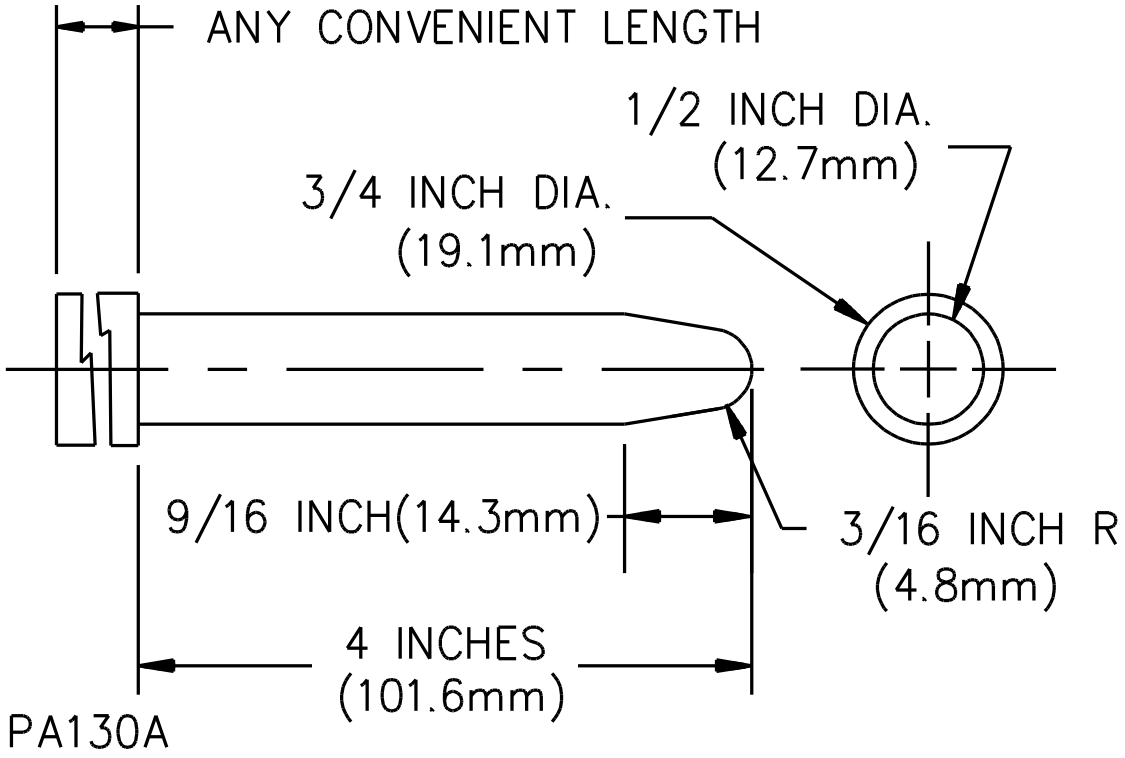
Figure 17.1

Straight Probe



18 Disconnecting Means

18.1 General

18.1.1 A unit substation marked for service equipment use shall be designed so that all ungrounded load conductors can be disconnected from the source of supply by the operation of the operating handle of a disconnecting means intended to be installed at the factory or in the field. Operation of the handle shall simultaneously disconnect all ungrounded conductors of the circuit. Markings in accordance with 40.7.1 – 40.7.3, 40.9.1 – 40.9.3, and 40.10 shall be provided.

Exception: An additional disconnecting means for the control circuit of a power operable service disconnect may be connected to the source on the line side of the service disconnect.

18.1.2 The device disconnecting means (a circuit breaker or fused switch) shall be capable of external manual operation to disconnect all ungrounded conductors under rated load conditions.

