

***Final and approved; this changed AC section is included with AC 29-2C and will later be incorporated into the next published change or revision to AC 29-2C.***

**CHAPTER 3  
AIRWORTHINESS STANDARDS  
TRANSPORT CATEGORY ROTORCRAFT**

**MISCELLANEOUS GUIDANCE (MG)**

**AC 29 MG 6. EMERGENCY MEDICAL SERVICE (EMS) SYSTEMS  
INSTALLATIONS INCLUDING: INTERIOR ARRANGEMENTS,  
EQUIPMENT, HELICOPTER TERRAIN AWARENESS AND  
WARNING SYSTEM (HTAWS), RADIO ALTIMETER, AND FLIGHT  
DATA MONITORING SYSTEM.**

a. Explanation. This section pertains to EMS configurations and associated rotorcraft airworthiness standards. EMS configurations are usually unique interior arrangements that are subject to the appropriate airworthiness standards, part 29 or its predecessor CAR part 7, to which the rotorcraft was certificated. No relief from the standards is intended except by § 21.21(b)(1) or an exemption. EMS configurations are seldom, if ever, done by the original manufacturer.

(1) The FAA has specified in the operating rules the minimum equipment required to operate as a helicopter air ambulance service provider (identified by an “\*” in this guidance). This equipment, as well as all other equipment presented for evaluation and approval, is subject to compliance with airworthiness standards. Any equipment not essential to the safe operation of the aircraft may be approved provided the use, operation, and possible failure modes of the equipment are not hazardous to the aircraft. Safe flight, safe landing, and prompt evacuation of the rotorcraft, in the event of a minor crash landing, for any reason, are the objectives of the FAA evaluation of interiors and equipment unique to EMS.

(i) For example, a rotorcraft equipped only for transportation of a non-ambulatory person (e.g., a police rotorcraft with one litter) as well as a rotorcraft equipped with multiple litters and complete life support systems and two or more attendants or medical personnel may be submitted for approval. These configurations will be evaluated to the airworthiness standards appropriate to the rotorcraft certification basis.

(ii) Transport category rotorcraft should comply with flightcrew and passenger safety standards, which will result in the need to reevaluate certain features of the basic certified rotorcraft related to the EMS arrangement, such as doors and emergency exits, and occupant protection. Compliance with airworthiness standards results in an emergency interior lighting system, placards or markings for doors and exits, exit size, exit quantity and location, exit access, safety belts, and possibly shoulder harnesses or other restraint or passenger protection means to be retained as part of the rotorcraft's

basic type design. The features, placards, markings, and “emergency” systems required as a part of the rotorcraft’s basic type design, should be retained unless specific replacements or alternate designs are necessary for the EMS configuration to comply with airworthiness standards.

(2) Many EMS configurations of transport rotorcraft are equipped with the following:

- (i) Attendant and medical personnel seats, which may swivel.
- (ii) Multiple litters, some of which may tilt.
- (iii) Medical equipment stowage compartments.
- (iv) Life support and other complex medical equipment.
- (v) Human infant incubator (isolette).
- (vi) Curtains or other interior light shielding for the flightcrew compartment.
- (vii) External loud speakers and search lights.
- (viii) Special internal and external communication radio equipment.
- \*(ix) Flight data monitoring system (FDMS).
- \*(x) Radio altimeter.
- \*(xi) Helicopter terrain awareness and warning system (HTAWS).

\*(3) All helicopter air ambulance service providers are required to operate at all times under a part 135 subpart L certificate. The equipment required to obtain operational approval includes:

\*(i) FDMS. The installation guidance is in paragraph b.(13) of this MG.

\*(ii) Radio Altimeter (RAD ALT). The installation guidance is in paragraph b.(14) of this MG.

\*(iii) HTAWS. HTAWS is required for operations under part 135 subpart L, Helicopter Air Ambulance Equipment, Operation, and Training Requirements; § 135.605, Helicopter Terrain Awareness and Warning System (HTAWS). The design standards are in Technical Standard Order (TSO)-C194 and the installation guidance is in AC 29-2 MG 18.

b. Procedures.

(1) General.

(i) Original type design information and criteria may or may not be available from the manufacturer. Availability of this information is dependent on whether the information is considered “public” (i.e., non-proprietary) or proprietary. It may be appropriate to reference the helicopter manufacturer’s “standard” features, placards, and markings in the applicant’s modification design data.

(ii) The EMS modification presented for approval usually contains equipment of one manufacturer’s model or design. The type design of the modification will have features to power and restrain the equipment, maintain the rotorcraft systems integrity, and to otherwise protect the occupants. See paragraph b.(17), which refers to equipment substitution.

(iii) All equipment installations in the helicopter must be approved. EMS helicopters typically include operations in which large medical equipment is not installed in the helicopter but instead is carried on to the helicopter as needed such as isolettes, large medical equipment, and other medical items. This equipment is not included as part of the rotorcraft type design modification because it is not considered a permanent installation in the helicopter. However, carry-on medical equipment must be evaluated as to how it affects the safety of the helicopter and its occupants (including the occupant in the isolette) while being carried in the helicopter. This carry-on equipment (including the isolette) must be properly restrained so it is not a hazard during flight operations. Consequently, the means to stow or store the medical carry-on items must be evaluated for the appropriate load factors relative to the helicopter so the means for stowage of the carry-on equipment does not fail. For instance, in the case of a carry-on isolette, the isolette is typically placed on top of an installed “mount” for the isolette. The “mount” is evaluated for carriage and restraining of the isolette. In some cases, an isolette may be completely self-contained and include other items, such as oxygen bottles required for the isolette occupant, which must also be evaluated for carriage of that equipment.

(2) Evacuation and Interior Arrangements. Access to the emergency exits or doors from any location in the cabin or compartment, access to and use of the exit or door opening means or release device, and the unobstructed area of the “standard” or type design exit are potential problems that should be addressed in the early design stage. Multi-litter arrangements may be especially critical.

