the minimum size may be No. 8 (AWG). Cables smaller than No. 6 (AWG) shall have an additional conductor(s) of the same size as one power conductor.

(b) A means of actuating a circuit-interrupting device, preferably at the outby end of the portable cable.

NOTE: The frame to ground potential shall not exceed 40 volts.

(c) A device(s) such as a diode(s) of adequate peak inverse voltage rating and current-carrying capacity to conduct possible fault current through the grounded power conductor. Diode installations shall include: (1) An overcurrent device in series with the diode, the contacts of which are in the machine's control circuit; and (2) a blocking diode in the control circuit to prevent operation of the machine with the polarity reversed.

§ 18.51 Electrical protection of circuits and equipment.

(a) An automatic circuit-interrupting device(s) shall be used to protect each ungrounded conductor of a branch circuit at the junction with the main circuit when the branch-circuit conductor(s) has a current carrying capacity less than 50 percent of the main circuit conductor(s), unless the protective device(s) in the main circuit will also provide adequate protection for the branch circuit. The setting of each device shall be specified. For headlight and control circuits, each conductor shall be protected by a fuse or equivalent. Any circuit that is entirely contained in an explosion-proof enclosure shall be exempt from these requirements.

(b) Each motor shall be protected by an automatic overcurrent device. One protective device will be acceptable when two motors of the same rating operate simultaneously and perform virtually the same duty.

(1) If the overcurrent-protective device in a direct-current circuit does not open both lines, particular attention shall be given to marking the polarity at the terminals or otherwise preventing the possibility of reversing connections which would result in changing the circuit interrupter to the grounded line.

(2) Three-phase alternating-current motors shall have an overcurrent-protective device in at least two phases such that actuation of a device in one phase will cause the opening of all three phases.

(c) Circuit-interrupting devices shall be so designed that they can be reset without opening the compartment in which they are enclosed.

(d) All magnetic circuit-interrupting devices shall be mounted in a manner to preclude the possibility of their closing by gravity.

§ 18.52 Renewal of fuses.

Enclosure covers that provide access to fuses, other than headlight, control-circuit, and handheld-tool fuses, shall be interlocked with a circuit-interrupting device. Fuses shall be inserted on the load side of the circuit interrupter.

§ 18.53 High-voltage longwall mining systems.

(a) In each high-voltage motor-starter enclosure, with the exception of a controller on a high-voltage shearer, the disconnect device compartment, control/communications compartment, and motor contactor compartment must be separated by barriers or partitions to prevent exposure of personnel to energized high-voltage conductors or parts. In each motor-starter enclosure on a high-voltage shearer, the high-voltage components must be separated from lower voltage components by barriers or partitions to prevent exposure of personnel to energized high-voltage conductors or parts. Barriers or partitions must be constructed of grounded metal or nonconductive insulating board.

(b) Each cover of a compartment in the high-voltage motor-starter enclosure containing high-voltage components must be equipped with at least two interlock switches arranged to automatically deenergize the high-voltage components within that compartment when the cover is removed.

(c) Circuit-interrupting devices must be designed and installed to prevent automatic reclosure.

(d) Transformers with high-voltage primary windings that supply control voltages must incorporate grounded electrostatic (Faraday) shielding between the primary and secondary windings. The shielding must be connected to equipment ground by a minimum No. 12 AWG grounding conductor. The secondary nominal voltage must not exceed 120 volts, line to line.

(e) Test circuits must be provided for checking the condition of ground-wire monitors and ground-fault protection without exposing personnel to energized circuits. Each ground-test circuit must inject a primary current of 50 percent or less of the current rating of the grounding resistor through the current transformer and cause each corresponding circuit-interrupting device to open.

(f) Each motor-starter enclosure, with the exception of a controller on a high-voltage shearer, must be equipped with a disconnect device installed to deenergize all high-voltage power conductors extending from the enclosure when the device is in the ''open'' position.

(1) When multiple disconnect devices located in the same enclosure are used to satisfy the above requirement they must be mechanically connected to provide simultaneous operation by one handle.

