configuration mechanically scanning aerials are externally mounted and normally housed within a weatherproof radome specially constructed to be transparent to the radio frequency being used. Close liaison is required between the equipment manufacturer, the radome manufacturer and the airframe manufacturer to ensure adequate electrical, aerodynamic and structural performance is achieved.

4 GENERAL PERFORMANCE

4.1 Calibrated ranging systems should not be susceptible to changes in rotorcraft configuration resulting from movement of flying controls or landing gear and/or carriage and discharge of external stores.

4.2 Aerials should be located to minimise mutual interference. A definition of the total aerial system should be agreed by the Rotorcraft Project Director.

4.3 Where aerials provide their associated system with bearing data relative to airframe their alignment must be achieved within the system manufacturers' prescribed limits. Jigs and dowel pins may be used to assist primary location and subsequent replacement.

LEAFLET 707/2

RADIO AND RADAR INSTALLATIONS

SERVICING

1 INTRODUCTION

1.1 This Leaflet gives recommendations on the installation of radio equipment to aid servicing.

2 GENERAL

2.1 Items of associated equipment of a particular system should be grouped together as far as is practicable. (Leaflet 112).

2.2 Where components are bolted to the rotorcraft structure, either quick release nuts or anchor nuts should be used, to ensure easy and quick removal. The use of loose nuts is not generally acceptable.

2.3 Units not provided with purpose built removing trays should be attached to airframe with quick release fasteners.

3 AERIAL SYSTEMS

3.1 As far as possible, and compatible with the structural requirements, aerials should be easy to replace in case of breakage or other failure.

4 AERIAL FEEDER AND ELECTRICAL CABLE INSTALLATION

4.1 Where a cable may be flexed, adequate slack should be provided.

4.2 The cleats securing radio cable assemblies to the airframe or to installed structure should be such that the connector can be removed from or placed in the cleat without the use of tools, except where bonding or special connector installations require a more positive form of cleat. Recommended forms of cleating include:

(i) Strapping for separating connectors of one installation from another to facilitate identification, except where a single connector is concerned,

(ii) Ducting and other runs with quick release attachments,

(iii) Spring clips,

(iv) Straps with button or buckle attachment,

(v) P. Clips

4.3 The above recommendations should be read in conjunction with the requirements of Leaflet 707, para 6.4.

LEAFLET 707/1

RADIO AND RADAR INSTALLATIONS

THE INSTALLATION OF AIRBORNE SPEECH COMMUNICATIONS SYSTEMS

1 INTRODUCTION

1.1 This Code of Practice sets out the principles recommended for application in installing airborne speech communications systems into military rotorcraft.

1.2 It is intended for use by the various Service agencies and rotorcraft contractors responsible for planning and designing the initial installation and any subsequent modifications, with the object of ensuring that each complete system operates as nearly as possible at its full capability.

1.3 It is strongly recommended that the provisions of the Code should be adopted by the installation designer wherever applicable; where a contractor proposes a departure from the recommended practice, the appropriate Rotorcraft Project Director should be consulted on alternative ways of meeting the objectives.

1.4 This document supplements but does not supersede the current series of publications relating to the installation of airborne electronic equipment and all mandatory requirements appearing in those publications must be met.

2 GENERAL

2.1 Speech communications systems are essential to the operation of military rotorcraft yet the rotorcraft environment is hostile to the efficient working of such systems. A detailed assessment during 1975 of a number of airborne speech communications installations showed that performance often fell far short of that achieved under the ideal conditions of a laboratory test bench. In most cases investigated, poor performance under flying conditions was found to be directly attributable to insufficient care in the planning and layout of the installation and to unsatisfactory integration of the individual equipment items.

2.2 The main problems are the degradation of speech signals by distortion and crosstalk and high levels of electrical noise which not only cause nuisance to the listener when endured for long periods but also affect the intelligibility of speech signals.

2.3 Distortion and cross talk frequently result from the presence of excessive signal levels at the inputs to the CCS amplifiers, which often have inadequate dynamic range. (CCS: Communications Control System - That section of the installation responsible for distributing and routing all baseband signals to the various crew stations and providing crew members with the facilities required to select, control and operate the available intercom and communications services).

2.4 The effects of the high level of acoustic noise existing in some rotorcraft environments can, at present, be reduced only by the use of noise cancelling microphones and by the provision of microphone switches which enable the system to operate with as few live microphones as possible; the reduction achieved by these means is limited.

2.5 Noise of electrical origin enters the installation at vulnerable points such as long and inadequately screened sensitive audio wiring, ground loops and microphone transformers located in areas affected by high level electro-magnetic fields.

2.6 No common standard of design and performance has yet been adopted for individual units of communications equipment and input/output signal levels and impedances vary widely, particularly between units obtained from different manufacturers.

3 CRITERIA

3.1 GENERAL

3.1.1 The standard of engineering must be such that the process of installing the system in a rotorcraft does not result in an unacceptable degradation of its performance when compared with that obtained on a test bench under ideal conditions. The installation is considered acceptable if the following requirements are met:

(i) Coupling of all types between the audio frequency signal lines in the inter-unit wiring, as installed in the rotorcraft, should be sufficiently low to reduce line-to-line crosstalk to better than -120 dB. (This figure assumes that all lines are correctly terminated and does not include any crosstalk occurring within the equipment items).

(ii) The frequency response of each complete audio channel should be within ± 1 dB of the amplitude/frequency characteristic specified for the basic system between 50 Hz and 7 kHz.

(iii) The attenuation of the transmitted signal due to losses in the cables and connectors for each complete signal path should not exceed 1 dB.

(iv) The total noise of electrical origin produced at each headset earpiece, under all operating conditions and with all gain controls set to maximum, should not exceed a sound pressure level of 60 dB above 20 micropascals. This level does not include any electrical noise inherent in the audio signals at the output terminals of the various radio receivers of local noise transmitted acoustically through the headgear.

3.2 SOUND PRESSURE LEVELS

3.2.1 The electrical level corresponding to a particular sound pressure level, in terms of millivolts rms developed across the telephone terminals, depends upon the characteristics of the particular type of headset used. The relevant factors are:

(i) the sensitivity of the telephone insert(s). This is usually quoted in dB sound pressure level above 20 micropascals per milliwatt of applied power, eg., 85 dB/mW,

(ii) the impedance of the telephone insert(s),

(iii) if two inserts are used, whether they are series or parallel connected,

(iv) if a single insert is used, the attenuation caused by the acoustic coupling tubes,

(v) the attenuation due to any built-in attenuator network.

3.2.2 The relationship between sound pressure level and the corresponding electrical levels for particular headsets is demonstrated in the following examples:

(i) Example 1

A Mark 2/3 flying helmet, using a single telephone insert coupled to the ear pads by acoustic tubes which attenuate the sound pressure level by 10 dB.

Insert impedance	:	300 ohms nominal at 1 kHz
Insert sensitivity	:	85 dB/mV

The maximum permitted sound pressure level will be reached when the applied noise power at the telephone insert is:

(85-10-60) dB down on 1 mW

In terms of voltage this is:

$$15\text{dB down on}\sqrt{\frac{1 \text{x} 300}{1000}}\ \text{V}$$

i.e. 15 dB down on 550 mV, which is approximately
100 mV rms.

(ii) Example 2

A headset using two 300-ohm telephone inserts wired in parallel:

Insert impedance	:	300 ohms nominal at 1 kHz
Insert sensitivity	:	(say) 100 dB/mW

Because the inserts are wired in parallel, the maximum permitted sound pressure level at either earpiece will be reached when the applied noise power across each insert is:

(110-60) dB down on 1 mW

In terms of voltage this is:

$$15\ \text{dB down on} \sqrt{\frac{1 \text{x} 300}{1000}}\ \text{V}$$

i.e. 50 dB down on 550 mV, which is approximately 1.7 mV rms.

In this example, the maximum permitted electrical noise level as fed to the crew member's headset is 1.7 mV rms across 150 ohms.

(iii) Example 3

A headset using two 300-ohm high-sensitivity inserts wired in parallel and fed via a single 13 dB attenuator pad.

Insert impedance	:	300 ohms
Insert sensitivity	:	123 dB/mW
Built in attenuator	:	13 dB

In this example, the effective sensitivity of the telephone inserts, as measured at the headset connector terminals is 123 - 13dB, = 110 dB and the maximum permitted noise voltage is, therefore, as in the previous example, 1.7 mV as measured across the headset telephone input impedance.

4 ELECTRICAL DESIGN

4.1 GENERAL

4.1.1 It is essential that the techniques used to meet the design requirements do not render the final installation vulnerable to degradation of performance in the rotorcraft environment. Among the aspects which are of particular concern in this respect are:

(i) the number of mic-tel connectors and recorders permanently wired into the flight-crew intercom circuit should be as small as possible,

(ii) the practice of connecting a number of ground-crew, auxiliary flight crew or passenger mic-tel jack points directly in parallel with flight crew jack points should be avoided,

(iii) the ground crew network should be switched completely out of circuit during flight,

(iv) in complex installations, consideration should be given to providing a separate intercom network for the flight deck crew stations, thus, reducing the number of sources of electrical noise feeding into the crew members' telephones.

4.2 PRELIMINARIES

4.2.1 The design of the installation should begin with an examination of each item of equipment to determine the extent of any incompatibility with other items in the system. In particular, input/output signal levels and impedances should be matched to ensure that the various amplifiers are not overloaded and that each sub-system operates at its optimum level. It should be noted that:

(i) published data sheets are written in terms of sinewave test signals, which bear little resemblance to speech,

(ii) speech signals can be defined and measured in a number of ways, some of which conceal the fact that significant peaks in the waveform commonly rise to levels five to eight times greater than the long term rms value,

(iii) quoted impedances are often recommended matching impedances, or even merely nominal or conventional load impedances, rather than the actual measured values. This can be significant when designing matching devices and also when considering the effects of variation of impedance which may result from parallel loading,

(iv) input and output impedances are sometimes dependent on frequency and can vary considerably over the audio frequency band.

4.2.2 The information required includes:

(i) input levels and load impedances and output levels and source impedances of the CCS equipment,

(ii) dynamic range of output signal levels obtained from the specified microphone when operated in the actual rotorcraft environment, taking into account the tolerances quoted in the microphone production test specification,

(iii) impedance, sensitivity and power requirement of the headset telephone insert when installed in the crew member's helmet; the variation of impedance with frequency should be measured in order to determine the need for a shaping network.

(iv) for each type of radio receiver:

(a) output impedance at 1000 Hz and its variation with frequency,

(b) recommended load,

(c) output signal level when the rf test signal applied to the aerial terminals is sinewave modulated to a depth of 80%, open-circuit and with the recommended load.

(d) audio frequency response curve and bandwidth of the audio output signal at the -3 dB points,

(v) the output signal level and source impedance over the audio frequency band and recommended load for all other signal sources feeding into the CCS.

Note: When defining tone or pulse signals, the amplitude must be taken as the peak rms value, whatever the waveshape,

(vi) for each type of radio transmitter:

(a) modulator input impedance at 1000 Hz and variation with frequency,

(b) input level/modulation depth characteristic at 1000 Hz. (If there is a choice between alternative high and low level modulator input circuits, the high level is to be preferred),

(c) modulation depth/sidetone audio output level characteristic at 1000 Hz, open-circuit and with the recommended load. Also, recommended load, output impedance at 1000 Hz and variation of impedance with frequency.

4.2.3 Preamplifiers or matching devices should be provided at all sub -system interfaces where the signal levels and impedance requirements are found to be incompatible and no other means exists within the sub-system for eliminating the incompatibility.

4.3 MICROPHONE PREAMPLIFIERS

4.3.1 Microphone preamplifiers may be used to raise the level of the microphone output signal or to isolate microphones operated in parallel input circuits. In the design of such amplifiers the following points should be noted:

(i) The input circuit should be matched to the impedance of the microphone in use.

(ii) The preamplifier should be able to handle the dynamic range of the microphone speech signal with less than 1% total harmonic distortion.

(iii) The output circuit should be designed to operate into the load impedance presented by the CCS (taking into account the possible variation caused by the connection of further preamplifiers in parallel), providing an output signal at the level specified for the system. If necessary, a preset gain control may be incorporated to permit accurate adjustment.

(iv) The frequency response at the -3 dB points should be 200 Hz to 6 kHz, with a sharp rate of cut-off outside this band.

(v) Microphone input transformers should not be used unless they are effectively screened.

(vi) The complete unit should be effectively screened against electro-magnetic radiation.

4.4 MATCHING DEVICES

4.4.1 In order to reduce distortion and to ensure that the system operates under optimum conditions, all equipment that feeds into the CCS should be matched into that system to provide the correct signal level at the recommended impedance. It is necessary also to ensure that, when operating in the transmit mode, the CCS microphone output circuit is correctly matched into each transmitter modulator. These requirements may necessitate the design and construction of special matching devices.

4.4.2 In its simplest form, for an unbalanced circuit, the matching device can consist of a single series resistor, but it is more usually an inverted L network or other suitable attenuator. The importance of maintaining symmetry in a balanced circuit should be noted.

4.4.3 Normally, the matching device should be designed so that it does not change the frequency response of the signal channel by more than ± 1 dB over the specified frequency band. However, when designing a matching device for a radio receiver having an audio bandwidth greater than 6 kHz, it is desirable to incorporate a bandpass filter to restrict the bandwidth to 200 Hz to 6 kHz at the -3 dB points. This, in conjunction with the following CCS amplifiers, will reduce the overall receiver channel bandwidth, thus limiting the higher frequency electrical noise and distortion products in the output signal.

4.4.4 It is important to describe each matching device fully in the installation documentation and to give any necessary adjustment and servicing instructions.

4.5 REDUNDANT CONTROLS

4.5.1 Some radio receivers are supplied with remote volume controls or controller panels. When the receiver audio output signal is fed into the CCS for distribution, these items are redundant because the system is already provided with selector switches and potentiometers specifically for the control of all incoming audio signals.

4.5.2 To avoid the possibility of operating controls in opposition and to eliminate unnecessary wiring with its attendant hazard of increased electrical noise and crosstalk, all redundant controls should be excluded from the installation.

4.6 SNEAK CIRCUIT PROTECTION

4.6.1 Sneak circuits are unintended electrical paths which permit the unwanted operation of control relays or diode switching circuits through apparently unassociated switches. Often this occurs when two relays are inadvertently connected in series through a common connection at the service selector switch and they are then sufficiently sensitive to operate from the power supply before the switch is closed to energize the selected relay.

4.6.2 If the CCS does not incorporate automatic protection against the possibility of sneak circuits, consideration should be given to the need for providing isolating diodes in series with the lines to all control relays and diode switching circuits, particularly to those in the radio transmitter-receivers.

4.7 DC SUPPLIES

4.7.1 In order to reduce electrical noise, it is essential to exclude raw (unsmoothed) dc from the system. All dc supplies to the installation, including those to amplifiers, relays, transmitter control lines and panel lamps, should be derived from adequate low-impedance filter networks preferably provided with effective transient suppressor circuits. Suitable suppressors should be fitted as necessary to eliminate high voltage switching spikes on transmitter control lines.

5 MECHANICAL DESIGN

5.1 PHYSICAL LAYOUT

5.1.1 In addition to normal consideration of convenience of operation and ready access for routine servicing, careful thought should be given to the physical location of units within the rotorcraft to ensure that:

(i) no unit (or its cabling) is placed in an area affected by strong electro-magnetic fields,

(ii) microphone preamplifiers are located very close to the microphones with which they are used. If they cannot be contained in the microphone housing, or mounted on the crew member's headgear, they should be located at the rotorcraft-side member of the personal equipment connector, or within the jack box,

(iii) all matching devices are located close to the associated radio transmitter, receiver, or audio signal source, so that the signal is maintained at its optimum level in the main connecting cables,

(iv) the specified compass safe distance is maintained.

5.2 LAYOUT DIAGRAMS

5.2.1 In order to take full account of all significant factors and to ensure satisfactory cable design, efficient screening and short cable runs, a layout diagram should be prepared showing in detail the complete electrical interconnections between all units in the installation. This diagram should show each cable screen and include all relevant items such as matching devices, terminal blocks, bulkhead connectors, junction boxes and plugs and sockets. It is an advantage also to indicate the positions of possible sources of electrical noise and interference.

5.2.2 The diagram will be particularly valuable in determining the correct grounding point for each screen and will also help avoid multiple ground connections and the resulting creation of ground loops or common impedance circuits which can lead to the introduction of electrical noise. In pursuing this requirement, it may be necessary to modify the grounding arrangement within certain equipment items.

5.3 CABLE ROUTEING

5.3.1 To reduce the pick-up of electrical noise and interference, the routeing of cables should be planned with care, taking into account the following points:

(i) No cable loom containing audio signal lines should carry ac power supply lines of any description.

(ii) All signal cables should be segregated from ac power supply cables and navigation lamp wiring, with a separation of at least 150 mm. Where it is impracticable to maintain this separation, areas of proximity should be restricted to the absolute minimum and cables which cross should do so at an angle of 90 degrees.

(iii) Cables should not pass through regions affected by strong electro-magnetic fields. Where conditions make adequate isolation impossible, suitable metal screening or a cable conduit should be provided.

(Note: At frequencies below about 1 kHz, copper and aluminium screens are not effective against magnetic fields. The only protection against magnetically induced interference is a ferro-magnetic conduit having a wall thickness equivalent to at least 0.05 mm of mumetal).

(iv) In areas close to rf transmitters and aerial systems, full advantage should be taken of the partial screening provided by the rotorcraft structure, which provides a useful degree of attenuation except where discontinuities occur at doors, windows and behind non-metallic structures.

(v) Consistent with all other requirements, cables should be kept as short as possible. The total length of cabling between each crew member's headset and the local CCS control unit should not exceed 5 metres, including the length of the actual headset connector.

5.4 WIRING

5.4.1 In addition to meeting the general requirements for all aerospace electrical wiring specified in DEF STAN 00-10, all wiring should conform to the following requirements:

(i) Where possible, specially designed multiway cables should be used in preference to made-up cable looms (see para 5.5). Each cable should be paired, twisted and provided with an outer tinned copper braided screen to reduce the exportation of interference to other rotorcraft systems and should then be insulated with an outer sheath.

(ii) Plugs, sockets and terminal blocks should be used as sparingly as possible; terminal blocks should be used in preference to plugs and sockets where space permits and quick disconnection is not essential.

(iii) Cable plugs, sockets and terminal blocks should be selected from the types listed in para 5.6.

(iv) All microphone signal leads and balanced audio lines, whether run independently, included in a multiway cable or incorporated in the wiring of a matching device or preamplifier, should consist of a pair of twisted leads, with a pitch not exceeding 10 mm, enclosed in a screen; the twisting should be maintained up to the connecting points.

(v) In multiway cables, all microphone lines should be grouped at the centre with the remaining wires arranged concentrically around them and signal lines should be alternated with non-signal lines, such as ground returns, dc power and control lines.

(vi) All telephone and unbalanced audio lines should consist of a single screened lead with a separate, unscreened return lead. If necessary, to avoid an excessive number of wires in multiway cables, several related unbalanced screened audio signal lines carrying signals at the same basic level can share a common unscreened signal return line. Telephone lines and receiver service lines should not share the same signal return line.

(vii) Each screened lead should be individually enclosed in an insulating sheath to isolate all screens throughout the length of the cable.

(viii) The rotorcraft structure should never be relied upon to provide the ground return path for any audio frequency signal line; a separate return lead should be provided for the unbalanced signal lines.