(i) The operation or use of devices for locking the position of swivel seats and for rapid installation and removal of litters (isolettes, etc.) should be labeled unless they are simple and obvious, and do not require exceptional effort. The design features of the device(s) and the seat or litter will influence the extent of information in any label necessary to ensure proper and safe installation for routine use and prompt evacuation when appropriate or necessary for the interior arrangement. The requirement for labels or markings (instructions, etc.) that applies to operation of seat or litter features, release devices, etc., is not relieved even if attendants are necessary for an evacuation as

discussed in paragraph b.(2)(iii). Placards or instruction cards that contain evacuation procedures do not necessarily contain detailed procedures for individual seats, litters, and so forth. Release devices that are simple and obvious and do not require exceptional effort are recommended. For example, a single central control for litter release would be preferred over multiple action release devices. However, seats and litters that require multiple actions to release or reposition may be acceptable if properly evaluated to determine that, in the event of an emergency landing, there is no obstruction or delay if rapid evacuation is necessary.

(ii) The passenger compartment or cabin should not be partitioned to impede access to the exits. A person seated in the compartment should have access to each exit in the compartment. All persons must be able or have provisions to rapidly clear (evacuate) the rotorcraft (see § 29.803(a)). A demonstration or a “walk-through” of appropriate evacuation procedures may be necessary to ensure the means and procedures are feasible and adequate.

(iii) When an evacuation demonstration is determined to be appropriate for compliance, 90 seconds should be used as the time interval for evacuation of the rotorcraft. Attendants and the flightcrew, trained in the evacuation procedures, may be used to remove the litter patients. It is preferable for the patient to remain in the litter; however, the patient may be removed from the litter to facilitate rapid evacuation through the exit. The patients are not ambulatory during the demonstration. Evacuation procedures should be included if isolettes are part of the interior. The demonstration may be conducted in daylight with the dark of the night simulated and the rotorcraft in a normal attitude with the landing gear extended. For the purpose of the demonstration, exits on one side (critical side) should be used. Exits on the opposite side are blocked and not accessible for the demonstration. This is representative of a rollover or exits blocked due to a fire.

(iv) Special evacuation procedures and trained attendants may not be required for simple and obvious means of evacuation for a single litter. Procedures may be prominently displayed in durable markings, placards, cards, and condensed or summarized in the emergency procedures section of the Rotorcraft Flight Manual (RFM) or an EMS configuration RFM supplement.

(v) If any medical attendants are required for evacuation, the attendants should be trained in these procedures and listed in the limitations section of the RFM. If attendants are not essential for safe rotorcraft operation or rapid evacuation, then an attendant is not a required “crewmember.”

(3) Restraint of Occupants and Equipment. The emergency landing conditions specified in § 29.561(b) dictate the design load conditions. See AC 29-2, sections 29.561 and 29.785 for further information.

(i) Whether seated or recumbent, the occupants must be protected from serious head injury as prescribed in § 29.785. Swivel seats and tilt litters may be used

provided they are substantiated for the appropriate loads for the position selected for approval. Placards or markings may be used to ensure proper orientation for flight, takeoff, or landing and emergency landing conditions. The seats and litters should be listed in the type design data for the configuration. See paragraph b.(17) for substitutions.

(ii) For recumbent occupants, harnesses, straps, a padded headboard, a diaphragm, or safety belts may be used if in compliance with the load requirements of § 29.561(b) and § 29.785(k). Harnesses or straps are recommended. When used, they should prevent the occupant from significant forward motion in order to reduce occupant injuries. Infants in isolettes should be similarly protected by padding and containment within the isolette and the isolette restrained for the load cases noted in this paragraph. If the infant is strapped to a removable platform, there should be proper restraint of the platform and infant within the isolette for the load cases noted in this paragraph. Isolette materials are also subject to the flammability standards noted in paragraph b.(4). The litter(s) and isolette(s) should be listed in the type design data for the EMS configuration.

(iii) An isolette used for the transport of infants presents a special case, in that it may be included as part of an approved EMS configuration or it may be carried on the rotorcraft as needed for transport of infants. If the isolette is self-contained and is not part of an approved EMS type design, it may be considered a carry-on item and not part of the EMS type design. In these cases, there is typically a means to position the carry-on isolette and properly restrain the isolette for transport as part of the EMS design configuration.

(A) When the isolette is carry-on equipment, the operator must ensure that the isolette does not create a safety risk or interfere with aircraft operations. AC 135-14, Emergency Medical Services/Helicopter (EMS/H), provides information and guidance to air ambulance and EMS/H operators for large carry-on medical equipment such as isolettes. AC 135-14 includes the provision that isolettes are to be restrained in an appropriate manner and evaluated for specific emergency landing load factors as required by earlier amendments of the rotorcraft regulatory requirements. Since publication of AC 135-14, the emergency landing load requirements have changed for rotorcraft. Consequently; the load factors specified in that AC may not be appropriate for rotorcraft, depending on the rotorcraft certification basis amendment level of the airworthiness standards. The minimum load factors should be no less than those specified in the certification basis of the rotorcraft transporting the medical equipment, such as isolettes.

(B) A placard indicating that the isolette should be evaluated per the guidance contained in AC 135-14 and restrained to the emergency landing load factors for rotorcraft occupants per 14 CFR 29.561(b)(3) or the appropriate reference based on the certification basis of the rotorcraft, should be placed in close proximity to the isolette mount location.

(iv) Galleys, medical supplies, and equipment compartments or modules should be restrained and the individual compartments must also contain the contents for the conditions noted in paragraph b.(3) of this guidance. Durable placards, decals, or markings should be used where appropriate to limit the maximum weight of any compartment and the whole module. Compartment latches having sufficient strength and displacement or engagement should be used to contain the contents for the conditions noted in paragraph b.(3) of this guidance. If necessary, a static load test or analysis should be employed to ensure the container or compartment remains intact and the latch does not disengage for the most critical conditions. Loose or unrestrained contents in an individual compartment, in combination with similar compartments, should require a magnification factor with the design conditions. Prudent design and location of compartments having heavy, unrestrained (loose) equipment will mitigate the potential effects of landing impact loads.

(4) Flammability of Materials. Interior materials must meet the flammability standards appropriate for the rotorcraft type design in § 29.853.

