Industrial Solutions

TECHNICAL AND APPLICATION GUIDE

AKD-20

Low voltage switchgear

by ABB

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Warranty and general information

Hazard classifications
The following important highlighted information appears throughout this document to warn of potential hazards or to call attention to information that clarifies a procedure.

Carefully read all instructions and become familiar with the devices before trying to install, operate, service or maintain this equipment.

Danger: Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

Warning: Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

Caution: Indicates that if the hazard is not avoided could result in minor or moderate injury.

Notice: Is used to notify of practices not related to personal injury.

Trademarks
EntelliGuard® G
EntelliGuard® TU
Arc Vault™ Protection System

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Warranty
This document is based on information available at the time of publication. While efforts have been made to ensure accuracy, the information contained herein does not cover all details or variations in hardware and software, nor does it provide for every possible contingency in connection with installation, operation, and maintenance. Features may be described herein that are not present in all hardware and software systems.

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AKD-20
General information

AKD-20 low voltage switchgear continues many of the traditions of the AKD switchgear lines while delivering new benefits, including:
- Enhanced arc flash protection;
- Smaller and lighter power circuit breakers;
- Higher interrupting ratings without the use of fuses;
- Smaller footprints associated with the higher ratings.

They're all part of the AKD-20 and EntelliGuard standard product offering. AKD-20 switchgear is manufactured in an ISO9002 certified ABB facility and built to the highest standards.

AKD-20 switchgear meets the demands of industrial, utility and commercial applications. It is designed and tested in accordance with the latest IEEE C37.20.1 standard, IEEE C37.20.7 arc-resistant standard, CAN/CSA-C22.2 No. 31, and UL 1558 standards (file no. E76012). AKD-20 has been conformance-tested to ANSI C37.51. Any equipment requiring UL 1558 or CSA labeling will be provided with a cUL label. (A cUL label is a third-party certification that indicates the switchgear is compliant to both ANSI/IEEE and CSA standards.)

ANSI standards require that switchgear operates at the ratings of devices installed. Switchgear short circuit ratings are based on two 30-cycle withstand tests with 15-second interval, performed at 15% power factor and 635 Vac maximum.For switchboards, a single 3-cycle withstand test at 20% power factor and 600 Vac maximum is performed.

AKD-20 switchgear is available with the ollowing ratings:
- 600 Vac nominal, 635 Vac maximum;
- 8000 amps AC main bus/6000 amps breaker max.;
- 50/60 Hz;
- 150 kA symmetrical short circuit;
- 2200 Vac rms dielectric.

AKD-20 switchgear breaker and auxiliary sections are constructed with 11-gauge frames and are furnished in 22", 30", 34" and 38" widths. The switchgear is designed to be operated in ambient temperatures between –30 °C and 40 °C [-22 °F and 104 °F].

Low voltage circuit breakers rated 800/1600/ 2000 amps can be stacked in four-high combinations resulting in reduced floor space requirements. The 11-gauge, bolted modular-designed steel frame permits flexibility in arrangements of breakers and associated components.

AKD-20 switchgear houses low voltage power circuit breakers, instrumentation, and other auxiliary circuit protective devices in single or multiple source configurations. AKD-20 switchgear can be applied either as a power distribution unit or as part of a unit substation in indoor or outdoor construction.

The breaker cubicles use cassette-type construction. A metal breaker cassette is incorporated into the breaker cubicle and includes the drawout mechanism, safety interlocks, and provisions for accessories such as shutters, position switches, secondary disconnects, and key interlocking.

The new EntelliGuard G low voltage power circuit breaker (LVPCB) offers every advantage of the traditional ironframe LVPCB while being smaller and lighter. The circuit breaker's frames have continuous current ratings from 800 A to 6000 A and sensors from 400 A to 6400 A, with rating plug values as low as 150 A. Short-circuit ratings are available up to 150 kA, with 65 kA, 85 kA, and 100 kA 30- cycle withstand ratings to match.

The EntelliGuard TU electronic trip unit family – with its unique waveform recognition instantaneous algorithm and the industry's only true Instantaneous Zone Selective Interlocking (I-ZSI) – provides unsurpassed flexibility, selectivity, and arc flash protection. EntelliGuard TU enables entire power distribution systems to be designed with 100% instantaneous protection in switchgear mains or feeders to achieve a reliable power distribution system. AKD-20 low voltage switchgear, EntelliGuard G LVPCB, and EntelliGuard TU trip units.

Standard and optional features - for enhanced operation and reliability

Cassette construction

AKD-20 switchgear has several key components that set it apart from previous ABB low voltage switchgear designs. The EntelliGuard G breaker fits into a metal cassette built in to the circuit breaker cubicles, as shown in Figure 1-1. AKD- 20 breaker cubicle construction uses an unventilated front door that provides closed-door access to breaker status indicators, mechanism operators, trip unit display and keypad, and it allows for closed-door drawout operation.