5.5 CABLE SPECIFICATIONS

5.5.1 Standards. All cables should be constructed to conform with the design requirements and wire specifications detailed in:

AP 113D17001 :	Cables, general use, aircraft and ground equipment
DEF STAN 61-11 (Pt 1) :	Cables, radio frequency
DEF STAN 61-12 (Pt 4) and (Pt 5) :	Interconnecting cables
DEF STAN 61-12 (Pt 6) and (Pt 8) :	Equipment wires
DEF STAN 61-12 (Pt 9) :	Cables, radio frequency

5.5.2 Materials. Multiway cables should be constructed using the following materials:

Wire	:	tinned annealed copper
Wire size	:	16/0.2 mm for cables with up to 6 cores 7/0.2 mm for cables with more than 6 cores
		(Note: Power lines can be duplicated as necessary for increased capacity).
Wire insulation	:	pvc or ptfe
Screening	:	tinned copper, braided with a minimum fill factor of 64%
Outer sheath	:	Glass fibre, braided and lacquered

5.5.3 Colour Coding

(i) The following basic colour coding should be used:

Microphone (+ve)	:	yellow
Microphone (-ve)	:	violet
Telephone (+ve)	:	blue
Telephone earth	:	brown
Audio service lines	:	white
Signal earth	:	Green
Intercom mic lines	:	orange/green and orange/black
Combined intercom line	:	orange
Override audio	:	pink
DC supply lines (+ve)	:	red
Panel lamps (dimmer)	:	red/green
DC return (0V)	:	black
R/T control lines	:	grey
Override control	:	pink/red
I/C mode switch	:	pink/green
R/T mode switch	:	pink/blue
Mute control	:	pink/brown

(ii) Where several lines in the same category are included in one cable, they should be distinguished by a coloured tracer added to the basic function colour. Tracers should be used in the following order:

1 Red
2 Orange
3 Green
4 Blue
5 Brown
6 Black

(iii) In accordance with AvP 118, the outer sheath of all cables carrying audio signal lines should be colour coded yellow to denote that they are category X; i.e., susceptible to interference.

5.5.4 Connector Pin Allocation

(i) The allocation of line functions to specific connector pins as established at the system LRUs, particularly within the CCS, should be preserved so far as possible throughout the installation.

Note: LRU - Line Replacement Unit. A separately referenced, individual unit of equipment scheduled as replaceable during first line servicing procedures on board the rotorcraft.

(ii) For connectors at which the established connection does not apply, the greatest practicable separation should be maintained between high and low level signal lines; such as microphone, telephone lines and audio service lines should be separated, with intervening pins used for ground, screening, dc supply and switch connections to provide some isolation.

(iii) All plug and socket shells should be connected to the dc ground return line and not the signal return line.

5.6 RECOMMENDED CONNECTORS

5.6.1 All cables connecting to LRUs will be fitted with the appropriate mating connector. Wherever possible, signal-line connectors specified for use elsewhere in the installation should be selected from the following recommended types:

(i) Terminal Blocks

(a) In accordance with BS 2G 197, but limited to sizes 6.32 and 4.40, colour black, fig. 1 and fig. 3 only.

(ii) Mic-tel Jacks and Sockets

(a) LEMO Type 2314 (Plessey Assembly Drawing No.508/1/17516/007).

(Note: The Pattern 107 NATO Jack plug and socket, 10H/9466652 and 10H/18574 respectively are not recommended because no contacts are available for the separate connection of the microphone and telephone line screens).

(iii) Multiway Plugs and Sockets

(a) DEF STAN 59-56 (Pt 1) Plugs and sockets electrical Pattern 602.

(b) Pattern 100 to DEF STAN 59-35 Part 1. Range available: 9, 15, 25, 37 and 50-way, normal or floating-bush mounting types.

(c) CANNON DPX rack mounting range.

5.7 SCREENING

5.7.1 The effectiveness of audio frequency cable screening can easily be impaired and it is, therefore, important to observe the following requirements:

(i) Cable screens should not be used to provide a signal return path; a separate lead should be used.

(ii) Each screen should be grounded at one point only. In general, this point should be at the cable termination nearest, electrically, to the main system distribution box.

(iii) Apart from the single grounding point, each cable screen should be insulated from all other screens and from all possible ground connections.

(iv) Apart from the outer cable screen and the headset connector, no screen should be connected directly to the metal shell or shield of a plug, socket or terminal block and each should be connected to a separate pin.

(v) The outer cable screen should be connected to the plug or socket shell only at one end of the cable.

(vi) The screen grounding point for all signal lines should be either a common signal (no dc power) ground busbar having a single connection to the airframe structure, or the body of an LRU bonded directly to the airframe.

(vii) At every plug, socket and terminal block, each cable screen should be allocated a separate pin to provide an individual through-connection, isolated from any local ground connection.

(viii) The outer cable screen should be connected to the shell of the plug or socket at one end of the cable only - the end nearest, electrically, to the main system distribution box. The plug/socket pin allocated to the outer screen should be wired to the chassis ground within each LRU.

(ix) On each headset connector, the plug/socket shell and internal shield should be connected to the microphone lead screen only.

(x) At each termination, cable screens should be kept intact as close as possible to the pin connection; the gap in the screening of each individual core should not exceed 20 mm.

(xi) Terminal blocks carrying audio frequency signal lines should be screened by means of a close fitting shield, grounded locally.

5.8 BONDING

5.8.1 It is essential that all permanently mounted items of equipment are efficiently bonded to the rotorcraft structure, as detailed in Leaflet 708.

6 INSTALLATION TESTING

6.1 GENERAL

6.1.1 A detailed and comprehensive test schedule should be prepared to prove that the installation meets the criteria defined in para 3. The schedule should include the tests listed in the following paragraphs.

6.2 CABLING

6.2.1 Insulation Resistance. Measure the insulation resistance between all cable cores and between each individual core and earth. This test is to be carried out on all installed cables while they are totally disconnected from power supplies, LRUs, matching devices and other electronic units. The insulation resistance should be not less than 100 megohms.

6.2.2 Continuity. Verify the electrical continuity and grounding of all cable screens, shields and conduits. The measured dc resistance should not exceed 10 milliohms.

6.2.3 Transmission Losses. With each signal path terminated in appropriate resistive loads, confirm that transmission losses at 1000 Hz do not exceed 1 dB.

6.2.4 Crosstalk. Confirm that, at 1000 Hz, the coupling between all signal lines when disconnected from all LRUs but terminated in appropriate resistive loads, does not give rise to a level of crosstalk exceeding -120 dB.

6.3 LRUs

6.3.1 Confirm that all LRUs are effectively bonded to the mounting structure, with a measured dc resistance not exceeding 10 milliohms.

6.4 COMPLETE SYSTEM

6.4.1 GENERAL

(i) Confirm that the necessary power supplies to the system are connected and are at the correct voltage levels.

(ii) Confirm that the complete system is fully operational and that the performance of each item of equipment meets the appropriate specification, in respect of audio output levels, distortion, crosstalk and power supply ripple rejection.

(iii) Confirm that the overall frequency response of each signal channel is within ± 1 dB of the specified amplitude/frequency characteristic from 50 Hz to 7 kHz (taking into account any filters incorporated in the matching devices).

6.4.2 Electromagnetic Compatibility

(i) Confirm that, with all other electrical installations in the rotorcraft operative, any unwanted signal appearing in any section of the system is at least 50 dB below the normal level of the wanted signal.

6.4.3 Electrical Noise (static test)

(i) Confirm that, with the rotorcraft ac generators switched on and all ac and dc power circuits operative, the induced electrical noise appearing on the microphone and audio service lines is at least 5O dB below the normal level of the wanted signal.

6.4.4 Electrical Noise (dynamic test)

(i) Under flight test conditions, with engines running and all electrical services operational, all dummy microphones switched on, and the intercom facility selected in isolation but with all volume controls set to maximum, confirm that the level of noise of electrical origin produced in the crew member's headset earpieces is at a sound pressure level not greater than 60 dB above 20 micropascals. This can be related to the electrical noise level developed across any particular type of telephone insert, as shown in para 3.2.

(Note: For the purpose of this test it is necessary to exclude electrical noise of acoustic origin. This can be achieved by the use of dummy microphones, manufactured by drilling a small hole in the diaphragm of a normal microphone and filling the unit with Araldite. The dummy microphone is thus acoustically dead but it is still susceptible to electrical pick-up).

LEAFLET 707/0

RADIO AND RADAR INSTALLATIONS

REFERENCE PAGE

AGARD

Advisory Report 53	..	Radomes Advanced Design
Advisory Report 75	..	Avionic Radome Materials

ARC Reports

CP146	..	..	Vibration and flutter of aircraft aerials

British Standards

3G 100	..	..	Specification for general requirements for equipment in use in aircraft
G 229	..	..	Schedule for environment conditions and test procedures for airborne equipment

Bibliography

TIL/BIB(U)/13	..	..	Bibliography of literature on aircraft radomes

Defence Standards

00-10	..	..	General design and manufacturing requirements for service electronic equipment
05-17	..	..	Electromechanical terms and graphical symbols
59-3	..	..	Terminals Electrical
59-4 (Part 7)	..	..	Plugs and Sockets Electrical
59-35 (Part 0)	..	..	Guide to connectors, electrical, and their application
59-41	..	..	Electromagnetic compatibility
59-71 (Part 1)	..	..	Instruments, electrical indicating (sealed)

MOD (PE) Specifications

DTD856	..	..	External finishes for radomes
DTD926	..	..	Process for the external finishing of radomes
DTD933	..	..	Fabrication of radomes

MOD Publications

AvP 118	..	..	Guide to Electromagnetic Compatibility in Aircraft systems

RAE Technical Notes

Chem.521	..	..	Rain erosion Part IV. An assessment of various materials
Chem.1209	..	..	Dielectric measurements on various radome materials and the effect of moisture absorption and temperature

<u>RAE Technical Notes</u> (Contd)

Chem.1215	..	..	Dielectric properties of some rubber-based core materials for sandwich radomes and the effects of moisture, temperature and frequency
Chem.1233	..	..	Dielectric measurements on some laminating resins and the effect of moisture absorption and temperature.
Chem.1267	..	..	Void-free laminates for radome construction
Chem.1365	..	..	The development of polyurethane coatings having good resistance to rain erosion
Chem.1368	..	..	Development of a reliable method for applying neoprene rain erosion resistant coatings to aircraft surfaces

<u>RAE Technical Memos</u>

FS (F) 510	..	..	Recommended Test Specification for the Electromagnetic compatibility of aircraft equipment

<u>UK AEA Culham Laboratories Report</u>

CLM-R-163	..	..	Recommended practice for lightning simulation and testing techniques for aircraft

<u>US Military Specifications and Standards</u>

MIL -E- 5400	..	..	Electronic Equipment, Airborne, General Specification for
MIL -I- 8700	..	..	Installation and Test of Electronic equipment in aircraft, general specification for
MIL -R- 7705	..	..	Radomes, general specification for
MIL-STD-12	..	..	Abbreviations for use on drawings, specifications, standards and in technical documents
MIL-STD-810	..	..	Environmental Test Methods
MIL-STD-877	..	..	Antenna subsystems, Airborne criteria for design and location of
MIL -W- 5088	..	..	Wiring, Aerospace Vehicle
MIL-STD-461	..	..	Electromagnetic Interference, Characteristics, Requirements for Equipments
MIL-STD-462	..	..	Electromagnetic Interference, Characteristics, Measurement of

LEAFLET 706/3

ELECTRICAL INSTALLATIONS

ACCESSORIES AND COMPONENTS

1 INTRODUCTION

1.1 This Leaflet makes general recommendations concerning the manner in which electrical accessories are applied and installed in various systems.

1.2 All accessories and components shall comply with BS 3G100.

2 DATA

2.1 General advice regarding the application of accessories and components is given in the documents listed in Table 1.

TABLE 1

ITEM	BS	DEF STAN	OTHER
Actuators		61-14	
Alternators	G124		
Batteries	G205	61-9	
Capacitors		59-44	
Circuit Breakers	(G142 (G179 (G216		
Connectors	(G713 (G180 (G184 (G202, 204 (G220 (G223 (G225	59-35 59-42 59-71	
Contactors	G172		
Cable Accessories	G198		
Electronic Components		58-95	
Fuses	G176	(59-96 (59-100	
Filters		59-45	
Generators	G134		
Heaters			
Indicators and Displays		66-26	
Indicators	(G133 (G191		
Invertors	(G174 (G196		
Lamp Units	G193	62-9	

TABLE 1 (continued)

ITEM	BS	DEF STAN	OTHER
Microswitches	9562	59-75	EL2123
Meters	(G146 (G147	61-1	
Proximity Devices	G218		
Relays	G208 G228	(59-7 (59-51	
Resistors		(59-30	
Rectifiers	G209		
Semi Conductors		(59-61 (59-62	
Systems	G183	59-27	
Switches	(G194 (G213 (G224	59-75	
Terminals	G197	(59-3 (59-40	
Transformers	(G127 (G207	59-76	
Wires and cables	(G212 (G230	61-12	

3 APPLICATIONS

3.1 Component and Accessories manufacturers' recommendations should be followed.

3.2 All mounting points of an accessory or component should be used to achieve a secure attachment to the airframe unless the unit is configured to permit alternative mountings or alternative orientation.

3.3 Components should be located so that electrical connections may be completed after installation. This particularly applies to ease of access to the terminal connections.

3.4 After completing the electrical connections exposed electrical conductors should be at the underside of the component; otherwise means should be provided to protect the exposed parts from falling debris etc.

3.5 Accessories and components should be purposefully orientated to gain the best advantages with regard to function, access, protection and (if appropriate) operation and indication.

3.6 Ensure that adequate grounding is provided when required. (see also Leaflet 708).

3.7 Electrical cables to a component should be adequately supported and should be installed in such a way that interchange of connections is not readily possible when the unit is removed for maintenance.

LEAFLET 706/2

ELECTRICAL INSTALLATIONS

POWER SUPPLIES

1 INTRODUCTION

1.1 This Leaflet gives further information on the standard power supplies and their applications to the installation.

2 CHOICE OF SUPPLY

2.1 BS 3G100, Part 3 details characteristics of three forms of electrical power supply for aircraft, namely constant frequency alternating current, variable frequency alternating current and direct current. The supply most suitable for the consumer item being fitted should be installed.

NOTE: BS 3G100 is gradually being incorporated into appropriate Defence Standards.

2.2 It is possible that more than one power system deriving power from engine driven generators may be fitted. It is possible that distribution to services may be provided at differing voltages derived through conversion devices, e.g., instrument supplies, emergency lighting supplies.

2.3 Choice of systems will depend, therefore, on :-

a) total power requirements

b) the nature of 1oads

c) the power to be provided by conversion devices

d) the alternative standby power required

e) the stored power required

2.4 Separate systems should not be interconnected, but circuits may be arranged to allow for one system to provide a standby power source for another by using a suitable conversion device.

2.5 The choice of power supply, i.e., nature of supply, capacity and means of distribution, should be approved by the Aircraft Project Director.

3 DESIGN OF MAIN SYSTEM

3.1 During the initial design stages of an aircraft the maximum continuous electrical load is not definitely known. For instance, there may be new equipment developed before the final acceptance date and this may be added as a requirement.

3.2 In addition, Leaflet 706, para 3.2.2 required a reserve of power at the time of the Final Conference in order to allow for further requirement of the aircraft during its service life.

3.3 In order to cover these two points it has been found by experience that 100% spare power should be allowed at the initial design stage based on the maximum continuous demand under the worst conditions of flight. The maximum continuous demand should not include high current peaks of short duration such as starting current for heavy motors. In calculating spare power, certain large loads, e.g., de-icing, need not be factored. When application of the requirement to the overall electrical power supply could lead to serious penalty the designer should consult the Aircraft Project Director.

3.4 In the case of an aircraft having four generators, the load at the time of the Final Conference plus the reserve of power required by Leaflet 706, para 3.2.2 should be met by any three generators. It should be possible to operate the aircraft after the loss of any two generators.

3.5 The main system should also be capable of accepting the maximum peak load and still maintain the required regulation. If this should mean larger capacity than arrived at above, then the larger capacity should befitted .

3.6 As some items of equipment may not provide their specified performance within the trip bands of voltage and frequency, deterioration of performance should be indicated by the equipment.

3.7 Where desirable, provision should be made for running alternative generator(s) while the aircraft is on the ground without resorting to the use of the aircraft engines. The same system may be used as a standby power system when the aircraft is airborne.

3.8 Where invertors are used as the main source of power for certain services, suitable trip devices should be provided in order to protect consumer items of equipment against damage if the characteristics of the output exceed the permitted limits.

3.9 Protection devices should be used wherever possible to localise possible faults that could occur within a main generator and distribution system.

3.10 Generator controls end indications should be logically grouped together at the cockpit or other crew station and should be so positioned that the controls and indications applicable to a particular power source are readily discernible.

3.11 The equipment and protection devices associated with separate power sources should be separately housed. Where possible feeder cables from separate systems should be segregated to reduce to a minimum the possibility of a common failure incapacitating more than one power source.

3.12 Distribution systems associated with a particular power source should not be installed in an assembly common to distribution systems associated with another power source.

3.13 Where more than one storage battery is required to achieve the desired total storage capacity these should be engineered as separate power sources and should not be located immediately adjacent to one another.

LEAFLET 706/1

ELECTRICAL INSTALLATIONS

GENERAL RECOMMENDATIONS

1 INTRODUCTION

1.1 This Leaflet makes general recommendations concerning the design of electrical installations in aircraft.

2 SAFETY IN THE EVENT OF FAILURE

2.1 GENERAL

2.1.1 The requirements of Leaflet 706, para 2.2 are aimed at ensuring that, in the event of cabin pressure failure, the most adverse combination of failures likely to occur in the electrical system will not prevent continued safe flight and landing with a probability of occurrence not greater than extremely unlikely. The circuits, components and installation of the electrical systems covered by these requirements shall be assessed accordingly and a fault analysis prepared in accordance with Leaflet 117 (to be issued) requirements.

2.1.2 Certain circuits are clearly vital to the safety of the aircraft (e.g. powered flying controls) but this may not be so obvious with other circuits. Examples of the latter are given below but it is emphasised that the list is not comprehensive and the designers should review the concept of a total system function in identifying potentially critical aspects of a particular electrical circuit:

a) flying control trimmer systems (see Leaflet 604)

b) undercarriages

c) explosive bolts

d) auto-stabilizer

e) wing folding

f) fuel systems (see Leaflet 702, para 9.2.4)

g) engine control

h) power supplies to essential navigation equipment and its displays

j) power supplies to terrain following guidance systems.

2.1.3 Electrical circuits which provide the primary initiation of vital systems should be wired in such a manner that no single failure of the wiring system can cause inadvertent operation of any circuit. Particular attention should be paid to ground connections in this respect. Multiple primary initiation circuits should be separately grounded direct to airframe.

2.1.4 Particular attention should be given to avoid the possibility of common mode faults occurring. All circuits should be analysed to identify the possibility of dormant faults occurring and the design or operating drills should provide for these accordingly. (An unnatural operating drill would not be acceptable).

2.2 WARNING OF FAILURE

2.2.1 Only warnings of failure for which there is an automatic or direct corrective action should be provided. Warnings may be cancelled automatically when corrective action is taken, but with regard to critical systems it is advantageous to annunciate a warning as a reminder that an abnormal condition exists.

2.2.2 Care should be taken to ensure that warning lights, indicator lights or annunciators show clearly and precisely the particular function that has failed. Whilst in general, systems will be designed to "fail-safe", the possibility of false indications should not occur.

