Marine Engine Wiring —SAE J378c

SAE Recommended Practice
Completely revised June 1978

THIS IS A PREPRINT WHICH IS SUBJECT TO REVISIONS AND CORRECTIONS. THE FINAL VERSION WILL APPEAR IN THE 1979 EDITION OF THE SAE HANDBOOK.

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LAND SEA AIR SPACE

PREPRINT

φ MARINE ENGINE WIRING—SAE J378c

SAE Recommended Practice

Report of Marine Technical Committee approved January 1969 and completely revised June 1978. Rationale statement available.

1. Scope—This recommended practice covers the requirements for all Marine inboard engine wiring assemblies and components.

2. Purpose—The purpose of this recommended practice is to insure that wiring used on marine engines meet the necessary safety standards of the industry. The recommendations cover methods that may be employed by manufacturers to minimize the possibility that engine wiring may be a source of ignition of explosive or flammable vapors and provide manufacturers installing engine electrical systems sufficient information to design and develop engine wiring harnesses safe for marine usage.

3. General—Normally, marine engines are installed in enclosed compartments which are difficult to ventilate well enough to purge quickly any explosive mixtures of flammable gases, particularly if a continuous fuel leak is present. For this reason, it is essential that precautions be taken to minimize all sources of possible ignition of explosive fuel air mixture that may be present.

Engine wiring can become a potential source of fuel vapor ignition in numerous ways, including damage to insulation covering, loose connections, accidental shorting at terminals, fatigue failures, etc. These occurences can be as much a matter of installation as of design.

Performance tests to determine the necessary external ignition-protection of complete wiring harnesses are not practical. Protection can be afforded by proper selection of components and installation practices in accordance with the following recommendations.

Minimum federal requirements for marine application are covered by US Coast Guard regulation 33 CFR Part 183 Subpart I.

4. Definitions

4.1 Engine Wiring—Any insulated electrical wiring of a marine engine necessary for operation, monitoring and/or control.

4.2 Caps, Low Tension—An insulating shield to protect against accidental shorting of terminal or terminations in low tension circuits.

4.3 Wire—The combination of a conductor surrounded by insulation.

4.4 Terminal—A metal fitting attached to the end of a wire to facilitate making electrical connections.

4.5 Connector—An insulated device that holds a terminal(s) for electrically interconnecting one or more wires.

4.6 Low Tension Wiring—Wiring used in a less than 50 V application.

4.7 Butt Splice—A splice in which the wire ends are positioned in the connection butt to butt.

4.8 End Cap Splice—A splice in which all wires enter at the same end.

4.9 Tee Connection—A form of a splice in which there are 3—4 connection points each 90 deg to each other.

5. Low Tension Wiring—The temperature rating of the wire insulation shall be determined by an accelerated aging test conducted in accordance with ASTM D 573, except samples of insulation are to be removed from the finished wire and aged 168 h. The test temperature shall be 30°C above the intended rated temperature. Tensile strength after aging shall not be less than 80% of the original tensile strength. The elongation after aging shall be at least 50% of the original elongation. Except for intermittent higher currents, each circuit must not carry a current greater than specified in Table 1 for the wire gauge and temperature rating. Resistance conductors that control circuit amperage and cranking motor circuit conductors are exempt from the requirements of Table 1.

Except where otherwise protected or not in contact with metal surfaces, the wiring circuits shall be grouped together and protected by non-metallic tape or braid covering capable of withstanding severe abrasion. Wiring not grouped together and protected shall be not less than No. 16 AWG.

The wiring assembly shall be cleated at intervals not greater than 18 in (455 mm) for proper support, and shall be located so that no portion is closer than 1 in (25 mm) to moving parts, and adequately spaced or shielded from high temperature surfaces. Wiring passing through holes in boat structure shall be adequately protected against chafing.

6. Low Tension Resistance Wire—This is a low tension wire having a precalculated resistance to limit the voltage applied to electrical devices. Since the nature of the wire is to limit the voltage applied to electrical devices, the distance of the device from the power source and the current demand of the device will determine the materials used. Because the operating conditions of every device are different, the materials used for the conductor and insulation of the resistance wire cannot be specifically described as standard; thus, the conductor and insulating materials must be carefully chosen for each application by the design engineer.