(i) For rotorcraft certified prior to adoption of Amendment 29-17 (1978), the cabin materials must be at least flash resistant and wall, ceiling linings, the covering of all upholstery, floors, and furnishings must be at least flame resistant. AC 23-2, Flammability Tests, contains test information about flash and flame-resistant material.

(A) Flash-resistant material may be characterized as that not exceeding a 20-inch-per-minute (horizontal) burn rate. See AC 23-2, Flammability Tests, for further information.

(B) Flame-resistant material may be characterized as that not exceeding a 4-inch-per-minute (horizontal) burn rate.

(ii) For rotorcraft certified to Amendment 29-17 adopted in 1978, the materials must be self-extinguishing as specified in the standards. For example, transparencies must be self-extinguishing as prescribed in § 29.853(a)(2).

(iii) Additionally, for rotorcraft certified to standards of Amendment 29-23 (1984), cushions of each passenger seat must have a “fire blocking layer” as prescribed in § 29.853(b).

(iv) When the isolette is included in the EMS configuration approval, the isolette materials are subject to the flammability standards of § 29.853. The current standards require that all materials, including transparencies, fabric (e.g., padding, covers), straps, etc., be self-extinguishing for each compartment used by crew or passengers.

(v) The applicant is urged to use self-extinguishing materials regardless of the certification basis.

(vi) For further information on materials, refer to AC 29-2, section 29.853. AC 23-2 also contains information about flash-resistant and flame-resistant material tests.

(5) Exit Signs or Markings and External Markings. The approved exits require signs and markings (instructions) for prompt evacuation even in darkness. The rotorcraft type design contains the required data. The maintenance manual and the RFM should also contain this information. See AC 29-2, section 29.811 for more information. Alternates may be approved, which then become part of the applicant's type design data. All U.S. transport rotorcraft presently in service should have an emergency interior lighting system to comply with § 29.811(f). (Refer to the certification basis of the rotorcraft.)

(6) Interior or "Medical" Lights. The view of the flightcrew must be free from glare and reflections that could cause interference. Use of a night vision imaging system (NVIS) should be a consideration in this evaluation. Curtains that meet flammability standards may be used. Complete partition or separation of the crew and passenger compartment is not prudent. Means for visual and oral communication are usually necessary. Refer to AC 29-2, section 29.773, which concerns pilot visibility.

(7) Patient Interference. When passengers or patients are located in close proximity to the pilot and the primary flight controls of the rotorcraft, a guard or shield should be installed, or the patient should be restrained to prevent inadvertent or potential patient interference with safe operation of the rotorcraft. The guard may be a part of the rotorcraft interior features. In addition, prompt evacuation should be ensured if a guard is used.

(8) External Devices.

(i) Search lights, loud speakers, baggage pods, etc., may be installed on the underside of or elsewhere on the rotorcraft. The strength of the attachments must be substantiated for the flight and landing conditions. The lights and the reflection from the lights should not adversely affect pilot view or visibility. Use of NVIS should be a consideration in this evaluation.

(ii) The device or pod located on the underside of the rotorcraft should not contact a level landing surface after "limit landing load" deflection of the landing gear. The gear should deflect without causing damage to the device. For example, if the limit landing load deflection is 8 inches, the device would need to have at least 8-inch clearance to avoid contact with the landing surface or have an equivalent feature of design. The physical characteristics of the rotorcraft design dictate the necessary clearance for landing gear deflection. In addition, the device should be designed and located on the rotorcraft to preclude penetration of the device into a critical area of the fuselage. For example, the device should be located to minimize the potential of penetration into a fuel line, fuel cell, primary control tube, or occupant seat for any reason.

(iii) A flight evaluation is necessary to determine the effects of the device on the rotorcraft flight characteristics and on flight crew visibility. In addition, recent service history has shown that external equipment and external fixture modifications can affect main rotor mast bending loads. In lieu of a mast bending survey, a pre and post modification flight test may be conducted at the same gross weights, center-of-gravity (CG), power, and density altitude to compare a critical control position parameter (typically longitudinal cyclic stick position) at pre and post modification  $V_{ne}$  airspeeds.

(A) If required, the post modification  $V_{ne}$  should be reduced so that the post modification longitudinal cyclic stick position is slightly aft of (or less than) the pre modification stick position. This alternative procedure assumes that the static longitudinal stability of the helicopter has not been altered by the modification. For helicopters with neutral static stability, a more comprehensive investigation may be required.

(B) In some cases, a control position parameter other than longitudinal stick position may be critical. For example, a heavy external device mounted to the side of the helicopter that gives a lateral CG close to the limit and an asymmetric yaw component would require pre and post modification lateral cyclic stick and pedal position measurements. Operating limitations other than  $V_{ne}$  may need to be established, or reduced from pre modification limitations, to ensure pre-modification mast bending is not exceeded.

(9) Miscellaneous. Various paragraphs in this MG contain guidance for the standards cited in the reference list (paragraph c.(1)). These paragraphs should provide insight into designing an EMS configuration that would be acceptable under the standards.

(10) Oxygen. EMS oxygen installations are supplied by either liquid or gaseous oxygen. Both types of systems are discussed in this paragraph.

(i) Liquid Oxygen.

(A) System General Description. Most liquid oxygen systems in use are installed in military aircraft and, as a result, much of this material is based on experience with these systems. A rotorcraft liquid oxygen system should be comprised of a liquid oxygen converter, tubing, fittings, quantity gage, heat exchangers, and appropriate pressure and flow control components as shown in figures AC 29 MG 6-1 and AC 29 MG 6-2. The installation may provide for replenishing the liquid oxygen supply by use of a quick-removable converter or, in the case of a fixed installation converter, by providing external access for connection to a portable service trailer. More complicated systems such as those with multiple converter assemblies are not discussed here since installation of those systems are not envisioned in rotorcraft at this time.

(B) System Components. All components should be aircraft qualified and suitable for use in an EMS rotorcraft application.