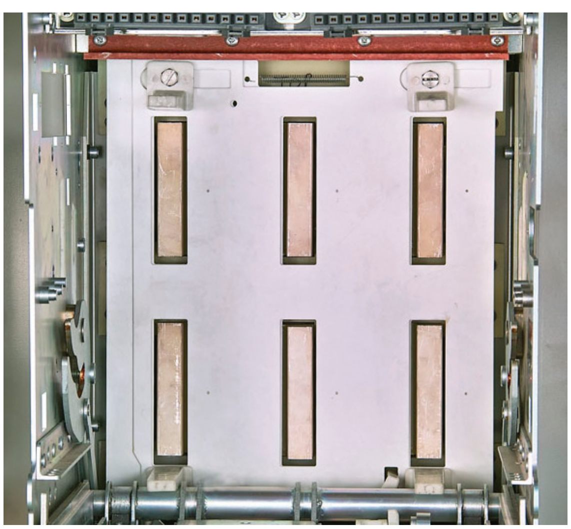

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Figure 1.1: Cassette construction

The breaker cubicle door has a standard quarter-turn latch and serves as a steel barrier between live parts and the operator. The cassette houses accessories as well as interlocks for the drawout breaker. Accessories include current transformers for discrete metering or relaying, drawout position switches, shutters, and key interlocks.

Repetitive duty

Circuit breakers are designed primarily to perform the function of circuit interruption under short-circuit conditions.

Nevertheless, modern circuit breakers' mechanisms are capable of many operations under full-load operation and in-rush conditions such as those encountered in motor starting applications. Industry standards have been established for the minimum performance, as indicated in Table 1.1. With adequate maintenance, EntelliGuard G/E can be expected to exceed the standards.

EntelliGuard breakers have been designed and tested to allow the user to extend the normal maintenance service interval up to two times the ANSI recommendation — a significant benefit for continuous process and 7-X-24 operations. See Table for additional information.

Power-operated circuit breakers, when operating under usual service conditions, shall be capable of operating the number of times specified in the following table. The operating conditions and the permissible effect of such operations upon the breaker are listed in Table and the footnotes. For instance, the breaker should be operated with rated control voltage applied. The frequency of operation should not exceed 20 in 10 minutes or 30 in an hour (rectifiers or other auxiliary devices may further limit the frequency of operation).

Servicing consisting of adjusting, cleaning, lubricating, tightening, etc., as recommended by the maintenance manual, is to be done at no greater interval than shown in the column titled “Number of operations between servicing” in Table.

No functional parts should require replacement during the listed operations. The circuit breaker should be in condition to carry its rated continuous current at rated maximum voltage and perform at least one opening operation at rated short-circuit current. After completion of this series of operations, functional part replacement and general servicing may be necessary. This standard applies to all parts of a circuit breaker that function during normal operation. It does not apply to other parts, such as overcurrent tripping devices that function only during infrequent abnormal circuit conditions.

Table 1.1: Repetitive duty and normal maintenance (from ANSI C37.16 table 5)

Circuit breaker frame size (amperes)	Number of operations between servicing	Number of operations rated continuous current switching(1)(2)(4)	Number of operations on-load closing and opening(1)	Number of operations in-rush current switching(3)(4)
800	1750	2800	9700	1400
1600	500	800	3200	400
2000	500	800	3200	400
3200	250	400	1100	-
4000	250	400	1100	-
5000	250	400	1100	-

1. Servicing consists of adjusting, cleaning, lubricationg, tightening, etc. as recommended by the manufacturer. When current is interrupted, dressign of contacts may be required as well. The operations listed are on the basis of servicing at intervals of six months or less.

2. With closing and opening currents up to the continuous current rating of the circuit breaker at voltages up to the rated maximum voltage (85% or higher power factor).

3. The number of operations was determined with closing currents up to 100% (80% power factor or higher) ofthe continuous current rating of the circuit breaker at voltages up to the rated maximum voltage. With closing and opening currents up to 600% (50% power factor or less) of the continuous current rating of the circuit breaker at voltages up to rated maximum voltage, the number of operations shown should be reduced to 10% of the number listed in the column.

4. If a fault operation occurs before the completion of the listed number of operations, servicing is recommended and possible functional part repmacement may be necessary depending on previous accumulated duty, fault magnitude, and expected future operations.

Temperature derating factors

The continuous current rating of EntelliGuard breakers is based on their use in an enclosure at 40° C ambient temperature and 105° C maximum breaker temperature for Class A tings of EntelliGuard breakers must be derated for ambient temperatures above 40° C. (Trip unit ambient is limited to 70° C.)

