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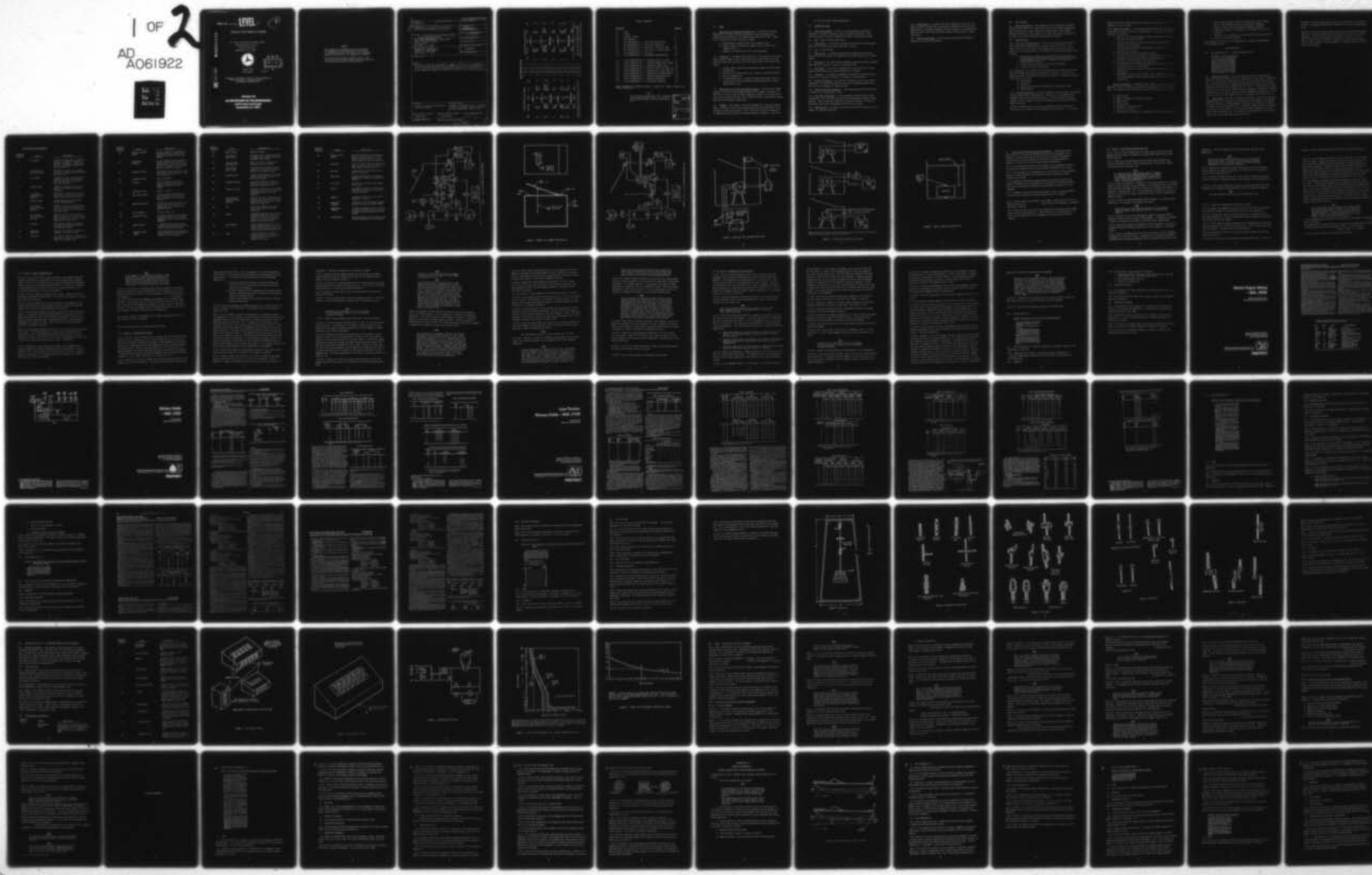

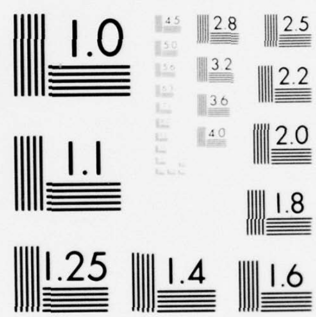

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NATIONAL BUREAU OF STANDARDS 1963 A

REPORT NO. CG-B-006-78 LEVEL II

ELECTRICAL SYSTEM STANDARD TEST PROCEDURE

U.S. Coast Guard Office of Boating Safety
Boating Technical Division
2100 2nd Street SW
Washington, D. C. 20590

January 1978

Final Report

Document is available to the U. S. public through the National Technical Information Service, Springfield, Virginia 22161

PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

WASHINGTON, D.C. 20590

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16. Abstract

The purpose of this test procedure is to specify a method that is acceptable to the United States Coast Guard and the equipment to be used in determining whether or not a particular electrical component is in compliance with the Electrical Systems Standard in Subpart I of Part 183 of Title 33, Code of Federal Regulations.

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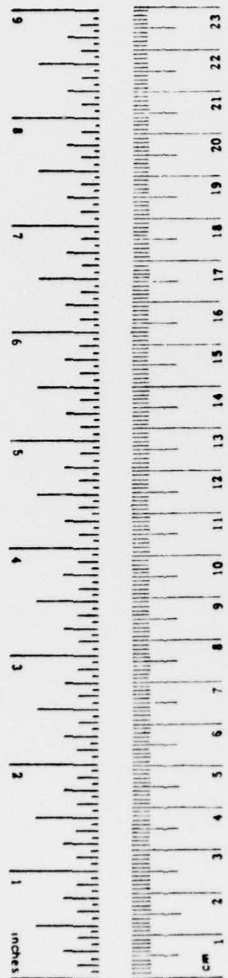
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

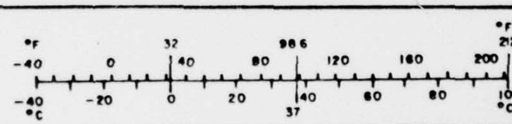
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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NOTE

Due to editorial changes some lines, paragraphs, and paragraph numbers normally in sequential order have been omitted from these test procedures.

1.0 SCOPE

1.1 Applicability of Federal Boat Safety Act -- The Electrical System Standard Test Procedures and the regulations to which they apply were issued under the authority of the Federal Boat Safety Act of 1971. "Boat" as it is defined in the Act includes any vessel:

a. Manufactured or used primarily for noncommercial use;
b. Leased, rented or chartered to another for the latter's non-commercial use; or
c. Engaged in the carrying of six or fewer passengers.

1.2 Exceptions -- The Federal Boat Safety Act of 1971 applies to all boats used on waters subject to the jurisdiction of the United States and on the high seas beyond the territorial seas for vessels owned in the United States except:

a. Foreign vessels temporarily using waters subject to United States jurisdiction;
b. Military or non-recreational public vessels of the United States;
c. Ship's lifeboats; and
d. A vessel whose owner is a State or subdivision thereof, which is used principally for governmental purposes and which is clearly identifiable as such.

1.3 Applicability of Electrical Systems Standard -- The Electrical System Standard for boats and associated equipment which appears in Subpart I of Part 183 of Title 33, Code of Federal Regulations applies to all boats that have gasoline engines for electrical or mechanical power or propulsion, except boats that have outboard engines only.

2.0 PURPOSE

-- The purpose of this test procedure is to specify a method that is acceptable to the United States Coast Guard and the equipment to be employed in determining whether or not a particular electrical component is in compliance with the Electrical Systems Standard in Subpart I of Part 183 of Title 33, Code of Federal Regulations.

3.0 GLOSSARY OF TERMS

3.1 Actual Installation -- Either (1) the configuration from which a component or system was removed in order to accomplish the test, or (2) the configuration for which a component or system is intended to be used.

3.2 CFR -- Code of Federal Regulations

3.3 Clearing Time -- The time as measured from the point of current application until point of zero current flow (open circuit).

3.4 CO_2 -- Carbon Dioxide

3.5 Dual Circuit -- A breaker constructed for protecting two circuits, but each circuit and breaker is separate from the other and acts as a single breaker.

3.6 Duty Cycle -- The time intervals devoted to starting, running, stopping and idling when a device is used for intermittent duty.

3.7 Duty Factor -- The ratio of working time to total time for an intermittently operating device, usually expressed as a percent.

3.8 Flashover -- An electrical breakdown or disruptive discharge over the surface of an insulating material in a gaseous or liquid medium.

3.9 Ignition Protection -- An electrical component is said to be ignition protected if its design precludes the ignition of flammable mixtures which may surround the component in normal service.

3.10 Maximum Interrupting Capacity -- The maximum current at which the fuse or breaker will interrupt the circuit.

3.11 Multi-Pole Construction -- Circuit breakers with more than one pole constructed so that all poles make and break simultaneously through a single actuator. When an overload is applied to one pole (circuit), all poles of the breaker shall open simultaneously and shall be trip-free.

3.12 Rated Current -- The nominal current value at which the fuse or circuit breaker is rated and identified.

3.13 Safe the Area -- As used in this test procedure, to "safe" an area means to reduce all pressures to zero PSIG, to disconnect or shut off any power supply, to remove any dangerous fluids or gases, or to accomplish any other act after a test which would help restore the test area to a normal safe status.

3.14 Typical Installation -- A configuration which could reasonably be expected in an actual installation.

4.0 TEST PROCEDURE

4.1 General Description -- The component to be tested shall be visually inspected upon receipt. All identifying data shall be noted and documented, such as manufacturer, date of manufacture, model number, serial number, voltage and amperage rating, capacity, test condition, general condition and any other observations which would be pertinent to the test.

4.2 Test Conditions

4.2.1 Test Article Identification -- The test article shall be identified with a test number immediately upon receipt at the test facility. This identification shall be marked on or attached to the test article for the duration of the testing process. As a minimum the following photographs shall be taken:

a. If installed in a boat, an as installed view or views showing the installation of the component, and a view showing the location of the component installation in relation to the total boat configuration and layout.

b. A close-up view or views of the individual component.

c. A view of the test configuration.

4.2.2 Personnel -- A minimum of two (2) people shall be required to perform the test and adequately monitor and document the results. In addition to these two people, two additional people may be required for safety and proper verification of the test:

1. Test Engineer
2. Technician
3. Quality Assurance Monitor (may only be required part time)
4. Safety Monitor

4.2.3 Storage and Handling -- All test components shall be handled in accordance with the manufacturer's requirements, if specified, or in accordance with accepted industry practices and standards. In no event shall the item be stacked, carried, dropped or otherwise mishandled such that the test results might be affected.

All test components shall be stored in accordance with the manufacturer's requirements with respect to time, temperature, humidity, etc. If no requirements are specified, normal conditions consistent with prudent engineering judgement shall be utilized.

4.2.4 Safety Requirements -- The following safety related items are recommended as minimum requirements to ensure the performance of a safe test to both the equipment and personnel:

a. The test area should be adequately vented, preferably outside, but protected from high wind, etc.

b. The test area should be located where access by unauthorized personnel can be prevented.

c. Test personnel should position themselves no closer than is necessary for the test.

d. Test personnel should wear protective glasses.

e. A safety monitor should stand by at a safe distance with a fire extinguisher ready to assist should an emergency occur.

f. No smoking shall be allowed in the test area.

g. An adequate pressure relief system should be utilized to relieve any pressure buildups in the system.

h. Adequate precautions relating to propane and air supplies shall be observed.

i. Any company, local, state or Federal rules, regulations or laws shall take precedence over any of the above and shall be in addition to the above.

Receiving Inspection -- Immediately upon receipt or as soon as possible thereafter, the test component or system shall be subjected to a visual inspection. The inspection shall consist of at least the following items observed

a. Date received
b. Name of component or system and quantity
c. Model number
d. Serial number
e. Shipping or transport damage
f. Quality of workmanship
g. Conformance to manufacturer's documentation and maintenance manuals

h. Dents, dings, abrasions; loose or missing screws, bolts, clamps, nuts; or other defects noted not attributable to shipping.

i. Capacity, rating or any other useful information observed

j. Proper identification in accordance with Paragraph 4.2.1 of this procedure

k. Inventory list to include any and all equipment and items received as part of this test procedure

Any discrepancies noted shall be documented and, if possible, photographed for a permanent record.

LAB EXAMINATIONS

5.0 LAB EXAMINATION NO. 1 -- IGNITION PROTECTION TEST

183.410(a) Ignition protection

(a) Each electrical component must not ignite a propane gas and air mixture that is 4.25 to 5.25 percent propane gas by volume surrounding the electrical component when it is operated at each of its manufacturer rated voltages and current loadings, unless it is isolated from gasoline fuel sources, such as engines, and valves, connections, or other fittings in vent lines, fill lines, distribution lines or on fuel tanks, in accordance with paragraph (b) of this section.

5.1 General Description -- Units with 100% duty factors that are known to get hot during their operation shall be subjected to a 7 hour (Part I) operational test. Upon successfully completing this test, the units shall then be placed in a controllable explosive atmosphere and an explosive mixture shall be induced internally into their case or housing (Part III or IV). Ignition of this internal mixture shall not ignite the external explosive atmosphere. Components identified as being sealed units may be tested by a water submergence test (Part II). Units which fail this test shall then be tested in accordance with Parts III or IV.

5.2 Test Article -- For Part I the test article shall consist of an electrical component which is intended to run continuously, either because it was designed for such operation by the manufacturer, or because of the function it performs in a boat. It shall be mounted first in a thermal chamber and then, if applicable in an explosive test chamber. The test shall simulate components operating in their actual environment, that is, a pump would be pumping fluid in a simulated system with typical pipe size, vertical rise, etc.

For Part II the test article shall consist of a sealed electrical component. It shall be submerged under water in a test tank to verify its sealing capability.

For Parts III and IV the test article shall consist of electrical components required to withstand internal ignitions without igniting the surrounding atmosphere. They shall be mounted in an explosion chamber similar to a typical installation and modified if required so that an explosive mixture can be induced internally into the component. Components tested in Part III shall not be operated.

Test Equipment and Schematic

Component Find No.	Title	Description
1	Air Supply	A supply of shop grade air used for mixing with propane to supply the explosive atmosphere. Can be facility air, high pressure bottled air or compressed air.
2	Mix Chamber Air Control Assembly	Controls air supply to mix chamber. Consists of a shutoff valve, regulator and check valve.
3	Mix Chamber	A chamber or tank rated at least at 125 PSIG where the air and propane are mixed together to form the explosive atmosphere.
4	Propane Supply	A supply of propane used for mixing with air to provide the explosive atmosphere.
5	Mix Chamber Propane Control Assembly	Controls the propane supply to the mix chamber. Consists of a shutoff valve, regulator and check valve.
6	Pressure Gauge	A pressure gauge used to monitor the mix chamber pressure.
7	Test Chamber Pressure Control Assembly	Controls the flow of the explosive mixture into the test chamber. Consists of a shutoff valve, regulator and check valve.
8	Test Chamber Air Purge Control Assembly	Controls the flow of air into the test chamber for purging out ignition gases. Consists of a shutoff valve, regulator and check valve.
9	Air Pump	A vacuum pump used for circulating the explosive atmosphere through the component housing.
10	Component Vent Valve	A shutoff valve used to isolate the component from the air pump.
11	Indicator	An indicator (pressure, temperature or equivalent) used to verify an ignition within the component case.

Component Find No.	Title	Description
12	Analyzer Selector valve	A 3-way, 2-position valve used for selecting either a sample of gas from the mix chamber or the test chamber.
13	Hydrocarbon Analyzer	A test instrument used for measuring hydrocarbon concentrations in sample gases (in this case, propane in air). Includes its own vacuum pump for drawing gas samples.
14	Bulkhead Fitting	A pressure fitting installed in the test chamber wall to provide access for a pressure line.
15	Bulkhead Fitting	Same as 14 above.
16	Diffuser	A gas diffuser system used to evenly distribute the explosive mixture throughout the test chamber.
17	Bulkhead Fitting	Same as 14 above.
18	Gas Sample Intake	A tube inlet positioned near the test component where a sample of gas is required if the analyzer is used.
19	Mounting Platform	A platform or base secured to the test chamber on which the test component can be mounted in its normal attitude.
20	Test Component	The unit under test.
21	Pressure Fitting	A fitting installed in the component housing used for flowing the explosive mixture through the test component.
22	Spark Igniter	A standard auto spark plug used for igniting the explosive mixture within the component housing.
23	Component Power Supply	A variable power source capable of supplying the required voltages to operate the test component.

Component Find No.	Title	Description
24	Spark Igniter	Same as 23 above.
25	Test Chamber Ignition Coil	A standard auto ignition coil used to supply high voltage to the test component spark igniter.
26	Test Component Ignition Coil	Same as 25 above. Could be the same coil used in 25 above.
27	High Voltage Power Supply	A standard 12 vdc battery or equivalent used to supply the primary voltage to the ignition coils.
28	Mounting Plate	A metal plate attached to the test chamber into which the spark igniter can be mounted.
29	Bulkhead Fitting	A pressure fitting installed in the test chamber wall to provide access for a pressure line.
30	Pressure Fitting	A fitting installed in the componen housing used for flowing the explosive mixture through the test component.
31	Test Component Pressure Control Assembly	Controls the flow of the explosive mixture into the component housing, consists of a shutoff valve, regulator and check valve.
32	Lid	Top of test chamber which opens and relieves pressure during explosions.
33	Hinge	A standard heavy duty door or gate hinge which connects the lid to the rest of the test chamber and allows lid to open and relieve pressure during explosions.
34	Test Chamber	A test chamber made of 3/4" or 1" plywood, approximately 2' x 2' x 2' lined with an insulator where controlled explosions can be set off.
34	Seal	A seal between the lid and the chamber to somewhat control internal atmosphere. Should not be completely airtight.

Component Find No.	Title	Description
36	Elastic Cord or Spring	An elastic cord or spring which maintains a slight tension on lid for sealing purposes but allows lid to relieve pressure during an explosion.
37	Vent Hole	A 2" x 6" hole in the lid covered with tape or vinyl to allow for air flow into chamber after an explosion.
38	Amp Meter	A meter used to measure the current flow in a circuit.
39	Dummy Load	A load simulating actual components which might be found in an electrical circuit.
40	Volt Meter	A meter used to measure the voltage in a circuit.
41	Battery	A standard automobile or boat battery which may be required when testing certain components.
42	Rheostat	A variable resistor used to vary the voltage in a circuit.
43	Mechanical Actuator	A lever arm used to actuate a component while it is in the test chamber.
44	Temperature Indicator	A remote instrument capable of indicating the temperature at the component as measured by thermocouples or equivalent.
45	Thermocouples	Two thermocouples used to measure the surface temperature of the component.

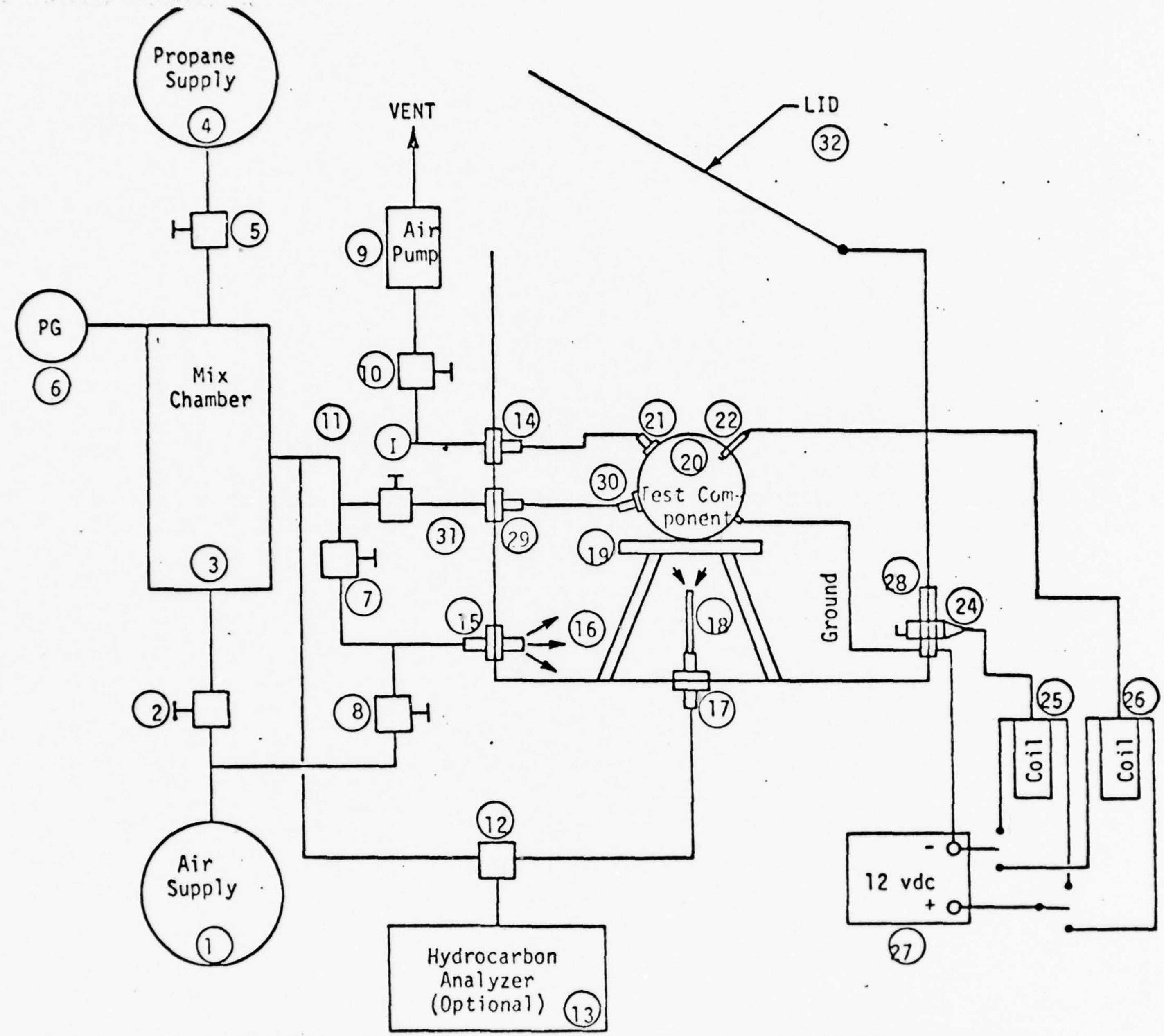


FIGURE 1. PART III AND PART IV EXPLOSION CHAMBER

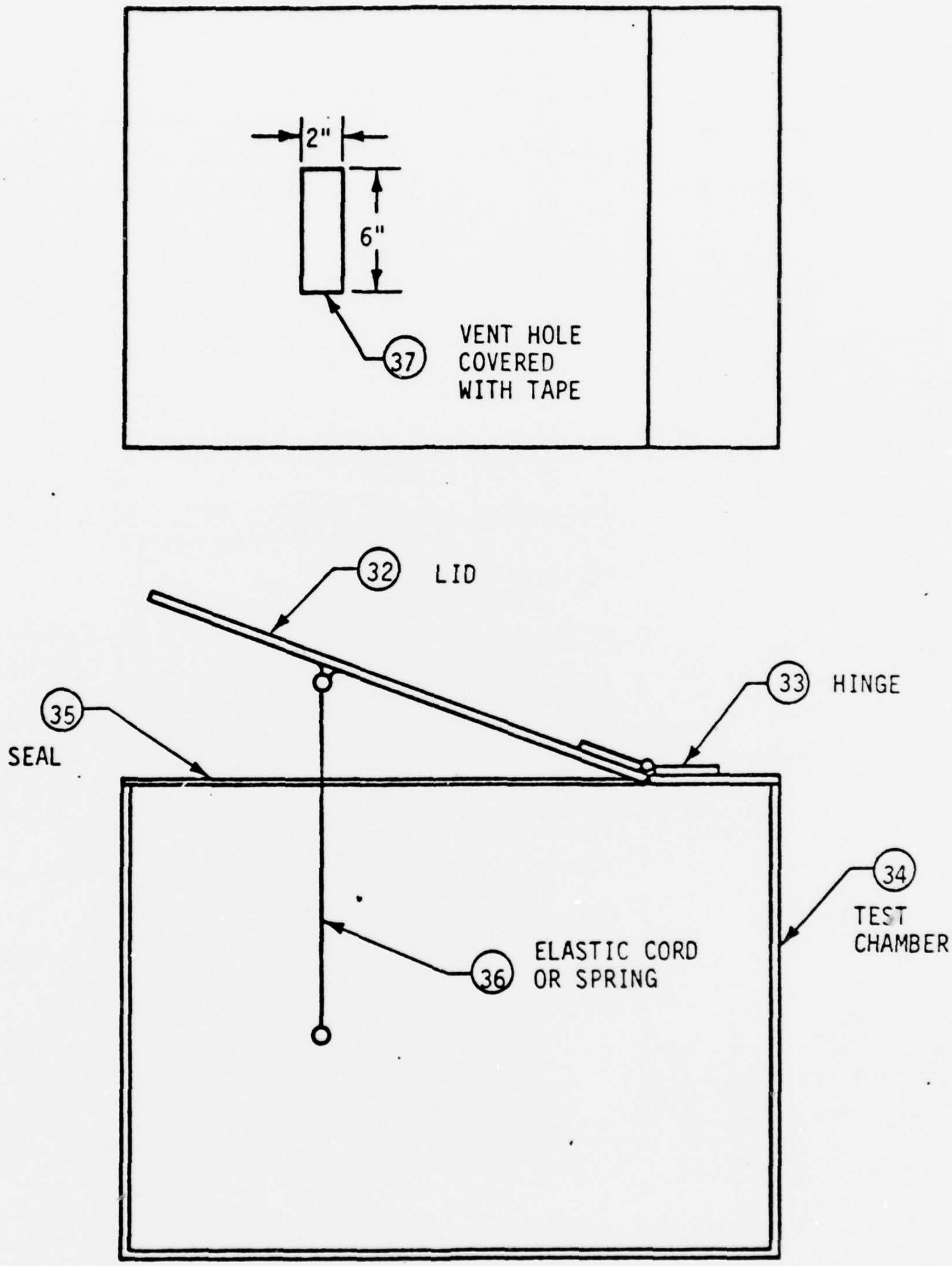


FIGURE 2. GENERAL TEST CHAMBER CONFIGURATION

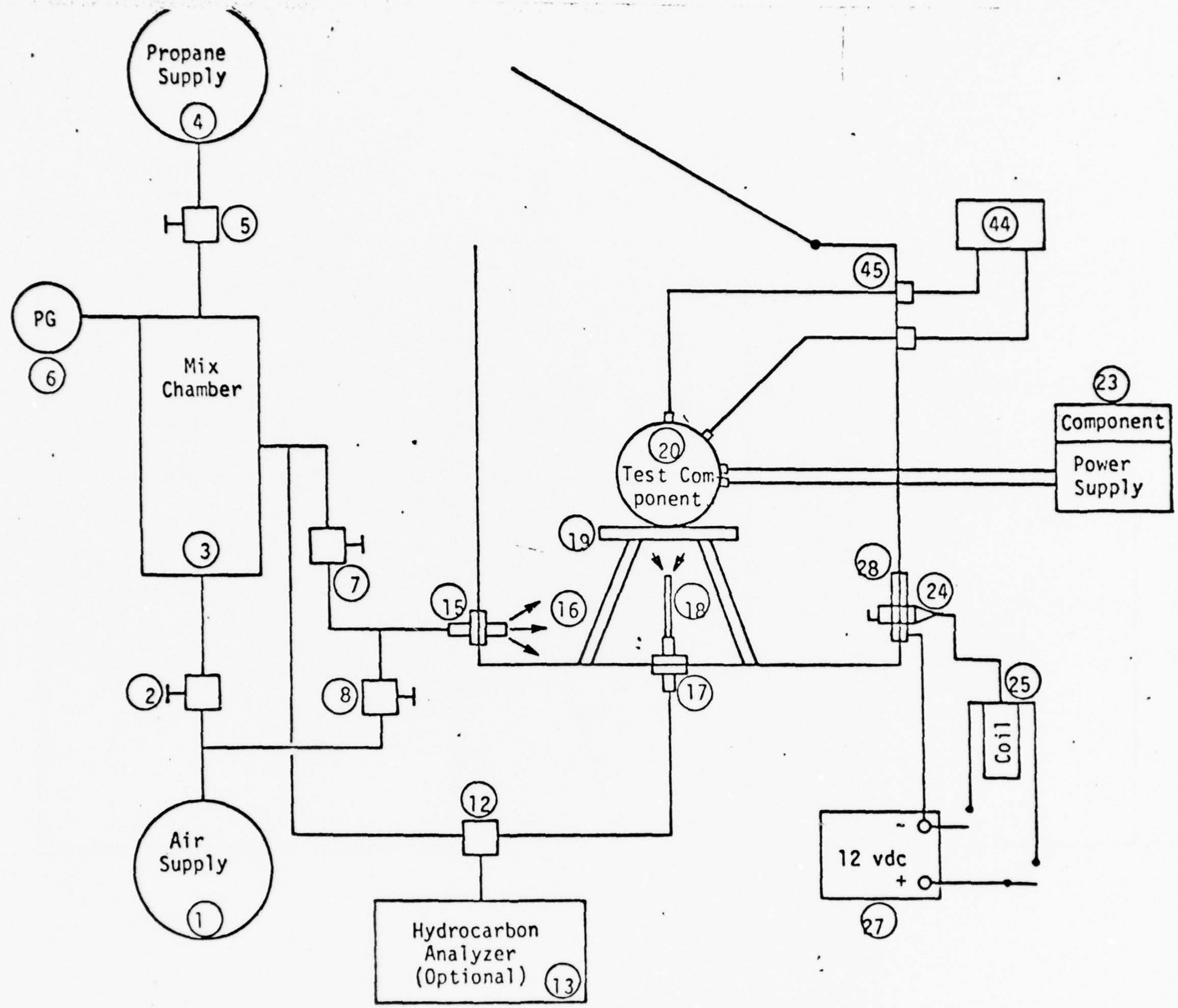


FIGURE 3. PART II - HIGH TEMPERATURE OPERATING TEST

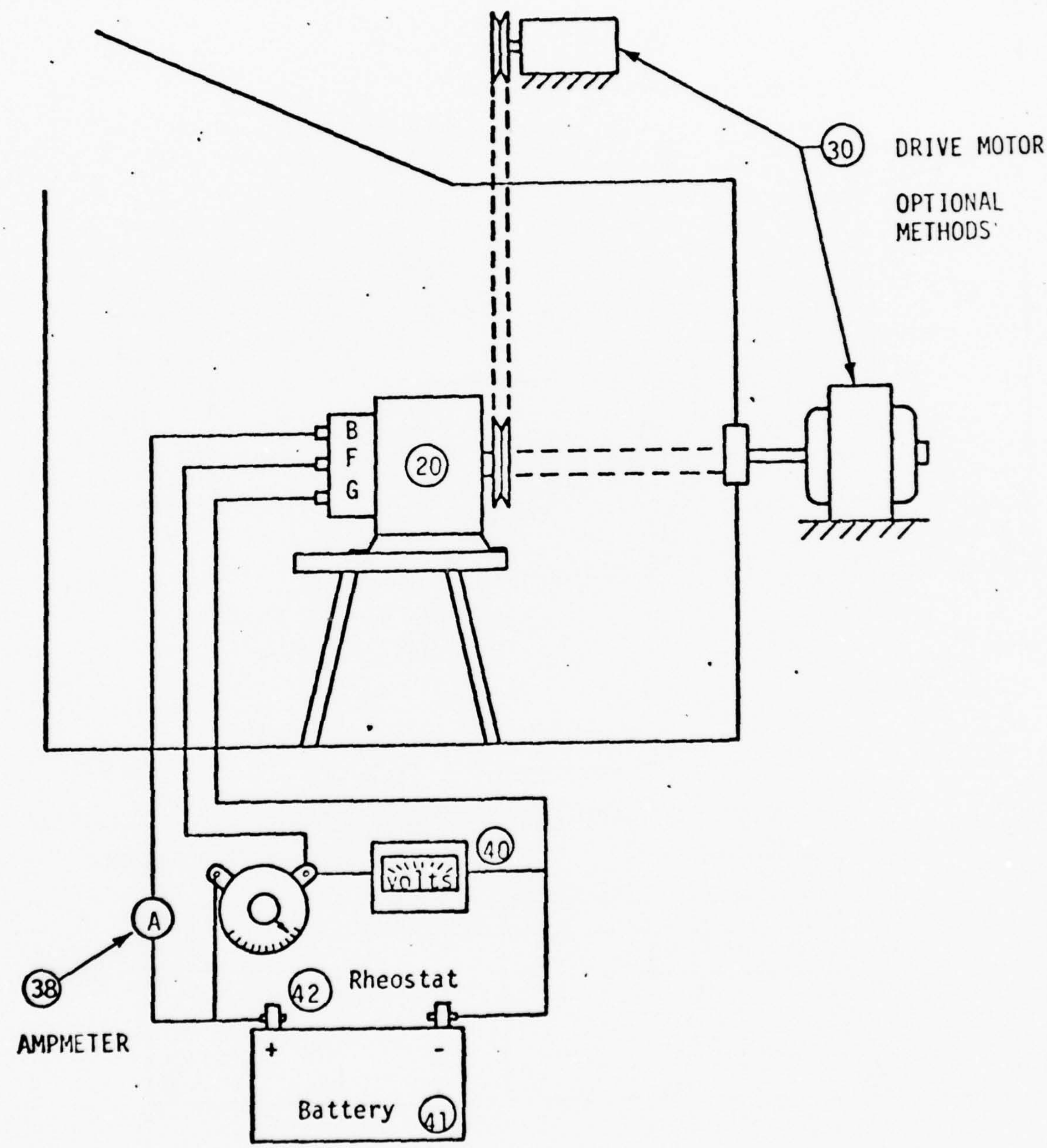
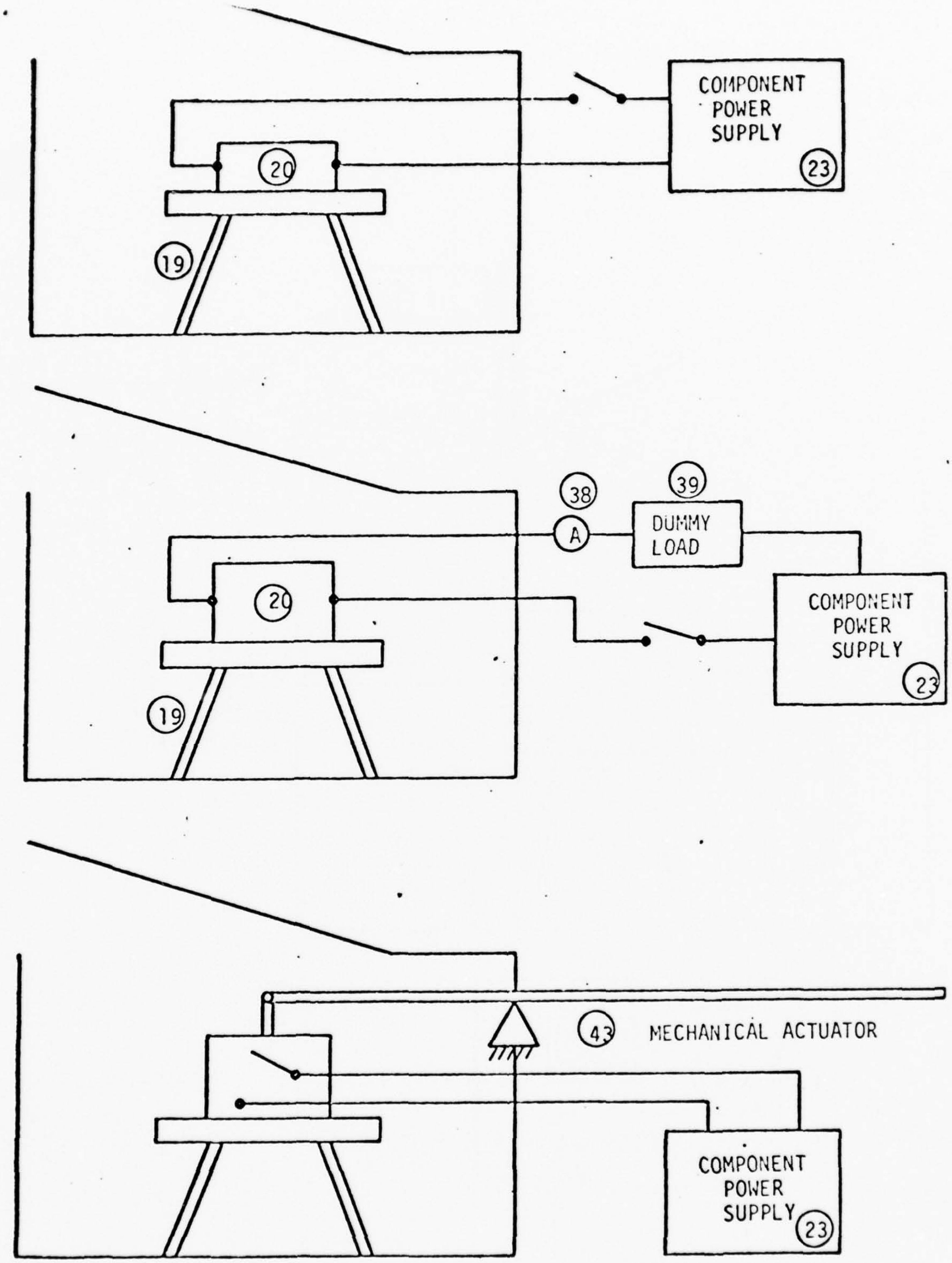


FIGURE 4. AUXILIARY TEST EQUIPMENT AND SETUPS



Above examples illustrate some of the typical auxiliary equipment which may be required to test certain components for Part IV.

