UL 869A

STANDARD FOR SAFETY

Reference Standard for Service Equipment

UL Standard for Safety for Reference Standard for Service Equipment, UL 869A

Fourth Edition, Dated November 10, 2006

Summary of Topics

This revision of UL 869A dated June 24, 2020 is being issued to:

> ***Update requirements to reflect changes to the 2020 edition of the NEC; 1.1, 6.1.1 – 6.1.7, 7.2, 8.1, 14.4.1, 14.4.4, 15.1, sections 6.1A and 6.2A, Table 5.1, and Annex A.***
>
> ***Miscellaneous editorial updates; 4.2, 6.2.2, 10.4 and Table 9.1.***

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated December 18, 2019 and April 10, 2020.

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UL 869A

Reference Standard for Service Equipment

Prior to the first edition, the requirements for the products covered by this standard were included in the Standard for Service Equipment, UL 869.

First Edition – March, 1987
Second Edition – June, 1993
Third Edition – June, 1998

Fourth Edition

November 10, 2006

The Department of Defense (DoD) has adopted UL 869A on November 16, 1987. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

This UL Standard for Safety consists of the Fourth edition including revisions through June 24, 2020.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 This standard provides specific service equipment requirements that are intended to be supplemented by requirements for other types of equipment (such as panelboards, switchboards, and the like) that may be used as service equipment. Requirements in this Standard are intended to apply to equipment designed for installation in accordance with the National Electrical Code (NEC), NFPA 70.

1.2 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involve a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.1.2 A component need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard or

b) Is superseded by a requirement in this standard.

2.1.3 A component shall be used in accordance with its recognized rating established for the intended conditions of use.

2.1.4 Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

2.2 Units of measurement

2.2.1 If a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

2.3 Undated references

2.3.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

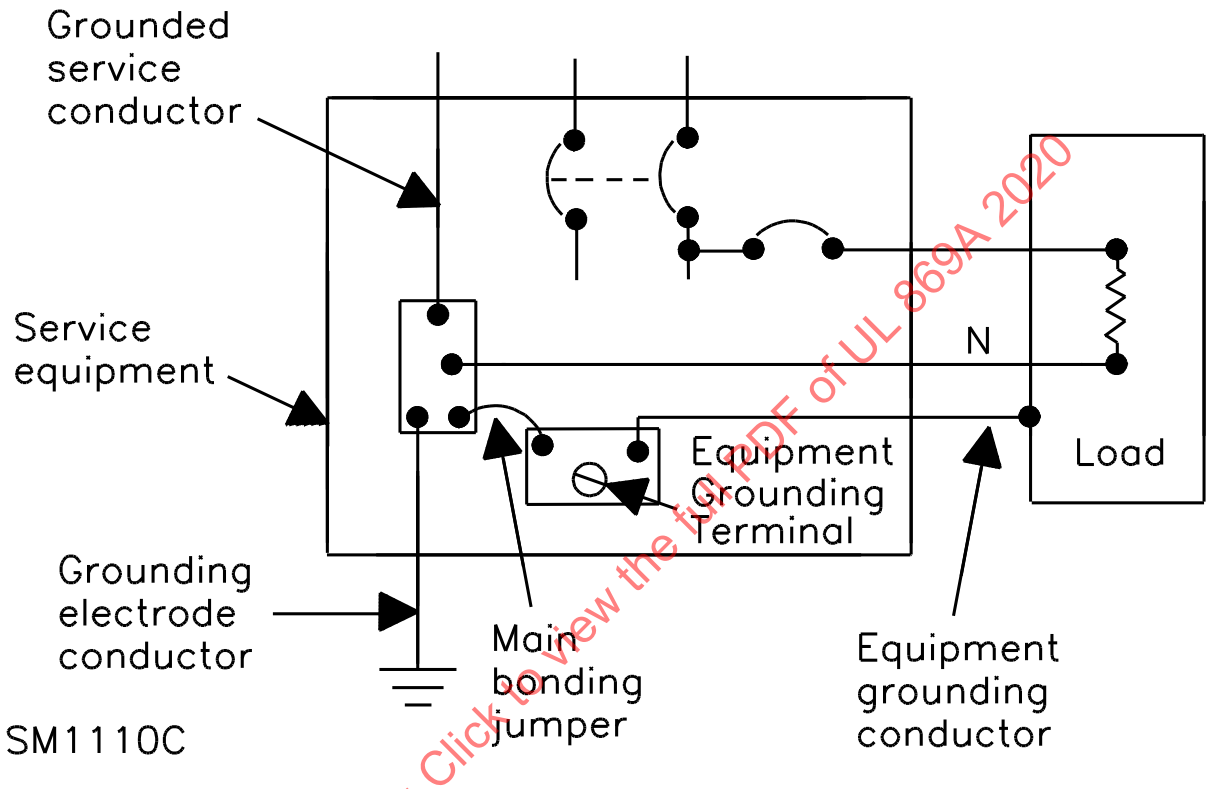
3 Glossary

3.1 For the purpose of this standard, the following definitions apply.

3.2 EQUIPMENT GROUNDING CONDUCTOR – The conductor used to connect the noncurrent-carrying metal parts of the equipment, raceways, and other enclosures to the grounded service conductor, to the grounding electrode conductor, or to both at the service equipment, as shown in Figure 3.1.

Figure 3.1

Grounding and bonding connections for grounded systems at the service equipment



3.3 GROUNDED SERVICE CONDUCTOR – The supply conductor that is intentionally grounded at the service, usually referred to as neutral. See Figure 3.1.