Table 1.2: Continuous current derating factors

Ambient temperature (°C)	Derationg factor
40	1.00
45	0.95
50	0.89
55	0.84[1]
60	0.77
65	0.71
70	0.63

1. Trip unit maximum

Altitude correction factors

When applying low voltage power circuit breakers at altitudes greater than 6,600 feet, their continuous current rating must be modified because a higher temperature use will be experienced for a given current rating. The voltage ratings must also be modified because of the lower dielectric strength of the air. The short-time and short-circuit current ratings are not affected by altitude. However, the short-circuit current ratings shall not exceed that of the voltage class before derating.

Table 1.3: Altitude correction factors (as listed in ANSI C37.13)

Altitude		Rating correction factor	
Meters	Feet	Continuous current	Voltage
2000	6600 (and below)	1.00	1.00
2600	8500	0.99	0.95
3900	13000	0.96	0.80

Humidity

Ferrous parts are zinc-plated for corrosion protection except for some parts made from alloy steels that are inherently corrosion resistant. Current-carrying parts are silver- or tinplated for corrosion protection and to assure electrical continuity. Heaters may be added to indoor sections operating in high humidity environments. Heaters are mounted in the bus/cable compartment in the rear of each section.

Table 1.4: Insulation values (dielectric test)

	kV
Breaker	2.2
Control wiring	1.5
Closing motor	0.9

Table 1.5: Breaker operating time (same for all frame sizes)

Close (time from energizing closing circuit until contacts touch)	Electrically operated	5 Cycles
Open (maximum clearing time)	With instantaneous overcurrent trip	3 Cycles
	With shunt trip	3.5 Cycles

Primary disconnect shutters
Optional shutters (Figure 1.2) can be specified for all breaker cubicles. An insulated cam opens the shutters when the breaker is racked in from the TEST position to the CONNECT position. The shutters close when the breaker is between the TEST and DISCONNECT positions. They can be locked in the closed position (Figure 1.3) when the breaker is removed from the cubicle, preventing access to the line and load stabs in the breaker cubicle. Shutters are provided as a standard feature for source and tie breakers on switchgear lineups with multiple sources. These applications include main-tie-main or main-generator lineups. Shutters for feeder breakers are optional in multisource lineups.

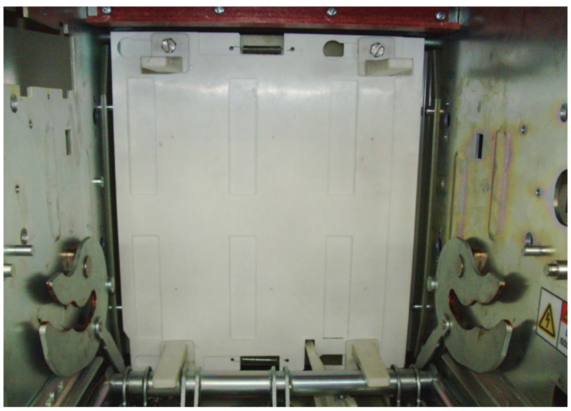

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Figure 1.2: Primary disconnect shutters (open and closed positions, respectively)

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Figure 1.3: Primary disconnect shutters (locked in the closed position)

Kirk key interlocks
Key interlocks can be added to the cassette to mechanically lock the breaker open, in a trip-free position, when the breaker is in the CONNECT position (Figure 1.4).

The cassette will accommodate either one or two Kirk key interlocks. Interlocking schemes prevent multiple breakers from being closed at the same time, such as a utility main and emergency generator, or preventing a tie breaker from being closed until a main circuit breaker is opened. Key interlocks are also used to prevent operation of a transformer primary switch unless the main secondary breaker is open. Key interlocks mounted in the breaker cassette stay with the breaker cubicle so that the interlock scheme is maintained even if a spare breaker is inserted into a main, tie, or generator breaker cubicle. Key interlocks also prevent breaker racking into any other position when engaged. Proper breaker position (CONNECT, TEST, or DISCONNECT) must be selected before engaging the key interlock.

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Figure 1.4: Kirk keys locking breakers (breaker in the CONNECT position)

Breaker rating rejection

The cassette also includes rating interlocks to prevent a breaker of incorrect short-circuit rating or continuous current rating from being installed into a cassette (Figure 1.5). There are three physical envelope sizes for the EntelliGuard G breaker. The physical size differences will not allow breakers of a different envelope size to fit into an incorrect compartment. Within an envelope size, a breaker with a higher short circuit rating will fit into a lower rated cassette if the continuous current rating of the breaker is less than or equal to the rating of the cassette.

As an example, an 800 A, 85 kA interrupting breaker can be installed into a 1600 A, 65 kA breaker cassette. However, a 1600 A breaker cannot be installed into an 800 A cassette, nor can a 65 kA breaker be installed into an 85 kA cassette.

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Figure 1.5: Breaker and cassette rejection (respectively)

Cassette interlocks

Drawout interlocks are part of the cassette and prevent the breaker from being moved into or out of the CONNECT position unless the circuit breaker is open (Figure 1.6). The interlocks also prevent closing a breaker unless it is in the fully CONNECT or TEST position. A spring discharge interlock releases any energy stored in the closing springs when the circuit breaker is removed from the cassette.

