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Electromechanical Power Controller/Relay, General Specification For

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Documents

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1. SCOPE:

1.1 Scope:

This specification establishes general requirements for a family of trip-free Electromechanical Power Controller/Relays (EMPC) with electronic overcurrent sensing and control, intended for use in electrical systems conforming to RTCA, D0160 Revision C. These devices will be utilized for the protection of ac and/or dc electrical systems, bus feeders, and electrical equipment.

1.2 Application Note:

System protection requirements vary by application and must be considered when selecting an appropriate EMPC or other protective device.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2422 Plating, Gold

2.2 US. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-PRF-5624	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-PRF-7808	Lubrication Oil, Aircraft Turbine Engine, Synthetic Base
MIL-A-8243	Anti-Icing and Deicing-Defrosting Fluid
MIL-PRF-15160/2/3	Fuses: Instrument, Power and Telephone (Nonindicating)
MIL-PRF-23699	Lubrication Oil, Aircraft Turbine Engine, Synthetic Base
MIL-C-87937	Cleaning Compound, Aircraft Exterior Surfaces, Water Dilutable
MIL-H-5606	Hydraulic Fluid, Petroleum Base; Aircraft; Missile and Ordnance
MIL-H-83282	Hydraulic Fluid, Fire Resistant, Synthetic, Hydrocarbon Base
MIL-PRF-83536	Relays, Electromagnetic, Established Reliability, General Specification for
FED-STD-H28	Screw Thread Standards for Federal Services
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-461	Control of Electromagnetic Interference Emissions and Susceptibility, Requirements for the
MIL-STD-462	Measurement of Electromagnetic Interference Characteristics, Test Method Standard for
MIL-STD-790	Standard Practices for Established Reliability and High Reliability Qualified Products List (QPL) Systems for Electrical, Electronic, and Fiber Optic Parts Specifications
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
MS20659	Terminal Lug, Crimp Style, Copper, Uninsulated, Ring-Tongue, Type 1, Class 1
MS25036	Terminal Lug, Crimp Style, Copper, Insulated, Ring-Tongue, Bellmouthed, Type II, Class 1
DOD-HDBK-263B	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

2.3 RTCA Publications:

Available from RTCA Inc., 1140 Connecticut Avenue, NW, Suite 1020, Washington, DC 20036.

RTCA/DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.4 Substitution of Industry/Commercial Equivalent Specifications:

The documents identified as applicable to this specification, to the extent specified herein, are considered baseline and preferred documents for devices produced in compliance to this specification. Substitution of Industry/Commercial equivalent specifications is acceptable if approved by the procuring authority, documented during solicitation, and identified on the specification sheets (see 3.1).

2.5 Order of Precedence:

In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS:

3.1 Specification Sheets:

The individual items requirements shall be as specified herein and in accordance with the applicable detail specification sheets. In the event of any conflict between requirements of this specification and the specification sheets, the latter shall govern.

3.2 Qualification:

The EMPCs furnished under this specification shall be a product which has been tested, and has passed the qualification inspection specified herein.

Qualification can be established by one of two methods:

- a. Qualify to an established Reliability Level (Type ER) using the Weibull Method and maintain qualification by continued testing to point of failure and plotting the failure point by established procedures (see 4.8).
- b. Qualify by the standard methods of following the Qualification test program of Table 5, and maintain qualification by repeated testing to Plan B and Plan C.

3.3 Materials:

Materials shall be used which will enable the EMPC to meet the performance requirements of this specification. Materials used externally shall be fungus inert per RTCA-DO-160 Revision C Section B, and shall be self-extinguishing, and shall not support combustion or give off noxious gasses in harmful quantities. Materials used internally shall not give off gasses in quantities sufficient to cause explosion of sealed enclosures, cause contamination of the contacts or other parts of the EMPC which prevent meeting the requirements specified herein. The selection of materials shall be as such as to provide maximum shelf life.

3.3.1 Metals: Metals shall be of a corrosion resistant type or shall be plated or treated to resist corrosion.

3.3.1.1 Plated Finishes:

- a. Use of tin plating is prohibited internally and externally. Use of tin-lead finishes or other tin-alloy finishes are acceptable provided that the minimum lead content is 3%.
- b. Use of zinc plating is prohibited internally and externally.
- c. Use of cadmium plating is prohibited internally and externally.