(2) The disconnect device must be rated for the maximum phase-to-phase voltage and the full-load current of the circuit in which it is located, and installed so that—

(i) Visual observation determines that the contacts are open without removing any cover;

(ii) The load-side power conductors are grounded when the device is in the ''open'' position;

(iii) The device can be locked in the ''open'' position;

(iv) When located in an explosion-proof enclosure, the device must be designed and installed to cause the current to be interrupted automatically prior to the opening of the contacts; and

(v) When located in a non-explosion-proof enclosure, the device must be designed and installed to cause the current to be interrupted automatically prior to the opening of the contacts, or the device must be capable of interrupting the full-load current of the circuit.

(g) Control circuits for the high-voltage motor starters must be interlocked with the disconnect device so that—

(1) The control circuit can be operated with an auxiliary switch in the ''test'' position only when the disconnect device is in the open and grounded position; and

(2) The control circuit can be operated with the auxiliary switch in the ''normal'' position only when the disconnect switch is in the closed position.

(h) A study to determine the minimum available fault current must be submitted to MSHA to ensure adequate protection for the length and conductor size of the longwall motor, shearer and trailing cables.

(i) Longwall motor and shearer cables with nominal voltages greater than 660 volts must be made of a shielded construction with a grounded metallic shield around each power conductor.

(j) High-voltage motor and shearer circuits must be provided with instantaneous ground-fault protection of not more than 0.125-amperes. Current transformers used for this protection must be of the single-window type and must be installed to encircle all three phase conductors.

(k) Safeguards against corona must be provided on all 4,160 voltage circuits in explosion-proof enclosures.

(l) The maximum pressure rise within an explosion-proof enclosure containing high-voltage switchgear must be limited to 0.83 times the design pressure.

(m) High-voltage electrical components located in high-voltage explosion-proof enclosures must not be coplanar with a single plane flame-arresting path.

(n) Rigid insulation between high-voltage terminals (Phase-to-Phase or Phase-to-Ground) must be designed with creepage distances in accordance with the following table:

MINIMUM CREEPAGE DISTANCES

Phase to phase voltage	Points of measure	Minimum creepage distances (inches) for comparative tracking index (CTI) range [1]			
		CTI≥500	380≤CTI<500	175≤CTI<380	CTI<175
2,400	0–0	1.50	1.95	2.40	2.90
	0–G	1.00	1.25	1.55	1.85
4,160	0–0	2.40	3.15	3.90	4.65
	0–G	1.50	1.95	2.40	2.90

[1] Assumes that all insulation is rated for the applied voltage or higher.

(o) Explosion-proof motor-starter enclosures must be designed to establish the minimum free distance (MFD) between the wall or cover of the enclosure and uninsulated electrical conductors inside the enclosure in accordance with the following table:

HIGH-VOLTAGE MINIMUM FREE DISTANCES (MFD)

Wall/cover thickness (in)	Steel MFD (in)			Aluminum MFD (in)		
	A [1]	B [2]	C [3]	A	B	C
¼	2.8	4.3	5.8	[4] NA	[4] NA	[4] NA
⅜	1.8	2.3	3.9	8.6	12.8	18.1
½	*1.2	2.0	2.7	6.5	9.8	13.0
⅝	*0.9	1.5	2.1	5.1	7.7	10.4
¾	*0.6	*1.1	1.6	4.1	6.3	8.6
1	(*)	*0.6	*1.0	2.9	4.5	6.2

NOTE: *The minimum electrical clearances must still be maintained.

[1] Column A specifies the MFD for enclosures that have available 3-phase bolted short-circuit currents of 10,000 amperes rms or less.

[2] Column B specifies the MFD for enclosures that have a maximum available 3-phase bolted short-circuit currents greater than 10,000 and less than or equal to 15,000 amperes rms.

[3] Column C specifies the MFD for enclosures that have a maximum available 3-phase bolted short-circuit currents greater than 15,000 and less than or equal to 20,000 amperes rms.

[4] Not Applicable—MSHA doesn't allow aluminum wall or covers to be ¼ inch or less in thickness (Section 18.31).

(1) For values not included in the table, the following formulas on which the table is based may be used to determine the minimum free distance.

