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## Doug Smith, MCP/CBO

- Inspector/Plan Reviewer for over 20 years
- 19 ICC certifications
- Certified ICC Master Code Professional and CBO
- Taught electrical, solar PV, and ESS classes for over 14 years
- Performed well over ten-thousand electrical, solar PV, and ESS plan reviews
- Serve on *NEC* CMP 10 representing IAEI
- Currently serve as a Technical Committee (TC) Member for the following UL standards:
  - UL 61730 (previously 1703) – Flat-Plate PV Modules and Panels
  - UL 1741 - Inverters, Converters, Controllers, and Int. equip…
  - UL 2703 – PV Mounting Systems/Clamps/Gnd. Lugs
  - UL 6703 – Connectors for Use in PV Systems
  - UL 9540 - Energy Storage Systems and Equipment

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## Course Objective/Intent

- The objective of this presentation is to explain the core *NEC* requirements concerning hazardous locations. This presentation is based on the 2020 *NEC*.
- The intent of this information is to be used as a guide only. This presentation is not intended to indicate any change in any code or local requirements by inference or omission. All diagrams are for illustration purposes only and actual wiring and installation may vary. This presentation is not intended to indicate if one piece or particular brand of equipment is better than another. Also, efficiency and ideal design considerations are not addressed herein. All applicable codes, standards, and manufacturer requirements must always be followed when designing, installing, and inspecting any electrical system or electrical components/equipment.

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## Learning Objectives

1. Understand differences between Class I, Class II, and Class III hazardous locations
2. Equipment required in hazardous locations
3. Protection techniques



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## Hazardous locations (examples)



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## Scope

- NEC 500.1 – Scope
- NEC Articles 500 through 504 pertain to any electrical equipment and wiring (for any voltages) in Class I, Divisions 1 and 2; Class II, Divisions 1 and 2; and Class III, Divisions 1 and 2 locations.
- Such areas may have a fire or explosion hazard due to flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, or ignitible fibers/flyings.

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## Classifications

- **Class I:** Fammable gasses or vapors or flammable liquids (see also *NEC* Article 501)
- **Class II:** Combustible dusts (see also *NEC* Article 502)
- **Class III:** Ignitible fibers or flyings (see also Article 503)



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## Definitions

- NEC Article 100 – See Part III of Article 100
- Combustible Dust: "Dust particles that are 500 microns or smaller (material passing a U.S. No. 35 Standard Sieve as defined in ASTM E11-2015, Standard Specification for Woven Wire Test Sieve Cloth and Sieves and Testing Sieves) and present a fire or explosion hazard when dispersed and ignited in air." NFPA 70 *National Electrical Code*©

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## Definitions

- NEC Article 100 (cont.)
- Dust-Ignitionproof. “Equipment enclosed in a manner that excludes dusts and does not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.”

NFPA 70 *National Electrical Code©*

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## Definitions

- NEC Article 100 (cont.)
- Dusttight. “Enclosures constructed so that dust will not enter under specified test conditions.”

NFPA 70 *National Electrical Code©*

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## Definitions

- NEC Article 100 (cont.)
- Explosionproof Equipment. “Equipment enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor that may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and that operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.”

NFPA 70 *National Electrical Code©*

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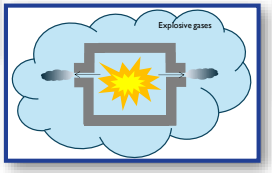
## Explosion Proof Equipment

*Larsenelectronics.com*



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## Definitions

- NEC Article 100 (cont.)
- Hermetically Sealed. “Equipment sealed against the entrance of an external atmosphere where the seal is made by fusion, for example, soldering, brazing, welding, or the fusion of glass to metal.” NFPA 70 *National Electrical Code©*


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## Definitions

- NEC Article 100 (cont.)
- Nonincendive Equipment. “Equipment having electrical/electronic circuitry that is incapable, under normal operating conditions, of causing ignition of a specified flammable gas-air vapor-air, or dust-air mixture due to arcing or thermal means.” NFPA 70 *National Electrical Code©*

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## “NPT” threaded conduit

- Threaded Conduit
  - The abbreviation “NPT” appears several times throughout Chapter 5 of the *NEC*.
  - It stands for **National (American) Standard Pipe Taper,** and is concerning threaded conduit and threaded conduit entries.



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## Definitions

- NEC Article 100 (cont.)
- Unclassified Locations. “Locations determined to be neither Class I, Division 1; Class I, Division 2; Class I, Zone 0; Class I, Zone 1; Class I, Zone 2; Class II, Division 1; Class II, Division 2; Class III, Division 1; Class III, Division 2; Zone 20; Zone 21; Zone 22; or any combination thereof.” NFPA 70 *National Electrical Code©*

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## Classifications of [Hazardous] Locations

- NEC 500.5
  - **(A)** Hazardous locations in the *NEC* are classified depending on the properties of a "flammable gas, flammable liquid-produced vapor, combustible liquid-produced vapors, combustible dusts, or fibers/flyings that may be present" in an area, and whether or not such are in a quantity or concentration which could present a flammable or combustible hazard.
  - The *NEC* requires that each room or area be considered individually when determining the classification.
  - Outside the scope of *NEC* Article 500 are any pyrophoric materials (which can ignite spontaneously when exposed to air).
  - *NEC* 500.5 also clarifies that any rooms and areas containing ammonia refrigeration systems which also have adequate mechanical ventilation (either continuous or by activation of a detection system) can be classified as unclassified locations.

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## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)
  - **(B)** Class I locations are those in where flammable gases or flammable liquid vapors are or may be present in quantities of an explosive or ignitable mixtures.
  - Class I locations includes those note in *NEC* 500.5(B)(1) and (B)(2).



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## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)
  - **500.5(B)(1)** Any of the following are considered a Class I, Division 1 location:
    - (1) An area where **under normal conditions** there's an ignitable concentration of flammable gases or flammable liquid-produced vapors, or
    - (2) An area where there will be frequently be ignitable concentrations of flammable gases or flammable liquid-produced vapors, **due to repair or maintenance** operations or because of leakage, or
    - (3) An area where a breakdown of equipment might release ignitible concentrations of flammable gases or flammable liquid-produced vapors **and "might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition."**


See also informational notes under *NEC* 500.5(B)(1)



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## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)

  **500.5(B)(2)** Any of the following are considered as a Class I, Division 2 locations:
  - (1) An area where flammable gases or flammable liquid-produced vapors are used/present, but such are "**normally confined within closed containers or closed systems**" and would escape only in cases of **accidental rupture or breakdown** of such containers or systems (and includes any abnormal operation of equipment), or


(see additional slides for more Class I, Division 2 areas)



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## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)
- (Class I, Division 2 locations continued):
  - (2) An area where ignitable concentrations of flammable gases or flammable liquid-produced vapors are **normally prevented by positive mechanical ventilation** and could become hazardous only through the failure/breakdown of the ventilating equipment, or
  - (3) An area which is next to a Class I, Division 1 location, and where there may occasionally be flammable gases or flammable liquid-produced vapors extending into the Class I, Division II area.
    - (the above area would not be considered a Class I, Division II location when adequate positive-pressure ventilation are provided and safeguards against ventilation failure are provided)

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## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)
  - **500.5(C)** Class II locations are areas where they're hazardous because of the presence of combustible dust.
  - Class II locations include those noted in *NEC* 500.5(C)(1) and (C)(2).