3.4 GROUNDING ELECTRODE CONDUCTOR – The conductor used to connect the grounding electrode to the grounded service conductor or to the equipment grounding conductor, or to both, at the service equipment as shown in Figure 3.1.

3.5 MAIN BONDING JUMPER – The conductor used for the connection between the grounded service conductor and the equipment grounding conductor at the service. See Figure 3.1.

3.6 SERVICE EQUIPMENT – Equipment, usually consisting of a circuit breaker, switch, or fuses, and related accessories, located near the point of entrance of supply conductors to a building or other structure and intended to constitute the main control and means of cutoff of the supply.

CONSTRUCTION

4 Wiring Terminals

4.1 Equipment intended to be used as service equipment shall be provided with wiring terminals in accordance with the end-use standard.

Exception: Equipment intended to supply a dwelling unit from a single-phase, 120/240 volt, 3-wire system may have line wiring terminals sized for the conductors having the ampere rating shown in Table 4.1 if marked as specified in 14.6.1.

Table 4.1
Dwelling unit conductors

Types and sizes				Ampacity, amperes
Copper,		Aluminum and copper-clad aluminum,		
AWG or kcmil	(mm^2)	AWG or kcmil	(mm^2)	
4	21.1	2	33.6	100
3	26.7	1	42.4	110
2	33.6	1/0	53.5	125
1	42.4	2/0	67.4	150
1/0	53.5	3/0	85.0	175
2/0	67.4	4/0	107	200
3/0	85.0	250	127	225
4/0	107	300	152	250
250	127	350	177	300
350	177	500	253	350
400	203	600	304	400

4.2 A wiring terminal provided for the connection of a service conductor rated 40 amperes or less shall be capable of accommodating a 8 AWG (8.4 mm^2) copper conductor. The terminal shall also be capable of accommodating a 6 AWG (13.3 mm^2) aluminum conductor if the equipment is marked for use with aluminum wire.

4.3 A connection that depends upon solder shall not be provided for the connection of the service conductors, the main bonding jumper, or the grounding electrode conductor.

4.4 A terminal for a grounded service conductor shall be provided for a conductor of a size in accordance with one of the following:

a) Same size as the ungrounded service conductors.

b) Reduced size if the equipment contains other circuit elements that determine the neutral load and the service equipment is marked with a reduced neutral rating.

c) Reduced size if the equipment has no provision for neutral connections to load circuits. The reduced size is to not be smaller than shown for the main bonding jumper in Table 9.1. The terminal shall be installed as covered in 9.5.

4.5 The equipment shall have a terminal for the connection of a grounding electrode conductor of the size indicated in Table 9.1.

4.6 Equipment intended for use on a grounded alternating-current supply system shall have the grounding electrode conductor terminal, as specified in 9.4, located on the neutral bus or neutral terminal strip on the supply side of the disconnecting means specified in 6.2.1.

Exception: The grounding electrode conductor terminal may be located on an equipment grounding terminal strip or ground bus on the enclosure if the main bonding jumper is a bus bar or wire installed between the neutral and the equipment grounding strip or ground bus.

4.7 Equipment intended for use on a direct-current system shall have a grounding electrode conductor terminal located on the enclosure or ground bus. The terminal shall not be located on the neutral.

4.8 Equipment having a metal enclosure and intended for use on an ungrounded supply system shall have the grounding electrode conductor terminal connected to the ground bus or to the enclosure in a location accessible during installation. If the enclosure is nonmetallic, means shall be provided for bonding metallic raceways together and for bonding equipment grounding conductors to the grounding electrode conductor terminal.

5 Equipment-Grounding Terminals

5.1 Service equipment shall be provided with a means for terminating an equipment-grounding conductor. The size shall be in accordance with Table 5.1.

Exception: Equipment marked in accordance with 14.8.2 or 14.8.3 is not required to be provided with such means.

Table 5.1
Equipment-grounding conductor

Rating, amperes	Size			
	Copper,		Aluminum or copper-clad aluminum,	
	AWG or kcmil	(mm^2)	AWG or kcmil	(mm^2)
15	14	2.1	12	3.3
20	12	3.3	10	5.3
30	10	5.3	8	8.4
40	10	5.3	8	8.4
60	10	5.3	8	8.4
100	8	8.4	6	13.3
200	6	13.3	4	21.2
300	4	21.2	2	33.6
400	3	26.7	1	42.4
500	2	33.6	1/0	53.5
600	1	42.4	2/0	67.4
800	1/0	53.5	3/0	85.0
1000	2/0	67.4	4/0	107
1200	3/0	85.0	250	127
1600	4/0	107	350	177
2000	250	127	400	203
2500	350	177	600	304
3000	400	203	600	304
4000	500	253	750	380
5000	700	355	1250	633
6000	800	405	1250	633

5.2 A pressure wire connector employed as an equipment grounding terminal shall comply with the requirements for such devices.

5.3 The equipment-grounding terminal or assembly shall be:

a) Green or the heads of the terminal screws shall be green or

b) Identified by the markings described in 14.8.1, located adjacent to the terminal or assembly or on a wiring diagram.

6 Disconnecting Means

6.1 General

6.1.1 Unless constructed in accordance with 6.1.2, equipment shall be constructed so that all ungrounded load conductors can be disconnected from the source of supply by the operation of one disconnect. Markings as specified in 14.4.1 – 14.4.3 shall be provided.

6.1.2 Two to six service disconnects shall be permitted where each service disconnect is in a separate enclosure, or as permitted by the requirements in end-product standards (such as panelboards, switchboards, and the like).