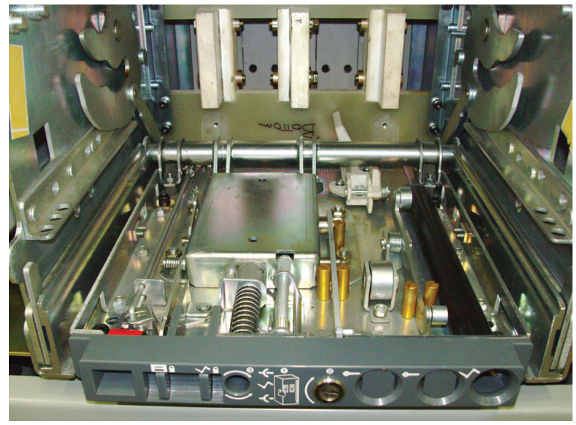

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Figure 1.6: Drawout interlocks

Padlocking provisions
Several types of padlocking provisions are standard on the cassette and breaker. The cassette has provisions for padlocking the shutters in the closed position (Figure 1.3) and for padlocking access to the racking mechanism (Figure 1.7).

The drawout rails have provisions for up to three padlocks to prevent a circuit breaker from being installed into the cassette (Figure 1.8). The circuit breaker has provisions for up to three padlocks that will keep the breaker open and mechanically trip free (Figure 1.9).

An optional padlockable cubicle quarter-turn latch is available unauthorized access to the breaker cubicle.

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Figure 1.7: Rack padlocked

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Figure 1.8: Drawout rail padlocked (and close-up)

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Figure 1.9: Breaker padlocked

Door interlock
An optional door interlock can be supplied on the cassette to automatically secure the breaker cubicle door and prevent entry into the breaker cubicle unless the circuit breaker is racked out to the TEST or DISCONNECT position.

Instrument panel
Standard construction includes a grounded steel instrument panel above each circuit breaker (Figure 1.10). This panel is used for mounting a variety of control circuit components – including fuses for the charge, close, and trip circuits; indicating lights, and the Reduced Energy Let-Thru switch. Control circuit fuses and indicating lamps are replaceable from the front of the panel. The panel is removable to provide access to wiring terminations. An engraved circuit nameplate is also provided on each breaker cubicle instrument panel.

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Figure 1-10: Instrument panel with RELT switch

Secondary disconnects
Breaker control circuit devices and trip unit inputs and outputs are connected to the breaker through secondary disconnects mounted on the front of the breaker and cassette (Figure 1.11). This provides convenient access to the secondary control terminal points for monitoring or troubleshooting.

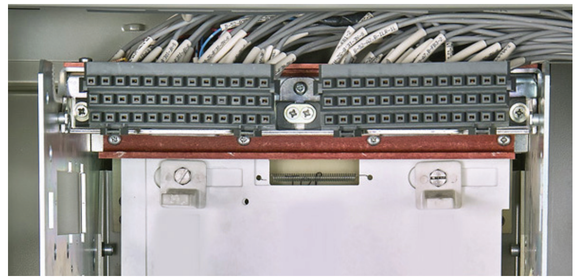

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Figure 1.11: Secondary disconnects

All breaker-mounted accessories have dedicated wiring points on the secondary disconnects. Adding accessories to the breaker requires only plugging the wire harness, included with the accessory, into the open points on the secondary disconnect.

Current transformers
Relaying class CTs can be supplied for Envelope 1, 2, and 3 breakers. The relaying class CTs are located in the breaker cassette and are mounted on the three upper primary disconnect stabs in the cubicle. Up to three relaying current transformersmay be mounted in the breaker cubicle. CT ratios, associated relaying class, and internal winding resistance are shown in Table 1.6, Table 1.7, and Table 1.8.

Relaying class CTs are used for ground fault protection on four-wire, double-ended switchgear applications. The relaying CTs indicated in Table 1.6, Table 1.7, and Table 1.8 are suitable for use with equivalent main and tie breaker ampere ratings. A detailed description of the 4- wire ground fault system is provided on page 63 (Figure 3.1).