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## Dust explosions

Images by Hans-Peter Scholz, Wikipedia.org

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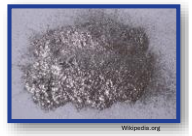
## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)
  - **500.5(C)(1)** Any of the following are considered as a Class II, Division 1 location:
    - (1) An area where **under normal conditions** there's combustible dust is in the air in quantities sufficient to produce explosive or ignitable mixtures, or
    - (2) An area where **mechanical failure could simultaneously cause** explosive/ignitable mixtures of combustible dusts to be produced **and** could provide a source of ignition, or
    - (3) An area where there's enough "Group E" combustible dusts (which are certain metallic dusts) present sufficient to be hazardous.
    - See *NEC* 500.6 for Material Groups, which is not covered in this presentation, but you may want to highlight such section in your *NEC*.



Wikipedia.org



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## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)
  **(C)(2)** Any of the following are considered as a Class II, Division **2** location:
  - (1) An area where combustible dust could be suspended in the air due to abnormal operations and would be in quantities sufficient to produce ignitable or explosive mixtures; or
  - (2) An area where combustible dust is present but are normally insufficient to become suspended in the air unless frequent malfunctioning of the equipment occurs; or
  - (3) An area where combustible dust accumulations could be sufficient to overheat equipment, or could be ignitable by abnormal operation or failure of electrical equipment.


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## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)
  - **500.5(D)** Class III locations are areas where easily ignitable fibers or flyings are present.
    - Such fibers and/or flyings are also not suspended in air in quantities enough to produce an ignitable mixture.
  - Class III locations include the areas noted in *NEC* 500.5(D)(1) and (D)(2).


Wikipedia.com



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## Classifications of [Hazardous] Locations (cont.)

- NEC 500.5 (cont.)
  - **(D)(1)** A Class III, Division 1 location is an area where easily ignitable fibers/flyings are handled, manufactured, or used.
  - **(D)(2)** A Class III, Division **2** location is an area where easily ignitable fibers/flyings are stored or handled (but not manufactured).


Wikipedia.com/flagstaffotos.com.au

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## Protection Techniques

- NEC 500.7 – Protection Techniques
- NEC Section 500.7(A) through (P) gives a list of “acceptable protection techniques” for electrical and electronic equipment in hazardous/classified locations.

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## Protection Techniques (cont.)

- NEC 500.7 (cont.)
  - Explosionproof Equipment
  - Dust Ignitionproof
  - Dusttight
  - Purged and Pressurized
  - Intrinsic Safety
  - Nonincendive Circuit
  - Nonincendive Equipment
  - Nonincendive Component
  - Oil Immersion
  - Hermetically Sealed
  - Combustible Gas Detection System
  - Other Protection Techniques

**New for the 2020 *NEC*** was added (L) Inherently Safe Optical Radiation, (M) Protected Optical Radiation, (N) Optical System with Interlock, (O) Protection by Skin Effect Trace Heating.

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## Protection Techniques (cont.)

- NEC 500.7 (cont.)
  - **(A) Explosionproof Equipment.** This method is allowed as a protection technique for equipment in a Class I, Division I or II location.
  - **(B) Dust Ignitionproof.** This method is allowed as a protection technique for equipment in a Class II, Division I or II location.
  - **(C) Dusttight.** This method is allowed as a protection technique for equipment in a Class II, Division II, or a Class III, Division I or II location.




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## Protection Techniques (cont.)

- NEC 500.7 (cont.)
  - **(D) Purged and Pressurized.** This method is allowed as a protection technique for equipment in any hazardous location which it's identified to be used in.
  - **(E) Intrinsic Safety.** This method is allowed as a protection technique for equipment in a Class I, Division I or II location; or Class II, Division 1 or 2; or Class III, Division 1 or 2 locations.
    - The requirements of *NEC* Articles 501 through 503 and Articles 510 through 516 do not apply to such installations. However applicable requirements of *NEC* Article 504 (for intrinsic safety equipment) do apply.

(see the additional protection techniques noted in *NEC* 500.7(F) through (P))

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## Equipment

- NEC 500.8 – Equipment
- NEC Articles 500 through 504 specify equipment, construction, and installation requirements which ensure safe performance under conditions of proper use and maintenance.


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## Equipment (cont.)

- **NEC 500.8 (cont.)**
  - **(A)** One of the following must be used to determine suitability of identified equipment:
    - The listing or labeling of equipment.
    - An equipment evaluation from a qualified testing laboratory or inspection agency.
    - Any other evidence such as a manufacturer's self-evaluation or an owner's engineering judgment, as long as such information is acceptable to the authority having jurisdiction.

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## Equipment (cont.)


For specific requirements regarding control switches in class 1 areas, see NEC 501.115




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## Equipment (cont.)


Thermostat



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## Equipment (cont.)


For specific requirements regarding receptacles in Class 1 areas, see NEC 501.145.



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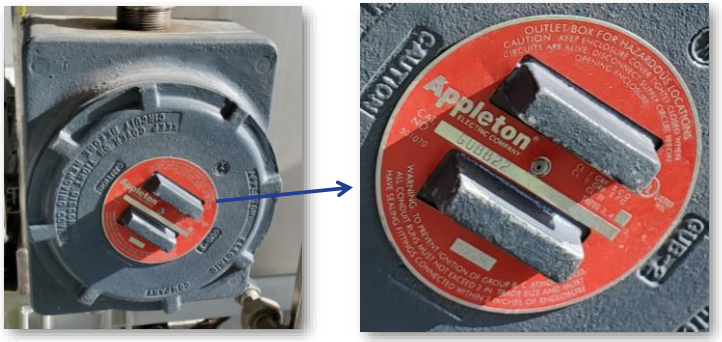
## Equipment (cont.)

For specific requirements regarding junction boxes in Class 1 areas, see either NEC 501.10(A)(3) [Class 1, Div 1], or 501.10(B)(4) [Class 1, Div 2].



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## Equipment (cont.)

For specific requirements regarding luminaires (light fixtures) in Class 1 areas, see NEC 501.130.


**For an explanation of equivalent maximum surface temperature based on T-ratings, see NEC 500.8(C).**



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## Equipment (cont.)