FIGURE 5. AUXILIARY TEST EQUIPMENT AND SETUPS

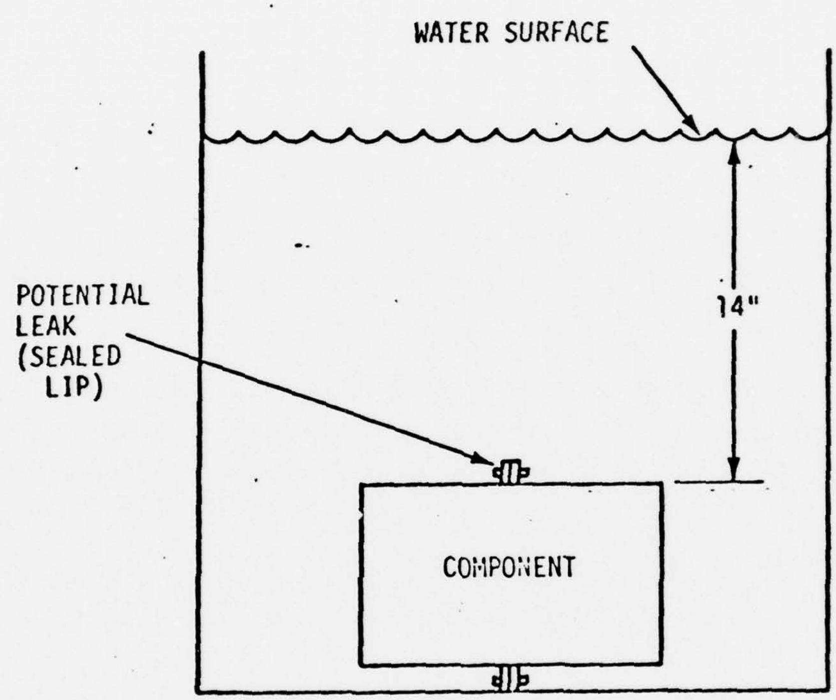


FIGURE 6. PART II WATER SUBMERGENCE TEST

5.7 Purpose of Ignition Protection Test Procedure -- The purpose of this test procedure is to specify an acceptable method and the equipment to be employed in determining whether or not a particular electrical component is in compliance with Section 183.410 of the Electrical Systems Standard in Subpart I of Part 183 of Title 33, Code of Federal Regulations.

5.7.1 This procedure shall be used to perform an ignition protection test on all electrical components which are not isolated from gasoline fuel sources.

5.7.2 All components shall be subjected to at least one part of this procedure but may be tested under more than one part as required by the particular component being tested.

5.7.3 Components identified as being ignition protected and verified by an approved independent testing laboratory as having passed an accepted industry test, may be considered as having met the requirements as specified in this procedure.

5.7.4 Components that are obviously unprotected or open, or are unacceptable for other reasons related to ignition protection shall be rejected.

5.7.5 Visually inspect the component to be tested. Review the results of the Receiving Inspection and verify that the component is acceptable and ready for testing.

5.7.6 Verify the applicability of this procedure to the component being tested before proceeding (Paragraph 5.2). Determine which test or tests (Part I, II, III or IV) the component shall be subjected to according to the specified criteria.

5.7.7 Part I - High Temperature Operating Test

5.7.7.1 Part I of this procedure shall be used to test all electrical components which are known or suspected of exceeding 200°C (392°F) during their normal operation.

5.7.7.2 Obtain all pertinent design and performance specifications from either the component itself or from the manufacturer, such as rated voltage and amperage, rpm, duty factor, etc.

NOTE

For components whose normal operating mode is automatic or if the duty factor cannot be obtained or is unknown, the components shall be considered for continuous duty (100%). Most of the components tested under this section will have 100% duty factors.

5.7.7.3 Secure the component if necessary to a mounting platform in an attitude similar to that in typical boat installation. All components shall be operated under conditions and loads similar to what they would actually experience, i. e. blowing air, pumping water, etc. Thus, the mounting platform for a bilge pump might be a pan filled with water to simulate a bilge in which the pump would normally be used.

5.7.7.4 Position the mounting platform and/or component in a thermal chamber and secure it to the base of the chamber as required.

NOTE

During this part of the test the component shall be operated under its normal rated condition but not in an explosive atmosphere.

5.7.7.5 Position at least two thermocouples capable of measuring 200°C at different locations on the surface of the component. If possible, locate them in areas which would be more likely to reach the highest temperatures.

5.7.7.6 Connect the component to whatever auxiliary equipment is required to simulate the normal operational conditions for that component. See Figures 4 and 5.

5.7.7.7 Verify the temperature within the test chamber as either $30°C^{+2.0}_{-0.0}$ or $50°C^{+2.0}_{-0.0}$ at the start of the test. Components which are normally mounted or installed within the engine compartment shall be subjected to the 50°C initial temperature. All other components shall be subjected to the 30°C initial temperature.

NOTE

Once the test has started external heat shall not be applied to the test chamber. The air in the chamber may be recirculated as long as this condition does not violate an operating requirement for that particular component.

5.7.7.8 Operate the component continuously according to the specifications and requirements as stated in Paragraphs 5.7.7.2 and 5.7.7.3 for a period of 7 hours at its rated conditions.

5.7.7.9 Continue the test for the full 7 hours, even if it appears that 200°C will not be reached. Continuously monitor the component surface temperatures.

5.7.7.10 If the highest temperature observed at any point exceeds 200°C, the component shall undergo the same operational test in an explosive atmosphere.

NOTE

The same component shall be used for the additional test.

5.7.7.11 Remove the thermocouples from the test chamber.

5.7.7.12 Remove the component from the test chamber and install the component in an explosion chamber in a configuration similar to the previous test.

5.7.7.13 Insulate any wires or controls as necessary to protect them from the chamber explosions. All wires and controls should be sealed at their point of entrance into the test chamber.

5.7.7.14 Verify that all safety precautions are in effect and that the system and test personnel are ready for the test to start. Verify a CO_2 or equivalent fire extinguisher is available and positioned properly.

5.7.7.15 Purge the mix tank with air for 10 minutes to ensure there are no other gases present.

5.7.7.16 Fill the mix tank with a mixture of propane gas and air. Verify the mixture is 4.75% ± 0.50% propane by volume using a suitable gas analyzer.

5.7.7.17 Using the explosive mixture in the mix tank, fill the test chamber with the mixture. Slowly purge the test chamber with the mixture until at least one complete atmosphere has been exchanged (to ensure uniformity of the chamber atmosphere). Continue to purge the test chamber with the propane/air mixture during the test at a rate of approximately 1 ft^3 per minute (just enough to maintain a slight positive pressure in the test chamber). Monitor the chamber atmosphere using the gas analyzer and adjust the purge mixture and flow as necessary to maintain the propane at 4.75% ± 0.50%.

5.7.7.18 Operate the component according to Paragraph 5.7.7.8 for a total of 7 hours. Monitor the gas analyzer at least every five minutes during the test and verify the mixture remains within the required limits throughout the test. Verify that the explosive mixture does not ignite by means of visual observation, the use of a pressure or temperature transducer, or by any other suitable means. At the end of 7 hours isolate all necessary test equipment from the test chamber and ignite the mixture in the test chamber or ignite a sample of the mixture from the test chamber to verify that an actual explosive mixture existed during the test.

NOTE

> All of the chamber mixture readings taken during the test must be within the required limits (4.75% ± 0.50% propane by volume) and the test ignition at the end of the test must be successful. If not, the entire test shall be repeated. When an out-of-tolerance mixture occurs, do not finish the test, but start over immediately.

If the component caused an ignition of the mixture in the chamber, the component shall be rejected. If the component did not cause the mixture to ignite, the component shall be deemed acceptable according to the requirements of Part I of this procedure. proceed to Parts II, III and IV.

5.7.7.19 Secure the test as required and safe the area.

5.7.8 Part II - Water Submergence Test

5.7.8.1 This procedure shall be used to perform a leak check on electrical components identified as being ignition protected because they are sealed units. Such units may be tested to this procedure instead of the applicable procedure utilizing an explosive atmosphere (Part III or Part IV). However, if the component fails this test, it shall be subjected to Part III or IV for actual determination of its being acceptable.

5.7.8.2 Visually inspect the component to be tested. Review the results of the Receiving Inspection (Data Form No. 1) and verify the component is acceptable and ready for testing.

5.7.8.3 Verify the applicability of this procedure to the component being tested before proceeding. This procedure shall be used only on sealed components which are not isolated from gasoline fuel sources.

5.7.8.4 Place the test component in a glass container of clear ordinary tap water. For components which are normally mounted or installed within the engine compartment the water shall be heated to $50°C^{+2.0}_{-0.0}$ at the start of the test. All other components shall be tested using water at a temperature of $30°C^{+2.0}_{-0.0}$ at the start of the test. Once the test has started no external heat shall be applied to the water.

The top of the component should be at least 14 in. (35.6 cm.) below the surface of the water. With the component below water, rotate it several times to ensure that no air has been entrapped on the exterior surface which could invalidate the test. Verify the unit will remain submerged when not being held or position an additional weight to hold it down. See Figure 6.

5.7.8.5 Determine by visual inspection the areas of the component which would be susceptible to external leakage, such as a gasket seam, a screw or bolt hole, etc. Position each area to the top (but at least 14 in. under the surface of the water) for 15 minutes (each area) and observe any indication of bubbles coming from the component.

NOTE

As an example, if a rectangular component was made of two parts and sealed together by a gasket, this would be considered as having four leakage areas (each side) and would require four 15 minute tests, each side being rotated to the top for 15 minutes and at least 14 in. below the surface of the water.

5.7.8.6 If any bubbles are observed coming from the component, the component shall be considered as having failed Part II of this procedure and shall be subjected to Part III or Part IV of this procedure for final determination of its acceptance. If no bubbles are observed coming from the component, the component shall be removed from the water.. Use a cloth and/or air to dry the external surface of the component. Disassemble the component and inspect the internal areas for any water. If water is found, the component shall be subjected to Part III or Part IV of this procedure for final determination of its acceptance.

If no water is found, the component shall be deemed acceptable according to the requirements of this procedure.

5.7.8.7 Secure the test as required and safe the area.

5.7.9 Part III - Induced Ignition Test

5.7.9.1 Part III of this procedure shall be used to test all electrical components which have rotating parts (slip rings, commutators, etc.) such as distributors, alternators, generators and motors. Some components with rotating parts are low energy devices and do not generate a spark of sufficient energy to ignite propane. They will be tested under Part IV in lieu of Part III. Other components that require open construction for ventilation and thus make it impracticable to ignition protect the component from a structural integrity standpoint, will be tested under Part IV in lieu of Part III.

5.7.9.2 Construct an explosion chamber and supporting equipment similar to the setup shown in the Test Schematic. The exact configuration and components may vary between test facilities. This is acceptable as long as the capability of the system is equivalent and the requirements of the procedure can be met satisfactorily. As a minimum the test system should have the following capabilities:

a. Supply and maintain an explosive mixture of propane and air (4.25 to 5.25 percent propane by volume) to the test chamber and the component.

b. Provide a chamber where the component can be tested in this explosive atmosphere and where the mixture can be ignited as required in complete safety.

c. Provide a power supply and an ignition source for igniting the explosive mixture.

5.7.9.3 Secure the component to a mounting platform in an attitude similar to that in a typical boat installation. The component shall not be operating during this test.

5.7.9.4 If the component contains a flame screen or is otherwise vented to the atmosphere (i. e. not sealed), two holes should be drilled and tapped in the component housing or case for installation of a spark plug (Find No. 22) and a small pressure fitting (Find No. 21). If tapping is not possible, a small bulkhead fitting with a jam nut can be used for the pressure fitting. A long reach gasket type spark plug with a manufactured jam nut can be used for the ignition source. In any case, these two holes should be sealed using gaskets and/or high temperature sealant. An explosion proof vacuum pump shall be used to pull the explosive mixture into the component through the vented areas from the external explosive atmosphere. If the component is sealed or nearly air-tight, an additional fitting (Find No. 30) is required for admitting the mixture into the component case from the supply system. All of these fittings shall be sized and located according to the limitations of the component.

5.7.9.5 Position the mounting platform and/or component in the center of the test chamber and secure it to the base of the chamber as required.

5.7.9.6 Connect a spark plug ignition wire to the spark plug (on the Component case) and insulate the section of wire inside the chamber. Connect a ground wire between the component case and the ground side of the spark ignition source.. Insulate the section of wire inside the chamber.

5.7.9.7 Connect a hardline (copper tubing) from outside the test chamber to the pressure fitting (or fittings if required) on the component case as shown on the Test schematic (Figure 1).

5.7.9.8 Verify that all safety precuations are in effect and that the system and test personnel are ready for the test to start. Verify a CO_2 or equivalent fire extinguisher is available and positioned properly.

5.7.9.9 Purge the mix tank with air for 10 minutes to ensure there are no other gases present.

5.7.9.10 Fill the mix tank with a mixture of propane gas and air. Verify the mixture is 4.75% ± 0.50% propane by volume using a suitable gas analyzer.

NOTE

Accomplish either Paragraph 5.7.9.11 or Paragraph 5.7.9.12 depending on whether or not the component is sealed or vented.

5.7.9.11 Vented or open components only (one pressure line to component)

5.7.9.11.1 Using the explosive mixture in the mix tank, fill the test chamber with the mixture. Slowly purge (3 - 4 ft^3/min.) the test chamber with the mixture until at least one complete atmosphere has been exchanged (to ensure uniformity of the chamber atmosphere).

5.7.9.11.2 Continue to purge the test chamber with the propane/air mixture during the test at a rate of approximately 1 ft^3 per minute (just enough to maintain a slight positive pressure in the test chamber). Monitor the chamber atmosphere using the gas analyzer and adjust the purge mixture and/or flow as necessary to maintain the propane at 4.75% ± 0.50%. During this purge open the inlet valve to the component case and operate the vacuum pump for a period of about 20 seconds to pull a quantity of the explosive atmosphere into the component case. Turn the vacuum pump off and close the vacuum pump inlet valve (Find No. 10).

5.7.9.11.3 Momentarily isolate all necessary test equipment from the test chamber and ignite the mixture in the component by firing the component spark plug.

NOTE

A failure to ignite may indicate the component should be tested by Paragraph 5.7.9.12 instead of Paragraph 5.7.9.11.

NOTE

A high voltage spark is required for this test. consequently, the only component which may not require a spark plug would be a distributor with the rotor gap verified acceptable (at least 0.060 in.). A multi-spark igniter is acceptable for the internal ignition. Components which normally operate in more than one position and whose flame path may be affected by such operation should be tested in both positions (such as a cranking motor energized with pinion in and out). The spark source should be installed as close as possible to that part of the component from which the arc would normally originate. For example, with an electric motor the spark source should be installed at the commutator end.

Verify the component internal ignition has occurred by any suitable means such as by audible detection, visual detection or a pressure or temperature transducer. The internal ignition in the component case shall not cause the explosive atmosphere in the test chamber to ignite. Verify the chamber atmosphere does not ignite by means of a visual observation, the use of a pressure or temperature transducer or by any other suitable means.

NOTE

Up to a maximum of 10 component internal ignitions may be attempted during each test chamber filling. After 10 component ignitions the chamber atmosphere shall be verified by Paragraph 5.7.9.11.4. At that point if the explosive atmosphere cannot be verified, only those 10 tests shall be repeated. The ten internal ignitions do not necessarily have to be in succession; that is, there may be 4 internal ignitions, 1 misfire, then 5 more ignitions. This would count as 9 successful tests as long as the chamber explosive atmosphere could be verified. It is permissible for 1 cycle to contain 10 tests while other cycles contain fewer tests, but a total of 50 successful tests must be accumulated.

5.7.9.11.4 After every 10 internal explosions in the component, ignite the explosive atmosphere in the test chamber or ignite a sample of the mixture from the test chamber to verify that an actual explosive mixture was present. A single spark igniter is required for atmosphere ignition

5.7.9.11.5 Repeat this test according to Paragraphs 5.7.9.11.1 through 5.7.9.11.4 until a total of 50 successful tests (internal ignitions) have been completed or until the test chamber atmosphere is ignited by one of the internal ignitions.

5.7.9.12 Sealed or closed components only (2 pressure lines to component).

5.7.9.12.1 Using the explosive mixture in the mix tank, fill the test chamber with the mixture. Slowly purge (3 - 4 ft^3/min.) the test chamber with the mixture until at least one complete atmosphere has been exchanged (to ensure uniformity of the chamber atmosphere).

5.7.9.12.2 Continue to purge the test chamber with the propane/air mixture during the test at a rate of approximately 1 ft^3 per minute (just enough to maintain a slight positive pressure in the test chamber). Monitor the chamber atmosphere using the gas analyzer and adjust the purge mixture and/or flow as necessary to maintain the propane at 4.75% $\pm$ 0.50%.

5.7.9.12.3 Open the purge control valves (Find No. 10) to the component and purge the component with the explosive mixture from the mix tank for about 20 seconds. Close the purge control valves.

<u>NOTE</u>

The vacuum pump (Find No. 9) is not required for this test.

5.7.9.12.4 Momentarily isolate all necessary test equipment from the test chamber and ignite the mixture in the component by firing the component spark plug.

<u>NOTE</u>

A high voltage spark is required for this test. Consequently, the only component which may not require a spark plug would be a distributor with the rotor gap verified acceptable (at least 0.60 in.). A multi-spark igniter is acceptable for the internal ignition. Components which normally operate in more than one position and whose flame path may be affected by such operation should be tested in both positions (such as a cranking motor energized with pinion in and out). The spark source should be installed as close as possible to that part of the component from which the arc would normally originate. For example, with an electric motor the spark source should be installed at the commutator end.

Verify this component internal ignition has occurred by any suitable means, such as by audible detection, visual detection or a pressure or temperature transducer. The internal ignition in the component case shall not cause the explosive atmosphere in the test chamber to ignite. Verify the chamber atmosphere does not ignite by means of a visual observation, the use of a pressure or temperature transducer or by any other suitable means.

NOTE

Up to a maximum of 10 component internal ignitions may be attempted during each test chamber filling. After 10 component ignitions, the chamber atmosphere shall be verified by Paragraph 5.7.9.12.5. At that point, if the explosive atmosphere cannot be verified, only those 10 tests shall be repeated. The ten internal ignitions do not necessarily have to be in succession, that is, there may be 4 internal ignitions, 1 misfire, then 5 more ignitions. This would count as 9 successful tests as long as the chamber explosive atmosphere could be verified. It is permissible for 1 cycle to contain 10 tests while other cycles contain fewer tests but a total of 50 successful tests must be accumulated.

5.7.9.12.5 After every 10 internal ignitions in the component, ignite the explosive atmosphere in the test chamber or ignite a sample of the mixture from the test chamber to verify that an actual explosive mixture was present. A single spark igniter is required for atmosphere ignition.

5.7.9.12.6 Repeat this test according to Paragraphs 5.7.9.12.1 through 5.7.9.12.5 until a total of 50 successful tests (internal ignitions) have been completed or until the test chamber atmosphere is ignited by one of the internal ignitions.

5.7.9.13 If any of the internal explosions caused the test chamber mixture to ignite, the component shall be rejected.

5.7.9.14 Secure the test system as required and safe the area.

5.7.10 Part IV - Propane/Air Mixture Exposure

5.7.10.1 Part IV of this procedure shall be used to test all electrical components which do not have rotating parts such as switches and circuit breakers. Some components with rotating parts are low energy devices and do not generate a spark of sufficient energy to ignite propane. They will be tested under Part IV in lieu of Part III. Other components that require open construction for ventilation and thus make it impracticable to ignition protect the component from a structural integrity standpoint, will be tested under Part IV in lieu of Part III.

5.7.10.2 Obtain all pertinent design and performance specifications either from the component itself or from the manufacturer, such as rated voltage, current, rpm, duty factor, etc.

NOTE

Most of the components tested in this section will be on-off type components and shall be operated within the limits of their normal duty cycle.

5.7.10.3 Construct an explosion chamber and supporting equipment similar to the setup shown in the Test Schematic. The exact configuration and components may vary between testing facilities. This is acceptable as long as the capability of the system is equivalent and the requirements of the procedure can be met satisfactorily. As a minimum the test systen should have the following capabilities:

a. Supply and maintain an explosive mixture of propane and air (4.25 percent to 5.25 percent propane by volume) to the test chamber and the component.

b. Provide a chamber where the component can be tested in this explosive atmosphere and where the mixture can be ignited as required in complete safety.

c. Provide a power supply for the component as required and an ignition source for igniting the explosive mixture if required.

5.7.10.4 Secure the component to a mounting platform in an attitude similar to that in a typical boat installation. The component shall be operated during this test in its normal duty cycle (in accordance with) at rated voltage and current.

5.7.10.5 If the component contains a flame screen or is otherwise vented to the atmosphere (i. e. not sealed or airtight), one pressure fitting (Find No. 21) should be located in the component housing or case for connection of a small exhaust tube or line. The line should be suitable for high temperatures and sealed at the entrance to the component. An explosion proof vacuum pump shall be used to pull the explosive mixture into the component through the vented areas from the external explosive atmosphere. If the component is sealed or nearly air tight, an additional fitting (Find No. 30) is required for admitting the mixture into the component case from the supply system. All of these fittings shall be sized and located according to the limitations of the component.

5.7.10.6 Position the mounting platform and/or component in the center of the test chamber and secure it to the base of the chamber as required.

4.7.10.7 Connect the component to whatever support equipment is required to simulate operational conditions at rated load. See Figures 4 and 5.

5.7.10.8 Insulate any electrical wires or mechanical controls as necessary to protect them from the chamber explosions.

5.7.10.9 Verify that all safety precautions are in effect and that the system and test personnel are ready for the test to start. Verify that a CO_2 or equivalent fire extinguisher is available and positioned peoperly.

5.7.10.10 Purge the mix tank with air for ten minutes to ensure there are no other gases present.

5.7.10.11 Fill the mix tank with a mixture of propane gas and air. Verify the mixture is 4.75% $\pm$ 0.50% propane by volume by using a suitable gas analyzer.

NOTE

Accomplish either Paragraph 5.7.10.12 or Paragraph 5.7.10.13 depending on whether or not the component is sealed or vented.

5.7.10.12 Vented or open components only (one pressure line to component).

5.7.10.12.1 Using the explosive mixture in the mix tank, fill the test chamber with the mixture. Slowly purge the test chamber with the mixture until at least one complete atmosphere has been exchanged to ensure uniformity of the chamber atmosphere.

5.7.10.12.2 Continue to purge the test chamber with the propane/air mixture during the test at a rate of approximately 1 ft^3/min (just enough to maintain a slight positive pressure in the test chamber). Monitor the chamber atmosphere using the gas analyzer to adjust the purge mixture and/or flow as necessary to maintain the propane at 4.75% $\pm$ 0.50%.

5.7.10.12.3 During this purge open the inlet valve to the component case and operate the vacuum pump for a period of about 20 seconds to pull a quantity of the explosive atmosphere into the component case.

5.7.10.12.4 Turn the vacuum pump off and close the component vent valve (Find No. 10).

5.7.10.13 Sealed or closed components only (2 pressure lines to component).

5.7.10.13.1 Using the explosive mixture in the mix tank, fill the test chamber with the mixture. Slowly purge the test chamber with the mixture until at least one complete atmosphere has been exchanged to ensure uniformity of the chamber atmosphere. Continue to purge the test chamber with the propane/air mixture during the test at a rate of approximately 1 ft^3/min (just enough to maintain a slight positive pressure in the test chamber). Monitor the chamber atmosphere using the gas analyzer and adjust the purge mixture and/or flow as necessary to maintain the propane at 4.75% $\pm$ 0.50%.

5.7.10.13.2 Open the purge valves to the component (Find No. 31 and 10) and purge the component with the explosive mixture from the mix tank for about 20 seconds. Close the purge valves.

5.7.10.14. Operate or cycle the component 10 times or until an internal component explosion occurs at a rate consistent with the fastest normal cycling that the component could be expected to experience. The conditions shall be as specified in Paragraph 5.7.10.4. If an internal ignition occurs, verify that the test chamber atmosphere does not ignite by visual observation, use of a pressure or temperature transducer or by any other suitable means. When an internal ignition occurs or after 10 cycles of operation, ignite the mixture in the test chamber or ignite a sample of the mixture from the test chamber to verify that an actual explosive mixture existed during the test. If the explosive mixture cannot be verified, refill the chamber according to Paragraph 5.7.10.12 or 5.7.10.13 and repeat only that portion of the test. Continue the test until 50 successful cycles have been completed.

NOTE

Each part of the test shall contain no more than 10 cycles of operation of the component, but may contain less than 10 cycles. Continue the test until 50 cycles have been accumulated. It is permissable for an internal component explosion to occur but not a requirement, as long as the test chamber atmosphere does not ignite due to the component. For this test items such as switches shall be cycled on and off. Solenoids and relays shall be energized and de-energized. Other components shall be cycled in a similar manner.

5.7.10.15 If operation of the component or the internal ignitions caused the test chamber mixture to ignite, the component shall be rejected.

5.7.10.16 Secure the test system as required and safe the area.

6.0 LAB EXAMINATION NO. 2

183.430 Conductors in circuits of less than 50 volts

(a) Each conductor in a circuit that has a nominal voltage of less than 50 volts must—

(1) Meet the requirements of § 183.435; or

(2) Meet—

(i) The insulating material temperature rating requirements of SAE Standard J378b dated November 1976; and

(ii) SAE Standard J1127 dated November 1975, or SAE Standard 1128 dated November 1975.

(b) This section does not apply to communication systems; electronic navigation equipment; resistance conductors that control circuit amperage; and pigtails of less than seven inches of exposed length.

6.1 This examination will determine compliance of conductor types with the requirements of §183.430.

6.1.1 Conductors which cannot be identified by Visual Examination No. 4 as being in compliance with §183.430 are to be tested in accordance with this examination.

6.2 APPARATUS

6.2.1 As prescribed in the attached SAE Standards:

a. Insulating material temperature rating requirements of SAE J378 dated November 1976, corrected February 1977;

b. J1127 dated November 1975; and

c. J1128 dated November 1975.

6.3 EXAMINATION SPECIMEN

6.3.1 All conductors on a boat determined by Visual Examination No. 4 to be tested for compliance.

6.3.2 The conductors may be taken from the boat or samples may be obtained from the manufacturer.

6.4 EXAMINATION PROCEDURE

6.4.1 The procedure shall be conducted in accordance with the procedures described in SAE J1127, SAE J1128 and the insulating material temperature rating requirements of SAE J378b.

6.4.2 Determine the type of conductor prior to testing by contacting the manufacturer. This will facilitate testing by avoiding the necessity of running all the tests.

6.4.3 If the type of conductor cannot be ascertained, perform the individual tests in a process of elimination approach to identify the conductor.

6.4.4 Report should include test sequence, validation of conductor type, sampling process and pass or fail.

Marine Engine Wiring —SAE J378b

SAE Recommended Practice
Completely Revised November 1976

THIS IS A PREPRINT AND WILL
APPEAR IN THE NEXT EDITION
OF THE SAE HANDBOOK

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

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PREPRINT

Report of Marine Technical Committee approved January 1969 and completely revised November 1976. Rationale statement available.

Scope—This recommended practice covers 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.

Purpose—The purpose of this recommended practice is to insure that wiring used on marine engines meets the necessary safety standards of the industry. These recommendations provide manufacturers installing engine electrical systems sufficient information to design and develop engine wiring harnesses safe for marine usage.

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.

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 failure, 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 always practical. Protection can be afforded by proper selection of components and installation practices in accordance with the following recommendations.

Low Tension Wiring—All wiring shall conform to SAE Standards J1127 and/or J1128. In addition, the temperature rating of the wire insulation shall be determined by an accelerated aging test conducted in accordance with ASTM D573, 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 where otherwise protected or not in contact with metal surfaces, the wiring circuits should be grouped together and protected by nonmetallic 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 for proper support, and shall be located so that no portion is closer than 1 in (25 mm) to moving parts, and at least 2 in (51 mm) from exhaust piping. Wiring passing through holes in metal members of boat structure shall be adequately protected against chafing.

Terminals shall be of the insulation gripping type that will insure a good mechanical and electrical joint, and of such composition as to be corrosion resistant. Exposed ungrounded terminals shall be protected to prevent accidental shorting. Plug connectors shall be of the locking type, splash proof, and incorporate means to relieve strain from soldered connections.

High Tension Wiring—High tension cable used in engine ignition systems shall conform with SAE Standard J557.

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 should be insulated. High tension cable terminals shall be tight fitting and installed so that conductor to terminal contact is made without any arc producing air gap.

Tight fitting flexible caps resistant to a minimum temperature of 120°C and petroleum products shall be used at the cable connections to spark plugs, coil, and distributor.

Color Code—The color code shown in Table 1 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. 1) 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.

TABLE 1—MARINE ENGINE WIRING COLOR CODE

Color	Abbrev.	Circuit	Connecting Components
Black	B	Grounds*	All return circuits
Red	R	Unprotected wires from battery	Battery to starter solenoid to ignition switch to ammeter
Yellow/Red	Y/R	Starting circuit	Starting switch to solenoid
Light Green	Lt Gr	Alternator field	Alternator field to regulator field terminal
Brown	Br	Alternator charge light	Alternator auxiliary terminal to light to regulator
Orange	O	Accessory feed	Ammeter to alternator output and accessory fuses or switches
Purple	Pu	Instrument feed	Ignition switch to coil regulator ignition terminal and electric instruments
Light Blue	Lt Bl	Oil pressure	Oil pressure sender to gage
Tan	T	Water temperature	Water temperature sender to gage
Gray	Gy	Tachometer	Tachometer sender to tachometer
Pink	Pk	Fuel gage	Fuel gage sender to gage

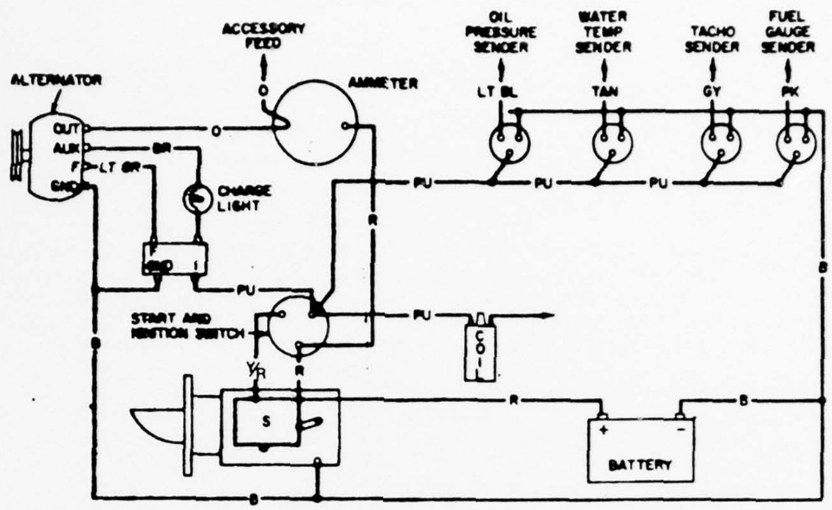
ACCESSORY FEED
ALTERNATOR
AMMETER
OIL PRESSURE SENDER
WATER TEMP SENDER
TACHO SENDER
FUEL GAUGE SENDER
LT BL
TAN
GY
PK
OUT
AUX
F
GND
O
BR
LT GR
CHARGE LIGHT
PU
R
B
START AND IGNITION SWITCH
COIL
S
Y/R
BATTERY
+
-

FIG. 1

Battery Cable
—SAE J1127

SAE Standard
Approved November 1975

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Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

PREPRINT

Report of Electrical Equipment Committee approved November 1975.

1. SCOPE—This standard covers battery cables intended for use at 50 volts or less in surface vehicle wiring. Requ[illegible]ments for cable sizes 6 thru 4/0 previously contained in SAE Stand[illegible], Low Tension Cable SAE J558 are included. Cable sizes 20 through 4 previously specified in SAE J558 are now included in SAE J1128.

2. SPECIFICATION TYPES

2.1 Type SGT—Starter or ground. Thermoplastic insulated.

2.2 Type SGR—Starter or ground. Synthetic rubber insulated.

2.3 Type SGX—Starter or ground. Cross linked polyethylene insulated.

3. GENERAL SPECIFICATIONS:

3.1 Conductors—Conductors shall be bunched, concentric or rope stranded as specified in the Appendix and shall be annealed copper wire in accordance with ASTM B-3. When tin or alloy coated wires are used they shall withstand the continuity test as specified under Strand coating test (paragraph 5.1). A separator shall be used between the uncoated conductor and the synthetic rubber insulation. When coated conductors are used no separator is required. The cross sectional area of stranded conductors shall not be less than the values specified in Table 1.

Minimum conductor area for circular mils is based on 98% of total minimum strand diameter as specified in ASTM B-3. Minimum conductor area for mm^2 is based on 98% of minimum strand diameter. Before processing with finish cable, the minimum strand diameter for metric strands shall not vary from the specified nominal by more than 1% expressed to the nearest .001 mm.

TABLE 1—CONDUCTORS

SAE Wire[a] Size	Metric Wire[b] Size	Minimum Conductor Area For Finished Cable Cir Mil	mm^2
6	4.0	25910	12.1
4	5.0	37360	18.3
2	6.0	62450	31.1
1	7.0	77790	38.1
0	8.0	98980	48.3
2/0	9.0	125100	59.8
3/0	10.0	158600	77.6
4/0	11.0	205500	98.5

[a] SAE wire size number indicates that the cross sectional area of the conductors approximate the area of American Wire Gauge for equivalent sizes.

[b] Metric wire size is the diameter of a solid wire with approximately the same cross sectional area as stranded conductors.
Metric dimensions are not direct conversion from circular mils.

See Appendix for various individual conductor constructions and nominal strand diameters.

3.2 Insulation—Insulation shall be homogeneous in character and shall be placed concentrically within commercial tolerances about the conductor. Insulation shall adhere closely to, but strip readily from, the conductors leaving them reasonably clean and in suitable condition for terminating.

Insulation thickness shall be in accordance with the appropriate table for the various cable types. Variations in insulation wall thickness are permissible due to eccentricity. However, the minimum wall thickness at any cross section of a test specimen shall not be less than 70% of the nominal wall thickness of insulation specified in the appropriate table for the various cable types. The minimum wall thickness shall be measured with a pin dial micrometer exerting at 25gr force and using a 0.043 in (1 mm) maximum diameter pin.

TABLE 2—INSULATION PROPERTIES

Cable Types	Min. Tensile Strength psi	kPa	Min. Elongation Percent
SGT	1600	11000	200
SGR	1000	6900	150
SGX	1500	10000	150

4. CABLE TYPE REQUIREMENTS

4.1 Construction—The conductors and insulation shall be as specified in paragraph 3 for each type of cable.

4.2 Test requirements—The test requirements for each type of cable shall be as indicated in Table 3.

4.3 Dimensions—the nominal wall thickness and maximum overall diameter of finished cable shall be as specified in Table 4.

TABLE 3—TEST REQUIREMENTS

Tests	Cable Types SGT	SGR	SGX
Strand Coating	x	x	x
Physical Properties	x	x	x
High Temperature	x	x	x
Dielectric	x		x
Cold Bend	x	x	x
Flame	x		x
Oil Absorption	x	x	x
Abrasion Resistance	x		x

5. TESTS

5.1 Strand Coating—Tin test shall be conducted on strands prior to stranding and shall be conducted per ASTM B-33. Alloy coated wire shall conform to ASTM B-189.

5.2 Physical Properties (Insulation)—Test samples of insulation that have been removed from the conductors shall be used. The conductor may be stretched for greater ease in removing it from the insulation. The sample may be tested as tube, slit-tube forms, or as dumbbells. The sample shall have marks placed upon it 2 in (50 mm) apart. The sample shall then be stretched at the rate of 20 in (508 mm) per min. The tensile strength shall be calculated upon the original cross section of the test sample before stretching. Physical tests shall be made at room temperature of 75 ± 5° F (21.1° C). For the purpose of these tests care must be used in cutting and obtaining samples of uniform cross section.

5.3 High Temperature—One in (25 mm) of insulation shall be removed from each end of a 24 in (610 mm) sample of finished cable. The sample shall be suspended around a cylindrical mandrel with a weight attached to each end of the sample. This condition shall be maintained in a circulating air oven. The mandrel size, weight, temperature and time shall be as specified in Table 5.

At the end of the above conditioning period the sample shall be removed from the oven and allowed to cool to room temperature. When cool the weights shall be removed and the sample bent in the reverse direction around the mandrel at a rate not to exceed one complete turn per minute. The sample shall then be subjected to the Dielectric test as specified in paragraph 5.4.

