

Δ **480.12 Battery Interconnections.** Flexible cables, as identified in Table 400.4, in sizes 2/0 AWG and larger shall be permitted within the battery enclosure from battery terminals to a nearby junction box where they shall be connected to an approved wiring method. Flexible battery cables shall also be permitted between batteries and cells within the battery enclosure. Such cables shall be listed and identified for the environmental conditions. Flexible, fine-stranded cables shall only be used with terminals, lugs, devices, or connectors in accordance with 110.14.

480.13 Ground-Fault Detection. Battery circuits exceeding 100 volts between the conductors or to ground shall be permitted to operate with ungrounded conductors, provided a ground-fault detector and indicator is installed to monitor for ground faults.

ARTICLE

N 495 Equipment Over 1000 Volts ac, 1500 Volts dc, Nominal

N Part I. General

N **495.1 Scope.** This article covers the general requirements for equipment operating at more than 1000 volts ac, 1500 volts dc, nominal.

Informational Note No. 1: See NFPA 70E-2021, *Standard for Electrical Safety in the Workplace*, for electrical safety requirements for employee workplaces.

Informational Note No. 2: See ANSI Z535.4-2011, *Product Signs and Safety Labels*, for further information on hazard signs and labels.

Informational Note No. 3: See IEEE 3001.5-2013, *Recommended Practice for the Application of Power Distribution Apparatus in Industrial and Commercial Power Systems*, for information regarding power distribution apparatus.

In developing the 2023 edition of the *NEC*®, areas of former Article 490, Equipment Over 1000 Volts, Nominal, were modified and relocated to new Article 495, Equipment Over 1000 Volts ac, 1500 Volts dc, Nominal. Some portions of former Article 490 have also been relocated into other areas of the *NEC*. For example, former 490.21, which deals with circuit-interrupter devices, has been relocated to 245.21 of new Article 245, Overcurrent Protection for Systems Rated Over 1000 Volts ac, 1500 Volts dc.

The threshold voltage for the requirements covering higher voltage equipment has been revised from 600 volts to 1000 volts beginning in the 2014 edition of the *NEC* to recognize that standard configurations commonly used in alternative energy systems operate at over 600 volts for increased efficiency and performance. One of the most impactful effects of those changes throughout the *NEC* was revision of former Article 490 to apply to equipment rated over 1000 volts rather than over 600 volts,



EXHIBIT 495.1 Construction differences between two classes of equipment.

and with that change, product certification standards were able to be modified. One of the best examples of how that change affected products is the availability of disconnecting means (safety switches) that are rated for 1000 volts dc, rather than that class of equipment being limited to 600-volt applications because it did not meet the product safety requirements in former Article 490. Prior to the change, switches to interrupt ac or dc circuits rated over 600 volts would have had to meet the “medium voltage” equipment requirements contained in former Article 490.

Exhibit 495.1 illustrates the construction differences between two classes of equipment: a 5000-volt disconnecting means and a 1000-volt disconnecting means.

N **495.2 Reconditioned Equipment.** Except as modified within this article, reconditioned equipment shall not be permitted.

N **495.3 Other Articles.**

N **(A) Oil-Filled Equipment.** Installation of electrical equipment containing more than 38 L (10 gal) of flammable oil per unit shall meet the requirements of Parts II and III of Article 450.

N **(B) Enclosures in Damp or Wet Locations.** Enclosures in damp or wet locations shall meet the requirements of 312.2.

N Part II. Equipment — Specific Provisions

N **495.22 Isolating Means.** Means shall be provided to completely isolate an item of equipment from all ungrounded conductors. The use of isolating switches shall not be required where there

are other ways of de-energizing the equipment for inspection and repairs, such as draw-out-type switchgear units and removable truck panels.

Isolating switches not interlocked with an approved circuit-interrupting device shall be provided with a sign warning against opening them under load. The warning sign(s) or label(s) shall comply with 110.21(B).

An identified fuseholder and fuse shall be permitted as an isolating switch.

N 495.23 Voltage Regulators. Proper switching sequence for regulators shall be ensured by use of one of the following:

- (1) Mechanically sequenced regulator bypass switch(es)
- (2) Mechanical interlocks
- (3) Switching procedure prominently displayed at the switching location

N 495.24 Minimum Space Separation. In field-fabricated installations, the minimum air separation between bare live conductors and between such conductors and adjacent grounded surfaces shall not be less than the values given in Table 495.24. These values shall not apply to interior portions or exterior terminals of equipment designed, manufactured, and tested in accordance with accepted national standards.