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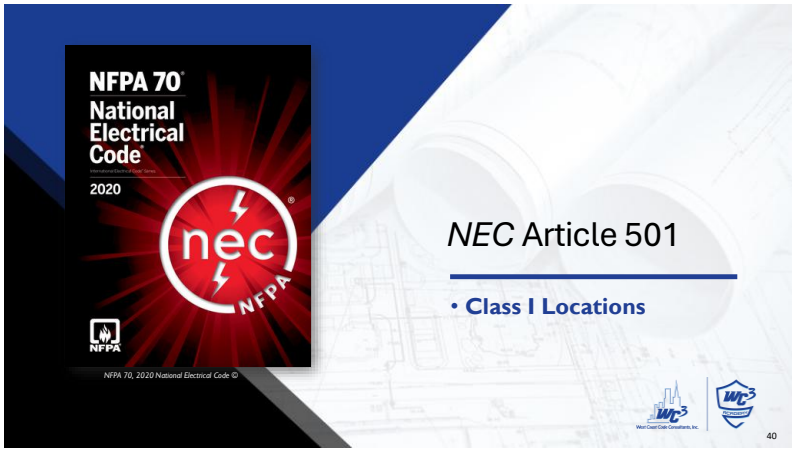


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## Class I locations


Euro Quality Coatings, Wikipedia.org


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## Zone [Rated] Equipment

- NEC 501.5 – Zone (Rated) Equipment
  - Equipment which is listed (and marked) for use in "Zone" 0, 1, or 2 locations is allowed to be used in Class I, Division 2 locations as long as it's for the same type of gas and has a suitable temperature class.
  - Equipment which is listed (and marked) for use in "Zone" 0 locations is allowed to be used in Class I, Division 1 or 2 locations as long as it's for the same type of gas and has a suitable temperature class. [see also *NEC* 505.9(C)(2)]

**Note:** Be aware that *NEC* Articles 505 and 506 deal with hazardous "zones". They're an alternative to the "division" classification system.

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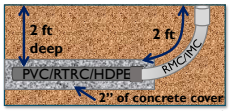
## Wiring Methods

- NEC 501.10 – Wiring Methods
  - The wiring methods for a Class I location must be per either *NEC* 501.10(A) or (B).

    **(A) Class I, Division 1:**
  - **(1)** The following wiring methods are allowed in a Class I, Division 1 location:
    - Threaded rigid metal conduit (RMC) or threaded steel intermediate metal (IMC) conduit. (see exception for PVC, RTRC, and HDPE conduit)
    - (b) Type MI cable with fittings listed for the location they're installed.

***NEC* 501.10(A)(1)(1) exception:**



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## Wiring Methods (cont.)

- NEC 501.10 (cont.)

  Allowable wiring methods in a Class I, Division I location (continued):
  - Type **MC-HL** cable can be used as long as it complies with all of the following:
    - Is listed for use in Class I, Zone 1 or Division 1 locations
    - Has a gas/vapor tight continuous corrugated metallic sheath
    - Has an overall jacket of suitable polymeric material
    - Has a separate equipment grounding conductor(s)
    - Termination connections must also be listed for the application.
    - Only allowed in industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation

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## Wiring Methods (cont.)

- NEC 501.10 (cont.)

  Allowable wiring methods in a Class I, Division I location (continued):
  - Type **ITC-HL** cable can be used as long as it complies with all of the following:
    - Has a gas/vapor tight continuous corrugated metallic sheath
    - Has an overall jacket of suitable polymeric material
    - Is terminated with fittings listed for the application
    - Only allowed in industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation
    - And installed in accordance with the provisions of Article 727.

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## Wiring Methods (cont.)

- NEC 501.10 (cont.)

  Allowable wiring methods in a Class I, Division I location (continued):
  - Optical fiber cables of types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC are allowed to be installed in raceways (as long as the raceway is one of the types noted per *NEC* 501.10(A)).
    - However, the optical fiber cables are required to be sealed per *NEC* 501.15.

2020
- Type TC-ER-HL cable.

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- Type P cable with metal braid armor.

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## Wiring Methods (cont.)

- NEC 501.10 (cont.)

  **(A)(2) Flexible Connections (in a Class 1, Division 1 area)**
  - The following flexible connections are permitted to be used when necessary for the equipment being supplied:
    - Flexible fittings which are listed for the location, or
    - Flexible cords which are terminated with cord proper cord connectors that are listed for the location (and must meet *NEC* 501.140), or
    - Listed TC-ER-HL cable can be used as long as the following is met:
      - Limited only up to 600 volts, nominal,
      - Not subject to physical damage,
      - Must be terminated with fittings listed for the location,
      - Listed for use in Class1, Div 1 or Zone 1 locations,
      - And is only allowed in in industrial establishments which has restricted public access and where the conditions of maintenance and supervision ensure that only qualified persons service the installation

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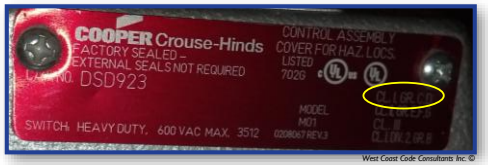
## Wiring Methods (cont.)

- NEC 501.10 (cont.)
- (A)(3) All boxes and fittings in a Class 1 Division 1 location must be approved for such locations.

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## Wiring Methods (cont.)

***NEC* 501.10(B): Class I, Division II locations**

- **(B)(1)** The following wiring methods are allowed in Class I, Division **2** locations:
  - Any of the wiring methods noted in 501.10(A) (for Class I, Division 1 areas).
  - Rigid metal conduit (RMC) and intermediate metal conduit (IMC) with listed thread-less fittings.
  - Any enclosed gasketed busways or enclosed gasketed wireways.
  - Type PLTC and Type PLTC-ER cable. The cable must be terminated with listed fittings (and must meet the requirements of *NEC* Article 725).
  - Type ITC and Type ITC-ER cable which is terminated with listed fittings (and meets the requirements of *NEC* Article 727).

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## Wiring Methods (cont.)

- NEC 501.10 (cont.)
  - Allowable wiring methods in a Class I, Division II location (continued):
    - Type MC, MV, TC, or TC-ER cable can be used, including in cable trays if 501.10(B)(1) requirements met.
    - Where metal conduit can't be used due to corrosive environment, the limited use of RTRC, PVC coated RMC or IMC, and PVC schedule 80 in industrial facilities (see requirements next slide for non-metallic conduit).


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## Wiring Methods (cont.)

- NEC 501.10 (cont.)
  Allowable wiring methods in a Class I, Division II location (continued):
  - Listed reinforced thermosetting resin conduit **(RTRC)** (marked with "-XW") or Schedule 80 PVC can be used as long as all of the following is met:
    - Where metallic conduit does not provide sufficient corrosion resistance
    - Listed factory elbows and associated fittings are required
    - Only allowed in industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation

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## Wiring Methods (cont.)

- NEC 501.10 (cont.)
  Allowable wiring methods in a Class I, Division II location (continued):
  - Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC are allowed to be installed in cable trays (or any of the acceptable raceways noted in *NEC* 501.10(B)).
    - However optical fiber cables are required to be sealed in per *NEC* 501.15.