2.2.3 Lamps, filament used as indicators should be replaceable without removing supports, panels or other components. Provision of individual press-to test or general lamp test circuits is recommended.

2.3 ALL ENGINE FAILURE CASE

2.3.1 The requirement of Leaflet 100, para 9.2 calls for the ability to make a descent and emergency landing with an extended glide in the event of all engines failing. Even where powered flying controls do not depend on electrical operation, the designer should consider what other electrical services may be required during the descent and ensure that adequate stored or auxiliary electrical power is available beyond that from windmilling engines.

2.3.2 Where the ability of the aircraft to meet this requirement depends on stored energy, the capacity of the battery must be such that it can meet standby requirements and still retain sufficient power to operate vital services with a reasonable safety margin (Leaflet 706, para 7.1.3).

3 CIRCUITS

3.1 BONDING AND GROUND STRAPS

3.1.1 Bonding straps fitted in accordance with Leaflet 708 may be used to meet the requirements of Leaflet 706, para 5.5.1 provided they are of sufficient cross sectional area to carry the full electrical load likely to be imposed on them.

3.1.2 The bonding, straps should be configured so as to minimise the risk of additional spark discharges.

3.2 REDUCTION OF VULNERABILITY (see also Leaflet 112)

3.2.1 When the installation necessitates all, or the majority of, the protective devices being located in one compartment, they should be split into at least two separate groups, with the maximum, available space being provided between the groups. Groups of protective devices on each side of the fuselage are preferred, each group having its own feeder cable. The added protection afforded by armour plate may be considered. Components of duplicated systems should not be located on a common radial path emanating from potential damage centres e.g., high energy rotors, potential weapon impact points, (see Leaflet 112) and should not be supplied from a common distribution bus bar.

3.2.2 Wiring should be arranged so that cables are in two or more groups with a reasonable space between them or preferably are divided on each side of the fuselage. Cables should leave panels in at least two groups spaced apart.

3.3 PROTECTION

3.3.1 When circuit breakers or fuses are used in series it is important to ensure that their characteristics are such that a fault in a sub-circuit will not cause the main feeder protection to operate. Supply and distribution cables should be located so that damage is unlikely to short circuit the protective device, e.g., fire in a cable loom.

4 WIRES CABLES AND CONNECTORS

4.1 WIRE AND CABLE INSTALLATION

4.1.1 When additional protection is not required open wire and cable looms may be installed. Otherwise protection of wires and cables may be provided by running them in ducts which should be:

a) large enough to allow additions to the number of wires and cables accommodated and to allow any single wire or cable to be withdrawn (see Leaflet 706, para 5.4.1),

b) adequately drained,

c) adequately flared or bushed with insulating material at the points of entry and exit,

d) such that the risk of damage to wires and cables being drawn into them is minimized,

e) fitted, when necessary, with easily detachable or hinged covers.

4.1.2 Wire and cable runs should be routed so as to avoid areas where heat is likely to be encountered. If it is unavoidable wire and cable assemblies likely to be subjected to high temperatures, i.e., those passing through bays adjacent to fire zones, those adjacent to hot air ducts or adjacent to the aircraft skin should be assembled from components having suitable high temperature duty rating. Where there is a danger of direct air impingement due to leakage protective guards should be considered.

4.1.3 Wire and cable assemblies should be adequately supported or protected to prevent chafing against adjacent objects under all conditions of vibration and loading of the aircraft. Wire and cable insulation should not be allowed to touch the aircraft structure.

4.1.4 Wires and cables should be securely clamped to relieve terminals and connections of mechanical load. Clamps should not affect the mechanical or electrical properties of the wire and/or cable being secured.

4.1.5 On aircraft with folding components, the wires and cables should be suitably protected from damage where they pass over hinged joints. The components should be able to fold without the disconnection of wires and cables being necessary.

4.1.6 To avoid replacement difficulties, wires and cables should not be twisted together, except where it is essential to minimise interference, e.g., 3 phase ac cables, armament feeders, Fly-By-Wire(FBW) and Full Authority Digital Engine Control (FADEC).

4.1.7 Wire and cable looms should be positioned so that they are unlikely to be used as hand or foot holds.

4.1.8 Where positive location of wire and cable terminations is not provided within an item of equipment, adjacent wires and cables should be secured together to prevent movement.

4.1.9 To allow remaking of connections, wire and cable lengths should allow for two remakes. If this is impractical in congested areas the advice of the Aircraft Project Director should be sought.

4.1.10 Sufficient slack should be left at the ends of the wires and cables to allow displacement of components to which the wires and cables are attached.

4.1.11 Adequate wire and cable lengths should be provided to allow full movement of all moving electrical apparatus and the wires and cables should be suitably run and supported to prevent damage.

4.1.12 For armament electrical wires and cables see Leaflet 710.

4.1.13 Bend radii of installed wiring should not be less than 10 times the outside diameter of the largest single wire or 6 times the overall diameter of the cable loom whichever is the larger.

4.1.14 Use of Wire and Cable: The use of wire and cable containing polyimide in various parts of an Aircraft is to be as follows:

a) General Purpose Wire and Cable: Electrical interconnection wire and cable with a specified minimum temperature rating of -65^{o}C to +135^{o}C is to be used in general purpose areas. Hybrid wires that utilize polyimide in their construction are acceptable for use in these areas. There are no restrictions on the use of wires or cables compliant with DEF STAN 61-12 Part 33 or an equivalent Specification demonstrated to fulfill these requirements as a minimum, noting that these wires and cables may contain an element of polyimide. See also Leaflet 706 para 6.6.

b) High Temperature Wire and Cable: Electrical interconnection wire and cable with a specified minimum temperature rating of -65^{o} to +260^{o}C is to be used in high temperature areas. Hybrid wires that utilize polyimide in their construction are most suitable for use in these areas. There are no restrictions on the use of wires or cables compliant with DEF STAN 61-12 Part 33 or an equivalent Specification demonstrated to fulfill these requirements as a minimum, noting that these wires and cables may contain an element of polyimide. See also Leaflet 706 para 6.6.

c) Severe Wind and Moisture Prone (SWAMP) Areas: Typical SWAMP areas include undercarriage bays, flap, slat, airbrake and wing fold areas. This environment is such that if a wire utilizing polyimide in its construction is selected for use, then greater justification for its use will be required by the MOD Project Director.

d) Pylons and Launchers: Pylons and launchers are areas of high levels of maintenance activity and demanding environmental conditions, including buffeting. Wire and cable used in these areas require a high degree of flexibility and external durability. Therefore, wire and cable used in these areas should only utlilize a top coat of known durability in their construction. Wires containing polyimide in their construction are **<u>NOT</u>** to be used in these areas.

4.2 CONNECTORS

4.2.1 MULTIWAY CONNECTORS

a) General guidance on the selection of a connector for a particular application with regard to environmental and operating requirements is given in DEF STAN 59-35 (Part 0), para 5.

b) Connectors to be reached through an access panel should be positioned to allow easy disengagement and removal. To facilitate servicing, sufficient lengths of wires or cable should be provided to allow the free connector to reach the panel opening.

c) Crimped terminations using approved tooling should be used except where hermetically sealed connectors with solder terminations are required.

4.2.2 TERMINAL POST

a) At a terminal post where two or more terminations are used they should normally be mounted in pairs back to back and where more than one pair of terminations is fitted to one side of a terminal, spacing washers should be inserted between the pairs.

b) In the case of a fully utilized single row double entry terminal the terminal ends should be interleaved from each side of each terminal to obviate the need for spacing washers.

c) Terminals reached through an access panel should face outward to facilitate manipulation.

d) Crimped terminations using approved tooling should be used.

4.3 LOCKING

4.3.1 Wherever possible stud terminals and nuts with lock washers or metallic stiffnuts should be used. The use of screws with loose washers is not acceptable.

4.3.2 Where tapped inserts or clinch nuts are used, they should be of an approved type with an integral locking.

4.4 INTERFERENCE PREVENTION (see also Leaflet 708)

4.4.1 Guidelines for Electromagnetic Compatibility are given in AvP 118 and should be adopted wherever possible in all cable and aerial installations. Problem areas should be resolved with the Aircraft Project Director.

4.4.2 Composite structures do not provide the inherent screening characteristics of metal fabrications.

5 BATTERIES

5.1 Batteries should not be fitted in engine nacelles.

5.2 When calculating the capacity of the batteries, account should be taken of the voltage to which the batteries will be charged in flight.

6 PROTECTION FROM MOISTURE

6.1 Cables connecting to equipment should, wherever possible, be arranged to run downwards from the item of equipment in drip loops. The ends of any spare cables or cores should be sealed to prevent the ingress of moisture.

6.2 Where apparatus is exposed and water can impinge upon it under any conditions, the apparatus should be suitably weatherproofed and the compartment provided with adequate drains.

6.3 Particular attention should be given to the type of protection provided on naval and other aircraft operating over the sea to prevent deterioration due to driven sea spray. (see DEF STAN 00-35 and BS 3G100 or superseding Defence Standard).

6.4 Junction boxes, distribution boxes, fuse boxes, etc., should be protected against deterioration due to ingress of moisture. Adequate draining and ventilation should be provided.

7 POWER INTERRUPTION

7.1 Where equipment is transferred from one power source to another the functioning of the equipment should not be adversely affected during the transfer period. The transfer period is defined as the time of departure from a steady state voltage and frequency to the time of recovery to a similar steady state voltage and frequency.

7.2 Where a 'no break' supply is required the transfer should be designed with a minimum interrupt.

8 ELECTRICAL SPECIFICATION

8.1 Attention is drawn to the requirements of DEF STAN 05-123 which require the Aircraft Contractor to agree with his sub-contractors for each particular item of electrical equipment a specification to the standard laid down in DEF STAN 05-123.

9 TEST FACILITIES

9.1 The purpose of the test facilities required by Leaflet 706, para 11 is to:

a) check the voltage and frequency

b) check the protection circuits which do not function under normal system operation

c) locate defective constituent parts of the electrical system, the repair of which is by replacement at First Line Servicing, e.g., generators, alternators, contractors, etc.

d) check the correct function of the system after rectification of defects.

LEAFLET 706/0

ELECTRICAL INSTALLATIONS

REFERENCE PAGE

Defence Standards

00-35	Environmental Handbook for Defence Materiel
00-40	Reliability and maintainability
00-41	Reliability and maintainability, MOD guide to practices and procedures
00-971	General specification for aircraft gas turbine engines
58-95	Electronic assemblies
59-3	Terminals electrical
59-4	Plugs and sockets, electrical
59-7	Relays, armature and relays, thermal
59-27	Precision instrument, rotating, sevo-components
59-30	Resistors, fixed, of assessed quality
59-35	Part 0: Connectors electrical for dc and low frequency applications
59-36	Selection electrical and electronic components for use in defence equipment
59-40	Lugs, terminals, and terminal strips
59-41	Electromagnetic compatibility
59-42	Heat shrink solder sheaths
59-44	Capacitors of assessed quality, selection and procurement
59-45	Filter networks
59-51	Relays, electrical, of assessed quality
59-56	Plugs and sockets, electrical
59-61	Semiconductor devices
59-71	Crimped electrical connections for copper conductors
59-75	Switches of assessed quality
59-76	Transformers and inductors
59-96	Fuse links, electrical
59-97	Heat shrinkable insulation sleeving
59-100	use holders, carriers and bases electrical fuse (block and extractor post types)
61-3 .. .. .. 61-5 to 61-7 .. .. 61-9 and 61-10 .. 61-12	Electrical wire and power distribution equipment
62-9	Lamp holders; lights, indicators, and lenses, indicator light, for use in equipment
62-10	Lamps, filament
66-7	Instruments; electrical indicating (sealed)
66-26	General requirements for aircraft instruments and displays

NOTE: BS 3G100 is gradually being incorporated into appropriate Defence Standards

British Standards

2G 100..	..	..	General requirements for electrical equipment and indicating instruments for aircraft
3G 100..	..	..	General requirements for equipment for use in aircraft
G 102 ..	..	..	General requirements for rotating electrical machinery
2G 124..	..	..	Ac generators for aircraft
2G 127..	..	..	Power and current transformers for use in aircraft electrical power supply systems
2G 132..	..	..	Electromagnetically operated contacters
2G 134..	..	..	Dc generators
G 142 ..	..	..	Heavy duty, electromagnetically operated, single-pole circuit breakers for extra low voltage dc systems in aircraft
2G 143..	..	..	Ac and dc rotary and linear actuators for aircraft
2G 146..	..	..	Dc motors for aircraft
2G 147..	..	..	Ac motors for aircraft
4G 173..	..	..	Connectors for ground electrical supplies for aircraft
G 174 ..	..	..	Invertors for secondary electrical supplies for aircraft
G 176 ..	..	..	Cartridge fuses for aircraft
5G 17 ..	..	..	Crimped joints for aircraft electrical cables and wires
G 179 ..	..	..	Hand operated circuit breakers for aircraft
G 180 ..	..	..	Permanent splicing of aircraft electrical cables
G 184 ..	..	..	Aluminium terminal ends and in-line connectors for hexagonal crimping to aircraft aluminium electric cables
G 194 ..	..	..	Lever-operated manual switches for aircraft
G 195 ..	..	..	Minyvin type electric cables for aircraft
2G 196..	..	..	Static invertors for aircraft
3G 197..	..	..	Stud-type terminal blocks for terminations on aircraft electric cables
3G 198..	..	..	Sleeves for aircraft electric cables and equipment wires
2G 202..	..	..	Specification for design and performance requirements for airframe - fit electrical connectors for dc and low frequency ac applications
G 203 ..	..	..	Unified screws with captive facing and locking washers
G 204 ..	..	..	Copper terminal ends for crimping to electric cables with copper conductors
5G 205..	..	..	Secondary batteries for aircraft
G 206 ..	..	..	Fepsil type electrical cable with copper conductors
G 207 ..	..	..	Aircraft electrical circuit diagrams
G 208 ..	..	..	General requirements for electrical relays up to 10A rating
G 209 ..	..	..	Transformer rectifier units
2G 210..	..	..	PTFE insulated equipment wires (with silver plated copper conductors)
G 212 ..	..	..	General requirements for aircraft electric cables
G 213 ..	..	..	Mechanically operated switches
G 216 ..	..	..	Hand operated, thermally compensated miniature, single and triple pole circuit breakers

G 217 ..	..	..	General requirements for cockpit lighting controllers
G 218 ..	..	..	Proximity switches for air-craft
2G 219..	..	..	General requirements for ground support electrical supplies
2G 221..	..	..	Minyvin type electric cables (metric units)
G 222 ..	..	..	Efglass type electric cables (metric units)
2G 223..	..	..	Screen termination devices for aircraft electric cables
G 244 ..	..	..	Lever operated manual switched for aircraft
G 225 ..	..	..	Performance of environment-resistant terminal junction modules with removable crimp-type contacts
G 227 ..	..	..	Tersil type electric cables (metric units)
G 228 ..	..	..	Clearance and fixing dimensions for 2A and 3A, two and four pole sealed electromagnetic relays for aircraft
2G 229..	..	..	Schedule for environment conditions and test procedures for airborne equipment
G 230 ..	..	..	General requirements for aircraft electrical cables (second series)
G 231 ..	..	..	Conditions for general purpose aircraft electrical cables and aerospace applications
G 232 ..	..	..	General requirements for general airframe or equipment interconnect use (135°C) wrapped insulation
G 233 ..	..	..	General requirements for general airframe or equipment interconnect use (135°C) extruded insulation
J 12	..	..	Pressure-sensitive adhesive identification
M 43 ..	..	..	Methods of zoning aircraft and referencing access doors and panels
M 44	..	..	Identification of aircraft servicing maintenance, general handling and safety - hazard points
4999	..	..	General requirements for rotating electrical machines
5000	..	..	Rotating electrical machines of particular types or for particular applications
9522	..	..	Rules for the preparation of detail specifications for circular electrical connectors of assessed quality for dc and low frequency ac applications

US Military Specifications

MIL-W-5088L .. Wiring, aerospace vehicle

Naval Weapons Specification

NWS 1006 Annex A

UK AEA Culham Laboratories Report

CLM-R-163 .. .. Recommended practice for lightning simulation and testing techniques for aircraft

LEAFLET 704/2

HYDRAULIC SYSTEMS

FATIGUE TESTING OF HYDRAULIC COMPONENTS

1 INTRODUCTION

1.1 This Leaflet contains information on the fatigue testing of hydraulic components and units required in Leaflet 704, para 15.

1.2 The general requirements for fatigue substantiation are defined in Leaflet 201 and associated leaflets. These requirements have been interpreted in this Leaflet for the particular application to hydraulic system components and units. The fatigue information in this Leaflet relates only to utility hydraulic system components and units in the pump and normal actuating circuits for the landing gear, bomb doors etc. , which are selected intermittently.

1.3 Fatigue testing of hydraulic powered flying controls is dealt with in Volume 1, Leaflet 206/5. In hydraulic circuits which are dedicated to powered flying controls and active control technology, the hydraulic circuit pressure pulsations will be determined from the test rig measurements defined in Volume 1, Leaflet 206/5, para 3. This spectrum with the factors in Leaflet 201 will be used for testing units. For active control technology applications see Volume 1, Leaflet 208. Where components and units are common to a number of primary and utility circuits, they should be qualified to the most severe spectrum in the interests of standardisation.

1.4 For a wheeled steering system and units refer to Leaflet 303, and for wheel brakes and braking refer to Leaflet 310.

1.5 For actuator mounting attachments etc., which are also loaded by system pressure pulsations in the hydraulic actuator, it is important that this fatigue damage is considered in the design of the airframe attachments.

1.6 Hydraulic components and units will be divided into 2 grades as specified in Leaflet 400, para 2. These requirements apply to Grade 'A' parts only.

2 LOAD/PRESSURE SPECTRUM

2.1 The rotorcraft constructor should determine the spectrum appropriate to each hydraulic component and unit in the system, and include this, with the required fatigue safety factors, in the detail specification for the item. For safety critical Grade 'A' components and units, and in cases of doubt the spectrum should be agreed to the satisfaction of the Rotorcraft Project Director in conjunction with Airworthiness Division RAE.

2.2 Consideration should be given to the loading from external sources including any effect of transient peak loads arising from kinetic energy and the arresting of movement by hydraulic or mechanical means (e.g., hydraulic actuators in some installations). Internal system pressure pulsations, including transient peak pressure, should also be included and considered in the fatigue spectrum, together with any thermal, vibration or other environmental conditions which may affect the fatigue life. In the case of hydraulic actuators it may be necessary to allow for the rotational friction of the attachment pins or bearings.

2.3 It is most important that the fatigue spectrum for each hydraulic unit and component is determined at an early stage of design and must be available in advance of any production series fatigue testing.

3 LIFE DETERMINATION

3.1 The safe life will normally be demonstrated by fatigue tests, and as defined in Leaflet 201. Fatigue test factors for safe life compliance are given in Leaflet 201.

3.2 For safety critical hydraulic components or units, and those which contain major structural features, such as mounting lugs, an estimate of safe life by calculation should be made at the early design phase, based on the principles in Leaflet 201 until a fatigue test is completed to confirm the design.

4 FATIGUE REQUIREMENTS FOR PARTICULAR CIRCUITS

4.1 The location of the component or unit in the system determines the spectrum for that component. An individual circuit or sub circuit is defined as the circuit containing all components and units which are operated by a particular selection. The location of non return valves in the system usually determines the pressure independence of parts of the system. The effects of all demands and the interaction between circuits should be considered.

5 TEST REQUIREMENTS

5.1 Leaflet 201 and its supporting leaflets give information on the derivation of test spectra and the safe life test factors to be achieved depending on the number of samples tested.