N 495.25 Backfeed. Installations where the possibility of backfeed exists shall comply with 495.25(A) and (B).

N (A) Sign. A permanent sign in accordance with 110.21(B) shall be installed on the disconnecting means enclosure or immediately adjacent to open disconnecting means with the following words or equivalent:

DANGER — CONTACTS ON EITHER SIDE OF THIS
DEVICE MAY BE ENERGIZED BY BACKFEED.

N (B) Diagram. A permanent and legible single-line diagram of the local switching arrangement, clearly identifying each point of connection to the high-voltage section, shall be provided within sight of each point of connection.

N Part III. Equipment — Switchgear and Industrial Control Assemblies

N 495.30 General. Part III covers assemblies of switchgear and industrial control equipment, including, but not limited to, switches and interrupting devices and their control, metering, protection, and regulating equipment where they are an integral part of the assembly, with associated interconnections and supporting structures.

N TABLE 495.24 *Minimum Clearance of Live Parts*

Minimum Clearance of Live Parts										
Nominal Voltage Rating (kV)	Impulse Withstand, Basic Impulse Level (BIL) (kV)		Phase-to-Phase				Phase-to-Ground			
			Indoors		Outdoors		Indoors		Outdoors	
	Indoors	Outdoors	mm	in.	mm	in.	mm	in.	mm	in.
2.4–4.16	60	95	115	4.5	180	7	80	3.0	155	6
7.2	75	95	140	5.5	180	7	105	4.0	155	6
13.8	95	110	195	7.5	305	12	130	5.0	180	7
14.4	110	110	230	9.0	305	12	170	6.5	180	7
23	125	150	270	10.5	385	15	190	7.5	255	10
34.5	150	150	320	12.5	385	15	245	9.5	255	10
	200	200	460	18.0	460	18	335	13.0	335	13
46	—	200	—	—	460	18	—	—	335	13
	—	250	—	—	535	21	—	—	435	17
69	—	250	—	—	535	21	—	—	435	17
	—	350	—	—	790	31	—	—	635	25
115	—	550	—	—	1350	53	—	—	1070	42
138	—	550	—	—	1350	53	—	—	1070	42
	—	650	—	—	1605	63	—	—	1270	50
161	—	650	—	—	1605	63	—	—	1270	50
	—	750	—	—	1830	72	—	—	1475	58
230	—	750	—	—	1830	72	—	—	1475	58
	—	900	—	—	2265	89	—	—	1805	71
	—	1050	—	—	2670	105	—	—	2110	83

Note: The values given are the minimum clearance for rigid parts and bare conductors under favorable service conditions. They shall be increased for conductor movement or under unfavorable service conditions or wherever space limitations permit. The selection of the associated impulse withstand voltage for a particular system voltage is determined by the characteristics of the overvoltage(surge) protective equipment.

Indicator instruments, such as voltmeters, ammeters, wattmeters, and protective relays, can be mounted on the panel doors as desired. This switchgear affords a high degree of safety because all live parts are metal-enclosed, and interlocks are provided for safe operation.

N 495.31 Arrangement of Devices in Assemblies. Arrangement of devices in assemblies shall be such that individual components can safely perform their intended function without adversely affecting the safe operation of other components in the assembly.

N 495.32 Guarding of High-Voltage Energized Parts Within a Compartment. Where access for other than visual inspection is required to a compartment that contains energized high-voltage parts, barriers shall be provided to prevent accidental contact by persons, tools, or other equipment with energized parts. Exposed live parts shall only be permitted in compartments accessible to qualified persons. Fuses and fuseholders designed to enable future replacement without de-energizing the fuseholder shall only be permitted for use by qualified persons.

An example of a high-voltage pad-mounted transformer and enclosure that may contain primary and secondary switches or circuit breakers is shown in Exhibit 495.2. The high-voltage compartment on the left of the exhibit has bayonet fusing and a load-break transformer on/off switch, which are both hot-stick operated.

N 495.33 Guarding of Energized Parts Operating at 1000 Volts, Nominal, or Less Within Compartments. Energized bare parts mounted on doors shall be guarded where the door must be opened for maintenance of equipment or removal of draw-out equipment.