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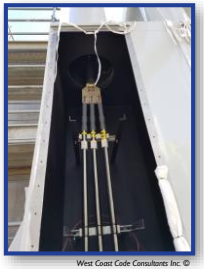
## Wiring Methods (cont.)

- NEC 501.10 (cont.)

  Allowable wiring methods in a Class I, Division II location (continued):
  - Cablebus is also permitted to be used in a Class I, Division II area.
  - Type P cable is also allowed under limited use.

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## Wiring Methods (cont.)

- NEC 501.10 (cont.)
  - **(B)(2) Flexible Connections (in a Class I, Division II area)**
  - The following flexible connections are permitted to be used when necessary for the equipment being supplied:
    - Listed flexible metal fittings.
    - Flexible metal conduit with listed fittings.
    - Type MC cable with interlocked armor and with listed fittings.
    - Liquidtight flexible metal conduit with listed fittings.
    - Liquidtight flexible nonmetallic conduit with listed fittings.
    - Flexible cord listed for extra-hard usage and terminated with listed fittings. There must also be within the cord an equipment grounding conductor.
    - Identified elevator cable of Type EO, ETP, or ETT (see *NEC* Table 400.4) which is listed for hazardous (classified) locations and is terminated with listed fittings.

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## Wiring Methods (cont.)

- NEC 501.10 (cont.)
- (B)(4) Boxes and fittings in a Class I, Division II location are NOT required to be explosionproof except as required per NEC 501.105(B)(2), 501.115(B)(1), and 501.150(B)(1).

**Note:** the above noted *NEC* sections deal with switches, circuit breakers, make-and-break contacts of switches, relays, alarm bells, and horns. It also includes motor controllers and fuses.


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## Sealing and Drainage

- NEC 501.15 – Sealing and Drainage
  - Seals in conduit (and cable systems) are required to comply with *NEC* 501.15(A) through (F).
  - Sealing compound is also required for Type MI cable termination fittings (this is to prevent moisture and other fluids from entering the cable insulation).

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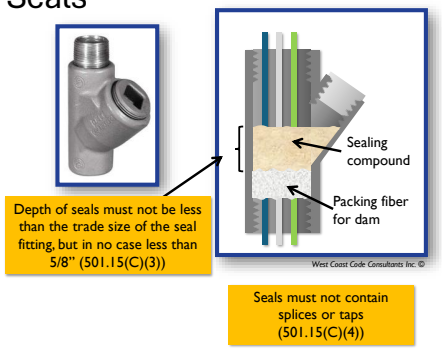
## Conduit Seals



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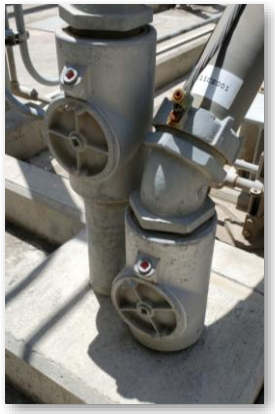
## Conduit Seals

Check out the size of these seals!!





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## Sealing and Drainage (cont.)

- NEC 501.15 (cont.)
  - **(A) Conduit Seals for Class I, Division 1 locations.**
  - For Class I, Division 1 locations, conduit seals are required to be located per *NEC* 501.15(A)(1) through (A)(4).

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## Sealing and Drainage (cont.)

- NEC 501.15 (cont.)
  - **(A)(1) Seals at Class 1, Div 1:** Every conduit which enters an explosion proof enclosure is required to have a conduit seal in any of the following conditions (items 1 or 2):
    - **(1)** The enclosure contains items such as switches, circuit breakers, fuses, relays, or resistors, or anything that may produce arcs or sparks, or can have temperatures which exceed 80% of the autoignition temperature of the gas or vapor present in such area of the equipment.
    - See exception for the above noted requirements (for hermetically sealed equipment, immersed in oil, factory sealed, or part of a nonincendive circuit).

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## Sealing and Drainage (cont.)

- NEC 501.15 – Seals at Class 1, Div 1 (cont.)
  - **(A)(1)(2)** If the conduit entering the box is metric designator 53 **(trade size 2) or larger**, and the enclosure has wire terminals, splices, or taps (seals must be provided).
  - An enclosure which is marked "Leads Factory Sealed", or "Factory Sealed," or "Seal not Required," or the equivalent cannot be considered to serve as a seal for another adjacent enclosure that is required to have a conduit seal.

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## Sealing and Drainage (cont.)

- An enclosure which is marked "Leads Factory Sealed", or "Factory Sealed," or "Seal not Required," or the equivalent cannot be considered to serve as a seal for another adjacent enclosure that is required to have a conduit seal.


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## Sealing and Drainage (cont.)

- NEC 501.15 (cont.)
  - Conduit seals must be installed within **18 inches** from the enclosure **OR as noted on the enclosure marking**.
  - Only explosionproof unions, couplings, reducers, elbows, and capped elbows are allowed to be installed between the sealing fitting and the explosionproof enclosure.

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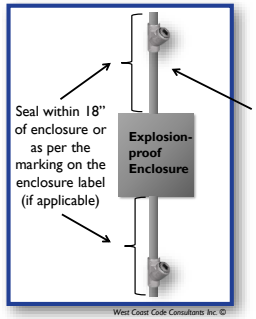
## Sealing and Drainage (cont.)

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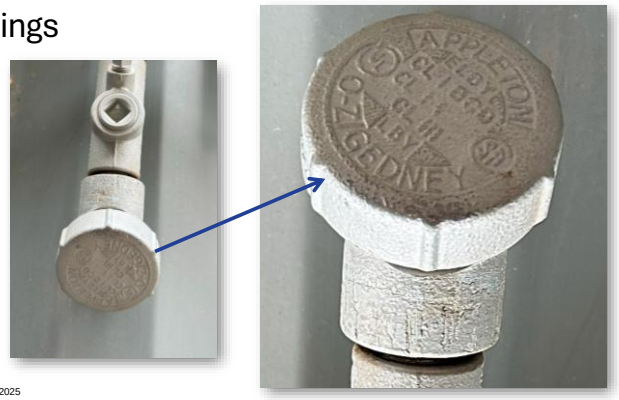
## Fittings



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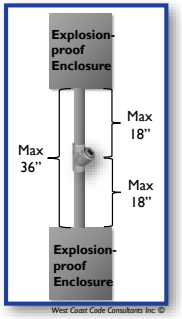
## Sealing and Drainage (cont.)

*NEC* 501.15(A)(3)(cont.)

- A single conduit seal can be used between two separate enclosures (which require seals) as long as the conduit between the two enclosures is not longer than 36" and the conduit seal is within 18" of each enclosure.

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## Sealing and Drainage (cont.)

- NEC 501.15 (cont.)

  **(A)(4) Boundary Seals for Class I, Division 1 locations.** A conduit seal is required for every conduit leaving a Division 1 location.