Extreme care should be used by the design engineer in choosing a conducting material that will satisfy the current demand of the device and not create a conductor temperature greater than the insulation temperature rating when measured in a 60°C ambient.

Circuits using this wire shall be carefully placed so that their temperature rise will not create a hazard to, or malfunction of any other circuit or engine function.

7. Wire Termination Requirements

7.1 To insure the quality of the connection between a terminal and wire and between a wire-to-wire splice, all terminal-to-wire and splice connections must pass the pull-off forces as listed in Table 2. These forces are the total separating forces which includes the weight of the connecting wire when tested in a vertical position.

7.1.1 Procedure—The method of setting up the specimens in the pull-off test fixture will vary according to the type of terminal or splice being tested. The test fixture shall be designed to hold one end of the terminal or wire stationary while the pull force is applied to the other end. Adaptors may be required to allow a common test fixture to be used to test the various types of terminals and splices. In general, each type shall be secured in a position with the necessary adaptors to hold the terminal or splice and keep the direction of pull a continuation in the line of the axis of the wire. The force shall then be applied gradually so there is no sudden application, jerking, or swinging. Fig. 1 illustrates the intention of the pull test set up on some types of terminals and splices. End cap type splices, however, shall have its wires pulled first in opposite directions, then with the end cap held securely, the wires shall be pulled individually away from the cap along the axis of the wire. If the cap contains wires of different sizes, test the smaller wire first. Tee connections and butt splices that contain more than one wire at either end shall shall be pulled parallel to the main wire then perpendicular to it.

Some type of terminals may be tested in pairs, such as, ring and lug types bolted back to back and knife disconnects mated together, provided the terminal wire barrels are kept parallel to each other and to the axis of the wire. (See Fig. 2.)

7.2 Each single friction terminal, spring type terminal and non-locking multiconducter plug that is outside of the electrical junction box must not separate when subjected to a 6 lb (26.7 N) tensile force for 1 min along the axial direction of the terminal or connector. Blade terminals when used shall conform to SAE J858. This force includes the weight of the connecting wires when tested in a vertical position. Condition the terminals or connectors prior to testing by connecting and disconnecting them six times, unless the terminals or connectors are specifically designed not to be disconnected and installed in the boat in such a way that they would not require disconnection for normal access, servicing or maintenance.

7.2.1 Procedure—Mated terminals and connectors shall be installed in a test fixture (Fig. 3) such that one of the halves of the terminal or connector is held secure and stationary while the other half is subjected to the 6 lb (26.7 N) tensile force. The force shall be applied gradually so there is no sudden application, jerking, or swinging.
Different adaptors will be required to hold the various types of terminals and connector types.

The φ symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

TABLE 1—ALLOWABLE AMPERAGE OF CONDUCTORS FOR UNDER 50 V

Conductor Size (AWG)	Temperature Rating of Conductor Insulation												
	60°C (140°F)		75°C (167°F)		80°C (176°F)		90°C (194°F)		105°C (221°F)		125°C (257°F)		200°C (392°F)
	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside or Inside Engine Spaces
18	10	5.8	10	7.5	15	11.7	20	16.4	20	17.0	25	22.3	25
16	15	8.7	15	11.3	20	15.6	25	20.5	25	21.3	30	26.7	35
14	20	11.6	20	15.0	25	19.5	30	24.6	35	29.8	40	35.6	45
12	25	14.5	25	18.8	35	27.3	40	32.8	45	38.3	50	44.5	55
10	40	23.2	40	30.0	50	39.0	55	45.1	60	51.0	70	62.3	70
8	55	31.9	65	48.8	70	54.6	70	57.4	80	68.0	90	80.1	100
6	80	46.4	95	71.3	100	78.0	100	82.0	120	102.0	125	111.3	135
4	105	60.9	125	93.8	130	101.4	135	110.7	160	136.0	170	151.3	180
3	120	69.6	145	108.8	150	117.0	155	127.1	180	153.0	195	173.6	210
2	140	81.2	170	127.5	175	136.5	180	147.6	210	178.5	225	200.3	240
1	165	95.7	195	146.3	210	163.8	210	172.2	245	208.3	265	235.9	280
0	195	113.1	230	172.5	245	191.1	245	200.9	285	242.3	305	271.5	325
00	225	130.5	265	198.8	285	222.3	285	233.7	330	280.5	355	316.0	370
000	260	150.8	310	232.5	330	257.4	330	270.6	385	327.3	410	364.9	430
0000	300	174.0	360	270.0	385	300.3	385	315.7	445	378.3	475	422.8	510

