KSC-STD-E-0002
Revision E, Change 2

HAZARDPROOFING OF ELECTRICALLY ENERGIZED EQUIPMENT,

STANDARD FOR

February 12, 2021

Engineering Directorate

National Aeronautics and
Space Administration

John F. Kennedy Space Center

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February 12, 2021

JOHN F. KENNEDY SPACE CENTER, NASA

RECORD OF REVISIONS/CHANGES

REV LTR	CHG NO.	DESCRIPTION	DATE
		Basic issue.	May 28, 1969
A		General revision.	August 24, 1976
B		General revision.	June 1, 1987
C		General revision.	September 28, 1998
D		General revision.	June 11, 2007
E		General revision.	March 12, 2009
	1	1. Clarified applicable locations in Section 1. 2. Added to/updated lists of applicable documents in 2.1.1 through 2.2. 3. Specified requirements for treatment of open-grain propellant in 5.1. 4. Added document reference and usage instruction to 5.3.2 through 5.3.2.2. 5. Updated document listing and added requirements to 5.4.e and 5.4.f. 6. Updated document list in Appendix A.	November 15, 2016
	2	General revision and editorial update.	February 12, 2021

CONTENTS

TABLES

1. PURPOSE AND SCOPE

This standard sets forth requirements for hazardproofing electrical installations and equipment in hazardous locations classified by the authority having jurisdiction (AHJ) and other locations designated as hazardous at Kennedy Space Center (KSC) to prevent ignition of flammable liquids or hazardous fluids, gases, vapors or open-grain solid propellants.

This document defines the minimum requirement that KSC ground systems and equipment must meet.

This document does not

- define how to design systems and equipment, or
- encompass hazardproofing requirements associated with lightning protection, grounding, operational safety, toxicity, or chemical reactions.

This standard does not apply to locations made hazardous because of the presence of high explosives (such as blasting agents or munitions) or pyrophoric materials (those that ignite spontaneously in air).

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. When this document is used for procurement, including solicitations, or is added to an existing contract, the specific revision levels, amendments, and approval dates of said documents shall be specified in an attachment to the solicitation/statement of work/contract. Unless a specific edition is cited, the latest released edition applies.

2.1 Governmental

2.1.1 Specifications

John F. Kennedy Space Center (KSC), NASA

120E3100001	Heavy Duty GSE Cable Specification, General
KSC-SPEC-E-0031	Cables, Electrical, Specification for

Military

MIL-DTL-22992	Connectors, Plugs and Receptacles, Electrical, Waterproof, Quick Disconnect, Heavy Duty Type, General Specification for

MIL-DTL-26482	Connectors, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting), Receptacles and Plugs, General Specification for
MIL-DTL-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, or Breech Coupling), Environment Resistant with Crimp Removable Contacts or Hermetically Sealed with Fixed, Solderable Contacts, General Specification for
MIL-PRF-39012	Connectors, Coaxial, Radio Frequency, General Specification for

2.1.2 Standards

John F. Kennedy Space Center (KSC), NASA

KSC-STD-132	Potting and Molding Electrical Cable Assembly Terminations, Standard for
KSC-STD-E-0011	Electrical Power Receptacles and Plugs, Standard for
KSC-STD-E-0022	Bonding, Grounding, Shielding, Electromagnetic Interference, Lightning and Transient Protection, Design Requirements for Ground Systems

2.1.3 Handbooks

John F. Kennedy Space Center (KSC), NASA

GP-864, Volume IIA	Electrical Ground Support Equipment Cable Handbook

2.2 Non-Governmental

Electrostatic Discharge Association

ANSI/ESD S20.20	ESD Association Standard for the Development of an Electrostatic Discharge Control Program for: Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

National Fire Association

NFPA 70	National Electric Code
NFPA 400	Hazardous Materials Code
NFPA 496	Standard for Purged and Pressurized Enclosures for Electrical Equipment
NFPA 497	Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

SAE International

SAE AS50151	Connectors, Electrical, Circular Threaded, AN Type, General Specification for

2.3 Order of Precedence

In the event of conflict between the documents cited herein and the contents of this document, the contents of this document shall supersede, except where otherwise noted. The NASA contract, purchase order, or program-level documentation shall take precedence over the contents of this document in the event of conflicting requirements. Nothing in this document supersedes applicable laws and regulation unless a specific exemption has been obtained.

