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Marine Engine Wiring

SAE Recommended Practice
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MARINE ENGINE WIRING—SAE J378 JUN84 SAE Recommended Practice

Report of the Marine Technical Committee, approved January 1969, last revised June 1984. 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 meets 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 occurrences can be as much a matter of installation as of design.

Performance tests to determine the necessary external ignition-protec-

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

tion of complete wiring harnesses are not practical. Protection can be afforded by proper selection of components and installation practices ϕ in accordance with the following recommendations. For inboard and stern ϕ drive engines, the minimum federal requirements are covered by U. S. 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, montoring, 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 ϕ longer than 18 in, not grouped together and protected shall be not less ϕ than SAE 16 gage.

The wiring assembly shall be cleated at intervals not greater than 18 in ϕ (455 mm) for proper support, shall be located so as to be protected ϕ from moving parts, and adequately spaced or shielded from high temperature surfaces. Wiring passing through holes in boat structure shall be ϕ adequately protected against chafing. For additional cable specification, see SAE J1127 and SAE J1128.

ϕ *6. Wire Termination Requirements*

ϕ **6.1** 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.

ϕ TABLE 2—MINIMUM PULL-OFF FORCE VALUES

Wire Size (AWG)	1 Min Design Test Tension Force		1 s Alternate Quality Control Test Tension Force	
	lb	N	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

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 their 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 be pulled parallel to the main wire then perpendicular to it.

Some types 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.)

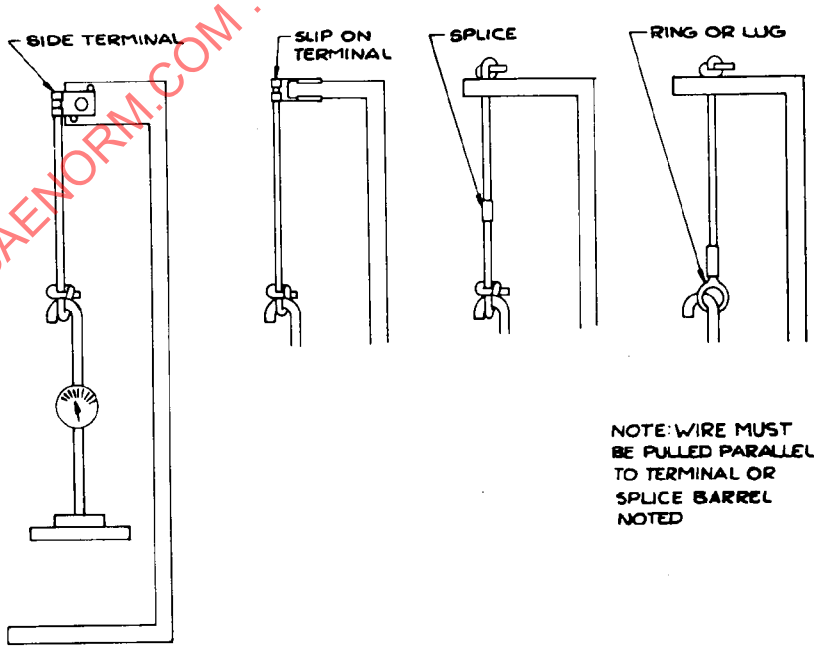

FIG. 1—EXAMPLES OF SOME TERMINAL PULL-OFF METHODS

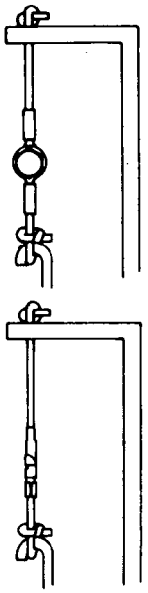

FIG. 2—PAIRING OF TERMINALS

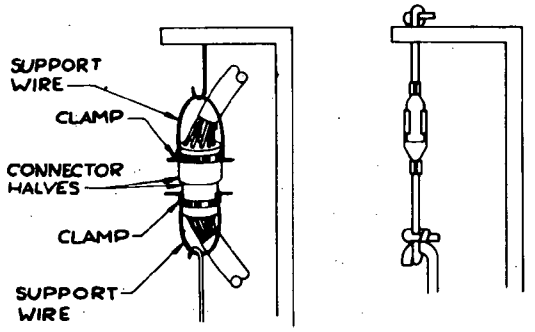

FIG. 3

ϕ TABLE 3—MARINE ENGINE WIRING

Purple	Ignition switch controlled
Black	Grounds
Red[a]	Unprotected battery wires
Red/Purple	Overcurrent protected battery wires
Yellow	Alternator AC output and alternator field
Green	Bonding
Brown and Brown/Stripe	Alternator starter to ignition module
Orange	Alternator DC output and accessory feeds
Light Blue	Oil pressure
Tan	Water temperature
Gray	Tachometer
Green/White	Engine trim in and/or tilt down
Green/Orange	Engine independent trim down
Blue/White	Engine trim out and/or tilt up
Blue/Orange	Engine independent trim up
White	Must not be used in under 50 V wiring
Yellow/Red	Starting circuit
Yellow/Black	Choke
Black/Yellow	Ignition stop
Brown/White	Trim position sender
Manufacturer's Discretion	Ignition triggering and color/stripe for functions not designated

[a] Red/Purple may be used for overcurrent protected wires.

7.2 Each single friction terminal, spring type terminal and non-locking multiconductor 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.

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.

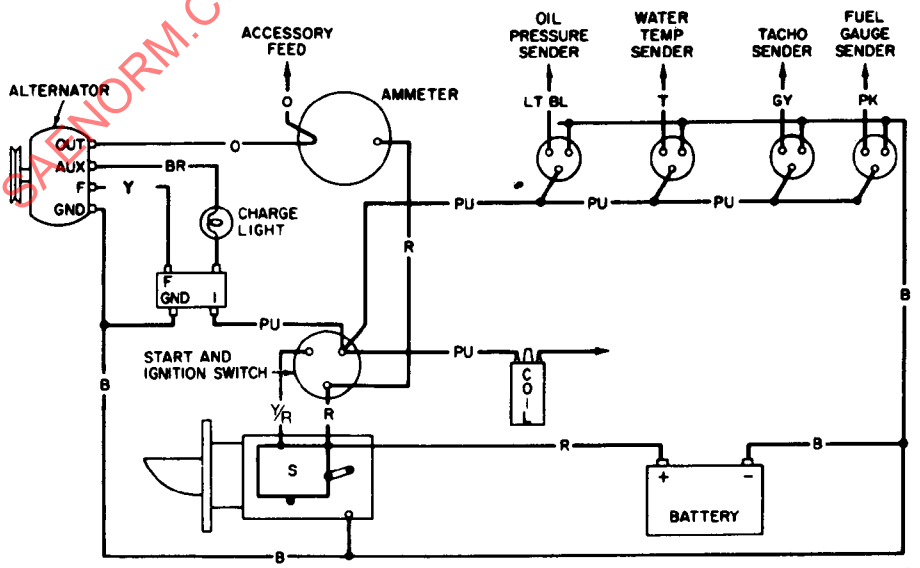

FIG. 4