TABLE 2–MINIMUM PULL-OFF FORCE VALUES

Wire Size (AWG)	1 Min Design Test Tension Force[a] lb	N	1 Second Alternate Quality Control Test Tension Force lb	N
18	10	44	18	80
16	15	66	28	124
14	30	133	35	155
12	35	155	40	177
10	40	177	45	200
8	45	200	50	222
6	50	222	80	355
5	60	266	90	400
4	70	311	100	444
3	80	355	120	532
2	90	400	135	600
1	100	444	150	666
0	125	556	175	778
00	150	667	225	1000
000	175	778	260	1155
0000	225	1000	330	1465

[a]Table 6 of US Coast Guard 33 CFR Part 183 Subpart I.

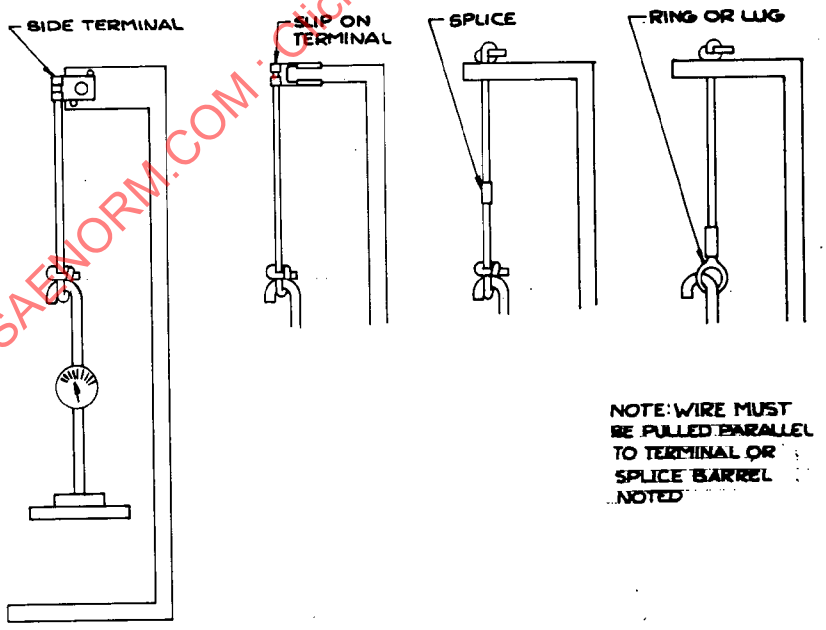

FIG. 1–EXAMPLES OF SOME TERMINAL PULL-OFF METHODS

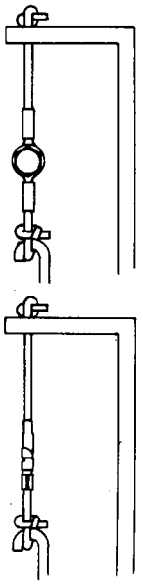

FIG. 2–PAIRING OF TERMINALS

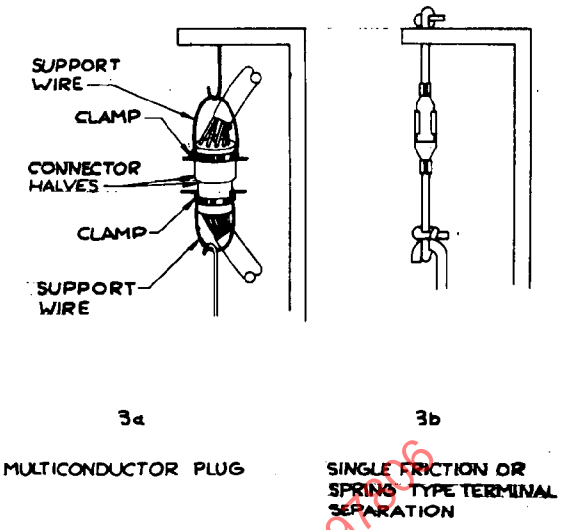

FIG. 3

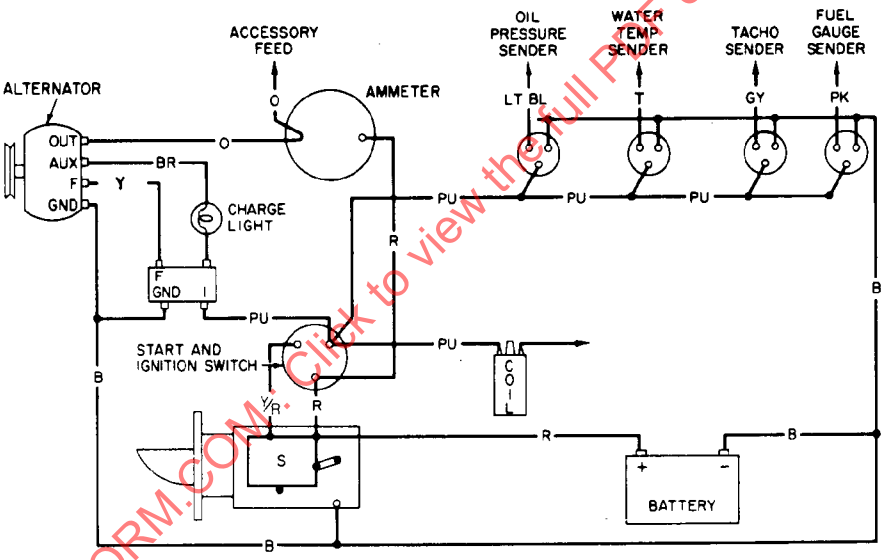

FIG. 4

8. Low Voltage Caps

8.1 Cap material shall be aged for 168 h at a temperature of 90 ±2°C (194 ±4°F) in an oven and allowed to cool to room temperature. The tensile strength after aging shall not be less than 80% of the original tensile strength. The elongation after aging shall be at least 50% of the original elongation. Tests shall be conducted as per ASTM D 412-75.

8.2 Cap material shall be submerged in each of the following liquids for a period of 5 h at 23 ±3°C (73 ±6°F). Tests may be in any sequence:

(a) ASTM Reference Fuel B.

(b) ASTM No. 3 Swelling Oil.

8.2.1 The test specimens shall be removed, blotted dry, and judged with respect to untested specimens.