3. DEFINITIONS

For the purpose of this document, the following definitions shall apply.

a. **authority having jurisdiction (AHJ):** Organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure. At KSC, the NASA Fire and Rescue Office is the AHJ.

b. **control drawing:** Drawing or other document provided by the manufacturer of the intrinsically safe or associated apparatus (or of the nonincendive field wiring apparatus or associated nonincendive field wiring apparatus) that details the allowed interconnections between the intrinsically safe and associated apparatus or between the nonincendive field wiring apparatus or associated nonincendive field wiring apparatus.

c. **facility:** Structure or building that serves a particular purpose.

d. **hazardous location:** Location where fire or explosion hazards may exist because of the presence of flammable gases, vapors, or liquids; combustible dust; or ignitable fibers or flyings. The area is classified in accordance with properties of the material

responsible for the potential hazard and with the likelihood of the hazard actually being present.

e. **purged and pressurized:** Condition achieved by (1) purging, or supplying an enclosure with a protective gas at a sufficient flow and positive pressure to reduce the concentration of any flammable gas or vapor initially present to an acceptable level; and (2) pressurizing, or supplying an enclosure with a protective gas, with or without continuous flow, at sufficient pressure to prevent the entrance of flammable gas or vapor, combustible dust, or ignitable fibers. (For further information, see NFPA 496.)

f. **intrinsically safe:** "An assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnecting cables in that those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits" (NFPA 70).

4. GENERAL REQUIREMENTS

Design for all new electrical equipment to be used in hazardous (classified) locations shall comply with the intent of the applicable guidelines of NFPA 70 (latest released edition),

NFPA 400 (latest released edition), NFPA 496 (latest released edition), and NFPA 497 (current version at start of project unless otherwise stated in project documentation).

The lead design engineer shall coordinate the design and implementation of hazardproofing for electrically energized equipment with the NASA Fire and Rescue Office, the AHJ over such activities at KSC.

5. GUIDELINES

Guidelines have been extracted from NFPA 70A, Article 500, and have been tailored to KSC-specific environment and requirements.

5.1 Hazardous Locations and Classifications

All areas designated as hazardous (classified) locations shall be properly documented in KSC drawings (see Appendix A). This documentation shall be available to those authorized to design, install, inspect, maintain, or operate electrical equipment at the location.

Hazardous locations are where fire or explosion hazards may exist because of the presence of flammable gases, vapors, or liquids; combustible dust; or ignitable fibers or flyings. Although combustible dust and flammable gases and vapors exist almost everywhere, they are usually present in only minute quantities, much less than necessary for a fire or explosion hazard to exist. Thus, the presence of flammable gases or vapors or combustible dust does not in itself define a hazardous location. These materials must be present in sufficient quantities (concentrations) to present a potential explosion hazard. Hazardous locations at KSC involve the storage, handling and distribution of liquid oxygen, liquid hydrogen, nitrogen tetroxide, monomethylhydrazine, and open-grain solid propellants.

NFPA 497 does not assign the following items as hazardous substances nor does it assign an NEC group classification. The substances shall be treated as follows:

a. nitrogen tetroxide – Class I, Group C

b. oxygen – Class I, Group D

c. methane – Class I, Group D

d. open-grain propellant – no class or group, equipment located within a 5-foot radius of open-grain propellant, the following requirements shall be adhered to:

   (1) Measures shall be taken to prevent electrostatic discharge (ESD) in accordance with program/project ESD control plans and procedures developed in accordance with ANSI/ESD S20.20 or approved equivalent.

   (2) Equipment shall be bonded according to KSC-STD-E-0022 to prevent ESD.

   (3) Electrical equipment shall be housed in nonventilated enclosures.

In North America, hazardous (classified) locations are divided into three classes, based on the explosive characteristics of the material. The classes of material are further divided into divisions or zones, based on the risk of fire or explosion that the material presents. Zones have three levels of hazard, whereas divisions have two levels. Table 1 illustrates the relationships among classes, divisions, and zones.

