SAE International™ SURFACE VEHICLE RECOMMENDED PRACTICE

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Superseding J378 OCT2004

Marine Propulsion System Wiring

RATIONALE

Remove the schematic diagram examples shown in Figure 5, and the reference to J 2202 in the reference section. Also removed SAE J1128 as an alternate reference in section 11. They represent older practices, and are only shown as examples for the purpose of clarifying color coding and were not meant to be recommendations of circuiting or component use. The industry has a well established practice of providing good wiring diagrams so the figure is unnecessary. Review and revise the color code chart to be consistent with current practice. Clarify scope to exclude high voltage DC Hybrid systems which are covered by specific standards.

1. SCOPE

This SAE Recommended Practice covers the requirements for all marine inboard engine wiring, wiring assemblies, wiring components, and wiring connectors connected to microprocessors associated with the operation of the propulsion system, operating at 50 V or less.

EXCEPTION—Outboard engines and engines in Personal Water Craft (PWC).

NOTE: See ABYC E11 for additional requirements related to electrical installations on small craft.

1.1 Purpose

The purpose of this document is to insure that electrical and electronic wiring and wiring components used in a marine propulsion system meet the necessary safety and performance requirements based upon the marine mechanical and electrical environment. The recommendations include 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 for marine usage.

1.2 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 mixtures that may be present.

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-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. For inboard and stern drive engines, the minimum federal requirements for electrical wiring are covered by Title 33 Code of Federal Regulations Part 183 Sections 183.410 to 183.460.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J858 Electrical Terminals - Blade Type

SAE J1127 Low Voltage Battery Cable

SAE J1128 Low Voltage Primary Cable

SAE J1191 High Tension Ignition Cable Assemblies - Marine

SAE J2030 Heavy-Duty Electrical Connector Performance Standard

2.1.2 Federal Publications

Available from the Superintendent of Documents, U. S. Government Printing Office, Mail Stop: SSOP, Washington, DC 20402-9320. Web: http://www.access.gpo.gov/nara/cfr/waisidx_99/33cfr183_99.html

Title 33 Code of Federal Regulations Part 183—Boats and Associated Equipment

2.1.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension

ASTM D 573 Test Method for Rubber—Deterioration in an Air Oven

ASTM D 471 Standard Test Method for Rubber Property—Effect of Liquids

2.1.4 ABYC Publication

ABYC documents can be ordered online at http://www.abycinc.org.

ABYC E11 AC and DC Electrical Systems on Boats

3. DEFINITIONS

3.1 BUTT SPLICE

A splice in which the wire ends are positioned in the connection butt to butt.

3.2 LOW VOLTAGE CAPS

An insulating shield to protect against accidental shorting of terminal or terminations in low-tension circuits.

3.3 CONNECTOR

An insulated device that holds a terminal(s) for electrically interconnecting one or more wires. Connectors shall conform to SAE J2030.

3.4 END CAP SPLICE

A splice in which all wires enter at the same end.

3.5 ENGINE WIRING

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

3.6 LOW TENSION WIRING

Wiring used in a less than 50 V application.

3.7 PERSONAL WATER CRAFT (PWC)

A vessel that uses an inboard engine powering a water jet pump as its primary source of motive power and which is designed to be operated by a person sitting, standing, or kneeling on the vessel rather than the conventional manner of sitting or standing inside the vessel.

3.8 SONIC-WELD SPLICE

A weld produced by the introduction of high-frequency mechanical vibration between two components until a metallurgic bond is formed at the weld interface.

3.9 TERMINAL

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

3.10 TEE CONNECTION

A form of a splice in which there are 3 to 4 connection points, each 90 degrees to each other.

3.11 WIRE

The combination of a conductor surrounded by insulation.

4. 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 (86 °F) 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 Figure 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 Figure 1.

Wiring longer than 455 mm (18 in), not grouped together and protected, shall be no less than 1 mm^2 (metric wire) or AWG 16 gauge (US inch dimensioned wire).