Table 1.6: AKD-20 Envelope 1 relaying current transformers

Current ratio	Relay class	ANSI metering class @60 Hz					Secondary winding resistance (Ohms @75 °C)	Cat #0173B4776
		B0.1	B0.2	B0.5	B0.9	B1.8		
100:5	-	2.4	1.2	-	-	-	0.0313	P001
150:5	-	1.2	1.2	-	-	-	0.0236	P002
200:5	-	0.6	1.2	2.4	-	-	0.0651	P003
250:5	C10	0.6	0.6	2.4	2.4	-	0.0460	P004
300:5	C10	0.3	0.6	1.2	2.4	-	0.0760	P005
400:5	C20	0.3	0.3	0.6	1.2	2.4	0.1063	P006
500:5	C20	0.3	0.3	0.6	1.2	1.2	0.1394	P007
600:5	C20	0.3	0.3	0.3	0.6	1.2	0.1509	P008
750:5	C20	0.3	0.3	0.3	0.3	0.6	0.1858	P009
800:5*	C20	0.3	0.3	0.3	0.3	0.6	0.2091	P010
1000:5*	C20	0.3	0.3	0.3	0.3	0.3	0.2673	P011
1200:5*	C50	0.3	0.3	0.3	0.3	0.3	0.3480	P012
1500:5*	C50	0.3	0.3	0.3	0.3	0.3	0.3948	P013
1600:5*	C50	0.3	0.3	0.3	0.3	0.3	0.4180	P014
2000:5*	C50	0.3	0.3	0.3	0.3	0.3	0.5109	P015

* Indicated relaying CTs may be used for ground fault protection on main and tie breakers in four-wire, double-ended switchgear applications

Table 1.7: AKD-20 Envelope 2 relaying current transformers

Current ratio	Relay class	ANSI metering mlass @60 Hz					Secondary winding resistance (Ohms @75 °C)	Cat #0173B4776
		B0.1	B0.2	B0.5	B0.9	B1.8		
100:5	-	2.4	2.4	-	-	-	0.03356	P001
150:5	C10	2.4	2.4	-	-	-	0.03830	P002
200:5	C10	0.6	1.2	2.4	2.4	-	0.04760	P003
250:5	C10	0.6	1.2	1.2	2.4	2.4	0.09670	P004
300:5	C20	0.6	0.6	1.2	1.2	2.4	0.04350	P005
400:5	C20	0.3	0.6	0.6	1.2	2.4	0.15097	P006
500:5	C50	0.3	0.3	0.6	0.6	1.2	0.18580	P007
600:5	C50	0.3	0.3	0.3	0.6	0.6	0.21136	P008
750:5	C50	0.3	0.3	0.3	0.3	0.6	0.26710	P009
800:5*	C50	0.3	0.3	0.3	0.3	0.6	0.29030	P010
1000:5*	C50	0.3	0.3	0.3	0.3	0.3	0.36002	P011
1200:5*	C100	0.3	0.3	0.3	0.3	0.3	0.39480	P012
1500:5*	C50	0.3	0.3	0.3	0.3	0.3	0.41810	P013
1600:5*	C50	0.3	0.3	0.3	0.3	0.3	0.42960	P014
2000:5*	C50	0.3	0.3	0.3	0.3	0.3	0.60340	P015
2500:5*	C100	0.3	0.3	0.3	0.3	0.3	0.70840	P016
3000:5*	C50	0.3	0.3	0.3	0.3	0.3	0.65030	P017
3200:5*	C50	0.3	0.3	0.3	0.3	0.3	0.70840	P018

* Indicated relaying CTs may be used for ground fault protection on main and tie breakers in four-wire, double-ended switchgear applications.

Table 1.8: AKD-20 Envelope 3 relaying current transformers

Current ratio	Relay class	ANSI metering class @60 Hz					Secondary winding resistance (Ohms @75 °C)	Cat #0173B4776
		B0.1	B0.2	B0.5	B0.9	B1.8		
2000:5	C100	0.3	0.3	0.3	0.3	0.3	0.5450	P001
2500:5*	C100	0.3	0.3	0.3	0.3	0.3	0.6387	P002
3000:5*	C100	0.3	0.3	0.3	0.3	0.3	0.7781	P003
3200:5*	C100	0.3	0.3	0.3	0.3	0.3	0.8477	P004
4000:5*	C50	0.3	0.3	0.3	0.3	0.3	0.8245	P005
5000:5*	C50	0.3	0.3	0.3	0.3	0.3	1.0450	P006
6000:5*	C50	0.3	0.3	0.3	0.3	0.3	1.7500	P007

* Indicated relaying CTs may be used for ground fault protection on main and tie breakers in four-wire, double-ended switchgear applications.

AKD-20 Bus Options

AKD-20 bus options are shown in Table 1.9. All horizontal and vertical bus bars (phase, neutral, and ground) are the standard tin-plated copper. Tin plating is desirable for many industrial applications such as wastewater treatment, pulp and paper, petrochemical and other areas where the environment may be damaging to silver plating. Tin-plated bus is also provided as standard for commercial and utility applications. An optional silver-plated bus may be specified for phase, neutral and ground buses. In all applications, the primary disconnect stabs for drawout breakers are provided with full silver plating. Primary disconnect stabs are removable and replaceable in the breaker cassette. Bare copper bus is standard in AKD-20 switchgear, as are insulated runbacks for feeder breakers 2000 A and smaller. Options for insulated horizontal bus, phase-isolated vertical bus, and bus compartment barriers for the phase bus are available as shown in Table 1.9.