Table 1. Classes, Divisions, and Zones of Hazardous Materials

Hazardous Material	Class, Division	Zone
Gases or vapors	Class I, Division 1	Zone 0 and Zone 1
Gases or vapors	Class I, Division 2	Zone 0

Locations shall be classified depending on the properties of the flammable vapors, liquids, or gases, or the combustible dust or fibers that may be present, and the likelihood that a flammable or combustible concentration or quantity is present. Where pyrophoric materials are the only materials used or handled, these locations shall not be classified. Each room, section, or area shall be considered individually in determining its classification.

5.2 Purging and Pressurizing

Purging is the process of supplying an enclosure with a protective gas at a sufficient flow and positive pressure to reduce the concentration of any flammable gas or vapor initially present to an acceptable level. This technique can be used to change a Class I or Class II, Division 1, location into a nonhazardous location or into a Division 2 location, or to change a Class I or II, Division 2, location into a nonhazardous location. It requires a noncombustible enclosure (which may be a control room or a machine room) that is first purged of any combustibles or flammables and then maintained at a positive pressure sufficient to prevent combustibles or flammables from entering the enclosure and being ignited by electrical equipment within the enclosure. The purging may be a continuous process or a single operation with a positive pressure maintained to make up for leaks. The pressurizing medium may be either air,

commonly used in control rooms where people will be working, or a nonflammable gas. In instrument enclosures in locations with corrosive atmospheres, specially processed and dried air or gas is used to protect the enclosed equipment against corrosion, as well as to prevent ignition of exterior flammable gases and vapors or combustible dust. (See NFPA 496.)

Where possible, enclosures and distributors that are required by the system should be located outside a hazardous area and an intrinsically-safe design for energized electrical equipment is preferred.

5.3 Equipment for Hazardous Areas

5.3.1 Class and Properties

Equipment shall be identified for not only the class of location but also the explosive, combustible, or ignitable properties of the specific gas, vapor, dust, fiber, or flyings that will be present. In addition, Class I equipment shall not have any exposed surface that operates at a temperature in excess of the ignition temperature of the specific gas or vapor. Class II equipment shall not have an external temperature higher than that specified. Class III equipment shall not exceed the maximum surface temperatures specified in NFPA 70, Article 503.5.

5.3.2 Cable Wiring Methods

Cable shall be protected from spillage of liquid oxygen, hydrogen, or other propellants and from mechanical damage. No electrical lines of any type shall be located in trenches containing propellant lines. Instrumentation, communication, control, and associated power equipment at KSC may be connected by hard-service cabling/cords as specified in GP-864, Volume IIA; 120E3100001; or KSC-SPEC-E-0031 (not recommended for new designs).

5.3.2.1 Mineral-Insulated Cable

Mineral-insulated cable is suitable for Division 1 locations and for all Class I and Class II locations. See GP-864, Volume IIA; 120E3100001; and KSC-SPEC-E-0031 (not recommended for new designs).

5.3.2.2 Metal-Clad Cable

Metal-clad cable (Type MC) is permitted for application in Class I, Division 2, locations. Use of this type of cable is not limited to any voltage class. Under restrictions, metal-clad cable

(Type MC-HL) and instrumentation tray cable (Type ITC-HL) are permitted in Class I, Division 1, locations. See NFPA 70; GP-864, Volume IIA; 120E3100001; and KSC-SPEC-E-0031 (not recommended for new designs).

5.3.2.3 Tray Cable

Power and control cable (Type TC) and other cable assemblies that do not permit gas migration are permitted in Class 1, Division 2, locations where (1) the overall sheath is compatible with materials within the hazardous area, (2) the conditions of maintenance and supervision ensure that only qualified persons service the installation, and (3) the cable is continuously supported and protected against physical damage using mechanical protection, such as struts, angles, or channels.