5.4 Dielectric Test—One in (25 mm) of insulation shall be removed from each end of a 24 in (610 mm) sample of finished cable and the two ends

TABLE 4 – DIMENSIONS[b]

SAE Wire Size	Metric Wire Size	SGT Nom. Wall in	SGT Nom. Wall mm	SGT Max. Dia. in	SGT Max. Dia. mm	SGR Nom. Wall in	SGR Nom. Wall mm	SGR Max. Dia. in	SGR Max. Dia. mm	SGX Nom. Wall in	SGX Nom. Wall mm	SGX Max. Dia. in	SGX Max. Dia. mm
6[a]	4	.060	1.52	.340	7.36	.047	1.19	.340	7.36	.043	1.09	.300	6.49
4[a]	5	.065	1.65	.420	8.86	.047	1.19	.420	8.86	.065	1.65	.420	8.86
2	6	.065	1.65	.505	12.74	.065	1.65	.505	12.74	.065	1.65	.505	12.74
1	7	.065	1.65	.557	13.86	.065	1.65	.557	13.86	.065	1.65	.557	13.86
0	8	.065	1.65	.600	14.95	.065	1.65	.600	14.95	.065	1.65	.600	14.95
2/0	9	.065	1.65	6.55	16.15	.065	1.65	.655	16.15	.065	1.65	.655	16.15
3/0	10	.078	1.98	.750	18.67	.078	1.98	.750	18.67	–	–	–	–
4/0	11	.078	1.98	.810	19.73	.078	1.98	.810	19.73	–	–	–	–

[a]The 6 and 4 gage wall thickness can be the same as for GPT. [b]Metric dimensions are not direct conversion from inches.

TABLE 5 – HIGH TEMPERATURE TEST

Cable Type	SGT SGR				SGX			
Test Conditions	120h/250 ± 2°F (121°C)				168h/302 ± 3°F (150°C)			
SAE Wire	Mandrel		Weight		Mandrel		Weight	
Size	in	mm	lb	kg	in	mm	lb	kg
6	10	254	6	2.72	10	254	6	2.72
4	10	254	6	2.72	10	254	6	2.72
2	10	254	6	2.72	10	254	6	2.72
1	10	254	6	2.72	10	254	6	2.72
0	10	254	10	4.54	10	254	10	4.54
2/0	10	254	10	4.54	10	254	10	4.54
3/0	10	254	10	4.54	—	—	—	—
4/0	10	254	10	4.54	—	—	—	—

Note: Metric dimensions and weights are direct coversion from inches and pounds.

connected together. The loop thus formed shall be immersed in water containing 5% salt by weight at room temperature so that not more than (152 mm) of each end of the sample protrudes above the solution. After being immersed for five hours and while still immersed the sample shall withstand the application of 1000V (rms) at 60 Hz between the conductor and the solution for 1 min without puncture of the insulation.

5.5 Cold Bend Test – One in (25 mm) of insulation shall be removed from each end of a 24 in (610 mm) sample of finished cable. The temperature of the sample shall be lowered at a rate of 122°F (50°C) per minute until the specified temperature is reached. This temperature shall be maintained for three hours. While the sample is still at this low temperature it shall be wrapped around a mandrel for 180 deg at a uniform rate of one turn in 10 s. The temperature and mandrel size shall be as specified in Table 6. Either a revolving or stationary mandrel may be used. When a revolving mandrel is used fasten one end of the sample to the mandrel. The sample shall then be subjected to the dielectric test as specified in paragraph 5.4.

5.6 Flame Test – A bunsen burner having a 1/2 in (13 mm) inlet, a nominal bore of 3/8 in (10 mm), a length of approximately 4 in (102 mm) above the primary inlets, equipped with a wing top flame spreader having a 1/16 x 2 in (1 x 51 mm) opening fitted to the top of the burner shall be used. A 24 in (610 mm) sample of finished cable shall be suspended taut in a horizontal position within a partial enclosure which allows a flow of sufficient air for complete combustion but is free from drafts. The top of a 2 in (51 mm) gas flame with an inner cone one-third its height shall then be applied to the center of the suspended cable. The time of application of the flame shall be 30 s for SAE wire 6 through 4/0. After removal of the bunsen burner flame the sample shall not continue to burn for more than 30 s.

5.7 Oil Absorption Test – One in (25 mm) of insulation shall be removed from each end of a 24 in (610 mm) sample of finished cable.

TABLE 6 – COLD BEND TEST

Cable Type	SGT	SGR		SGX
Test Conditions	3h/-40°F (-40°C)			
SAE Wire	Mandrel		Weight	
Size	in	mm	lb	kg
6	10	254	6	2.72
4	10	254	6	2.72
2	10	254	6	2.72
1	18	457	6	2.72
0	18	457	10	4.53
2/0	18	457	10	4.53
3/0	18	457	10	4.53
4/0	18	457	10	4.53

Note: Metric dimensions and weights are direct conversion from inches and pounds.

The sample shall be immersed to within 1 1/2 in (38 mm) from the ends of the insulator in a liquid containing equal parts of kerosene and SAE 10W engine oil at a temperature of 118 - 122°F (48 - 50°C) for a period of at least 20 h. The outside diameter of the cable shall not increase more than 15%. The sample shall then be bent around a 10 in (254 mm) mandrel and then subjected to the Dielectric Test, paragraph 5.4.

5.8 Abrasion Resistance – One in (25 mm) of the insulation shall be removed from one end of a 36 in (914 mm) sample of finished cable. The sample shall then be placed taunt, without stretching between the cable clamps as shown in military specification MIL-T-5438. Using the weight support bracket and weight specified in Table 8. The sample shall then be subjected to the abrasion test. After each reading the sample shall be moved 2 in (51 mm) and rotated clockwise 90 deg. Eight readings shall be obtained for each sample. Obtain an average by calculating the arithmetic mean of all readings. Discard all readings above the arithmetic mean and average the remaining readings. The average shall define the abrasion resistance of the cable under test. Values for individual cables are shown in Table 7.

TABLE 7–ABRASION TEST (REQUIREMENTS)

SAE Wire Size	Minimum Resistance - Inches (mm) of Tape SGT in	SGT mm	SGX in	SGX mm
6	135	3429	25	635
4	135	3429	135	3429
2	135	3429	135	3429
1	135	3429	135	3429
0	135	3429	135	3429
2/0	135	3429	135	3429
3/0	135	3429	–	–
4/0	180	4572	–	–

Note: Metric dimensions are direct conversion from inches.

TABLE 8–ABRASIONS TEST (CONDITIONS)

SAE Wire Size	Br	SGT-SGX lb	kg
6	C	4.25	1.93
4	C	4.25	1.93
2	C	4.25	1.93
1	C	4.25	1.93
0	C	4.25	1.93
2/0	C	4.25	1.93
3/0	C	4.25	1.93
4/0	C	4.25	1.93

APPENDIX–RECOMMENDED CONDUCTOR CONSTRUCTIONS (AWG STRANDS)

SAE Wire Size	CLASS I No. Strands/AWG Size (in)	CLASS II No. Strands/AWG Size (in)
6	37/21 (.0285)	7 x 19/27 (.0142)
4	61/22 (.0253)	7 x 19/25 (.0179)
2	127/23 (.0226)	7 x 19/23 (.0226)
1	127/22 (.0253)	7 x 37/25 (.0179)
0	127/21 (.0285)	7 x 37/24 (.0201)
2/0	127/20 (.0320)	7 x 37/23 (.0226)
3/0	–	7 x 37/22 (.0253)
4/0	–	19 x 22/23 (.0226)

RECOMMENDED CONDUCTOR CONSTRUCTIONS (METRIC STRANDS)

SAE Wire Size	Metric Size	CLASS I No. Strands/mm Size	CLASS II No. Strands/mm Size
6	4.0	37/.66	
4	5.0	61/.63	–
2	6.0	127/.57	7 x 19/.57
1	7.0	127/.63	7 x 19/.63
0	8.0	127/.71	7 x 19/.71
2/0	9.0	127/.79	7 x 19/.79
3/0	10.0	–	7 x 37/.63
4/0	11.0	–	7 x 37/.71

Note: Stranding other than those shown above for both SAE and metric wire sizes are acceptable providing they meet the minimum conductor area specified in Table 1.

Low Tension Primary Cable — SAE J1128

SAE Standard
Approved November 1975

THIS IS A PREPRINT AND WILL
APPEAR IN THE NEXT EDITION
OF THE SAE HANDBOOK

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

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Report of Electrical Equipment Committee approved November 1975.

1. SCOPE—This standard covers low tension primary cable intended for use at 50 V or less in surface vehicle wiring. Requirements for cable sizes 20 through 4 previously contained in SAE Standard, Low Tension Cable—SAE J558 and SAE Recommended Practice, Low Tension Cable Thermosetting Insulation—SAE J878, are included. Cable sizes 6 through 4/0 previously specified in SAE J558 are now included in SAE J1127.

2. SPECIFICATION TYPES

2.1 Type GPT—General Purpose, thermoplastic insulated.

2.2 Type HDT—Heavy Duty, thermoplastic insulated.

2.3 Type GPB—General Purpose, Thermoplastic insulated, braided.

2.4 Type HDB—Heavy Duty, thermoplastic insulated braided.

2.5 Type STS—Standard Duty, synthetic rubber insulated.

2.6 Type HTS—Heavy Duty, synthetic rubber insulated.

2.7 Type SXL—Standard Duty, crosslinked polyethylene insulated.

3. GENERAL SPECIFICATIONS

3.1 Conductors—Conductors shall be bunched, concentric, or rope stranded as specified in the Appendix and shall be annealed copper wire in accordance with ASTM B-3. When tin or alloy coated wires are used they shall withstand the continuity test as specified under strand coating test (paragraph 5.1). A separator shall be used between the uncoated conductor and the synthetic rubber insulation. When coated conductors are used no separator is required. The cross sectional area of stranded conductors shall not be less than the values specified in Table 1.

Minimum conductor area for circular mils is based on 98% of total minimum strand diameter as specified in ASTM B-3. Minimum conductor area for mm² is based on 98% of minimum strand diameter. Before processing the final cable, the minimum strand diameter for metric strands shall not vary from the specified nominal by more than 1% expressed to the nearest .001 mm.

TABLE 1—CONDUCTORS

SAE Wire[a] Size	Metric Wire[b] Size	Minimum Conductor Area For Finished Cable Cir Mil[a]	mm[2b]
20	0.8	1072	.508
18	1.0	1537	.760
16	1.2	2336	1.12
14	1.5	3702	1.85
12	2.0	5833	2.96
10	2.5	9343	4.65
8	3.0	14810	7.23
6	4.0	25910	12.1
4	5.0	37360	18.3

[a]SAE wire size number indicates that the cross sectional area of the conductors approximate the area of American Wire Gauge for equivalent sizes.

[b]Metric wire size is the diameter of a solid wire with approximately the same cross sectional area as stranded conductors. Metric dimensions are not direct conversion from circular mils.

See Appendix for various individual conductor constructions and nominal strand diameters.

3.2 Insulation—Insulation shall be homogeneous in character and shall be placed concentrically within commercial tolerances about the conductor. Insulation shall adhere closely to, but strip readily from, the conductors leaving them reasonably clean and in suitable condition for terminating.

Insulation thickness shall be in accordance with the appropriate table for the various cable types. Variations in insulation wall thickness are permissible due to eccentricity. However, the minimum wall thickness at any cross section of a test specimen shall not be less than 70% of the nominal wall thickness of insulation specified in the appropriate table for the various cable types. The minimum wall thickness shall be measured with a pin dial micrometer exerting a 25 g force and using a 0.043 in (1 mm) maximum diameter pin.

The physical properties of the insulation shall be as shown in Table 2.

TABLE 2—INSULATION PROPERTIES

Cable Types	Min Tensile Strength psi	kPa	Min Elongation Percent
GPT HDT	2300	15860	125
GPB HDB	1000	6900	100
STS HTS	1600	11030	250
SXL	2500	10340	150

3.3 Braid

3.3.1 General Purpose Braid—When the construction includes a braided covering a closely woven braid of cotton or other fibrous material shall be applied over the insulation. All braided coverage shall be thoroughly covered or saturated with a firmly adhering compound that will present a finished appearance. Adjacent layers of cable when wound on a reel shall not stick to one another at any temperature under 140°F (40°C).

3.3.2 Heavy Duty Braid—The braid shall be made up of one-half .028 in (0.7 mm) paper twine and one-half cotton yarn. The cable shall be braided so that all of the paper twine shall be in one direction and the cotton yarn in the opposite direction. The braid shall be finished or coated with a compound as specified in paragraph 3.3.1.

4. CABLE TYPE REQUIREMENTS

4.1 Construction—The conductors, insulation and braid shall be as specified in paragraph 3 for each type of cable.

4.2 Test Requirements—The test requirement for each type of cable shall be as indicated in Table 3.

TABLE 3—TEST REQUIREMENTS

Tests	CABLE TYPES GPT	HDT	GPB	HDB	STS	HTS	SXL
Strand Coating	x	x	x	x	x	x	x
Physical Properties	x	x	x	x	x	x	x
High Temperature	x	x	x	x	x	x	x
Dielectric	x	x	x	x	x	x	x
Cold Bend	x	x	x	x	x	x	x
Flame	x	x			x	x	x
Oil Absorption	x	x	x	x	x	x	x
Overload					x	x	x
Short Circuit					x	x	x
Pinch	x	x			x	x	x
Abrasion Resistance	x	x			x	x	x

4.3 Dimensions—The nominal wall thickness and maximum overall diameter of finished cable shall be as specified in Table 4.

5. TESTS

5.1 Strand Coating—Tin test shall be conducted on strands prior to stranding and shall be conducted per ASTM B-33. Alloy coated wire shall congorm to ASTM B-189.

5.2 Physical Properties (Insulation)—Test samples of insulation that have been removed from the conductors shall be used. The conductor may be stretched for greater ease in removing it from the insulation. The sample may be tested as tube, slit-tube forms, or as dumbbells. The sample shall have marks placed upon it 2 in (50 mm) apart. The sample shall then be stretched at the rate of 20 in (508 mm) per min. The tensile strength shall be calculated upon the original cross section of the test sample before stretching. Physical tests shall be made at room temperature of 75 ± 5°F (21.1°C). For the purpose of these tests care must be used in cutting and obtaining samples of uniform cross section.

5.3 High Temperature—One in (25 mm) of insulation shall be removed

TABLE 4 – DIMENSIONS[a]

SAE Wire Size	Metric Wire Size	GPT Nom Wall in	GPT Nom Wall mm	GPT Max Dia in	GPT Max Dia mm	HDT Nom Wall in	HDT Nom Wall mm	HDT Max Dia in	HDT Max Dia mm	GPB Nom Wall in	GPB Nom Wall mm	GPB Max Dia in	GPB Max Dia mm
20	0.8	.023	.58	.095	2.34	.036	.91	.120	2.95	.022	.56	.155	2.92
18	1.0	.023	.58	.100	2.50	.037	.94	.130	3.24	.022	.56	.135	3.43
16	1.2	.023	.58	.115	2.84	.040	1.02	.145	3.58	.022	.56	.145	3.68
14	1.5	.023	.58	.125	3.18	.041	1.04	.165	4.19	.022	.56	.165	4.19
12	2.0	.026	.66	.150	3.81	.046	1.17	.190	4.83	.027	.69	.195	4.95
10	2.5	.031	.79	.185	4.67	.046	1.17	.215	5.42	.031	.79	.230	5.84
8	3.0	.037	.94	.245	6.10	.055	1.40	.280	6.98	.037	.94	.301	7.65
6	4.0	.043	1.09	.305	7.72	.060	1.52	.340	8.60	.047	1.19	.360	9.14
4	5.0	.044	1.12	.375	9.32	.068	1.73	.420	10.44	.047	1.19	.437	11.10

SAE Wire Size	Metric Wire Size	HDB Nom Wall in	HDB Nom Wall mm	HDB Max Dia in	HDB Max Dia mm	STS and SXL Nom Wall in	STS and SXL Nom Wall mm	STS and SXL Max Dia in	STS and SXL Max Dia mm	HTS Nom Wall in	HTS Nom Wall mm	HTS Max Dia in	HTS Max Dia mm
20	0.8					.029	.74	.110	2.71	.036	.91	.125	3.08
18	1.0	.022	.56	.155	3.94	.030	.76	.120	3.00	.037	.94	.135	3.37
16	1.2	.022	.56	.170	4.32	.032	.81	.135	3.33	.040	1.02	.150	3.70
14	1.5	.022	.56	.190	4.83	.035	.89	.155	3.94	.041	1.04	.165	4.19
12	2.0	.027	.69	.230	5.84	.037	.94	.180	4.57	.046	1.17	.200	5.08
10	2.5	.031	.79	.255	6.48	.041	1.04	.210	5.30	.048	1.22	.225	5.67
8	3.0					.043	1.09	.245	6.10	.055	1.40	.270	6.73
6	4.0					.055	1.40	.335	8.47	.062	1.57	.350	8.85
4	5.0												

[a]Metric dimensions are not direct conversion from inches.

from each end of a 24 in (610 mm) sample of finished cable. The sample shall be suspended around a cylindrical mandrel with a weight attached to each end of the sample. This condition shall be maintained in a circulating air oven. The mandrel size, weight, temperature and time shall be as specified in Table 5.

At the end of the above conditioning period the sample shall be removed from the oven and allowed to cool to room temperature. When cool the weights shall be removed and the sample bent in the reverse direction around the mandrel specified in Table 5 for the bend test at a rate not to exceed one complete turn per minute. The sample shall then be subjected to the Dielectric test as specified in paragraph 5.4.

5.4 Dielectric Test—One in (25 mm) of insulation shall be removed from each end of a 24 in (610 mm) sample of finished cable and the two ends twisted together. The loop thus formed shall be immersed in water containing 5% salt by weight at room temperature so that not more than 6 in (152 mm) of each end of the sample protrudes above the solution. After being immersed for five hours and while still immersed the sample shall withstand the application of 1000 V at 60 Hz between the conductor and the solution for one minute without puncture of the insulation.

5.5 Cold Bend Test—One in (25 mm) of insulation shall be removed from each end of a 24 in (610 mm) sample of finished cable. The temperature of the sample shall be lowered at a rate of 122°F (50°C) per minute until the specified temperature is reached. This temperature shall be maintained for three hours. While the sample is still at this low temperature it shall be wrapped around a mandrel for 180 deg at a uniform rate of one turn in 10s. The temperature and mandrel size shall be as specified in Table 6. Either a revolving or stationary mandrel may be used. When a revolving mandrel is used fasten one end of the sample to the mandrel. The sample shall then be subjected to the Dielectric test as specified in paragraph 5.4.

5.6 Flame Test—A bunsen burner having a 1/2 in (13 mm) inlet, a nominal bore of 3/8 in (10 mm), a length of approximately 4 in (102 mm) above the primary inlets, equipped with a wing top flame spreader having a 1/16 x 2 in (1 x 51 mm) opening fitted to the top of the burner shall be used. A 24 in (610 mm) sample of finished cable shall be suspended taut in a horizontal position within a partial enclosure which allows a flow of sufficient air for complete combustion but is free from drafts. The top of a 2 in (51 mm) gas flame with an inner cone one-third its height shall then be applied to the center of the suspended cable. The time of application of the flame shall be 15 s for SAE wire size 10 through 20 and 30 s for SAE wire size 8 and larger. After removal of the bunsen burner flame the sample shall not continue to burn for more than 30 s.

5.7 Oil Absorption Test—One in of insulation shall be removed from each end of a 24 in (610 mm) sample of finished cable. The sample shall be immersed to within 1-1/2 in (38 mm) from the ends of the insulator in a liquid containing equal parts of kerosene and SAE 10W engine oil at a temperature of 118-122°F (48-50°C) for a period of at least 20 h. The outside diameter of the cable shall not increase more than 15%. The sample shall then be bent around a mandrel as specified in Table 7, and then subjected to the Dielectric Test, paragraph 5.4.

5.8 Overload Test—In an ambient temperature of 75 ± 5°F (23.9°C) a 60 in (1524 mm) sample cable suspended in air or lying on a transite table top shall be subjected to an overload current sufficient to raise the conductor temperature to 400 ± 3°F (204°C) and to hold it there for a period of 30 min (thermocouple to be inserted into sample conductor stranding 18 in (457 mm) from one end). After the overload test cut 18 in (457 mm) from each end of the cable and discard. The remaining 24 in (610 mm) portion which was in the center of the original 60 in (1524 mm) shall then be subjected to the Dielectric test, paragraph 5.4.

5.9 Short Circuit Test (18 gage only)—Using six 36 in (914 mm) lengths and one 48 in (1219 mm) length of 18 gage cable strip 1 in (25.4 (25.4 mm) of insulation from each end of the 48 in (1219 mm) length. Twist the six 36 in (914 mm) lengths around the 48 in (1219 mm) length

TABLE 5–HIGH TEMPERATURE TEST

Cable Type Test Conditions	GPT HDT GPB HDB 120h/250 ± 2°F (121°C)				STS HTS 120h/275 ± 3°F (135°C)				SXL 240h/302 ± 3°F (135°C)			
SAE Wire Size	Mandrel		Weight		Mandrel		Weight		Mandrel		Weight	
	in	mm	lb	kg	in	mm	lb	kg	in	mm	lb	kg
20	4.5	114	1.0	0.45	4.5	114	1.0	0.45	0.50	12.77	1.0	0.45
18	4.5	114	1.0	0.45	4.5	114	1.0	0.45	0.50	12.7	1.0	0.45
16	6.5	165	1.0	0.45	6.5	165	1.0	0.45	0.50	12.7	1.0	0.45
14	6.5	165	1.0	0.45	6.5	165	1.0	0.45	0.75	19.0	1.0	0.45
12	6.5	165	3.0	1.36	6.5	165	3.0	1.36	0.75	19.0	3.0	1.36
10	10.0	254	3.0	1.36	10.0	254	3.0	1.36	1.00	25.4	3.0	1.36
8	10.0	254	3.0	1.36	10.0	254	3.0	1.36	2.00	50.8	3.0	1.36
6	10.0	254	6.0	2.72	10.0	254	6.0	2.72	3.00	76.2	6.0	2.72
4	10.0	254	6.0	2.72	10.0	254						

Cable Type SAE Wire Size	Bend Test Mandrel Dia. GPT HDT GPB HDB		STS	HTS	SXL	
	in	mm	in	mm	in	mm
20	3	76.2	3	76.2	1.0	25.4
18	3	76.2	3	76.2	1.0	25.4
16	3	76.2	3	76.2	1.0	25.4
14	6	152.4	6	152.0	3.0	76.2
12	6	152.4	6	152.0	3.0	76.2
10	6	152.4	6	152.0	6.0	76.2
8	6	152.4	6	152.0	6.0	152.4
6	10	254.0	10	254.0	6.0	152.4
4	10	254.0				

NOTE: Metric dimensions and weights are direct conversion from inches and pounds.

TABLE 6–COLD BEND TEST

Cable Type Test Conditions	GPT HDT GPB HDB 3h/-40°F (-40°C)				STS HTS 3h/-40°F (-40°C)				SXL 3h/-60°F (-51°C)			
SAE Wire Size	Mandrel		Weight		Mandrel		Weight		Mandrel		Weight	
	in	mm	lb	kg	in	mm	lb	kg	in	mm	lb	kg
20	3.0	76	1.0	0.45	3.0	76	1.0	0.45	1.0	25.4	1.5	0.68
18	3.0	76	1.0	0.45	3.0	76	1.0	0.45	1.0	25.4	1.5	0.68
16	3.0	76	1.0	0.45	3.0	76	1.0	0.45	1.0	25.4	1.5	0.68
14	6.0	152	1.0	0.45	6.0	152	1.0	0.45	3.0	76.2	3.0	1.36
12	6.0	152	3.0	1.36	6.0	152	3.0	1.36	3.0	76.2	5.0	2.27
10	6.0	152	3.0	1.36	6.0	152	3.0	1.36	3.0	76.2	5.0	2.27
8	6.0	152	3.0	1.36	6.0	152	3.0	1.36	6.0	152.0	5.0	2.27
6	10.0	254	6.0	2.72	10.0	254	6.0	2.72	6.0	152.0	7.0	3.17
4	10.0	254	6.0	2.72								

TABLE 7 – OIL ABSORPTION TEST

SAE Wire Size	GPT HDT GPB HDB Mandrel		STS HTS Mandrel		SXL Mandrel	
	in	mm	in	mm	in	mm
20	3.0	76.0	3.0	76.0	1.0	25.4
18	3.0	76.0	3.0	76.0	1.0	25.4
16	3.0	76.0	3.0	76.0	1.0	25.4
14	6.0	152.0	6.0	152.0	3.0	76.0
12	6.0	152.0	6.0	152.0	3.0	76.0
10	6.0	152.0	6.0	152.0	3.0	76.0
8	6.0	152.0	6.0	152.0	6.0	152.0
6	10.0	254.0	10.0	254.0	6.0	152.0
4	10.0	254.0				

NOTE: Metric dimensions and weights are direct conversion from inches and pounds.

TABLE 8 - PINCH TEST

SAE Wire Size	Minimum Pinch Resistance									
	GPT		HDT		STS		HTS		SXL	
	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg
20	5	2.3	9	4.1	8	3.6	10	4.5	11	5.0
18	6	2.7	10	4.5	8	3.6	10	4.5	16	7.2
16	6	2.7	13	5.9	8	3.6	10	4.5	18	8.2
14	8	3.6	15	6.8	8	3.6	10	4.5	20	9.0
12	8	3.6	18	8.2	8	3.6	10	4.5	25	11.0
10	10	4.5	24	10.9	8	3.6	10	4.5	30	14.0
8	11	5.0	32	14.5	8	3.6	10	4.5	35	16.0
6	15	6.8	43	19.5	8	3.6	10	4.5	40	18.0
4	27	12.2	54	24.5						

Note: Metric dimensions and weights are direct conversion from inches and pounds.

with approximately a 4 in (102 mm) lay. Position so that 6 in (152 mm) of the 48 in (1219 mm) cable extends beyond each end. Tape into position using woven glass tape with 1/3 lap. Apply a constant 55 amp current to the center conductor of the bundle for three minutes. Turn off current and allow bundle to cool. Disconnect power source and test for short circuits between all conductors. Use 1000 V (rms) test voltage. There shall be no shorting of conductors and when the glass tape is removed from the bundle the individual wires shall be readily separated without tearing the insulation on the individual cables. This test is conducted to check the thermosetting properties of the insulation.

5.10 **Pinch Test**–One in (25 mm) of insulation shall be removed from one end of a 36 in (914 mm) sample of finished cable. The sample shall then be placed taut without stretching across a 1/8 in (3 mm) diameter steel bar and be subjected to the force of a weighted steel anvil. Increasing wieght shall be applied to the steel anvil at a rate of 5 lb (2.27 kg) per min with a level advantage of 10 at the moment the insulation is pinched through the 1/8 in (3 mm) diameter rod will contact the conductor and the test shall stop. The weight in the receptacle shall then be recorded. After each reading the sample shall be moved 2 in (51 mm) and rotated clockwise 90 deg. Four readings shall be obtained for each sample. Obtain an average by calculating the arithmetic mean of all those readings. The average shall define the pinch resistance of the cable under test.

Note: The Pinch Test apparatus shall be equivalent to that shown in Fig. 1. The minimum values for each cable type and size shall be as shown in Table 8.

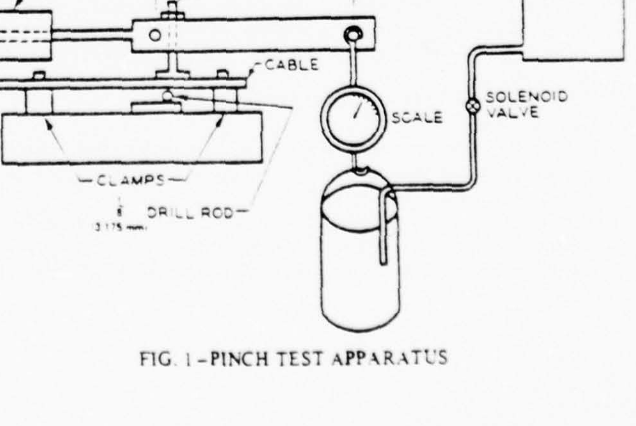


FIG. 1 – PINCH TEST APPARATUS

TABLE 9 - ABRASION TEST (REQUIREMENTS)

Minimum Resistance - Inches of Tape

SAE	GPT		HDT		STS		HTS		SXL	
Wire Size	in	mm	in	mm	in	mm	in	mm	in	mm
20	18	457	16	406	18	457	30	762	22	559
18	21	533	22	559	21	533	35	889	27	686
16	22	559	29	737	22	559	40	1016	30	762
14	12	305	15	381	12	305	18	457	14	356
12	16	406	20	508	16	406	22	559	18	457
10	20	508	27	686	20	508	30	762	24	610
8	25	635	46	1168	25	635	35	889	39	991
6	25	635	50	1270	25	635	60	1524	39	991
4	30	762	60	1524						

Note: Metric dimensions are direct conversion from inches.

TABLE 10–ABRASION TEST (CONDITIONS)

Test Conditions

SAE	GPT			HDT			STS			HTS			SXL		
Wire Size	Br Br	lb	kg	Br	lb	kg	Br	lb	kg	Br	lb	kg	Br	lb	kg
20	A	1	0.45	B	3	1.36	A	1	0.45	B	1	0.45	A	1	0.45
18	A	1	0.45	B	3	1.36	A	1	0.45	B	1	0.45	A	1	0.45
16	A	1	0.45	B	1	1.36	B	1	0.45	B	1	0.45	B	1	0.45
14	B	3	1.36	B	4.25	1.93	B	3	1.36	B	3	1.36	B	3	1.36
12	B	3	1.36	B	4.25	1.93	B	3	1.36	B	3	1.36	B	3	1.36
10	B	3	1.36	B	4.25	1.93	B	3	1.36	B	3	1.36	B	3	1.36
8	B	3	1.36	C	4.25	1.93	B	3	1.36	C	3	1.36	B	3	1.36
6	C	4.25	1.93	C	4.25	1.93	C	4.25	1.93	C	4.25	1.93	C	4.25	1.93
4	C	4.25	1.93	C	4.25	1.93									

Note: Metric weights are direct conversion from pounds.

5.11 **Abrasion Resistance**–One in (25 mm) of the insulation shown shall be removed from one end of a 36 in (914 mm) sample of finished cable. The sample shall then be placed taut, without stretching between the cable clamps as shown in military specification MIL-T-5438. Using the weight support bracket and weight specified in Table 10. The sample shall then be subjected to the abrasion test. After each reading the sample shall be moved 2 in (51 mm) and rotated clockwise 90 deg. Eight readings shall be obtained for each sample. Obtain an average by calculating the arithmetic mean of all readings. Discard all readings above the arithmetic mean and average the remaining readings. The average shall define the abrasion resistance of the cable under test. Values for individual cables are shown in Table 9.

6. REFERENCE INFORMATION

6.1 Color Code

6.1.1 Recommended colors–The color of the cables should match as closely as possible the following colors as set forth by "The Color Association of the U.S. Inc., 9th Edition."

6.1.2 Stripes–Where additional color combinations are required it is possible to apply color stripes. The stripes shall be applied longitudinally along the cable. Black or white stripes are recommended but other colors may be specified.

TABLE 11–TECA COLORS 9TH EDITION

Color	Nom.	Dark	Light
White	70003	70004	-
Red	70180	70082	70179
Pink	70098	70099	70097
Orange	70072	70041	70071
Yellow	70205	70068	70067
Lt Green	70062	70063	70061
Dk Green	70065	70066	70064
Lt Blue	70143	70144	70142
Dk Blue	70086	70087	70085
Purple	70135	70164	70134
Tan	70093	70094	70092
Brown	70107	70108	70106
Gray	70152	70153	70185
Black	None	-	-

APPENDIX—RECOMMENDED CONDUCTOR CONSTRUCTIONS (AWG STRANDS)

SAE Wire Size	Class III No. Strands/ AWG Size (in)	Class IV No. Strands/ AWG Size (in)
20	7/28 (.0126)	
18	16/30 (.0100)	65/36 (.0050)
16	19/29 (.0113)	
14	19/27 (.0142)	
12	19/25 (.0179)	
10	19/23 (.0226)	
8	19/21 (.0285)	
6	37/21 (.0285)	7x19/27 (.0142)
4	61/22 (.0253)	7x19/25 (.0179)

Recommended Conductor Constructions (Metric Strands)

SAE Wire Size	Metric Wire Size	Class III No. Strands/ mm Size
20	.8	7/.31
18	1.0	19/.23
16	1.2	19/.28
14	1.5	19/36
12	2.0	19/.455
10	2.5	19/.57
8	3.0	19/.71
6	4.0	37/.66
4	5.0	61/.63

Note: Stranding other than those shown above for both SAE and metric wire sizes are acceptable providing they meet the minimum conductor area specified in Table 1.

7.0 LAB EXAMINATION NO. 3

183.435 Conductor types in circuits of 50 volts or more

(a) Each conductor in a circuit that has a nominal voltage of 50 volts or more must be—

(1) A conductor that has insulation listed and classified moisture resistant and flame retardant in Article 310, NFPA No. 70-1975, National Electric Code 1975;

(2) A flexible cord type SO, STO, ST, SJO, SJT, or SJTO listed in Article 400, NFPA No. 70-1975, National Electric Code 1975;

(3) A conductor that meets IEEE Std. 45-1971, dated December 3, 1970;

(4) A conductor listed for marine use by an independent testing laboratory which provides listing, labeling, and follow-up service; or

(5) A conductor that meets the mechanical water absorption and flame retardant standards of UL Standard 83, dated July 8, 1976.

(b) Where the nominal circuit voltage of each of three or more current carrying conductors in a duct, bundle, or cable is 50 volts or more, the amperages of each of those conductors must not exceed the value in Table 5 multiplied by the correction factor in note 2 to Table 5 for the number of conductors that carry 50 volts or more.

(c) This section does not apply to communication systems; electronic navigation equipment; resistance conductors that control circuit amperage conductors in secondary circuits of ignition systems; and pigtails of less than seven inches of exposed length.

7.1 SCOPE

7.1.1 This examination will determine compliance with the requirements of §183.435(a).

7.1.2 Conductors noted by visual examination No. 5 as not being identified to be in compliance with §183.435(a), are to be tested in accordance with this examination.

7.2 APPARATUS

7.2.1 Article 310, NFPA, No. 70-1975, National Electric Code 1975; IEEE Std. 45-1971 dated December 3, 1970; UL Standard 83, dated July 8, 1976; independent testing laboratories standards if applicable; other equipment as prescribed in these listed standards.

7.3.0 EXAMINATION SPECIMEN

7.3.1 All conductors on a boat determined by Visual Examination No. 5 to be tested for compliance.

7.3.2 The conductors may be taken from the boat or samples may be obtained from the manufacturer.

7.4 EXAMINATION PROCEDURE

7.4.1 Try to determine the conductor type by contacting the manufacturer. If it is one of the types as described in §183.435(a)(1), 183.435(a)(2) or 183.435(a)(3), then it is in compliance.

7.4.2 If the conductor is listed by an independent testing laboratory as described in §183.435(a)(4), obtain that laboratory's standards used to test the conductor.

7.4.2.1 Forward a copy of the standard(s) to USCG Headquarters (G-BBT) where final compliance determination will be made.

7.4.3 If the conductor is not identified in Paragraphs 4.1 or 4.2. then the conductor will be tested in accordance with the mechanical water absorption and flame retardant standards in UL Standard 83, dated July 8, 1976.

7.4.3.1 Failure of the conductor to meet those requirements in UL 83 determines noncompliance.

7.4.4 If a conductor is identified in Paragraphs 4.1 or 4.2 and if doubt exists as to its ability to meet those standards for which it is listed, notify USCG Headquarters (G-BBT).

7.4.4.1 If USCG Headquarters (G-BBT) agrees that a conductor's listing is questionable, the conductor will be tested in accordance with the appropriate standard as listed below:

a. Article 310-NFPA 70-1975

   Flame retardant and mechanical water absorption properties tests in UL 83, dated July 8, 1976: and

   Flame retardant and moisture resistance properties tests in UL 1063, dated April 1, 1973.

b. Article 400-NFPA 70-1975

Tests in UL 62, dated April 14, 1975

c. IEEE Std. 45-1971

d. Independent Testing Laboratory Standard

7.4.4.2 Failure of the conductor to meet the standard to which it is tested does not denote noncompliance. The conductor type will be tested as described in Paragraphs 4.3 and 4.3.1.

7.4.5 Report should include test sequence, validation of conductor type and sampling process.

7.4.6 Discrepancies will be recorded and the manufacturer of the conductor will be notified.

8.0 LAB EXAMINATION NO. 4

183.440 <u>Requirements for conductors in high voltage secondary circuits of ignition systems</u>

(a) Each conductor in a secondary circuit of an ignition system must meet SAE Standard J557, dated January, 1968.

(b) The connection of each ignition conductor to a spark plug, coil, or distributor must have a tight fitting cap, boot, or nipple.

8.1 This examination will determine compliance with §183.440(a).

8.1.1 Conductors noted by Visual Examination No. 6 as not being in compliance with §183.440(a), are to be tested in accordance with this examination.

8.2 APPARATUS

8.2.1 As prescribed in SAE Standard J557, dated January 1968.

8.3.0 EXAMINATION SPECIMEN

8.3.1 All conductors on a boat determined by Visual Examination No. 6, to be tested for compliance.

8.3.2 The conductors may be taken from the boat or samples may be obtained from the manufacturer.

LOW TENSION WIRING AND CABLE TERMINALS AND SPLICE CLIPS—SAE J163

SAE Recommended Practice

Report of Electrical Equipment Committee approved January 1974

Scope—This SAE Recommended Practice covers the application requirements for terminals and splice clips attached to stranded low tension wiring and cable as shown in J878 and J558. In addition, it covers maximum voltage drop limits for friction type connections.

Use of Terminals—Friction (quick disconnect) type brass connections should be used only where the maximum temperature (environmental ambient plus rise due to current), measured at the center of the terminal surface, does not exceed the capabilities of the physical properties of the material. Maximum temperatures for terminal materials other than brass should also be determined prior to using so as to be compatible with the physical properties of these materials.