18.2 Ground fault protection

18.2.1 In a unit substation marked for service equipment use, ground fault protection of equipment shall be provided for a supply side service disconnecting means rated 1000 amperes or more in a 3-phase, wye-connected circuit of more than 150 volts to ground. The ground fault sensing and relaying equipment provided shall operate to cause the service disconnecting means to open all ungrounded conductors of the faulted circuit. The maximum setting of the ground fault protection shall be 1200 amperes. The system is assumed to be solidly grounded unless the unit substation is marked as covered in 40.9.5.

Exception No. 1: If marked in accordance with 40.9.4 (a) or (b), ground fault protection need not be provided for a source intended to supply power to a continuous industrial process system.

Exception No. 2: If marked in accordance with 40.9.6, ground fault protection need not be provided for a source intended to supply power to a fire pump, or an alternate source for an emergency or legally required standby system.

18.2.2 If ground fault protection is provided, though not required in 18.2.1, it shall comply with the requirements for the installation of ground fault protection equipment in this standard.

Exception: If the unit substation is marked in accordance with 40.9.7, the ground fault protection may initiate an audible or visual signal rather than open an alternate source for emergency or legally required standby systems.

18.2.3 A ground fault protection system that employs a sensing element that encircles the neutral conductor (if any) and all ungrounded conductors of the protected circuit (zero sequence type) shall be installed in such a manner that the sensing element is located on the load side of any grounding or bonding connections to the neutral. It may be on the line or load side of the disconnecting device for the protected circuit.

18.2.4 A ground fault protection system that combines the outputs of separate sensing elements for the neutral (if any) and each ungrounded conductor (residual type) shall be installed in such a manner that the neutral sensing element is located on the load side of any grounding or bonding connection to the neutral. The ungrounded conductor sensors may be on the line or load side of the disconnecting device for the protected circuit.

18.2.5 A ground fault protection system that employs a single sensing element to detect the actual fault current (ground return type) shall be installed in such a manner that the sensing element detects any current that flows in the grounding electrode conductor, the main bonding jumper, and any other grounding connections within the unit substation that may be made to the neutral. This will require that the neutral be insulated from noncurrent-carrying metal.

Exception: Connections to the neutral may be made as covered in 21.1.5 and 22.1.13.

18.2.6 A ground fault protection sensor shall be securely mounted to reduce the possibility of damage to it or its leads during shipment.

18.2.7 If the design of ground fault sensing and relaying equipment is such that a reset operation is required to restore the equipment to functional status following operation due to a ground fault or test:

a) The design shall be such to prevent closing and maintaining contact of the disconnecting device to be controlled by the ground fault sensing and relaying equipment until the reset operation is performed; or

b) Such means shall be incorporated in the disconnect device.

18.3 Neutral disconnecting means

18.3.1 In a unit substation having a neutral and intended for service equipment use, means shall be provided for disconnecting the neutral service conductor from the interior wiring. This may be incorporated in the disconnecting means referred to in 18.1.1 or may be in the form of one or more removable links. The disconnecting means shall be on the load side of the grounding electrode terminal and of the main bonding jumper.

18.3.2 The disconnect link specified in 18.3.1 shall take the form of a link, or similar conducting piece, designed to make connection between two terminals. Simple removal of bolts from a single bus bar joint is not acceptable.

18.3.3 A disconnect link shall be located, guarded, recessed, or enclosed so that unintentional contact with any uninsulated, ungrounded part on the line side of the main switch or circuit breaker will not occur while the link is being removed or replaced.

18.3.4 The disconnect link shall be accessible without opening a compartment intended to be sealed or otherwise rendered inaccessible by the serving agency (electric utility or power company).

19 Overcurrent Protection

19.1 A unit substation shall contain transformer primary overcurrent protection rated not more than 125 percent of the transformer primary current rating.

Exception No. 1: Primary overcurrent protection rated not more than 250 percent of the primary current may be used if the unit substation is provided with a single main secondary overcurrent protective device rated not more than 125 percent of the transformer secondary current rating.

