



Division of J.B. Nottingham and Co., Inc.
75 Hoffman Lane
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**PORTABLE POWER DISTRIBUTION SYSTEMS
FOR FIREFIGHTING AND EMERGENCY SERVICES**

From

**Fire Power Division of J.B. Nottingham & Co., Inc.
75 Hoffman Lane
Islandia, NY 11749**

I INTRODUCTION

1.1 Fire Power, Division of J.B. Nottingham & Co., Inc., requested Factory Mutual (FM) Approval of their Portable Power Distribution Systems for Firefighting and Emergency Services, as described in Paragraph 1.2, for temporary wiring installations in both indoor and outdoor locations. This Approval program does not include load consuming devices that are intended to be connected to the portable power distribution systems as depicted in the attachments to this report, as requested by the manufacturer.

1.2 The specific portable power distribution systems described by this report will be listed in the FM Approval Guide as follows. The “WT” in the description column designates watertight design for indoors and outdoors, and is not part of the model designation.

<u>Model No.</u>	<u>Part No.</u>	<u>Description</u>
3B20-3S	M164501	Distribution Block, 120 V.A.C. 20A, WT.
3FT20-S	M101607	Female Plug, 120 V.A.C. 20A, WT.
3FT20-S	M101610	Female Plug, 120 V.A.C. 20A, WT.
3MT20	M102402	Male Plug, 120 V.A.C., 20A, WT.
3MT20	M102413	Male Plug, 120 V.A.C., 20A, WT.
3RT20	M128900	Female Receptacle, 120 V.A.C., 20A, WT.
3RT20-OB	M165200	Female Receptacle, 120 V.A.C., 20A, WT.
3MT20/3FT20-S	M164300	Extension Cord, 50', 120 V.A.C., 20A, WT.
3MT20/3FT20-S	M164301	Extension Cord, 100', 120 V.A.C., 20A, WT.
3MT20/3FT20-S	M164302	Extension Cord, 25', 120 V.A.C., 20A, WT.
1-3MT20/2-3FT20-S	M164400	Junction, 120 V.A.C., 20A, WT.
3B20-3S/3MT20	M164500	Distribution Block w/ Male Plug, 120 V.A.C., 20A, WT.



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1.3 Approval of the portable power distribution systems for firefighting and emergency services is based on the requirements of the following standard.

TITLE	AUTHOR-NUMBER	DATE
Power Distribution Cable Equipment	FM-3852	DRAFT

FM-3852 is based in large part on standards recognized by the American National Standards Institute.

1.4 The portable power distribution systems are specifically intended to provide temporary power to equipment used by firefighting and emergency rescue services, such as for lighting systems and exhaust ventilation fans used by firefighting personnel. FM Approval requirements were developed as part of this testing program with review stages by the manufacturer, and two Firefighting Companies, the Norwood Public Fire Department, Norwood, Massachusetts, and the Westwood Public Fire Department, Westwood, Massachusetts. As described herein, some of the testing program of the product for FM Approval was conducted at these fire departments, and examination results were based on the comments offered by the fire department personnel. Specifically mentioned in this report for the cooperation and assistance provided in this effort is Chief Thomas J. Barry Jr., Norwood Fire Department and Lieutenant William P. Scoble, Westwood Fire Department. The test program described herein is a practical simulation of the conditions that power distribution equipment will undergo in actual use. The system is not indestructible and no one would expect it to be. The test program anticipated the environmental conditions that the power distribution system can be exposed to, such as water immersion, exposure to degrading chemicals and mechanical abuse. This system affords the required degree of protection for the firefighting and emergency rescue services against electrical shock and injury. The use of the system outdoors is a practical concern. The system is designed to be watertight when fully and properly mated to the rated plug, receptacle or protective cover when not mated. It is not intended that actual mating be done in a driving rain storm, but protection is provided against water entry when fully mated, including intermittent submersion, for example in shallow puddles as would be expected at a firefighting or rescue scene. Although intended for a fire fighting scene, the power distribution systems are not fireproof, neither are the hoses used for fire extinguishment, and fire exposure may result in destruction of insulation and exposure of live conductors. Installation and use of the system for temporary power shall be in accordance with the manufacturer's instructions and applicable code requirements.