Electrical connections and splices of standard types must be protected, as application dictates, from moisture, salt, soil accumulation, acid, or corrosive vapor which will deteriorate the connection beyond the limits of this recommended practice.

Performance Requirements (Electrical)—Terminals or splice clips shall be attached to wire or cable in such a manner that, following the humidity test, the voltage drop across the attachment shall not exceed the values in Table 1. Friction connections (terminal to terminal) shall be such that following four repeated insertions and the humidity test, the voltage drop across the connection shall not exceed the values in Table 2. For a terminal to be acceptable, all specimens tested must meet the requirements.

Test Procedure—Tests shall be conducted at 73 ± 5°F (23 ± 3°C). Test samples shall consist of terminals or splice clips attached to 12 in. (305 mm) of wire. It is suggested that at least 10 specimens of each wire size be subjected to each test.

Voltage Drop Test—Measurements shall be made after the temperature of the specimen has stabilized (2 h under test load).

Measurements across a wire to terminal attachment shall be made between the center of the conductor grip and a point on the cable core 3 in. (76.2 mm) behind the conductor grip. Probe point on the cable core shall be stripped and solder dapped. For preinsulated terminals, the measurements shall be made between a point in front of the conductor grip within $\frac{1}{16}$ in. (1.6 mm) of the end of the insulation and a point on the cable core 3 in. (76.2 mm) behind the conductor grip. The voltage drop across the attachment is defined as the difference between this reading and the voltage drop through the 3 in. (76.2 mm) of wire.

Measurements across a splice clip connection shall be made between points on cable cores 3 in. (76.2 mm) behind the center of the conductor grip crimp. Probe points on the cable core shall be stripped and solder dapped. The voltage drop across the splice is defined as the difference between this reading and the voltage drop through the 6 in. (152 mm) of wire. Measurements shall be made across each combination of conductor pairs in the splice. The current value shall be selected according to the smaller gage cable in the cable pair being measured.

Measurements across a friction connection shall be made between the centers of the conductor grips of two joined line connector type terminals and from the center of the conductor grip of a line terminal to a similar point on a joined fixed terminal.

For preinsulated terminals, the voltage drop across the wire to terminal attachment plus the 3 in. (76.2 mm) of cable shall be determined first per the above procedure. Then the terminals shall be connected and measurements across the connection shall be made from the stripped solder dapped points on the cable cores of two joined line connector type terminals and from the same point on the cable core to a point on a joined fixed terminal equivalent to that used for uninsulated terminals. The voltage drop across the friction connection is defined as the difference between this reading and the previous measurement(s) for the same specimen(s) (wire drop plus attachment drop).

Humidity Test—The humidity test shall consist of 100 h at 95–100% relative humidity at 100 ± 5°F (38 ± 3°C). (Demineralized water shall be used.) Specimens shall be prepared as follows:

1. Mounted at least 1 in. (25.4 mm) apart on test boards.
2. Placed in the humidity cabinet with the axis of each specimen in a horizontal plane and such that it has all surfaces of the terminal completely exposed and not in contact with other objects.
3. Removed from the cabinet after the prescribed exposure period and allowed to dry 24 h at room condition before final MVD test.

TABLE 1—WIRE TO TERMINAL OR WIRE TO WIRE (SPLICE CLIP METHOD) VOLTAGE DROP (AFTER HUMIDITY TEST)

Wire/Cable (SAE Gage)	Test Current, A	Drop, mV	
		Uninsulated Terminal	Preinsulated Terminal
20	5	3	3.5
18	10	5	5.5
16	15	8	9
14	20	10	11
12	30	15	17
10	40	20	22
8	50	25	—
6	60	15	—
4	70	18	—
2	80	20	—
0	90	23	—
00	100	25	—

TABLE 2—FRICTION VOLTAGE DROP (AFTER HUMIDITY TEST AND FOUR INSERTIONS)

Wire/Cable (SAE Gage)	Test Current, A	Drop, mV
20	5	7.5
18	10	15
16	15	22.5
14	20	30
12	30	45
10	40	60
8	50	75

FUSIBLE LINKS—SAE J156a

SAE Standard

Report of Electrical Equipment Committee approved February 1970 and last revised April 1977

1. Scope—This SAE Recommended Practice covers the details, use, and design evaluation testing of fusible links for motor vehicle electrical wiring protection. The specifications as listed are known good practice and are not intended to restrict new materials or construction.

2. Definition—A fusible link is a special section of low tension cable designed to open the circuit when subjected to an extreme current overload. Its purpose is to minimize wiring system damage when such an overload occurs accidentally in those circuits protected by the fusible link.

3. General Specifications

3.1 Conductors—Conductors shall conform to the specifications shown in Table 1 of SAE J1128.

3.2 Insulation—The insulating material shall meet the requirements shown in SAE J1128 Type HTS. A special insulation with a tensile strength of 1000 psi (6900 kPa) minimum and STS wall may also be used.

3.3 Wire Size—The fusible link must be of a smaller wire size than any connecting cable in the circuits being protected. Wire sizes are to be deter-

Construction

(a) Conductor—See Section 2, Conductors.
(b) Insulation—See Section 2, Insulation.
(c) Inner Braid—(when specified) See Section 2, Inner Braid.
(d) Sheath—See Section 2, Sheath.
(e) Size—See Section 2, Size.
(f) Marking—See Section 2, Marking.

Tests—The cable shall meet the following tests:

Life Cycle —See Test No. 1
High Temperature—See Test No. 2
Low Temperature —See Test No. 3
Hot Oil Test —See Test No. 4

Type HTB—High Tension, Metallic Conductor, Rubber Insulation, Braided Covering.

Construction

(a) Conductor—See Section 2, Conductors.
(b) Insulation—See Section 2, Insulation.
(c) Outer Braid—See Section 2, Outer Braid.
(d) Sheath—See Section 2, Sheath.
(e) Size—See Section 2, Size.
(f) Marking—See Section 2, Marking.

Tests—The cable shall meet the following tests:

High Potential —See Test No. 5
Corona —See Test No. 6
Low Temperature—See Test No. 7
Life Cycle —See Test No. 8

Type HTT—High Tension, Metallic Conductor, Thermoplastic Insulation.

Construction

(a) Conductor—See Section 2, Conductors.
(b) Insulation—See Section 2, Insulation.
(c) Inner Braid—(when specified) See Section 2, Inner Braid.
(d) Sheath—See Section 2, Sheath.
(e) Size—See Section 2, Size.
(f) Marking—See Section 2, Marking.

Tests—The cable shall meet the following tests:

Life Cycle —See Test No. 1
High Temperature—See Test No. 2
Low Temperature —See Test No. 3

4. Tests—All electrical tests shall be made with 60 cycle alternating current. The voltage specified shall be mean effective values (root-mean square). Voltage shall be increased from zero to the prescribed test value at a uniform rate of rise approximately but not exceeding 3 kv per sec or as otherwise specified.

1. Life Cycle Test—One end of a suitable length of cable shall be secured to a ½-in. diameter mandrel. A weight of 10 lb shall be attached to the free end. The mandrel and cable specimen shall then be rotated. Five complete turns shall be wound around the mandrel, coils touching. The cable shall then be unwound and rewound in the opposite direction. The complete winding cycle shall be performed twice.

The specimen shall then be wound on a 1-in. dia mandrel so that there are five turns spaced ¾ in. apart. At the time of winding on the 1-in. mandrel, one end of the cable shall be firmly attached to the mandrel and a 5-lb weight shall be attached to the outside of the other end of the specimen. The mandrel and specimen shall then be placed in a snug fitting, belled metal shield. The specimen with mandrel and shield shall be subjected to the following tests.

(a) Heat 5 hr at 250 ± 3 F. Remove from the oven and immerse in water maintained at 120 ± 3 F for a period of 18 hr. Remove and drain for 30 min. Subject specimen to 15,000 v applied between conductor and sheath for 30 min. Follow by

(b) Immerse in SAE 30 oil and maintain at 194 ± 5 F for 18 hr. Remove and drain 30 min. Subject specimen to 15,000 v applied between conductor and sheath for 30 min. Follow by

(c) Immerse in kerosene for a period of 18 hr at room temperature. Drain for 4 hr. After completion of tests, the insulation shall not crack, rupture, show excessive swelling or other evidence of damage.

2. High Temperature Test—Suitable lengths of cable shall be suspended straight in a ventilated oven maintained at a temperature of 250 ± 3 F for 48 hr. The specimen shall then be removed from the oven, allowed to cool to room temperature, then wrapped 360 deg around a ½-in. mandrel. Cracking of the outer jacket shall constitute failure.

3. Low Temperature Test—Suitable lengths of straight specimens shall be placed in a cold chamber maintained at −30 F for 24 hr. Without removing from the cold chamber, wrap specimen 360 deg around a 3-in. diameter mandrel which has also been subjected to the same time and temperature as the specimen. Cracking of the outer jacket shall constitute failure.

4. Hot Oil Test—Twenty-inch specimens shall be immersed in SAE 30 oil maintained at a temperature of 250 ± 5 F for a 40-hr period. The ends of the specimens shall protrude 3 in. above the oil and be 1 in. apart. The oil shall be circulated during the test. Remove from oil and allow to cool to room temperature, wipe free of oil and wrap center portion 360 deg around a ½-in. dia mandrel against curvature of bend. Excessive swelling, cracking or rupture of jacket shall constitute failure.

5. High Potential Test—One inch of insulation shall be removed from each end of an 18-in. length of the cable and the exposed ends of the conductor twisted together. The loop so formed shall be immersed in water at 68 F (20 C) ± 5 F so that 4 in. of each leg of the loop protrudes above the surface of the solution. After 24-hr immersion and while still immersed, a potential of 20,000 v shall be applied between the conductor of the cable and the water and shall be maintained for 20 min. The cable shall withstand this test without failure.

6. Corona Test—A 5-ft length of cable, having a 5-lb weight attached to the free end, shall be wound 10 turns on a metal rod 1 in. in diameter, with adjacent turns touching. The cable shall then be secured to prevent slipping or release of tension. A potential of 10,000 v shall be applied between the conductor of the cable and the metal rod and maintained for 30 min. The potential shall then be raised to 20,000 v and maintained for 2 hr.

This test shall be started with cable and metal rod at a temperature of 68 F (20 C) ± 5 F. The cable shall withstand this test without failure.

7. Low Temperature Test—A sample of the cable 5 ft in length, shall be stretched straight on a rack and subjected to a temperature of −10 F (−23.3 C) ± 5 F for 12 hr. The cable shall then be wrapped around a 3-in. mandrel, with cable and mandrel at a temperature of −10 F. Cracking of the outer covering of the cable shall constitute failure.

8. Life Cycle Test—One end of a 5-ft specimen shall be firmly attached to suitable cylindrical mandrel with a diameter of ½ in.; a weight of 5 lb shall be firmly attached to the end of the specimen. The specimen shall be wound in a clockwise direction on the mandrel with the coils touching. It shall then be unwound and rewound in a counter-clockwise direction so that the coils again touch. This procedure shall be repeated until no less than two bends in each direction have been imposed on the specimen. The specimen shall then be removed from the ½-in. and wound on a 1-in. mandrel so that there are five turns spaced ¾ in. apart. At the time of winding on the 1-in. mandrel, one end of the cable shall be firmly attached to the mandrel and the 5-lb weight attached to the outside of the other end of the specimen. After winding, a close fitting brass sleeve with belled ends shall be placed over the wound mandrel. The test specimen shall then be subjected to the procedure and conditions specified in Table 1 and shall not be removed from the 1-in. dia mandrel until they have been completed.

9. Resistance Test—The resistance of Type HTLR and Type HTHR shall be within the limits shown in Table 2 when measured with a standard commercial multi-purpose meter with a low voltage power source by using ½ in. probes on each lead and a 13 in. piece of cable. Probes must be carefully inserted ½ in. into the conductor. The cable should then be tested as follows:

(a) Measure resistance of cable after 50 lb tension.

(b) Measure resistance of cable after being wound and unwound five turns on a ½-in. dia mandrel. Wind cable under 5 lb tension.

TABLE 1—OPERATIONS TO BE PERFORMED AND CONDITIONS TO BE MAINTAINED

Time Consumed, hr	First 24-Hr Period	Second 24-Hr Period	Third 24-Hr Period	3-1/2-Hr Period
3	Rest	Rest	Drain	Drain
1/2	Corona Test 15 kv	Corona Test 15 kv	Corona Test 15 kv	Corona Test 15 kv
1/2	Rest	Rest	Rest	—
20	Bake in oven at 176 ±20 F.	Soak in 5% sodium chloride solution at room temperature, ends protruding not more than 8 in. nor less than 4 in.	Soak in solution of 1 part kerosene,* 1 part motor fuel, 2 parts engine SAE 30 oil, ends protruding not more than 8 in. nor less than 4 in.	—

*Kerosene conforming with Federal Specification VV-K-211.

TABLE 2—RESISTANCE OF TYPES HTLR AND HTHR CABLES

Cable	Resistance - Ohms per Ft	
	Low Limit	High Limit
Type HTLR	3000	7000
Type HTHR	6000	12000

HIGH TENSION IGNITION CABLE—SAE J557

SAE Standard

Report of Electrical Equipment Division approved July 1921 and last revised by Electrical Equipment Committee June 1961. Reaffirmed without change January 1968.

Scope—The specifications contained in this report cover high tension cable used in motor vehicles or tractor engine ignition systems.

1. Specification Types

Type HTLR—High Tension, Low Resistance Conductor, Rubber Insulation, Synthetic Sheath.

Type HTHR—High Tension, High Resistance Conductor, Rubber Insulation, Synthetic Sheath.

Type HTS—High Tension, Metallic Conductor, Rubber Insulation, Synthetic Sheath.

Type HTB—High Tension, Metallic Conductor, Rubber Insulation, Braided Covering.

Type HTT—High Tension, Metallic Conductor, Thermoplastic Insulation.

2. General Specifications

Conductors—Type HTLR and Type HTHR—The conductor shall consist of a resistor element capable of producing a specified designed resistance in the finished cable.

Type HTS, Type HTB and Type HTT—The metallic conductor shall consist of 7 or 19 strands of wire having a lay twisted to the left as viewed from the observer. The diameter of the stranded group shall not exceed 0.060 in. or be less than 0.030 in. The individual wires shall be treated so that there will be no interaction between the wire and insulating compound.

Insulation—A homogeneous insulating compound shall be applied directly over the conductor. The insulating compound on Types HTS, HTB and HTT shall adhere closely to, but shall strip readily from the wires of the conductor, leaving them reasonably clean. The thickness of the insulating compound shall be such that it will meet the applicable tests for each cable type.

Inner Braid—When specified, an open braid of suitable textile shall be applied over the insulation.

Sheath—When specified, a synthetic material shall be applied concentrically over the insulation or over the inner braid, if used. It shall be so compounded as to meet the tests specified. Adjacent layers of cable, when wound on reel or coil or packed in sets, shall not stick to one another at any temperature under 121 F.

Outer Braid—When specified, a protective braid shall be applied over the insulation compound. The braid shall be so treated as to be resistant to heat, oil, water and gasoline. Adjacent layers of cable, when wound on a reel or when packed in sets, shall not stick to one another at any temperature under 105 F.

Size—The outside diameter of the cable shall be within 0.270 to 0.285 in. Cable may be slightly flattened or oval in section, but the average of two diameters measured 90 deg apart at any section must be within the values specified.

Marking—When specified, the manufacturer's name and/or manufacturer's identification, the quarter, year, and cable type shall be legibly and reasonably permanently marked on the outside of the cable at intervals not exceeding 2 ft.

3. Cable Construction

Type HTLR—High Tension, Low Resistance Conductor, Rubber Insulation, Synthetic Sheath.

Construction

(a) Conductor—See Section 2, Conductors.
(b) Insulation—See Section 2, Insulations.
(c) Inner Braid—(when specified) See Section 2, Inner Braid.
(d) Sheath—See Section 2, Sheath.
(e) Size—See section 2, Marking.
(f) Marking—See Section 2, Marking.

Tests—The cable shall meet the following tests:

Life Cycle	—See Test No. 1
High Temperature	—See Test No. 2
Low Temperature	—See Test No. 3
Hot Oil Test	—See Test No. 4
Resistance	—See Test No. 9

Type HTHR—High Tension, High Resistance Conductor, Rubber Insulation, Synthetic Sheath.

Construction

(a) Conductor—See Section 2, Conductors.
(b) Insulation—See Section 2, Insulation.
(c) Inner Braid—(when specified) See Section 2, Inner Braid.
(d) Sheath—See Section 2, Sheath.
(e) Size—See Section 2, Size.
(f) Marking—See Section 2, Marking.

Tests—The cable shall meet the following tests:

Life Cycle	—See Test No. 1
High Temperature	—See Test No. 2
Low Temperature	—See Test No. 3
Hot Oil Test	—See Test No. 4
Resistance	—See Test No. 9

Type HTS—High Tension, Metallic Conductor, Rubber Insulation, Synthetic Sheath.

Construction

(a) Conductor—See Section 2, Conductors.
(b) Insulation—See Section 2, Insulation.
(c) Inner Braid—(when specified) See Section 2, Inner Braid.
(d) Sheath—See Section 2, Sheath.
(e) Size—See Section 2, Size.
(f) Marking—See Section 2, Marking.

Tests—The cable shall meet the following tests:

Life Cycle	—See Test No. 1
High Temperature	—See Test No. 2
Low Temperature	—See Test No. 3
Hot Oil Test	—See Test No. 4

Type HTB—High Tension, Metallic Conductor, Rubber Insulation, Braided Covering.

Construction

(a) Conductor—See Section 2, Conductors.
(b) Insulation—See Section 2, Insulation.
(c) Outer Braid—See Section 2, Outer Braid.
(d) Sheath—See Section 2, Sheath.
(e) Size—See Section 2, Size.
(f) Marking—See Section 2, Marking.

Tests—The cable shall meet the following tests:

High Potential	—See Test No. 5
Corona	—See Test No. 6
Low Temperature	—See Test No. 7
Life Cycle	—See Test No. 8

Type HTT—High Tension, Metallic Conductor, Thermoplastic Insulation.

Construction

(a) Conductor—See Section 2, Conductors.
(b) Insulation—See Section 2, Insulation.
(c) Inner Braid—(when specified) See Section 2, Inner Braid.
(d) Sheath—See Section 2, Sheath.
(e) Size—See Section 2, Size.
(f) Marking—See Section 2, Marking.

Tests—The cable shall meet the following tests:

Life Cycle	—See Test No. 1
High Temperature	—See Test No. 2
Low Temperature	—See Test No. 3

4. Tests—All electrical tests shall be made with 60 cycle alternating current. The voltage specified shall be mean effective values (root-mean square). Voltage shall be increased from zero to the prescribed test value at a uniform rate of rise approximately but not exceeding 3 kv per sec or as otherwise specified.

1. Life Cycle Test—One end of a suitable length of cable shall be secured to a ½-in. diameter mandrel. A weight of 10 lb shall be attached to the free end. The mandrel and cable specimen shall then be rotated. Five complete turns shall be wound around the mandrel, coils touching. The cable shall then be unwound and rewound in the opposite direction. The complete winding cycle shall be performed twice.

The specimen shall then be wound on a 1-in. dia mandrel so that there are five turns spaced ¾ in. apart. At the time of winding on the 1-in. mandrel, one end of the cable shall be firmly attached to the mandrel and a 5-lb weight shall be attached to the outside of the other end of the specimen. The mandrel and specimen shall then be placed in a snug fitting, belled metal shield. The specimen with mandrel and shield shall be subjected to the following tests:

(a) Heat 5 hr at 250 ± 3 F. Remove from the oven and immerse in water maintained at 120 ± 3 F for a period of 18 hr. Remove and drain for 30 min. Subject specimen to 15,000 v applied between conductor and sheath for 30 min. Follow by:

(b) Immerse in SAE 30 oil and maintain at 194 ± 5 F for 18 hr. Remove and drain 30 min. Subject specimen to 15,000 v applied between conductor and sheath for 30 min. Follow by:

(c) Immerse in kerosene for a period of 18 hr at room temperature. Drain for 4 hr. After completion of tests, the insulation shall not crack, rupture, show excessive swelling or other evidence of damage.

2. High Temperature Test—Suitable lengths of cable shall be suspended straight in a ventilated oven maintained at a temperature of 250 ± 3 F for 48 hr. The specimen shall then be removed from the oven, allowed to cool to room temperature, then wrapped 360 deg around a ½-in. mandrel. Cracking of the outer jacket shall constitute failure.

3. Low Temperature Test—Suitable lengths of straight specimens shall be placed in a cold chamber maintained at −30 F for 24 hr. Without removing from the cold chamber, wrap specimen 360 deg around a 3-in. diameter mandrel which has also been subjected to the same time and temperature as the specimen. Cracking of the outer jacket shall constitute failure.

4. Hot Oil Test—Twenty-inch specimens shall be immersed in SAE 30 oil maintained at a temperature of 250 ± 5 F for a 40-hr period. The ends of the specimens shall protrude 3 in. above the oil and be 1 in. apart. The oil shall be circulated during the test. Remove from oil and allow to cool to room temperature, wipe free of oil and wrap center portion 360 deg around a ½-in. dia mandrel against curvature of bend. Excessive swelling, cracking or rupture of jacket shall constitute failure.

5. High Potential Test—One inch of insulation shall be removed from each end of an 18-in. length of the cable and the exposed ends of the conductor twisted together. The loop so formed shall be immersed in water at 68 F (20 C) ± 5 F so that 4 in. of each leg of the loop protrudes above the surface of the solution. After 24-hr immersion and while still immersed, a potential of 20,000 v shall be applied between the conductor of the cable and the water and shall be maintained for 20 min. The cable shall withstand this test without failure.

6. Corona Test—A 5-ft length of cable, having a 5-lb weight attached to the free end, shall be wound 10 turns on a metal rod 1 in. in diameter, with adjacent turns touching. The cable shall then be secured to prevent slipping or release of tension. A potential of 10,000 v shall be applied between the conductor of the cable and the metal rod and maintained for 30 min. The potential shall then be raised to 20,000 v and maintained for 2 hr.

This test shall be started with cable and metal rod at a temperature of 68 F (20 C) ± 5 F. The cable shall withstand this test without failure.

7. Low Temperature Test—A sample of the cable 5 ft in length, shall be stretched straight on a rack and subjected to a temperature of −10 F (−23.3 C) ± 5 F for 12 hr. The cable shall then be wrapped around a 3-in. mandrel, with cable and mandrel at a temperature of −10 F. Cracking of the outer covering of the cable shall constitute failure.

8. Life Cycle Test—One end of a 5-ft specimen shall be firmly attached to suitable cylindrical mandrel with a diameter of ½ in.; a weight of 5 lb shall be firmly attached to the end of the specimen. The specimen shall be wound in a clockwise direction on the mandrel with the coils touching. It shall then be unwound and rewound in a counter-clockwise direction so that the coils again touch. This procedure shall be repeated until no less than two bends in each direction have been imposed on the specimen. The specimen shall then be removed from the ½-in. and wound on a 1-in. mandrel so that there are five turns spaced ¾ in. apart. At the time of winding on the 1-in. mandrel, one end of the cable shall be firmly attached to the mandrel and the 5-lb weight attached to the outside of the other end of the specimen. After winding, a close fitting brass sleeve with belled ends shall be placed over the wound mandrel. The test specimen shall then be subjected to the procedure and conditions specified in Table 1 and shall not be removed from the 1-in. dia mandrel until they have been completed.

9. Resistance Test—The resistance of Type HTLR and Type HTHR shall be within the limits shown in Table 2 when measured with a standard commercial multi-purpose meter with a low voltage power source by using ½ in. probes on each lead and a 13 in. piece of cable. Probes must be carefully inserted ½ in. into the conductor. The cable should then be tested as follows:

(a) Measure resistance of cable after 50 lb tension.

(b) Measure resistance of cable after being wound and unwound five turns on a ½-in. dia mandrel. Wind cable under 5 lb tension.

TABLE 1—OPERATIONS TO BE PERFORMED AND CONDITIONS TO BE MAINTAINED

Time Consumed, hr	First 24-Hr Period	Second 24-Hr Period	Third 24-Hr Period	3-1/2-Hr Period
3	Rest	Rest	Drain	Drain
1/2	Corona Test 15 kv	Corona Test 15 kv	Corona Test 15 kv	Corona Test 15 kv
1/2	Rest	Rest	Rest	—
20	Bake in oven at 176 ±20 F.	Soak in 5% sodium chloride solution at room temperature, ends protruding not more than 8 in. nor less than 4 in.	Soak in solution of 1 part kerosene,* 1 part motor fuel, 2 parts engine SAE 30 oil, ends protruding not more than 8 in. nor less than 4 in.	—

Kerosene conforming with Federal Specification VV-K-211.

TABLE 2—RESISTANCE OF TYPES HTLR AND HTHR CABLES

Cable	Resistance - Ohms per Ft	
	Low Limit	High Limit
Type HTLR	3000	7000
Type HTHR	6000	12000

8.4.0 EXAMINATION PROCEDURE

8.4.1 The procedure shall be conducted in accordance with SAE Standard J557 dated January 1960

8.4.2 Report should include test sequence, validation of conductor type, sampling process, discrepancies and pass or fail determination.

9.0 LAB EXAMINATION NO. 5

183.450(e) <u>Pull Testing of Conductor-Conductor and Connector-Connector joints</u>

(e) Each connection that is outside of a junction box and that is used to join conductors to each other or that is used to join a conductor to a connector must not break when subjected for one minute to a tensile force shown in Table 6 for the smallest conductor size in the connection.

TABLE 6.—TENSILE TEST VALUES FOR CONDUCTOR SPLICES

(CONDUCTOR-CONDUCTOR AND CONDUCTOR-CONNECTOR JOINTS)

Wire size (AWG):	*Tensile force pounds*
18	10
16	15
14	30
12	35
10	40
8	45
6	50
5	60
4	70
3	80
2	90
1	100
0	125
00	150
000	175
0000	225

9.1 SCOPE

9.1.1 This examination will determine compliance with §183.450(e).

9.1.2 Those splices and connections identified in Paragraph 5.6 of Visual Examination No. 8 are to be tested in accordance with this examination.

9.2 APPARATUS

9.2.1 Test fixture with securing devices and weights as shown in Figure 1.

9.2.1.1 Weights must be suitable to provide pulling forces from 10 to 225 pounds.

9.3 TEST SPECIMENS

9.3.1 All spliced connections identified in Paragraph 5.6 of Visual Examination No. 8 are to be tested.

9.3.1.1 The test specimens shall be taken directly from the boat(s) or the boat wiring harness(es) as assembled by the manufacturer (see Figure 2 for examples).

9.3.2 To facilitate securing to the test fixture, the conductors on each side of the splice or connector shall be approximately eighteen (18) inches long whenever possible.

9.3.3 Short leads and pigtails less than seven (7) inches long shall be cut as long as possible.

9.3.4 If more specimens are required for further tests, representative samples assembled by the manufacturer shall be obtained.

9.4 TEST CONDITIONS

9.4.1 The tests shall be conducted at room temperature.

9.5 PREPARATION FOR TEST

9.5.1 The methods of setting up the specimens in the test fixture will vary according to the type of connection and connector being tested.

9.5.2 Conductors that are spliced together using an end cap shall be pulled first in opposite directions. Then the cap shall be secured to a holding device and the conductors pulled down individually away from the cap. If the cap contains conductors of different sizes, test the smallest conductor first.

9.5.3 Closed ring, eyelet, and lug type connectors shall be tested in pairs, bolted back-to-back, so as to provide contact surface equivalent to that obtained in normal use. The conductor barrels shall be parallel (180°) to each other.

9.5.3.1 The bolt shall be an appropriate size for the terminal hole. If the terminal contains two bolt holes, a bolt shall be installed in both.

9.5.3.2 The bolts shall be securely tightened.

9.5.4 All conductors in splices shall be pulled in opposite directions. This applies to crimp type, screw or bolt type, parallel or butt and four-way. If a tee connection is used it shall be pulled parallel to the main conductor, then perpendicular to it.

9.5.4.1 If a splice contains different conductor sizes, perform the pull test using the tensile force values for the smallest conductor (Reference Table 6 of this report taken from the regulations).

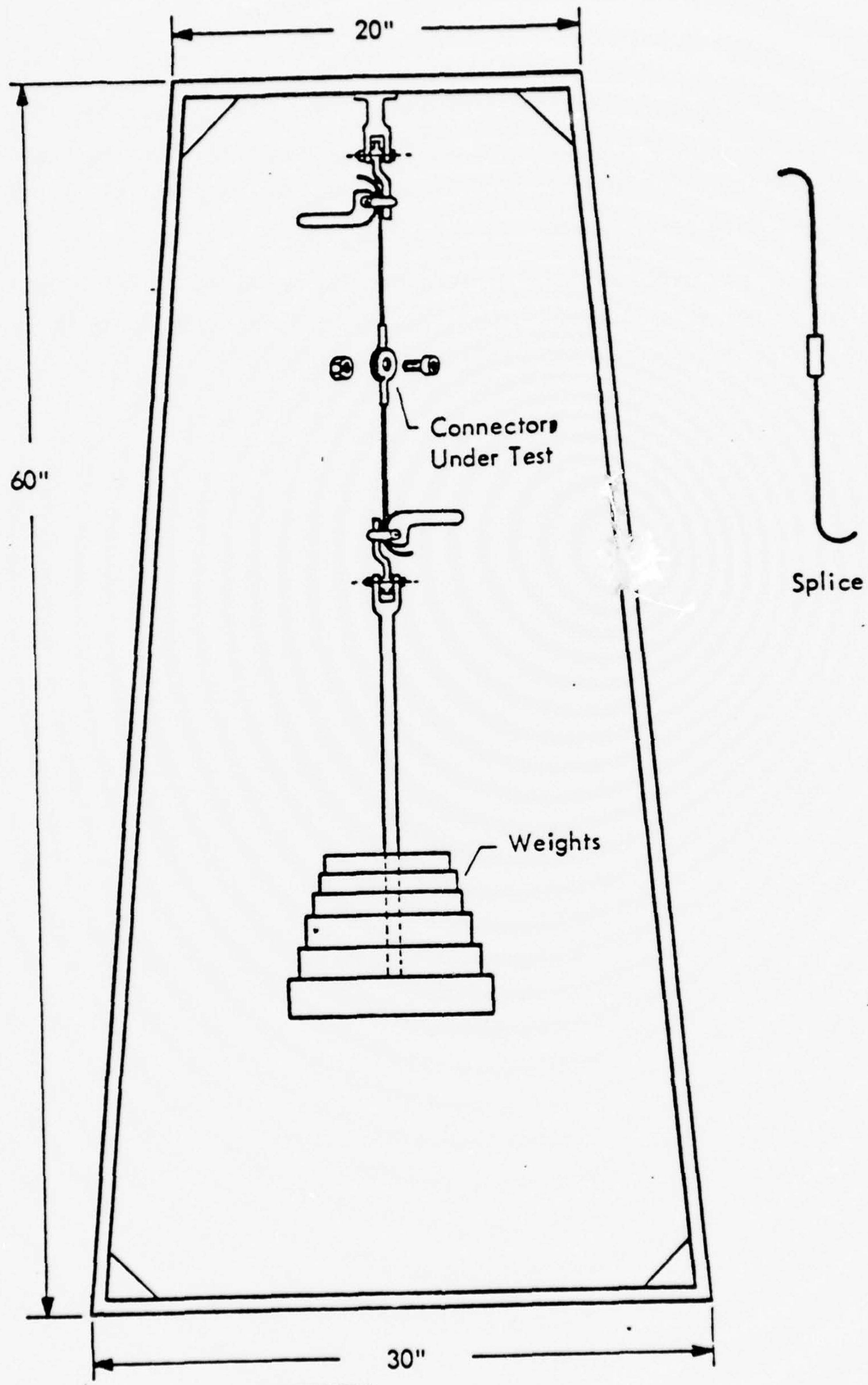


Figure 1. Test Fixture

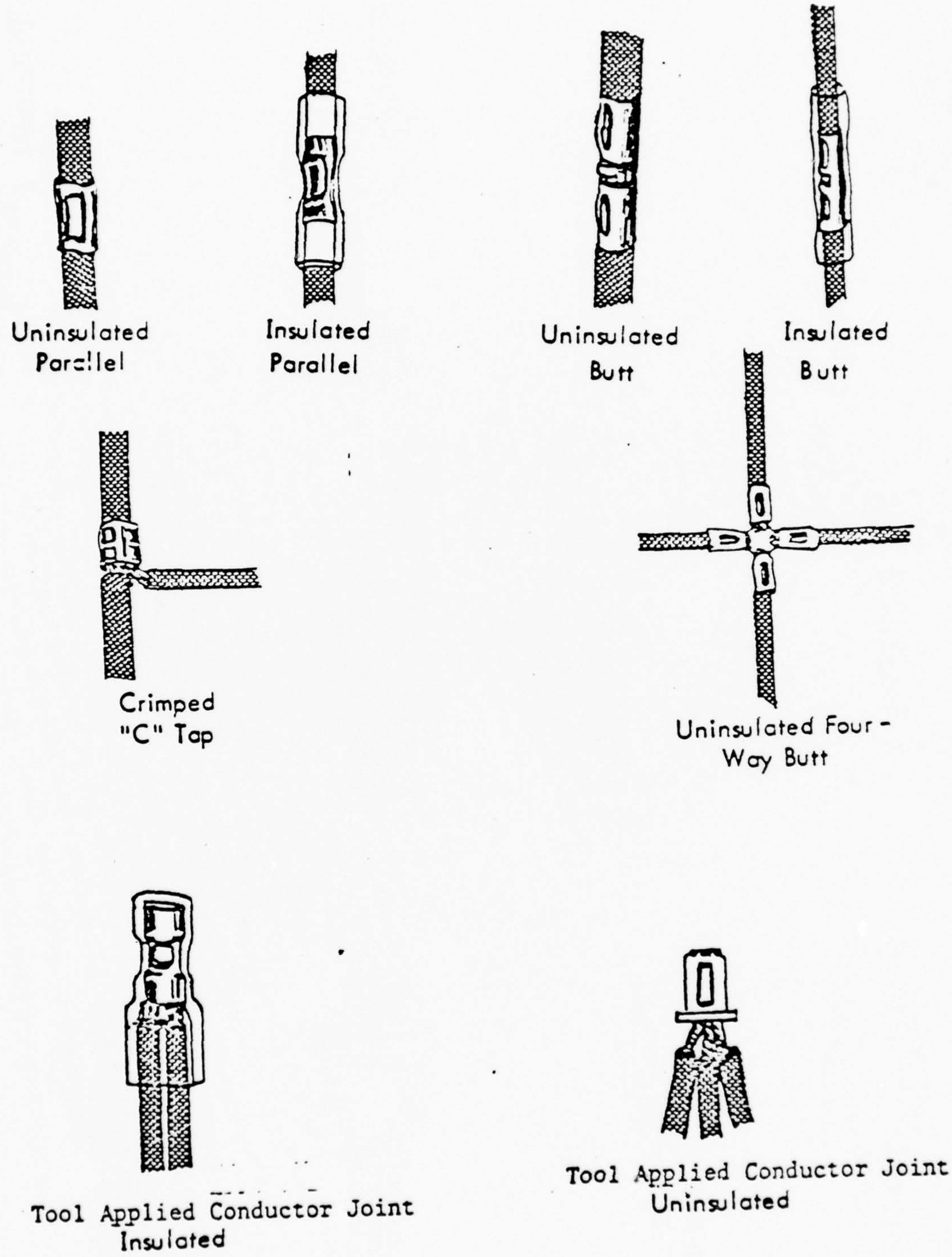


Figure 2. Examples of Test Specimens

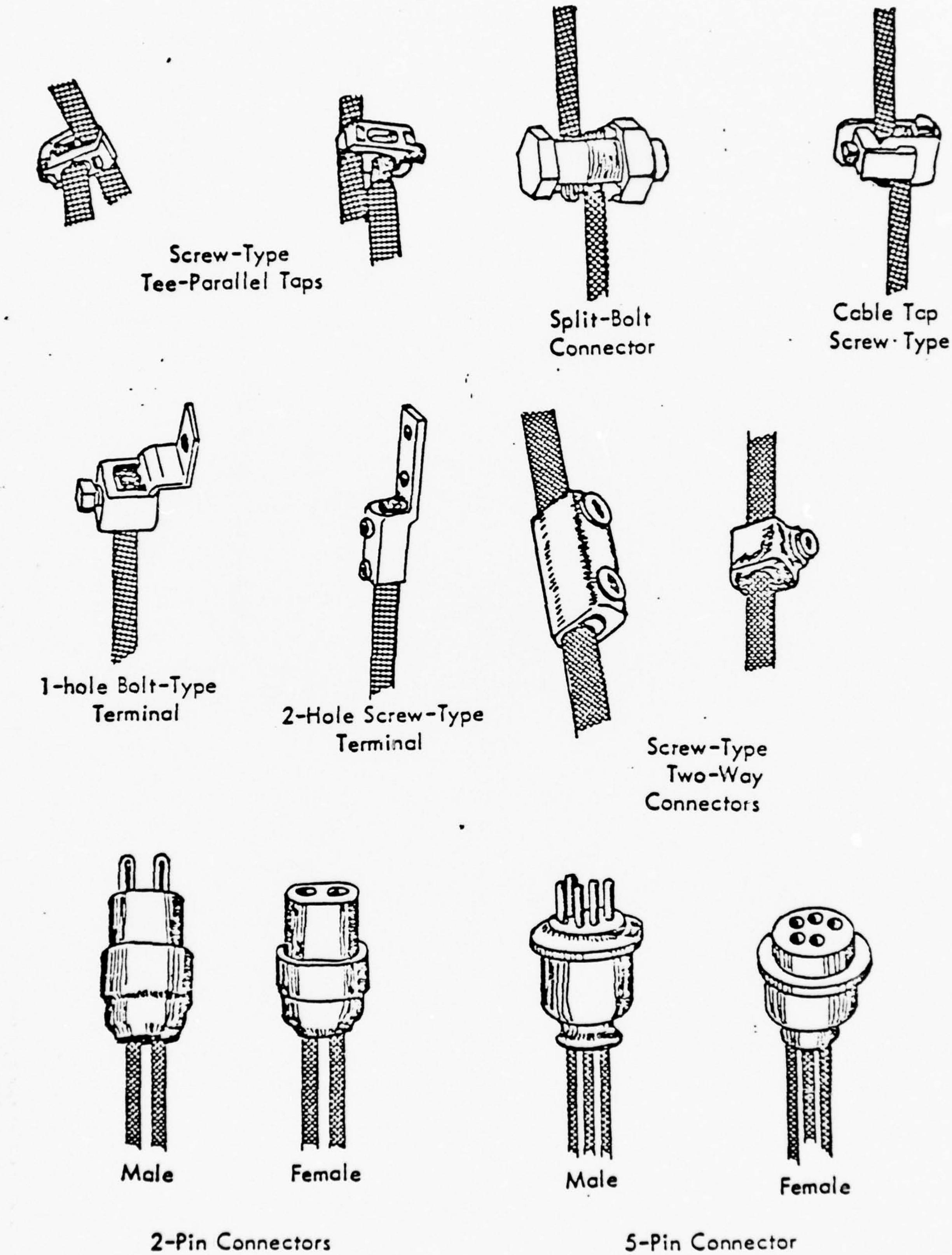


Figure 2. (Concluded)