Exception No. 2: A unit substation not marked as suitable for use as service equipment, but marked for location in the circuit in accordance with the requirement in 40.6.1, is not required to contain overcurrent protection in the primary circuit.

19.2 A fuse or circuit breaker pole shall be provided for the protection of each outgoing ungrounded load conductor.

Exception: Overcurrent protection in the secondary of the transformer is not required for a single phase transformer having a 2-wire (single voltage) secondary and for a three-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary if the unit substation has primary overcurrent protection that complies with the following conditions:

a) The rating of the overcurrent protective device shall not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio and

b) The overcurrent protective device shall be rated not more than:

1) 125 percent of the transformer primary current rating when the transformer is rated 9 amps or more;

2) 167 percent of the transformer primary current rating when the transformer is rated less than 9 amps; and

3) 300 percent of the transformer primary current rating when the transformer is rated less than 2 amps.

19.3 A 2-pole circuit breaker used in a 3-phase unit substation marked for use on an end grounded delta system shall be rated 3-phase.

19.4 The primary overcurrent protection required in 19.1 may consist of a main overcurrent device (a fuse or a circuit breaker pole) in series with each ungrounded service conductor, or of not more than six overcurrent devices connected on the line side to each ungrounded service conductor that feeds separate loads.

19.5 No overcurrent device shall be placed in any permanently grounded conductor unless it simultaneously opens all conductors of the circuit.

19.6 A fuseholder shall be of the cartridge type, Type S, or Edison base plug type.

19.7 A plug fuse or fuseholder shall not be used in a circuit exceeding 125 volts between conductors.

Exception: A plug fuse or fuseholder may be used in a circuit supplied by a system having a grounded neutral and having no conductor at more than 125 volts to ground.

19.8 A cartridge fuse or fuseholder of the 300-volt type shall not be used in a circuit of more than 300 volts between conductors.

Exception: A cartridge fuse or fuseholder rated 300 volts complies with the intent of the requirement when it is used in a single-phase circuit supplied by a system having a grounded neutral and having no conductor at more than 300 volts to ground.

19.9 The screw shell of a plug type fuseholder shall be connected to the load side of the circuit.

19.10 A disconnecting means shall be provided on the supply side of each cartridge fuse.

19.11 A unit substation shall be designed and constructed so that fuses will be readily accessible, when the disconnecting means specified in 19.10 is open, so that they may be replaced without a person touching any live part.

19.12 An interchangeable circuit breaker trip unit need not be factory installed if it can be mounted in place without disassembly of any electrical connection other than terminal connectors.

19.13 An accessible means shall be provided in a unit substation so that each branch circuit can be independently de-energized. A switch, a plug fuse or other device incorporating a screw shell, and a circuit breaker are acceptable as such means.

19.14 The primary of a ground fault protection control circuit transformer may be connected on the line or load side of the main disconnect or may be connected to an external source. The primary of such a transformer shall be connected to two line voltage parts (not line and neutral). If connected to the line side of the main, or an external source, a fused disconnect switch or circuit breaker rated for use as service equipment and providing overcurrent protection shall be installed ahead of the transformer or control circuit. Overcurrent protection is not required for the control circuit if wired to the load side of the main disconnect unless the control circuit wiring leaves the unit substation or the control circuit contains a snap switch. Markings as covered in 40.9.3 or 40.10.4 shall be provided if the transformer is not connected to the load side of the main disconnect.

19.15 The control circuit of a ground fault protection system shall be connected on the line side of the main disconnect if a test or monitor panel is provided and if such connection is required for proper functioning of the panel.

19.16 The conductors of a remote control switch circuit are considered to be protected by overcurrent devices rated at not more than 300 percent of the ampacity of the conductors. It will be assumed that the control circuit conductors outside the unit substation will be 14 AWG (2.1 mm^2) minimum.