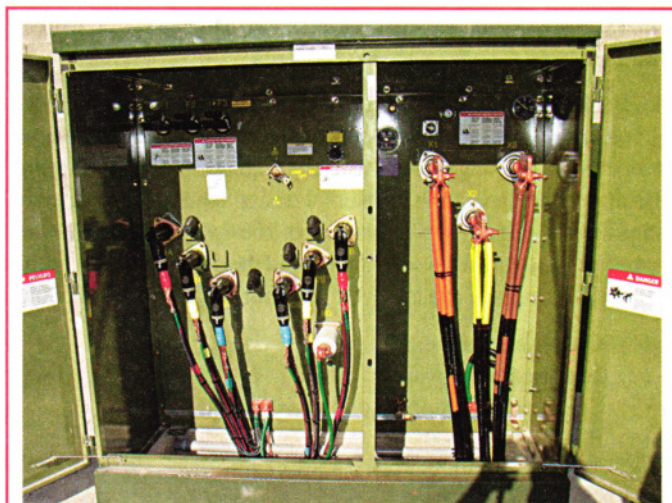


EXHIBIT 495.2 Open view of a tamperproof pad-mounted transformer for loop-feed application with load-break elbow connectors. (Courtesy of Schneider Electric)

N 495.34 Clearance for Cable Conductors Entering Enclosure.

The unobstructed space opposite terminals or opposite raceways or cables entering a switchgear or control assembly shall be approved for the type of conductor and method of termination.

N 495.35 Accessibility of Energized Parts.

N (A) High-Voltage Equipment. Doors that would provide unqualified persons access to high-voltage energized parts shall be locked. Permanent signs in accordance with 110.21(B) shall be installed on panels or doors that provide access to live parts over 1000 volts and shall read DANGER — HIGH VOLTAGE — KEEP OUT.

N (B) Control Equipment. Where operating at 1000 volts, nominal, or less, control equipment, relays, motors, and the like shall not be installed in compartments with high-voltage parts or high-voltage wiring, unless both of the following apply:

- (1) The access means is interlocked with the high-voltage switch or disconnecting means to prevent the access means from being opened or removed when the high-voltage switch is in the closed position or a withdrawable disconnecting means is in the connected position.
- (2) All high-voltage parts or high-voltage wiring in the compartment that remains energized when a fixed mounted high-voltage switch is in the open position or a withdrawable disconnecting means is in the isolating (fully withdrawn) position are protected by insulating or grounded metal barriers to prevent accidental contact with energized high-voltage parts or wiring.

N (C) High-Voltage Instruments or Control Transformers and Space Heaters. High-voltage instrument or control transformers and space heaters shall be permitted to be installed in the high-voltage compartment without access restrictions beyond those that apply to the high-voltage compartment generally.

N 495.37 Equipment Grounding Connections. The metal cases or frames, or both, such as those of instruments, relays, meters, and instrument and control transformers, located in or on switchgear or control assemblies, and the frames of switchgear and control assemblies shall be connected to an equipment grounding conductor or, where permitted, the grounded conductor, in accordance with 250.190.

N 495.38 Door Stops and Cover Plates. External hinged doors or covers shall be provided with stops to hold them in the open position. Cover plates intended to be removed for inspection of energized parts or wiring shall be equipped with lifting handles and shall not exceed 1.1 m² (12 ft²) in area or 27 kg (60 lb) in weight, unless they are hinged and bolted or locked.

N 495.39 Gas Discharge from Interrupting Devices. Gas discharged during operating of interrupting devices shall be directed so as not to endanger personnel.

N 495.40 Visual Inspection Windows. Windows intended for visual inspection of disconnecting switches or other devices shall be of suitable transparent material.

N 495.41 Location of Industrial Control Equipment. Routinely operated industrial control equipment shall meet the requirements of 495.41(A) unless infrequently operated, as covered in 495.41(B).

N (A) Control and Instrument Transfer Switch Handles or Push Buttons. Control and instrument transfer switch handles or push buttons shall be in a readily accessible location at an elevation of not over 2.0 m (6 ft 7 in.).

Exception: Operating handles requiring more than 23 kg (50 lb) of force shall be located no higher than 1.7 m (66 in.) in either the open or closed position.

N (B) Infrequently Operated Devices. Where operating handles for such devices as draw-out fuses, fused potential or control transformers and their primary disconnects, and bus transfer and isolating switches are only operated infrequently, the handles shall be permitted to be located where they are safely operable and serviceable from a portable platform.

N 495.42 Interlocks — Interrupter Switches. Interrupter switches equipped with stored energy mechanisms shall have mechanical interlocks to prevent access to the switch compartment unless the stored energy mechanism is in the discharged or blocked position.

N 495.43 Stored Energy for Opening. The stored energy operator shall be permitted to be left in the uncharged position after the switch has been closed if a single movement of the operating handle charges the operator and opens the switch.

N 495.44 Fused Interrupter Switches.