The wiring assembly shall be supported at intervals not greater than 455 mm (18 in) shall be located so as to be protected from moving parts, and spaced or shielded from high temperature surfaces so that the wire insulation or sheath will not exceed its temperature rating. Wiring passing through holes shall be provided with grommets, bushings or other means to protect against abrasion. Wiring shall be routed above anticipated levels of bilge water or away from areas where water may accumulate, except wiring for submerged equipment such as bilge pumps. For additional cable specification, see SAE J1127 and SAE J1128.

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 which shall be capable of withstanding the abrasion test covered in Section 5.

5. ABRASION TEST FOR NON-METALLIC TAPE OR BRAID COVERING

5.1 Principle

Three individual samples of identical construction shall be selected from a test lot. These samples shall be constructed the same as for all other sizes to be qualified by this test sample. The samples to be qualified by this test lot shall not have a cover thickness less than those of the test lot. After 1000 test cycles, each sample in the test lot shall not have any conductor material exposed.

5.2 Procedure

The test samples shall be preconditioned for at least 24 h at 23 °C ± 2 °C (73 °F ± 3.6 °F) and (50% ± 5%) relative humidity. Testing shall be performed at the previous temperature with an unused abrasive surface for each sample.

The abrasive surface shall be 25 x 76 mm ± 5 mm (1 x 3 in ± 0.2 in) 240 grit, medium grade, AlO_3 emery cloth firmly affixed to a hard surface which will cycle back and forth 76 mm ± 5 mm (3 in ± 0.2 in) in each direction.

CONDUCTOR SIZE ENGLISH (AWG)	CONDUCTOR SIZE METRIC (mm^2)	60°C (140°F) OUTSIDE ENGINE SPACES	60°C (140°F) INSIDE ENGINE SPACES	75°C (167°F) OUTSIDE ENGINE SPACES	75°C (167°F) INSIDE ENGINE SPACES	80°C (176°F) OUTSIDE ENGINE SPACES	80°C (176°F) INSIDE ENGINE SPACES	90°C (194°F) OUTSIDE ENGINE SPACES	90°C (194°F) INSIDE ENGINE SPACES	105°C (221°F) OUTSIDE ENGINE SPACES	105°C (221°F) INSIDE ENGINE SPACES	125°C (257°F) OUTSIDE ENGINE SPACES	125°C (257°F) INSIDE ENGINE SPACES	200°C (392°F) OUTSIDE OR INSIDE ENGINE SPACES
18	(0.8)	10	5.8	10	7.5	15	11.7	20	16.4	20	17.0	25	22.3	25
16	(1)	15	8.7	15	11.3	20	15.6	25	20.5	25	21.3	30	25.7	35
14	(2)	20	11.6	20	15.0	25	19.5	30	24.6	35	29.8	40	35.6	45
12	(3)	25	14.5	25	18.8	35	27.3	40	32.8	45	39.3	50	44.5	55
10	(5)	40	23.2	40	30.0	50	39.0	55	45.1	60	51.0	70	62.3	70
8	(8)	55	31.9	65	48.8	70	54.6	70	57.4	80	68.0	90	80.1	100
6	(13)	80	46.4	95	71.3	100	78.0	100	82.0	120	102	125	111	135
4	(19)	105	60.9	125	91.8	130	101	135	110	160	136	170	151	180
2	(32)	140	81.2	170	127	175	138	180	147	210	178	225	200	240
1	(40)	165	95.7	195	146	210	163	210	172	245	208	265	235	280
0	(50)	195	113	230	172	245	191	245	200	285	242	305	271	325
00	(62)	225	130	265	198	285	222	285	233	330	280	355	316	370
000	(81)	260	150	310	232	330	257	330	270	385	327	410	384	430
0000	(103)	300	174	380	270	385	300	385	315	445	378	475	422	510

Temperature Rating of Conductor Insulation

FIGURE 1 - ALLOWABLE AMPERAGE OF CONDUCTORS FOR SYSTEMS UNDER 50 VOLTS

One test cycle equals 360 degrees rotation of the outside diameter and one back and forth movement of the abrasive surface.