  - The seal fitting can installed on either side of the boundary, but must be within 10 feet of the boundary. Such boundary seal is required to minimize any gas or vapor traveling down the conduit into other areas of the building.
  - For the conduit, there cannot be any unions, couplings, box or other fittings installed between the conduit seal and the point at which the conduit leaves the Division1 location (except a listed explosionproof reducer installed at the conduit seal is permitted).

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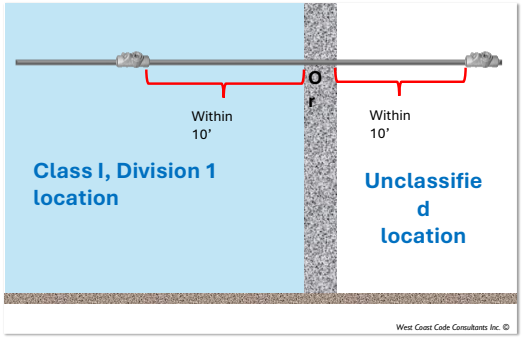
Seal within 10' of either side of boundary [*NEC* 501.15(A)(4)]

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## Sealing and Drainage (cont.)

- *NEC* 501.15(A)(4) Class I, Division 1 Boundary Seals (cont.)
  - **Exception #1:** Unbroken (continuous) lengths metal conduit which contains no unions, couplings, boxes, or fittings, that passes completely through a Division 1 location is permitted to NOT have boundary seals if the conduit only terminates in unclassified locations. Any fittings also cannot be installed within **12 inches** of either side of the boundary.
  - **Exception #2:** When conduit is installed underground and where the boundary is below grade, the sealing fitting is allowed to be installed after the conduit emerges from grade, but there cannot be any unions, couplings, boxes, or fittings, in the conduit between the sealing fitting and the point at which the conduit emerges from below grade.

For conduit seals in Class I, Division 2 locations see *NEC* 501.15(B)

69

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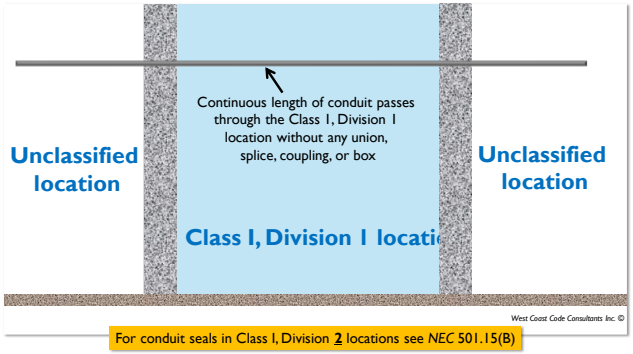
## Seals not required:




For conduit seals in Class I, Division **2** locations see *NEC* 501.15(B)

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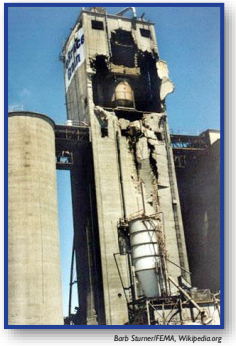
## Class II Locations


Wikipedia.org


Barb Sturm/FEMA, Wikipedia.org

72

## 502.5 Explosionproof Equipment

- NEC 502.5 – Explostionproof Equipment
- Explosionproof equipment and wiring is not required and is also not be acceptable in **Class II locations** unless also identified for such locations.


73

73

## Wiring Methods

- NEC 502.10 – Wiring Methods
  - Wiring methods Class II area are required to comply with *NEC* 502.10(A) or (B).
  - **(A)** In **Class II, Division 1** locations, the following wiring methods are allowed:
    - Threaded rigid metal conduit (RMC), or threaded steel intermediate metal conduit (IMC).
    - Type **MI cable** with termination fittings listed for the location.
    - Type **MC-HL cable** which is listed for use in Class II, Division 1 locations can be used as long as the following is also met:
      - Only allowed in industrial establishments with limited public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation,
      - It has a a gas/vapor tight continuous corrugated metallic sheath,
      - Has an overall jacket of suitable polymeric material,
      - Has a separate equipment grounding conductor(s)
      - And is terminated with fittings listed for the location.

74

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## Wiring Methods (cont.)

NEC 502.10 (cont.)

- Allowable wiring methods in a Class II, Division I location (continued):
- Optical fiber cables Types OFNP, OFCP, OFNR,OFCR, OFNG, OFCG, OFN, and OFC are allowed as long as they're installed in one of the permitted conduits noted in *NEC* 502.10(A). Optical fiber cables must also be sealed per *NEC* 502.15.
- Listed Type ITC-HL cable is permitted as long as the following is met:
  - Only allowed in industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation,
  - Has a gas/vapor tight continuous corrugated metallic sheath
  - Has an overall jacket of suitable polymeric material,
  - Terminated with fittings listed for the application,
  - And installed per the applicable requirements of *NEC* Article 727.

2020 • Limited use of TC-ER-HL and Type P cable added.

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## Wiring Methods (cont.)

- NEC 502.10 (cont.)
  - **Flexible Connections (for a Class I, Division I locations)**
  - When flexible connections are required, any of the following is permitted:
    - Dusttight flexible connectors.
    - Liquidtight flexible metal conduit with listed fittings.
    - Liquidtight flexible nonmetallic conduit with listed fittings.
    - Interlocked armor Type MC cable (which has an overall outer jacket) and terminated with fittings listed for Class II, Division 1 locations.
    - Flexible cords listed for extra-hard usage and terminated with listed dusttight cord connectors. Flexible cords must also meet the requirements of *NEC* 502.140.
    - Identified elevator cable of Type EO, ETP, or ETT and terminated with listed dusttight fittings.

2020 • Limited use of TC-ER-HL cable and Type P cable.

76

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## Wiring Methods (cont.)

- NEC 502.10 (cont.)
  - **(A)(3)** Boxes and fittings are required to have threaded bosses for connections to conduit or cable terminations and connections must be dusttight.
  - When there are taps, joints, or terminal connections in boxes or fittings, or if the boxes or fittings are located in a Group 'E' location (certain combustible metal dusts), such boxes or fittings must be "**identified**" for Class II locations.

**See the definition of "identified" in *NEC* Article 100.**

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## *NEC* Article 100

NEC Article 100 – Definition of "Identified"

- "Recognizable as suitable for the specific purpose, function, use, environment, application, and so forth, where described in a particular *Code* (*NEC*) requirement."
- The informational note says: "Some examples of ways to determine suitability of equipment for a specific purpose, environment, or application include investigation by a qualified testing laboratory (listing and labeling), an inspection agency, or other organizations concerned with product evaluation."

**See also *NEC* 500.8(A), which has ideas for determining suitability of "identified" equipment, such as requiring certificates demonstrating compliance.**

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## Wiring Methods (cont.)