6.1.3 With respect to 6.1.1 and 6.1.2, disconnecting means provided for:

a) Power monitoring equipment;

b) Surge-protective devices;

c) The control circuit of a ground-fault protection system; or

d) The control circuit of a power-operable service disconnecting means

shall not be considered a service disconnecting means.

6.1.4 The disconnecting means referred to in 6.1.1 and 6.1.2 may be either a switch or circuit breaker that is capable of being opened manually. A multipole circuit breaker shall be of the common trip type.

6.1.5 The service disconnecting means shall be capable of external manual operation to disconnect all ungrounded conductors under rated load conditions.

Exception: An electrically operated switch or circuit breaker need not be capable of being externally disconnected by hand.

Note: External operation requires access to the operating handle without accessing uninsulated live parts within an enclosure.

6.1.6 A service disconnecting means shall indicate whether it is in the open (off) or closed (on) position.

6.1.7 The operating mechanism for the service disconnecting means shall be readily accessible. Operating mechanisms of switches and circuit breakers located behind doors or covers shall be considered readily accessible and capable of external manual operation so long as the mechanism may be accessed without the use of a tool, other than keys.

Note: Section 230.92 of the National Electrical Code, allows service overcurrent devices to be locked in specific circumstances.

6.1A Guarding against inadvertent contact

6.1A.1 Service equipment shall be constructed such that, with every service disconnect in the off position, ungrounded uninsulated live parts on the supply side of a service disconnect are protected against inadvertent contact by persons while servicing any field connected load terminal, including a neutral load terminal, a branch circuit equipment grounding terminal, or the neutral disconnect link. See Annex A for examples of how exposure to inadvertent contact can be determined.

Note: In accordance with the Standard for Electrical Safety in the Workplace, NFPA 70E, an electrically safe work condition should be established prior to working on electrical equipment. Accessibility requirements do not endorse working on energized electrical equipment.

6.2 Neutral disconnect

6.2.1 In a device having provision for the connection of a grounded service conductor, the disconnecting means referred to in 6.1.1 and 6.1.2 shall simultaneously interrupt the grounded conductor, or other means shall be provided for disconnecting the grounded service conductor from the interior wiring of the building.

6.2.2 The disconnecting means required in 6.2.1 may be any of the following:

a) A link, screw, or similar conducting piece that connects two terminals.

b) Wire connectors or a terminal plate or bus provided with wire-binding screws and upturned lugs or the equivalent for clamping 10 AWG (5.3 mm^2) or smaller wires.

c) A stud provided with wire connectors or lugs or with nuts and cupped washers for clamping 10 AWG or smaller wires.

d) A multiwire connector.

6.2.3 With respect to 6.2.2 (b), (c), and (d), the disconnecting means is considered to be the joint between the load conductor and the load conductor connector.

6.2.4 A single wire connector may be employed for both the disconnecting means for the grounded service conductor and the connecting means of the grounding electrode conductor if the connector is acceptable for multiple conductors.

6.2.5 The service disconnecting means for the grounded service conductor, as specified in 6.2.1 – 6.2.4, shall be located or otherwise:

a) Guarded;

b) Recessed; or

c) Enclosed

so as to avoid unintentional contact with uninsulated, ungrounded parts on the line side of the service disconnect switches or circuit breakers while removing or replacing the disconnecting means.

6.2.6 The disconnecting means for the grounded service conductor is to be located on the load side of:

a) The main bonding jumper as specified in 9.1 and

b) The grounding electrode conductor terminal as specified in 4.6.

6.2A Connections on the line side of the service disconnect

6.2A.1 The following connections shall be permitted on the line side of the service disconnect:

a) Cable limiters;

b) Meters, meter sockets, or meter disconnect switches rated 1000 v or less and in an all metal housing;

c) Instrument transformers (current and voltage), high-impedance shunts, surge arresters, and Type 1 surge-protective devices;

d) Load management devices if overcurrent protection is provided;

e) Taps for load management devices, optional standby power systems, fire pump equipment, and fire and sprinkler alarms;

f) Control circuits of power operable service disconnecting means, including control circuits of options standby power systems, if overcurrent protection and disconnecting means are provided;

g) Ground-fault protection systems or Type 2 surge-protective devices, if overcurrent protection and disconnecting means are provided;

h) Interconnected electric power production sources, such as solar photovoltaic, wind, or fuel cell systems;

i) Taps for communications equipment under the exclusive control of the service utility if overcurrent protection and disconnecting means are provided.

Exception: A disconnecting means is not required if the equipment is part of a meter socket, such that access can only be gained with the meter removed.

j) Meter-mounted transfer switches rated 1000 volts or less, capable of transferring the load served.