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II. EXAMINATION AND TESTS

2.1 Samples of the portable power distribution system sub-assemblies, considered to be representative of production models, were examined, tested, and compared to the manufacturer's drawings. All data is on file at FM along with the other documents and correspondence applicable to this program.

Testing was performed in an ambient temperature range between 65° to 85° F (18° to 30°C), Unless otherwise stated.

2.2. Protection Against Electrical Shock - The portable power distribution systems were examined and tested to verify the required degree of protection against electrical shock is provided.

2.2.1 Accessibility - The live contact area on the female outlets of the plug, distribution block and receptacles, when not mated, are recessed so that no live parts are accessible when tested with the IEC rigid and articulated accessibility probes. No live parts are accessible when the appropriate plugs, distribution block and receptacles are mated as the initial contact between the male pins and female barrels is made within a recessed opening area. This is satisfactory.

2.2.2 Protective Ground - Only the 3B20-3S distribution block has an accessible non-current carrying conductive part. This conductive part, a hook, is bonded to the protective ground female barrel terminal with a circuit resistance not exceeding 0.1 ohm. When mating the various assemblies, mechanical, contact between the protective ground male pin and the female barrel make first and break last as compared to the making and breaking of the live primary pin connections. This is satisfactory.

A green colored protective ground conductor, with a cross-sectional area equivalent to that of the primary conductors in the cable, is bonded to the protective ground terminals (pins) of each end connector assembly. This provides a protective ground path for external non-current carrying conductive parts of a load that may be connected to the power distribution systems. This is satisfactory.

2.2.3 Dielectric Tests - A test potential of 1250 V.A.C. (2 times the rated voltage, plus 1000 volts) was applied between each primary conductor and between primary conductors tied together and the protective ground conductor for one minute.

Since the assemblies of the portable power distribution system have a protective insulation exterior material (double insulated), the mated assemblies were wrapped in aluminum foil and dielectric tested between primary conductors tied together and the foil wrap. A test potential of 2500 V.A.C. (2 times the potential used above) was applied for one minute.



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The same dielectric test potential was also applied for one minute between the primary conductors tied together and aluminum foil that was wrapped around the female plug, distribution block and receptacles when capped with its protective cover.

As a result of these tests, the test potentials were maintained with no indication of insulation breakdown. This is satisfactory.

2.2.4 Polarization - The male plug is designed to mate with the intended female plug, distribution block or receptacles in only the correct polarized state. This is satisfactory.

2.2.5 Spacing - electrical spacing between uninsulated live parts and uninsulated grounded parts on the plugs, distribution block and receptacles meet the 3/16 inch minimum requirement. This is satisfactory.

2.2.6 Leakage Current Tests - With the male plug mated with the intended female plug, distribution blocks or receptacles, the leakage current measured between the primary conductors and the protective ground conductor, when tested at the rated operating voltage did not exceed 0.5 mA. The mated plugs and distribution block were wrapped in aluminum foil and a leakage current was then measured between the primary conductors and the foil wrap. Leakage current during these tests did not exceed 0.5 mA when tested at the rated operating voltage. The same leakage current test measurement was also performed between the primary conductors tied together and aluminum foil was wrapped around the female plug, distribution block or receptacle when capped with its protective cover. Leakage current test results are satisfactory.

2.2.7 Accelerated-Aging Test - This test was conducted on various colored HYPALON® materials from which the connectors of the portable power distribution system equipment are molded. These materials were subjected to an oxygen atmosphere at 158°F at pressure of 300 psi for 96 hours. As a result of this oxygen atmosphere exposure, the change in hardness on the samples was less than 10%. This is satisfactory.

2.3 Protection Against Injury and Fire - The portable power distribution system equipment was examined and tested to verify that the required degree of protection against injury and fire is provided.

2.3.1 Flame Retardant - Flammability tests were conducted on the SO and SOWA cable's outer jacket on various colored HYPALON® insulating materials from which the connectors of the portable power distribution system equipment are molded. These materials were subjected to five flame applications, ON for 15 seconds and OFF for 15 seconds. After the fifth application, the materials self-extinguished before one minute upon removal of the flame and did not burn through. This is satisfactory.