5.2 Where two or more samples are tested the geometric mean of the results should achieve the required factored life.

5.3 In all cases if there is close similarity to other components of known fatigue life a fatigue test may not be necessary, see Leaflet 704 para 15.4.2. Evidence of life determination by analogy should be agreed with the Rotorcraft Project Director in conjunction with Airworthiness Division RAE.

5.4 Where different parts of the same component (e.g., an actuator) normally operate under different spectra, each part should be subjected to the spectrum appropriate to that particular part.

5.5 To use test spectra corresponding as nearly as possible to service conditions, flight by flight loading and internal pressures should be used whenever this is possible within a realistic timescale. This is particularly important for safety critical Grade 'A' components and units.

5.6 The test cycling may be repeated as rapidly as convenient providing the external loading is achieved on the test specimen, and a close approximation to a square wave pressure curve is obtained for internal pressure cycles. Further, the rate of test cycling must allow the pressure or load (and hence the stresses in components) to reduce to the required minimum level prior to the next test cycle.

LEAFLET 713/1

MAGNETIC COMPASS INSTALLATIONS

EFFECT OF MAGNETIC STRUCTURE

1 INTRODUCTION

1.1 This Leaflet gives information on the effect of magnetic structure on magnetic compasses and makes recommendations on the positioning of such structures.

2 GENERAL

2.1 Magnetic poles will generally occur at discontinuities and joins in the structure, and the interfering field on the compass is due to the cumulative effect of those free poles. The magnitude of a free pole is dependent on the cross sectional area of the member at which the pole occurs, while the effect of such a pole on the compass varies as the inverse square of the distance from the compass. An assessment of the effect of components of the rotorcraft structure which have become magnetised through shock can be obtained by means of the following relationship:

$$F = 4\,\frac{\ell^{\frac{3}{2}} A^{\frac{1}{4}}}{d^2}$$

Where F	….	microtesla	….	field
ℓ	….	metres	….	length of the member
A	….	square metres cross sectional area		
d	….	metres	….	distance from the pole to the compass

It should be noted that this is an empirical equation which takes into account the demagnetising factor, the earth's field, and the mean value of effective permeability when subjected to shock. The equation is only valid for values of:

$\frac{\ell^2}{A}$ less than 6,500.

2.2 Assuming that the maximum permissible interference field F, for any one pole is 1 microtesla for the direct indicating compass and 0.1 microtesla for the remote indicating compass, then the minimum distance of the pole from the compass is given by:

(i) direct indicating compass, $d = 2\ell^{\frac{3}{4}} A^{\frac{1}{8}}$ and

(ii) remote indicating compass, $d = 6.3\ell^{\frac{3}{4}} A^{\frac{1}{8}}$

2.3 Magnetic materials should therefore not be used adjacent to the compass position. For remote indicating compasses, the minimum distances of these materials from the detector unit are laid down in Leaflet 713. For direct indicating compasses, these materials should preferably not be used closer than 3/4 metre (2½ ft) to the compass. If it is not possible to comply with the above limitations the Contractor should discuss the position with the Rotorcraft Project Director at an early stage in the design.

3 FASTENERS

3.1 Where fasteners have to be used in the vicinity of the compass, an assessment of the effect of magnetic material can be obtained using the equation given above. Since the length of the fastener is generally small, much smaller distances d will be permissible. Where a number 'n' are being used, the total field can be assumed to be nF and hence the mean distance d will be given by:

(i) direct indicating compass, $d = 2n^{\frac{1}{2}} \ell^{\frac{3}{4}} A^{\frac{1}{8}}$ and

(ii) remote indicating compass $d = 6.3n^{\frac{1}{2}} \ell^{\frac{3}{4}} A^{\frac{1}{8}}$

4 PARTS SUBJECTED TO SEVERE SHOCK

4.1 In general the magnetisation of structure will be random and should be reasonably stable. Parts, however, which are subjected to severe shock, such as undercarriage units, gun blast tubes, etc., will become magnetised to an extent depending on the orientation of the item in the earth's magnetic field at the moment it experienced the shocks.

LEAFLET 724/1

INSTRUMENT/DISPLAY INSTALLATIONS

EXPOSURE TO SUNLIGHT

1 SPECIFICATION AND TESTING REQUIREMENTS

1.1 Under certain conditions direct or reflected sunlight may provide a background luminance that submerges the information symbology on electronic display screens.

1.2 Guidance in the specification and testing requirements of such displays will be found in the following U.S. Military Specifications.

MIL-D-81641 (AS) - DISPLAY, HEAD-UP - General Specification

MIL-D-87213 (USAF) DISPLAYS, AIRBORNE, ELECTRONICALLY/OPTICALLY GENERATED.

LEAFLET 724/0

INSTRUMENT/DISPLAY INSTALLATIONS

REFERENCE PAGE

<u>British Standards</u>

N 100	General design requirements for aircraft oxygen systems and equipment
3G 100	Specification for general requirements for equipment for use in aircraft
G199	Schedule for tables relating to altitudes, airspeed and Mach numbers for use in aeronautical instrument design and calibration
2011	Basic environmental testing procedures

<u>Defence Standards</u>

00-10	General design and manufacturing requirements for service electronic equipment
07-55	Environmental testing of service material
53-96	Clamps, mounting (imperial and metric) for aircraft instruments
59-35 (Part 0)	Guide to connectors, electrical, and their application Part 0: Connectors, electrical for dc and low frequency application
59-41	Electromagnetic compatibility
61-7	Identification of electrical and electronic systems wiring and components
66-26	General requirements for aircraft instruments and display
66-27	Pressure connections on aircraft instruments and associated equipment
66-28	Electronically and/or optically generated aircraft displays for fixed wing aircraft (when available)

<u>US Mil Specifications</u>

MIL-D-81641(AS) ..	Display, head-up, general specification
MIL-D-87213(USAF)..	Displays, airborne, electronically optically generated

<u>MOD(PE) Publications</u>

AvP 118	Guide to electromagnetic compatibility in aircraft systems

LEAFLET 721/1

EMERGENCY LIFERAFT INSTALLATIONS

GENERAL RECOMMENDATIONS

1 INTRODUCTION

1.1 This leaflet gives information on the multi-seat liferafts in prepacked stowages developed by MOD(PE) and makes recommendations for their installations in rotorcraft.

1.2 Designers are free to design their own liferaft stowages if they wish, but to meet the requirements of Leaflet 721 they must be of the pre-packed type.

2 GENERAL

2.1 Emergency liferafts are fragile pieces of equipment and are damaged extremely easily, thus, a pre-packed liferaft container or pan has accordingly been developed and is available. It consists of a removable box containing the liferaft and its equipment complete, with the operating mechanism separately mounted. There is provision for the stowage cover to be fitted without the pre-packed stowage so that the rotorcraft can be flown with the liferaft removed. These items can all be removed from the rotorcraft in a matter of minutes without the use of tools. Servicing of the equipment and unpacking and packing of the liferaft can then be carried out in ideal conditions after removal to the safety equipment section, and a serviceable replacement set can be fitted to the rotorcraft with comparative ease.

3 LOCATION OF LIFERAFTS

3.1 The overriding consideration in the choice of location of the liferaft stowage is to ensure safe ejection and inflation of the liferaft and ease of boarding for the crew. To this end the following points are relevant:

(i) The position should be such that the risk of damage due to an internal surge of water during, ditching is minimised.

(ii) The liferaft should be ejected onto the water as near as possible to an emergency exit which is likely to be well clear of the waterline after ditching.

(iii) There should be no risk of the liferaft being damaged or trapped by aerials, hot jet pipes, or other projections during ejection.

3.2 The possibility of leakage of fuel or oil into the stowage should not be overlooked as both have a rapid and highly detrimental effect on liferaft fabrics. A position should therefore be chosen which minimises this risk and when possible, advantage should be taken of the protection afforded by existing airframe structure to meet the possible case of the entry of fuel or oil due to enemy action.

3.3 The whole liferaft installation should be readily accessible for examination and servicing. The need for easy access to carry out a routine inspection is particularly important.

4 LIFERAFT RELEASE

4.1 The automatic release should normally be by means of a submersion actuator, which when immersed in water operates on the electrolytic principle. The actuator, upon immersion, should close a circuit, permitting electricity to flow and actuate the release system. The system designer should be aware that the voltage output from an electrolytic cell varies in proportion with the salinity of the water in which it is immersed, thus when selecting the minimum voltage necessary to initiate system operation due cognizance should be taken of the voltage output from the cell when immersed in fresh water. The submersion actuator should be attached to an "always live" bus of the primary rotorcraft electrical system so that the actuator is always ready to complete the circuit, by permitting electricity to flow and actuate the release system at a time of emergency. The time taken to reach sufficient voltage can be varied by design and should be arranged so that release does not occur prematurely but nevertheless takes place as rapidly as possible after the rotorcraft has stopped following ditching.

4.2 In addition the submersion actuator should have its own source of power so that in the event of failure of the primary electrical system the actuator will function. The submersion actuator should be located inboard, at the lowest possible point below the flotation waterline of the rotorcraft. The actuator should be identified and protected against inadvertent operation. The manner of the protection should not interfere with the operation of the actuator nor prevent its inspection.

4.3 The release handles should be easily identifiable and this can be assisted by locating them near some prominent structural feature of the rotorcraft. Care should be taken to ensure that unintentional operation of the liferaft release control is avoided and that no dangers of inadvertent release can result from expansion effects in the control circuits due to temperature changes or flexing of the airframe structure.

5 GAS CYLINDER DISCHARGE INDICATOR UNIT

5.1 This system normally incorporates a diaphragm which ruptures when the gas bottle discharges to leave a visual indication of the bottle discharge. The units should normally be mounted in the cover of the liferaft stowage, but if the indicators would not be readily seen in that position they can be fitted in some position slightly remote from the liferaft stowage. They should not be located where engine exhaust gases can impinge upon them or where they can be obscured by oil or other contaminants.

6 GAS CYLINDER SEEPAGE DIVERSION VALVE

6.1 For protection against the possibility of a slow leak from the gas cylinder valve prematurely inflating the raft, consideration should be given to a suitable additional valve which, at low pressure, would divert the gas to atmosphere.

7 LIFERAFTS STOWED IN VALISES

7.1 When liferafts stowed in valises are permitted by the Service staff care should be taken to choose a location that will permit manhandling through a suitable exit. When a number of valises are carried they should be distributed between various ditching exits.

7.2 The liferaft emergency pack should be stowed within the appropriate valise and as this has to be manhandled within the rotorcraft in an emergency, it should be noted that the combined weight of the two may be as much as 55 kg.

7.3 The valises should preferably be secured within a compartment of appropriate size, without the need for special securing straps but, if the latter are used an appropriate type of quick release should be provided which can be readily undone when wet.

LEAFLET 721/0

EMERGENCY LIFERAFT INSTALLATIONS

REFERENCE PAGE

<u>RAE Technical Notes</u>

SME 192 .. .. .. Determination of loads arising on liferaft stowage retaining devices in flight.

LEAFLET 719/4

PRESSURISED GAS STORAGE VESSELS

FRAGMENTATION TEST REQUIREMENTS FOR GAS/OIL HYDRAULIC ACCUMULATORS

1 INTRODUCTION

1.1 This leaflet provides details of the Gunfire Test, (see Leaflet 719 para 5.8) to check the liability of vessels to shatter explosively. The test is based on MIL-C-7905E - 'Cylinders, Compressed Gas, Non Shatterable' and also encompasses the requirements of para 4.7.10 of MIL-A-8897A - 'Accumulators, Hydraulic, Cylindrical, 3000 PSI Aircraft, Type II Systems'.

2 FRAGMENTATION RESISTANCE

2.1 The cylinder, when tested as specified in para 3 below shall remain in one piece and exhibit no evidence of shattering. The material of the cylinder shall not tear excessively in any one direction. If wire or fibre wrapping is used, the wrapping may come loose from the cylinder.

3 GUNFIRE TEST

3.1 Cylinders shall be subjected to gunfire under the following conditions:

(i) Each vessel shall be charged with the appropriate gas and fluid to the design pressures at gun range ambient air temperature,

(ii) The cylinder shall be supported in a manner similar to a typical rotorcraft mounting,

(iii) Attached to the oil port shall be a length of tubing with a shut-off valve located 900mm from the port,

(iv) The ammunition shall be 0.5 calibre incendiary projectile,

(v) The range shall be 23 metres maximum,

(vi) The projectile shall be so directed that it will hit the fluid side of the cylinder approximately mid-way between the piston and the mounting strap,

(vii) All shots shall be tumbled by the use of a non-metallic tumbling board placed close enough to the target to provide adequate tumbling,

(viii) The tumbled projectile shall have a minimum velocity of 792 m/s at the point of impact with the cylinder,

(ix) The minimum size entry hole made by the tumbled projectile shall be 13mm x 39 mm.

(x) Verify that the projectile trajectory and tumble are satisfactory. This may be determined by the location and visual appearance of a hole made by the passage of the projectile through vertically suspended sheets of paper at the target area.

LEAFLET 719/3

PRESSURISED GAS STORAGE VESSELS

FRAGMENTATION TEST REQUIREMENTS

1 INTRODUCTION

1.1 This leaflet provides details of the Gunfire Test, (see Leaflet 719 para 5.8) to check the liability of vessels to shatter explosively. The test is based on Military Specification MIL-C-7905E 'Cylinders, Compressed Gas, Non Shatterable'.

2 FRAGMENTATION RESISTANCE

2.1 The cylinder, when tested as specified in para 3 below shall remain in one piece, except cylinders that are 64 mm or less in diameter, will be permitted to separate into 2 pieces, and exhibit no evidence of shattering. If wire or fibre wrapping is used, the wrapping may come loose from the cylinder.

3 GUNFIRE TEST

3.1 Cylinders greater than 64 mm in diameter shall be subjected to gunfire under the following conditions:

(i) Each vessel shall be charged with the appropriate gas to the design pressure P_d at gun range ambient air temperature,

(ii) The cylinder may be supported but not constrained,

(iii) The ammunition shall be 0.5 calibre M.2, armour-piercing,

(iv) The range shall be 46 metres maximum,

(v) The various cylinders taken for test shall be tested, each progressively, in a different position, as follows:

(a) With the longitudinal axis of the cylinder normal to the line of fire,

(b) With the longitudinal axis of the cylinder 45 degrees (.785 rad) from normal toward the gun position,

(c) With the longitudinal axis of the cylinder parallel to the line of fire with inlet port face away from the gun position,

(vi) All shots shall be tumbled,

(vii) The tumbled projectile shall have a minimum velocity of 792 m/s at the point of impact with the cylinder,

(viii) The minimum size entry hole made by the tumbled projectile shall be 13 mm by 39 mm,

(ix) Verify that the projectile trajectory and tumble are satisfactory. This may be determined by the location and visual appearance of a hole made by the passage of the projectile through vertically suspended sheets of paper at the target area.

The cylinder shall pass the requirements of para 2.1

3.2 Cylinders 64 mm or less in diameter shall be subjected to gunfire under the following conditions:

(i) The cylinder shall be charged to its design pressure at gun range ambient air temperature,

(ii) The cylinder may be supported but not constrained,

(iii) The ammunition shall be .30 calibre armour piercing, with a muzzle velocity of 853 ± 30 m/s,

(iv) The range shall be approximately 18 m,

(v) Shots shall not be tumbled,

(vi) The various units taken for tests shall be positioned as in para 3.1 (v).

The cylinder shall pass the requirements of para 2.1.

Further details of the test and the number of vessels to be tested can be obtained from MIL-C-7905E.

LEAFLET 719/2

PRESSURISED GAS STORAGE VESSELS

FATIGUE AND STATIC TEST EXAMPLES

1 INTRODUCTION

1.1 This leaflet contains fatigue and static test examples for pressurised gas storage vessels.

2 FATIGUE TEST EXAMPLE (see Leaflet 719 Para 4.10)

2.1 Suppose a particular vessel is required to have a Service Life of 10,000 cycles and that the following results are obtained in the fatigue type test of Leaflet 719 para 5.5:

Cycles	$\log_{10}$
25020	4.39829
31570	4.49927
39980	4.60184
40100	4.60314
48770	4.68815
50190	4.70062

2.2 The mean ($\bar{x}$) of the logs is 4.58188 and the standard deviation is given by:

$$S = \left(\sum_{i=1}^{n} (x_i - \bar{x})^2 / (n-1) \right)^{1/2}$$

Where x_i are the statistics (the logs) and n the number of statistics.

2.3 In this case the standard deviation is 0.11556 and this gives a coefficient of variation v = S/ x = 0.02522. From the table in Leaflet 719 para 5.5.3 the required factor F = 3.8 and hence the required geometric mean life is 38,000 cycles.

2.4 The achieved geometric mean life is given by:

$$\text{Antilog} \left(\sum_{i=1}^{n} \log x_i \right) / n$$

= Antilog 4.58188

= 38,184 cycles

Which is just satisfactory.

3 STATIC TEST EXAMPLE (see Leaflet 719 Para 5.7)

3.1 Suppose the following results are obtained in the burst tests (all expressed as percentages of the design ultimate pressure):

105, 107, 110, 112, 113, 115

3.2 The mean of these six statistics is 110.333% DUP. Using the above formula the standard deviation is 3.77712% DUP; and the coefficient of variation is 0.03423. The factor F in the table of Leaflet 719 para 5.7.3 is the ratio of the minimum acceptable mean value of the results to the design ultimate. From the table by interpolation F is 1.07 and the minimum acceptable value of the mean is therefore 107. As 110.333 is greater than 107 the results are considered satisfactory.

LEAFLET 719/1

PRESSURISED GAS STORAGE VESSELS

DEFINITION OF ENERGY LEVELS FOR VULNERABILITY TEST REQUIREMENTS

1 INTRODUCTION

1.1 This leaflet defines energy levels for pressurised gas storage vessel vulnerability test requirements.

2 HIGH ENERGY LEVELS

2.1 Defined as energy levels greater than 44.75kJ (equivalent to 20 mm explosive shell). Tests to check liability of vessels to shatter explosively are mandatory.

3 MEDIUM ENERGY LEVELS

3.1 Defined as energy levels less than 44.75kJ but greater than 13.6kJ. Consultation with the Rotorcraft Project Director is required to decide whether vulnerability tests are necessary. Where the vessels are situated within containers or equipment able to absorb the released energy and particles, the risk of damage to adjacent equipment, structure, or personnel, may be low and no special tests may be required. In addition the vessels may have been constructed in such a manner as to remove the danger of fragmentation.

4 LOW ENERGY LEVELS

4.1 For vessels pressurised to low energy levels defined as less than 13.6kJ it can be assumed that there will be no special vulnerability hazards and vulnerability tests are not required.

5 STORED ENERGY

5.1 The following formulae may be used for the calculation of energy level(W):

5.1.1 <u>For diatomic gases (e.g., Air, Oxygen, Nitrogen)</u>

W = 2pv where W is in Kilojoules (kJ), p is Megapascals (MPa) and v in litres,

5.1.2 <u>For monatomic gases (e.g., Helium)</u>

W = 1.5pv where W is in Kilojoules (kJ), p is in Megapascals (MPa), and v in litres,

5.1.3 <u>For all liquefiable gases (e.g. Carbon Dioxide or Freon)</u>. Simple formulae are not accurate. The stored energy must be calculated as the change of internal energy when the gas expands reversibly from Pd to atmospheric pressure.