N (A) Supply Terminals. The supply terminals of fused interrupter switches shall be installed at the top of the switch enclosure or, if the terminals are located elsewhere, the equipment shall have barriers installed to prevent persons from accidentally contacting energized parts or dropping tools or fuses into energized parts.

N (B) Backfeed. Where fuses can be energized by backfeed, a sign shall be placed on the enclosure door identifying this hazard.

N (C) Switching Mechanism. The switching mechanism shall be arranged to be operated from a location outside the enclosure where the operator is not exposed to energized parts and shall be arranged to open all ungrounded conductors of the circuit simultaneously with one operation. Switches shall be lockable open in accordance with 110.25.

N 495.45 Circuit Breakers — Interlocks.

N (A) Circuit Breakers. Circuit breakers equipped with stored energy mechanisms shall be designed to prevent the release of the stored energy unless the mechanism has been fully charged.

N (B) Mechanical Interlocks. Mechanical interlocks shall be provided in the housing to prevent the complete withdrawal of the circuit breaker from the housing when the stored energy mechanism is in the fully charged position, unless a suitable device is provided to block the closing function of the circuit breaker before complete withdrawal.

N 495.46 Circuit Breaker Locking. Circuit breakers shall be capable of being locked in the open position or, if they are installed in a draw-out mechanism, that mechanism shall be capable of being locked in such a position that the mechanism cannot be moved into the connected position. In either case, the provision for locking shall be lockable open in accordance with 110.25.

N 495.47 Switchgear Used as Service Equipment. Switchgear installed as high-voltage service equipment shall include a ground bus for the connection of service cable shields and to facilitate the attachment of safety grounds for personnel protection. This bus shall be extended into the compartment where the service conductors are terminated. Where the compartment door or panel provides access to parts that can only be de-energized and visibly isolated by the serving utility, the warning sign required by 495.35(A) shall include a notice that access is limited to the serving utility or is permitted only following an authorization of the serving utility.

Switchgear must include a ground bus for the service cable shields. The bus must extend to the compartment where the service conductor terminals are located. It also provides a location for the connection of temporary protective grounding equipment for protection of personnel during servicing of the equipment.

See also

120.5 of NFPA 70E®, *Standard for Electrical Safety in the Workplace®*, 2021 edition, for temporary protective grounding equipment requirements, as it relates to establishing an electrically safe work condition (ESWC)

N 495.48 Substation Design, Documentation, and Required Diagram.

N (A) Design and Documentation. Substations shall be designed by a qualified licensed professional engineer. Where components or the entirety of the substation is listed by a qualified electrical testing laboratory, documentation of internal design features subject to the listing investigation shall not be required. The design shall address but not be limited to the following topics, and the documentation of this design shall be made available to the authority having jurisdiction:

- (1) Clearances and exits
- (2) Electrical enclosures
- (3) Securing and support of electrical equipment
- (4) Fire protection
- (5) Safety ground connection provisions
- (6) Guarding live parts
- (7) Transformers and voltage regulation equipment
- (8) Conductor insulation, electrical and mechanical protection, isolation, and terminations

- (9) Application, arrangement, and disconnection of circuit breakers, switches, and fuses
- (10) Provisions for oil-filled equipment
- (11) Switchgear
- (12) Overvoltage (surge) protection equipment

N (B) Diagram. A permanent, single-line diagram of the switchgear shall be provided in a readily visible location within the same room or enclosed area with the switchgear and shall clearly identify the following:

- (1) Interlocks
- (2) Isolation means
- (3) All possible sources of voltage to the installation under normal or emergency conditions

The marking on the switchgear shall cross-reference the diagram.

Exception: Where the equipment consists solely of a single cubicle or metal-enclosed substation containing only one high-voltage switching device, diagrams shall not be required.

N 495.49 Reconditioned Switchgear. Reconditioned switchgear, or sections of switchgear, shall be permitted. If equipment has been damaged by fire, products of combustion, or water, it shall be specifically evaluated by its manufacturer or a qualified testing laboratory prior to being returned to service.

N Part IV. Mobile and Portable Equipment

N 495.61 General.

N (A) Covered. The provisions of this part shall apply to installations and use of high-voltage power distribution and utilization equipment that is portable, mobile, or both, and include but not be limited to the following:

- (1) Substations and switch houses mounted on skids
- (2) Trailers or cars
- (3) Mobile shovels
- (4) Draglines
- (5) Cranes
- (6) Hoists
- (7) Drills
- (8) Dredges
- (9) Compressors
- (10) Pumps
- (11) Conveyors
- (12) Underground excavators

N (B) Grounding and Bonding. Grounding and bonding shall be in accordance with Part X of Article 250.