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2.3.2 Comparative Tracking Index (CTI) Test - Black and red colored HYPALON® samples were CTI tested per ASTM D3638-85. Electrodes, spaced 4 mm (0.16 in) apart, were positioned on each test sample. The voltage to the electrodes was set up to 750 volts. Fifty drops of 0.1% ammonium chloride solution with an electrolyte resistivity of 385 ohm/cm (23°C) were then allowed to fall on each test sample between the electrodes from a height of not more than 40 mm (1.6 in). The solution drop size was 10 mm³ (0.0015 in³) while the droppings occurred at a rate of 1 drop per 30 seconds. Test results were satisfactory as no tracking was evident on the HYPALON® test samples.

2.3.3 Hot Wire Ignition (HWI) Test - Black and red colored HYPALON® samples were HWI tested per ASTM D3874-90. No. 24 AWG Nichrome heater wire, 10 inches in length, was wrapped five complete turns around each test sample. The heater wire was energized to dissipate 6.5 W/in. for a duration time of not less than 60 seconds. Test results were satisfactory as the HYPALON® test samples did not ignite.

2.3.4 Internal Temperature Test - The temperature rise of the male pin and female barrel contact area of the mated plugs and receptacles did not exceed a temperature rise of 54° (30° C), referenced to 23°C ambient temperature, when operated at the maximum current rating. This is satisfactory.

2.3.5 External Temperature Test - The external temperature rise of the mated plugs, receptacles and cables was not greater than 11°C, referenced to 23° ambient temperature rise, when operated at the maximum current rating. Listed cables with properly sized conductors, as required by the National Electrical Code, ANSI/NFPA-70, are used with the plugs and distribution block. This is satisfactory.

2.3.6 Fault Test - The mated plugs and receptacle were fault tested by applying a test current of 1000 Amperes, 60 Hz, for a minimum of 3 cycles (50 ms). The mated plugs and receptacle were then satisfactorily dielectric tested as described in Paragraph 2.2.3. This is satisfactory.

2.3.7 Overload Test - The male and female plugs were subjected to 50 cycles of making and breaking 30 Amps (150% of its rated current) at 120 V.A.C. with an 80% power factor. The making and breaking was performed mechanically at a rate 10 cycles a minute. One cycle consisted of the male plug being completely inserted in the female plug and then completely withdrawn. Test results were considered satisfactory as no electrical or mechanical failure occurred.

2.3.8 Resistance to Arcing Test - The same male and female plugs that were Overload Tested, as described in Paragraph 4.3.7, were subjected to an additional 200 cycles of making and breaking 30 Amps (150% of its rated current) at 120 V.A.C. with an 80% power factor. Test results were considered satisfactory as no electrical tracking, formation of a permanent carbon conductive path, or ignition of the material resulted.



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2.4 Mechanical Requirements - The portable power distribution system equipment was examined and tested to determine if sufficient mechanical strength and stability is provided to ensure protection from electrical shock and injury.

2.4.1 Crushing Test - To simulate the portable power distribution system being run over by automotive traffic and including firefighting vehicles, the assemblies, mated and unmated, were run over by a fire department's ladder type fire truck. Also laboratory crush test value of 1800 pounds between two steel plates for one minute time duration. Laboratory crush test valve of 1800 pounds was based on axle weight information for a fire department's ladder type fire truck. Laboratory crush tests were performed on assemblies that were exposed to ambient temperatures of 75°F (24°C) and 0°F (-18°C) fro at least 24 hours. No breakage of deformation occurred as a result of the crush tests. Following the crush test, a satisfactory dielectric test, as described in Paragraph 2.2.3, was performed. The plugs and distribution blocks were then checked for proper mating/unmating as described in Paragraph 2.4.5. This is satisfactory.

The crush test is not applicable to the receptacles, since they are panel-mount devices.

2.4.2 Security of Pins Test - The male pins on the plug did not loosen or displace more than 3/32 inch when the pins were subjected to a straight pull force of 20 pounds for two minutes. This is satisfactory.

2.4.3 Tensile Strength (Strain Relief) Tests - No Breakage or loosening resulted when the plugs and distribution blocks were subjected to tensile strength tests, which consisted of straight pull and torque tests. The following straight pull and torque forces were applied for one minute. With the plug and distribution block firmly secured in place, the following forces were applied on the cable six inches from the plug of distribution block mold area. This test is satisfactory.