5.2 In the formulae of para 5.1: p shall be P_d and v the design volume of the vessel at 20°C.

5.3 If p is in bars instead of MPa divide W by 10 (1 Bar = 0.1 MPa).

LEAFLET 716/2

STATIC AND PITOT PRESSURE SYSTEMS

AERODYNAMIC REPEATABILITY

1 INTRODUCTION

1.1 This Leaflet defines the acceptable methods of demonstrating aerodynamic repeatability of pitot-static heads and outlines the recommended procedure for the manufacture of static plates.

2 WIND TUNNEL TEST

2.1 The pitot/pitot-static head should be mounted in a wind tunnel or in front of a free jet with the tube aligned along the axis of the airflow. The airflow should have a minimum velocity of 85 kt. Both pitot and static readings (where applicable) should be taken at this airspeed. The data should be compared with that of a calibrated standard. There should be at least one such calibrated standard. Acceptance/Rejection criteria is stated in Leaflet 716, para 4.

3 DESIGN GUIDELINES FOR STATIC PLATES

3.1 The static plate should consist of a plate with integral fittings to connect to the static pressure line. The plate should be manufactured to have the same surface profile as that of the rotorcraft, to within 0.01% over the linear dimensions of the plate. It should be located on an area of the rotorcraft where distortion of the plate will not occur as a result of stressing during operation, service or maintenance, in order to ensure static pressure repeatability.

3.2 Any gap between the static plate and the rotorcraft surfaces should not exceed 0.25mm. The surface finish should be no worse than 0.1µm R_a.

4 ALTERNATIVE TEST METHODS

4.1 The use of a calibrated wind tunnel for the purposes of checking repeatability may be impractical or too expensive. Alternative methods such as laser measurement or silhouette profiles should be considered, but only adopted with the agreement of the Rotorcraft Project Director.

LEAFLET 716/1

STATIC AND PITOT PRESSURE SYSTEMS

TESTS

1 INTRODUCTION

1.1 This Leaflet gives the methods of carrying out the leakage tests required by Leaflet 716, para 12.

2 LEAKAGE TEST OF PIPING SYSTEM

2.1 This test should be carried out before coupling the pressure head, instruments, and other related equipment to the system.

Note: When making this test, no additional capacity, other than that of the pressure gauge, should be included in the system, as the capacity of the system affects the leakage rate.

2.2 After blanking off as necessary, a pressure of 69 kPa (gauge) should be applied to the pitot and static pipe lines in turn. After allowing about 3 minutes for adiabatic temperature change effects to settle out, measure again at 69 kPa then hold this pressure without any measurable fall for a period of 10 minutes.

3 LEAKAGE TEST OF COMPLETE INSTALLATION

3.1 This test should be carried out with the pressure head (and/or static vent), instruments, and other related equipment properly connected to the pressure lines (see also Note to para 2.1).

3.2 The pressure in the static system should be reduced until the rotorcraft altimeter (or a special test altimeter coupled into the system) reads just over 5,000 ft, the rate of pressure change not exceeding approximately 10,000 ft/min. After allowing about 3 minutes for adiabatic temperature change effects to settle out, measure the time for the altitude to drop from 5,000 ft to 4,800 ft, lightly tapping the altimeter to overcome breakout friction (stiction).

3.3 With the static system open to the atmosphere, the pressure in the pitot system should be increased until the rotorcraft ASI (or a special test ASI coupled into the system) reads just over 130 kt. After allowing about 3 minutes for adiabatic temperature change effects to settle out, measure the time for the ASI reading to fall from 130 kt to 125 kt lightly tapping the ASI to overcome stiction.

LEAFLET 716/0

STATIC AND PITOT PRESSURE SYSTEMS

REFERENCE PAGE

RAE Reports

Aero 2507	.. ..	Pressure lag in pipes, with special reference to aircraft speed and height measurements

RAE Library Bibliographies

293	.. ..	Fuselage static vents

ARC Reports

CP 475	.. ..	Free flight experiments on the measurement of free stream static pressure at transonic speeds with particular reference to the MK.9 pitot-static head

Defence Standards

47-21	.. ..	Flexible hose assemblies for pitot and static systems in aircraft (Metric)
47-25	.. ..	Pipelines and pipe couplings for aircraft fluid systems (metric)

British Standards

M23	.. ..	Specification for an identification scheme for pipelines

LEAFLET 713/4

MAGNETIC COMPASS INSTALLATIONS

ACCEPTANCE OF TYPE TESTS

1 INTRODUCTION

1.1 This Leaflet gives information on the Admiralty Compass Observatory (ACO) acceptance of type tests called for in Leaflet 713 para 11.

1.2 The tests given in this Leaflet should be considered as a guide and the actual tests, which will depend on the various equipments fitted in the rotorcraft, should be agreed with the QinetiQ Land Magnetic Facilities MoD Portland Bill Portland Dorset DT5 2JT. (They should be consulted at an early stage when it is proposed to design a compass system into a new rotorcraft, or into an existing rotorcraft where extensive modifications are required).

1.3 The definitions and methods of determining and correcting the coefficients referred to in this Leaflet and in Leaflet 713 are given in AP 3456D, Part 1, Section 6, Leaflet 2.

2 OBJECT OF TESTS

2.1 The object of the tests is to check:

(i) the functioning of the compass, including its power supply/supplies, and

(ii) the effects of the rotorcraft's magnetism and electrical equipment and wiring.

The compass installation should also be examined for ease of viewing, manipulation and servicing.

3 FUNCTIONING OF COMPASS, INCLUDING ITS POWER SUPPLY/SUPPLIES

3.1 Type testing of the proposed compass systems should include performance tests at the ACO.

4 EFFECT OF AIRFRAME

4.1 The magnetic sensors of the compass systems in the rotorcraft should be removed and replaced by ACO calibrated Survey compasses. A 16 point swing will then be carried out to determine the coefficients B,C,D and E at the magnetic sensor positions. These coefficients should not exceed the values given in Leaflet 713, Table 2 (i) and (ii).

5 EFFECT OF EQUIPMENT AND COMPONENTS

5.1 Tests should be made on 4 headings approximately 45° apart to determine the effects of the following (the tests should be carried out using the rotorcraft compasses, if suitable, otherwise ACO survey compasses will be used):

(i) Switching on and off all electrical and radio equipment (ignoring surges) with power supplied:

(a) external, and

(b) from the internal power supplies in all modes of operation, including engine running.

(ii) (a) Detachable equipment and components, and

(b) movable equipment and components (controls, flaps, hood, seat, drop tanks, control locks etc).

(iii) Undercarriage.

5.2 When checking the effect of raising the undercarriage, if steel jacks are required, care should be taken to ensure that their effect on the detector unit is taken into account. It is sometimes possible to do this test in a hanger if the magnetic field inside the hanger is uniform and not greatly different from that outside.

5.3 The changes of deviation caused as a result of the above should not exceed the values given in Leaflet 713 Table 2, sub paras (iii) to (xii).

6 DETERMINATION OF TILT ERROR

6.1 In order to enable a rotorcraft with a tail wheel type undercarriage to be swung in the tail down position, the tilt error should be determined by observing the change of compass heading between tail down and tail up attitudes on both East and West heading. The tilt error is the mean of the two values of change observed (regardless of algebraic sign).

6.2 If a crane is used for lifting the rotorcraft to the tail up attitude, the crane may be left in position during the test provided it is not electrically operated and provided it is not close to the sensitive elements of the compasses.

7 TEST FACILITIES

7.1 Depending on the type of rotorcraft and the nature of the tests required, some or all of the following will be necessary:

(i) Compass base cleared of other rotorcraft, steel trestles and ladders, etc.

(ii) Adequate stable ground power supply (the type with a charger incorporated and fitted with a voltmeter is preferable).

(iii) Rotorcraft fully equipped, and serviceable.

(iv) The necessary ground handling personnel and equipment, including non-magnetic ladders for access to detector units, etc.

(v) Any test and alignment equipment that is normally required for calibrating the compasses of the rotorcraft e.g., PHTS, sighting rods and test sets etc.

LEAFLET 713/3

MAGNETIC COMPASS INSTALLATIONS

DEMAGNETISATION

1 INTRODUCTION

1.1 This Leaflet gives the methods which can be used when demagnetisation of a part is necessary to comply with the requirements of Leaflet 713. The method used will depend on the structure or components to be demagnetised. Further information may be obtained from the RAFLO, Admiralty Compass Observatory, Slough.

2 GENERAL

2.1 In general, the AC coil method is satisfactory for the routine demagnetisation of components before assembly, except where the component has a larger cross-sectional area, eg undercarriage units. In these cases, the formation of eddy currents in the metal reduces the effective intensity of the demagnetisation field. To overcome this a DC coil method is used. If it should be necessary to demagnetise fixed members of the rotorcraft structure after assembly then an AC wiper magnet may be used. This method may also be used for components which by reason of their size or shape cannot readily be passed through a demagnetising, coil. It is not suitable for components having a large cross-sectional area.

2.2 In all cases care should be taken in selection of the site for demagnetisation since the presence of masses of iron may adversely affect the operation.

3 AC COIL METHOD

3.1 With this method the component to be demagnetised is passed through a coil supplied with alternating current. The coil is mounted with its axis parallel to the E-W line so that the component is not subject to the earth's field. The field intensity within the coil necessary for satisfactory demagnetisation depends on the nature of the steel being demagnetised, but will be proportional to the coercive force of the steel. In most cases a field intensity of approximately 1000 amperes/metre will be found sufficient although it may occasionally be necessary to use a field intensity as high as 2000 amperes/metre.

4 DC COIL METHOD

4.1 The component to be demagnetised is placed within a coil large enough to enclose it completely, the axis of the coil being E-W. The direct current through the coil is reversed at approximately 2 second intervals and gradually reduced from a high value giving a field intensity of at least 800 amperes/metre to zero.

5 WIPER MAGNET METHOD

5.1 This method makes use of an AC magnet having U-shaped iron core. The member of the structure to be demagnetised is placed as nearly as possible at right angles to the earth's field. The magnet is then placed in contact with and moved slowly along the member. This operation is then repeated three or four times and before switching off the current the magnet should be removed away from the member.

Note: The DC coil technique, the AC wiper magnet technique and equipments are also described in CSDE Report 232/75. (Central Servicing Development Establishment, RAF Swanton Morley).

LEAFLET 713/2

MAGNETIC COMPASS INSTALLATIONS

EFFECT OF WIRING

1 INTRODUCTION

1.1 This Leaflet gives the precautions which should be taken when ground return systems are used in rotorcraft, to ensure that stray magnetic fields set up by current loops do not deviate the compass.

1.2 It is difficult to prescribe any set method of treatment, and each problem has to be treated very much on its merits. The following broad classification can, however, be made, but further information and advice on wiring layout may be obtained from the RAFLO, Admiralty Compass Observatory, Slough.

2 RE-ROUTEING OF WIRING FURTHER AWAY FROM THE COMPASS

2.1 Re-routeing of wiring, further away from the Compass can be applied particularly to light current leads installed close to the compass.

3 ALTERATION OF THE GROUNDING POINT

3.1 Often the deviation is due to the supply lead to equipment which is grounded locally. The interference can be eliminated by running a grounded lead from the equipment adjacent to the supply lead to a fresh grounding point some distance away. In this way, the part of the circuit adjacent to the compass can be made double pole. Where this kind of modification is used, the question of effective radio noise suppression should be considered and it may be necessary to install an additional suppressor in the grounding lead. In all cases advice should be obtained from the appropriate authority to prevent the cause of EMC problems.

4 MOVING CABLES INTO THE SAME HORIZONTAL PLANE AS THE COMPASS

4.1 If the lead producing the interference is moved to the same horizontal plane as the compass, the magnetic field produced by the lead at the compass will be vertical and will not cause deviations of the compass except when the rotorcraft is pitched or rolled. This method of correction is acceptable providing a pitch or roll of 10° does not result in more than 1° deviation of the compass.

5 INTRODUCTION OF CABLE LOOPS

5.1 This method involves the introduction of a loop of cable carrying the main current of the circuit to be corrected, this loop being arranged to produce a component of field which just cancels the component of field due to the lead. It is a method which is rarely used and should only be employed in an emergency when other methods have failed.

LEAFLET 725/0

AVIONIC EQUIPMENT INSTALLATIONS

REFERENCE PAGE

Defence Standards

DEF STAN 00-10	..	..	General design and manufacturing Requirements for Service Electronic Equipment
DEF STAN 00-13	..	..	Guide to the achievement of Testability in Electronic and Allied Equipment
DEF STAN 00-14	..	..	Guide for the Defence Industry in the use of ATLAS
DEF STAN 00-18	..	..	Avionic Data Transmission Interface Systems
DEF STAN 00-29	..	..	Fungal Contamination Effecting the Design of Military Materiel
DEF STAN 00-31	..	..	(Interim) The Development of Safety Critical Software for Airborne Systems
DEF STAN 00-41 (PART 1)			MOD Practices and Procedures for Reliability and Maintainability
DEF STAN 00-50	..	..	Guide to Chemical Environmental Contaminants and Corrosion Effecting the Design of Military Materiel
DEF STAN 00-52	..	..	General requirements for Test Specifications and Test Schedules
DEF STAN 07-55	..	..	Environmental Testing of Service Material (Progressively superseded by DEF STAN 00-35)
DEF STAN 59-35	..	..	Connectors Electrical and Connectors Fibre Optic
DEF STAN 59-36	..	..	Electronic Components for Defence Purposes
DEF STAN 59-41	..	..	Electro Magnetic Compatibility
DEF STAN 66-27	..	..	Pressure Connections on Aircraft Instruments and Associated Equipment

ARINC Documents

SPEC IEEE/ARINC	..	..	Abbreviated Test Language for all systems (ATLAS)
ARINC 404A	..	..	Air Transport Equipment Cases and Racking
ARINC 600	..		Avionic equipment interfaces
DRAFT ARINC 604	..	..	Guidance for Design and use of Build in Test Equipment (BITE)
DRAFT ARINC 607	..	..	Design Guidance for Avionic Equipment

US Mil Specs/Stds

MIL-T-23103	..	..	Thermal Performance Evaluation, Airborne Electronic Equipment and Systems, General Requirements for
MIL-STD-1760	..	..	Aircraft/Stores Electrical Interconnection System
DOD-STD-1788	..	..	Avionics Interface Design Standard
MIL-STD-2165	..	..	Testability Program for Electronic Systems and Equipments

British Standards

3G100	..	..	General Requirements for Electrical Equipment and indicating Instruments for Aircraft

LEAFLET 1006/1

ICE PROTECTION SYSTEMS
GENERAL FLIGHT TEST REQUIREMENTS

TEST INSTRUMENTATION PARAMETERS

1. INTRODUCTION

1.1 Details of parameter ranges, accuracy, resolutions, etc., are given in Leaflet 1000/1, Table 1.

1.2 The following parameters should be considered and recorded for the tests detailed in Leaflet 1006. Other parameters may be necessary to establish the ability of any individual Ice Protection System to function and perform in the Rotorcraft environment and to enable the Rotorcraft to operate in all the climatic conditions laid down in the Rotorcraft Specification. Dependent upon rotorcraft configuration, some of the described parameters may not be valid whilst others may be derived from the parameter list.

ITEM	PARAMETER
	GENERAL
1	Time Base
2	Manual Event Marker
3	Crew Speech
	FLIGHT CONDITION
4	Airspeed (Each Independent System)
5	Altitude (Pressure and Radio)
6	Outside Air Temperature (OAT)
7	Rotorcraft Attitude
8	Pitch Rate
9	Roll Rate
10	Yaw Rate
11	All Up Weight
	FLIGHT CONTROLS
12	Stick Positions
13	Yaw Control Position
14	Collective Pitch Control Position
15	Control Servo Positions
16	Control Surface Settings
17	Control Surface Positions
18	Control Input Forces
19	Rotor Blade Pitch, Flap and Lag Angles

ITEM	**PARAMETER**
	PERFORMANCE PARAMETERS
20	Engine and APU Parameters
21	Fuel Flows
22	Fuel Temperatures/Pressures
23	Rotor Speeds
24	Engine Torques
25	Rotor Drive Shaft Torques
26	Delta Torques
	LOADS (Applicable to all rotors fitted)
27	Rotating Control Loads
28	Rotor Head Loads (Flap and Lag)
29	Rotor Blade Loads (Flap, Lag and Torsion)
30	Loads in Flight Critical Static or Dynamic Components
	SYSTEMS
31	Pressures, Temperatures and Flows as Appropriate
32	Electrical Loads
	TEST CONDITION
33	Ice Severity (Liquid Water Content)
34	Vernier Ice Accretion
35	Water Droplet Size
36	Snow Severity (Visibility or Liquid Water Content) and Type
	ICE PROTECTION SYSTEMS
37	Temperatures, Pressures and Flows as appropriate
38	Photographic and/or Video Installations as appropriate

Note: In consideration of the above parameters, sufficient instrumentation should be provided to determine whether there is any detriment to the performance of the Environmental Control System(s), the Electrical System(s), the Engine and Transmission Cooling System(s), etc. caused by ice/snow blockage of air inlets and outlets.

2. TELEMETRY

2.1 The tests of Leaflet 1006 are considered to be of a particularly hazardous nature, therefore telemetry may prove advantageous in some instances. Where telemetry is not available for reasons of logistics or whatever, then an extensive provision of real-time on-board monitoring should be made available directly to the pilot and/or to the flight test crew.

2.2 Details of parameter ranges, etc, are given in Leaflet 1000/1, Table 2. Critical parameters must be visually displayed at all times and loss or failure of a parameter may thus result in the abort of tests. If telemetry is necessary, all appropriate parameters required for telemetric monitoring should be defined and agreed with the Rotorcraft Project Director in advance of the trials.

LEAFLET 1004/1

HYDRAULIC SYSTEMS

TEST INSTRUMENTATION PARAMETERS

1 INTRODUCTION

1.1 Details of parameter ranges, accuracies, resolutions, etc., are given in Leaflet 1000/1, Table 1.

1.2 The following parameters are considered to be the minimum for the tests detailed in Leaflet 1004. Such other parameters as are necessary to establish the ability of the Hydraulic System(s) to function and perform to specification in the rotorcraft environment should be determined by consultation with the equipment manufacturer(s)/supplier(s) and the Official Trials Establishments and agreed with the Rotorcraft Project Director.

ITEM No	PARAMETER
1	Time Base
2	Manual Event Marker
3	Crew Speech
4	Indicated Airspeed
5	Altitude (pressure)
7	Total Temperature (or Ambient Temp/OAT)
9	Pitch Attitude
10	Roll Angle
12	Heading
16	Longitudinal Acceleration
17	Lateral Acceleration
18	Normal Acceleration
20	Landing Gear Position
25	Stick Position (Pitch)
26	Stick Position (Roll)
27	Yaw Control Pedal Position
36	Yaw Control Positions
37	Port Brake Pressure
38	Starboard Brake Pressure
39	FCS State/Mode
100	Collective Pitch Control Position
103	Main Rotor Speed
105	Main Rotor Collective Pitch
106	Tail Rotor Pitch
121	Rotor Brake Temp
125	Fore and Aft Servo Position
126	Lateral Servo Position
127	Collective Servo Position
128	Yaw Servo Position
129	Pitch Series Actuator Position
130	Roll Series Actuator Position
131	Collective Series Actuator Position
132	Yaw Series Actuator Position
	Hydraulic Pump Fluid Outlet Temperatures
	Hydraulic Reservoir Fluid Temperatures
	Hydraulic Pump(s) Fluid Inlet Pressure
	Hydraulic Pump(s) Fluid Delivery Pressure
	Hydraulic Accumulator Fluid Pressure
	Main Servo(s) Axial Vibration
	Secondary Servo(s) Axial Vibration
	Tail Servo Axial Vibration

LEAFLET 727/5

HEALTH AND USAGE MONITORING SYSTEMS

DEMONSTRATION OF COMPLIANCE

1 Demonstration of compliance the requirements of Leaflet 727 can be assisted by:

(i) ensuring that a HUM system features in all rotorcraft specification and cost plan documents produced by the Design Authority, including preliminary specifications, and that the scope of the monitoring provisions is defined.