(1) Liquid Oxygen Converter. A liquid oxygen converter assembly is a self-powered system for the storage of liquid oxygen and for its conversion to gaseous oxygen when required. A principal part of the converter assembly is a vacuum insulated container. Pressure relief valves should be provided to allow the escape of gas generated when oxygen is not being expended in the supply line. Oxygen losses from a converter assembly vary from 5 to 20 percent per 24 hours depending on the size of the container, its installation environment, and so forth. Aircraft qualified and approved converters suitable for EMS rotorcraft use are available in either 5 or 50-liter capacities. Size selection should be determined by flow rate and duration requirements. Performance characteristics of each converter size are available from the manufacturer.

(2) Shutoff Valve Assembly. This valve must be accessible to a flightcrew member and be mounted in the supply line on or as close as possible to the outlet of the converter. This valve provides for the confinement of the remaining supply of liquid oxygen to the converter in the event of an emergency. Since the system pressure is low, the use of an electrically actuated shutoff valve is satisfactory to accomplish this function. In some installations, where the evaporating coil is immediately adjacent to the converter, a flow fuse has been used to accomplish this function. Use of a flow fuse must be supported by a system fault analysis and testing to show maximum normal flow will not result in nuisance trips, and reliable trips will be provided for malfunction conditions resulting in excess flow.

(3) Filler Valve. Some designs combine this function with the build-up and vent valve assembly as shown in figure AC 29 MG 6-2.

(4) Build-up and Vent Valve Assembly. This valve is positioned in the "vent" position when the system is being filled with oxygen and in the "build-up position" at other times. Some designs combine this function with the filler valve as shown in figure AC 29 MG 6-2.

(5) Pressure Build-up Coil Assembly and Pressure Closing Valve. With the build-up and vent valve in the "build-up" position gas that is formed is allowed to apply pressure to the liquid to provide adequate flow through the check valve to the evaporating coil assembly. A connection to a pressure relief valve is also provided.

(6) Evaporating Coil Assembly. This is provided to convert the liquid oxygen into a gaseous form. The evaporating coil assembly should be of sufficient capacity to maintain the design flow quantity to the dispensing regulators at a temperature within +10 and -20°F of cabin ambient temperature. MIL-D-19326G contains a discussion of installation considerations for this unit.

(7) Vent Line. Gaseous oxygen escapes through this line. At the conclusion of the fill operation, liquid oxygen will flow overboard in a steady stream from

this line to indicate the container is full of liquid oxygen. The vent line should be located to drain overboard at the bottom of the rotorcraft fuselage. Flow from the overboard vent should be directed so as not to create a hazard for personnel and not allow liquid oxygen to come in contact with the rotorcraft. The vent lines should be insulated to prevent frosting and sweating if they pass over equipment that will be harmed by water dripping from the lines, or drip pans should be installed under the lines. There should be no hydrocarbon fills or drains, forward or above, in proximity to the vent outlet.

(8) Regulator. A regulator should be installed in the supply line downstream from the heat exchanger. The regulator should reduce the liquid oxygen converter operating pressure to a supply pressure of 50 pounds per square inch gauge (PSIG) to be compatible with the normal operating pressure of medical oxygen equipment.

(9) Flow Control Valve. This valve provides a calibrated flow of gaseous oxygen from an operating supply of  $50 \pm 5$  PSIG. A valve whose proof pressure is specified at 80 PSIG and has a burst pressure rating of 350 PSIG would be considered satisfactory.

(10) Check Valve. This valve prevents gaseous oxygen in the supply system from backing up into the liquid oxygen in the container and increasing the vaporization rate of the liquid oxygen by exposure to the gas. This valve is normally an integral part of the liquid oxygen converter assembly.

(11) Quantity Indicators. A quantity indicator should be installed at the appropriate rotorcraft crew station to permit monitoring of the liquid oxygen supply. The indicator when installed in the rotorcraft should indicate the amount of liquid oxygen in the converter. Adequate clearance should be provided for the indicator connectors so that they can be readily disconnected by servicing personnel. Provisions should be made for the storage of the rotorcraft connectors to the liquid oxygen converter when they are disconnected. Liquid oxygen quantity indicating equipment is available in three types: capacitance gauging, electro-mechanical transducer indication, and differential pressure type indication.

(12) Pressure Relief Valves. Pressure relief valves are provided to vent overboard through the overboard vent system any excess pressures developing within the system.

(13) Lines. Lines should be either solid tubing or flexible hoses. Examples of acceptable solid tubing are aluminum alloy conforming to AMS 4071 or corrosion resistant annealed steel (304) conforming to MIL-T-8506. Flexible hoses should be used for rotorcraft system connections to removable converters and to other applications where relative movement may occur. Flexible hoses should be wire-braid-covered bellows or wire-braid-covered tetrafluoroethylene. Flexible hoses conforming to MS90457 or MS24548 are satisfactory. MS90457 hose is flexible to  $-297^{\circ}\text{F}$  ( $-183^{\circ}\text{C}$ ), and MS24548 hose is flexible to  $-65^{\circ}\text{F}$  ( $-54^{\circ}\text{C}$ ). Synthetic lines such as plastic, nylon, or

rubber should not be used for lines subjected to continuous pressure, or for application where the line will not be visible. Lines that are not visible are those that are located behind liners or in the walls of the fuselage.

(14) Fittings. If in contact, dissimilar metals should be suitably protected against electrolytic corrosion. Line assemblies should be terminated with “B” nuts or a similar manufactured terminating connection. Universal adapters (AN 807) or friction nipples used in conjunction with hose clamps should be avoided in pressurized systems.

(15) Drain Valve. Systems that have permanently installed containers should include a drain valve located to allow for complete draining of the liquid oxygen container. An acceptable drain valve would be one in accordance with MK-V-25962 that is suitably capped. A cap in accordance with AN 929-5 with a permanently attached chain is a suitable cap.

(16) Low Pressure, Low Level Warning System. It is recommended that provisions be included in the system to alert the appropriate aircraft crew member that the level of the oxygen supply has reached some low level. It is recommended that low level be actuated when less than 10 percent of the full container capacity is available. If low system pressure is also monitored, the low pressure valve selected should be such that any drop in supply line pressure upon inhalation should not activate the low pressure warning function.

(C) Component Installation. The following are typical installation considerations that should be addressed when designing the oxygen system.