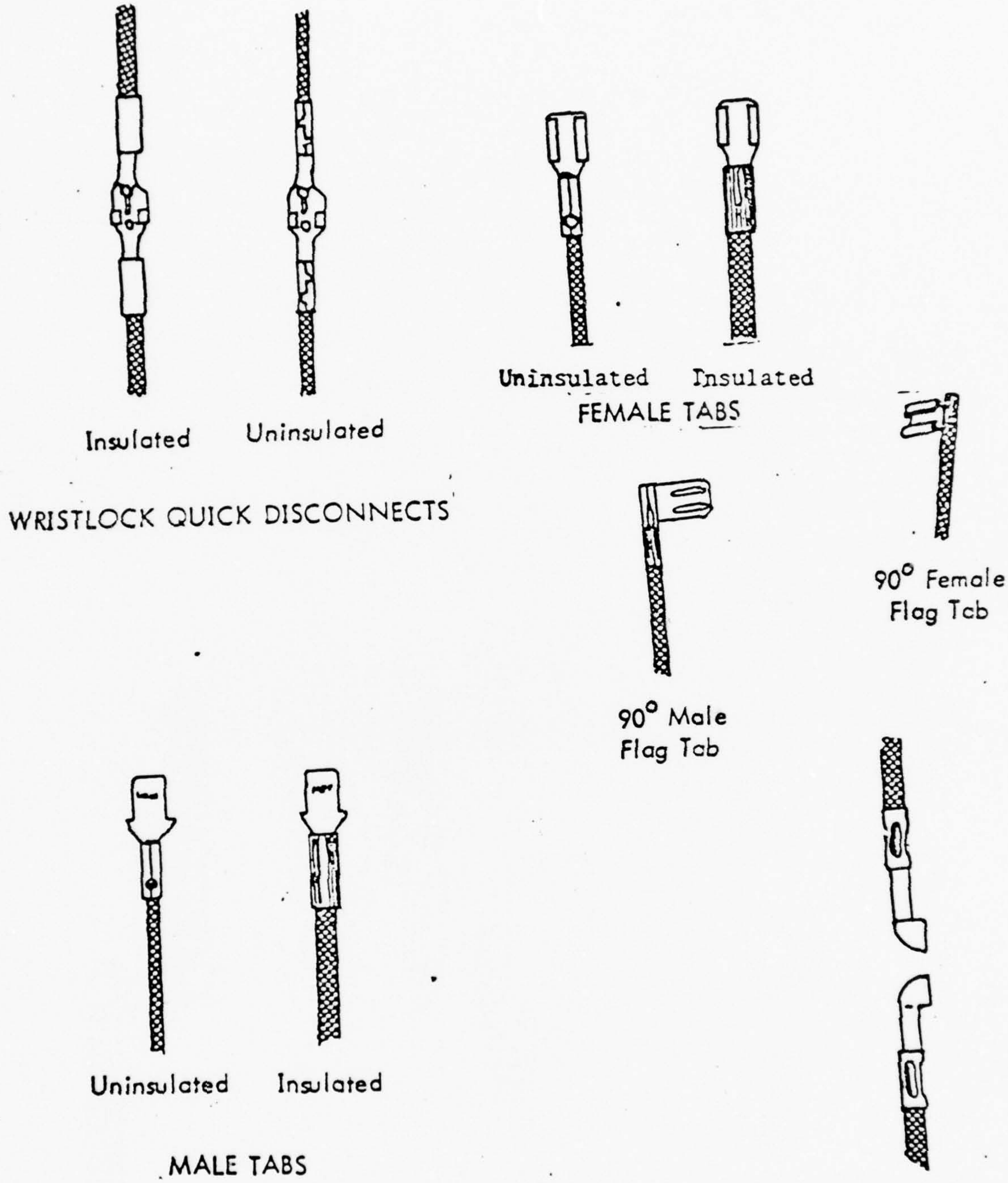
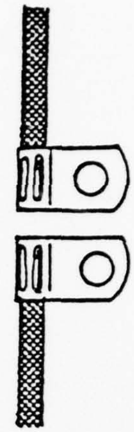
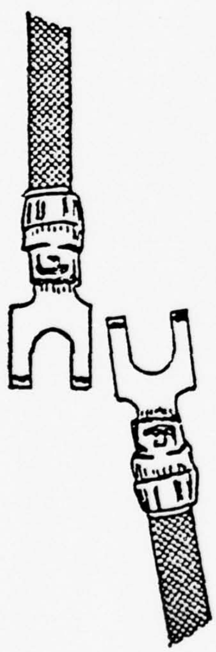


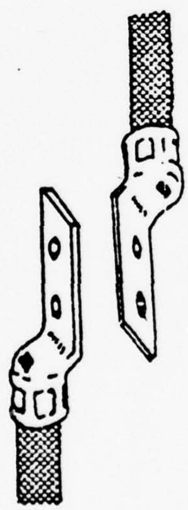
Figure 2. (Continued)



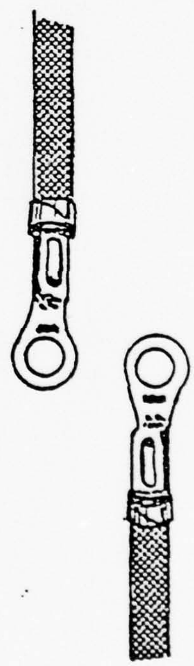
Flag Uninsulated



Forked Tab Terminals



Two-Hole Terminals



Ring Terminals

Figure 2. (Continued)

9.5.4 Wristlock and knife-type quick disconnect splices shall be mated together for the pull test.

9.5.4.1 Quick disconnect tab-type connectors shall be tested singly with the tab secured to the test fixture with a holding device.

9.5.5 Multi-pin electrical connectors shall be secured to the test fixture with an appropriate holding device.

9.5.5.1 Each conductor is to be pull tested in order of increasing size.

9.5.5.2 If possible, remove each conductor and its respective pin connector for the test.

9.6.0 PROCEDURE

9.6.1 The specimen shall be installed in the test fixture (Figure 1).

9.6.2 Add weights gradually so there is no sudden application or jerking during the test.

9.6.3 The splices, connectors and connections shall withstand a tensile force at least equal to the values shown in Table 6 for a period of one minute.

9.6.4 There shall be no stripping of threads, shearing of parts or other injury to the connectors. There shall be no breakage of the conductor strands or looseness between the conductor and the connector.

10.0 LAB EXAMINATION NO. 6 -- OVERCURRENT PROTECTION TEST PROCEDURE

10.1 General Description -- The component to be tested shall be visually inspected upon receipt. All identifying data shall be noted and documented, such as manufacturer, date of manufacture, model number, serial number, capacity, test condition, general condition, and any other observations which would be pertinent to the test. AC and DC fuses and circuit breakers shall be tested for proper calibration. The circuit breakers shall be tested for proper manual resetting and trip-free operation.

10.2 Test Conditions

10.2.1 Test Article -- All AC and DC circuit breakers and fuses shall be mounted on plywood or equivalent test fixtures which simulate an actual installation in a boat. Breakers and fuses installed in a boat shall be removed from the boat and mounted on plywood or equivalent test fixtures which simulate the actual installation

10.2.2 Test Media -- Components shall be tested using alternating current of a given rms ampere or direct current of the same ampere value.

10.2.3 Other -- This procedure shall be used only to bench test fuses and circuit breakers for proper calibration and operation. Other procedures shall be used to verify proper sizing and location for adequate overcurrent protection of the electrical system.

All tests shall be based on the manufacturer's specifications, conditions and timer characteristic curves. These include or assume good connections, adequate wire size, no prior loads, and the test conducted in open air at a certain temperature or temperature range.

10.3 Test Equipment and Material

Component Find No.	Title	Description
1	Test Mounting Fixture	Test Fixture constructed of plywood or equivalent used for mounting circuit breakers or fuse panels in a manner similar to that found in a boat.

Component Find No.	Title	Description
2	Calibration Resistance	A resistance equivalent to the resistance of the test component used when setting the test amperage.
3	Current Source	Current transformer with a variable output.
4	Ammeter	An ammeter with a range sufficien to test for proper calibration of the components (as shown an induction type with a digital or gauge readout).
5	Heat Chamber	A heat chamber capable of 140°F (60°C) for testing calibration at higher than ambient temperature.
6	Test Component	Overcurrent protection device (fuse or circuit breaker) to be tested.
7	Calibration Switch	A manual switch for closing calibration circuit when correct amperage is being set.
8	Timer	A timing mechanism capable of measuring tenths of seconds used to measure the time delay of a fuse or circuit breaker. Manual operation suitable for longer times (greater than 1 sec.).
9	Power Supply	A power supply used to operate the timer and supply the current transformer (probably 110 vac).
10	Timer Switch	A manual switch for turning off the timer during calibration or when circuit opens. During testing the timer starts when power is applied.
11	Oscilliscope	Used for measuring very short interruption times when manual timer is not suitable. Capable of reading milliseconds to 50 sec.
12	Component Switch	A manual switch for closing breaker test circuit after calibration has been completed

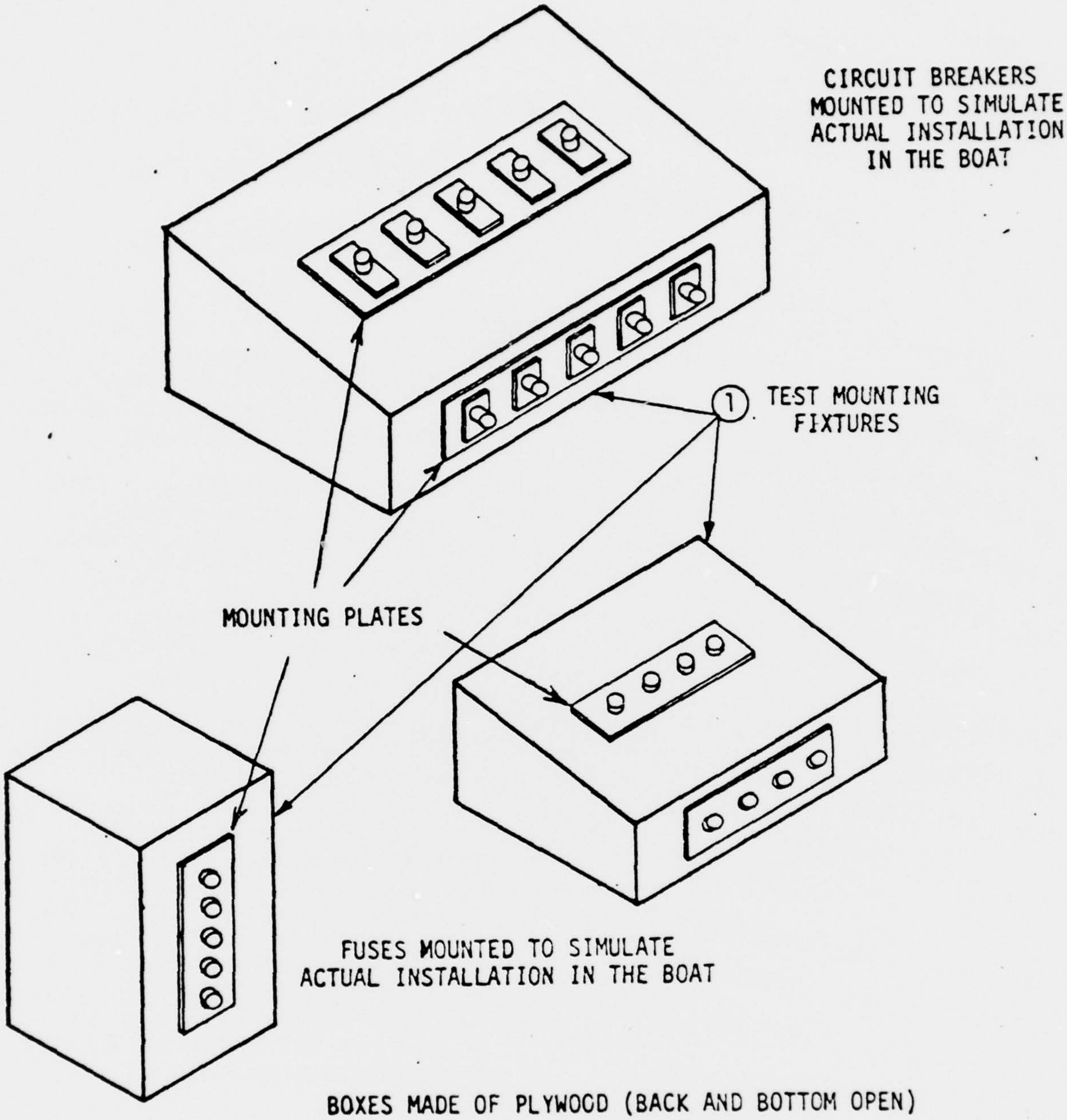


FIGURE 1. TEST HOLDING FIXTURE

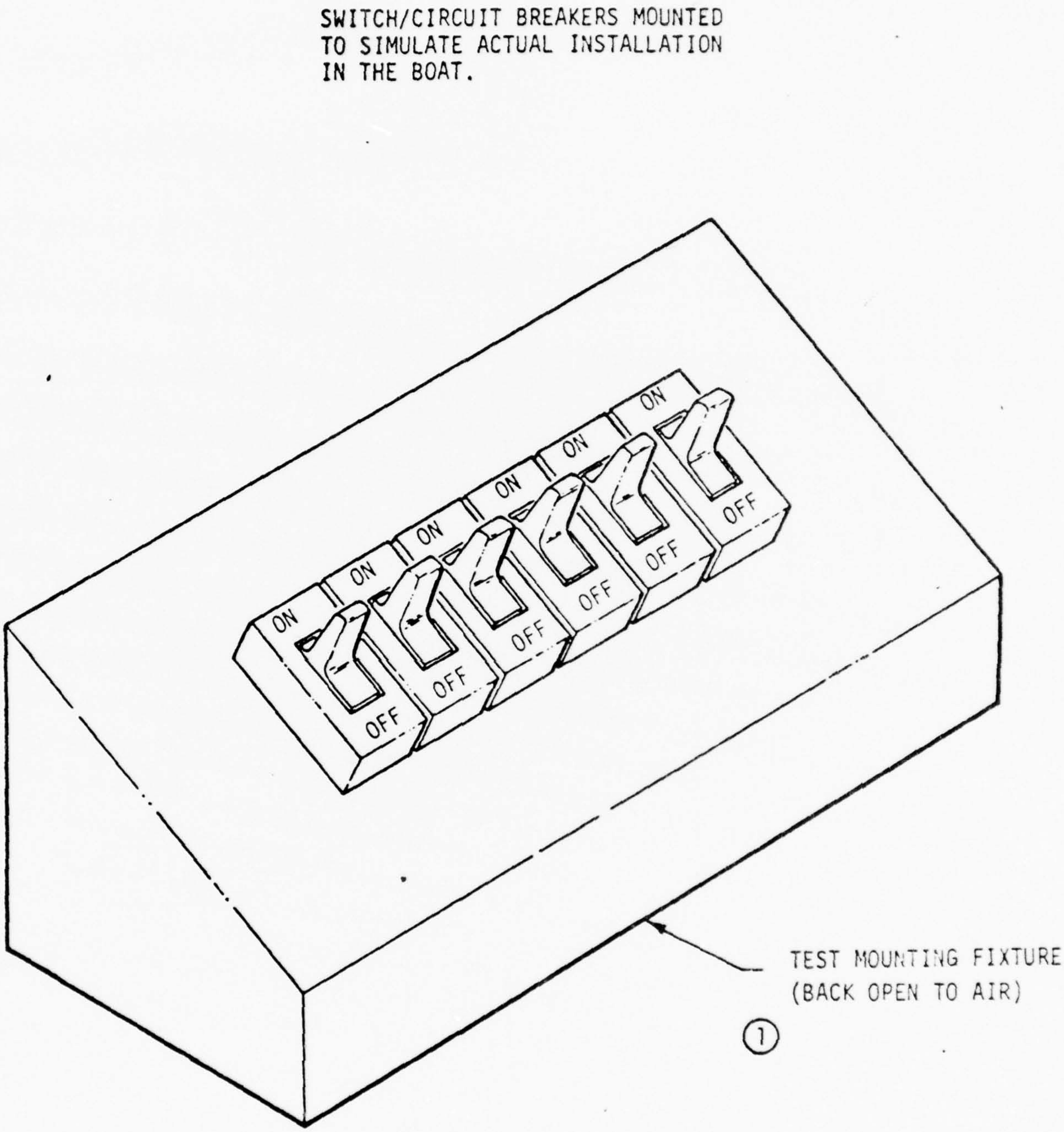


FIGURE 2. TEST HOLDING FIXTURE

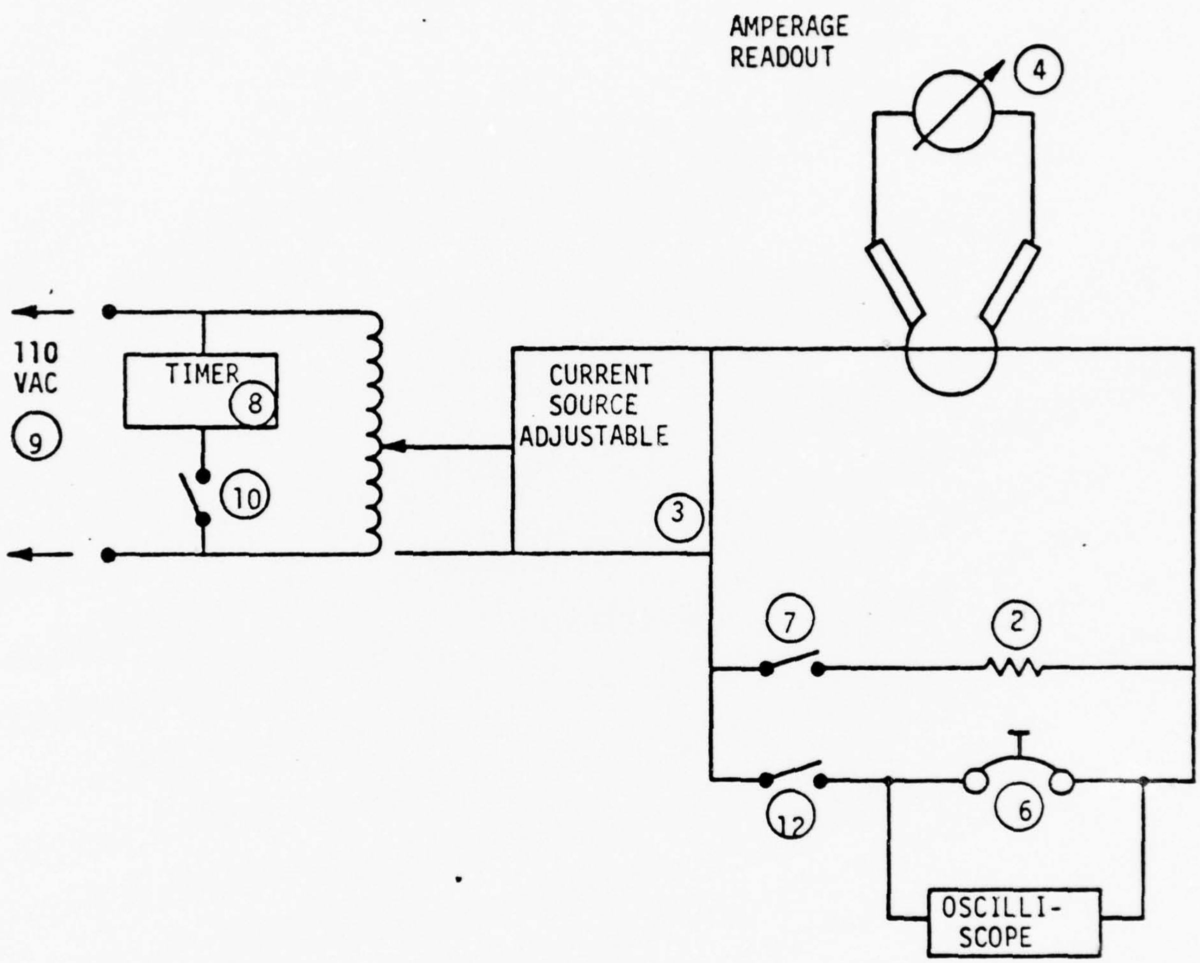
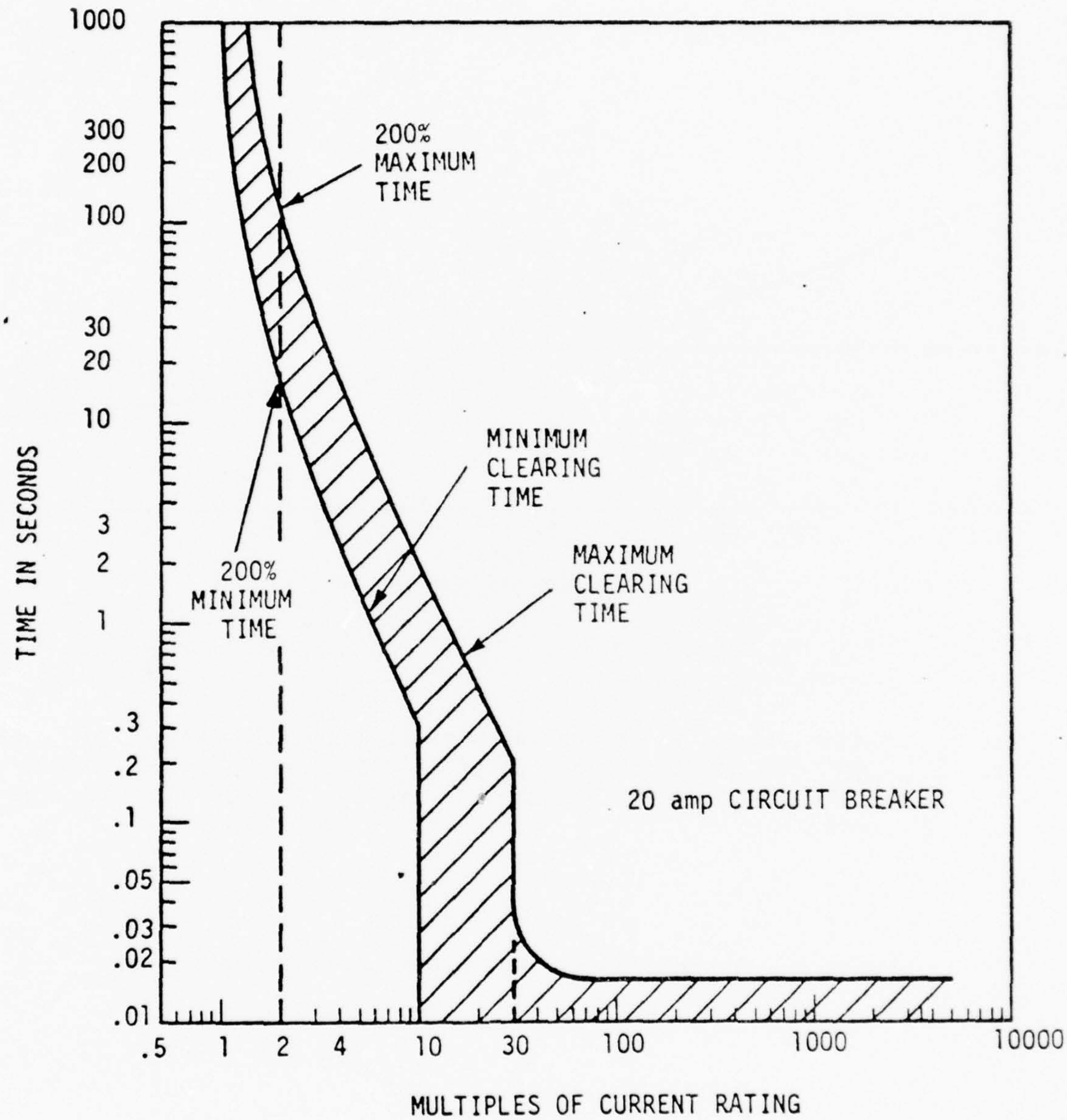
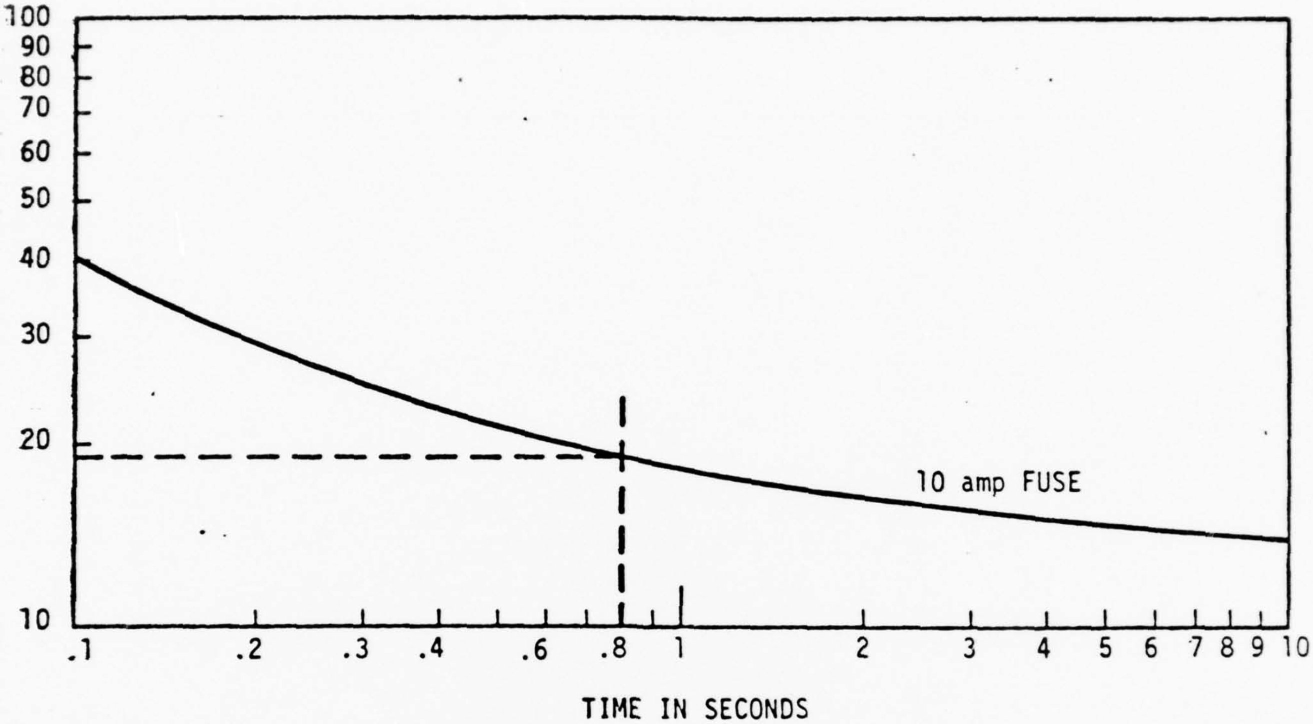


FIGURE 3. CALIBRATION TEST SETUP



The minimum magnetic trip test current shall be determined as follows. Extend the vertical portion of the maximum clearing time until it intersects the current axis. This multiple value plus 100 amps shall be the minimum test current. In the above example the test current would be 30 x 20 + 100 = 700 amps.

FIGURE 4. TYPICAL CIRCUIT BREAKER TIME - CURRENT CHARACTERISTIC CURVE



EXAMPLE: If circuit opens in .8 seconds when applying 200 percent of rated current (20 amps), the corresponding current is 19 amps. 19 $\pm$ 10 percent = 19 $\pm$ 1.9 amps. 20 amps falls within these limits (17.1 - 20.9). Consequently, the fuse is acceptable.

FIGURE 5. TYPICAL FUSE TIME-CURRENT CHARACTERISTIC CURVE

10.4 Test -- Overcurrent Protection Equipment

10.4.1 This procedure shall be used to perform a bench test of AC and DC circuit breakers and fuses only. Calibration and trip-free operation shall be verified. All such devices in the boat shall be tested by repeating the applicable sections of this procedure.

10.4.2 Visually inspect the component to be tested. Review the results of the Receiving Inspection and verify the component is acceptable and ready for testing.

10.4.3 Verify the applicability of this procedure to the component being tested before proceeding.

10.4.4 Remove the circuit breakers and/or fuses to be tested from the boat if they are installed. Mount them on a plywood or equivalent test fixture similar to the actual installation or similar to a typical installation (see Test Schematic Figures 1 and 2). The circuit breaker or fuse should be in open air (not in an enclosed air space).

10.4.5 Verify all pertinent technical specification data is available on each component, either as marked on the component or as obtained from the supplier or manufacturer. As a minimum this shall include rated current, maximum rated voltage, time current characteristic curve, applicable frequency (if AC), and maximum interrupting capacity.

10.4.6 Calibration Test (Fuses and Circuit Breakers)

10.4.6.1 Circuit Breakers

10.4.6.1.1 A calibration test shall be performed on all circuit breakers by the application of 100%, 135% and 200% of the rated current (rms) of the device at 25±3°C (77±5°F). Determine 100%, 135% and 200% of the rated current of the device

10.4.6.1.2 If the circuit breaker has a magnetic trip in addition to the thermal trip, an additional test shall be conducted at 25±3°C (77±5°F) and at a current sufficient to adequately verify its operation. See Figure 4 for a typical time current characteristic curve and for determination of the magnetic trip test current. Determine the required test current

NOTE

If a dual-circuit or multi-pole type breaker is used, all tests in this section (Paragraph 10.4.6.1) shall be accomplished on each circuit.

10.4.6.1.3 Verify the ambient temperature at the start of the test is 25±3°C (77±5°F). The temperature shall remain within this range throughout the entire test.

NOTE

All tests shall be conducted in open air (25±3°C) using proper wire with good test connections. The breakers shall have had no prior load. This means they must be at the ambient temperature. Consequently, once a test has been performed the circuit breaker must be allowed to return to this temperature prior to starting the next test.

10.4.6.1.4 Measure the resistance of the circuit breaker and insert an equivalent resistance into the circuit (Find No. 2). Adjust the current source to give 100% of the rated current of the device as measured at the ammeter (Find No. 4).

NOTE

An equivalent resistance is used to give a preliminary current source setting for the start of the test without causing the circuit breaker to heat up or open during the calibration of the current source. Once the calibration of the current source is completed, the test can be started immediately. The same resistance measurement can be used throughout the test.

10.4.6.1.5 Disconnect the calibration resistance from the test circuit and connect the circuit breaker into the setup.

10.4.6.1.6 Apply the 100% rated current (as determined from the pre-test calibration) to the breaker and start the electric timer (Find No. 8). Immediately verify the current is 100% of rated current (±0.25 amps). Do not adjust the current source to maintain this current during the test.

NOTE

This is an initial reading at the start of the test only. No attempt should be made to maintain the initial current. If the initial reading is out of tolerance, re-calibrate the circuit and repeat the test after allowing the circuit breaker to return to ambient temperature.

Apply the 100% current for a period of 2 hours as measured by the electric timer. Verify that the circuit breaker is capable of carrying this 100% load without interrupting the circuit.

10.4.6.1.7 Disconnect the circuit breaker and reconnect the calibration resistance into the test circuit. Adjust the current source to give 135% of the rated current of the device. Disconnect the calibration resistance and reconnect the circuit breaker.

10.4.6.1.8 Allow the circuit breaker to return to ambient temperature (25±3°C) after the last test.

10.4.6.1.9 Apply the 135% rated current to the breaker and start the electric timer. Immediately verify that the current is 135% of rated current (±0.25 amps). Do not adjust the current source to maintain this current during the test.

NOTE

This is an initial reading at the start of the test only. As the test progresses the current flow will decrease. No attempt should be made to maintain the initial current. If the initial reading is out of tolerance, re-calibrate the circuit and repeat the test after allowing the circuit breaker to return to ambient temperature.

Observe the ammeter and the circuit breaker for the point of circuit interruption and immediately stop the electric timer.

Verify that this time falls within the following specified limits:

current rating 50 amps or less -- 60 minutes maximum
current rating more than 50 amps -- 120 minutes maximum

10.4.6.1.10 Disconnect the circuit breaker and reconnect the calibration resistance into the test circuit. Adjust the current source to give 200% of the rated current of the device. Disconnect the calibration resistance and reconnect the circuit breaker.

10.4.6.1.11 Allow the circuit breaker to return to ambient temperature (25±3°C) after the last test.

10.4.6.1.12 Apply the 200% rated current to the breaker and start the electric timer. Immediately verify the current is 200% of rated current (±0.50 amps). Do not adjust the current source to maintain this current during the test.

NOTE

This is an initial reading at the start of the test only. As the test progresses the current flow will decrease. No attempt should be made to maintain the initial current. If the initial reading is out of tolerance, recalibrate the circuit and repeat the test after allowing the circuit breaker to return to ambient temperature.

Observe the ammeter and the circuit breaker for the point of circuit interruption and immediately stop the electric timer.

Verify that this time falls within the minimum and maximum clearing times as specified by the manufacturer's time-current characteristic curve. See Figure 4 for a typical curve.

NOTE

The following test shall be performed only on circuit breakers which contain a magnetic trip. The Trip-Free Test (Paragraph 8.4.7) may be performed at this time prior to the following test.

10.4.6.1.13 Disconnect the circuit breaker and reconnect the calibration resistance into the test circuit. Adjust the current source to give the required magnetic trip test current. See Figure 4 for determination of this current. Disconnect the calibration resistance and reconnect the circuit breaker.

10.4.6.1.14 Allow the circuit breaker to return to ambient temperature (25±3°C) after the last test.

10.4.6.1.15 Connect an oscilloscope across the circuit breaker to record the clearing time required by the breaker.

10.4.6.1.16 Apply the test current to the breaker and observe the clearing time as indicated on the oscilloscope.

Verify that this time falls within the maximum clearing time as specified by the manufacturer's time-current characteristic curve.

10.4.6.1.17 If the component fails any of the above applicable tests, it shall be rejected.

If the component passes all of the above applicable tests, the component shall be acceptable according to the requirements of this part of the procedure. continue on to the trip-free test (Paragraph 10.4.7).

NOTE

If the circuit breaker trips at less than its rated current, it is not a failure for the purposes of compliance with §183.455.

10.4.6.2 Fuses

10.4.6.2.1 A calibration test shall be performed on all fuses by the application of 110%, 135% and 200% of the rated current (rms) of the device at 75±5°F (25±3°C). Determine 110%, 135% and 200% of the rated current of the fuse See Figure 5 for a typical time-current characteristic curve.

10.4.6.2.2 Verify the ambient temperature at the start of the test is 75±5°F (25±3°C). The temperature shall remain within this range throughout the entire test.

NOTE

All tests shall be conducted in open air (75±5°F) using proper wire and good test connections. The fuses shall be at the ambient temperature prior to starting each test.

10.4.6.2.3 Three fuses of the same type and rating shall be required to complete this test. Measure the resistance of one of these fuses and use this value in all three tests (110, 135 and 200 percent). Save the fuse on which the resistance measurement was taken and use it for the 200% test.

10.4.6.2.4 Insert an equivalent resistance into the circuit (Find No. 2) as determined in Paragraph .4.6.2.3. Adjust the current source to give 110% of the rated current of the fuse as measured at the ammeter (Find No. 4).

NOTE

An equivalent resistance is used to give a preliminary (but fairly accurate) current source setting for the start of the test without causing the fuse to heat up or blow during the calibration of the current source. Once the calibration of the current source is completed the actual test fuse can be installed in place of the calibration resistance and the test is ready to start.

10.4.6.2.5 Replace the calibration resistance with the test fuse.

10.4.6.2.6 Apply the 110% rated current as determined from the pre-test calibration to the fuse and start the electric timer (Find No. 8) at the same time. Immediately verify the current is 110% of rated current (±0.25 amps). Do not adjust the current source to maintain this current during the test.