(ii) ensuring that in all design workshare statements relating to collaborative projects the responsibilities for HUM systems, reliability, maintainability, and component monitoring functions are clearly defined.

(iii) ensuring that in any safety assessments carried out (e.g,. Failure Modes and Effects Analysis) specific requirements for health monitoring and usage monitoring necessary to achieve desired levels of safety and mission availability are addressed by the proposed monitoring provisions.

(iv) ensuring that a Development plan for HUM is produced and implemented which satisfies the requirements for developing the algorithms, the sensor installations, and the HUM system. The development plan should also make provision for interface activities necessary for definition of the ground station, and for any early adjustments to caution and warning levels that may be necessary in service.

(v) providing evidence to support the selection and implementation of algorithms adopted.

LEAFLET 727/4

HEALTH AND USAGE MONITORING SYSTEMS

DEVELOPMENT AND VALIDATION TESTING

1 MONITORING FUNCTIONS

1.1 Each monitoring function will be designed to provide varying levels of data and information depending on the nature and criticality of the system being monitored. Methods of certification and validation therefore need to be chosen accordingly.

2 ALGORITHMS AND SENSORS

2.1 The best vehicle for developing and validating algorithms and sensors, is on component rig tests - particularly where tests are continued to failure, and on prototype rotorcraft.

2.2 Where tests to failure are instituted specifically for health monitoring purposes components with naturally produced defects, are preferable to deliberately manufactured (seeded) faults.

2.3 Care should be taken to obtain adequate data at the commencement of test and immediately after each component disassembly if these cannot be avoided.

2.4 Continuous data should be recorded wherever possible, but where not so, representative 'snap-shots' of data at regular intervals should be retained for analysis. Archiving of such recorded data is essential for the development and validation of algorithms.

2.5 Sensor and cable installations should be monitored carefully for reliability and maintainability in addition to performance evaluation in the test rotorcraft environment.

2.6 Algorithms should be evaluated against data from earlier models of rotorcraft where appropriate.

2.7 In parallel with algorithm development in the tests described, criteria and preliminary threshold values should be established for caution and warning status indications.

2.8 In establishing caution and warnings, criteria and threshold values the differences in load and environmental conditions between rig tests and the in-service rotorcraft should be considered.

3 SOFTWARE

3.1 The procedures for testing and validation of airborne software are detailed in interim DEF STAN 00-31 (The Development of Safety Critical Software for Airborne Systems).

4 HUM SYSTEM VALIDATION

4.1 System integration rigs and dynamic system models should be used at an early stage of HUM system validation wherever possible, using recorded rig test data or other rotorcraft data where appropriate.

4.2 Fully integrated system validation should be undertaken on prototype rotorcraft or on Ground Test Vehicles.

4.3 A period of HUM system evaluation on in-service rotorcraft will be advantageous. Where monitored components are subject to fixed Time Between Overhaul (TBO) maintenance, evidence of component condition at overhaul should be used to validate the HUM algorithms and sensor installations. Also the HUM system provisions should be used to reduce the number of sample inspections required for TBO extension.

LEAFLET 727/3

HEALTH AND USAGE MONITORING SYSTEMS

RECOMMENDED TECHNIQUES

1 INTRODUCTION

1.1 The purpose of the health and usage monitoring (HUM) system is to improve the safety, availability, and the life cycle costs of the rotorcraft. To achieve this purpose it is essential that the health Monitoring techniques selected are effective and practical. This requires high reliability and accessibility of sensors and associated cabling, high reliability of the algorithms used in terms of accurate numerical assessment of conditions or damage accumulated, rapid and efficient processing of algorithms and acceptable cost and weight. This leaflet provides guidance on the selection and implementation of monitoring functions for major components, and makes recommendations concerning appropriate techniques. Engines and APU's are excluded from consideration in this leaflet, but need to be included in the design of the HUM system. (See DEF STAN 00-971 - General Specification for Aircraft Gas Turbine Engines).

1.2 Whilst the Civil Aviation Authority recognises the importance of health and usage monitoring to their requirements for higher levels of safety, particularly in transmissions and rotor systems (see Ref 1), the approach adopted is not considered acceptable by the Ministry of Defence for the design of new military rotorcraft. The approach of the Civil Aviation Authority is to allow airworthiness credit, where appropriate, against the more stringent safety requirements which have been introduced. The Ministry of Defence, however, considers it necessary to introduce specific requirements in DEF STAN 00-970 to ensure that the benefits of advanced health and usage in monitoring technology are realised in military rotorcraft.

1.3 The relative contribution of components and systems is to airworthiness failures reported in Military rotorcraft is given in Ref 2 (Fig A) and Ref 3 (para 1.7), and for civil rotorcraft in Ref 4 (para 3) and Ref 5 (p 61-6).

2 GENERAL

2.1 The primary cause of vibration in rotorcraft, and of the problems that result, is the unsteady nature of aerodynamic loading of the rotor(s). In addition to causing damage to the airframe, rotor-induced vibration causes much of the unreliability experienced in installed equipment, stores, and problems for the aircrew which can affect their ability to operate the rotorcraft.

2.2 Where a safety analysis (e.g., failure modes, effects, and criticality analysis) is carried out in the assessment of a component design, the results should be studied to assess the health monitoring requirements. Allowance should be made for the damage tolerance properties of certain components and systems as this will affect this assessment, both in terms of monitoring technique and rejection criteria.

2.3 It is recognised that the nature of substantiating health monitoring algorithms and intervention criteria requires extension of the activity beyond the in-service date. It may not always be practicable to make modifications to hardware after the in-service date.

2.4 Procedures need to be established for feed-back of health and usage monitoring data from operators to the Design Authority:

(i) to establish that the rotorcraft is being used within limits assumed in design and that the substantiation of components remains valid.

(ii) to confirm the anticipated correlation between health monitoring indications and component condition. This will require data relating to healthy, degrading, and degraded state of components.

(iii) to permit controlled changes to algorithms or intervention criteria to be made to all rotorcraft of the type in service.

2.5 A facility should be provided to implement, with the agreement of the Rotorcraft Project Director, any software modifications found necessary with increasing operational experience of the rotorcraft.

2.6 Evidence should be provided of the effectiveness of the proposed techniques when applied to the proposed rotorcraft components, whether or not the techniques correspond closely to those described in this leaflet.

2.7 Review of health and usage monitoring developments in rotorcraft are given in Refs 6, 7 and 8.

3 COMPONENTS AND APPROPRIATE TECHNIQUES

3.1 The full definition of a major component or system given in the appropriate installation Leaflet should be noted in selecting monitoring provisions.

3.2 Components are reviewed under the following para headings:-

Rotor systems	-	para	4
Flight control systems	-	para	5
Transmission systems	-	para	6
Airframe and Undercarriage	-	para	7
Fuel systems	-	para	8
Electrical systems	-	para	9
Avionics systems	-	para	10
Anti-Icing system	-	para	11
Central warning system	-	para	12
Event recording	-	para	13

3.3 Where appropriate an indication will be given where ground-based health monitoring techniques and laboratory facilities are advocated, either to supplement on-board provisions or as the only effective technique for that potential failure mode. Organisational requirements, and some of the potential problems associated with off-rotorcraft health monitoring facilities are discussed in Ref 9.

4 ROTOR SYSTEMS

4.1 SCOPE

4.1.1 This para includes rotor blades, hubs, dampers, anti-vibration devices, control and all other components that form part of the rotating assemblies, but excludes the transmission and rotor drive shafts.

4.2 BACKGROUND

4.2.1 A review of health monitoring methods and the nature of rotor loading applied to rotor systems is given in Ref 7 P4-16, and 10.

4.3 ROTOR ASSEMBLIES - HEALTH AND VIBRATION CONTROL MONITORING

4.3.1 Rotor Track and Balance Monitoring (RTBM)

(i) Advanced methods of RTBM are capable of diagnosing faults within rotor blades, lag-plane dampers, and rotor assemblies. Some of the faults may be maladjustments or other conditions for which corrective adjustments are permitted. Other faults may require component replacement or battle damage repair. It is important to correct adjustment errors to minimise the effects of rotor vibration on aircrew, the rotorcraft, installed equipment, and stores. An RTBM system is therefore required to identify conditions in which vibration limits are exceeded, to diagnose the cause, and to advise appropriate remedial action and degree of urgency:-

- (a) adjustments within permitted limits.
- (b) component replacement.
- (c) battle damage repair.

(ii) Permanently mounted sensors should be provided for monitoring the track and lag of the rotor blades, and triaxial vibration adjacent to the main and auxiliary rotors. Flight trials may indicate other (or additional) vibration sensor locations. The positioning of the sensors should be optimised and defined in the maintenance manual. Where blade tracking requires attachments to the blades, on a permanent or temporary basis, they should not affect adversely the aerodynamic performance (particularly in autorotation). Neither should the radar, infra-red or acoustic signature be affected, nor most importantly the visibility of the rotorcraft by day or by night.

(iii) The system should be capable of day and night, all weather operation, and capable of operation by a single member of the aircrew.

(iv) Vibration limits at the defined sensor positions should be included in the display in addition to the actual values.

(v) The installed sensor measurement accuracies should be better than:-

(a) Blade Track: ± 3 mm in flap, ± 3 mm in lag at 10 m radius. This accuracy is necessary to establish trends with forward speed, ground, and hover, and for diagnosis of faults.

(b) Balance: Imbalance amplitude 0.05 ips, phase angle ±0.5°. All vibration data should be digitised at a sampling rate equal to 512 multiples of rotor speed.

(vi) Equipment associated with RTBM has been known to cause EMC problems. Therefore RTBM equipment should conform to the EMC specification for the rotorcraft, both in respect of radiated and conducted energy.

(vii) Hard copy output recommending rotor adjustments should be considered for use by maintenance personnel.

(viii) Rotor adjustments should be limited to track rods, specified tabs, chordwise and spanwise balance weights, where permitted. All permissible adjustments, limits, procedures, and tooling required should be fully defined in the rotorcraft maintenance manual.

(ix) Analysis software should control the acquisition and checking of track and balance data with display menu prompts. From time-averaging data, trends in the behaviour of each blade and the rotor assembly should be automatically computed for the ground and flight conditions specified, and stored for down-loading via the data transfer device. All adjustments made should be input to the on-board system, stored for down-loading, and the information used for improving the algorithms.

(x) Rotor track and balance measurements should be capable of completion within one flight, although it is considered that the 'best' balance may require additional flights. This is particularly true on twin-rotor rotorcraft.

(xi) Faults developing in the rotor system or pitch control system can manifest themselves through changes in blade track or rotor balance, and would be expected to continue producing changes with fault progression. Where practicable therefore the frequency of adjustments associated with a normal, healthy rotor should be established, and this frequency monitored to determine whether fault check list procedures should be invoked.

(xii) Sufficient recording allowance should be made for track and balance data including time/date and description of subjective assessment of vibration and changes made, for several test flights appropriate to the rotor design and rotorcraft operations.

(xiii) On rotorcraft fitted with an external Maintenance Data Panel (MDP) it should be possible to operate the RTBM facilities from the cockpit and from the MDP.

(xiv) The integrity status of track sensor, accelerometers, and rotor azimuth reference signals should be displayed together with rotor rpm and indicated airspeed.

(xv) Particular consideration should be given to relaxation of limits for wartime operation, to extending permissible adjustments, and to jury-rigged corrections to compensate for battle damage.

(xvi) Rotor track and balance checking procedures should have an on-request capability.

(xvii) Further information on rotor faults and the capabilities of RTBM is given in Refs 11-15.

4.3.2 Rotor Related Vibration

(i) Rotor induced vibration can result in potentially serious faults developing in the rotor and rotating control systems. Some faults cause changes in amplitude of rotor order frequencies and are traditionally traced through manual check-list procedures relating to known component characteristics. Other faults produce signature changes related to the frequency characteristics of that component which differ from rotor orders but occur in a similar frequency range.

(ii) Therefore facilities should be provided to:

(a) indicate rotor order vibration vectors or trends which are out-of-limits.

(b) indicate other specific characteristic frequencies which are out-of-limits on level or trend.

(c) detect the growth in amplitude and number of non predetermined frequencies in this range.

Exceedance (a) would precipitate track and balance checks followed by check-list procedures prompted on the display, or output of other diagnostic information included in the software.

Exceedance (b) would immediately invoke component identification(s), any built-in diagnostic functions, and check-list procedures prompted by the display.

Exceedance (c) could invoke amber caution indications with cause unknown, and maintenance indications requiring a manual/visual check of the complete rotorcraft.

Gross exceedances in any category should invoke red caption warnings together with component identification, where practicable, in accordance with Leaflet 105.

(iii) Vibration 'snap-shots' should be recorded for down-loading to ground-based facilities, but processed on-board to enable status to be assessed relative to the three categories described above, and cautions or warnings displayed if the appropriate limits are exceeded. Provisions should be made to store a number of processed or raw vibration snap-shots signatures, together with rotor reference signals, as agreed with the Rotorcraft Project Director.

(iv) Minimal data processing requirements recommended are a 1024 point Fast Fourier Transform, frequency ranges 0-20R and 0-10T for conventional rotor blade complements, and a resolution of 0.02 inches per second.

(v) Further information on the application of these techniques is given in Ref 15.

4.4 ROTOR ASSEMBLIES - USAGE MONITORING

4.4.1 Parameters to be monitored may vary between different rotor designs especially in respect of the number of 'finite-life' components substantiated on a safe-life basis. Examples given below are based on a rotor usage monitoring system designed for a particular rotorcraft (Ref 17).

(i) Rotor Hours: e.g., time for NR ≥80%. This will eliminate errors experienced with manual recording.

(ii) Rotor Starts: e.g., when NR >80% rising.

(iii) Torque (main and tail rotors): maximum values and the number and magnitude of torque reversals at rotor speeds above 80%. Torque resolution should be better than ± 2%. Phase displacement and FM Telemetry strain-gauge torquemeters have proved satisfactory in rotorcraft applications.

(iv) Strain. Strain gauges can be bonded onto life-limited rotating components using the same technology as strain gauge type torquemeters. Particular care is required in the selection of the gauge and the bonding process and the provision of adequate protection against climatic and maintenance environments. It may be necessary to compromise the ideal gauge location (from a stress-measurement viewpoint) to achieve satisfactory reliability and life. The provision of additional gauges at the time of manufacture may reduce the effects of fatigue life scatter, although all gauges (in use or otherwise) start to consume fatigue life immediately upon installation. Signals can be transferred from rotating components to stationary structure by means of frequency modulated capacitive/inductive systems with high integrity.

In addition to cumulative damage and exceedance monitoring, strain gauge data from the rotor head can be used to compute and display ROTOR HEAD MOMENT where this is required to be controlled as in the example of Ref 17 during ground taxi manoeuvres. A potential problem with the strain gauging of large components is the calibration necessary for the instrumented component.

4.5 ROTOR BLADES

4.5.1 Health Monitoring

(i) Metal blades tend to be life-limited by potential fatigue fracture of the spars - these should be protected by pressure-leak systems, or crack detection wires or fibres, interfacing the health and usage monitoring system. Pressure-leak systems are well established and have proved effective (e.g., 'BIM', 'IBIM', & 'ISIS'). Crack detection wires or fibres require more development work and in-service experience. Conducting paint has been used for detection of surface cracks. Most experience to date is with ground-based NDT techniques.

(ii) Composite blades are less likely to fracture, but are likely to take up water at different rates, especially when new or when operated in very high humidity. This usually manifests itself through rotor imbalance (covered in para 4.4). Delamination of fibres near the surface in outboard regions would be expected to change the aerodynamic characteristics of the blade and show up in track monitoring and in vibration (1R vertical) monitoring. Embedded optical fibres for monitoring strain or fracture could be effective throughout the blade, but much development work still needs to be done. It is essential that incorporation of such fibres does not reduce the strength of the blade.

4.5.2 Usage Monitoring: The considerations of para 4.4 apply to rotor blades.

4.5.3 Blade Icing: Ice accretion on rotor blades may be detected by a change in vibration amplitudes at blade passing frequency.

4.6 ROTOR HUBS AND BLADE ATTACHMENTS

4.6.1 Health Monitoring:- Whilst on-line monitoring of metallic components with strain or fracture fibres may be considered feasible, experience to date is limited to ground-based inspections (visual and NDT) which still need to the carried out on a scheduled basis and in the course of check-list inspections following RTBM or Vibration (1R and NR) limit exceedances (see para 4.3.1. (xi)). For fibre-composite hub structures with redundant load paths, the inclusion of optical fibres for strain or fracture detection could be considered.

4.6.2 Usage monitoring:- The considerations of para 4.4 apply to rotor blades and blade attachments.

4.7 ROTOR HEAD BEARINGS - BLADE RETENTION AND ARTICULATION

4.7.1 Health Monitoring:

(i) Rolling element bearings are unlikely to feature in new rotor system designs because of adverse weight, life and reliability characteristics, but if featured could be monitored as per drive shaft bearings (see para 6.7) together with high integrity signal transmission as per para 4.4.1 (iv).

(ii) Elastomeric bearings may be amenable to thermal monitoring or stiffness checks, but current experience is limited to visual examination for delamination (cracks and debris) - see Ref 18, P32-19, and Ref 19.

(iii) Bearingless arrangements could be treated as per para 4.6.1.

4.7.2 Usage Monitoring: The considerations of para 4.4 apply to rotor head bearings.

4.8 LAG DAMPERS

4.8.1 Health Monitoring: Damper faults can manifest themselves through lead-lag track errors and at a later stage in airframe vibration whilst on the ground with rotors turning, especially during run-up and run-down. The provisions of para 4.3.2 are therefore appropriate.

4.8.2 Usage Monitoring: The considerations of para 4.4 apply to the structural components of lag plane dampers.

5 FLIGHT CONTROL SYSTEMS

5.1 SCOPE

5.1.1 This para includes pilot's controls, non-rotating pitch control systems, electrical and hydraulic power supplies and servo-control systems, mechanical linkages, stability augmentation systems, active control systems.

5.2 BACKGROUND

5.2.1 A review of health monitoring methods appropriate to flight control systems is given in Ref 7 p A4-18.

5.3 CONTROL LINKAGES AND BEARINGS

5.3.1 Health Monitoring: Control linkages have failed due to unforeseen vibration conditions arising from changes in stiffness with time. Vibration monitoring at strategic points could therefore be considered, monitoring excessive changes of amplitude at characteristic frequencies. Hollow linkages can be monitored for fracture by the use of pressure-leak systems. Whilst this has been implemented on a visual-inspection basis, the time to failure from crack detection would justify on-line provisions. Wear in rod-end bearings may manifest itself by a change in system vibration characteristics but otherwise will require ground-based inspections. Rolling element thrust bearings have been successfully covered with temperature monitoring and vibration.

5.3.2 Usage Monitoring: The functions listed in para 4.5 could be appropriate to rod-end bearings provided that sufficient consistency in manufacture can be maintained.

5.4 HYDRAULIC POWER SUPPLIES AND CONTROL SYSTEMS

5.4.1 Status Monitoring: The pressure in multiple circuits should be monitored to identify any loss of redundancy. Multiple servo-valves could likewise be monitored for jamming (e.g., the system described in Ref 17).