A constant normal force of 45 N ± 0.5 N (10 lb ± 2 oz) shall be applied to the abrasive surface (see Figure 2).

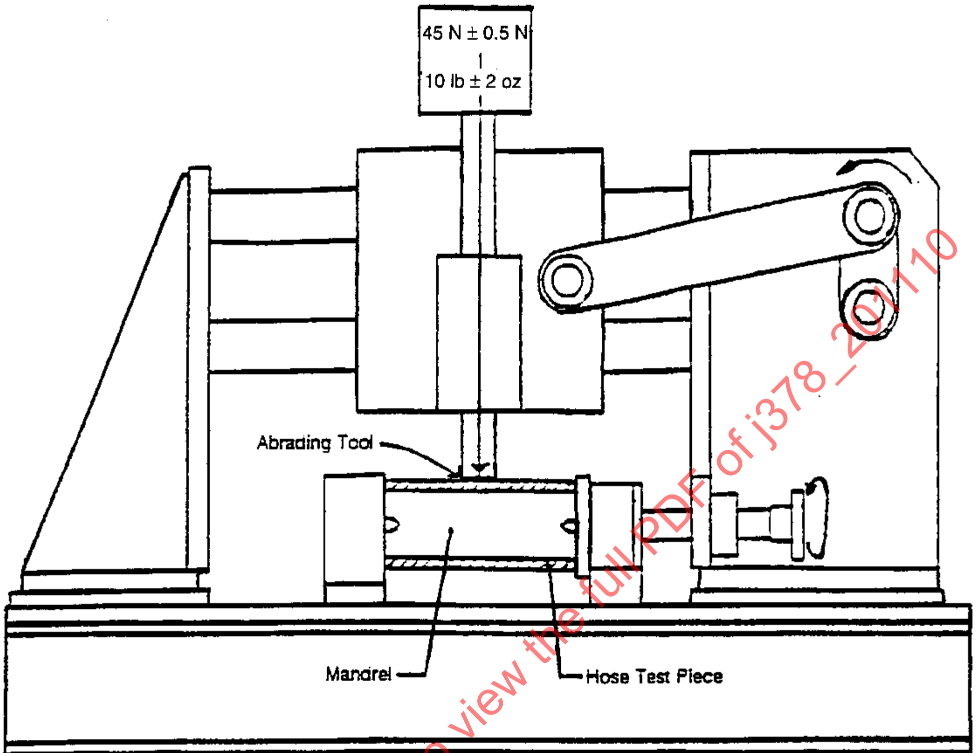

FIGURE 2 - TYPICAL ABRASION TEST FIXTURE

6. WIRE TERMINATION REQUIREMENTS

6.1 All terminal-to-wire and splice connections must pass the pull-off forces as listed in Table 1. These forces are the total separating forces, which includes the weight of the connecting wire when tested in a vertical position.

TABLE 1 - MINIMUM PULL-OFF FORCE VALUES

Wire Size METRIC (mm^2)	Wire Size ENGLISH (AWG)	1 Min Design Test Tension Force N	1 Min Design Test Tension Force lb	1 s Alternate Quality Control Test Tension Force N	1 s Alternate Quality Control Test Tension Force lb
(0.8)	18	44	10	80	18
(1)	16	66	15	124	28
(2)	14	133	30	155	35
(3)	12	155	35	177	40
(5)	10	177	40	200	45
(8)	8	200	45	222	50
(13)	6	222	50	355	80
(19)	4	311	70	444	100
(32)	2	400	90	600	135
(40)	1	444	100	666	150
(50)	0	556	125	778	175
(62)	00	667	150	1000	225
(81)	000	778	175	1155	260
(103)	0000	1000	225	1465	330

6.2 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. Adapters 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 adapters to hold the terminal or splice and keep the direction of pull along the axis of the wire. The force shall then be applied gradually so there is no sudden application, jerking, or swinging. Figure 3A 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 Figures 3A and 3B).