5.3.2.4 Flexible Cords: Class I, Divisions 1 and 2

5.3.2.4.1 Permitted Uses

Flexible cords are permitted for

a. connection between portable lighting equipment or other portable equipment and the fixed portion of their supply circuit;

b. that portion of the circuit where the fixed wiring methods cannot provide the necessary degree of movement for fixed and mobile electrical equipment, where the flexible cord is protected from damage by location or by a suitable guard, and only in an industrial establishment where conditions of maintenance and engineering supervision ensure that only qualified persons install and service the installation;

c. electric submersible pumps with means for removal without entering the wet-pit (the extension of the flexible cord within a suitable raceway between the wet-pit and the power source is permitted); and

d. electric mixers intended for travel into and out of open-type mixing tanks or vats.

5.3.2.4.2 Required Characteristics

Where flexible cords are used, they shall

a. be a type listed in NFPA 70 for “extra hard use,”

b. be terminated in approved connectors capable of being safety-wired and pre-potted and molded in accordance with KSC-STD-132,

c. contain, in addition to the conductors of the circuit, a grounding conductor complying with all applicable code standards,

d. be connected to terminals or to supply conductors in an approved manner,

e. be supported by clamps or other suitable means so there is no tension on the terminal connections,

f. be provided with suitable seals where the flexible cord enters boxes, fittings, or explosionproof enclosures, and

g. be of continuous length, having no splices.

5.4 Electrical Connections for Meters, Instruments, and Relays

To comply with the intent of NFPA 70, process control instruments may be connected through flexible cord, attachment plug, and receptacles and shall be allowed for use in hazardous (classified) locations provided the following conditions are met. (See MIL-DTL-38999, series III; SAE AS50151; MIL-DTL-22992; MIL-DTL-26482; MIL-PRF-39012; GP-864, Volume II; and KSC-STD-E-0011 for approved connectors.)

NOTE

Connectors classified as "weatherproof" with threaded coupling nuts are acceptable for use with instrumentation, communication, controls, and associated power cabling.

a. A switch complying with all applicable standards—not an attachment plug—is used to interrupt current.

b. The current does not exceed maximum specified amperes at rated volts, direct current (dc), for instrumentation, controls and associated power cable for specific hazardous environments, and maximum specified amperes at rated volts dc for communication and associated power cabling for specific hazardous environments.

c. The power supply cord, which may be of any length, is listed in NFPA 70 for "extra hard use" (or for "hard use" if protected by location) and is supplied through an attachment plug and receptacle of the locking and grounding type.

d. Only necessary receptacles are provided.

e. The receptacle carries a label with a warning against unplugging under load. Enclosures located in hazardous locations shall be labeled with the following statement: Warning! De-energize all circuits prior to cable mating or demating.

f. A method is provided that is outside the hazardous zone to interrupt current prior to disconnecting the connector. Operational procedures shall require de- energizing all circuits and power prior to making or breaking any connections to electrical enclosures.

6. QUALITY ASSURANCE PROVISIONS

This section is not applicable.

7. PREPARATION FOR DELIVERY

This section is not applicable.

8. NOTES

8.1 Intended Use

This standard is intended for use by design organizations engaged in the design of electrical equipment to be used in hazardous (classified) and other locations designated as hazardous by the AHJ at KSC.

NOTICE: The Government drawings, specifications, or data are prepared for the official use by, or on behalf of, the United States Government. The Government neither warrants these Government drawings, specifications, or other data, nor assumes any responsibility or obligation, for their use for purposes other than the Government project for which they were prepared or provided by the Government, or any activity directly related thereto. The fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded, by implication or otherwise, as licensing in any manner the holder or any other person or corporation nor conveying the right or permission, to manufacture, use, or sell any patented invention that may relate thereto.

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APPENDIX A. ELECTRICAL-POWER HAZARDOUS-ZONE DOCUMENTATION

Drawing	Title
80K60591	Launch Complex 39 RPSF Electrical Power Hazardous Area Zones
80K60592	Launch Complex 39 SLF Electrical Power Hazardous Area Zones
80K60649	Launch Complex 39 MLP 1, 2 & 3 Electrical Power Hazardous Area Zones
80K60650	Launch Complex 39 TPSF Electrical Power Hazardous Area Zones
GSDO-SPEC-1184	Exploration Ground Systems Program Electrical Hazard Area Zones Specification