19.17 If a unit substation contains a lighting or appliance type panelboard as covered in 19.18, the panelboard shall be protected by a main overcurrent protective device not exceeding the panelboard bus ampacity. The main overcurrent protection provided in the primary circuit may serve to protect a

panelboard in the secondary circuit of a single phase transformer having a two-wire (single voltage) secondary if the protection does not exceed the value determined by multiplying the panelboard current rating by the secondary-to-primary transformer voltage ratio.

19.18 A lighting or appliance branch circuit panelboard as specified in 19.17 is one having more than 10 percent of its overcurrent devices rated 30 amperes or less, for which neutral connections are provided.

19.19 A lighting or appliance branch circuit panelboard shall not have more than 42, nor provision for more than 42, overcurrent protective devices other than those in the mains.

19.20 The minimum ampere rating of a lighting or appliance panelboard shall be as covered in the Standard for Panelboards, UL 67.

19.21 A lighting or appliance panelboard shall comply with the requirements for a Class CTL panelboard as covered in the Standard for Panelboards, UL 67.

20 Switching Means

20.1 A switching means shall be acceptable for the particular application and shall have a current and voltage rating not less than the circuit it controls.

20.2 A switching device controlling a coil shall be rated for both the inrush and sealed or steady state current of the coil.

20.3 A device that is rated for across the line motor starting of an alternating-current motor is acceptable for alternating-current pilot duty without further tests provided the power factor for the motor test was 0.5 or less and the overload test current was at least 150 percent of the pilot duty inrush current at the same voltage. Switching devices rated in accordance with Table 20.1 are considered to comply with this requirement.

Table 20.1
Horsepower rating versus pilot duty rating

Horsepower rating 1-phase (120 – 600 volts)	Alternating current pilot duty rating
1/10	125 VA (light duty)
1/2	360 VA (standard duty)
1	720 VA (heavy duty)

20.4 A switch used to connect a load to various sources or potentials shall be a type that has been investigated and rated for such use. This would include a switch used for switching a voltmeter, frequency meter, and power factor meter between various phases.

20.5 A switching and overcurrent protective device that is rated for continuous operation at 100 percent of its current rating shall be installed in accordance with instructions provided by the manufacturer for such a unit concerning minimum compartment size, amount of necessary ventilation, type and size of conductor, or the like.

20.6 The design and construction of a switching device shall be such that live parts will not be exposed during intended operation, and shall be such as to provide ample strength and rigidity.

20.7 There shall be a positive off position for the operating handle and stops to remove undue strain from switch parts shall be provided.

20.8 A handle or other member that indicates the position of switch or breaker contacts (closed or open) shall be designed so that the door, front, or cover cannot be secured in place in the intended manner so that the handle or member indicates off with the switch blades or contacts in the closed position.

20.9 If a circuit breaker or switch is mounted such that movement of the operating handle, either vertically or rotationally, between the on and off positions results in one position being above the other position, the upper position shall be the on position. This requirement does not apply to a circuit breaker or switch that is operated horizontally or that is operated rotationally with the on and off positions at the same level nor to a switching device having two on positions such as a transfer switch or a double throw switch.

20.10 Screws and nuts serving to attach operating parts to a moveable member shall be staked, upset, or otherwise locked in position to prevent loosening under continued use.

20.11 If there are both switches and fuses in either mains or branches, the current rating of a switch shall be not less than the maximum rating of the fuse the fuseholder will accommodate.

21 Spacings

21.1 General

21.1.1 The spacings in a unit substation shall be as indicated in Table 21.1.

Exception No. 1: The distance between a door or cover over a fuseholder and:

a) The center contact of an Edison-base fuseholder shall not be less than 1-9/16 inches (39.7 mm).

b) The center contact of a Type S fuseholder shall not be less than 1-5/16 inches (33.3 mm).

Exception No. 2: The spacings between screw shells of plug fuseholders that are protected by surrounding walls of insulating material, and a metal cover plate, shall not be less than 1/4 inch (6.4 mm) if the depth of the receptacle as measured from the top of the wall to the plane of the center contact is not less than 3/4 inch (19.1 mm). The measurement is to be made without a Type S adapter in place.