(1) Location. The oxygen equipment, lines, and fittings should be located as remotely as practicable from sources of flammable fluids, high heat and electrical items, fuel, oil, hydraulic fluid, batteries, exhaust stacks, manifolds, and so forth. Oxygen lines should not be grouped with lines carrying flammable fluids. If possible, converters should not be in line with the plane of rotation of a turbine. System components should not be installed in an environment that will exceed the temperature limit of the component, and no part of the system should be installed in an area that will exceed 350°F (176°C). To minimize loss due to heat, the liquid oxygen converter should not be located near equipment that dissipates a high quantity of heat.

(2) Converter Mounting. The oxygen container should be readily accessible to servicing personnel. If the container is not removable for servicing, the filler should be external to the aircraft with adequate contamination protection. Mounting provisions for the converter and plumbing to the evaporating coil assembly should include a drain pan with an overboard drain.

(3) Flexible Hoses. Hoses should be of sufficient length to provide unstressed connections and be protected against chafing on surfaces or objects that may damage the wire covering. The bend radius imposed on the hoses during

installation and replacement should not be less than the minimum established by the hose specifications.

(4) Lubricants. No lubricants should be used on liquid oxygen pipe fittings. MIL-T-27730 Teflon tape may be used on male pipe fittings when required. Teflon tape should not be used on flared tube fittings, straight threads, coupling sleeves, or on the outer side of tube flares. None of the tape should be allowed to enter the inside of a fitting. Krytox fluorinated grease by E.I. Dupont De Nemours and Company, or an equivalent, may be used sparingly on seals.

(5) Tubing Routing and Mounting. There should be at least 2 inches of clearance between the oxygen system and flexible moving parts of the rotorcraft. There should be at least a ½-inch clearance between the oxygen system and rigid parts of the rotorcraft. The oxygen system tubing, fittings, and equipment should be separated at least 6 inches from all electrical wiring, heat conduits, and heat emitting equipment in the rotorcraft. Insulation should be provided on adjacent hot ducts, conduits, or equipment to prevent heating of the oxygen system. In routing the tubing, the general policy should be to keep total length to a minimum. Allow for expansion, contraction, vibration, and component replacement. All tubing should be mounted to prevent vibration and chafing. This should be accomplished by the proper use of rubberized or cushion clips installed at 24-inch intervals (copper) or 36-inch intervals (aluminum) and as close to the bends as possible. The tubing, where passing through or supported by the rotorcraft structure, should have adequate protection against chafing by the use of flexible grommets or clips. The tubing should not strike against the rotorcraft structure during vibration and shock encountered during normal use of the rotorcraft.

(6) System Marking. The rotorcraft should be permanently and legibly marked, as applicable, in the locations specified below (a minimum letter height of ¼ - inch is recommended):

(i) Adjacent to the overboard vent opening:

**CAUTION  
LIQUID OXYGEN VENT**

(ii) On outside surface of filler box cover plate:

**LIQUID OXYGEN (BREATHING) FILL ACCESS**

(iii) On underside surface of filler box cover plate:

**CAUTION - KEEP CLEAN, DRY, AND FREE FROM OILS**

(iv) In prominent place when filler box is open, preferably near liquid oxygen drain valve:

**DO NOT OPEN DRAIN VALVE UNTIL DRAIN HOSE  
AND DRAIN TANK ARE CONNECTED**

(v) Other placards, such as one at the converter cautioning about the presence of liquid oxygen, may also be appropriate.

(7) Other installation criteria are given in Chapter 6 of AC 43.13-2, Acceptable Methods, Techniques, and Practices-Aircraft Alterations, and should be given consideration.

(D) Precautions. The referenced Society of Automotive Engineers (SAE) report contains precautions peculiar to a liquid oxygen installation, and this material should be reviewed. It should also be emphasized that liquid oxygen equipment and the aircraft being serviced must be electrically grounded during servicing to prevent an accumulation of static electricity and discharge. The following considerations are included for special emphasis:

(1) System Cleanliness. The completed installation should be free of oil, grease, fuels, water, dust, dirt, objectionable odors, or any other foreign matter, both internally and externally prior to introducing oxygen in the system.

(2) Closures. Lines that need to be disconnected during rotorcraft maintenance checks or overhaul, due to the location of the converter within the rotorcraft, should be capped to prevent materials that are incompatible with oxygen from entering the system when the system integrity is broken. Caps that introduce moisture and tapes that leave adhesive deposits should not be used for these purposes. All openings of lines and fittings should be kept securely capped until closed within the installation.

(3) Degreasing. All components of the oxygen system should be procured for oxygen service use in an "oxygen clean" condition. Parts of the oxygen system, such as tubing, not specifically covered by cleaning procedures should be degreased using a vapor phase trichloroethane degreaser. Ultrasonics may be used in conjunction with vapor phase degreasing for the cleaning of components.

(4) Purging. The system should be purged with hot, dry 99.5 percent pure oxygen gas in accordance with the manufacturers recommendations after:

(i) Initial assembly of the oxygen system; and

(ii) After system closure whenever the oxygen system pressures have been depleted to zero, or the system has been left open to atmospheric conditions for a period of time or is opened for repairs.

(5) Maintenance and Replacement. All parts of the oxygen system should be installed to permit ready removal and replacement without the use of special

tools. All tubing connections and fittings should be readily accessible for leak testing with a leak test compound formulated for leak testing oxygen systems and for tightening of fittings without removing surrounding parts.

(ii) Gaseous Oxygen.

(A) General. This guidance is intended to supplement the existing guidance in AC 43.13-2, Chapter 6. If there are any differences within the two ACs, this guidance prevails since it pertains specifically to part 29 requirements.

(B) System Components.

(1) High Pressure Cylinders. Many installations utilize hospital type cylinders rather than aviation type cylinders. A concern with the hospital type cylinders is the yoke and the hard plastic washer that is commonly used with these cylinders. It is very difficult to properly attach these yokes since the rotorcraft provides a high vibration environment and no positive lock is provided. Leaks are a continuous problem with this configuration. Yokes are available for these bottles that provide for a positive lock. Improved washers that provide for a good elastomeric seal and include a metal ring to limit crushing the washer are also available. If the hospital type bottles are to be used, only the modified yokes and improved seals should be considered for future installations. The preferred cylinder is the aviation type cylinder with the integral shut-off valve and regulator. All cylinders should be DOT approved.