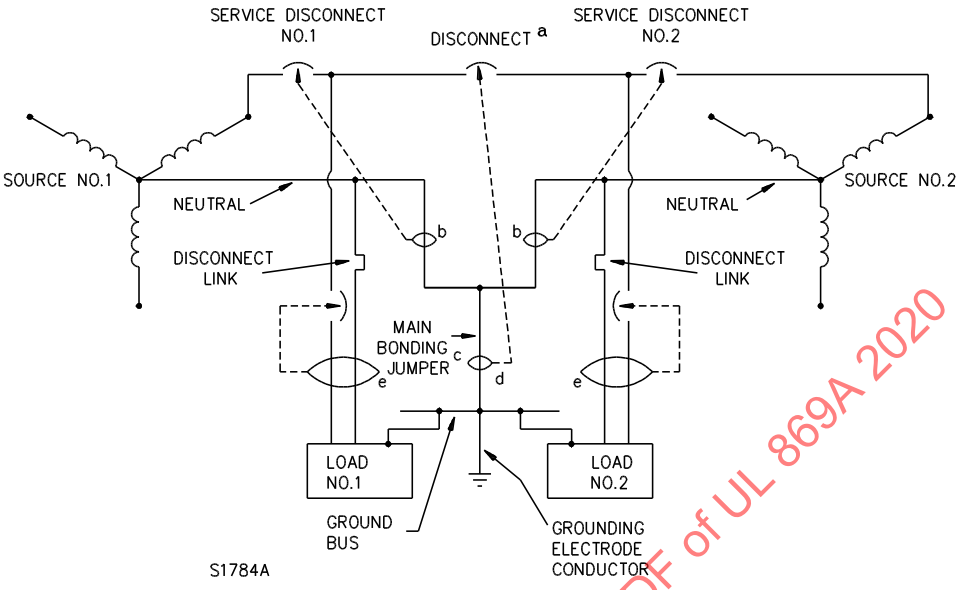
6.3 Transfer equipment

6.3.1 Transfer equipment shall operate such that all ungrounded conductors of one source of supply are disconnected from the load before any ungrounded conductors of the second source are connected to the load.

Exception: If the transfer equipment is constructed as specified in 6.4.1 – 6.4.3 and Figure 6.1, two or more sources may be connected simultaneously in parallel through the transfer equipment.

Figure 6.1

Multiple source equipment



[a] Tie switch or tie breaker.

[b] Additional ground return type ground fault protection sensors utility interlocked with sensor specified in note d so as to function only when fault current is also sensed as covered in note d.

[c] Size of main bonding jumper based on largest service disconnect.

[d] Ground return type ground fault protection sensor in accordance with 7.6.

[e] Zero sequence or residual type ground fault protection sensor in accordance with 7.4.

6.4 Multiple source equipment

6.4.1 If the equipment is intended to parallel different sources, synchronizing equipment shall be provided. Other equipment that may be provided includes:

a) Over and under voltage relays;

b) Reverse power relays; and

c) Over and under frequency relays.

6.4.2 A circuit breaker that is marked "line" and "load" or a fused switch shall not be used as a tie-breaker, tie-switch, or source disconnect if the source is intended to be paralleled with other sources.

Exception: Fused switches may be used if both ends of each fuseholder are disconnected from either voltage source when the switch is in the "off" position.

6.4.3 An unfused switch used as a tie switch shall be of a type that has been tested for reverse line and load connections.

Exception: If a tie switch has not been tested for reversed line and load connections, the equipment shall be marked to indicate that the tie switch is not to be opened under load as described in 14.7.3.

7 Ground Fault Protection

7.1 It is assumed that 3-phase, 3-wire equipment will be connected to a solidly grounded 3-phase, 4-wire, wye-connected service unless the marking specified in 14.5.5 (b) is provided. The ground fault protection system shall be investigated to determine that it functions in accordance with the field testing instructions in Field Testing of Ground Fault Protection of Equipment, Section 15.

7.2 Equipment intended for 3-phase, 4-wire, solidly grounded wye-connected services rated in excess of 150 volts to ground, but not exceeding 1000 volts phase-to-phase, shall be provided with ground fault protection for each service disconnecting means rated 1000 amperes or more. The ground fault protection 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.

Exception: Ground fault protection need not be provided for equipment marked in accordance with 14.5.5.

7.3 Compliance with the requirements specified in 7.1 anticipates that each service disconnect device to which the requirement applies is provided with automatic tripping means for actuation by ground fault sensing and relaying equipment that may be, although not required to be, a part of the service disconnect device.

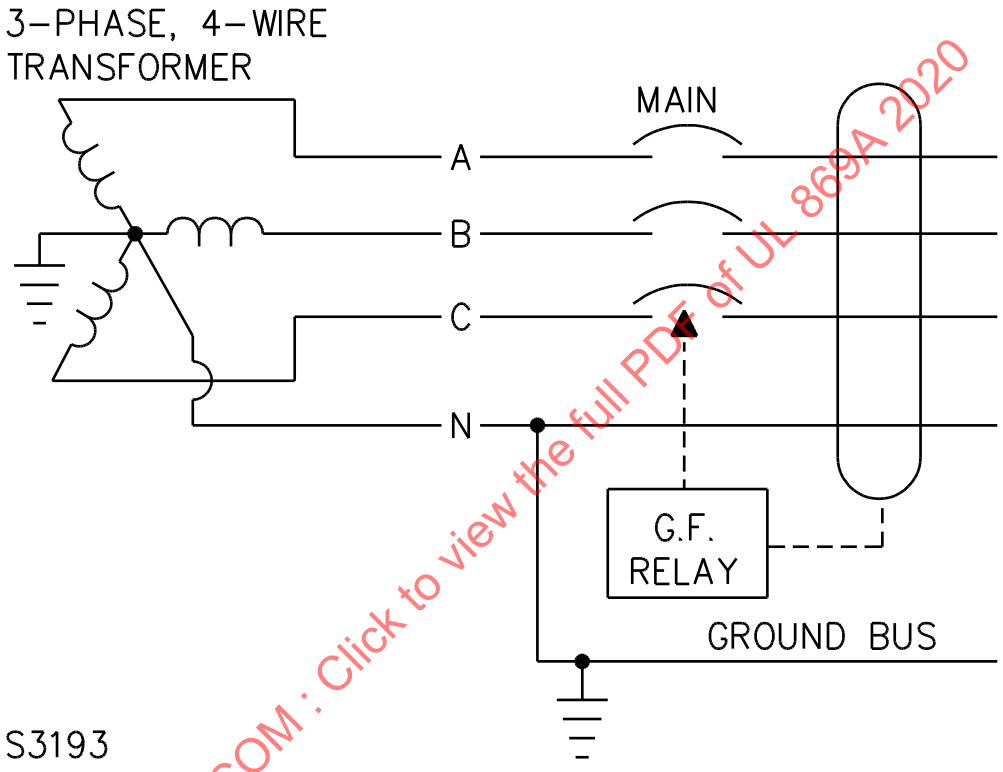
7.4 If provided, ground fault sensing and relaying equipment that is not a part of the disconnect device shall be mounted in the equipment enclosure and connected to the disconnect device and power source. The rating of the disconnect device control circuit shall be compatible with that of the sensing and relaying components.