NOTE

This is an initial reading at the start of the test only. As the test progresses the current flow will decrease. No attempt should be made to maintain the initial current. If the initial reading is out of tolerance, re-calibrate the circuit and repeat the test after allowing the fuse to return to ambient temperature.

10.4.6.2.7 Replace the fuse with the calibration resistance. Adjust the current source to give 135% of the rated current of the fuse. Replace the calibration resistance with the same fuse used in the 110% test. Allow the fuse to cool back to ambient temperature.

10.4.6.2.8 Apply the 135% rated current (as determined from the pre-test calibration) to the fuse and start the electric timer at the same time. Immediately verify the current is 110% of rated current (±0.25 amps). Do not adjust the current source to maintain this current during the test. See the Note in Paragraph .4.6.2.6 above.

10.4.6.2.9 Observe the ammeter (Find No. 4) and the fuse for point of circuit interruption. Immediately stop the timer when the fuse blows.

Verify that this blow time is no more than 60 minutes.

10.4.6.2.10 Repeat this test according to Paragraphs 10.4.6.2.7, 10.4.6.2.8 and 10.4.6.2.9 using a new fuse of the same type and rating.

Verify that this blow time is not more than 60 minutes.

10.4.6.2.11 Replace the fuse with the calibration resistance. Adjust the current source to give 200% of the rated current of the fuse. Replace the calibration resistance with the new fuse which was originally used to determine the calibration resistance.

10.4.6.2.12 Connect an oscilloscope across the fuse to record the clearing time required by the fuse.

10.4.6.2.13 Apply the 200% rated current (as determined by the pre-test calibration). Observe the clearing time as indicated by the oscilloscope. Verify that the applied current falls within ±10% of the corresponding current for that time as determined from the manufacturer's time-current characteristic curve for that particular fuse. See Figure 5 for an example of this determination.

10.4.6.2.14 If the fuse fails any of the above tests, it shall be rejected. If the fuse passes all of the above tests, it shall be deemed acceptable according to the requirements of this procedure.

10.4.6.2.15 Secure the test setup.

10.4.7 Trip-Free Calibration Test (Circuit Breakers Only)

10.4.7.1 A trip-free calibration test shall be performed on AC and DC circuit breakers by applying 200% of the rated current load using a standard current source and verifying the manual reset and trip-free capability of the circuit breaker.

10.4.7.2 The circuit breaker shall be subjected to one complete cycle of operation. A cycle shall be defined as the following:

1. Circuit verified at 100% rated current;
2. Application of 200% rated current;
3. Breaker opens (circuit interrupted);
4. Restraint removed;
5. Breaker manually reset; and
6. Circuit verified at 100% rated current.

NOTE

The same test setup as that used in calibration test may be used for this test except no timer is required.

10.4.7.3 Verify that the circuit breaker is in the "ON" position and that the circuit is not interrupted with the application of 100% of rated current or less.

10.4.7.4 Restrain the handle of the circuit breaker in the "ON" position and apply the 200% current load to the breaker.

10.4.7.5 Monitor the circuit and verify that the contacts open and the circuit is interrupted (time will depend on the particular circuit breaker under test). This is trip-free operation.

10.4.7.6 Remove the restraint from the circuit breaker handle. The handle should move to the tripped or "OFF" position and should not automatically return to the "ON" position.

NOTE

Some circuit breakers have an intermediate or "tripped" position between the "ON" and "OFF" positions, which the breaker takes upon automatic tripping.

10.4.7.7 Readjust the current load to 100% of rated current and then manually reset the circuit breaker to the "ON" position. Depending on the type of breaker being tested, this may require first cycling the breaker to the "OFF" position and then to the "ON" position. A cooling off period may be required in some cases before the circuit breaker can be reset to the "ON" position.

10.4.7.8 After the breaker has been reset to the "ON" position, verify the circuit continuity has been restored. If the circuit is not restored, the circuit breaker shall be rejected.

If the circuit is restored, the circuit breaker shall be deemed acceptable according to the requirements of this procedure.

NOTE

If a dual-circuit type breaker is used, this test shall be accomplished on each circuit as if it was a single circuit.

NOTE

If a multi-pole type breaker is used, this test shall be accomplished on each pole. When an overload is applied to one pole, all poles of the breaker shall open simultaneously and shall be trip-free.

10.4.7.9 Secure the test setup.

VISUAL EXAMINATIONS

11 FIELD/VISUAL EXAMINATION NO. 1

183.410 Isolation of fuel and fuel vapors from ignition sources

(b) An electrical component is isolated from a gasoline fuel source if—

(1) A bulkhead that meets the requirements of paragraph (c) of this section is between the electrical component and the gasoline fuel source;

(2) The electrical component is—

(i) Lower than the gasoline fuel source and a means is provided to prevent fuel and fuel vapors that may leak from the gasoline fuel source from becoming exposed to the electrical component; or

(ii) Higher than the gasoline fuel source and a deck or other enclosure is between it and the gasoline fuel source; or

(3) The space between the electrical component and the gasoline fuel source is at least two feet and the space is open to the atmosphere.

(c) Each bulkhead required by paragraph (b)(1) of this section must—

(1) Separate the electrical component from the gasoline fuel source and extend both vertically and horizontally the distance of the open space between the fuel source and the ignition source;

(2) Resist a water level that is 12 inches high or one-third of the maximum height of the bulkhead, whichever is less, without seepage of more than one-quarter fluid ounce of fresh water per hour; and

(3) Have no opening located higher than 12 inches or one-third the maximum height of the bulkhead, whichever is less, unless the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, and similar items, or doors, hatches, and access panels, and the maximum annular space around each item or door, hatch or access panel must not be more than one-quarter inch.

.1 SCOPE

.1.1 This examination will determine compliance with paragraphs §183.410(b) and 183.410(c). The individual test procedures contained in this examination are referenced in the following paragraphs.

.1.2 Contact the boat manufacturer to determine if he intended to comply with §183.410(b) and 183.410(c) by providing ignition protected electrical components in the boat.

11 .1.2.1 If the boat manufacturer intended to provide ignition protected electrical components throughout the boat, then go to Lab Examination No. 1.

.1.2.2 If the boat manufacturer intended to provide either some ignition protected electrical components and means of isolation, or provide only means of isolation, then continue with this examination.

.1.3 Identify all electrical components that are either labeled as ignition protected, or are certified by the boat manufacturer to be ignition protected.

.1.3.1 List all these ignition protected electrical components on Examination Sheet No. 1, and mark the electrical components for easy identification during the examination.

.1.3.2 A list is to be used to verify those electrical components which are ignition protected by comparing it with acceptable marine listings, Coast Guard listings or Lab Examination No. 1.

.2 APPARATUS

.2.1 Water, hose, pump (hand/mechanical), ruler (graduated in 16ths of an inch), sponge, measuring cup (graduated in ¼ oz.), eye dropper, level (bubble type), and explosimeter.

.3 EXAMINATION SPECIMEN

.3.1 This examination shall be conducted using the boat itself.

.4 EXAMINATION CONDITIONS

.4.1 This examination shall be conducted with the boat in its normal unloaded static floating condition (see Instruction A).

.5 EXAMINATION PROCEDURE

.5.1 Locate all gasoline fuel sources such as engines, valves, connectors, or other fittings in vent lines, fill lines, distribution lines, or on fuel tanks.

.5.2 Note the location of all electrical components with respect to gasoline fuel sources located in Paragraph .5.1, except for those listed.

11 .5.2.1 If a non-ignition protected electrical component is separated from a gasoline fuel source by a bulkhead, the bulkhead shall be tested for compliance with §183.410(c) in Paragraph .6, Test Procedure No. 1.

.5.2.2 If a non-ignition protected electrical component is not isolated from a gasoline fuel source by a bulkhead that complies with §183.410(c), and the electrical component is lower than the gasoline fuel source, then apply Paragraph .7, Test Procedure No. 2.

.5.2.3 If a non-ignition protected electrical component is not isolated from a gasoline fuel source by a bulkhead that complies with §183.410(c), and the electrical component is higher than the gasoline fuel source, then apply Paragraph .8, Test Procedure No. 3.

.5.2.4 If a non-ignition protected electrical component and a gasoline fuel source are separated by at least two feet and the space between the items is open to the atmosphere, then apply Paragraph .9, Test Procedure No.4.

.5.3 In general, these Test Procedures are not applicable when the electrical component is located within an engine or fuel tank compartment where the entire atmosphere could be saturated with gasoline vapors.

.5.4 At the conclusion of this examination, indicate those ignition protected electrical components that did not have to be ignition protected because proper isolation was provided.

.6 TEST PROCEDURE NO. 1

.6.1 Examine the bulkhead to make sure it extends to the fullest extremes possible, terminating at decks, overheads, other bulkheads, the hull of the boat and similar structures.

.6.1.1 Proper termination of the bulkhead extremes (perimeter) above the water resistance area (.6.2) is considered acceptable when the perimeter is fitted as closely as possible to other structure surfaces.

.6.1.2 There should be no vent holes, corners snipped off, limber holes or handholds.

.6.1.3 Proper joining of the bulkhead perimeter to other structures for maximum isolation integrity is obtained by coating the junction with epoxy

11 resin, a single layer of fiberglass, etc.

.6.2 Measure the maximum vertical height of the bulkhead from the lowest part of the bulkhead. The measurement is made on the same side as the gasoline source.

.6.2.1 If the measured height divided by three(3) is less than 12 inches, use that value as the required height of the bulkhead that must be water resistant.

.6.2.2 If the measured height divided by three (3) is equal to or greater than 12 inches, use 12 inches as the required height of the bulkhead that must be water resistant.

.6.3 Add a quantity of fresh water to the compartment on the side of the bulkhead being tested up to the level determined in Paragraph .6.2.1 or .6.2.2.

.6.3.1 Let the water stand for at least one hour.

.6.3.1.1 To minimize the quantity of water necessary for the test, it is permissible to provide water boundaries as close as one foot away from the bulkhead being tested.

.6.3.2 The water resistant area of the bulkhead shall not leak more than ¼ oz. of fresh water per hour.

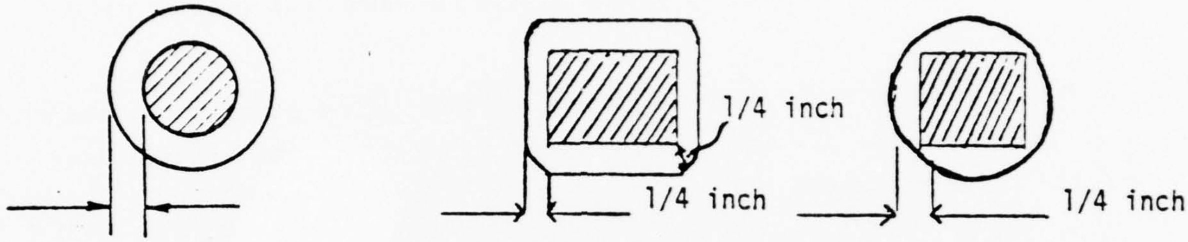
.6.3.2.1 Moisture condensation on the opposite side of the bulkhead under test is not considered leakage.

.6.3.3 Use the eye dropper and/or sponge to collect the leakage and place it in a measuring cup.

.6.4 Any isolation bulkhead that leaks more than the amount allowed in Paragraph .6.3.2, shall be noted in the examination report and any electrical components that are not isolated from a gasoline fuel source because of bulkhead failure shall be required to be ignition protected unless other means of isolation as provided in Test Procedures 2, 3 and 4 prevail and satisfy the isolation requirements.

.6.4.1 Inspect the bulkhead above the water resistant area. Determine that all openings are kept to a minimum size to allow for the passage of conductors, 11 mechanical equipment, ducting and similar items.

.6.4.2 To establish an acceptable opening dimension around piping, ducting, and wiring, etc., the symmetrical annular space around the item shall be no greater than ¼ inch.



.6.4.3 The installation of a permanent type fairlead, filler, bushing or grommet to fill the space or part of the space around the piping, ducting, wiring, etc., shall be acceptable if it will not damage the item passing through it.

.6.4.4 The item does not have to remain centered in the opening after measurements are taken.

.6.5 Any isolation bulkhead that contains excessive openings, i. e. openings having either greater than ¼ inch symmetrical spacing or nothing passing through them, shall be noted in the report and any potential sources of ignition installed in adjacent spaces shall be required to be ignition protected unless other means of isolation as provided in Test Procedures 2, 3 and 4 prevail and satisfy the isolation requirements.

.6.6 Any doors, hatches or access panels that are installed in the bulkhead have to meet the same requirements as the respective part of the bulkhead in which they are installed.

.6.6.1 For example, if a door extends into the water resistant area, the portion of the door in that water resistant area will have to pass the water resistance test in conjunction with the rest of the bulkhead. The portion of the door above the water resistant area will have to meet the ¼ inch symmetrical annular space requirement.

INSTRUCTION "A"

METHOD OF DETERMINING:

"NORMAL UNLOADED STATIC FLOATING CONDITION (POSITION)"

To determine the "normal unloaded static floating condition (position)" of a boat:

1. Place the unloaded boat in the water.

NOTE

The "unloaded boat" shall contain all permanently installed items such as, but not limited to, batteries and seats and shall include engine oil and fuel in the fuel system filled to the designed capacity.

The unloaded boat shall not contain items such as live loads, portable fuel tanks, paddles, PFDs, tool kits, lines, flags, portable lights or other loose gear.

2. With the boat in calm water, mark Point A at the intersection of the stem and the waterline, Point B_p at the intersection of the transom, the port hull side or port hull bottom, and the water line, and Point B_s at the intersection of the transom, the starboard hull side or starboard hull bottom, and the waterline.

3. In the absence of a clearly defined transom, instead of marking Points B_p and B_s, mark a Point C at which the waterline and the aftermost part of the boat in the water intersect.

4. Remove the boat from the water.

5. Place the boat on chocks, a dolly or a trailer.

6. Adjust the chocks, dolly or trailer to level the marked points.

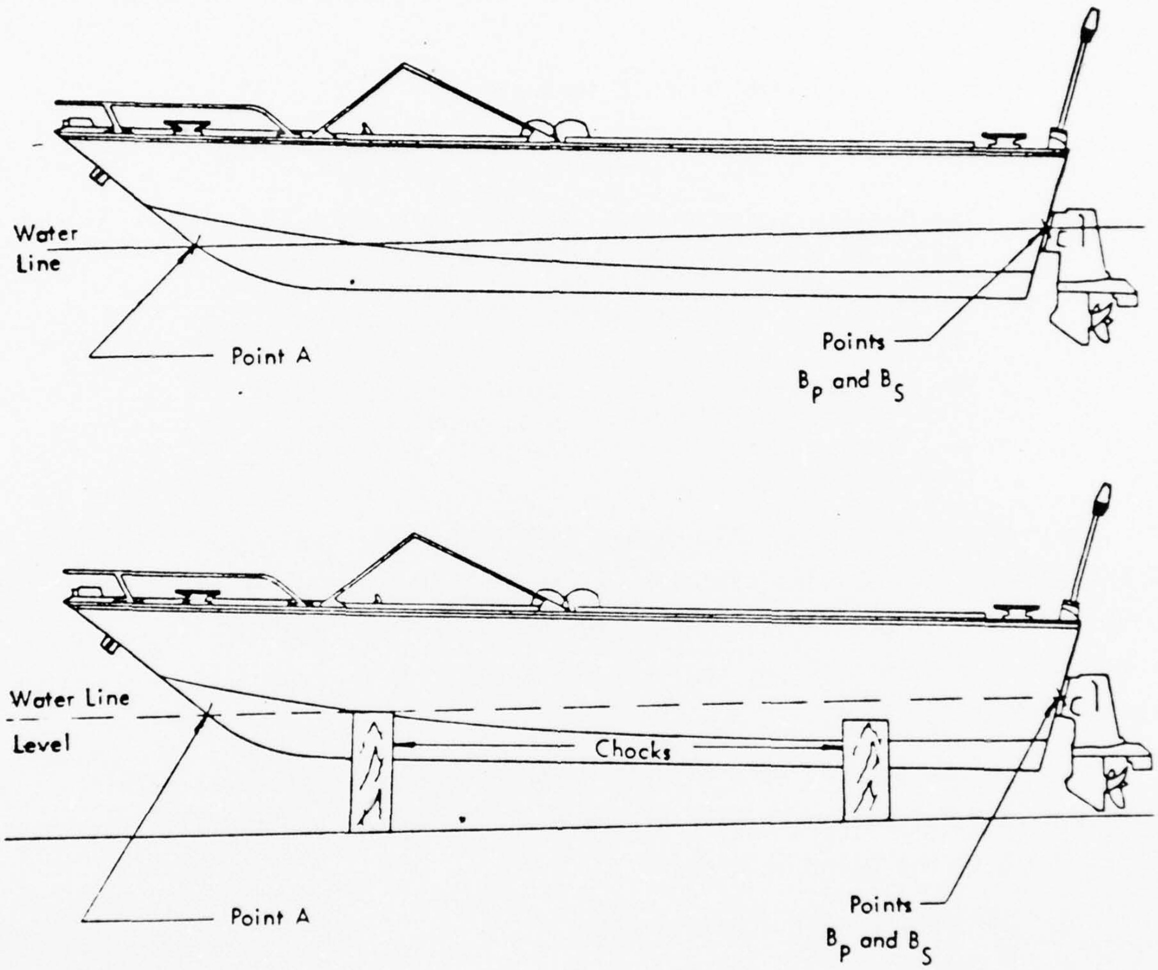


Figure A. Normal Unloaded Static Floating Condition

11 .7. TEST PROCEDURE NO. 2

.7.1 Using a bubble-type level, determine that the electrical component is lower than the gasoline fuel source.

.7.1.1 If the topmost opening or point of possible leakage on the gasoline fuel source is above any part of the electrical component, then this test procedure applies.

.7.2 Determine if a means is provided that will prevent gasoline fuel and fuel vapors from becoming exposed to the electrical component.

.7.2.1 Consider the heavy nature of gasoline vapors when evaluating the means of prevention.

.7.2.2 A partial bulkhead, rigid shield, high coaming, etc., are examples of possible means of prevention.

.7.2.3 Generally, this approach will not be acceptable if the gasoline or vapor cannot be channeled away from the immediate area of the electrical component, such as overboard, into an open cockpit area, or into another compartment or space. If the electrical component and gasoline fuel source are installed within the same closed compartment or space, this means of isolation will not be acceptable.

.8 TEST PROCEDURE NO. 3

.8.1 Using a bubble-type level, determine that the electrical component is higher than the gasoline fuel source.

.8.1.1 If the topmost opening or point of possible leakage on the gasoline fuel source is below the entire electrical component, then this procedure applies.

.8.2 Generally, this test does not apply to electrical components installed in engine rooms or engine compartments with gasoline fuel sources, because the enclosed engine space could become saturated with gasoline vapor. Use the same test as in Paragraph .7.2.3 to confirm nonapplication.

.8.2.1 The intent is to apply this test procedure to electrical components that are in a space or compartment that is above the gasoline fuel source compartment, such as an engine room. Also, installations that enclose the

11 engine and gasoline fuel sources with an engine box or similar structure are considered suitable isolation.

.8.3 Determine if a deck, engine box, or other similar solid enclosure is between the electrical component and the gasoline fuel source.

.8.3.1 Note any specific design considerations that should be made or matters of noncompliance in the report.

.9.0 TEST PROCEDURE NO. 4

.9.1 Measure the distance between the electrical component and the gasoline fuel source.

.9.1.1 This distance can be in any orientation, i. e. it does not have to be horizontal, but can be vertical or on a diagonal.

.9.2 If the distance measured in Paragraph .9.1 is at least two (2) feet determine whether that distance is open to the atmosphere.

.9.2.1 Open to the atmosphere means that for every cubic foot of net compartment volume, there is at least 15 square inches of unobstructed access to the atmosphere.

.9.3 If there is at least two (2) feet of space directly between the electrical component and the gasoline fuel source and the space is open to the atmosphere, then acceptable isolation is provided.

.9.3.1 Note in the report any matters of noncompliance or any specific design considerations that should be made.

12 FIELD/ VISUAL EXAMINATION NO. 2

183.415 Grounding of cranking motor circuits

If a boat has more than one gasoline engine, grounded cranking motor circuits must be connected to each other by a common conductor circuit that can carry the starting current of each of the grounded cranking motor circuits.

.1 SCOPE

.1.1 This examination will determine compliance with section 183.415.

.2 APPARATUS

.2.1 Wire gauge, outside vernier calipers.

.3 EXAMINATION SPECIMEN

.3.1 This examination shall be conducted on boats that have more than one (1) gasoline engine with a grounded cranking motor circuit.

.4 EXAMINATION PROCEDURE

.4.1 Identify the cranking motor circuits that are grounded.

.4.1.1 Note and include in the report, the starting current of each cranking motor identified in Paragraph .4.1.

.4.2 Identify and label the common conductor circuit connecting the grounded cranking motor circuits.

.4.2.1 Contact the boat manufacturer if necessary to properly identify the common conductor circuit.

.4.3 For a two (2) engine system, only one (1) common conductor is needed.

.4.3.1 The common conductor must be large enough to carry the largest cranking motor starting current as identified in Paragraph .4.1.1. If the common conductor is as large as the largest cranking motor conductor, then it complies.

.4.4 For a three (3) or more engine system, the common conductor circuit may consist of various size conducotrs, but each conductor that connects directly to an engine must be large enough to carry the starting current of that engine. If the common conductor is as large as the largest cranking

12 motor conductor, then it complies.

.4.4.1 Use an outside vernier caliper or wire gauge to measure the conductor size to compare with the battery power supply conductor.

.4.5 The common conductor circuit does not have to meet the requirements of Section 183.425 for being stranded or insulated.

.4.5.1 The common conductor circuit can be made up of solid conductors, braided conductors, solid bus bars, or the boat's hull if it is metallic.

.4.5.2 If the common conductor circuit is composed of conductors listed in Paragraph 3.4.5.1 above, contact the manufacturer to determine whether he has test data or calculations that indicate proper sizing of these conductors for carrying the currents of any of the cranking motor circuits.

.4.5.3 If in doubt about the proper sizing of the conducotrs, report this information for further testing.

.4.6 Actual testing of the common conductor circuit will be performed at a testing facility or at the boat manufacturer's site if it is convenient.

183.420 Tests for battery movement

(a) Each installed battery must not move more than one inch in any direction when a pulling force of 90 pounds or twice the battery weight, whichever is less, is applied through the center of gravity of the battery as follows:

(1) Vertically for a duration of one minute.

(2) Horizontally and parallel to the boat's center line for a duration of one minute fore and one minute aft.

(3) Horizontally and perpendicular to the boat's center line for a duration of one minute to starboard and one minute to port.

.5 SCOPE

.5.1 This test will determine compliance with Paragraph 183.420(a), Subpart I, of the Electrical Systems Standard, which covers battery installations.

12 .5.1.1 Each battery installed with its own individual mounting will be tested by the test procedures in Section .9 -- Procedure for Single Battery Installations.

.5.1.2 Each group of batteries installed within a battery mounting where individual batteries depend on adjacent batteries for support will be tested by the test procedures in Section .10 -- Procedure for Multiple Battery Installations.

.6 APPARATUS

.6.1 Spring scale (minimum 100 lb. scale), rule (graduated in inches), plastic coated steel cable with grasping eyes at ends (1/8 inches diameter by 6 feet or more in length), ratchet come-a-long, sharp cutting tool and white chalk.

.7 TEST SPECIMEN

.7.1 Battery(ies) as installed.

.8 TEST CONDITIONS

.8.1 Perform the test using all necessary safety precautions, particularly relative to preventing battery electrolyte spillage and accidental short circuiting with battery terminals if the battery breaks loose during testing.

.9 PROCEDURE FOR SINGLE BATTERY INSTALLATION

.9.1 Locate the battery geometric center of gravity. The horizontal pulling forces will be through the mid-height of the battery and the vertical pulling force will be through the mid-length or mid-width of the battery (See Figure 1).

.9.1.1 Remove the battery and weigh it. If the weight is 45 pounds or greater the test force will be 90 pounds. If the battery weighs less than 45 pounds, the test force will be twice the battery weight.

.9.2 If the battery is in a battery box or similar enclosure, drill holes in the enclosure to accomodate the steel cable in all modes of the pulling tests so that the pulling force will not act directly upon the enclosure.

.9.2.1 Mark reference points on the battery and supporting surfaces to use as a means to measure battery movement.

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ELECTRICAL SYSTEM STANDARD TEST PROCEDURE. (U)

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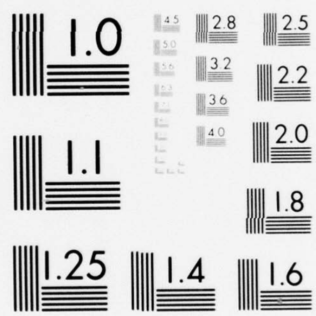

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NOTE

Preparations for the test that require loosening or removal of battery mounting should be performed with care to avoid jeopardizing the original battery restraint integrity.

.9.3 Place the cable around the battery at the mid-height point with the cable ends leading forward.

.9.3.1 Hook up the scale to the ends of the cable and connect the scale to the come-a-long. Hook the come-a-long to a rigid structure capable of withstanding at least 90 lbs. of force at a point in the horizontal plane of the mid-height of the battery.(See Figures 2 and 3).

.9.3.2 Remove the slack from the cable and then adjust the come-a-long to exert the applicable test force determined in Paragraph .9.1.1 on the scale and cable combination.

.9.4 Exert the test force for one minute and then release the force.

.9.5 Measure the distance the battery (reference point) moved.

.9.6 Reposition the battery in accordance with its designed installation for the next test.

.9.7 Repeat Paragraphs .9.3 to .9.6 for testing in the other horizontal directions.

.9.8 Repeat Paragraphs .9.3 to .9.6 for testing in the vertical direction but place the cable around the mid-length or mid-width of the battery, and suspend the scale and come-a-long above the center of the battery.

.9.9 The battery reference points shall not move more than one inch in any test direction.

.10 PROCEDURE FOR MULTIPLE BATTERY INSTALLATIONS

.10.1 Locate the geometric center of gravity of the multiple battery installation by physically measuring the dimensions of the batteries involved and averaging the heighth, width and length measurements (See Figure 4).

.10.1.1 Weigh the batteries individually.

.10.1.1.1 Apply the test force criteria to each battery weight, i. e. if the battery weighs less than 45 pounds, the test force for that battery will

12 be twice the battery weight; if the battery weighs 45 pounds or greater the test force will be 90 pounds.

.10.1.1.2 Find the sum of the battery test forces determined in Paragraph .10.1.1.1 for all batteries concerned.

.10.2 If the batteries are enclosed drill holes in the enclosure to accomodate the steel cable in all modes of the pulling test so the pulling force will not act directly on the enclosure.

.10.2.1 Mark reference points on the batteries and supporting structures to provide a means to measure battery movement.

NOTE

> Preparations for the test that require loosening or removal of battery mounting should be performed with care to avoid jeopardizing the original battery restraint integrity.

.10.3 Place the cable around the group of batteries with the cable ends leading forward and the cable at the height of the geometric center of gravity determined in Paragraph .10.1 (See Figure 5).

.10.3.1 Hook up the scale to the ends of the cable and connect the scale to the come-a-long. Hook the come-a-long to a rigid structure that is capable of withstanding the test force determined in Paragraph .10.1.1.2. The connection must be in the horizontal plane of the geometric center of gravity of the batteries.

.10.3.2 Remove the slack from the cable and then adjust the come-a-long to exert the test force determined in Paragraph .10.1.1.2 on the scale and cable combination.

.10.3.3 Exert the test force for one minute and then release the force.

.10.3.4 Measure the distance the battery reference marks moved.

.10.3.5 Repeat Paragraphs .10.3 to .10.3.4 for testing in the other horizontal directions.

.10.4 Repeat Paragraphs .10.3 to .10.3.4 for testing in the vertical direction placing the cable around the geometric center of gravity of the batteries and suspend the scale and come-a-long above the center of gravity.

12 .10.5 The battery reference marks shall not move more than one inch in any test direction.

183.420

(b) Each battery must be installed so that metallic objects cannot come in contact with the ungrounded battery terminals.

(c) Each metallic fuel line and fuel system component within 12 inches and above the horizontal plane of the battery top surface as installed must be shielded with dielectric material.

(d) Each battery must not be directly above or below a fuel tank, fuel filter, or fitting in a fuel line.

(e) Hydrogen gas discharged by a battery must not accumulate in the boat.

(f) The positive terminal of each battery must be identified by the letters "POS", or "P", or the symbol "+" marked on the terminal or on the battery case near the terminal.

(g) Each battery terminal connector must not depend on spring tension for its mechanical connection to the terminal.

.11 PROPER BATTERY INSTALLATION

.11.1 SCOPE

.11.1.1 These observations and measurements will determine if the battery installation complies with Sections 183.420(b), (c), (d), (e), (f) and (g) of Subpart I of the Electrical Systems Standard, which cover battery installations.

.11.2 The observations and measurements will be made with the battery as installed.

.11.3 APPARATUS

.11.3.1 Rule (graduated in inches), plumb bob, 3/4 inch diameter ball gauge with handle and explosimeter.

.11.4 TEST SPECIMEN

.11.4.1 Battery(ies) as installed.

.11.5 TEST CONDITIONS

.11.5.1 Perform the test using all necessary safety precautions, particularly

12 relative to preventing accidental short-circuiting with the battery terminals.

.11.6 TEST PROCEDURE

.11.6.1 To determine that metallic objects cannot come in contact with ungrounded battery terminals use the 3/4 inch ball gauge. Place the ball on or against each ungrounded battery terminal or terminals to determine if it will touch the surface of the terminal(s).

.11.6.1.1 A battery in a battery box or similar enclosure as installed where the battery top is completely covered, automatically passes the test.

.11.6.2 Measure the distance from all metallic fuel lines and fuel system components to battery top surfaces if the metallic fuel lines and fuel system components are above the horizontal plane of the battery top surfaces (See Figure 6).

.11.6.2.1 Any metallic fuel line and fuel system component within 12 inches must be shielded with dielectric material.

.11.6.2.2 The dielectric material does not have to be attached to the metallic fuel component, but can be a permanent shield installed between the battery and the metallic fuel component.

.11.6.2.3 Examples of dielectric materials that can act as shielding are plastic, wood, rubber, PVC, electricians tape, glass and fiberglass.

.11.6.2.4 Battery box covers or other protective coverings on batteries that are removed when installing or removing a battery are not acceptable as permanent dielectric shielding.

.11.6.3 Suspend a plumb-bob from all exterior surfaces (including the bottom) of any fuel tank, fuel filter, or fitting in a fuel line that appears to be above a battery to determine if the item is directly above the battery.

.11.6.3.1 The point of the suspended plumb-bob must not touch any part of the battery.

.11.6.4 Suspend a plumb-bob from all exterior surfaces (including the bottom) of a battery to determine if the battery is directly above a fuel tank, fuel filter or fitting in a fuel line (See Figure 7).

.11.6.4.1 The point of the suspended plumb-bob must not touch any part of

12 a fuel tank, fuel filter or fitting in a fuel line.

.11.6.5 To determine that hydrogen gas discharged by a battery does not accumulate within the boat, inspect the battery installation and the boat structure above the battery.

.11.6.5.1 A battery box cover or similar enclosure must have some means of venting the enclosure.

.11.6.5.2 Any part of the boat structure above the battery where hydrogen gas can accumulate such as underneath a gunwale or similar pocket must not accumulate hydrogen to the extent that an explosive mixture exists.

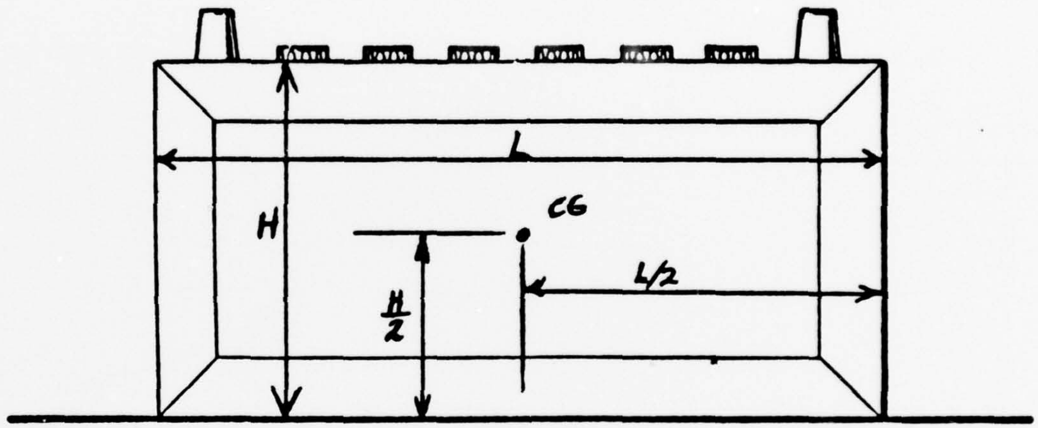
.11.6.5.3 If in doubt about hydrogen gas accumulation, charge the battery for one hour and use an explosimeter to test the quality of the air in the area in question.

.11.6.6 Determine if the positive terminal of the battery is identified by "POS", "P" or "+" marked on the terminal or on the battery case near the terminal.

NOTE

For ease of identification, the positive terminal is larger in diameter than the negative terminal.

.11.7 Determine that the battery terminal connectors are secured to the battery and that the connectors do not depend on spring tension for their mechanical connection to the terminal.