(2) Lines.

(i) General. Any lines that pass through potential fire zones should be stainless steel.

(ii) High Pressure. Use of high pressure lines may be necessitated by the use of a pressure regulator that is remote from the cylinder. The intent is to locate the regulator as close as physically possible to the cylinder, and to minimize the use of fittings. Lines of 6-inch lengths are encouraged with 18-inch lengths being the maximum in unusual circumstances. Lines made of stainless steel are recommended.

(iii) Low Pressure. Although lines may only be subjected to low pressures, if they are located behind upholstery or for any reason are not 100 percent visible during normal operation, they should be solid metal lines or high pressure flexible lines that conform to SAE 100R14A specifications for stainless braided hoses. Other oxygen lines, so called "green lines," should only be used in locations that are 100 percent visible during normal operation. This would restrict their use to the run between the mask and the bulkhead disconnect in the aircraft cabin. Synthetic lines such as plastic, nylon, or rubber are not recommended for applications that will be exposed to continuous pressure (i.e., as opposed to pressurized when needed). These materials can cold flow.

(3) Fittings.

(i) High Pressure. Intercylinder connections are made with regular flared or flareless tube fittings with stainless steel. Usually fittings are of the same material as the lines. Mild steel or aluminum alloy fittings with stainless steel lines are discouraged. Titanium fittings should never be used because of a possible chemical reaction and resulting fire.

(ii) Low Pressure. Fittings for metallic low pressure lines are flared or flareless, similar to high pressure lines. Line assemblies should be terminated with "B" nuts in a similar manner to a manufactured terminating connection. Universal adapters (AN 807) or friction nipples used in conjunction with hose clamps are not accepted for use in pressurized oxygen systems.

(4) Shut-off Valve. Each system should contain a shutoff valve that is located as close as practical to the high pressure cylinder(s), and it should be assessable to a flightcrew member. High pressure cylinders should use slow opening and closing system shut-off valves. Where the regulator is part of the cylinder, and low pressure oxygen is controlled, the emphasis in slow acting valves is not as significant, and use of a flow fuse may be possible. Use of a flow fuse must be supported by a system fault analysis and testing to show maximum normal flow will not result in nuisance trips, and reliable trips will be provided for malfunction conditions resulting in excess flow.

(5) Regulators. The regulator should be mounted as close as possible to the cylinders (see paragraph b.(10)(i)(B)(8) of this guidance). If non-aviation qualified regulators are considered, their service history should be reviewed and careful consideration given to the manufacturer's environmental qualification. Radio Technical Commission for Aeronautics Document D0-160 is a recognized and accepted standard for environmental considerations. As a minimum, consideration should be given to operation during altitude, temperature, and vibration extremes.

(6) Placards. Appropriate placards should be provided with the installed system. Emphasis should be placed on any precautions that are appropriate during filling of the system and so forth.

(7) Filler Connections. When a filler connection is provided, it is recommended it be located outside the fuselage skin or isolated in a manner that would prevent leaking oxygen from entering the rotorcraft. Careful evaluation should also be made of any nearby sources of fuel, oil, or hydraulic fluid under normal or malfunction conditions. Each filler connection should be placarded. In addition, any valves (on aircraft or ground servicing equipment) associated with high pressure should be slow acting.

(C) "Provisions Only" Considerations. In some instances systems are approved that only include provisions for a supply system consisting of the high

pressure cylinders, regulators, and their associated lines and fittings. In these instances, a placard should be provided that refers to a supply system that is considered satisfactory for the remainder of the installation. An example of an acceptable placard for this situation is:

Oxygen Supply System must be in accordance with the requirements given in STC SH \_\_\_\_\_. Deviations to the configuration specified must be evaluated and approved by the Manager (include reference to the appropriate FAA ACO).

(11) Medical Communication Equipment. This equipment is provided to allow for communication between the rotorcraft and ground medical personnel. It includes voice communication and may also include telemetry equipment for the transmission of graphic data. It should be demonstrated that this equipment functions properly and the range at which this determination was made recorded in the project file. The functional demonstration should include a 360° turn (clockwise and counterclockwise) to ensure no significant sections of signal blanking exist. The remainder of the emphasis on this equipment should be to ensure that operation of this equipment does not interfere with normal operation of any rotorcraft systems whose installation is required for safe operation of the rotorcraft.

(12) Cabin Lighting. EMS interiors normally include higher intensity cabin lighting than other interiors. This lighting capability should be carefully evaluated to ensure it does not interfere with operation of the rotorcraft. In some installations a special curtain is required to separate the cockpit from any interference by the lighting. The FAA project file should document the approach of how this evaluation was conducted. See paragraph b.(6) for other curtain considerations.

\*(13) FDMS. If required under an operating regulation, an FDMS (not to be confused with a flight data recorder (FDR) certificated under § 29.1459) may be comprised of a system or combination of systems that record a helicopter's flight performance and operational data. An FDR certificated under § 29.1459 and the appropriate operating rules would be acceptable to meet this requirement; however, an FDMS would not be adequate to meet the § 29.1459 requirement for an FDR. The FDMS should be capable of capturing digital or analog raw data, images, cockpit voice or ambient audio recordings, or any combinations thereof, according to a broadly defined set of parameters including information pertaining to the aircraft's state, condition, and system performance. This data can be used to perform post flight analysis and provide critical information to investigators in the event of an incident or accident as well as to promote operational safety. When used in conjunction with an FAA-approved flight operations quality assurance (FOQA) program, part 135 certificate holders would be required to collect flight performance and operational data that characterizes the state of the helicopter and its subsystems that the certificate holder determines is pertinent to its safety program. FDMS data should be recorded and stored on digital media, and when selecting a location to install the hardware device used for storing the data, consideration should be given to the potential for survival in

the event of a crash. The system should receive electrical power from the helicopter's bus that provides the maximum reliability without jeopardizing service to essential or emergency loads, and capable of being operated continuously from the time power is applied to the aircraft until power is removed from the aircraft.