Exception: Ground fault sensing, relaying equipment, or both, that is not a part of the disconnect device may be in a separate enclosure if the combination has been found acceptable and the service equipment is marked in accordance with 14.5.1.

7.5 A ground fault protection system that employs a sensing element that encircles the grounded service conductor, if any, and all ungrounded conductors of the protected circuit (commonly referred to as a zero-sequence type system) shall be connected in such a manner that the sensing element is located on the load side of any grounding or bonding connection to the grounded service conductor. It may be on the line or load side of the disconnecting device for the protected circuit. A typical zero-sequence type system is shown in Figure 7.1.

Figure 7.1

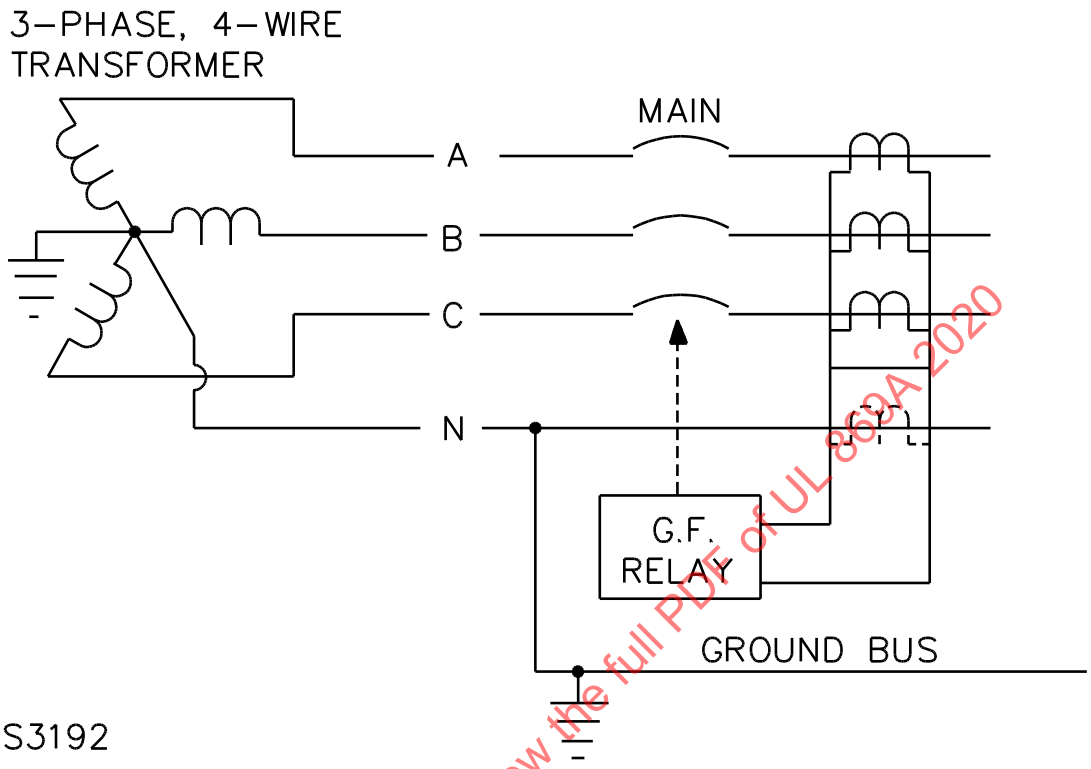
Zero-sequence system



7.6 A ground fault protection system that combines the outputs of separate sensing elements for the grounded service conductor, if any, and each ungrounded conductor (commonly referred to as a residual type system) 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 grounded service conductor. The ungrounded conductor sensors may be within or on the line or load side of the disconnecting device for the protected circuits. A typical residual type system is shown in Figure 7.2.