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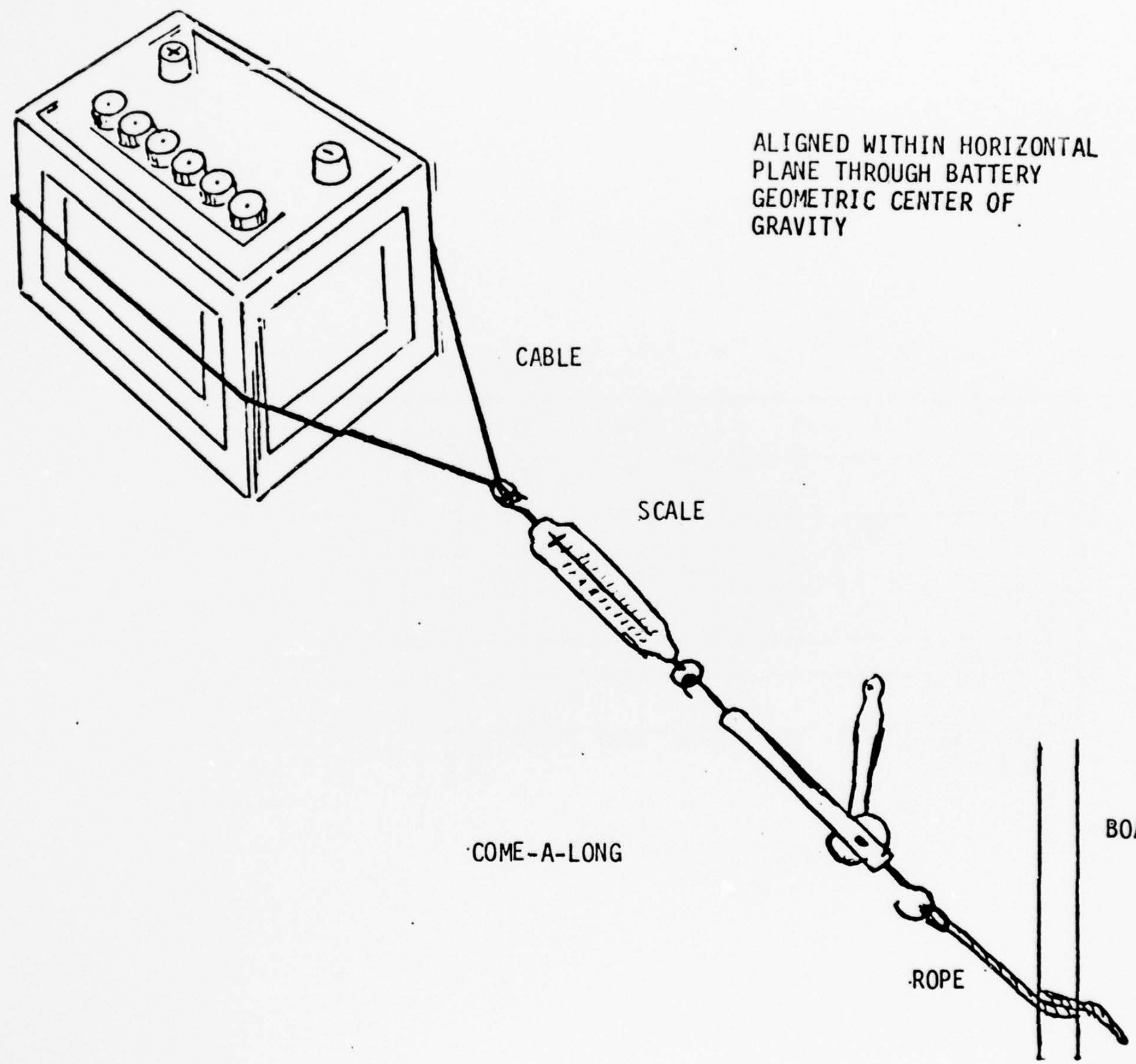
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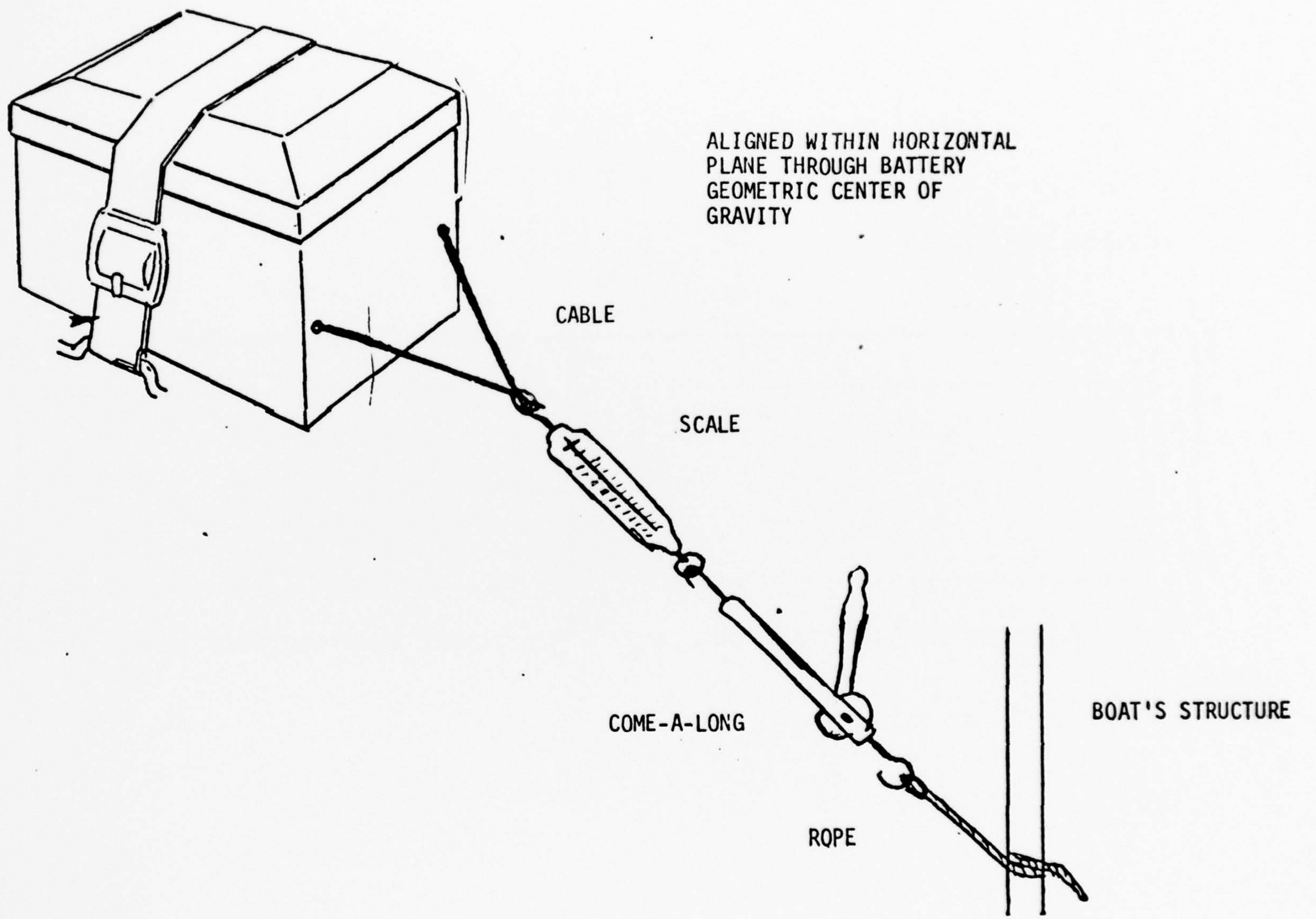
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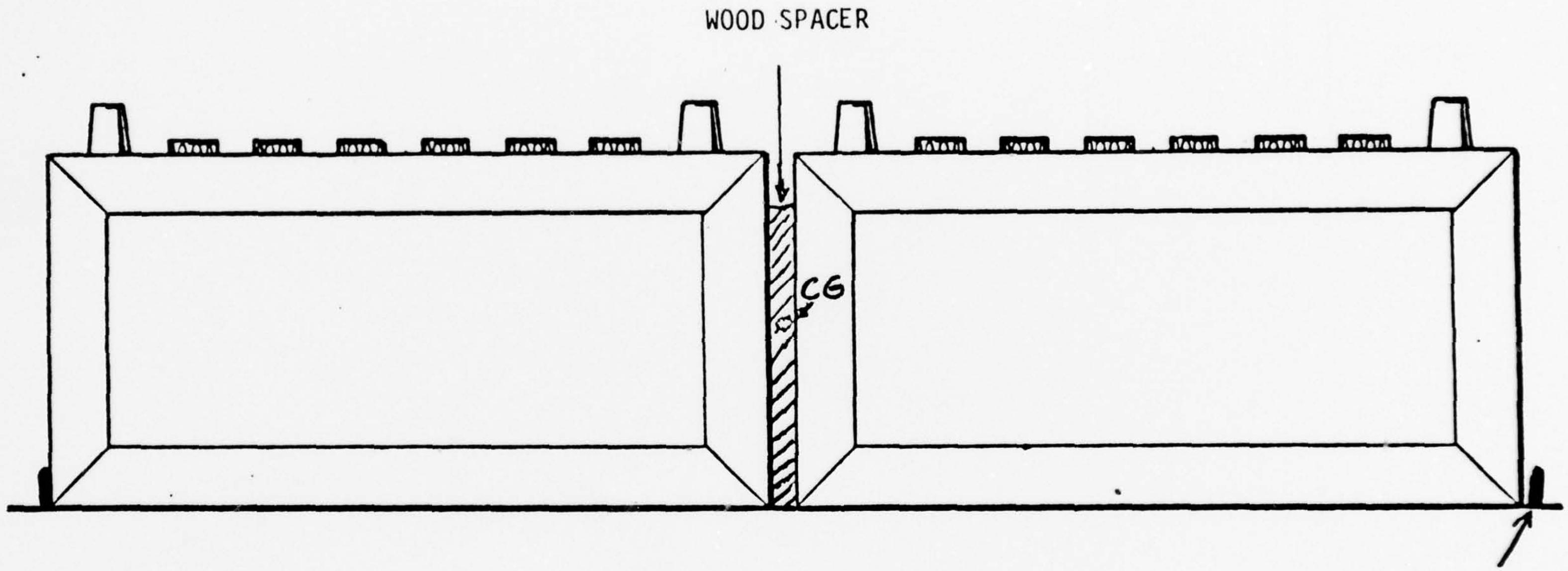

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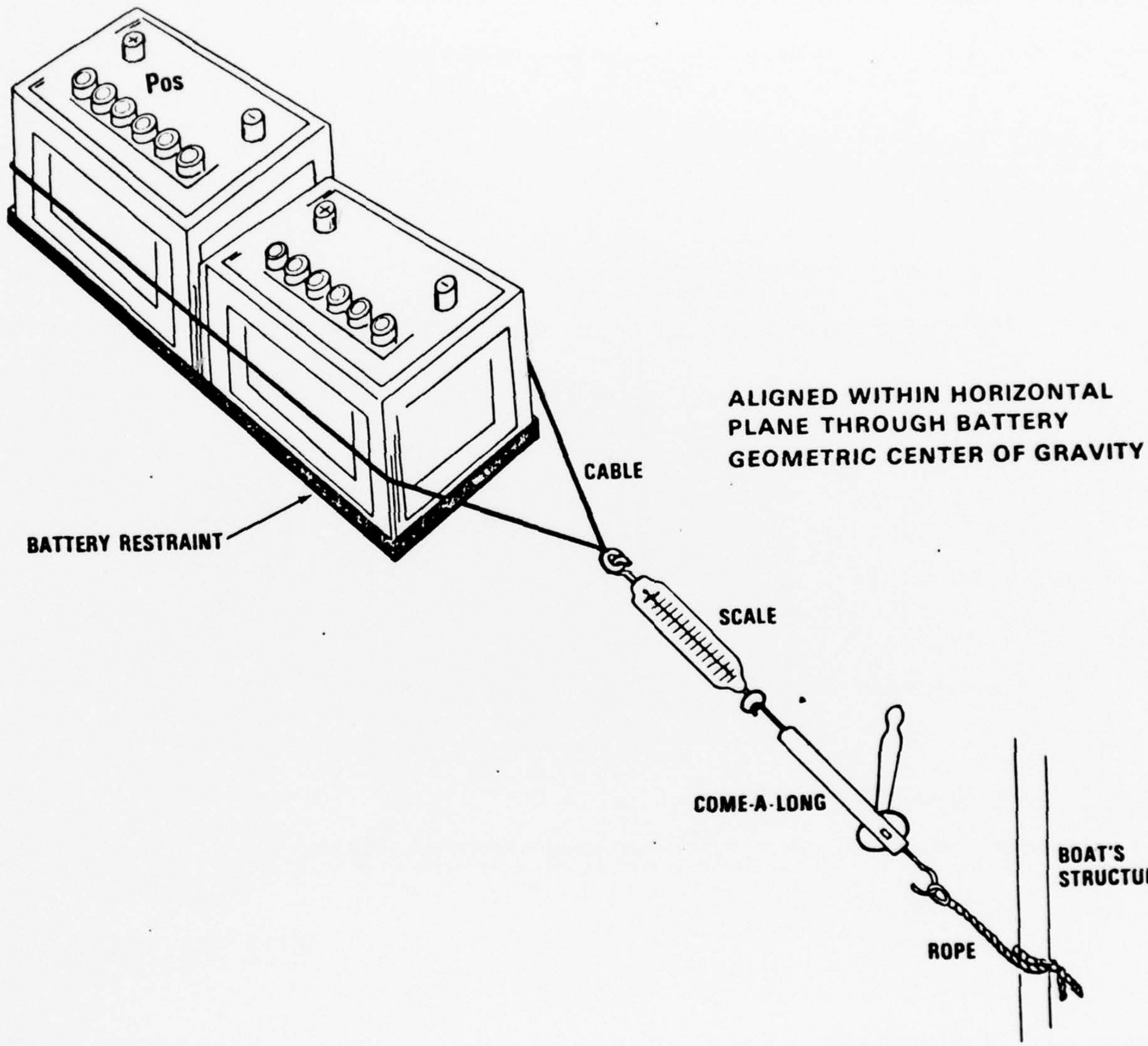
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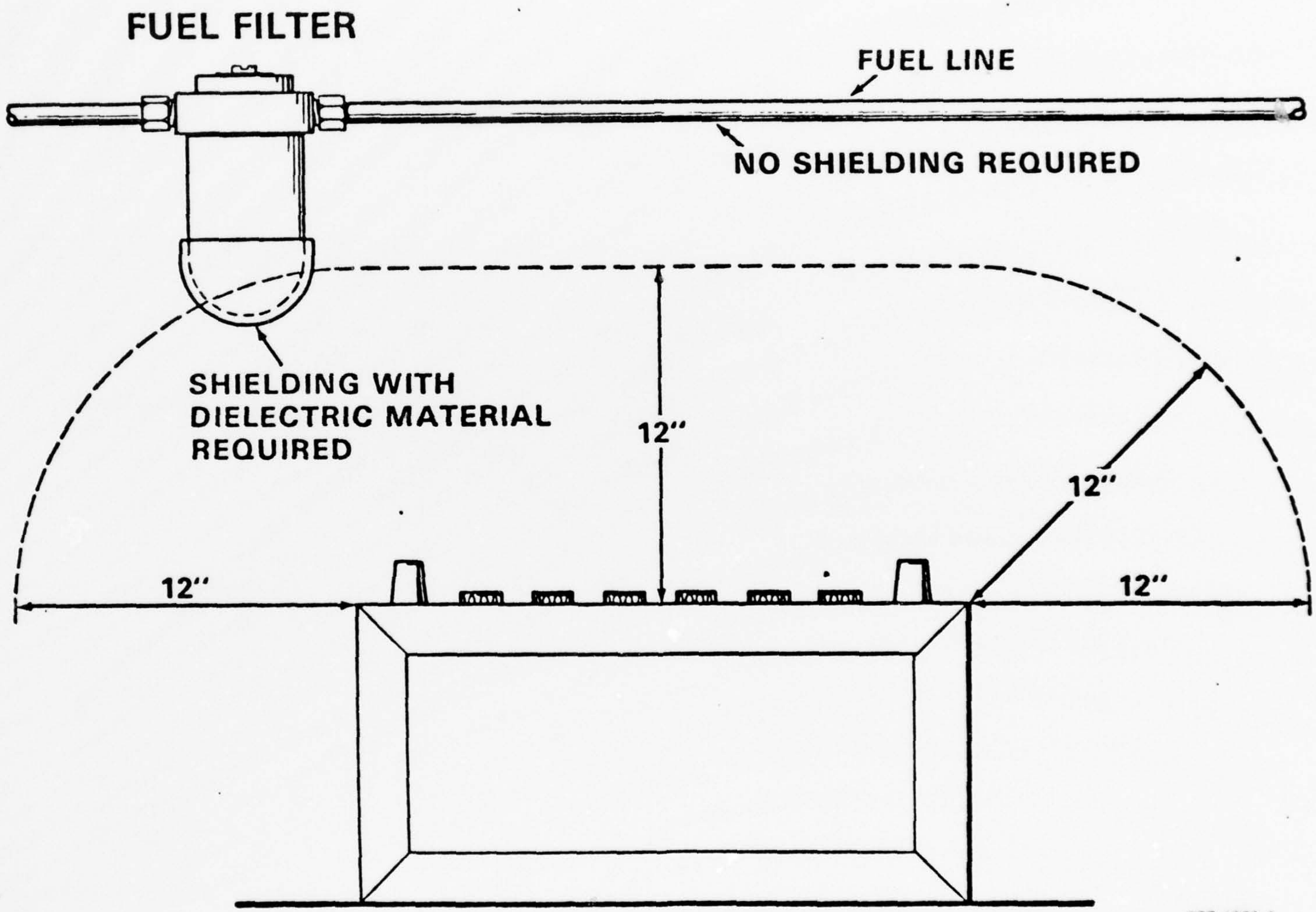
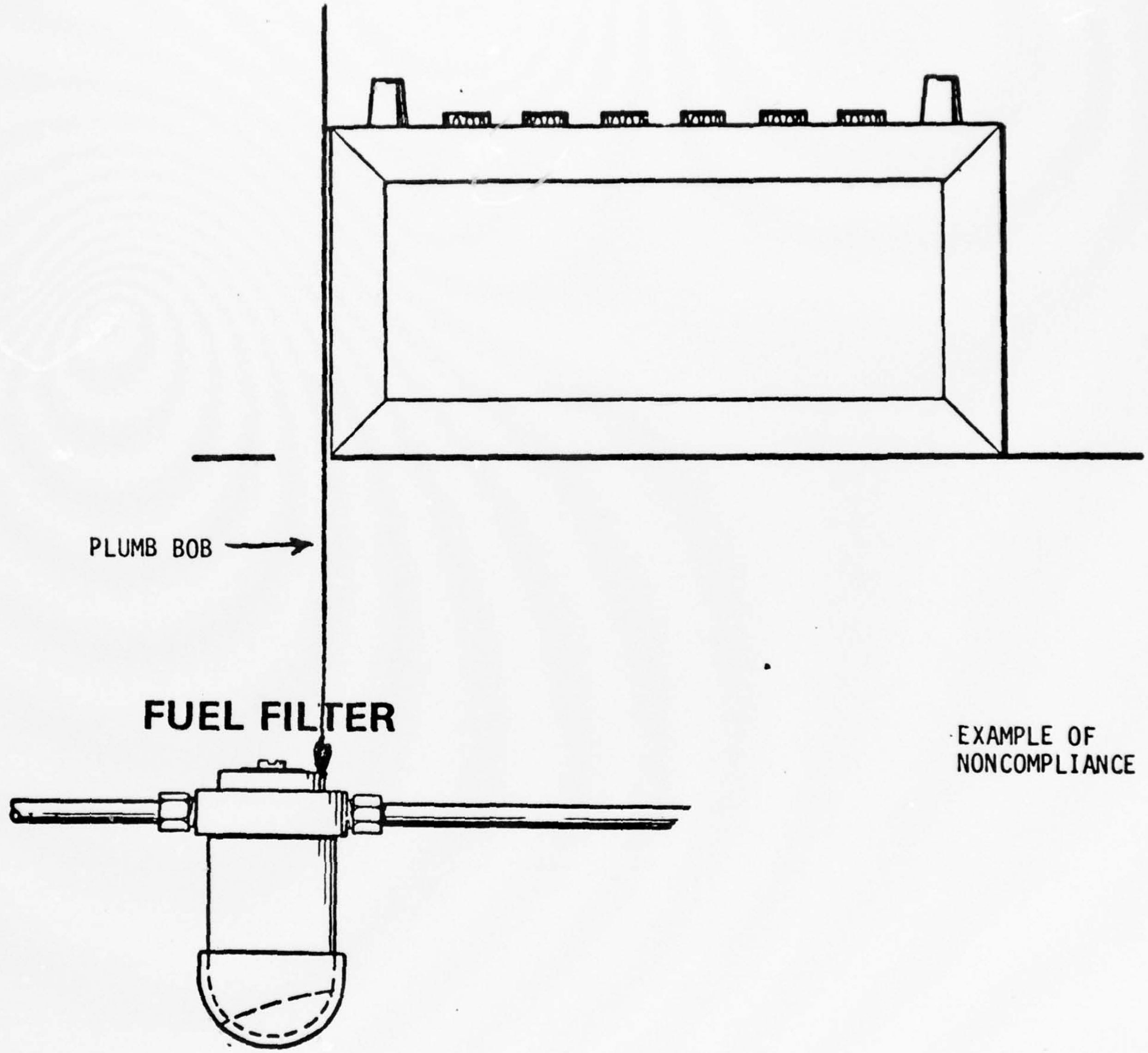
BOAT'S
STRUCTURE
ROPE

METALLIC FUEL SYSTEM COMPONENT SHIELDING



183.420(c)



EXAMPLE OF
NONCOMPLIANCE

13 .0 VISUAL EXAMINATION NO. 3

183.425 General requirements for all conductors

(a) Each conductor must be insulated, stranded copper.

(b) Except for intermittent surges each conductor must not carry a current greater than that specified in Table 5 for the conductor's gauge and temperature rating.

(c) For conductors in engine spaces, amperages must be corrected by the appropriate correction factor in note 1 of Table 5.

(d) Each conductor in a multiconductor sheath must be at least a No. 18 AWG conductor.

(e) Each conductor installed separately must be at least a No. 16 AWG conductor.

(f) Each No. 18 AWG conductor in a multiconductor sheath may not extend out of the sheath more than 30 inches.

(g) This section does not apply to communication systems; electronic navigation equipment; resistance conductors that control circuit amperage; high voltage secondary conductors and terminations that are in ignition systems; pigtails of less than seven inches of exposed length; and cranking motor conductors.

.1 SCOPE

.1.1 This examination will determine compliance with Section 183.425, Subpart I, Electrical Systems Standard, covering general requirements for all conductors.

.2 APPARATUS

.2.1 Outside vernier caliper or micrometer, ruler (graduated in 16ths of an inch), wire gauge, knife, verious samples of wire sizes (#18 through #4), various screwdrivers, wire stripper, pliers, ammeter and voltmeter.

.3 EXAMINATION SPECIMEN

.3.1 All conductors as installed on the boat.

.3.2 Disregard conductors used with communications systems (telephones, radios, stereo equipment, etc.), electronic navigation equipment (sonar, radar, fathometer, loran, etc.) and conductors used as resistance conductors, high voltage secondary conductors in ignition systems, pigtails with less than seven (7) inches of exposed length and cranking motor conductors.

.4 EXAMINATION CONDITION

13 .4.1 Ensure that the electrical systems are not energized and batteries are disconnected to avoid accidental shock hazard.

.5 EXAMINATION PROCEDURE

.5.1 Determine whether all current carrying conductors are copper stranded conductors, except for those conductors noted in Paragraph .3.2.

.5.1.1 It may be necessary to disconnect and strip some conductors to perform this examination.

.5.1.2 Note discrepancies.

.5.2 Determine that the smallest conductor size installed in a multiconductor sheath is no smaller than No. 18 AWG.

.5.2.1 Contact the boat manufacturer to obtain this information from his inventory or whatever other records he maintains.

.5.2.1.1 The conductors may be labeled with their sizes.

.5.2.2 If no information is available, then measure the diameter of an individual strand using a micrometer. Square the diameter of the strand (in mils) and multiply times the number of strands in the conductor. This will give the total circular MIL area of the conductor.

.5.2.2.1 Compare the result with Table 1 to verify the conductor size.

NOTE

If a conductor contains strands of various sizes, measure the diameter of each strand, square the diameter, and add the individual circular MIL areas to obtain the circular MIL area of the conductor.

13

TABLE 1

CONDUCTOR SIZES

AWG SIZE	Minimum Acceptable CM Area
18	1537
16	2336
14	3702
12	5833
10	9343
8	14810
6	25910
4	37360
2	62450
1	77790
0	98980
00	125100
000	158600
0000	205500

To calculate the circular mil area of a stranded conductor, use the formula:

$$CM = d^2 \times N$$

Where d is the diameter of one strand in mils (.001 inch) and N is the number of strands in the conductor.

.5.3 Determine that the smallest size installed separately or in groups outside of a sheath is no smaller than No. 16 AWG.

.5.3.1 Repeat Paragraphs .5.2.1 through .5.2.2.1 to verify the conductor size.

.5.4 Short leads or pigtails less than seven (7) inches of exposed length may be smaller than No. 18 AWG.

.5.5 Determine that any No. 18 AWG conductor does not extend out of its multiconductor sheath more than thirty (30) inches, measured along its exposed length.

13 .5.6 Determine whether conductors are properly sized so as not to carry currents greater than the allowable currents noted in Table 5 of the regulations (See Table 2).

.5.6.1 Obtain a wiring diagram or schematic of the boat's electrical system from the boat manufacturer.

.5.6.2 If a diagram is not available, visually examine and analyze the boat's conductor installation and draw a schematic. Write the wire sizes on the schematic for all circuits, the item or equipment with which they connect, and the current load (amperes) of the equipment.

.5.6.3 If the current load is not marked on the equipment nameplate, obtain this information from the equipment manufacturer. If this information cannot be found, energize the equipment and use an ammeter to determine its current loading.

.5.6.4 Obtain the insulation temperature rating information from the manufacturer (See Examination Procedures for Sections 183.430 and 183.435).

.5.6.5 Determine the voltage of each circuit on the schemtaic to help differentiate between low and high voltage conductors (less than 50 volts or greater than or equal to 50 volts). If this information cannot be obtained, use a voltmeter to determine the circuit voltage.

.5.6.6 Obtain the allowable amperages the conductors may carry from Table 2. Apply the appropriate correction factors from Notes 1 and 2 of Table 2. (See Section 183.435(b) of the regulations for high voltage conductors).

.5.6.7 Compare the allowable amperages determined in Paragraph .5.6.1 through .5.6.5 and note discrepancies.

ALLOWABLE AMPERAGE OF CONDUCTORS - TABLE 2

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)
18	10	10	15	20	20	25	25
16	15	15	20	25	25	30	35
14	20	20	25	30	35	40	45
12	25	25	35	40	45	50	55
10	40	40	50	55	60	70	70
8	55	65	70	70	80	90	100
6	80	95	100	100	120	125	135
4	105	125	130	135	160	170	180
3	120	145	150	155	180	195	210
2	140	170	175	180	210	225	240
1	165	195	210	210	245	265	280
0	195	230	245	245	285	305	325
00	225	265	285	285	330	355	370
000	260	310	330	330	385	410	430
0000	300	360	385	385	445	475	510

NOTES

1. See the following table:

	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)
Temperature rating of conductor	0.58	0.75	0.78	0.82	0.85	0.89	1.00

2. See the following table:

Number of current carrying conductors:	Correction factor:
3	0.70
4 to 6	.60
7 to 24	.50
25 and above	.40

14 VISUAL EXAMINATION NO. 4

183.430 Conductor types in circuits of less than 50 volts

(a) Each conductor in a circuit that has a nominal voltage of less than 50 volts must—

(1) Meet the requirements of § 183.-435; or

(2) Meet—

(i) The insulating material temperature rating requirements of SAE Standard J378b dated November 1976; and

(ii) SAE Standard J1127 dated November 1975, or SAE Standard 1128 dated November 1975.

(b) This section does not apply to communication systems; electronic navigation equipment; resistance conductors that control circuit amperage; and pigtails of less than seven inches of exposed length.

.1 SCOPE

.1.1 This examination will determine compliance with Section 183.430 of Subpart I of the Electrical Systems Standard in conjunction with Laboratory Examination No. 2.

.2 APPARATUS

.2.1 Voltmeter

.3 EXAMINATION SPECIMEN

.3.1 All conductors installed on the boat used in circuits of less than 50 volts.

.3.2 Disregard conductors used with communication systems (telephones, radios, stereo equipment, etc.), electronic navigation equipment (sonar, radar, fathometer, loran, etc.), and conductors used as resistance conductors and pigtails of less than seven (7) inches of exposed length.

.4 EXAMINATION PROCEDURE

.4.1 Identify all conductors that are in circuits of less than 50 volts, using the voltmeter if necessary.

.4.2 Examine the conductors for labels regarding conductor type.

.4.2.1 If a conductor is not labeled, obtain the conductor-type information from the boat manufacturer.

.4.2.2 If the boat manufacturer cannot provide this information, contact

14 the conductor vendor.

.4.3 If the information is still not available, contact USCG Headquarters (G-BBT).

.4.4 Headquarters will initiate action to find out whether a conductor complies with Section 183.430.

.4.5 If the conductor is labeled or identified as complying with Section 183.435, then it complies with Section 183.430.

15 VISUAL EXAMINATION NO. 5

183.435 Conductor types in circuits of 50 volts or more

(a) Each conductor in a circuit that has a nominal voltage of 50 volts or more must be—

(1) A conductor that has insulation listed and classified moisture resistant and flame retardant in Article 310, NFPA No. 70-1975, National Electric Code 1975;

(2) A flexible cord type SO, STO, ST, SJO, SJT, or SJTO listed in Article 400, NFPA No. 70-1975, National Electric Code 1975;

(3) A conductor that meets IEEE Std. 45-1971, dated December 3, 1970;

(4) A conductor listed for marine use by an independent testing laboratory which provides listing, labeling, and follow-up service; or

(5) A conductor that meets the mechanical water absorption and flame retardant standards of UL Standard 83, dated July 8, 1976.

(b) Where the nominal circuit voltage of each of three or more current carrying conductors in a duct, bundle, or cable is 50 volts or more, the amperages of each of those conductors must not exceed the value in Table 5 multiplied by the correction factor in note 2 to Table 5 for the number of conductors that carry 50 volts or more.

(c) This section does not apply to communication systems; electronic navigation equipment; resistance conductors that control circuit amperage conductors in secondary circuits of ignition systems; and pigtails of less than seven inches of exposed length.

.1 SCOPE

.1.1 This examination will determine compliance with §183.435 in conjunction

15 with Laboratory Examination No. 3.

.2 APPARATUS

.2.1 Voltmeter

.3 EXAMINATION SPECIMEN

.3.1 All conductors installed on the boat used in circuits of 50 volts or more.

.3.2 Disregard conductors used with communications equipment (telephones, radios, stereo equipment, etc.), electronic navigation equipment (sonar, radar, fathometer, loran, etc.), and conductors used as resistance conductors, high voltage secondary conductors in ignition systems, and pigtails with less than seven (7) inches of exposed length.

.4 EXAMINATION PROCEDURE

.4.1 Identify all conductors that are in circuits of 50 volts or more, using the voltmeter if necessary.

.4.2 Examine the conductors for any labels identifying their type.

.4.2.1 If a conductor is not labeled, obtain the conductor-type information from the boat manufacturer.

.4.2.2 If the manufacturer cannot provide this type of information, contact the conductor vendor.

.4.3 If the information is still unavailable, contact USCG Headquarters (G-BBT).

.4.4 If a conductor is labeled, but is not labeled as one of the conductors required in §183.435(a), contact Headquarters (G-BBT).

.4.5 If in doubt about a conductor-type, contact Headquarters (G-BBT).

.4.6 To determine whether a bundled conductor is in compliance with §183.435(b) for derating conductors, use Visual Examination No. 3, Paragraphs .5.6 through .5.6.7.

16 VISUAL EXAMINATION NO. 6

183.440 Requirements for conductors in high voltage secondary circuits of ignition systems

(a) Each conductor in a secondary circuit of an ignition system must meet SAE Standard J557, dated January, 1968.

(b) The connection of each ignition conductor to a spark plug, coil, or distributor must have a tight fitting cap, boot, or nipple.

.1 SCOPE

.1.1 This examination will determine compliance with §183.440 in conjunction with Laboratory Examination No. 4.

.2 EXAMINATION SPECIMEN

.2.1 All conductors used in a secondary circuit of an ignition system.

.3 EXAMINATION PROCEDURE

.3.1 Identify all conductors used in secondary circuits of ignition systems.

.3.2 Examine the conductors for labeling that indicates whether a conductor meets SAE Standard J557.

.3.3 If a conductor is not labeled, obtain the conductor-type information from the boat manufacturer or the conductor vendor.

.3.4 If in doubt about a conductor-type, contact USCG Headquarters (G-BBT).

.3.5 Examine the conductors to make sure the connections to the spark plugs and coil and distributor towers have tight fitting boots or nipples in accordance with §183.440(b).

.3.5.1 A properly fitted boot or nipple will offer some resistance to pulling, and will often make a "popping" sound when it releases from the spark plug or tower.

.3.5.2 Any doubt about the proper fitting of a boot or nipple must be noted in the report.

17

VISUAL EXAMINATION NO. 7

183.445 Tests for proper conductor installation

(a) Except for the first 36 inches of a conductor leading from a battery terminal, each conductor or group of conductors must be supported by clamps, or straps not more than 18 inches apart, unless the conductor or group of conductors is enclosed in a rigid duct or conduit. The clamps, straps, ducts, and conduits must be designed to prevent chafing or damage to the conductor insulation.

(b) If a conductor or group of conductors is connected between two components that can move in relation to each other, each conductor or group of conductors must have a loop, slack, or other strain relief.

(c) Each conductor or group of conductors that passes through a bulkhead, structural member, junction box, or other rigid surface must be protected from abrasion.

(d) This section does not apply to communications systems; electronic navigation equipment; and high voltage secondary conductors and terminations in the ignition system.

.1 SCOPE

.1.1 These tests will determine compliance with Section 183.445 in Subpart I of the Electrical Systems Standard covering conductor installation.

.1.2 A conductor or group of conductors will be examined as installed in the boat.

.2 APPARATUS

.2.1 Rule graduated in inches.

.3 TEST SPECIMEN

.3.1 All conductors installed in the boat that are not specifically excepted from the standard.

.4 PROCEDURES

.4.1 Determine that straps and clamps used to support a conductor or group of conductors are within 18 inches of each other, within 18 inches of conductor terminations, or within 18 inches of duct or conduit ends.

17 .4.1.1 The distances are measured directly between the clamps, straps, terminations, ducts or conduits. The distances are not measured along the conductors (See Figure next page).

.4.1.2 A sheath used to bundle conductors will be considered a single conductor for the purposes of measurement between supports. Ducts or conduits do not have to be supported by clamps or straps.

.4.2 Determine whether all clamps, straps, ducts, or conduits used to support conductors are designed to prevent chafing or damage to the conductor insulation.

.4.2.1 Acceptable clamps, straps, ducts or conduits will not have sharp edges or rough surfaces exposed to the conductors.

.4.3 Determine whether all conductors passing through a bulkhead, structural member, junction box or other rigid surface are protected from abrasion.

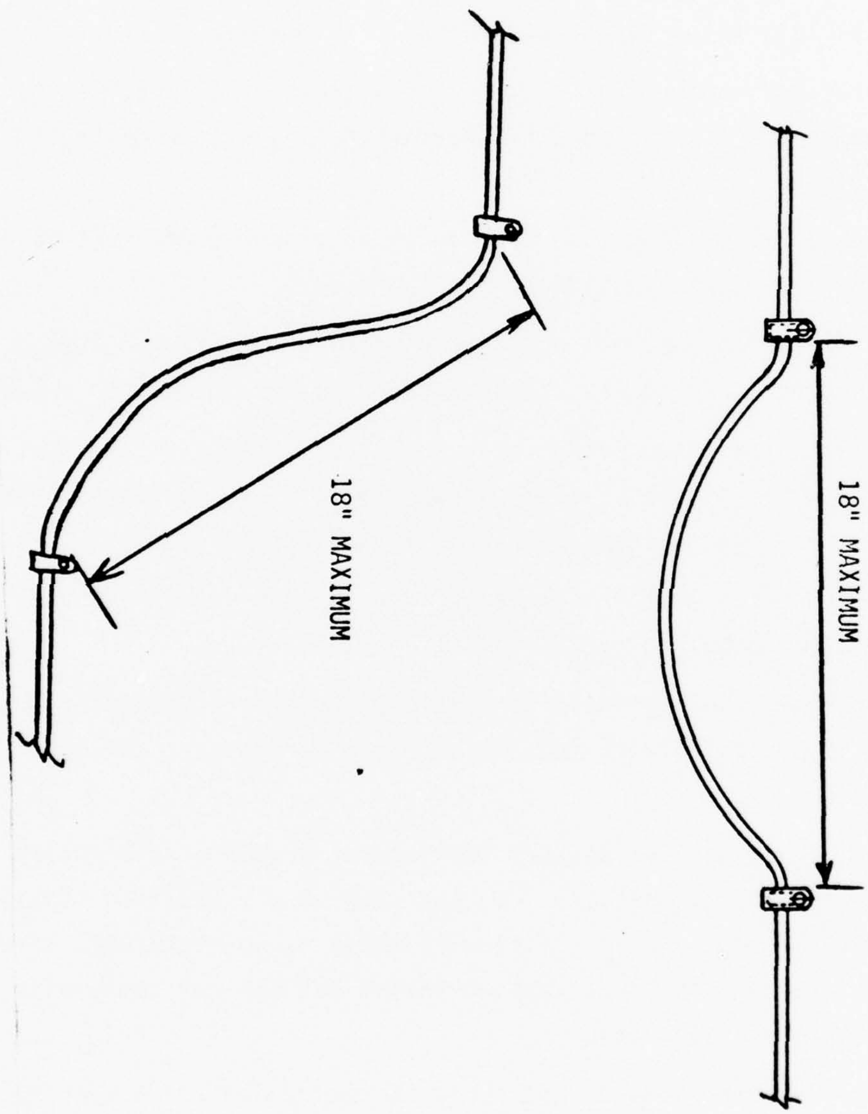
.4.3.1 Some acceptable methods for conductor protection are the installation of grommets, stuffing tubes, electricians tape, flexible tubing, sheathing, conduits or clamping the conductor away from rigid surfaces.

.4.3.2 Conductors must be kept away from sharp or rough edges on both metallic and non-metallic parts.

.4.4 Determine whether there is strain relief for a conductor or groups of conductors installed between two items or components that can move in relation to each other.

.4.4.1 An acceptable method for testing for proper strain relief is to operate the components that can move and observe the provided strain relief. There is insufficient strain relief when there is no measurable catenary in a conductor or group of conductors connected between two components that can move in relation to each other.

.4.5 These requirements do not apply to record and radio systems, electronic navigation equipment, high voltage secondary conductors and terminations in ignition systems.


18" MAXIMUM
18" MAXIMUM

183.450 Proper termination of conductors

(a) Each connection to a screw terminal or stud that is outside of a junction box or enclosure must be connected by a closed ring connector, eyelet connector, captive spade connector, mechanical locking connector, or spring locking connector.

(b) Each stripped conductor connected to a compression screw terminal that is outside a junction box or enclosure must be secured mechanically to provide strain relief for the stripped conductor connection.

(c) Each single friction connector, spring type connector, and multi-connector plug that is outside of a junction box or enclosure must not separate if subjected to a six pound tensile force along the axial direction of the connector for one minute.

(d) A soldered connection that is outside a junction box or enclosure must not be the sole means of connection between two or more conductors or between a conductor and a connector, except a conductor may be soldered to a connector that joins the conductor to a battery terminal or stud, if the length of the soldered joint is at least 1.5 times the diameter of the stranded portion of the battery conductor.

(e) Each connection that is outside of a junction box or enclosure and that is used to join conductors to each other or that is used to join a conductor to a connector must not break when subjected for one minute to a tensile force shown in Table 6 for the smallest conductor size in the connection.

(f) Each ungrounded terminal or stud that is continuously energized must meet § 183.455 or must have a boot, nipple, cap, cover, or shield that prevents accidental short-circuiting at the terminals or studs.

(g) Each termination composed of an ungrounded current carrying conductor, terminal fitting, and connector must be protected from accidental short circuiting with—

(1) Another termination from another circuit composed of an ungrounded current carrying conductor, terminal fitting, and connector; or

(2) Any metal that is grounded.

(h) A conductor must not be joined to another conductor by a wire nut or wire screw.

(i) This section does not apply to communication systems and electronic navigation equipment.

18 .1 SCOPE

.1.1 This examination will determine compliance with §183.450 except for §183.450(e).

.1.2 Connections and splices that must comply with §183.450(e) will be tested in accordance with Laboratory Examination No. 5, but not within the scope of this examination.

.2 APPARATUS

.2.1 Micrometer, ruler (graduated in 16ths of an inch), pliers, 10 pound spring scale, wire cutters, knife, soldering iron and 3/4 inch hard, non-metallic ball with a handle.