(i) Safety. The FDMS equipment should not, under normal or fault conditions, adversely affect the airworthiness of the systems to which it is interfaced or of other aircraft systems. The equipment should be installed in accordance with all applicable safety regulations. The equipment should be tested under the standards of RTCA DO-160F, "Environmental Conditions and Test Procedures for Airborne Equipment," or subsequent issue. The European Organization of Civil Aviation Equipment (EUROCAE) specification ED-14 may be used in lieu of RTCA DO-160. Additional crashworthiness testing may be conducted according to EUROCAE specification ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recording Systems." Equipment testing should be conducted to the categories most applicable to the aircraft type, and the location of the equipment to be installed. The equipment manufacturer typically defines the test class within each environmental category. The objective of this level of testing is to ensure that the equipment does not present a hazard to the aircraft, and can survive and continue to operate under the environmental conditions to which it will be subjected throughout its life. Specific testing may be required to demonstrate that the equipment performs its intended function when operated over the full environmental conditions to which it has been declared to comply. Consideration should be given to the extremes at which it may be subjected during an incident or accident. These tests can be undertaken during the specified RTCA DO-160F (or later revision) tests or separately. Analysis may be substituted for a test where its use can be shown to produce equivalent evidence of compliance. The system should be capable of recording up to 2 hours of image or acoustical data and 6-hours of aircraft parameter data. The applicant determines and maintains the data stream format and parameter documentation, including which parameters are recorded, how often the parameters are recorded, the bit resolution of each parameter, the operational range of each parameter, and the conversion algorithm from decimal units to engineering units. The Design Assurance Level (DAL) for an FDMS that is required by an operating regulation is DAL "D." RTCA DO-178B (or later revision) provides acceptable software development standards, which in this case would be for DAL "D" software. RTCA DO-254 (or later revision) provides acceptable airborne electronic hardware (AEH) development standards, which in this case would be for DAL "D" AEH.

Note: The duration between data downloads for the promotion of operational safety within a FOQA program is directly correlated to the recording capabilities of the system installed.

(ii) Recording. The FDMS should be capable of capturing and recording any combination of the following parameters in order to monitor the aircraft's state, condition, and system performance:

- Positioning system time.

- Positioning system latitude.
- Positioning system longitude.
- Positioning system altitude.
- Positioning system error.
- Altitude.
- Heading.
- Pitch attitude.
- Pitch rate.
- Roll attitude.
- Roll rate.
- Yaw rate.
- Air speed.
- Ground speed.
- Ambient acoustic data.
- Engine parameters.
- Main rotor revolutions per minute.
- Transmission ambient audio.
- Any other parameters deemed appropriate by the operator.

Notes: Parameters may be recorded directly or deduced from recorded data from the FDMS. Additional guidance on parameters can be found in EUROCAE specification ED-155.

Recording individual pilots, using hot microphones, on separate pilot audio channels can provide useful information in the investigation of incidents and accidents.

(iii) Maintenance. The maintenance requirements to ensure the serviceability and continued airworthiness of the FDMS are typically established by the equipment manufacturer and installer. These maintenance instructions should be included in the applicable helicopter model instruction for continued airworthiness.

\*(14) Radio Altimeter (RAD ALT). RAD ALTs installation is required. Its information display must be in the pilot's primary field of view in all helicopters operating under a part 135 certificate. The minimum performance requirements for an FAA approved RAD ALT system can be found in TSO-C87.

(15) Other EMS Equipment. These items of equipment installed for the EMS mission are considered optional equipment and should be operated to ensure they function properly. This evaluation would normally be done by someone knowledgeable about the particular type of equipment, since correct operation of the equipment is essential to a valid determination that the required rotorcraft systems are not being interfered with. This includes all removable pieces of medical equipment that are used for patient care. The primary purpose of the evaluation of this equipment is to emphasize the possibility of any interference between operation of the EMS equipment

and the systems whose installation is required for safe operation of the aircraft, the adequacy of the installation provisions, and assurance that failure modes will not result in a hazardous condition for the rotorcraft.

(16) Miscellaneous. The following areas are not peculiar to EMS installations; however, their significance is enhanced by the complexity of an EMS installation.

(i) Compatibility. Many EMS installations are a collection of several STCs and may also include some FAA field approvals. For this situation, it should be shown that the overall installation provides for safe operation of the aircraft. Operation of a search light, if included, should be addressed since in using this system it can be difficult to keep light from interfering with the pilot view.

(ii) Electrical Load Analysis. An electrical load analysis should be conducted, and additional guidance is available in AC 29-2 MG 1. If the analysis indicates the generator(s) can be overloaded, appropriate measures should be taken to account for the problem. In some instances (e.g., in a visual flight rules (VFR) approved rotorcraft), a placard that specifies certain operating limitations may be satisfactory, while in other instances (e.g., in an instrument flight rules (IFR) approved rotorcraft), an electrical interlock may be in order. In general, if the amount of overload is relatively small and the rotorcraft is not an IFR-approved rotorcraft, the placard solution will probably be satisfactory, whereas if the amount of possible overload is significant, it is more likely that an interlock scheme will be necessary.

(iii) Aircraft Grounding. It should be emphasized in an appropriate place in the STC data (e.g., RFM, maintenance information) that any time the EMS systems are being operated or serviced (e.g., oxygen) on the ground, the rotorcraft itself must be grounded.

(iv) Electrical Outlets. All electrical outlets provided in the cabin should be the three-prong grounded type. When not in use, these outlets should be suitably protected against the entry of fluids.

(v) Placards. All medical outlets (e.g., air, oxygen, vacuum) should be placarded. Electrical power outlets should be placarded for type of voltage and amperage capacity. A placard stating "No Smoking When Oxygen Is In Use" should be included. Other placards would include information appropriate to the oxygen system, operation of special controls, etc.

(vi) Equipment in Cargo and Baggage Compartments. When components are added to the compartment, revisions should be made to protect the system components due to shifting cargo. In addition, when oxygen components are installed, the compartment should be placarded against the storage of oil or hydrocarbons. A smoke detector is recommended for a compartment if oxygen cylinders are installed in a closed, non-accessible compartment. Also, the compartment weight limitations placard

should be changed. AC 29-2, section 29.787 pertains to cargo and baggage compartments.