<u>Plug Description</u>	<u>Straight Pull (lbs)</u>	<u>Torque (ft. lbs)</u>
3B20-3S on 12/3 AWG cable	150	1.0
3MT20 on 12/3 AWG cable	150	1.0
3FT20-S on 12/3 AWG cable	150	1.0

The tensile strength tests are not applicable to the receptacles, since they are panel-mount devices and do not include cable as part of the assembly.

2.4.4 Impact Resistance Test - No breakage of deformation resulted when the plugs, distribution block and 3RT20 receptacle were subjected to an impact caused by dropping a cylindrical 10 pound weight, having a flat face that is 2 inches in diameter, from a height of 18 inches. The plugs and distribution blocks were then checked for proper mating/unmating as described in Paragraph 2.4.5. This is satisfactory.



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The impact resistance test is not applicable to the 30RT20-OB receptacle, since it is intended to be mounted in a weatherproof enclosure.

2.4.5 Insertion and Withdrawal Forces - The appropriate plugs, distribution block, receptacles, and protective covers were able to be mated manually as intended. The female plug and distribution block are provided with nylon pins which prevent the mated assemblies from working themselves free. With the nylon pins removed from the assemblies, the force required to disconnect the male plug from the female receptacles and the protective cover from the female receptacles were measured and found to be greater than the minimum requirement of 4 and 5 pounds respectively. This is satisfactory to ensure that the mated plugs, distribution block, receptacles and protective covers are not able to work themselves free.

2.4.6 Flex Test - No detachment or loosening resulted when the female plug was subjected to a 5000 cycle flex test. The flex test was performed by firmly securing the plug end in place with the cable hanging vertically, then moving the cable that is connected to the plug back and forth in a plane through an angle of approximately 180 degrees. Following the flex test, a satisfactory dielectric test, as described in section 4.2.3., was performed. This is satisfactory.

No additional flex testing was considered necessary, as the mold area of the male and distribution block assemblies is similar to that of the female plug.

2.4.7 Endurance tests - Endurance test of 5000 cycles under load conditions (120 V.A.C., 20 Amps, 80% power factor) was performed on the male and female plugs. A 5000 cycle endurance test was also performed on the protective cover and female plug. The endurance tests were performed mechanically at a rate of 10 cycles per minute. An endurance test cycle consisted of the male plug or protective cover being completely inserted in the female plug and then completely withdrawn. No excessive wear resulted on the tested plugs and protective cap cover which can occur during normal use or affect the watertight design for outdoor use as described in Paragraphs 2.4.5 and 2.5. This is satisfactory.

Endurance testing was not necessary on the capped and mated distribution block and receptacles as the male pin/female barrel designs are identical to that of the male and female plugs.

2.5 Extended Environmental Tests - The following tests verify the rated suitability for outdoor use as marked on the portable power distribution system equipment. Prior to this testing, the test samples were crush tested, impact resistance tested, tensile strength tested and no-load endurance tested, as described in Paragraphs 2.4.1, 2.4.3, 2.4.4, and 2.4.7, respectively.

2.5.1 Hosedown Test - The mated plugs, mated plug and distribution block and capped female plug and distribution block were subjected to a stream of water from a hose with a 1-1/8 inch (28.6 mm) diameter nozzle, delivering 250 gallons (946 l) per minute.



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The water was directed at the samples from all sides from a distance of 10 to 12 feet (3 to 3.7 m) for 1 minute. Immediately following the hosedown, a satisfactory dielectric and leakage current tests, as described in Paragraphs 4.2.3 and 4.2.6, were performed on the mated and capped equipment. The mated equipment was then unmated and found to successfully prevent water from reaching the male pins/female barrel contact area. The protective cap covers were also removed from the female plug and distribution block and were found to successfully prevent water from reaching the female barrel contact area. This is satisfactory.

2.5.2 IP68 Rating Tests - The following test verify the industrial power distribution equipment listed in Section 1.5 to be rated as IP68 (i.e., provides for a degree of protection defined as dust tight and rated for continuous immersion). Factory Mutual Research representative Mr. Patrick Bryne witnessed continuous immersion and insulation resistance tests at the manufacturer's facility in Islandia, NY.