3.3.1.2 Dissimilar Metals: When dissimilar metals are used in intimate contact with each other, protection against electrolysis and corrosion shall be provided. Active electrolytic corrosion is not acceptable. When dissimilar metals are in contact, a 0.2 V maximum per compatible couple must not be exceeded.

3.3.2 Interface and Construction Requirements: EMPCs shall meet the interface and construction requirements (see 3.1) (i.e., weight, physical dimensions).

3.3.2.1 Case: Unless otherwise specified (see 3.1), the case shall not be electrically connected to the contacts or coil, however, it may be used as part of the magnetic circuit.

3.3.2.1.1 Case Grounding: Means for EMPC case to ground shall be as specified to the maximum impedance (see 3.1).

3.3.3 Sealing (see 4.6.2): EMPCs may be hermetically sealed, environmentally sealed or gasket sealed and vented and must meet the performance requirements (see 3.1). Adjunct sealant, if used, must comply with the following characteristics: a) shall not extend above 20% of the length of the exposed terminals above the glass meniscus; b) trace color is permitted if it is a natural result of the sealing process.

- 3.3.4 Electrostatic Discharge Sensitivity (ESDS): EMPCs, when applicable, shall be classified as ESDS sensitive.
- 3.3.4.1 ESDS Protection Program: This requirement is applicable to all manufacturers who handle ESD component parts and/or materials in the EMPC manufacturing and/or testing process. The manufacturer shall establish and maintain an ESD control program. Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification. As a minimum, this system must address the identification of ESD sub-components and end items, facilities, training, design protection, handling procedures, marking, cleaning, preservation, packaging, and quality assurance. A model ESD control program is available from the qualifying activity and may be used as a guideline document. Further guidance for ESD control is available from the EOS/ESD Association and EIA.
- 3.3.5 Contacts: Contacts shall have load ratings and arrangements as specified (see 3.1), and shall be capable of carrying the rated current continuously as well as making and breaking the rated current under tested conditions specified in this document.
- 3.3.6 Coils: Coils shall be insulated electrically from the contacts and the case. The coil resistance and rated voltage (or current) shall be as specified (see 3.1). Unless otherwise specified, coils shall be designed for continuous operation at maximum rated voltage, temperature and altitude.
- 3.3.7 Latching EMPCs: Latching EMPCs with two coils shall be so designed that if both coils are energized simultaneously, the contacts shall not assume a neutral position and the status output must be in agreement with the power contacts.
- 3.3.8 Attitude: The EMPC shall be constructed to insure proper operation when mounted in any attitude.
- 3.3.9 Mounting Brackets: When brackets are used, they shall be an integral part of the EMPC housing or shall be securely attached thereto in a manner to prevent any movement between the EMPC and the mounting bracket in service use.
- 3.3.10 Enclosures:
- 3.3.10.1 Unsealed Enclosure: Unsealed EMPCs shall be totally enclosed for mechanical and dust protection and shall be explosion-proof (see 3.19). The enclosure design shall be such that pressure differentials cannot exist between the inside and outside. Metal covers shall be provided with a means for grounding as specified (see 3.1).
- 3.3.10.2 Hermetically Sealed Enclosure: Hermetically sealed enclosures shall be constructed as a gas-tight enclosure. Hermetically sealed EMPCs, other than vacuum EMPCs, shall be purged of all air and filled with a suitable gas. The gas leakage rate shall be in accordance with 4.6.2.

- 3.3.11 Threaded Parts (see 3.1): All threaded parts shall be in accordance with FED-STD-H28. Where practical, all threads shall be in conformity with the coarse thread series. The fine thread series shall be used only for applications that might show a definite advantage through their use.
- 3.3.12 Installation Clearances (see 3.1): No special tools shall be required for installation.
- 3.3.13 Terminals (electric): When applicable (see 3.1), no rotation or other loosening of a terminal, or any fixed portion of a terminal, shall be caused by material flow or shrinkage, or (for threaded terminals) any mechanical forces specified in Table 1 involved in connection or disconnection, throughout the life of the EMPC.