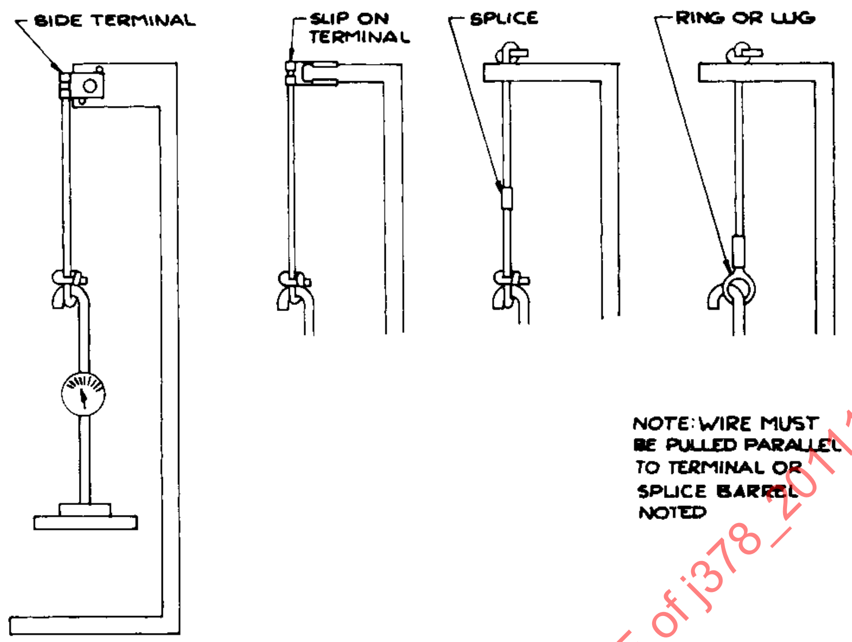

FIGURE 3A - EXAMPLES OF SOME TERMINAL PULL-OFF METHODS

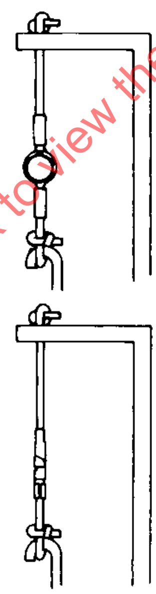

FIGURE 3B - PAIRING OF TERMINALS

7. CONNECTOR MOISTURE RESISTANCE REQUIREMENTS

7.1 Connectors used on or connected to microprocessors associated with marine propulsion systems shall pass the water immersion and fluid immersion tests.

7.2 Water Immersion

7.2.1 Preconditioning

The wired, or mated, connectors shall be placed in an oven at 125 °C ± 3 °C (257 °F ± 5 °F) for 1 h.

7.2.2 Procedure

Remove the samples from the preconditioning oven and immediately immerse the samples in a 5% by weight salt water solution containing 0.1 g/L wetting solution to a depth of one meter for 4 h at 23 °C ± 3 °C (73 °F ± 5 °F).

7.2.3 Pass/Fail Criteria

7.2.3.1 Weatherproof Connectors

Continuity with one probe in the test solution and one probe attached to the conductor shall constitute failure.

7.2.3.2 Exposed Connectors

Any visual evidence of water on the conductor after complete removal of the cover shall constitute failure.

7.3 Fluid Immersion Test

7.3.1 Procedure

Submerge a sample of wired and mated connector to each listed fluid at 85 °C ± 3 °C (185 °F ± 5 °F) for 5 min, then allow to air dry for 24 h. This completes one cycle. Each sample is to be subjected to a total of 5 cycles. An untested sample is required to pass this test in each fluid.

The fluids are:

a. Gasoline: ASTM D 471, Reference fuel B

b. Power Steering Fluid: ASTM D 471, IRM903

c. Engine Coolant: 50% distilled water and 50% ethylene glycol mixture

7.3.2 Pass/Fail Criteria

Visual swelling, cracking or continuity with one probe in the solution and one probe connected to the conductor shall constitute failure.