5.4.2 Health Monitoring: Wear in pumps and valves may be detectable by monitoring pressure and temperature performance characteristics relative to base-line. Ground-based analysis of fluid samples for contamination is well established practice, one effective method being described in Ref 20.

5.5 ELECTRICAL AND ELECTRO-OPTICAL CONTROL SYSTEMS

5.5.1 Status Monitoring: Components and circuits would be expected to be furnished with Built-in-Test facilities, which should be interfaced by the HUM system to continuously assess the level of redundancy existing.

6 TRANSMISSION SYSTEMS

6.1 SCOPE

6.1.1 This para includes gearbox internal components, lubrication systems, drive shafts and support bearings, couplings, freewheels, and rotor brakes; but excludes casings, load struts, and mounting features, which are more conveniently covered in para 7.

6.2 BACKGROUND

6.2.1 A reviews of health and usage monitoring methods applicable to rotorcraft transmissions are given in Refs 2, 6 and 7 (A4-8 to A4-14).

6.3 INTERNAL COMPONENTS - HEALTH MONITORING

6.3.1 Complementary Methods

(i) To provide adequate monitoring of gearbox internals, a suite of facilities is required to cover the range of possible failure modes, which include fracture of gears, hubs, splines and shafts which may not release much debris; surface fatigue of gear teeth and bearings which tend to release steel particles greater than 1 milligram before becoming a risk to airworthiness; and fatigue scuffing, micropitting, fretting, corrosion, etc., releasing very small particles (individually sub-visible) that may be ferrous or non-ferrous. The facilities should therefore comprise effective: -

(a) vibration monitoring (primarily for fracture modes).

(b) ferrous wear debris monitoring (primarily for surface fatigue modes).

(c) non-ferrous wear debris monitoring (primarily for retention failures and non-ferrous bearing cages).

(d) oil analysis (primarily for corrosion and small scale wear processes).

(ii) On-line systems exist with successful service experience for (a) and (b) but not for (c) and (d). Monitor filters of the coarse strainer type have successful application experience whilst much finer versions of order 100 microns (see Ref 6) are lacking in field experience - both are normally configured for ground inspections, although indicating screens of the coarser variety are available. A range of effective laboratory analysis techniques exist for (d) (see Refs 9 and 21).

Application experience with a suite of complementary techniques is given in Refs 6, 22, 23.

(iii) When implementing complementary monitoring methods, care is required to ensure that:-

(a) rejection status warnings are not generated by early indications from a system which responds to slowly developing wear modes (e.g., Ref 23).

(b) indications of damage initiation and progression are not derogated by 'satisfactory' indications from laboratory methods appropriate to slowly propagating modes (e.g., Ref 31, para 2.3).

6.3.2 Vibration Analysis

(i) A vibration analysis technique with application experience to service rotorcraft gearboxes of both fixed shaft axis and epicyclic configurations, and with demonstrated success in detecting localised gear tooth bonding fatigue failure, employs Signal Averaging. Important factors in defining the signal average computation include frequency range and resolution and averaging period. The choice of appropriate algorithms to post-process the signal average, prior to the application of numerical assessment parameters, will critically affect the ability to detect incipient failures at the earliest stage. Successes with this technique relate primarily to gear tooth cracks and fractures, and warnings several flights/ hours in advance of fractures have been demonstrated. The techniques have also successfully detected gear web and shaft fractures and gear tooth pitting (see Ref 24).

(ii) The technique is capable of pin-pointing precisely the shaft on which the affected gear is mounted and hence could be used to indicate appropriate flight control and maintenance actions.

(iii) It is not possible to guarantee that this technique will detect all possible fracture modes within every type of gearbox with sufficient warning to complete a mission, but it is capable of significantly enhancing the airworthiness of all gearboxes, and should therefore be included as a vital element of the health and usage monitoring systems.

(iv) Fractures of quill shafts and cracks in gearbox casings (bearing housings) have also been detected by vibration analysis, by examining the variation with time of amplitudes of gear meshing harmonics and shaft order 'sidebands'.

(v) Experience with detection of localised and distributed tooth surface damage and bearing spalling by vibration analysis has been moderately successful. Depending on gearbox complexity and gear tooth geometry, vibration analysis may usefully complement wear debris analysis for such failure modes.

(vi) Particular care is required in the application of vibration analysis to:-

(a) sample data at constant speed and in a prescribed torque window.

(b) obtain datum samples of data representing the new or overhauled condition of the gearbox. (Manufacturing and assembly tolerances within design limits can cause significant variations in processed vibration data as can natural frequency response changes). Some vibration monitoring parameters need to be assessed with respect to datum conditions.

(c) react to decreasing trends in vibration analysis parameters. In very many parameters both normalised and absolute, the extension of surface damage and of cracks result in decreasing trends of the descriptor following a rise from initial values relating to the undamaged condition.

(vii) Where vibration analysis packages are encapsulated in self-contained hardware, care must be taken to ensure that the requirements of Leaflet 727, para 6.3.3 are satisfied.

6.3.3 Ferrous Wear Debris Monitoring

(i) Service arisings on transmission systems tend to be dominated by wear of steel components, which is manifested by ferrous debris. The size, morphology, and generation rate characteristics tend to vary with type of component and material, wear mode, and damage progression. It is important to both cost of ownership and monitoring system credibility issues to be able to distinguish between manufacture/assembly debris and acceptable or benign wear modes on the one hand, and potentially serious arisings on the other. Even potentially serious conditions can take several hundreds of hours to develop to the stage where they become a safety hazard (see Ref 38). Seldom can wear modes be arrested by service action other than component replacement. Monitoring provisions should therefore be capable of indicating the point at which component replacement is necessary, with sufficient safety margins included.

(ii) On-line ferrous wear debris monitoring systems exist with service experience that are capable of monitoring particle size and generation rate, but not particle morphology. It is necessary therefore to be able to extract sample wear debris for visual examination at the rotorcraft, and further analysis with laboratory equipment in order to identify the nature of the process, and the component releasing the debris.

(iii) Where the gearbox construction permits, it may not be necessary to fit on-line sensors to all sumps or scavenge lines of a gearbox. Thus it may be possible in complex gearboxes to provide one on-line sensor for status monitoring purposes and a number of magnetic plugs to facilitate fault isolation and diagnosis by inspection.

(iv) In the design of the gearbox and lubrication system consideration should be given to maximising debris transport efficiency to the sensors. Wherever possible probe type sensors should be located in areas of full flow such as sump outlets, or in main scavenge lines with 'dog-leg' arrangements or vortex separators which direct the debris towards the sensor. Sensors which encompass the oil flow should be placed as close as possible to the scavenge pipe entry. For sump-mounted probes consideration should be given to incorporation of lightweight debris catchment trays having smooth surfaces, shaped to facilitate oil washing of debris onto the probes.

(v) Wear debris monitoring systems capable of full-flow monitoring are preferred.

(vi) Preferably the sensor should have debris retention capability in order to facilitate post-flight inspection of the debris produced in flight, when outside acceptable limits.

(vii) Sensors having debris retention capability should be immune to 'chip dance', loss of retention, and should be fitted in self-sealing housings to facilitate inspection.

(viii) Wear sensors should have continuous operation characteristics to ensure debris is not missed.

(ix) Wear sensors should be capable of producing an output proportional to the mass of the debris as it is entrained or passes through the sensor, and thence be capable of providing trend and total accumulation information through on-line analysis.

(x) The wear sensor system should be capable of discriminating between 'large' and 'small' particles. It is particularly important to be able to assess the mass trends and accumulation of particles of length greater than 300 microns or mass greater than 0.1 mgms. It should not be possible for a slow accumulation of small debris to be interpreted as a number of large particles.

(xi) Care should be taken in the interpretation of wear trend data. Whilst a significant or even total reduction in wear rate following a significant period of increasing wear may signify a reduction in the wear process, the component could be in a hazardous condition and therefore be prone to rapid failure.

(xii) Wear debris monitoring outputs should not be affected by aeration of the oil nor by temperature, vibration or EMC environment of the sensors.

(xiii) The wear debris monitoring system should have full built-in-test capability including the facility to simulate the presence of a significant wear particle at the sensors.

(xiv) Where debris data analysis is encapsulated in dedicated hardware, care must be taken to ensure that the requirements of Leaflet 727 para 6.3.3 are satisfied.

(xv) Further considerations relative to on-line wear debris monitoring may be found in Ref 25.

(xvi) Two on-line wear debris monitoring systems that exhibit many of the above characteristics, and have mature experience in rotorcraft transmission applications are described in Refs 26-30.

6.3.4 Non-Ferrous Wear Debris Monitoring.

(i) The release of non-ferrous wear debris tends to be common occurrence in service, also the movement of non-ferrous, often non-metallic compounds, associated with gearbox assembly. Whilst non-ferrous materials are not usually involved in highly stressed rolling or sliding contacts other than as a surface coating they do feature in support structures and in rotating assemblies. Wear modes may take longer to develop to a serious condition than in steel components such as gears and bearings, but they nevertheless can affect the integrity of the transmission and need to be effectively monitored. Many of the considerations discussed in relation to ferrous wear debris monitoring also apply to non-ferrous debris. On-line monitoring systems are less well developed for non-ferrous debris, however, and greater reliance upon laboratory based methods is necessary (see Ref 9).

(ii) Whilst experience has been gained with on-line analysis of non-ferrous wear debris in space applications, and the technology developed for rotorcraft applications (Ref 32), there is little or no rotorcraft experience with the technique.

(iii) Rotorcraft experience exists (on the CH 47D transmission) in the form of electrical indicating screens. These would be appropriate for any conducting particles.

(iv) Industrial experience exists with filter blockage measurement configured to produce trend information, but there is no experience with rotorcraft applications. There is rotorcraft experience with remote indication of main oil filter-blockage, which could therefore be considered for wear rate determination until devices with greater precision become available.

6.3.5 Oil Parameters:

(i) Trend analysis of the parameters identified in para 6.5.1 can be performed to reduce the possibility of degradation in the gearbox reaching caution or warning status.

(ii) Transducers appropriate to the above are discussed in para 6.5.2 (ii).

6.4 INTERNAL COMPONENTS - USAGE MONITORING

6.4.1 The processing of torque data is sufficient to satisfy the usage monitoring requirements of rotorcraft gearbox internal components to determine:

(i) cumulative damage sustained by life-limited components.

(ii) limit exceedance data.

6.4.2 An example of a mandatory requirement for continuous assessment of cumulative damage is given in Ref 17 (MGB tail take-off gears with no design allowance for load scatter). The means for satisfying that requirement is also described.

6.4.3 The resolution accuracy required in torque-measurement is ± 1% which is achievable in the torque monitoring systems described in Refs 17, 33 and 34.

6.4.4 Mean torque signals should be sampled at a frequency of 10 Hz or greater.

6.4.5 The torque range corresponding to the lowest gear endurance limit to the maximum conceivable conditions should be divided into a number of bands as determined from stress-life considerations. In addition to storing the total time accumulated within each band, damage counts should be computed for each life-limited gear in the transmission by applying Miners Law and the fatigue damage characteristics of the material (S-N curve) to the appropriate torque time data. Damage counts are normally expressed as a fraction of the predicted life available such that unit value signifies that predicted life has been consumed.

6.4.6 When determining which gears and shafts should be included in the analysis by virtue of damage threshold exceedance, the most adverse of emergency conditions should be applied.

6.4.7 Each incidence of torque 'red-line' exceedance should be recorded together with maximum amplitude, elapsed time, time of occurrence, and gearbox serial number. The addition of keyed in sortie codes could assist with improving the design knowledge relating to operational load spectra.

6.5 LUBRICATION AND COOLING SYSTEMS

6.5.1 Status Monitoring. System warning and caution indications should be triggered by abnormal oil pressure and temperature, oil filter blockage, or low oil level.

6.5.2 Health Monitoring

(i) Trend analysis of the above parameters can be performed to reduce the possibility of degradation in the oil system leading to caution or warning alerts.

(ii) Solid state transducers for measuring oil temperature and pressure offer the resolution accuracy required. OAT and torque data may need to be included in the analysis to account for effects of ambient temperature and load. Electro-optical sensors with no moving parts are in use for measuring static oil and fuel levels in rotorcraft with multi-sensor configurations available to improve resolution accuracy.

6.6 DRIVE SHAFTS AND COUPLINGS - HEALTH MONITORING

6.6.1 Vibration monitoring is advocated for detecting damage in drive shafts and couplings (see Ref 4 Table 6). This may be accomplished by monitoring spectrum changes at shaft speed and sub-harmonics with signals from accelerometers mounted on gearbox casings or airframe structure, or possibly from vibratory torque.

6.7 DRIVE SHAFT SUPPORT BEARINGS - HEALTH MONITORING

6.7.1 Temperature measurement by use of thermocouples affixed to the bearing housing is advocated, based on successful tests. There is also test evidence to support the use of the 'Shock Pulse' method employing tuned accelerometers, with carrier frequencies of the order of 30 kHz (see Ref 35).

6.8 FREEWHEEL UNITS

6.8.1 Health Monitoring

(i) Both cam-and-roller freewheels and sprag type clutches are prone to wear with consequent risk of sudden loss of drive.

(ii) The nature of freewheel operation makes on-line monitoring of wear very difficult. Freewheels should therefore continue to be made accessible for post-flight inspection.

6.8.2 Usage Monitoring

(i) Freewheel actuation could be monitored via the electrical actuation signals and occurrences of slam engagement recorded and flagged up for post-flight inspection or replacement.

(ii) Rotor starts and freewheel actuations could be recorded and correlated with inspection findings.

6.9 ROTOR BRAKES

6.9.1 Health Monitoring

(i) Consideration should be given to monitoring Rotor Brakes for wear with special attention to possible fire hazards with hydraulically operated brakes. Correlation of temperature and rotor brake actuation would contribute to reducing the fire hazard.

(ii) Pad wear could be monitored by means of buried electrical contacts similar to automobile practice.

(iii) Actuation mechanisms could be monitored for intermittent electrical faults comparing input and response (rotor deceleration).

7 AIRFRAME AND UNDERCARRIAGE

7.1 SCOPE

7.1.1 This para includes the whole of the rotorcraft structure and attachments including gearbox casings, mountings, engine supports, active airframe vibration control systems, the undercarriage, and stores supports.

7.2 BACKGROUND

7.2.1 A review of health monitoring of structures is given in Ref 7, p A4-20/21 and Ref 8, p10.

7.3 STRUCTURE - HEALTH MONITORING

7.3.1 Some of the difficulties in using strain gauges and the precautions to be adopted are discussed in para 4.4.1 (iv). Calibration problems are likely to be more severe on large components such as airframes. Automatic no load offset checks may improve long term accuracy of mean load measurements. Where the strain data required can be obtained from detachable parts (such as gearbox mounting struts or tail-fold lugs), the calibration problems are greatly reduced and this strategy should be employed wherever practicable.

7.3.2 There remains the possibility of bonded wires or optical fibres to aid visual inspections and NTD methods, but experience in rotorcraft applications is lacking. Ample provision should therefore be made in the design of structures to permit visual inspection.

7.3.3 The problems of corrosion is expected to persist whilst metallic structures are used for gearbox casings, support decking, linkages, etc. Visual inspection is expected to remain the primary method of corrosion control.

7.4 STRUCTURE - USAGE MONITORING

7.4.1 Direct load measurement is desirable because of its ability to cater automatically for varying weight, centre of gravity position and configuration (e.g., under-slung load carriage), as well as abnormal conditions such as icing. The implementation problems which may be encountered are described in para 4.4.1 (iv) and 7.3.1.

7.4.2 In view of the practical instrumentation problems in adopting a direct load measurement technique, a parametric approach may therefore be appropriate in conjunction with a dynamic model of the structure (e.g., Ref 8). The dynamic stress at any point in the structure will depend upon the flight conditions (e.g., rotor torques, airspeed, flight control positions etc). The relationship between these will need to be established from strain-gauged development rotorcraft with the object of minimising the number of variables and structural points to be included in the algorithm. It should be recognized, however, that such algorithms are likely to be very complicated if they are to cover all flight regimes, and successful implementation of this technique has yet to be achieved.

7.5 ACTIVE CONTROL OF STRUCTURAL DYNAMIC RESPONSE (ACSR) - HEALTH MONITORING

7.5.1 The relatively large number of accelerometers employed in a system such as that described in Ref 36 provides a good opportunity for monitoring the structural integrity and usage of the airframe and major components. In addition the components of the ACSR system may require health and status monitoring. The structural health monitoring could be performed in the controller which is the heart of the ACSR system, or alternatively within the HUM system. Likewise the health monitoring of the hydraulic or electric actuation system could be performed in the ACSR or in the HUM system, employing the considerations of para 5.4 and 5.5. The controller would be expected to be furnished with full Built-in Test facilities which should be interfaced by the HUM System.

7.6 UNDERCARRIAGES

7.6.1 Health Monitoring

(i) Control of corrosion is expected to remain a ground inspection activity as indicated in para 7.3.3.

(ii) Fractures/damage developing in either skid type or wheeled undercarriages may be detectable before failure by vibration monitoring on the ground (see para 4.8.1) supported by check-list inspections.

7.6.2 Usage Monitoring. The number of take-off landing cycles may provide a first order control of undercarriage lifing. To improve on this would require the measurement or computation of gross weight, sink rate, and for wheeled undercarriages taxi parameters.

8 FUEL SYSTEMS

8.1 SCOPE

8.1.1 This para includes the fuel tanks, fuel lines, filters, pumps, valves, contents gauges, switches, and fuel gauging computers.

8.2 BACKGROUND

8.2.1 A review of the health monitoring of fuel systems is given in Ref 7 A4-21, and Ref 8, p12.

8.3 STATUS MONITORING

8.3.1 Conventional fuel contents monitoring could be supplemented by monitoring as a function of time, engine condition, and transfer algorithms to check for:-

(i) low fuel
(ii) leaks
(iii) failure of automatic fuel transfer.

8.3.2 Fuel pressure downstream of the booster pump could be monitored to detect:-

(i) booster pump failure
(ii) leaks
(iii) fuel filter blockage.

8.3.3 Built-in Test indications on the Fuel Gauging Computer (FGC) should be interfaced by the HUM system.

8.3.4 Fuel filter blockage could be monitored by remote blockage indicator.

8.4 HEALTH AND USAGE MONITORING

8.4.1 Health and usage monitoring of pumps, valves and transfer valve actuation systems could be considered in relation to the safety analysis, redundancy provisions, maintenance policy, and FGC monitoring provisions.

(i) Health monitoring techniques described in para 5.4.2 are appropriate to fuel system components.

(ii) Usage monitoring could be related to total engine operating hours.

9 ELECTRICAL SYSTEMS

9.1 SCOPE

9.1.1 The systems include the batteries, AC generators, Transformer Rectifier Unit (TRU), DC and AC Bus systems, Electrical Anti-icing system.

9.2 HEALTH MONITORING

9.2.1 Temperature monitoring of batteries, generators, and TRU's could provide warnings in advance of overheat STATUS indications.

10 AVIONICS SYSTEMS

10.1 SCOPE

10.1.1 This para includes all avionics systems and data highways installed for the operation and maintenance of the rotorcraft, including the HUM system; internal and external communications systems; and all mission related equipment.

10.2 STATUS MONITORING

10.2.1 It is anticipated that all avionics systems will be furnished with all monitoring functions necessary for establishing operational status and diagnosis of faults.

11 ANTI-ICING SYSTEM (Air)

11.1 SCOPE

11.1.1 Included are all components in heated air flow systems (e.g., for engine intake anti-icing) - principally heaters and valves.