- NEC 502.10 (cont.)
  - **(B)** In **Class II, Division 2** locations, the following wiring methods are allowed:
    - All the same wiring methods allowed per *NEC* 502.10(A).
    - Rigid metal conduit (RMC), intermediate metal conduit (IMC), electrical metallic tubing (EMT), or dusttight wireways.
    - Type MC, MV, TC, or TC-ER cable with listed termination fittings.
    - Type PLTC and Type PLTC-ER cable (meeting *NEC* Article 725), including installation in cable tray systems. The cable shall be terminated with listed fittings.
    - Type ITC and Type ITC-ER cable (per *NEC* 727.4) and terminated with listed fittings.
    - Reinforced thermosetting resin conduit (RTRC) factory elbows and fittings under specific circumstances (see *NEC* 502.10(B)(1)(7))
    - PVC coated IMC or RMC.
    - Schedule 80 PVC (limited use)
    - Certain types of optical fiber cables (see *NEC* 502.10(B)(1)(8)).
    - Cablebus
    - Type P cable (limited use).

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## Wiring Methods (cont.)

- NEC 502.10(B)(2) (for Class II, Division 2 locations)
  - When flexible connections are required, see *NEC* 502.10(A)(2).
  - **(B)(4)** All boxes and fittings are required to be dust-tight.

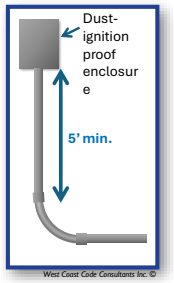
See *NEC* Table 110.28 for enclosure types (for under 600V)

Image from cablejoints.co.uk

80

## Seals for Class II, Divisions 1 and 2 locations:

- NEC 502.15 – Seals for Class II…
  - When there's a conduit (or raceway) between an enclosure that is required to be dust-ignitionproof and an enclosure that is <u>not</u> required to be ignitionproof, of the following means must be provided to prevent dust from entering the dust-ignitionproof enclosure:
    - 1. An "effective" and permanent seal
    - 2. The raceway (conduit) is longer than 10' horizontally
    - 3. A 5' (or longer) vertical raceway and also extends downward from the dust-ignitionproof enclosure
    - 4. Or a raceway installed which would be equivalent to items #2 or #3 noted above.
    - See additional information on next slide.

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## Seals for Class II, Divisions 1 and 2 locations (cont.):

- NEC 502.15 (cont.)
  - When the raceway is connected between an enclosure that must be dust-ignitionproof and the other enclosure is located in an unclassified location, seals are not required.
  - Sealing fittings are required to be accessible.
  - The seals are <u>not</u> required to be the explosionproof type.
  - The informational note says that electrical sealing putty is one method of making a seal.

Note: this presentation does <u>not</u> cover Article 503 (Class III locations).


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## 5<u>10</u>.2 – General (how to apply the requirements of *NEC* Articles 511 through 517):

- (Before beginning) NEC 510.2 – General
  - *NEC* 510.2 says that the general rules of Articles 500 through 504 apply to wiring and equipment in hazardous locations noted in Articles 511 through 517.
  - However, if a more specific requirement is noted under Articles 511 through 517, then such requirements would apply.

***NEC* Articles:**
**511** – Commercial Garages, Repair and Storage
**513** – Aircraft Hangers
**514** – Motor Fuel Dispensing Facilities
**515** – Bulk Storage Plants
**516** – Spray Application, Dipping, Coating, Printing Using Flammable or Combustible Materials
**517** – Health Care Facilities

84

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## Commercial garages


Ildar Sagdejev, Wikipedia.org


Berezhnyi, Wikipedia.org

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## Scope

- NEC 511.1 – Scope
- NEC Article 511 applies to occupancies which include areas used for service and repair operations for vehicles (which includes, but is not limited to, passenger automobiles, buses, trucks, and tractors) AND in which volatile flammable liquids or flammable gases are used for fuel or power of the vehicles.

86

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## Definitions

- NEC Definitions (see Part III of Article 100)
- Major Repair Garage. "A building or portions of a building where major repairs, such as engine overhauls, painting, body and fender work, and repairs that require draining of the motor vehicle fuel tank are performed on motor vehicles, including associated floor space used for offices, parking, or showrooms."

NFPA 70, *National Electrical Code* ©


Mouleesha – Wikipedia.org

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## Definitions (cont.)

- Minor Repair Garage. "A building or portions of a building used for lubrication, inspection, and minor automotive maintenance work, such as engine tune-ups, replacement of parts, fluid changes (e.g., oil, antifreeze, transmission fluid, brake fluid, air-conditioning refrigerants), brake system repairs, tire rotation, and similar routine maintenance work, including associated floor space used for offices, parking, or showrooms."

NFPA 70, *National Electrical Code* ©

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## Area Classification (General Requirements)

- NEC 511.3 – Area Classification General Requirements
  - In locations where Class I liquids or gaseous fuels are stored, handled, or transferred, the electrical wiring and electrical utilization equipment must be designed in accordance with the requirements for Class I, Division 1 or 2 hazardous (classified) locations as classified in accordance with ***NEC* 500.5 and 500.6, and *NEC* Article 511**.
  - A Class I location cannot extend beyond an unpierced wall, roof, or other solid partition which has no openings.

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## Area Classification (cont.)

- NEC 511.3 (cont.)
- (A) Parking garages which are used for parking or storage are allowed to be unclassified locations.

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## Area Classification (cont.)

- **NEC 511.3(B) – Repair Garages With Dispensing**

  Any major or minor repair garages that dispense motor fuels into the fuel tanks of vehicles, must have the dispensing functions and components classified in accordance with ***NEC* Table 514.3(B)(1)** (Article for fuel dispensing facilities) in addition to any classification required by Article 511 of the *NEC*.
  - The types of fuels the above noted requirement is talking about includes flammable liquids having a flash point below 38°C (100°F) such as gasoline, or gaseous fuels such as natural gas, hydrogen, or LPG.
- Where Class I liquids (other than fuels) are dispensed, the area within **3 feet** of any fill or dispensing point, extending in all directions, is required to be a **Class I, Division 2 location**.

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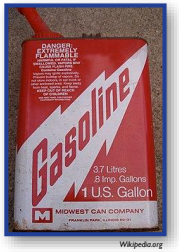
## Area Classification (cont.)

- NEC 511.3(C)(cont.)
- In major or minor repair garages where vehicles using Class I liquids (including gasoline) or heavier-than-air gaseous fuels (such as LPG) are repaired, the hazardous classification of the area must be per NEC Table 511.3(C).




Wikipedia.org

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## Area Classification (cont.)

- NEC 511.3(D)(cont.)
- In major repair garages where vehicles using lighter-than- air gaseous fuels (hydrogen and natural gas are examples of such types of gases) are repaired or stored, the hazardous classification of the area must be per NEC Table 511.3(D).