Exception No. 3: Spacings within a component, such as industrial control equipment, a heating element, a clock-operated switch, and the like within a unit substation and located on the load side of the service disconnect and overcurrent protection shall comply with the requirements applicable to the component. Spacings between exposed live parts of the component and the overall enclosure (other than inherent spacings) and spacings between exposed live parts of individual components shall comply with Table 21.1 or Table 21.2 as applicable.

Exception No. 4: Spacings in the control circuit of a magnetically operated device may be as covered in 21.1.10.

21.1.2 In applying Table 21.1 and Table 21.2 it is assumed that:

a) The voltage from a live part (other than the neutral) to grounded dead metal equals the line-to-line voltage of the system.

b) The voltage from a neutral live part to grounded dead metal equals the line-to-neutral voltage of the system.

Exception: Spacings are not required for constructions as covered in 21.1.4.

c) Spacings at a fuseholder are to be measured with a fuse of the maximum standard dimensions (including the maximum projections for assembly screws and rivets) in place. Dimensions of fuses

and fuseholders will be found in the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; the Standard for Low-Voltage Fuses – Part 4: Class CC Fuses, UL 248-4; the Standard for Low-Voltage Fuses – Part 5: Class G Fuses, UL 248-5; the Standard forLow-Voltage Fuses – Part 6: Class H Non-Renewable Fuses, UL 248-6; the Standard for Low-Voltage Fuses – Part 7: Class H Renewable Fuses, UL 248-7; the Standard for Low-Voltage Fuses – Part 8: Class J Fuses, UL 248-8; the Standard for Low-Voltage Fuses – Part 10: Class L Fuses, UL 248-10; the Standard for Low-Voltage Fuses – Part 11: Plug Fuses, UL 248-11; and the Standards for Fuseholders, UL 4248 series.

d) Spacings are to be measured through cracks unless a clamped insulating joint has passed the test covered in 27.3.1, a clamped insulating joint is a joint between two pieces of insulation that are under pressure as shown in Figure 21.1. Adhesives, cements, or the like, if used to effect a seal in lieu of a tightly mated joint, shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Table 21.1
Minimum acceptable spacings

Voltage involved		Minimum spacing between live parts of opposite polarity				Minimum spacing through air and over surface between live parts and grounded metal parts,	
		Through air,		Over surface,			
Greater than	Maximum	inch	(mm)	inch	(mm)	inch	(mm)
0	125	1/2	12.7	3/4	19.1	1/2	12.7
125	250	3/4	19.1	1-1/4	31.8	1/2	12.7
250	600	1	25.4	2	50.8	1[a]	25.4

NOTE – Minimum acceptable spacings other than as covered in 21.1.1 and Table 21.2.

[a] A through air spacing of not less than 1/2 inch (12.7 mm) is acceptable:

1) At a circuit breaker or a switch, other than a snap switch;

2) Between uninsulated live parts of a meter mounting base and grounded dead metal; and

3) Between grounded dead metal and the neutral of a 277/480-volt, 4-wire unit substation.

21.1.3 With regard to Table 21.1 and Table 21.2:

a) An isolated dead metal part (such as a screw head or a washer) interposed between uninsulated live parts of opposite polarity or between an uninsulated live part and grounded dead metal is considered to reduce the spacing by an amount equal to the dimension of the interposed part along the path of measurement. An electrostatic shield in a transformer is considered to be:

1) An opposite polarity part if it is or has provision to be connected in the field to an electric potential;

2) A grounded part if it is or has provision to be connected to ground; or

3) An isolated metal part if not connected as covered in (1) or (2).

b) In measuring an over surface spacing, any slot, groove, or the like, 0.013 inch (0.33 mm) wide or less in the contour of insulating material is to be disregarded.

c) In measuring an over surface spacing, an air space of 0.013 inch or less between a live part and an insulating surface is to be disregarded, and the live part considered in contact with the insulating material.

d) A film-coated wire is considered insulated with respect to other turns of the same winding, but is otherwise considered an uninsulated live part.