11.2 HEALTH MONITORING

11.2.1 Temperatures could usefully be monitored to provide warnings in advance of failure status indications.

12 CENTRAL WARNING SYSTEM (CWS)

12.1 SCOPE

12.1.1 The system includes the Central Warning Panel, Master caution and warning lights, audio warnings, and any other displays (e.g., Power Systems Display Unit) other than dedicated HUM system displays which are used for cautionary or warning messages. The CW lights and Power Systems data may be included in the same display unit (e.g., Ref 37).

12.2 In addition to monitoring the status of all Central Warning Systems HUM system displays, master warning light and audio warnings could be used to provide back-up CWS functions.

13 EVENT RECORDING

13.1 The HUM system can also be used to supplement subjective assessments be aircrew of abnormalities occurring in the rotorcraft, and external occurrences, by making provision for aircrew initiated event recordings.

13.2 In determining Non-Volatile Memory requirements in the HUM system consideration should be given to the recording of 'snap-shots' of all sensor inputs and processed data, and the number of such events between data down-loads. Such 'snap-shots' should be annotated with time and date information.

13.3 Memory buffers could be continuously up-dated with the above data to provide snap-shot recordings before and after incidents identified by aircrew.

13.4 In certain circumstances, 'snap-shot' recordings could be initiated by the HUM system.

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LEAFLET 727/2

HEALTH AND USAGE MONITORING SYSTEMS

SYSTEM COMPONENTS

1 INTRODUCTION

1.1 This leaflet describes equipments that may satisfy the system requirements detailed in Leaflet 727, paras 4 and 5. An example is the system architecture proposed for the HUM system on the EH101 Helicopter as discussed in Ref 1.

2 SENSORS

2.1 In addition to those sensors fitted to the rotorcraft for engine and flight control purposes there are a wide range of flight-worthy sensors available that are appropriate to the monitoring functions required. Care should be exercised in selecting sensor types to ensure compatibility with the operational and maintenance environment to which they are to be subjected.

2.2 Where possible redundancy should be provided, either within the sensor selected, or through back-up sensors that can satisfy this need, if necessary with reduced sensitivity.

2.3 Where appropriate, sensors should have mounting provisions which facilitate removal for inspection or replacement without jeopardising the integrity of the monitored component, or requiring time-consuming maintenance action. An example is the need for self-sealing housings for gearbox wear sensors.

2.4 In selecting sensor types calibration burdens should be minimised.

3 SIGNAL INTERFACING

3.1 Data from particular sensors may be required for other systems in addition to the HUM system (e.g., electronic flight instruments and engine control systems). Sensor interface units separate from data processing units could therefore be beneficial in avoiding duplication of analog to digital conversion etc (see Ref 1).

4 DATA PROCESSING AND STORAGE

4.1 Dedicated processing of health and usage monitoring data may have significant benefits in avoiding derogation of the monitoring function, and in minimising re-certification effort relating to software changes (see interim DEF STAN 00-31 - The Development of Safety Critical Software for Airborne Systems).

4.2 Some health monitoring inputs such as vibration require analogue to digital conversion of high frequency signals and result in high rate digital data. Such data rates may necessitate dedicated data links between signal interface units and signal processing.

4.3 The acquisition of vibration data at high sample rates may create a large volume of data. Selection of the processing hardware should pay due attention to the required accuracy (method of representation of values in integer or real form) and to the speed of processing. Use of multiple processor schemes or schemes employing dedicated signal processing hardware should be considered.

4.4 A crash-protected recorder is not required for HUM purposes because these relate to assisting continued airworthiness of the rotorcraft. However HUM output data could provide useful information to accident investigators, and consideration should therefore be given to data transfer to the Accident Data Recorder or Cockpit Voice Recorder where fitted.

4.5 An example of how HUM systems can be integrated with Flight Data Recording systems is given in Ref 2.

4.6 Inclusion of a universal time of day and date clock within the HUM system is necessary for off-rotorcraft correlation of independently recorded data.

4.7 Flexibility in memory usage is useful. For example the memory may be segmented to store recent data which is being continually updated, and historical data which is updated less frequently.

4.8 In determining the data storage capacity and partitioning required consideration should be given to the operational and training roles of the particular rotorcraft. Down-loading of HUM data from rotorcraft employed on combat roles or deployed on small ships may not be possible for periods measured in weeks.

4.9 Health monitoring of the HUM system is addressed in Leaflet 727/3, para 10. It is anticipated that the HUM system will be adequately furnished with Built-in Test indications suitable for status monitoring. Considerations should be given to precisely what loss of data and what loss of functionality should constitute HUM system Caution and Warning Status conditions provided by the HUM system.

5 DATA DISPLAY

5.1 A display with alphanumeric keys and function keys to control data acquisition and data display should be placed within easy reach of the pilot (e.g., Refs 1, 3 and 4). If a multi-function display is used, consideration should be given to the hierarchy of display priorities.

5.2 The cockpit display needs to be large enough to accommodate status flags for all cautions and warnings that might arise at any time, plus keyword and legend information to identify the subject system and its condition, not necessarily simultaneously displayed.

REFERENCES

No.		Title, etc.
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LEAFLET 727/1

HEALTH AND USAGE MONITORING SYSTEMS

DEFINITION OF TERMS

1 INTRODUCTION

1.1 A number of monitoring functions are needed to provide an overall monitoring system capability as specified in Leaflet 727. These functions are identified and defined in the following paras. It is considered impracticable to include all monitoring functions in the title of the system - a Health and Usage Monitoring System therefore may contain functions additional to health and usage.

2 DEFINITION OF TERMS

2.1 HEALTH MONITORING

2.1.1 Health Monitoring is a process which provides a means of determining the continued serviceability of components, systems, or structures, without the need for component removal for inspection. The process involves repetitive tests or inspections, and when analysis is performed by an on-board system the time delay between data sampling and output of results an be minimised.

2.1.2 Examples of health monitoring outputs include:

(i) Systems serviceable.

(ii) General alert - impending unserviceability.

(iii) Diagnosis of specific component, mode of degradation, and severity of degradation.

(iv) Prognosis of continued serviceability.

(v) Confirmation of degradation and unserviceability.

2.1.3 The term 'health monitoring' is used in preference to 'condition monitoring' which in civil aircraft usage has a quite different meaning unrelated to preventive maintenance (see Ref 1).

2.2 USAGE MONITORING

2.2.1 Usage Monitoring is a process which assesses the life consumption of life-limited components, systems, and structures by monitoring actual damage exposure (e.g., due to combinations of loads, speeds, temperatures, etc.). Allied to this is the recording of information relating to the exceedances of placarded limits, whether in emergency conditions or normal operations. The activity relates primarily to components substantiated on a 'safe-life' basis (see Leaflet 200).

2.3 STATUS MONITORING

2.3.1 Status Monitoring covers:-

(i) Functional Status - cockpit indication of 'red warning' or 'amber cautions' (see Leaflet 105) initiated by limit exceedances relating to health, usage or other status monitoring outputs.

(ii) Redundancy Status - monitoring the degree of redundancy remaining in systems containing additional components to provide continued serviceability following the failure of any of those components.

(iii) Switch/Valve Position Status - monitoring the position (selected and actual) of any multiple-way switch or valve which affects the operation of the rotorcraft (e.g., fuel valves, anti-icing system switches).

2.4 PERFORMANCE MONITORING

2.4.1 Performance monitoring is the primary method of relating system deterioration to consequence, and is primarily applied to engines but can be applied to all fluid dynamic systems, gearbox lubrication systems being one example.

2.5 VIBRATION CONTROL MONITORING

2.5.1 Vibration control monitoring is the means of signifying unacceptable vibration levels in relation to:-

(i) pilot comfort and performance.

(ii) damage to the structure, components, and equipment.

(iii) requirements in the Specification for the Rotorcraft.

2.6 ON-BOARD MONITORING.

2.6.1 On-Board Monitoring signifies any monitoring function for which data sampling and analysis is performed by a system on the rotorcraft, whether the system be installed or portable (i.e., no reliance upon ground equipment). A functional block diagram is shown in Fig 1.

2.7 GROUND BASED MONITORING

2.7.1 Ground-Based Monitoring signifies any monitoring function for which data sampling is obtained from the operational or, stationary rotorcraft, but analysis is performed by ground-based equipment at the rotorcraft or in a laboratory.

2.7.2 It is recognised that some functions may be analysed on board, but be subject to further analysis off the rotorcraft.

2.8 ON-LINE DATA PROCESSING

2.8.1 On-line Data Processing refers to the processing of data in 'real time', i.e., no significant delay between data equipment and processing.

2.9 BUILT-IN-TEST (BIT)

2.9.1 BIT is a diagnostic facility incorporated in self-contained systems such as engines or avionics equipment that is available for interfacing to the HUM system or for ground inspection.

2.10 ON-CONDITION-MAINTENANCE

2.10.1 On-Condition Maintenance is a primary maintenance process having repetitive inspections or tests to determine the condition of components, systems, or portions of structure with regard to continued serviceability. Corrective action is taken when required by item condition, (see Ref 1).

REFERENCES

No.		Title, etc.
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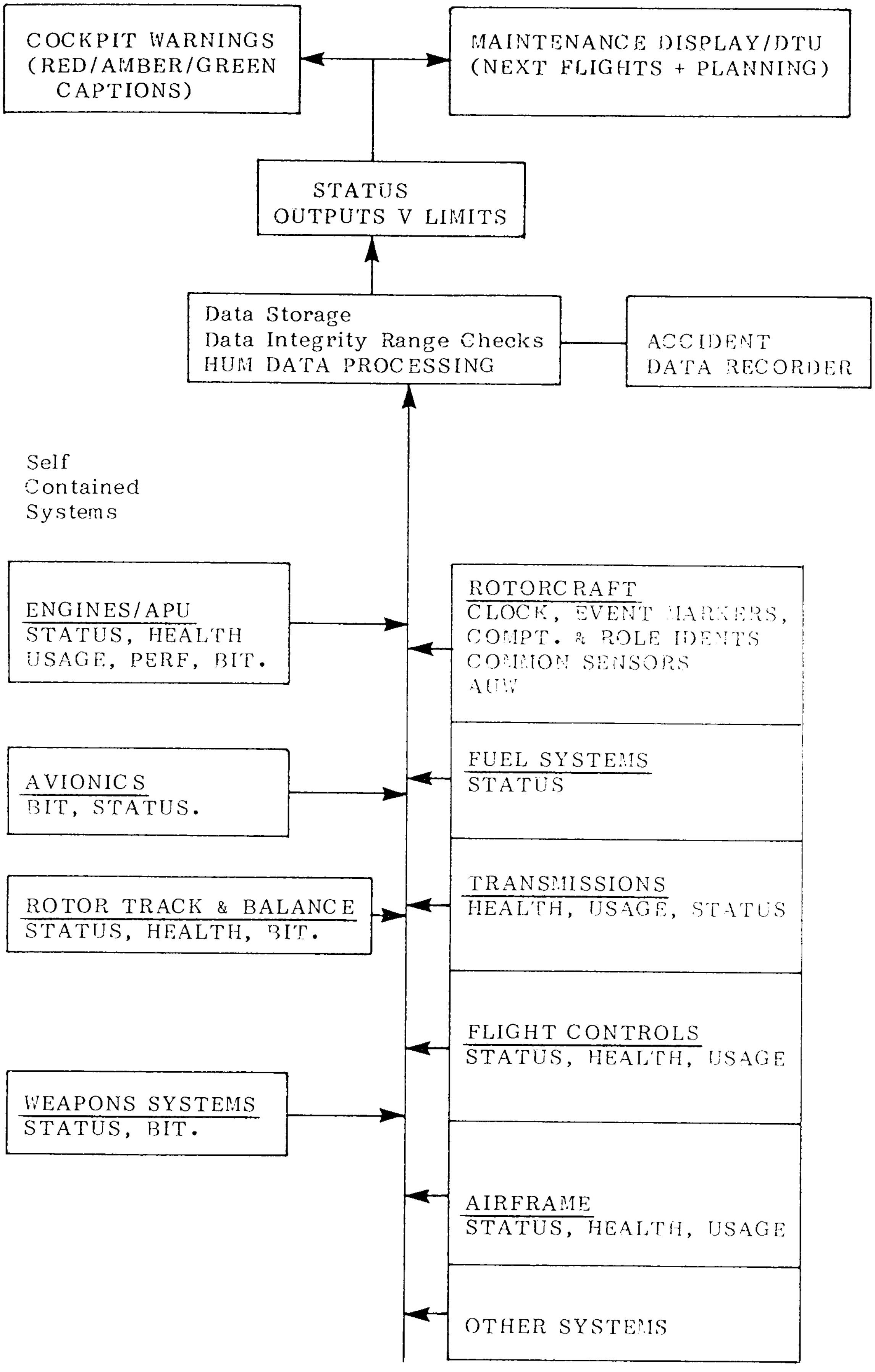

FIG 1 FUNCTIONAL BLOCK DIAGRAM

LEAFLET 725/3

AVIONIC EQUIPMENT INSTALLATIONS

GENERAL AND INTERFACE REQUIREMENTS

1 CASE DESIGN

1.1 Typical equipment case design specifications are ARINC 404A and ARINC 600. These specifications define, standard modular case designs, standard racks or mounting trays, hold downs, temperature control systems for the equipment, and standard electrical connectors for connection of the equipment to the rotorcraft wiring.

1.2 ARINC 404A is primarily the standard for Civil Rotorcraft equipment, it is however suitable for many military applications, and is referenced, and its requirements quoted in US specification DOD-STD-1788, "AVIONICS INTERFACE DESIGN STANDARD".

2 CONNECTORS

2.1 Guidance in the selection and use of connectors is stated in:

DEF STAN 00-10, Part 5
DEF STAN 59-35 (Part 0)
DEF STAN 59-36 (Part 2)
CECC MUAHAG Preferred Products List Vol 3 (Connectors)

2.2 Rectangular connectors of the direct rack and panel type should be used on rack or tray-mounted equipment units. Engagement of mating connectors is by movement of the unit relative to the rack or tray. The connectors should incorporate an alignment device, such as guide pins, to ensure correct mating. Equipments using this form of interconnection require means of locking or clamping, and may, also require means of separation/removal.

3 GENERAL REQUIREMENTS

3.1 Units should comprise discrete physical modules, readily changeable at second line and capable of being tested to an approved specification.

3.2 Line Replacement Item (LRI) pressurisation should be avoided where possible.

3.3 Memory circuits should be non-volatile and programmable in service.

3.4 The maximum acceptable reduction as a percentage of the Mean Time Between Failure (MTBF) due to the inclusion of BIT should be no more than 5 per cent.

3.5 Minimising The False Alarm Rate. The false alarm rate due to the inclusion of BIT should be typically no greater than one per cent of system failure rate.

LEAFLET 725/2

AVIONIC EQUIPMENT INSTALLATIONS

DATA HIGHWAYS AND AIRCRAFT TO AIRCRAFT COMPATIBILITY

1 INTRODUCTION

1.1 Guidance and advice on the transmission of data and inter aircraft compatibility of data transfer is provided in DEF STAN 00-18. Guide to Avionic Data Transmission Interface Systems.

(i) Serial, Time Division, Command/Response Multiplex Data Bus.

(ii) Single Source, Single/Multiplex Link, Serial Digital Transmission Interface System.

(iii) Discrete Signal Interface.

(iv) Fibre Optic, Single Source, Digital Data Transmission.

2 STANDARDISATION

2.1 Standardisation has been attained by the adoption of US Specification MIL-STD-1553. This standard is embodied in DEF STAN 00-18 (Part 2) Serial, Time Division, Command/Response Multiplex Data Bus. It defines the requirements for digital, command/response time division multiplexing techniques for a 1MHz serial data bus and specifies the data bus and its interface electronics.

2.2 All aircraft/aircraft store interfaces which require electrical and information transfer will be designated in accordance with MIL-STD-1760.

LEAFLET 725/1

AVIONIC EQUIPMENT INSTALLATIONS

THERMAL MANAGEMENT

1 INTRODUCTION

1.1 This Leaflet amplifies the requirements of Leaflet 725, para 6.3.1.

2 EVALUATION

2.1 The Equipment Manufacturer should evaluate the Equipment Cooling requirements to ensure that the equipment will operate within the requirements defined by the rotorcraft manufacturer.

2.2 Initial requirements should be obtained by analysis and calculation. This calculation should be confirmed by evaluation tests on the prototype or early production equipment.

2.3 The cooling requirements should be determined when the Equipment is operating in the mode which provides the maximum heat output.

2.4 The requirements to maintain the Equipment at or below the maximum permissible operating temperature should be confirmed for all variations of ambient temperature and pressure which are applicable.

3 REFERENCES

3.1 Procedures for acquiring thermal performance data, and evaluating thermal performance of Airborne Electronic Equipment and Systems, are detailed in MIL-T-23103.

LEAFLET 1006/2

ICE PROTECTION SYSTEMS
GENERAL FLIGHT TEST REQUIREMENTS

FLIGHT SAFETY

1. It is acknowledged that icing is very difficult to forecast accurately and that its severity is generally unknown prior to an actual encounter. Further to this, icing is frequently encountered during the deteriorating phase of a weather pattern. It is therefore important that when icing flights are undertaken that there is adequate clear air below the cloud layer to ensure an area of retreat where further ice build-up will be inhibited, and if necessary a safe precautionary landing can be an available option. High rates of descent from cloud in icing conditions should be used with caution as when entering air which is at positive temperature there will be a possibility of damage to rotors and engines from ice shedding from the airframe and the ability to recover from an auto rotative descent with iced rotors may be unproven. For some testing artificial icing produced by spray tankers may provide a safer and more controllable test environment.

2. Initial penetration into icing with an untried rotorcraft and/or system should only be undertaken in the following conditions:

a) Clear air for 1000 vertical feet (300 metres) below the cloud layer.

b) Horizontal visibility for one nautical mile (2 km) below the cloud layer.

c) Open terrain with low population density and minimal obstruction.

d) Predefined torque, stress, load and vibration limits to be available for initial penetration.

e) If available, air to ground telemetry of flight safety data to minimise work load on pilot/crew.

f) Predefined airframe accretion and exposure limits before evacuating the condition.

g) Predefined aircraft system critical parameter limits to be available prior to all encounters and throughout the test programme.

3. Once an understanding of the rotorcraft’s behaviour in icing conditions is acquitted some of the criteria in para 2 above may be relaxed following discussion and agreement with the Rotorcraft Project Director. An example might be the relaxation of Para 2 (i) to allow IMC recovery in non-icing air.

4. It should be noted that, with or without rotor protection, asymmetric ice shedding can result in severe vibration and or damaging stresses/loads, with the probability of vibration increasing as the temperature decreases. Experience would suggest that caution should be exercised when the conditions are such that the probability of occurrence of any of the following is high: rapid torque rise, natural cyclic shedding, asymmetric shedding, airframe accretion resulting from wet snow versus dry snow, run-back ice resulting from

melt on heated areas, cloud water droplet size etc. To some extent the ice shedding characteristics will vary from one rotorcraft to another, this feature alone calls for caution during the exploratory phase.

5. Full cold weather survival equipment should be carried in the rotorcraft and the crew should carry personal survival equipment together with current cold weather survival and local working instructions. Aircrew will normally carry parachutes when operating in icing conditions above 3000 ft, along with life jacket and dinghy if operating over water. Consideration should be given to the most suitable survival equipment assembly for the likely hazards on each particular trial.

6. Further advisory material on the operation and trials of rotorcraft in icing conditions can be found in Reference 1.

REFERENCES

No.	Title etc.
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