(vii) Safety Assessment. When installing any new equipment or modifying existing equipment, a safety assessment must be made to assure the FAA that all possible failure conditions that could occur from these changes have been adequately addressed to show compliance to the regulations.

(17) Equipment Substitution. The EMS modification that is presented for approval will contain specific items of equipment, and the approval will make reference to this equipment. If other equipment (e.g. new model, manufacturer) is to be substituted, then an evaluation should be made to ensure the substitute equipment is also satisfactory. This evaluation would normally consist of comparing the attachment means, design features, failure modes, specifications, and operation of the two units. The purpose of the evaluation is to ensure there are no differences that have an adverse effect on the airworthiness of the installation. Other differences would not be considered significant. A specific seat and litter design is approved as a part of the EMS configuration. Substitutions may be approved in accordance with the standards.

c. Related Regulations and References.

(1) Regulatory Sections. 14 CFR 29.337, 29.471, 29.561, 29.773, 29.783, 29.785, 29.803, 29.805, 29.809, 29.811, 29.813, 29.815, 29.831, 29.853, 29.1301, 29.1309, 29.1353, 29.1357, 29.1411, 29.1431, 29.1557(d), 29.1583(d), 29.1585, 29.1589, part 91, and part 135.

(2) Other References Refer to the current version of each document.

(i) Helicopter Association International, Emergency Medical Services Recommended Guidelines.

(ii) National Highway Traffic Safety Administration, Air Ambulance Guidelines.

(iii) AC 23-2, Flammability Tests.

(iv) AC 43.13-2, Acceptable Methods, Techniques, and Practices-Aircraft Alterations.

(v) AC 135-14, Emergency Medical Services/Helicopter (EMS/H).

(vi) Oxygen Equipment for Aircraft, Society of Automotive Engineers Aerospace Information Report No. 825.

(vii) MIL-D-19326G, Design and Installation of Liquid Oxygen Systems in Aircraft, General Specification for Military Specification.



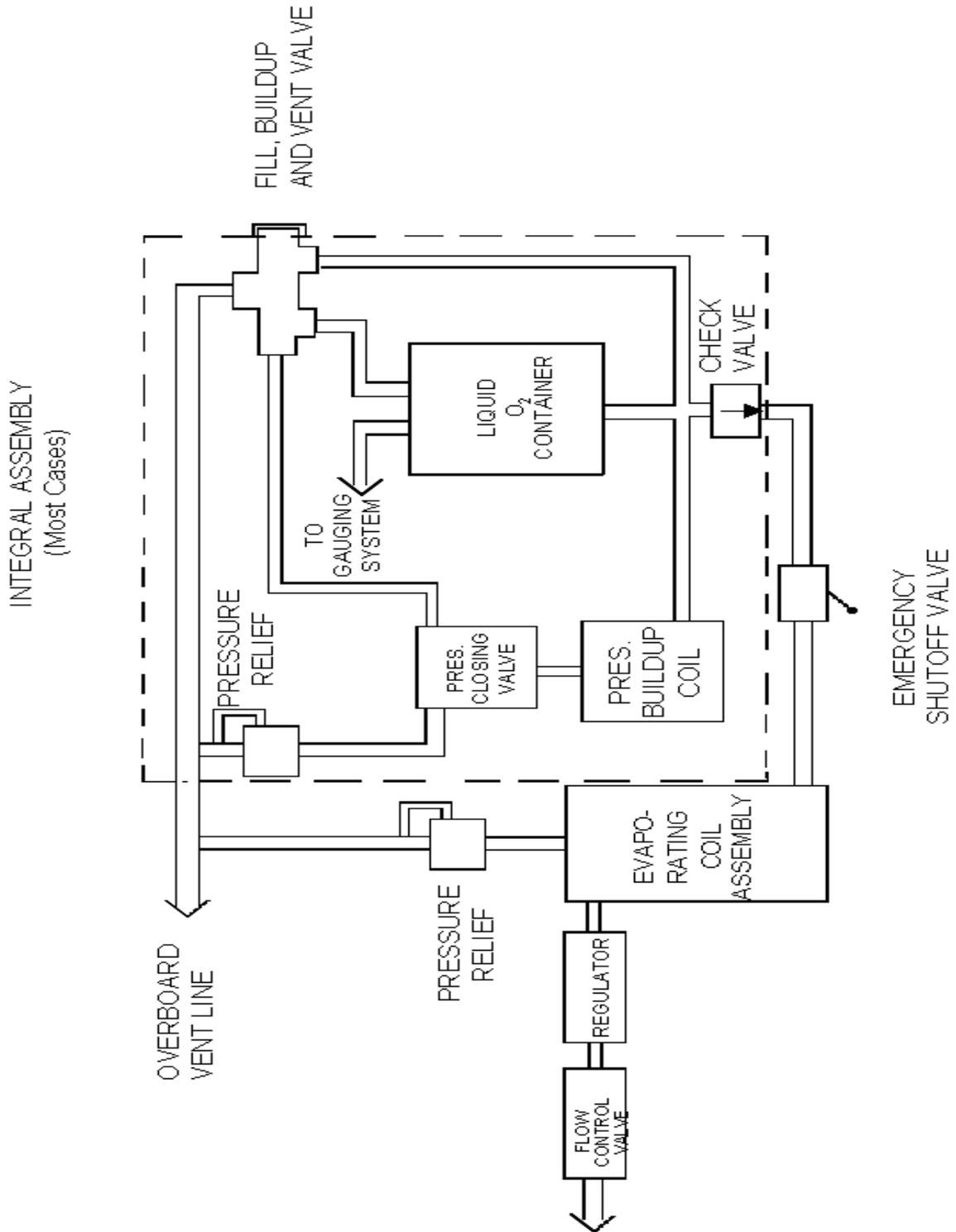


FIGURE AC 29.MG 6-2 TYPICAL LIQUID OXYGEN SYSTEM - USING COMBINATION VALVE