TABLE 1 - Strength of Threaded Terminals (Static Value of Pull and Torque)

Thread Size	Force in Pounds	Test Torque in Pound-Inches	Recommended Installation Torque Pound-Inches
4-40 (.112 UNC)	5	4.4	3.3
6-32 (138 UNC)	30	10.0	7.5
8-32 (.164 UNC)	35	20.0	15.0
10-32 (.190 UNF)	40	32.0	24.0
1/4-28 (.250 UNF)	50	75.0	56.3
5/16-24 (.312 UNF)	70	100.0	75.0
3/8-24 (.375 UNF)	100	150.0	112.5
7/16-20 (.438 UNF)	100	150.0	112.5
1/2-20 (.500 UNF)	100	150.0	112.5

- 3.3.13.1 Stud Terminals (threaded): When applicable (see 3.1), stud terminals shall be supplied with hardware as specified. With the hardware supplied, a minimum of three complete threads shall remain above the nut when it is backed off three complete turns from a position with all hardware tightened in place.
- 3.3.13.1.1 Stud Terminal Seat: When applicable (see 3.1), each terminal shall have a terminal seat that shall provide adequate current conducting path to meet specification.
- 3.3.13.1.2 Strength of Stud Terminals: When tested as specified in 4.7.11 stud terminals shall withstand the static value of pull and test torque specified in Table 1.

- 3.3.14 Mounting Studs: Mounting studs shall be as specified (see 3.1). No rotation, loosening, or deformation of fixed portions shall occur because of material flow or any mechanical forces involved in installation or removal of the EMPC. The mounting studs shall withstand for 1 min, without damage, the static values of pull and torque specified in Table 2.

TABLE 2 - Strength of Mounting Studs (Static Values of Pull and torque)

Thread Size	Force in Pounds	Test Torque in Pound-Inches	Recommended Installation Torque Pound-Inches
40-40 (.112 UNC)	7	10	7.5
6-32 (.138 UNC)	25	18	13.5
8/32 (.164 UNC)	35	37	27.8
10-32 (.190 UNF)	50	60	45.0
1/4-28 (.250 UNF)	60	100	75.0
5/16-24 (.312 UNF)	80	160	120.0
3/8-24 (.375 UNF)	115	275	206.3
7/16-20 (.438 UNF)	140	475	356.3

- 3.3.15 Plug-In Termination: Plug-in termination shall conform to the dimensions specified (see 3.1). The mounting arrangement of the EMPC shall be so designed that it's stability will be provided by an auxiliary mounting means other than the electrical terminals of the socket. Plug-in terminals shall be gold plated in accordance with AMS 2422.
- 3.3.16 Solder-Lug Terminals: Solder-lug terminals used for a 2 A rating or less shall be designed to allow the securing of two AWG #20 stranded wires with 19 strands. Terminals used for more than 2 A rating shall be designed to allow the securing of three wires the size of which shall be as specified (see 3.1).

3.3.17 Terminal Marking: Terminal identification shall be as specified (see 3.1), and in accordance with Table 3.

TABLE 3 - Dual Coil Relay Markings

Coil Energized	Contacts Closed Load	Contacts Closed Auxiliary
X1-X2	A1-A2	11-12
	B1-B2	31-32
	C1-C2	51-52
	Etc.	Etc.
Y1-Y2	A3-A2 (or A3-A4)	21-22
	B3-B2 (or B3-B4)	41-42
	C3-C2 (or C3-C4)	61-62
	Etc.	

3.4 Dielectric Withstanding Voltage:

When tested as specified in 4.7.1, the leakage current shall not exceed 1.0 mA rms. The dielectric withstanding test shall be followed by the insulation resistance test of 4.7.2.

3.5 Insulation Resistance:

When EMPCs are tested as specified in 4.7.2, the insulation resistance shall be a minimum of 100 MΩ, unless otherwise specified (see 3.1). Following endurance testing, the insulation resistance shall be 50 MΩ minimum.

3.6 Electrical Characteristics:

The traditional relay electrical characteristics of pickup voltage, dropout voltage, hold voltage, maximum coil current, operate time, and release time are applicable to the EMPC only if there is direct access available to the coil or if the control circuitry is "transparent" for one, some, or all of these characteristics. Direct access may be possible by external terminals or through the use of test points which are not used in the actual application. Control circuitry is considered transparent if it has no impact upon the electromechanical relay which constitutes the output of the EMPC for a particular electrical characteristics. Other relay electrical characteristics, such as contact voltage drop and contact bounce, are directly applicable to the EMPC regardless of the presence of test points or transparent control circuitry. The controlling specification sheet (see 3.1) will determine the applicability of and specify any required test points for each characteristic.