2.5.2A Dust Exclusion Test (IP6X) - The industrial power distribution equipment was suspended in a circulating dust atmosphere of 200 mesh talc. The test was carried out for eight hours. At the conclusion of the test, excess dust was removed from the samples' exterior and the samples were opened and evaluated. It was found that the industrial power equipment excluded the entry of dust on the electrical contacts. This is satisfactory.

2.5.2B Continuous Immersion Test (IPX8) - The industrial power distribution equipment connected to each of their respective connectors was suspended in a test tank. The tank was filled with water such that the highest point of the industrial connector was at least 6 feet (1.83 m) below the surface of the water. The samples were removed from the tank after being submerged for at least 7 days. The excess water was removed from the enclosure surfaces, and the enclosure was opened. Upon examination, it was found that the samples had excluded the entry of water on the electrical contacts. This is satisfactory.

2.5.2C Insulation Resistance Tests - The industrial power distribution equipment, connected to each of their respective connectors, was subjected to insulation resistance tests while immersed in water as described in Section 4.5.2B. the insulation resistance measurements were conducted daily. Measurements between the following points on the test samples resulted in insulation resistance of greater than 200 Mohms. This is satisfactory.

- Between each primary conductors and the surrounding water.
- Between protective ground conductor and surrounding water.

2.5.3 Corrosion Test - This test was waived as the only conductive metal parts on the portable power distribution system equipment are the male pins, female contact barrels and the external hook on the 3B20-3S Distribution Block, which are all made of brass material. This is satisfactory as the brass material is not subject to corrode.



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2.5.4 External Icing Test - Since the capped distribution blocks contain areas (cavities) that could accumulate ice, these areas were completely filled with water and placed in a 0°F environment for 24 hours to determine if water freezing and ice expansion would affect the operation or ability of the distribution blocks to exclude water. As a result of the water freezing and ice expansion in the distribution block, no evidence of deformation, cracking or its ability to exclude the entrance of water occurred. This is satisfactory. The assemblies were then checked for proper mating and unmating as described in Paragraph 2.4.5.

Since the capped and mated plugs and receptacle exclude the entrance of water, as described in Paragraph 4.5.1, this test was waived on the plugs and receptacle as they do not contain areas that could accumulate ice or have external operators that could be damaged by ice. This is satisfactory.

2.5.5 Moisture Absorption Resistance Test - This test was conducted on samples of the SO and SOWA cables' outer jacket and on various colored HYPALON® materials from which the portable power distribution system equipment is molded. These samples were immersed in distilled water for 48 hours. As a result of this immersion, the samples were absorbed less than 2.7 percent of water and no evidence of cracking or bubbling was evident. This is satisfactory.

2.5.6 Exposure to Deteriorating Liquids- This test was conducted on samples of the SO and SOWA cables' outer jacket and on various colored HYPALON® materials from which the portable power distribution system equipment is molded. These samples were immersed in ATSM reference Oil No. 1 and ASTM Reference Fuel C Liquids for 2 hours. As a result of these immersions, the samples passed the flame retardant test as described in Paragraph 2.3.1. This is satisfactory.

2.5.7 Fire Exposure Test - the mated plugs, mated plug and distribution block and the 12/3 AWG SO cable used as part of the assemblies were each exposed to a burning Class B brand grid (6 X 6 X 2-1/4 inch). The Class B Brand material was exposed to a flame for 4 minutes, as described per ASTM E108-90, and then placed on top of the mated plugs, mated plugs and distribution block and on the cable. After the class B material self-extinguished (which was approximately 20 minutes), a dielectric test, as described in Paragraph 4.2.3, was satisfactorily performed on the mated plugs and mated plug and distribution block. A dielectric test on the cable portion of the assemblies could not be performed as the insulation was destroyed, and therefore exposing live conductors.

This test was performed to demonstrate what can happen to the power distribution system when exposed to a fire, such as that at a fire scene. This test represents just a minimum amount of energy that can result from a fire, as compared to the energy that is present at a major fire scene.



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As a result of this test and engineering judgment, it is evident that current power distribution equipment used by fire departments, including this system, will result in destruction of insulation and exposure of live conductors when exposed to fire or ember type materials for an undetermined amount of time. The manufacturer's Installation Bulletin 017 includes a "CAUTION" statement concerning the effects of exposure to fire or ember type materials which may result in insulation destruction and exposure of live conductors.