When the insulated/ isolated bus option is specified, all main bus joints are covered with an insulating cap so that only the feeder cable terminations are exposed. Bus compartment barriers provide polyester-glass barriers between the bus compartment and the cable compartment. Additional isolation can be provided in the cable compartment of each vertical section by specifying section barriers.

The section barrier option provides a combination of steel and polyester-glass barriers in the rear of each vertical section. The steel barrier provides isolation between sections in the cable termination area, and the polyester-glass barriers provide isolation in the main bus area. When supplied, the section barrier option prevents exposure to the cable terminations in adjacent vertical sections when performing any operations in the rear of a section.

Table 1.9: AKD-20 switchgear bus options

Main bus rating (A)	2000	3200	4000	5000	6000	8000
Vertical bus rating (A)						2000/3200/4000/5000/6000
Insulated main bus/Isolated vertical bus	-	-	-			
Bus compartment barriers	-	-	-	-	-	-
Section barriers (Rear)	-	-	-	-	-	-
Neutral bus rating (A)						2000/3200/4000/5000/6000
Ground bus (0.25” x 3” Cu)				1 Bar		2 Bars
Short circuit bracing (kA)						65/85/100/150/200
30-cycle withstand (kA)						65/85/100

Expansion capabilities
AKD-20 switchgear is designed to be easily expanded to handle increased loading. It is very common, and advisable, to specify “fully equipped future breaker” cubicles when ordering a substation or lineup. The fully equipped future breaker cubicle contains line and load side primary disconnects, cassette with drawout rails and interlocks, and a cubicle door with a cover over the breaker cutout. At time of manufacture, the cubicle can also be outfitted with any specified metering, protection, and control devices, or these can be added when the breaker is installed. Adding a new feeder breaker can then be as simple as removing a cover from the cubicle door and installing the breaker.

Standard bus configurations used in AKD-20 have built-in provisions for future bus extensions. Should the switchgear have no future breaker compartments, additional vertical sections can be mechanically and electrically connected to the AKD-20 lineup without modifications. AKD-20 sections can also be added to existing AKD-8 and AKD-10 equipment. A 2-in. to 8-in. spacer may be required when adding sections to existing equipment.

IR Windows
Optional Infrared (IR) Scanning Windows (Figure 1.12) can be provided in the switchgear rear covers to facilitate the use of IR cameras for performing thermal scans of cable terminations. Use of the IR windows minimizes exposure to live conductors while performing this preventive maintenance operation. Crystal-type IR windows are used on both indoor NEMA 1 and outdoor NEMA 3R applications. IR windows have a gasketed cover plate secured with tamper-resistant hardware.

Quantity and location of the IR windows are dependent on the breaker stacking arrangement. Typically, one IR window is furnished per feeder breaker, but breaker placement and depth of the rear cable compartment can allow the field of view of the IR window to cover multiple breaker terminations.

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Figure 1.12: Infrared feeder stacks

Remote racking

All EntelliGuard G breaker cassettes include provisions to accept a remote racking device that allows the operator or electrician to move the breaker anywhere between the DISCONNECT and CONNECT positions without standing in front of the circuit breaker cubicle. The remote racking device (Figure 1.13) attaches to the cassette without opening the cubicle door. It is powered from any standard 120 Vac receptacle. The control box (Figure 1.14) on the end of the 30-foot cord has switches (power, breaker type, direction, and RUN) to control the operation of the remote racking device, allowing the operator to stand outside the arc flash boundary while racking a circuit breaker into or out of its cubicle.

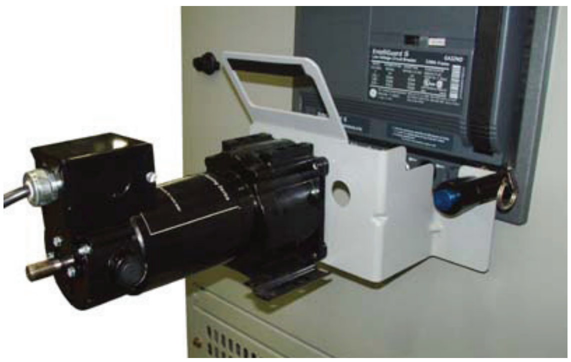

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Figure 1.13: Remote racking device

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Figure 1.14: Remote racking controller

Cable space

The conduit entrance area (Figure 1.15) meets NEC requirements for cable termination and bending space. Extended depth frame options are available in 7-in. or 14- in. sizes for applications requiring additional cable space. Breaker section widths can also be increased from 22 in. to 30 in. or from 30 in. to 38 in. for additional cable space.