Figure 7.2

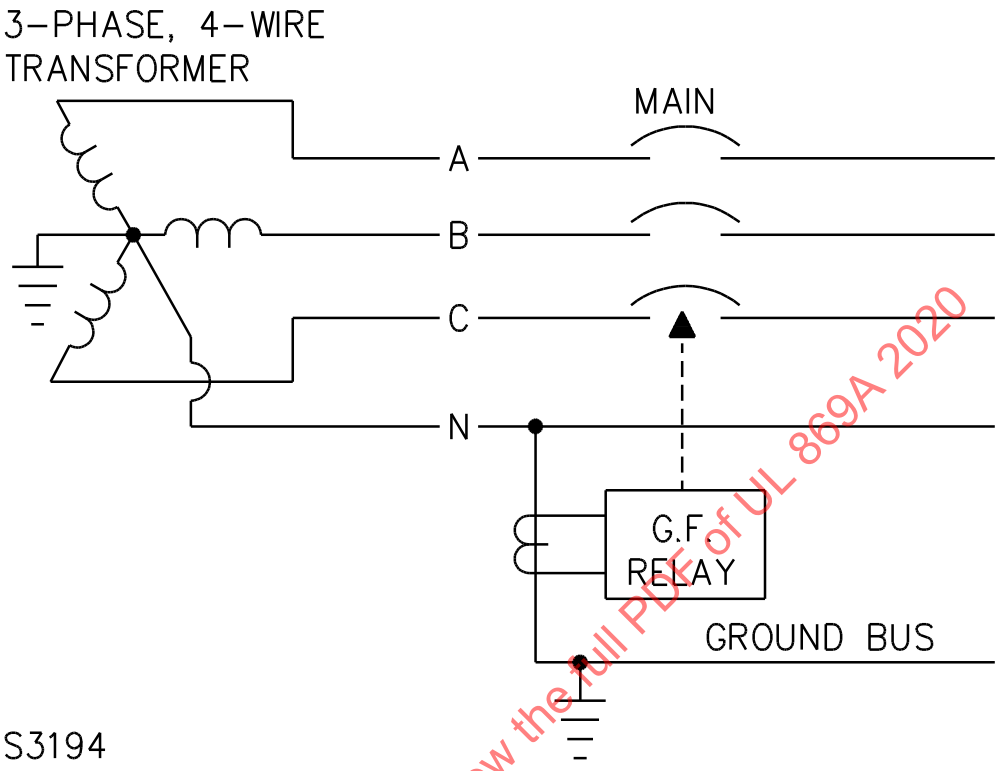
Residual system



7.7 A ground fault protection system that employs a single sensing element to detect the actual fault current (commonly referred to as a ground return system) 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 connection within the equipment that may be made to the grounded service conductor. This will require that, other than for the connections mentioned, the grounded service conductor be insulated from the noncurrent-carrying metal. A typical ground return system is shown in Figure 7.3.

Figure 7.3

Ground return system



7.8 If the construction 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, the construction shall prevent the 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.

7.9 The primary of a ground fault protection control circuit transformer may be connected on the line or load side of the main disconnect. The primary of the control circuit transformer shall be connected to two line voltage parts (not a phase conductor and the grounded service conductor). When connected to the line side of the main, a fused disconnect switch or circuit breaker that is suitable for service equipment and that provides overcurrent protection shall be installed on the line side of the transformer or control circuit or both, and the service equipment shall be marked as specified in 14.5.3. Overcurrent protection is not required for the control circuit when wired to the load side of the main disconnect unless the control circuit wiring leaves the enclosure.

7.10 The secondary circuit of a control power transformer for the ground fault protection system shall be grounded if the circuit extends or may extend beyond the equipment in which the transformer is mounted and if the secondary voltage:

a) Is less than 50 volts and the transformer supply is greater than 150 volts to ground or the transformer supply at any voltage is ungrounded or

b) Is 50 volts or greater and the secondary circuit can be grounded so that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts.

7.11 If a transformer secondary is required to be grounded in accordance with 7.10 a main bonding jumper shall be factory connected to the transformer secondary and to the ground bus (or the terminal

specified in 4.7 for the grounding electrode conductor if there is no ground bus). The size of the main bonding jumper shall be as specified in Table 9.1 based on the transformer secondary current rating.

7.12 In equipment incorporating ground fault protection of the ground return type as described in 7.7, the main bonding jumper shall be factory connected to the neutral bus and to the enclosure or the ground bus, and the equipment shall be marked as specified in 14.1.1 or 14.1.2.

7.13 Equipment with ground fault protection shall comply with 10.5, 14.5.2, and 14.5.4.

8 Overcurrent Protection

8.1 The equipment may be provided with overcurrent protection. When overcurrent protection is provided, each ungrounded service conductor shall be protected.

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

9 Provision for Bonding and Grounding

9.1 For other than a high-impedance grounded neutral system as covered in 9.3, if the grounded service conductor is not mounted directly on the enclosure as specified in 9.2, a main bonding jumper shall be provided to bond the enclosure to the grounded service conductor of an alternating-current system. The jumper shall be of copper or aluminum and shall have a cross-sectional area as specified in Table 9.1. When the jumper is not used, the minimum required spacings shall be maintained. Unless the intended use and method of installation of the jumper are obvious, instructions for its installation shall be provided. The main bonding jumper shall be located on the supply side of the grounded service conductor disconnect. A main bonding jumper shall not be provided for equipment intended only for use with direct current.

Exception: The bonding jumper may be a steel or brass screw as described in notes d through g of Table 9.1.

Table 9.1
Size of grounding electrode conductor and main bonding jumper

Service equipment ampere rating not exceeding	Size of main bonding jumper (minimum)[a,b,c]				Cross section of main jumper (minimum)[a,b]				Size of grounding electrode conductor (minimum)			
	Copper,		Aluminum,		Copper,		Aluminum,		Copper,		Aluminum,	
	AWG kcmil	(mm^2)	AWG kcmil	(mm^2)	$Inches^2$	(mm^2)	$Inches^2$	(mm^2)	AWG	(mm^2)	AWG kcmil	(mm^2)
90	8	8.4	6	13.3	0.013[d]	8.39	0.021[d]	13.55	8	8.4	6	13.3
125	6	13.3	4	21.2	0.021[d]	13.55	0.033[d]	21.29	6	13.3	4	21.2
150	6	13.3	4	21.2	0.021[e]	13.55	0.033[e]	21.29	6	13.3	4	21.2
200	4	21.2	2	33.6	0.033[e]	21.29	0.052[e]	33.55	4	21.2	2	33.6
225	2	33.6	0	53.6	0.052[f,g]	33.55	0.083[f,g]	53.55	2	33.6	0	53.6
400	0[h]	53.6	3/0[h]	85.0	0.083[g,h]	53.55	0.132[g,h]	85.16	0	53.6	3/0[h]	85.0
500	0	53.6	3/0[h]	85.0	0.083	53.55	0.132	85.16	0	53.6	3/0	85.0
800	2/0	67.4	4/0	107.2	0.105	67.74	0.166	107.10	2/0	67.4	4/0	107.2
1000	3/0	85.0	250	127	0.132	85.16	0.196	126.45	3/0	85.0	250	127
1200	250	127	250	127	0.177	114.19	0.196	126.45	3/0	85.0	250	127