8.2.2 Tested specimens shall not lose more than 40% of their tensile strength or swell by more than 50% of any dimension as a result of being subjected to the conditions under paragraph 8.2, paragraph (a) and (b).

8.3 Dielectric strength of cap material shall be 100 V/mil minimum after completion of aging tests under paragraphs 8.1 and 8.2.

9. High Tension Wiring–High tension cable assemblies used in engine ignition systems shall conform with SAE J1191.

Separators, stand-offs, or abrasion resistant sleeving shall be used where necessary to maintain adequate separation between cables and to protect cable insulation. Harness clamps shall be insulated. High tension cable to terminal connections shall withstand the tensile forces of 20 lb (89 N) minimum. The cable with terminals and boot attached shall not disconnect from a spark plug when a 6 lb (26.7 N) tensile force is applied for 1 min to the lead and pulled parallel to the axis of the spark plug.

10. Color Code–The color code shown in Table 3 is recommended for marine engines and their associated components. Colored sleeves at the terminal ends of wires may be used in lieu of solid colored wires. The circuit diagram (Fig. 4) is for the purpose of clarifying color coding and not to recommend particular circuiting or components. Components which may be wired in various ways, switches and circuit protection, are not shown, but should be wired the color corresponding to the particular branch of the circuit in which they are used.