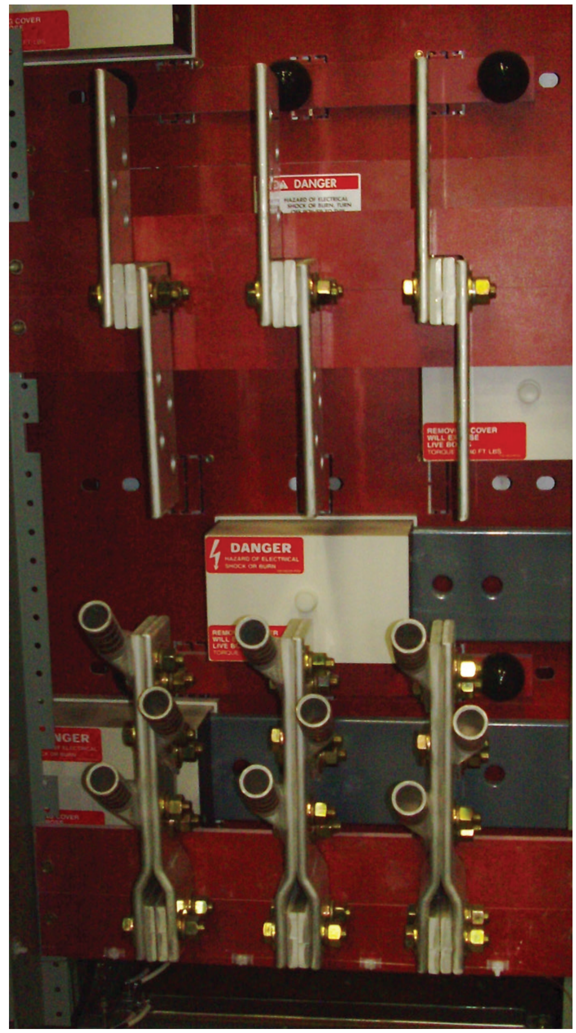

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Figure 1.15: Cable conduits

Breaker lifting device
Installed on the top of the switchgear, this rail-mounted hoist provides the means for installing and removing EntelliGuard G breakers from the switchgear cubicles (Figure 1.16). The overhead breaker lifting device is standard on outdoor-protected aisle construction and optional on indoor construction. Alternatively, a hydraulic breaker lifter may be used to install and remove breakers. Lifting spreaders are provided as a standard accessory for each switchgear lineup. The breaker lifting spreader is the interface between the cable hook on the breaker lifting device and the circuit breaker. Lifting spreaders are also used with the hydraulic breaker lifter.

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Figure 1.16: Lifted breaker

Paint finish
The sheet metal parts that form the AKD-20 switchgear cubicles and sections are protected by a powder coat paint process, which utilizes polyester powder, electrostatically applied to properly prepared parts. Switchgear parts are moved through the process on a continuously moving overhead conveyor system.

A 10-stage surface preparation process includes:
- Two stages of cleaning – hot alkaline wash;
- Three stages of counter-flow rinsing;
- A phosphate treatment stage – heated iron phosphate coating;
- Rinse;
- Non-chrome sealer;
- Rinse;
- Final de-ionized water rinse.

The parts are dried in a separate oven and then travel to the Power Coat Room, where temperature and humidity are maintained within specific limits. Located in the Powder Coat Room is the Powder Coat Booth, where the sheet metal parts receive a coating of polyester powder, 2-3 mils thick. The polyester powder meets UL1332 and has a UL Yellow card certifying compliance with this UL specification.

The Powder Coat Booth includes manual spray guns that are used for reinforcement of recessed areas prior to the application of powder by automatic guns, ensuring that all parts are completely coated on all surfaces. Next, parts travel to the Cure Oven where the powder is flowed and cured to a hard, uniform finish.

The resulting ANSI-61 light gray paint finish far exceeds the requirements of UL1558 and ANSI C37.20.1, which require a minimum 200 hour salt spray test. Parts that have the powder coat applied per this process have passed 600 hours of neutral salt spray testing per ASTM B-117.

Other testing includes passing 1,000 hours in a humidity cabinet, cross hatch adhesion, impact and ductility tests. Meeting or exceeding the UL, ANSI, and ASTM requirements demonstrates that the paint finish on the AKD-20 switchgear enclosure will be able to provide long service in severe operating environments.

Seismic certification
AKD-20 switchgear with EntelliGuard G circuit breakers has been shake-table tested in accordance with ICC-ES-AC156 to the requirements of IEEE-693-2005 and IBC-2015. AKD-20 switchgear has been certified for use in all IBC- 2015 Seismic Use Groups, Occupancy Importance Factors, and Seismic Design Categories, as well as qualified to IEEE- 693 for Moderate and High Seismic Loading conditions. Additionally, AKD-20 has been approved by the Office of Statewide Health Planning and Development (OSHPD) for applications in healthcare facilities.

Outdoor options and features
Outdoor-protected aisle equipment comes standard with an overhead hoist (Figure 1.17). For outdoor non-walk-in equipment, an optional hydraulic breaker lift may be used.

—
Figure 1-17: Overhead hoist

For ease of breaker installation, outdoor protected-aisle equipment comes standard with double doors on the right side of the equipment aisle (as viewed facing front of the equipment). On longer lineups an additional door is provided on the left side of the equipment.