Table 21.2
Motor circuit or control circuit spacings

Voltage involved		Minimum acceptable spacings					
		Between uninsulated live parts of opposite polarity and between an uninsulated live part and an exposed or uninsulated dead metal part other than the enclosure				Between uninsulated live parts and the walls of a metal enclosure, including fittings for conduit or armored cable	
		Through air[a],		Over surface,		Shortest distance,	
More than	Maximum	inch	(mm)	inch	(mm)	inch	(mm)
0	150	1/8	3.2	1/4	6.4	1/2	12.7
150	300	1/4	6.4	3/8	9.5	1/2	12.7
300	600	3/8	9.5	1/2	12.7	1/2	12.7

[a] The spacing between wiring terminals of opposite polarity shall not be less than 1/4 inch (6.4 mm) in any case if the terminals are in the same plane. A metal piece attached to the enclosure shall be considered to be a part of the enclosure for the purpose of this note if deformation of the enclosure is likely to reduce the spacing between the metal piece and a live part.

21.1.4 Terminals and other parts intended to be connected to the grounded conductor of a circuit are considered to be uninsulated live parts unless such parts are mounted directly on or in permanent electrical connection with grounded dead metal.

21.1.5 If the enclosure or ground bus is factory bonded to the neutral as covered in 22.1.12 and 22.1.13, any conductive part connected to the neutral that would interfere with the operation of a ground fault protection system, if in contact with the enclosure, shall be insulated and provided with at least 1/8 inch (3.2 mm) spacings through air or over surface to the enclosure. For zero sequence type ground fault protection, or the residual type ground fault protection, parts that would interfere with its operation if grounded include all neutral parts on the load side of the neutral current sensing means. For the ground return type, parts that would interfere with its operation if grounded include all conductive parts connected to the neutral except those on the ground side of the sensing means.

21.1.6 The spacing (through air and over surface) shall be not less than 1/8 inch (3.2 mm) between uninsulated live parts of the same polarity:

a) On the load side of their respective switches or circuit breakers for parts in different circuits and

b) On the line and load sides of a fuseholder, switch, or circuit breaker.

Exception: With regard to Exception No. 3 to 21.1.1 and the Exception to 21.1.7, the spacings within a component on the load side of a service disconnect and overcurrent protection may be less than 1/8 inch (3.2 mm).

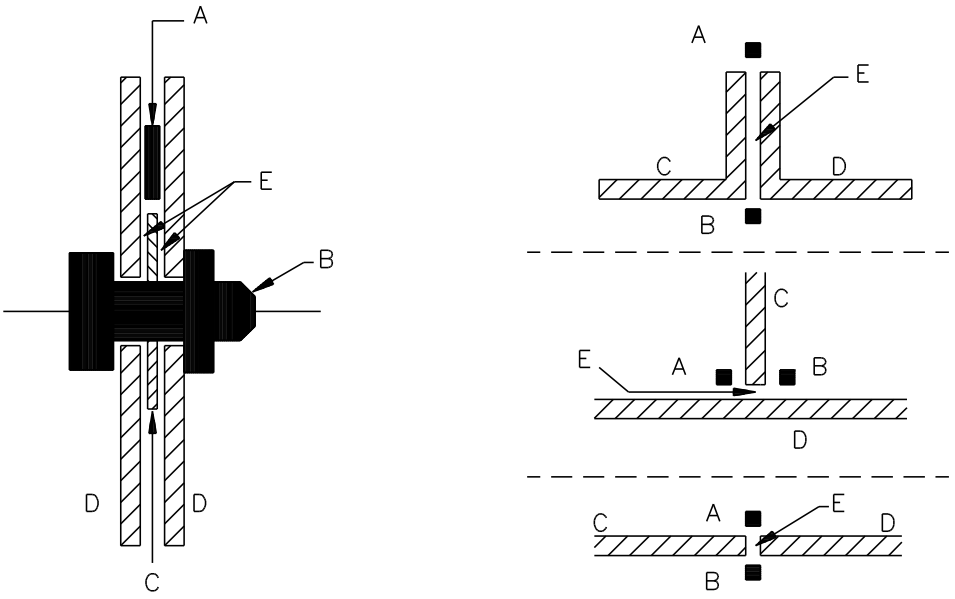
21.1.7 Spacings of a component serving as the service disconnect shall comply with Table 21.1 and 21.1.6. Spacings less than those of Table 21.1 in a meter socket base are subjected to a dielectric voltage-withstand test in accordance with the Exception to 27.1.1.