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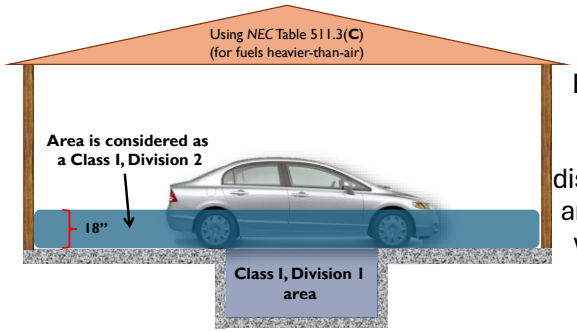


Example: Major repair garage with fuel dispensing/draining and NOT provided with ventilation:

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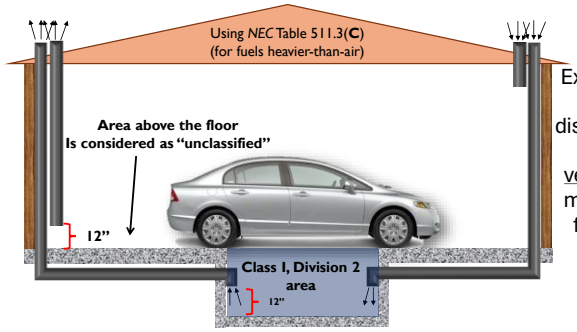


Example: Major repair garage with fuel dispensing/draining and provided with ventilation of 1ft$^3$/per minute/per sq. foot of floor space (ie. 4 air changes per hour):

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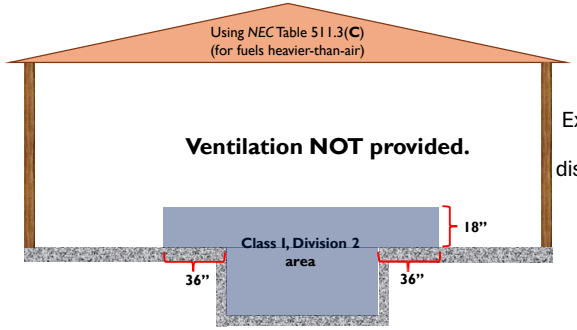


Example: Minor repair garage without fuel dispensing/draining and NOT provided with ventilation:

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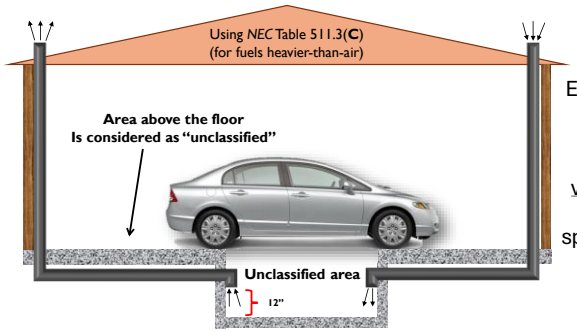


Example: Minor repair garage without fuel dispensing/draining and provided with ventilation of 1ft$^3$/per min./per ft$^2$ of floor space (ie. 4 air changes per hour):

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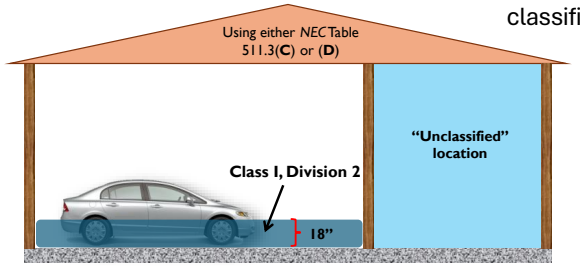
Areas adjacent to classified locations:




Areas adjacent to classified locations where flammable vapors are not likely to be released, where mechanically ventilated at a rate of four or more air changes per hour **or** designed with positive air pressure **or** where effectively cut off by walls or partitions

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## Lighter-than-air fuels:

- For major repair garages (where lighter-than-air gas fueled vehicles are repaired or stored) see NEC Table 511.3(D).

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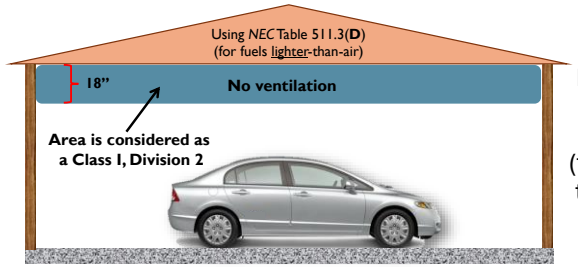


Example: Major repair garage where vehicles (fueled by lighter-than-air gas) are stored or repaired:

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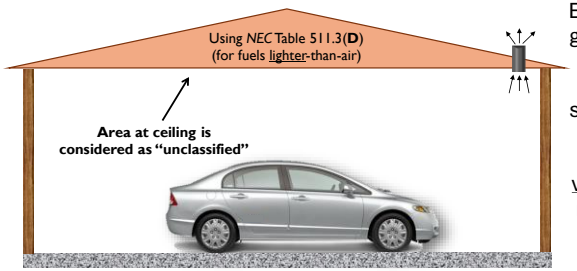


Example: Major repair garage where vehicles (fueled by lighter-than-air gas) are stored or repaired, but such areas are provided with ventilation of $1ft^3$/per min./per $ft^2$ at ceiling (ie. 4 air changes per hour):

101

101

## Wiring and Equipment Above a Class I Location:

- **NEC 511.7 – Wiring and Equipment…**
  - **(A)(1)** Any fixed wiring above a Class I location must be in metal raceways, rigid non-metallic conduit, ENT, EMT, FMC, LFMC, LFNC.
  - The wiring could also be MC cable, AC cable, MI cable, PLTC cable, TC cable, or ITC cable. (see also the requirements if cellular floor raceways are used)

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## Wiring and Equipment Above a Class I Location (cont.):

- NEC 511.7(B)(1) Fixed equipment must be located above a Class I location or must be identified for such location.
  - If equipment is less than **12 feet** above the floor and such equipment can produce sparks, arcs, or pieces of hot metal (which includes cutouts, switches, charging panels, generators, motors, BUT NOT counting receptacles, lamps, or lampholders), such equipment must be the **totally enclosed type or be constructed to prevent the escape of sparks or hot metal**.
  - Lamps and Lampholders mounted over areas where vehicles are driven, or are located where they could be damaged, must be mounted more than 12 feet above the floor, **or** they must be the totally enclosed type or be constructed so to prevent the escape of sparks or hot metal.

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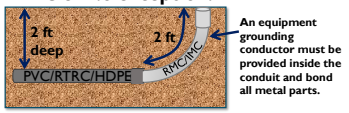
## Wiring Underground

- NEC 511.8 – Wiring Underground Below Class I Location
- Any wiring located underground must be installed in threaded rigid metal conduit (RMC) or intermediate metal conduit (IMC).

***NEC* 511.8 exception:**

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## GFCI Protection for Personnel

- NEC 511.12 – GFCI Protection for Personnel
- Any 15A or 20A receptacles (at 125V) must be provided with GFCI protection where required per NEC 210.8(B).