N (C) Protection. Approved enclosures or guarding, or both, shall be provided to protect portable and mobile equipment from physical damage.

(D) Disconnecting Means. Disconnecting means shall be installed for mobile and portable high-voltage equipment according to the requirements of Part VIII of Article 230 and shall disconnect all ungrounded conductors.

N 495.62 Overcurrent Protection. Motors driving single or multiple dc generators supplying a system operating on a cyclic load basis shall not require overload protection if the thermal rating of the ac drive motor cannot be exceeded under any operating condition. The branch-circuit protective device(s) shall provide short-circuit and locked-rotor protection and shall be permitted to be external to the equipment.

N 495.63 Enclosures. All energized switching and control parts shall be enclosed in grounded metal cabinets or enclosures. These cabinets or enclosures shall be marked DANGER — HIGH VOLTAGE — KEEP OUT and shall be locked so that only authorized and qualified persons can enter. The danger marking(s) or label(s) shall comply with 110.21(B). Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without opening locked doors. With doors closed, safe access for normal operation of these units shall be provided.

N 495.64 Collector Rings. The collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded to prevent accidental contact with energized parts by personnel on or off the machine.

N 495.65 Power Cable Connections to Mobile Machines. A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include terminal connections to the machine frame for the equipment grounding conductor. Ungrounded conductors shall be attached to insulators or be terminated in approved high-voltage cable couplers (which include equipment grounding conductor connectors) of proper voltage and ampere rating. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so that only authorized and qualified persons can open it and shall be marked as follows:

DANGER — HIGH VOLTAGE — KEEP OUT.

The danger marking(s) or label(s) shall comply with 110.21(B).

N 495.66 High-Voltage Portable Cable for Main Power Supply. Flexible high-voltage cable supplying power to portable or mobile equipment shall comply with the grounding and bonding requirements in Parts V, VI, and X of Article 250 and the flexible cable requirements in Part III of Article 400.

N Part V. Boilers

N 495.70 General. The provisions of Part V shall apply to boilers operating over 1000 volts, nominal, in which heat is generated

by the passage of current between electrodes through the liquid being heated.

N 495.71 Electrical Supply System. Boilers shall be supplied only from a 3-phase, 4-wire solidly grounded wye system, or from isolating transformers arranged to provide such a system. Control circuit voltages shall not exceed 150 volts, shall be supplied from a grounded system, and shall have the controls in the ungrounded conductor.

N 495.72 Branch-Circuit Requirements.

N (A) Rating. Each boiler shall be supplied from an individual branch circuit rated not less than 100 percent of the total load.

N (B) Common-Trip Fault-Interrupting Device. The circuit shall be protected by a 3-phase, common-trip fault-interrupting device, which shall be permitted to automatically reclose the circuit upon removal of an overload condition but shall not reclose after a fault condition.

N (C) Phase-Fault Protection. Phase-fault protection shall be provided in each phase, consisting of a separate phase-overcurrent relay connected to a separate current transformer in the phase.

N (D) Ground Current Detection. Means shall be provided for detection of the sum of the neutral conductor and equipment grounding conductor currents and shall trip the circuit-interrupting device if the sum of those currents exceeds the greater of 5 amperes or

7½ percent of the boiler full-load current for 10 seconds or exceeds an instantaneous value of 25 percent of the boiler full-load current.

N (E) Grounded Neutral Conductor. The grounded neutral conductor shall be as follows:

- (1) Connected to the pressure vessel containing the heating elements
- (2) Insulated for not less than 1000 volts
- (3) Have not less than the ampacity of the largest ungrounded branch-circuit conductor
- (4) Installed with the ungrounded conductors in the same raceway, cable, or cable tray, or, where installed as open conductors, in close proximity to the ungrounded conductors
- (5) Not used for any other circuit

N 495.73 Pressure and Temperature Limit Control. Each boiler shall be equipped with a means to limit the maximum temperature, pressure, or both, by directly or indirectly interrupting all current flow through the heating elements. Such means shall be in addition to the temperature, pressure, or both, regulating systems and pressure relief or safety valves.

N 495.74 Bonding. All exposed non-current-carrying metal parts of the boiler and associated exposed metal structures or equipment shall be bonded to the pressure vessel or to the neutral conductor to which the vessel is connected in accordance with 250.102, except the ampacity of the bonding jumper shall not be less than the ampacity of the neutral conductor.

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