Exception: Spacings within a circuit breaker or a molded case switch may be as covered by the requirements applicable to that component.

21.1.8 Spacings are to be measured with all terminals unwired and wired with conductors terminated in accordance with 16.11 – 16.14, but no conductor smaller than 12 AWG (3.3 mm^2) is to be employed.

Figure 21.1

Clamped insulating joint



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NOTES –

1) Parts A, B – Live parts of opposite polarity, or a live part and grounded metal part with spacing through the crack between C and D less than required in Table 21.1 or Table 21.2.

2) Parts C, D – Insulating barriers clamped tightly together so that the dielectric strength between A and B is greater than the equivalent air spacing.

3) Part E – The clamped insulating joint.

21.1.9 In measuring between an uninsulated live part and a conduit bushing installed at a knockout, it is to be assumed that a bushing having the dimensions indicated in Table 21.3 (but without a locknut inside the enclosure) is in place.

Table 21.3
Conduit bushing dimensions

Trade size of conduit,	Overall diameter,		Height,	
inch	inch	(mm)	inch	(mm)
1/2	1	25.4	3/8	9.5
3/4	1-15/64	31.4	27/64	10.7
1	1-19/32	40.5	33/64	13.1
1-1/4	1-15/16	49.2	9/16	14.3
1-1/2	2-13/64	56.0	19/32	15.1
2	2-45/64	68.7	5/8	15.9
2-1/2	3-7/32	81.8	3/4	19.1
3	3-7/8	98.4	13/16	20.6
3-1/2	4-7/16	113	15/16	23.8
4	4-31/32	126	1	25.4
4-1/2	5-35/64	140	1-1/16	27.0
5	6-7/32	156	1-3/16	30.2
6	7-7/32	183	1-1/4	31.8

21.1.10 All screws and nuts, other than those specified in 20.10, shall be staked, headed over, upset, or otherwise prevented from loosening such as by use of a locknut or lock washer.

Exception: Prevention of loosening is not required if it can be shown that no reduction of spacings can result from the loosening or falling out of such threaded parts.

21.1.11 The spacings in the control circuits of a magnetically operated device shall be as indicated in Table 21.2.

21.1.12 A pressure wire connector shall be prevented from turning that would result in less than the minimum acceptable spacings. The means for turn prevention shall be reliable, such as a shoulder or boss; a lock washer alone is not acceptable.

Exception: Means to prevent turning need not be provided if spacings are not less than the minimum acceptable values:

a) When the connector, and any connector of opposite polarity, have each been turned 30 degrees toward the other, and

b) When the connector has been turned 30 degrees toward other opposite polarity live parts and toward grounded dead metal parts.

21.2 Insulating barriers

21.2.1 The barrier referred to in 21.2.2 and 21.2.3 is insulating material that separates uninsulated live parts of opposite polarity or separates an uninsulated live part from a grounded dead metal part (including the enclosure) if the through air spacing between the parts would otherwise be less than the minimum acceptable value.