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## Motor Fuel Dispensing Facilities



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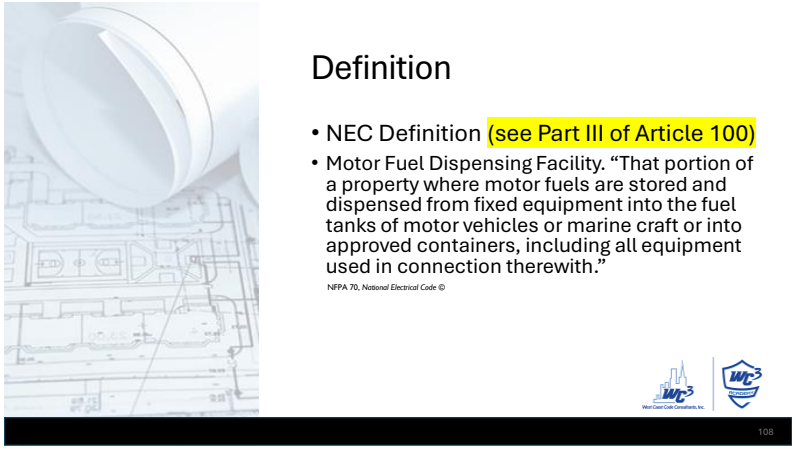


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## Location Classifications

- **NEC 514.3(A)**
- When the AHJ determines that flammable liquids with a flash point less than 100˚F (such as gasoline) will not be handled, then such location can be unclassified.

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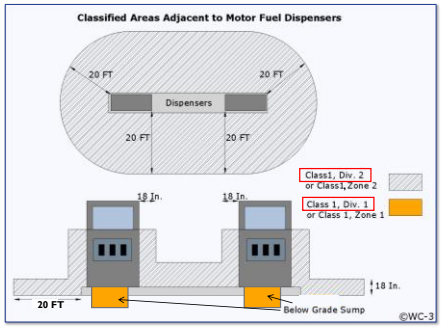
## Location Classifications (cont.)

- **NEC 514.3(B)(1)**
  - Deals with areas where **Class I liquids** are stored, handled, or dispensed, use *NEC* Table 514.3(B)(1) to determine classification for certain areas.
    - When dealing with above storage tanks, see also *NEC* Table 515.3.
- **NEC 514.3(B)(2)**
  - Deals with areas where compressed natural gas (CNG), liquified natural gas (LNG), LP-gas, or hydrogen gas are dispensed for motor vehicles.
    - When CNG or LNG (which is lighter-than-air gases) fuel dispensers are installed under a canopy (or other enclosure), such canopy must be designed so to not allow accumulation of the gas, or the area beneath the canopy must be a Class I, Division 2 hazardous location.

110

## *NEC* Figure 514.3

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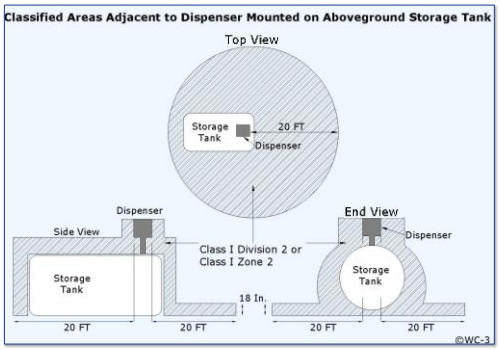
## *NEC* Figure 514.3(B)




**See also *NEC* Tables 514.3(B)(1) and (B)(2) for classifications of individual locations and around specific equipment**

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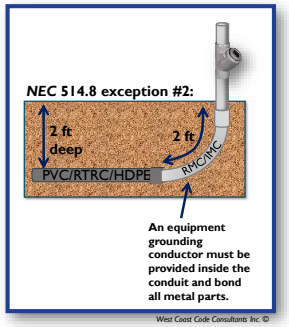
## Wiring Underground

- NEC 514.8 – Wiring Underground
  - Any wiring located underground must be installed in threaded rigid metal conduit (RMC) or intermediate metal conduit (IMC).
  - Seals are required at each end of the conduit (within 10' of where the conduit emerges from grade) where such conduit extends under a Class I, Division 1 or 2 location.

(See also *NEC* 514.9 for seals)




113

## Conduit Seals



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## Disconnects (for Fuel Dispensers)

- **NEC 514.11(A) – Disconnects**
  - Every fuel dispenser is required to have a clearly identified emergency shutoff device or disconnect.
  - Such disconnect is required to be located not less than **20 feet**, but not more than **100 feet** from the dispenser it serves.
  - The required disconnect must disconnect any other pump which serves the dispenser and must also shut off all power, control, and signal circuits to the dispenser. (this also **includes the grounded or neutral conductors**)
  - If multiple disconnects are provided, they must all be interconnected.
  - Resetting of the devices must be per manual means as permitted by the AHJ.

(see also NEC 514.13 for additional disconnect requirements for maintenance of the equipment)

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## Disconnects (for Fuel Dispensers)(cont.)

- **NEC 514.11(B)(cont.)**
- For a motor dispensing facility which is attended, the required disconnect(s) for the dispenser(s) must be readily accessible to the attendant.


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## Disconnects (for Fuel Dispensers)(cont.)

- **NEC 514.11(C)(cont.)**
- For a motor dispensing facility which is NOT attended, the required disconnect(s) for the dispenser(s) must be readily accessible to the patron (ie. the person using the dispenser), and there must also be an additional readily accessible disconnect to each group of dispensers on an individual island.

Pilla Electrical Products, Inc


West Coast Code Consultants Inc. ©

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## Grounding/Bonding

- NEC 514.16 – Grounding/Bonding
  - All metal parts, metal raceways, or metallic sheaths of cables must be bonded together and be grounded.
  - When bonding in a Class I location, the requirements of *NEC* 501.30 must also be met.


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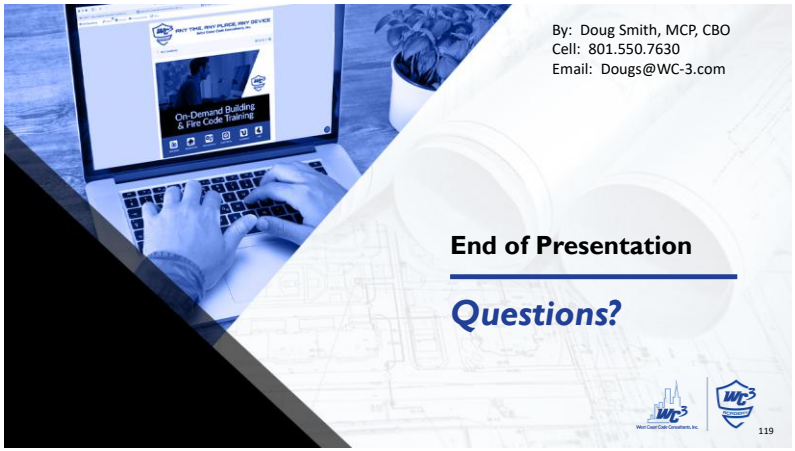


By: Doug Smith, MCP, CBO
Cell: 801.550.7630
Email: Dougs@WC-3.com

**End of Presentation**

***Questions?***

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