Table 9.1 Continued on Next Page

Table 9.1 Continued

Service equipment ampere rating not exceeding	Size of main bonding jumper (minimum)[a,b,c]				Cross section of main jumper (minimum)[a,b]				Size of grounding electrode conductor (minimum)			
	Copper,		Aluminum,		Copper,		Aluminum,		Copper,		Aluminum,	
	AWG kcmil	(mm^2)	AWG kcmil	(mm^2)	$Inches^2$	(mm^2)	$Inches^2$	(mm^2)	AWG	(mm^2)	AWG kcmil	(mm^2)
1600	300	152	400	203	0.236	152.26	0.294	189.68	3/0	85.0	250	127
2000	400	203	500	253	0.294	189.68	0.353	227.74	3/0	85.0	250	127
2500	500	253	700	355	0.353	227.74	0.515	332.26	3/0	85.0	250	127
3000	600	304	750	380	0.412	265.81	0.589	380.00	3/0	85.0	250	127
4000[i]	750	380	1000	506	0.589	380.00	0.810	522.58	3/0	85.0	250	127

[a] The cross section may be reduced to 12.5 percent of the total cross section of the largest main section of the largest main service conductor(s) of the same material (copper or aluminum) for any phase on service equipment rated 1200 amperes and above. This applies when the cross section of the service conductor is limited by the wire terminal connectors provided.

[b] For service equipment rated 1200 amperes or more that has wiring terminals intended to connect service conductor wires sized larger than 600 kcmil (304 mm^2) copper or 750 kcmil (380 mm^2) aluminum, the cross section of the main bonding jumper shall be at least 12.5 percent of the total cross section of the largest main service conductor(s) of the same material (copper or aluminum) for any phase.

[c] These are also sizes for the grounded service conductor of 4.4(c).

[d] A No. 8 (4.2 mm diameter) or larger brass or No. 10 (4.8 mm diameter) or larger steel screw, the head of which has a green finish that is visible after installation, may be used.

[e] A No. 10 or larger brass or steel screw, the head of which has a green finish that is visible after installation, may be used.

[f] A No. 10 or larger brass screw, the head of which has a green finish that is visible after installation, may be used.

[g] A 1/4 inch (6.4 mm) diameter or larger brass or steel screw, the head of which has a green finish that is visible after installation, may be used.

[h] When the ampere rating is 400 amperes and the wire terminal connectors for the main service conductors are rated for two 3/0 AWG (85 mm^2) copper or two 250 kcmil (127 mm^2) aluminum conductors but will not accept a 600 kcmil (304 mm^2) conductor, these values may be reduced to 2 AWG [0.052 square inch, (33.55 mm^2)] copper or 1/0 AWG [0.083 square inch, (53.55 mm^2)] aluminum.

[i] For service ratings in excess of 4000 amperes, the main bonding jumper shall be sized not less than 20 percent of the service rating. The conductor size shall be selected in accordance with the allowable current density per conductor as defined in the National Electrical Code, ANSI/NFPA 70. The main bonding jumper shall have a total cross section area not less than 0.589 square inch (380 mm^2) for copper and 0.810 square inch (523 mm^2) for aluminum. The grounding electrode conductor shall not be less than 250 kcmil (127 mm^2) for copper and 400 kcmil (203 mm^2) for aluminum.

9.2 For other than a high-impedance grounded neutral system as covered in 9.3, in equipment intended and marked for use on alternating-current circuits only, the grounded service conductor terminal or terminals may be mounted directly on or otherwise in permanent electrical connection with the enclosure and shall be marked as specified in 14.1.3. A main bonding jumper shall comply with the values in Table 9.1 and shall be located on the supply side of the grounded service conductor disconnect. If the main bonding jumper is removable, but is connected at the factory to the grounded service conductor terminal and to the enclosure, the equipment shall be marked as specified in 14.1.3. Equipment containing a removable main bonding jumper that is not factory connected between the grounded service conductor and enclosure shall be marked as specified in 14.2.1 or 14.2.2.

9.3 Equipment intended for service equipment use may be provided with a high-impedance grounded neutral system if provided for in the requirements for the end product.

9.4 Equipment intended for use as service equipment shall have provision for connection of a grounding electrode conductor sized in accordance with Table 9.1 as specified in 4.3 and 4.5 – 4.8.

9.5 With respect to 4.4(c), the equipment shall have a terminal for a grounded service conductor even though there is no provision for a load conductor to be connected to the grounded service conductor. If there is no provision for such a load conductor, the grounded service conductor terminal shall:

a) Accommodate a conductor of the same size as the main bonding jumper shown in Table 9.1,

b) Be bonded to the enclosure, and

c) Be directly connected to the grounding electrode conductor terminal.

Exception: The terminal may be omitted if the equipment is marked as specified in 14.7.4.

10 Spacings

10.1 Other than as covered in 10.2 – 10.5, the spacings in equipment used as service equipment shall not be less than indicated in Table 10.1 within or on the line side of a service disconnect. These spacings shall also be maintained on the line side of the service overcurrent protection. Grounded dead metal includes the enclosure and any dead metal that may be in electrical connection with the enclosure.