(i) Steel Wall/Cover:

$$MFD = 2.296 \times 10^{-6} \; \frac{(35 + 105\,(C))\,(I_{sc})\,(t)}{(C)\,(d)} - \frac{d}{2}$$

(ii) Aluminum Wall/Cover:

$$MFD = 1.032 \times 10^{-5} \; \frac{(35 + 105\,(C))\,(I_{sc})\,(t)}{(C)\,(d)} - \frac{d}{2}$$

Where C is 1.4 for 2,400 volt systems or 3.0 for 4,160 volt systems, I_{sc} is the 3-phase short circuit current in amperes of the system, t is the clearing time in seconds of the outby circuit-interrupting device and d is the thickness in inches of the metal wall/cover adjacent to an area of potential arcing.

(2) The minimum free distance must be increased by 1.5 inches for 4,160 volt systems and 0.7 inches for 2,400 volt systems when the adjacent wall area is the top of the enclosure. If a steel shield is mounted in conjunction with

an aluminum wall or cover, the thickness of the steel shield is used to determine the minimum free distances.

(p) The following static pressure test must be performed on each prototype design of explosion-proof enclosures containing high-voltage switchgear prior to the explosion tests. The static pressure test must also be performed on every explosion-proof enclosure containing high-voltage switchgear, at the time of manufacture, unless the manufacturer uses an MSHA accepted quality assurance procedure covering inspection of the enclosure. Procedures must include a detailed check of parts against the drawings to determine that the parts and the drawings coincide and that the minimum requirements stated in part 18 have been followed with respect to materials, dimensions, configuration and workmanship.

(1) *Test procedure.* (i) The enclosure must be internally pressurized to at least the design pressure, maintaining the pressure for a minimum of 10 seconds.

(ii) Following the pressure hold, the pressure must be removed and the pressurizing agent removed from the enclosure.

(2) *Acceptable performance.* (i) The enclosure during pressurization must not exhibit—

(A) Leakage through welds or casting; or

(B) Rupture of any part that affects the explosion-proof integrity of the enclosure.

(ii) The enclosure following removal of the pressurizing agents must not exhibit—

(A) Visible cracks in welds;

(B) Permanent deformation exceeding 0.040 inches per linear foot; or

(C) Excessive clearances along flame-arresting paths following retightening of fastenings, as necessary.

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§ 18.54 High-voltage continuous mining machines.

(a) *Separation of high-voltage components from lower voltage components.* In each motor-starter enclosure, barriers, partitions, and covers must be provided and arranged so that personnel can test and troubleshoot low- and medium-voltage circuits without being exposed to energized high-voltage circuits. Barriers or partitions must be constructed of grounded metal or nonconductive insulating board.

(b) *Interlock switches.* Each removable cover, barrier, or partition of a compartment in the motor-starter enclosure providing direct access to high-voltage components must be equipped with at least two interlock switches arranged to automatically de-energize the high-voltage components within that compartment when the cover, barrier, or partition is removed.

(c) *Circuit-interrupting devices.* Circuit-interrupting devices must be designed and installed to prevent automatic re-closure.

(d) *Transformers supplying control voltages.*

(1) Transformers supplying control voltages must not exceed 120 volts line to line.

(2) Transformers with high-voltage primary windings that supply control voltages must incorporate a grounded electrostatic (Faraday) shield between the primary and secondary windings. Grounding of the shield must be as follows:

(i) Transformers with an external grounding terminal must have the shield grounded by a minimum of No. 12 A.W.G. grounding conductor extending from the grounding terminal to the equipment ground.

(ii) Transformers with no external grounding terminal must have the shield grounded internally through the transformer frame to the equipment ground.

(e) *Onboard ungrounded, three-phase power circuit.* A continuous mining machine designed with an onboard ungrounded, three-phase power circuit must:

(1) Be equipped with a light that will indicate a grounded-phase condition;

(2) Have the indicator light installed so that it can be observed by the operator from any location where the continuous mining machine is normally operated; and

(3) Have a test circuit for the grounded-phase indicator light circuit to assure that the circuit is operating properly. The test circuit must be designed