- 3.6.1 Maximum Control Circuitry Current (including coils): When required and tested as described in 4.7.3.5, the maximum current required by the control circuitry of the electromechanical power controller shall not exceed the specified values (see 3.1). A latch type EMPC may have both a transient (switching) and steady state (at rest) requirement.
- 3.6.2 Contact Voltage Drop or Contact Resistance (4.7.4): Electromechanical power controllers shall have a contact voltage drop no greater than 0.125 V prior to load endurance cycling or no greater than 0.150 V after load endurance cycling when tested as specified in 4.7.4. The EMPC with auxiliary contacts rated at 2 A or less shall have a contact resistance value for those auxiliary contacts no greater than 0.05 Ω prior to load endurance (life) cycling and 0.15 Ω after load endurance (life) cycling when tested as specified in 4.7.4.1. Auxiliary contacts rated 6 V dc minimum and 5 to 2 MA shall have a contact resistance not greater than 50 Ω .
- 3.6.3 Operating Voltage Range: When required and tested as specified in 4.7.3, the specified pickup, hold, and dropout voltage of the EMPC shall be as specified (see 3.1). For latching EMPCs the operate voltage to close contacts and the operate voltage to open contacts shall be as specified (see 3.1).
- 3.6.4 Operate and Release Time (4.7.5): Operate and release times are the times required for the electromechanical output of the EMPC to respond to an externally generated close or open command and are applicable only if such a command can be applied directly to the EMPC coil or if the control circuitry is transparent to such a command. The response time of the EMPC to an internally generated open or close command (e.g., overcurrent trip) is a function of that EMPCs trip curve envelope (see 3.1) and not necessarily related to operate or release times. When the EMPC is tested as specified in 4.7.5, the operate and release time shall be within specified limits (see 3.1). The operate and release times shall not include the contact bounce time. The operate and release time of each pole of a multi-pole relay shall be within 2 ms of each other. Unless make-before-break action is specified (see 3.1), double throw EMPCs shall show no evidence of any normally open contact closing before all normally closed contacts open; any normally closed contacts shall not make before all normally open contacts break. For latching EMPCs release time does not apply, only operate to open and operate to close contacts.
- 3.6.5 Contact Bounce (4.7.5): When the EMPC is tested as specified in 4.7.5, the contact bounce shall be within specified limits (see 3.1). Contact break bounce on release of normally open contacts, when specified (see 3.1), shall be less than 100 μ s.
- 3.6.6 Transfer Time (see 4.7.5.3): When the EMPC has double throw contacts, transfer time shall be measured and meet the requirements as specified (see 3.1).

3.7 Abnormal Circuit Conditions:

The function of the EMPC is to merge the switching capability of a relay with the protective capability of devices such as circuit breakers, ground fault interrupters, etc. Accordingly, the EMPC has an envelope which defines a range of abnormal circuit conditions and time to trip. This trip curve envelope defines the protective capability of the EMPC. Although the EMPC responds to excessive current, other protective functions may include over/under voltage, phase rotation and over/under frequency. Only when the EMPC protective functions do not include excessive current, and the electromechanical output coil is accessible (see 3.6) are overload and rupture applicable (see 3.1).

- 3.7.1 Calibration: The EMPC shall be designed such that no re-calibration is required during the life of the unit.
- 3.7.2 Trip Curve Envelope: The EMPC shall meet the trip curve envelope as specified (see 3.1) when tested as described in 4.7.20 over the life of the unit and throughout the specified temperature range.

TABLE 4 - Tripping Times for Calibration Tests (see 3.1)

Calibration Tests	Percent Rated Current	Ambient Temp. $\pm 5^{\circ}\text{C}$	Tripping Time
Minimum Ultimate Trip	115	25	No Trip 1 h Min.
Maximum Ultimate Trip	138	25	Must Trip 1 h Max.
Overload & Trip Free	200	At	
	400	-55, +25	(see 3.1)
	1000	and +71	
Ambient effect on Calibration	115	-55	No Trip 1 h Min.
(Ultimate & Trip Free Limits)	150		Must Trip 1 h Max.
	115	+71	No Trip 1 h Min.
	138		Must Trip 1 h Max.

- 3.7.3 Coordination (4.7.21): When coordination is a requirement (see 3.1), a pair of EMPCs with a minimum two to one current rating ratio shall be connected in series to overloads of 200, 400, and 1000% rating of the lower rated EMPC. Under these conditions, only the EMPC with the lower nominal current rating must trip (open the circuit) while the EMPC with the higher current rating must remain in the closed position. There shall be no electrical or mechanical malfunctions.