Exception No. 1: A spacing between:

a) Adjacent screw-shells of Edison-base plug fuseholders that are protected by surrounding walls of insulating material,

b) Parts of the upper-contactor rings of adjacent Type S plug fuseholders, and

c) Such screw-shells or upper-contact-ring parts and a metal cover plate

may not be less than 1/4 inch (6.4 mm) if the depth of the receptacle, as measured from the top of the wall (insulating material) to the plane of the center contact, is not less than 3/4 inch (19.1 mm).

Exception No. 2: The spacings may not be less than 1/8 inch (3.2 mm) between switch blades and the enclosure cover when the switch is in the off position and the blades are dead.

Exception No. 3: Inherent spacings of meter socket bases, circuit breakers, and molded case switches shall comply with the requirements applicable to such components.

Exception No. 4: If a service disconnect serves as a motor feeder (or motor branch circuit) disconnect, the spacings within a motor controller located on the load side of the motor feeder (or motor branch circuit) short-circuit protection shall comply with the requirements applicable to such a component.

Table 10.1
Minimum spacings

Voltage involved[a]		Between uninsulated live parts of opposite polarity				Between uninsulated live parts and any grounded dead metal			
Greater than	Maximum	Over surface,[b]		Through air,		Over surface,		Through air,	
Volts		inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
0	125	3/4	19.1	1/2	12.7	1/2	12.7	1/2	12.7
125	250	1-1/4	31.8	3/4	19.1	1/2	12.7	1/2	12.7
250	600	2	50.8	1	25.4	1	25.4	1/2	12.7

NOTE – An isolated dead-metal part (such as a screwhead or 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.

[a] It is assumed that the voltage from a grounded service conductor live part to grounded dead metal equals the line-to-neutral voltage of the system.

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

10.2 The distance between a door or cover over a fuseholder and:

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

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

10.3 There shall be a spacing of not less than 1/8 inch (3.2 mm) between parts of the same polarity on the line and load sides of the service overcurrent protection and between the line and load sides of a service disconnect.

10.4 Spacings within equipment rated at 40 amperes or less are to be measured with the equipment wired with 8 AWG (8.4 mm^2) conductors. In measuring a spacing, a metallic part such as a screw head or washer interposed between uninsulated live parts of opposite polarity or between an uninsulated live part and a grounded dead metal part is considered as reducing the spacing by an amount equal to the dimensions of the metallic part in the direction of measurement.

10.5 If the enclosure or ground bus is factory bonded to the grounded service conductor, any conductive part connected to the grounded service conductor 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, parts that would interfere with its operation if grounded include all grounded service conductor parts on the load side of the grounded service conductor current sensing means. For the ground return type, parts that would interfere with its operation if grounded include all conductive parts connected to the grounded service conductor except those on the ground side of the sensing means.

10.6 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.

10.7 If the connection mentioned in 10.6 is solely by means of a screw, strap or other bonding device that can be readily removed and is not depended upon to perform a mechanical function, the equipment shall:

a) Comply with the requirements in Ground Fault Protection, Section 7, when the bonding device is removed or

b) Be marked as specified in 14.1.3.

PERFORMANCE

11 Ground Fault Protection System Test

11.1 The ground fault protection system shall be investigated to determine that it functions as intended, using the test instructions provided in Field Testing of Ground Fault Protection of Equipment, Section 15.

MANUFACTURING AND PRODUCTION TEST

12 Ground Fault Protection Equipment Test

12.1 A factory test shall be conducted on each piece of equipment incorporating ground fault protection equipment to determine that the ground fault protection equipment functions. The system shall be energized at 57 percent or less of rated voltage with the system pick-up value set at any convenient level. With a simulated ground fault current (as described in 12.2) caused to flow, the ground fault protection system shall operate as intended. Following this test, with simulated ground fault current no longer flowing, an attempt shall be made to close the main switch or circuit breaker without pushing any reset button. If

the switch or circuit breaker will stay closed, the simulated ground fault current shall be reapplied and the ground fault protection system is to function.

Exception: The applied voltage may be approximately rated voltage if the particular combination of transformer, ground fault sensing and relaying equipment, and disconnecting means has previously been tested at 57 percent or less of rated voltage.

12.2 One method of simulating a ground fault current is by wrapping a number of turns of wire through the sensor and passing a current of approximately 125 percent of the pick-up setting of the relay divided by the number of turns through the wire.

RATINGS

13 General

13.1 Equipment, other than a device designated as "Service equipment for motors," shall have a main (overall) rating in volts and amperes.

Exception: Equipment consisting of two or more independent sections may have a separate ampacity rating for each section, switch, or circuit breaker.

13.2 A device consisting of only a single main switch and fuseholder may also have an overall rating in horsepower. Any switch of any other device may be rated in horsepower provided that:

a) The switch controls not more than one branch circuit and

b) The horsepower marking is not shown in such manner or location that it is likely to be construed as the overall rating of the service equipment.

13.3 A device designated as "Service equipment for motors" shall be rated in volts and horsepower only.

Exception: The ampere rating of the disconnect switch may be included if the significance of such rating is plainly indicated by an associated marking; for example, "Disconnect switch _____ amperes."

MARKINGS

14 General

14.1 Bonded neutral

14.1.1 Equipment having a neutral that is factory bonded to the enclosure and that can accommodate not more than six main disconnecting means shall be marked "Suitable only for use as service equipment."

14.1.2 Equipment having a neutral that is factory bonded to the enclosure and that can accommodate more than six main disconnecting means shall be marked "Suitable only for use as service equipment. Install not more than six main disconnecting means."

14.1.3 Equipment that has the neutral bonded at the factory by a removable bonding means shall be marked "Bonded neutral, remove bonding means for test purposes only."