.3 EXAMINATION SPECIMEN

.3.1 All conductor terminations on the boat that are outside a junction box or similar enclosure.

.3.2 An enclosure as used in §183.450 means a switch box, panel box, distribution panel with a door or cover, closed control box and similar items.

.4 EXAMINATION CONDITIONS

.4.1 Circuits should not be energized in order to prevent any possible shock hazard during the testing.

.5 EXAMINATION PROCEDURE

.5.1 Determine if connectors installed on the ends of conductors that connect to screw terminals or studs are of the closed ring, eyelet, captive spade, mechanical or spring locking type. (See Figure No. 1).

.5.2 Determine whether stripped conductors that are connected to a compression screw terminal have additional mechanical securing of the conductor to provide strain relief for the termination (See Figure No. 2).

.5.3 Determine whether each electrical disconnect such as a single friction connector, spring type connector, single and multi-connector plugs and similar items are securely fastened by subjecting the connection to a six (6) pound pull test for one minute along the axial direction of the conductor(s).

NOTE

Actual compliance testing for connections will involve a large sampling of the same connection. The resultant pull test values must be at least six (6) pounds for 80% of the specimens while the minimum test value for an individual connection cannot be less than four (4) pounds. If during this visual examination a connection cannot withstand a four pound pull, then the sampling approach described above shall be initiated.

.5.3.1 The pull test may be performed on the connector as it is installed in the boat or it may be removed by cutting the conductors at least one foot away on either side of the connection.

.5.3.2 Condition the connector by connecting and disconnecting it six (6) times prior to the pull test.

.5.3.3 Perform the test by securing one side of the connection (Figure) and applying the pulling force to the other side with the spring scale.

.5.3.4 Apply the test force gradually, not with a jerking motion, and maintain the test force for one (1) minute duration. The connector must not separate at less than four (4) pounds (See Note above).

.5.4 Determine whether any soldered connections have an additional means of mechanical connection such as crimping, swaging, twisting or tying.

.5.4.1 It may be necessary to remove the solder with a knife or soldering iron to observe the actual connection.

.5.5 Conductor terminations to battery connectors are allowed to be soldered without additional mechanical connection.

.5.5.1 Determine whether the soldered connection is 1.5 times the diameter of the conductor by measuring the diameter of the stranded portion of the conductor and the length of the soldered connection.

.5.5.2 The length of the soldered connection must be at least 1.5 times the diameter of the conductor.

.5.6 Identify, record and tag splices and connections that must meet the requirements of §183.450(e) so they can be identified for testing in Laboratory Examination No. 5.

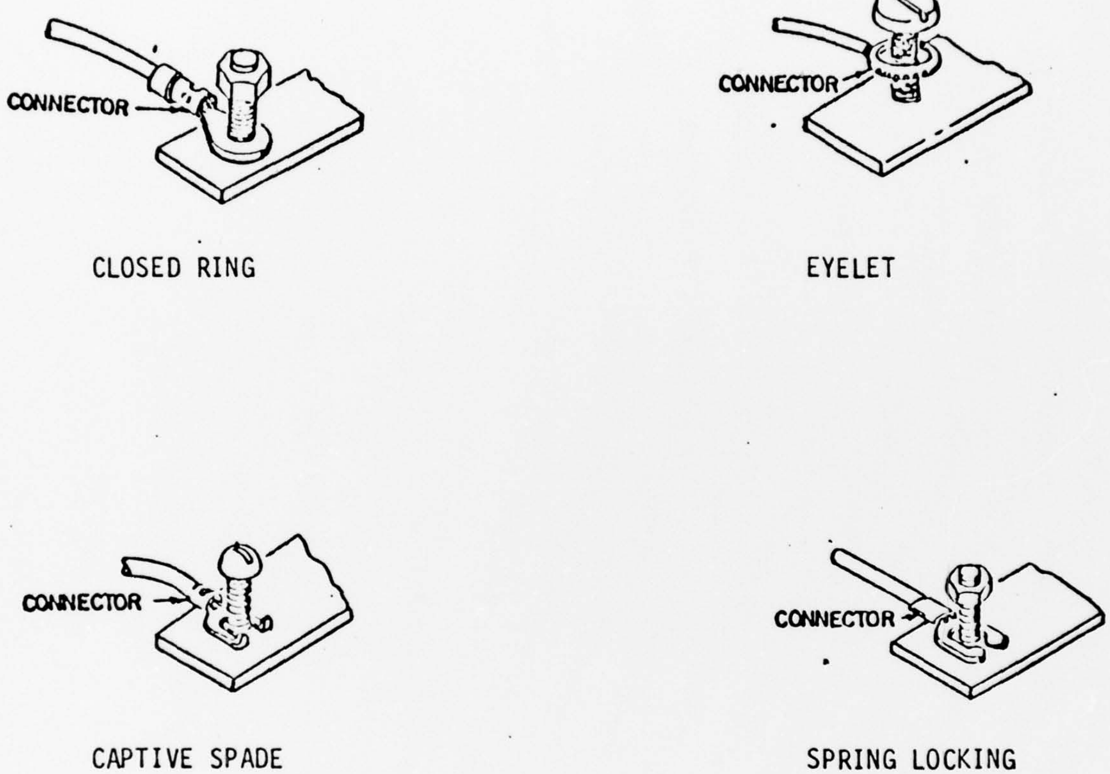


FIGURE NO. 1 -- CLOSED RING, CAPTIVE SPADE, EYELET AND SPRING LOCKING CONNECTORS

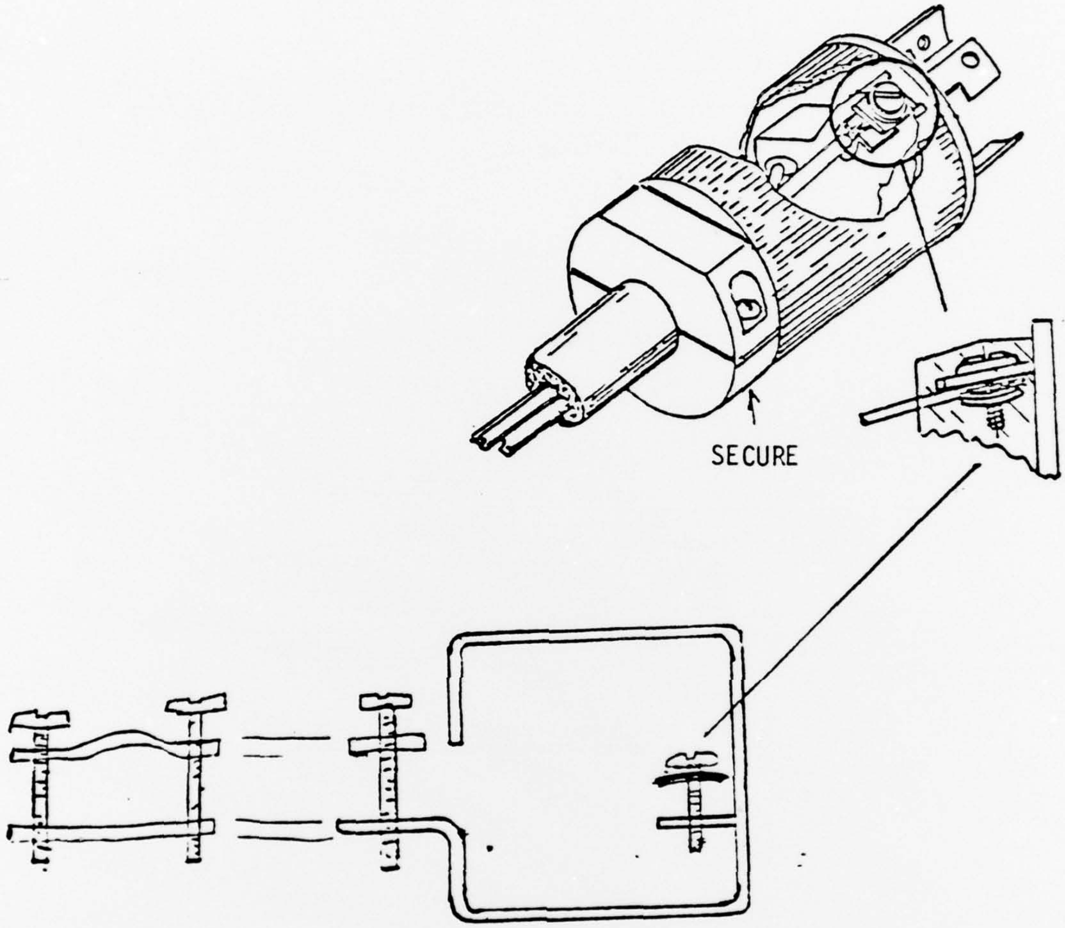
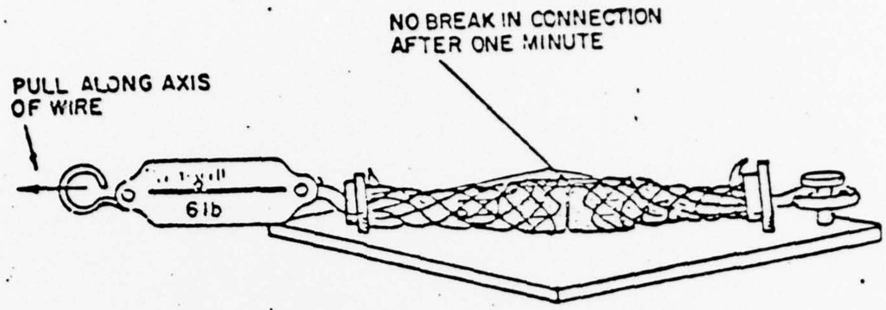
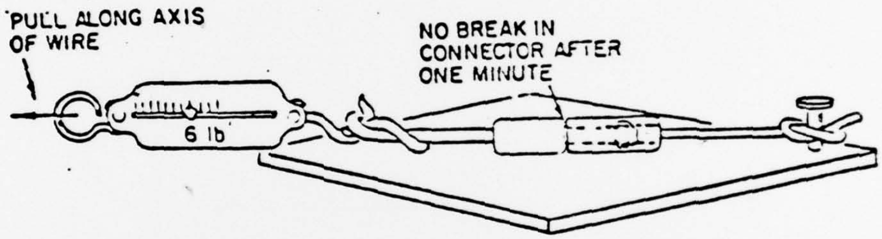


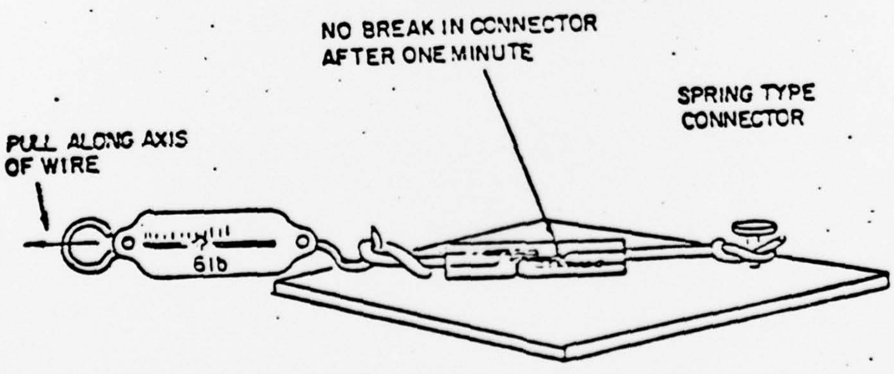
FIGURE NO. 2 -- ADDITIONAL MECHANICAL SECURING FOR STRIPPED CONDUCTORS CONNECTED TO A COMPRESSION SCREW TERMINAL



MULTICONDUCTOR PLUG



SINGLE FRICTION CONNECTOR



SPRING TYPE CONNECTOR

FIGURE NO. 3 -- PULL TEST FOR CONNECTORS

18 .5.7 Determine whether ungrounded terminals or studs that are continuously energized meet the requirements of §183.455 (Visual Examination No. 9), or if they have a boot, nipple, cap, cover or shield that prevents accidental short circuiting at the terminal or stud.

.5.7.1 The terminals or studs in question are generally found on battery switches, starter solenoids, starter motors, generators or alternators.

.5.7.2 "Continuously energized" means that the terminal is hot even when the engine is not running.

.5.7.3 Those continuously energized terminals or studs that meet the requirements of §183.455 (Visual Examination No. 9) do not have to meet this test.

.5.7.4 To determine whether the continuously energized terminals or studs are protected from accidental short circuiting in accordance with .5.7, try to touch the terminal or stud with the 3/4 inch hard, non-metallic ball.

.5.7.4.1 If the terminal or stud has no cap, boot, nipple or other obvious means of physical protection, and no overcurrent protection, noncompliance is automatic.

.5.7.4.2 If the terminal or stud cannot be touched by the 3/4 inch ball because the cap, boot, nipple, etc. is in the way, then compliance is established.

.5.8 Determine whether ungrounded current carrying terminations are protected from accidental short circuiting.

.5.8.1 A termination consists of a conductor, terminal fitting, and a connector. (See Figure 4).

.5.8.2 Locate all terminations affected by this requirement.

.5.8.3 Loosen the termination at the terminal fitting and move the connector within the full limits of its installation. The metallic part of the termination must not touch the metallic part of any other termination or any metal that is grounded. (See Figure 4).

.5.8.3.1 The termination may touch another termination that is part of the same circuit.

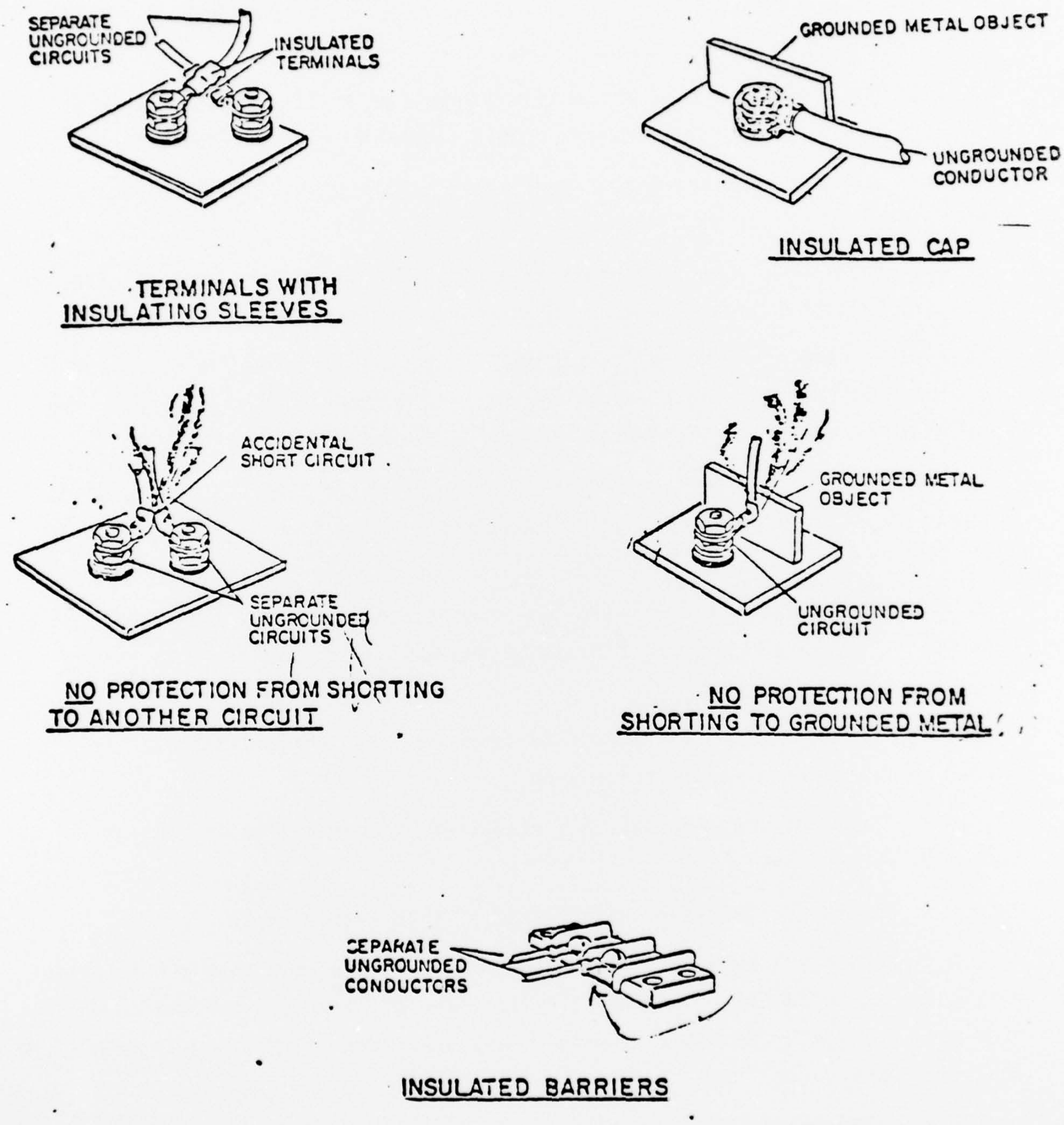


FIGURE NO. 4 -- UNGROUNDED CURRENT CARRYING TERMINATIONS

18 .5.8.4 Repeat Paragraph .5.8.3 for multiple termination installations and move all the terminals towards each other.

.5.9 Determine whether wire nuts or wire screws are used by inspecting the boat. Wire nuts and wire screws are not permitted anywhere in the boat except as noted in Paragraph .5.9.1.

.5.9.1 Wire nuts and wire screws are permitted within the casing, housing, or enclosure of an appliance such as a refrigerator, stove, toaster, etc. This exception does not apply to a conductor installed in an appliance by the boat manufacturer.

19 VISUAL EXAMINATION NO. 9

183.455 and 183.460 Overcurrent protection

183.455

(a) Each ungrounded current-carrying conductor must be protected by a manually reset, tripfree circuit breaker or fuse.

(b) A manually reset, tripfree circuit breaker or fuse must be—

(1) At the source of power for each conductor;

(2) At the point where the conductor size is reduced to a smaller gauge; or

(3) At the origin of a circuit, if the circuit breaker or fuse has a current rating that prevents overloading of the smallest conductor in the circuit.

(c) The current rating of each circuit breaker or fuse must not exceed—

(1) For circuits of less than 50 volts, 150% of the value of the amperage in Table 5 for the conductor size it is protecting; and

(2) For circuits of 50 volts or more, the value of the amperage in Table 5 for the conductor size it is protecting. If this value does not correspond to a standard size or rated circuit breaker or fuse the next larger size or rated circuit breaker or fuse may be used if it does not exceed 150% of the allowed current capacity of the conductor.

(d) The voltage rating of each circuit breaker or fuse must not be less than the nominal circuit voltage of the circuit it is protecting.

(e) This section does not apply to resistance conductors that control circuit amperage; conductors in secondary circuits of ignition systems; pigtails of less than seven inches of exposed length; and power supply conductors in cranking motor circuits.

19 183.460

(a) Each ungrounded supply conductor from a storage battery must have a manually reset, tripfree circuit breaker or fuse, unless the supply conductor is in the main power feed circuit from the battery to an engine cranking motor. The circuit breaker or fuse must be within 72 inches of the battery measured along the conductor, unless the circuit has a switch that disconnects the battery.

(b) Each ungrounded output conductor from an alternator or generator, except for self-limiting alternators or generators, must have a circuit breaker or fuse that has a current rating that does not exceed 120 percent of the maximum rated current of the alternator or generator at 60° C.

.1 SCOPE

.1.1 This examination will determine compliance with §183.455 and §183.460 in Subpart I of the Electrical Systems Standard covering overcurrent protection.

.2 APPARATUS

.2.1 Rule (graduated in 16ths of an inch), allowable amperage table and wire gauge.

.3 EXAMINATION SPECIMEN

.3.1 Boat's electrical system. Prints and plans of the electrical system may be used as an aid.

.3.2 Employ the procedures in Visual Examination No. 3 to determine conductor sizes and current carrying capacities.

.4 EXAMINATION CONDITION

.4.1 Electrical systems should not be energized to eliminate any possible shock hazard during the examination.

.5 EXAMINATION PROCEDURE

.5.1 Identify all electrical circuits in the boat's electrical system.

.5.1.1 Identify all conductors and circuits that are grounded. A grounded conductor or circuit is one that is intentionally led to a ground for the

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purpose of acting as a ground conductor, such as a battery negative terminal lead.

.5.1.2 Identify all ungrounded conductors and circuits regarding whether they are low (less than 50 volts) or high (greater or equal to 50 volts) voltage.

15.2 Determine whether all ungrounded current carrying conductors are protected by an overcurrent protection device (OPD).

.5.2.1 Locate all overcurrent protection devices (OPD), i. e. manually reset tripfree circuit breakers or fuses.

.5.2.2 Determine whether the OPD is within seven (7) inches of the source of power for each conductor, measured along the conductor. The seven inches of jumper conductor must meet all the requirements in Subpart I as they apply to conductors.

.5.2.3 Determine whether the OPD is located at the origin of a circuit if the circuit breaker or fuse has a current rating that prevents overloading of the smallest conductor in the circuit.

.5.2.4 Determine whether the OPD is within 40 inches of the source of power for each conductor measured along the conductor if the conductor is protected from physical damage by its own sheath or enclosure such as a junction box, control box or enclosed panel.

.5.2.5 Identify the OPDs regarding their voltage and current ratings.

.5.2.6 The voltage ratings of the OPDs must not be less than the voltage of the circuit or conductor it is protecting.

.5.3 Determine the allowable current carrying capacities of all conductors (Visual Examination No. 3).

15.3.1 Determine whether the current rating of the OPD protecting a conductor or circuit exceeds the rating allowed in §183.455(c).

.5.3.1.1 If a low voltage conductor or circuit, the OPD current rating cannot exceed 150% of the current carrying capacity of the conductor it is protecting.

.5.3.1.2 If it is a high voltage conductor or circuit, the OPD current rating cannot exceed the current carrying capacity of the conductor it is protecting, unless there is no standard OPD rating available, and then the OPD current rating can be the next available size OPD, not to exceed 150% of the current carrying capacity of the conductor it is protecting.

19 .3.2 If an OPD is protecting two (2) or more conductors, its current rating as determined in .5.3.1.1 and .5.3.1.2 is calculated using the conductor with the smallest current carrying capacity.

.5.4 The current and voltage ratings of OPDs will be tested in Laboratory Examination No. 6.

.5.4.1 For this Visual Examination, determine the OPD ratings from the markings on the OPD.

.5.4.2 If in doubt about an OPD's rating, note it in the report.

.5.5 Main power feed circuits to engine cranking motors are excepted from these requirements.

.5.6 The OPDs for all other supply conductors from a storage battery must be located within seventy-two (72) inches of the battery terminal measured along the conductor.

.5.6.6 The seventy-two (72) inch location requirement for OPDs is relaxed if there is a switch in that supply circuit that is designed to be used to disconnect the battery.

.5.6.2 A manually reset trip-free circuit breaker that has a manual on-off switch capability fulfills this requirement. A battery disconnect switch also provides this capability.

.5.6.3 If a switch exists, then the OPD may be located anywhere in that supply circuit between the battery terminal and the circuit load (bus bar, distribution panel, etc.).

.5.7 Identify ungrounded output conductors from alternators and generators (including ship service generators) that are not self-limiting.

.5.7.1 The ungrounded output conductors must have an OPD whose current rating does not exceed 120% of the maximum rated current of the alternator or generator at 60° C.

.5.7.2 This rating information will normally be marked on the alternator or generator. If not, contact the manufacturer to find out.

federal register

MONDAY, JANUARY 31, 1977

PART XI

DEPARTMENT OF TRANSPORTATION

Coast Guard

■

BOATS AND ASSOCIATED EQUIPMENT

Safety Standards for Electrical Systems

Subpart I—Electrical Systems

GENERAL

AUTHORITY: 46 U.S.C. 1454; 49 CFR 1.46(n)(1).

Subpart I—Electrical Systems

GENERAL

§ 183.401 Purpose, applicability, and effective dates.

(a) This subpart applies to all boats that have gasoline engines for electrical or mechanical power or propulsion, except outboard engines.

(b) The sections in this subpart are effective on the following dates:

August 1, 1977: § 183.401, § 183.405, § 183.420, § 183.445.
February 1, 1978: § 183.415, § 183.425, § 183.430, § 183.435, § 183.440, § 183.450, § 183.455, § 183.460.

§ 183.402 Definitions.

As used in this subpart—(a) "ASTM" means American Society for Testing and Materials. ASTM standards in this subpart may be examined at Coast Guard Headquarters, Room 4314, Trans Point Building, 2100 2nd St., SW., Washington, D.C. 20590 and may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

(b) "AWG" means American Wire Gauge.

(c) "Electrical component" means electrical equipment such as, but not limited to, conductors, solenoids, motors, generators, alternators, distributors, resistors, appliances and electrical control devices.

(d) "IEEE" means Institute of Electrical and Electronic Engineers, Inc. IEEE standards in this subpart may be examined at Coast Guard Headquarters, Room 4314, Trans Point Building, 2100 2nd St., SW., Washington D.C. 20590 and may be obtained from the Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, N.Y. 10017.

(e) "NFPA" means National Fire Protection Association. NFPA standards in this subpart may be examined at Coast Guard Headquarters, Room 4314, Trans Point Building, 2100 2nd St., SW., Washington, D.C. and may be obtained from the National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02110.

(f) "Pigtails" means external power conductors or wires that are part of electrical components and appliances, such as bilge pumps, blowers, lamps, switches, solenoids, and fuses.

(g) "SAE" means Society of Automotive Engineers, Inc. SAE standards in this subpart may be examined at Coast Guard Headquarters, Room 4314, Trans Point Building, 2100 2nd St., SW, Washington, D.C. 20590 and may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

(h) "Sheath" means a material used as a continuous protective covering, such as electrical tape, molded rubber, molded plastic, or flexible tubing, around one or more insulated conductors.

(i) "UL" means Underwriters Laboratories Inc. UL standards in this subpart may be examined at Coast Guard Headquarters, Room 4314, Trans Point Building, 2100 2nd St., SW, Washington, D.C. 20590 and may be obtained from Underwriters Laboratories Inc., 207 East Ohio Street, Chicago, IL 60611.

§ 183.405 General.

Each electrical component on a boat to which this subpart applies must meet the requirements of this subpart unless the component is part of an outboard engine or part of portable equipment.

MANUFACTURER REQUIREMENTS

§ 183.410 Ignition protection.

(a) Each electrical component must not ignite a propane gas and air mixture that is 4.25 to 5.25 percent propane gas by volume surrounding the electrical component when it is operated at each of its manufacturer rated voltages and current loadings, unless it is isolated from gasoline fuel sources, such as engines, and valves, connections, or other fittings in vent lines, fill lines, distribution lines or on fuel tanks, in accordance with paragraph (b) of this section.

(b) An electrical component is isolated from a gasoline fuel source if—

(1) A bulkhead that meets the requirements of paragraph (c) of this section is between the electrical component and the gasoline fuel source;

(2) The electrical component is—

(i) Lower than the gasoline fuel source and a means is provided to prevent fuel and fuel vapors that may leak from the gasoline fuel source from becoming exposed to the electrical component; or

(ii) Higher than the gasoline fuel source and a deck or other enclosure is between it and the gasoline fuel source; or

(3) The space between the electrical component and the gasoline fuel source is at least two feet and the space is open to the atmosphere.

(c) Each bulkhead required by paragraph (b)(1) of this section must—

(1) Separate the electrical component from the gasoline fuel source and extend both vertically and horizontally the distance of the open space between the fuel source and the ignition source;

(2) Resist a water level that is 12 inches high or one-third of the maximum height of the bulkhead, whichever is less, without seepage of more than one-quarter fluid ounce of fresh water per hour; and

(3) Have no opening located higher than 12 inches or one-third the maximum height of the bulkhead, whichever is less, unless the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, and similar items, or doors, hatches, and access panels, and the maximum annular space around each item or door, hatch or access panel must not be more than one-quarter inch.

§ 183.415 Grounding.

If a boat has more than one gasoline engine, grounded cranking motor circuits must be connected to each other by a common conductor circuit that can carry the starting current of each of the grounded cranking motor circuits.

§ 183.420 Batteries.

(a) Each installed battery must not move more than one inch in any direction when a pulling force of 90 pounds or twice the battery weight, whichever is less, is applied through the center of gravity of the battery as follows:

(1) Vertically for a duration of one minute.

(2) Horizontally and parallel to the boat's center line for a duration of one minute fore and one minute aft.

(3) Horizontally and perpendicular to the boat's center line for a duration of one minute to starboard and one minute to port.

(b) Each battery must be installed so that metallic objects cannot come in contact with the ungrounded battery terminals.

(c) Each metallic fuel line and fuel system component within 12 inches and above the horizontal plane of the battery top surface as installed must be shielded with dielectric material.

(d) Each battery must not be directly above or below a fuel tank, fuel filter, or fitting in a fuel line.

(e) Hydrogen gas discharged by a battery must not accumulate in the boat.

(f) The positive terminal of each battery must be identified by the letters "POS", or "P", or the symbol "+" marked on the terminal or on the battery case near the terminal.

(g) Each battery terminal connector must not depend on spring tension for its mechanical connection to the terminal.

§ 183.425 Conductors: general.

(a) Each conductor must be insulated, stranded copper.

(b) Except for intermittent surges each conductor must not carry a current greater than that specified in Table 5 for the conductor's gauge and temperature rating.

(c) For conductors in engine spaces, amperages must be corrected by the appropriate correction factor in note 1 of Table 5.

(d) Each conductor in a multiconductor sheath must be at least a No. 18 AWG conductor.

(e) Each conductor installed separately must be at least a No. 16 AWG conductor.

(f) Each No. 18 AWG conductor in a multiconductor sheath may not extend out of the sheath more than 30 inches.

§ 183.401 [Amended]

Section 183.401, paragraph (b) is amended by changing the effective date for § 183.410 from August 1, 1978, to February 1, 1979.

(g) This section does not apply to communication systems; electronic navigation equipment; resistance conductors that control circuit amperage; high voltage secondary conductors and terminations that are in ignition systems; pigtails of less than seven inches of exposed length; and cranking motor conductors.

§ 183.430 Conductors in circuits of less than 50 volts.

(a) Each conductor in a circuit that has a nominal voltage of less than 50 volts must—

(1) Meet the requirements of § 183.435; or

(2) Meet—

(i) The insulating material temperature rating requirements of SAE Standard J378b dated November 1976; and

(ii) SAE Standard J1127 dated November 1975, or SAE Standard 1128 dated November 1975.

(b) This section does not apply to communication systems; electronic navigation equipment; resistance conductors that control circuit amperage; and pigtails of less than seven inches of exposed length.

§ 183.435 Conductors in circuits of 50 volts or more.

(a) Each conductor in a circuit that has a nominal voltage of 50 volts or more must be—

(1) A conductor that has insulation listed and classified moisture resistant and flame retardant in Article 310, NFPA No. 70-1975, National Electric Code 1975;

(2) A flexible cord type SO, STO, ST, SJO, SJT, or SJTO listed in Article 400, NFPA No. 70-1975, National Electric Code 1975;

(3) A conductor that meets IEEE Std. 45-1971, dated December 3, 1970;

(4) A conductor listed for marine use by an independent testing laboratory which provides listing, labeling, and follow-up service; or

(5) A conductor that meets the mechanical water absorption and flame retardant standards of UL Standard 83, dated July 8, 1976.

(b) Where the nominal circuit voltage of each of three or more current carrying conductors in a duct, bundle, or cable is 50 volts or more, the amperages of each of those conductors must not exceed the value in Table 5 multiplied by the correction factor in note 2 to Table 5 for the number of conductors that carry 50 volts or more.

(c) This section does not apply to communication systems; electronic navigation equipment; resistance conductors that control circuit amperage conductors in secondary circuits of ignition systems; and pigtails of less than seven inches of exposed length.

§ 183.440 Secondary circuits of ignition systems.

(a) Each conductor in a secondary circuit of an ignition system must meet SAE Standard J557, dated January, 1968.

(b) The connection of each ignition conductor to a spark plug, coil, or distributor must have a tight fitting cap, boot, or nipple.

TABLE 5.—*Allowable amperage of conductors*

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)
18	10	10	15	20	20	25	25
16	15	15	20	25	25	30	35
14	20	20	25	30	35	40	45
12	25	25	35	40	45	50	55
10	40	40	50	55	60	70	70
8	55	65	70	70	80	90	100
6	80	95	100	100	120	125	135
4	105	125	130	135	160	170	180
3	120	145	150	155	180	195	210
2	140	170	175	180	210	225	240
1	165	195	210	210	245	265	280
0	195	230	245	245	285	305	325
00	225	265	285	285	330	355	370
000	260	310	330	330	385	410	430
0000	300	360	385	385	445	475	510

NOTES

1. See the following table:

	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)
Temperature rating of conductor	0.58	0.75	0.78	0.82	0.85	0.89	1.00

2. See the following table:

Number of current carrying conductors:	Correction factor
3	0.70
4 to 6	.60
7 to 24	.50
25 and above	.40

§ 183.445 Conductors: Support and protection.

(a) Except for the first 36 inches of a conductor leading from a battery terminal, each conductor or group of conductors must be supported by clamps, or straps not more than 18 inches apart, unless the conductor or group of conductors is enclosed in a rigid duct or conduit. The clamps, straps, ducts, and conduits must be designed to prevent chafing or damage to the conductor insulation.

(b) If a conductor or group of conductors is connected between two components that can move in relation to each other, each conductor or group of conductors must have a loop, slack, or other strain relief.

(c) Each conductor or group of conductors that passes through a bulkhead, structural member, junction box, or other rigid surface must be protected from abrasion.

(d) This section does not apply to communications systems; electronic navigation equipment; and high voltage secondary conductors and terminations in the ignition system.

§ 183.450 Conductors: termination.

(a) Each connection to a screw terminal or stud that is outside of a junction box or enclosure must be connected by a closed ring connector, eyelet connector, captive spade connector, mechanical locking connector, or spring locking connector.

(b) Each stripped conductor connected to a compression screw terminal that is outside a junction box or enclosure must be secured mechanically to provide strain relief for the stripped conductor connection.

(c) Each single friction connector, spring type connector, and multi-connector plug that is outside of a junction box or enclosure must not separate if subjected to a six pound tensile force along the axial direction of the connector for one minute.

(d) A soldered connection that is outside a junction box or enclosure must not be the sole means of connection between two or more conductors or between a conductor and a connector, except a conductor may be soldered to a connector that joins the conductor to a battery terminal or stud, if the length of the soldered joint is at least 1.5 times the diameter of the stranded portion of the battery conductor.

(e) Each connection that is outside of a junction box or enclosure and that is used to join conductors to each other or that is used to join a conductor to a connector must not break when subjected for one minute to a tensile force shown in Table 6 for the smallest conductor size in the connection.

(f) Each ungrounded terminal or stud that is continuously energized must meet § 183.455 or must have a boot, nipple, cap, cover, or shield that prevents accidental short-circuiting at the terminals or studs.

(g) Each termination composed of an ungrounded current carrying conductor, terminal fitting, and connector must be protected from accidental short circuiting with—

(1) Another termination from another circuit composed of an ungrounded current carrying conductor, terminal fitting, and connector; or

(2) Any metal that is grounded.

(h) A conductor must not be joined to another conductor by a wire nut or wire screw.

(i) This section does not apply to communication systems and electronic navigation equipment.

§ 183.455 Overcurrent protection: general.

(a) Each ungrounded current-carrying conductor must be protected by a manually reset, tripfree circuit breaker or fuse.

(b) A manually reset, tripfree circuit breaker or fuse must be—

(1) At the source of power for each conductor;

(2) At the point where the conductor size is reduced to a smaller gauge; or

(3) At the origin of a circuit, if the circuit breaker or fuse has a current rating that prevents overloading of the smallest conductor in the circuit.

(c) The current rating of each circuit breaker or fuse must not exceed—

(1) For circuits of less than 50 volts, 150% of the value of the amperage in Table 5 for the conductor size it is protecting; and

(2) For circuits of 50 volts or more, the value of the amperage in Table 5 for the conductor size it is protecting. If this value does not correspond to a standard size or rated circuit breaker or fuse the next larger size or rated circuit breaker or fuse may be used if it does not exceed 150% of the allowed current capacity of the conductor.

(d) The voltage rating of each circuit breaker or fuse must not be less than the nominal circuit voltage of the circuit it is protecting.

(e) This section does not apply to resistance conductors that control circuit amperage; conductors in secondary circuits of ignition systems; pigtails of less than seven inches of exposed length; and power supply conductors in cranking motor circuits.

TABLE 6.—TENSILE TEST VALUES FOR CONDUCTOR SPLICES

(CONDUCTOR-CONDUCTOR AND CONDUCTOR-CONNECTOR JOINTS)

Wire size (AWG):	Tensile force pounds
18	10
16	15
14	30
12	35
10	40
8	45
6	50
5	60
4	70
3	80
2	90
1	100
0	125
00	150
000	175
0000	225

§ 183.460 Overcurrent protection: special applications.

(a) Each ungrounded supply conductor from a storage battery must have a manually reset, tripfree circuit breaker or fuse, unless the supply conductor is in the main power feed circuit from the battery to an engine cranking motor. The circuit breaker or fuse must be within 72 inches of the battery measured along the conductor, unless the circuit has a switch that disconnects the battery.

(b) Each ungrounded output conductor from an alternator or generator, except for self-limiting alternators or generators, must have a circuit breaker or fuse that has a current rating that does not exceed 120 percent of the maximum rated current of the alternator or generator at 60° C.

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CGD 74-209)