3.7.4 Trip Free Calibration: When tested as specified in 4.7.23 the EMPC shall trip and remain in the tripped position even when the control line remains in the “on” position. Following overload trip the control line must first be moved to the “off” position before the device can be re-closed. Other logic inputs are possible (see 3.1).

3.8 Thermal Shock:

When EMPCs are tested as specified in 4.7.10 there shall be no damage to the EMPC, loosening of terminals, or cracking or flaking of glass insulation (other than cracking or chipping of the glass meniscus). Following the test the EMPC shall meet the requirements of 3.4, 3.5, and 3.6.

3.9 Shock (see 3.1):

When EMPCs are tested as specified in 4.7.13 there shall be no opening of closed contacts in excess of 10 μ s and there shall be no closure or abnormal bridging of open contacts in excess of 1 μ s and no evidence of mechanical or electrical damage.

3.10 Vibration (see 3.1):

When EMPCs are tested as specified in 4.7.14 there shall be no opening of closed contacts in excess of 10 μ s and there shall be no closure or abnormal bridging of open contacts in excess of 1 μ s and no evidence of mechanical or electrical damage.

3.11 Electromagnetic Interference and Compatibility:

When EMPCs are tested as specified in 4.7.15 the conducted emission shall not exceed the specified value (see 3.1) except when clearing a fault.

3.12 Salt Atmosphere (Corrosion):

When EMPCs are tested as specified in 4.7.7 there shall be no evidence of breaking, cracking, chipping, or flaking of the finish, nor exposure of the base metal, due to corrosion, which would adversely affect performance characteristics of the EMPC.

3.13 Overload:

When EMPCs are tested as specified in 4.7.16 there shall be no electrical failure, such as contact sticking, welding or failure to make or break the specified overload current. Blowing of the fuse connected between case and load system ground or neutral shall constitute failure. The terminal temperature rise shall not exceed 75 °C. (Monitoring of terminal temperature rise required only during qualification testing.)

3.14 Rupture:

When EMPCs are tested as specified in 4.7.17 there shall be no electrical failure, such as contact welding or failure to make or break the specified rupture current. Blowing of the fuse connected between case and load system ground or neutral shall constitute failure. The terminal temperature rise shall not exceed 75 °C. (Monitoring of terminal temperature rise required only during qualification testing.)

3.15 Endurance (Life) at Rated Contact Load:

EMPCs shall be tested as specified in 4.7.18 and 4.7.19. EMPCs shall be tested at each contact rating specified (see 3.1). There shall be no mechanical or electrical failure. Failure to make, carry or break the load or blowing the fuse connected between case and load system ground or neutral shall constitute a failure. The terminal temperature shall not exceed the maximum specified (see 3.1). (Monitoring of the terminal temperature is required only during qualification testing.)

3.15.1 Low Level (see 3.1) (Applicable to Auxiliary Contacts Only): EMPCs shall be cycled per 4.7.19.4 for the maximum number of cycles specified for the power contacts and the auxiliary contacts shall be monitored for a maximum contact resistance of 100 Ω .

3.15.2 Mixed Loads (Applicable to Auxiliary Contacts): When EMPCs are tested as specified in 4.7.19.5 there shall be no mechanical or electrical failures. The contact voltage drop shall not exceed the values specified in 3.6.2.

3.16 Mechanical Life (see 4.7.19.6):

The EMPC shall be capable of operating at 25% of rated resistive load for two times the rated minimum operating cycles of resistive electrical endurance (see 3.1). When the EMPCs are tested as specified in 4.7.19.6, EMPC shall remain mechanically and electrically operative.

3.17 Humidity (Applicable to Unsealed, Environmentally Sealed and Hermetically Sealed EMPCs with Potted Wire Leads) (see 4.7.6):

When subjected to the humidity test of 4.7.6, EMPCs shall not exhibit a leakage current in excess of 100 mA with a potential of 150 V rms applied between the terminals and other exposed metal parts.

3.18 Sand and Dust (Applicable to Unsealed EMPCs) (see 3.1):

When EMPCs are tested as specified in 4.7.8 there shall be no evidence of damage sufficient to impair the operation of the EMPC. Following the test the EMPC shall meet the requirements of 3.6.

3.19 Explosion Proof (Applicable to Unsealed EMPCs):

When EMPCs are tested as specified in 4.7.9, any explosion internal to the EMPC shall not rupture the case or ignite the external fuel mixture in the test chamber.