All aisle doors are padlock capable from the exterior and come standard with panic door latches on the interior (Figure 1.18). Consult the factory if additional doors or door location modifications are required.

—
Figure 1-18: Panic door

—
Figure 1.19: Handle with padlock (front view)

—
Figure 1.20: Handle with padlock (side angle)

All outdoor switchgear comes standard with hinged rear doors with built-in padlock provisions. For both front and rear doors, use a No. 3 Master padlock (0.281 in. diameter, 0.73 in. high closed [measured inside the lock shank]), or a No. 1 Master padlock (0.312 in. diameter shank, 0.92 in. high closed [measured inside the lock shank]) for locking the handle. (See Figure 1.19 and Figure 1.20.)

EntelliGuard G
Circuit breakers and trip units

Circuit breaker standards and references
EntelliGuard G circuit breakers are the newest line of low voltage power circuit breakers (LVPCBs) evolved from the exceptional designs and practices of legacy breakers. EntelliGuard G breakers offer a truly global product platform that meets industry standards throughout the Americas, Europe and Asia (ANSI, UL, CSA, IEC, Lloyds Register of Shipping, etc.).

New, state-of-the-art EntelliGuard TU trip units enable breakers with advanced technology to provide system protection, local and remote monitoring, relaying, and communications. EntelliGuard TU trip units may be supplied with either Modbus or Profibus communications protocols. The breaker-trip unit system delivers superior circuit protection without compromising selectivity or arc flash protection.

The EntelliGuard system is yet another evolution of ABB core competencies in reliable electric power distribution, circuit protection, and arc flash protection. EntelliGuard G 3-pole breakers are the standard in ABB AKD- 20 low voltage switchgear.

The breakers are suitable for 240 Vac, 480 Vac, and 600 Vac applications, and they provide advanced circuit protection, limit arc fault energy, and preserve system coordination without sacrificing any of these critical functions. Refer to Table 2.1 for applicable design and testing standards for EntelliGuard G breakers.

Table 2.1: Device standards and references

ANSI certified low voltage power circuit breaker
C37.13
C37.16
C37.17
C37.20.1
C37.50
UL1066

EntelliGuard G devices are available in all standard, 100% rated, ANSI, UL ratings in drawout designs (Table 2.2). AII configurations can be manually or electrically operated with multiple and redundant accessories. Table 2.3 and Table 2.4 describe EntelliGuard G short circuit and interrupting ratings for automatic and non-automatic breakers.

Table 2.2: Device ratings, ANSI/UL1066 LVPCB

Breaker size	Envelope 1		Envelope 2		Envelope 3	
Type (see Table 2-3)	S	N/H/P	N	E/M	M	B/L
Available current sensors	400	400	-	400	-	-
	800	800	-	800	-	-
	1200	1200	-	-	-	-
	-	1600	-	1600	-	-
	-	2000	-	2000	-	-
	-	-	3200	3200	-	3200
	-	-	-	-	4000	4000
	-	-	-	-	5000	5000
	-	-	-	-	6000	6000

Table 2.3: ANSI/UL1066 LVPCB interrupting ratings

Interrupting rating tier ANSI/UL1066 devices, I_{CU}					Breaker / Cassette size, continuous current range, close and latch rating							
	240 V	480 V	600 V		Envelope 1		Envelope 2				Envelope 3	
Type	240 V max	580 V max	630 V max	1/2 sec (30-cycle) withstand, I_{CW}	Cont. curr.	C and L	Cont. curr.	C and L	Cont. curr.	C and L	Cont. curr.	C and L
S	65.000	65.000	50.000	50.000	400–1200 A	42	-	-	-	-	-	-
N	65.000	65.000	65.000	65.000	400–2000 A		3200 A	65	-	-	-	-
H	85.000	85.000	65.000	65.000	400–2000 A		-	-	-	-	-	-
P	100.000	100.000	65.000	65.000	400–2000 A		-	-	-	-	-	-
E	85.000	85.000	85.000	85.000	-		-	-	400–3200 A	65	-	-
M	100.000	100.000	100.000	85.000	-		-	-	400–3200 A		4000–6000A	
B	100.000	100.000	100.000	100.000	-		-	-	-	-	3200–6000A	100
L	150.000	150.000	100.000	100.000	-		-	-	-	-	3200–6000A	

Table 2.4: Non-automatic circuit breaker – ANSI version ratings

Breaker type	Amps	Rated interrupting current (kA)	Rated endurance, number of operations		
			Minimum eechanical endurance	Minimum electrical endurance @480 V	Minimum electrical endurance @600 V
S	800	42	12.500	10.000	7.500
N	800	42	12.500	10.000	7.500
N	1600	42	12.500	10.000	7.500
N	2000	42	12.500	7.500	5.000
M	3200	65	5.000	5.000	5.000
B	4000	100	5.000	3.000	2.000
B	5000	100	5.000	2.000	1.500

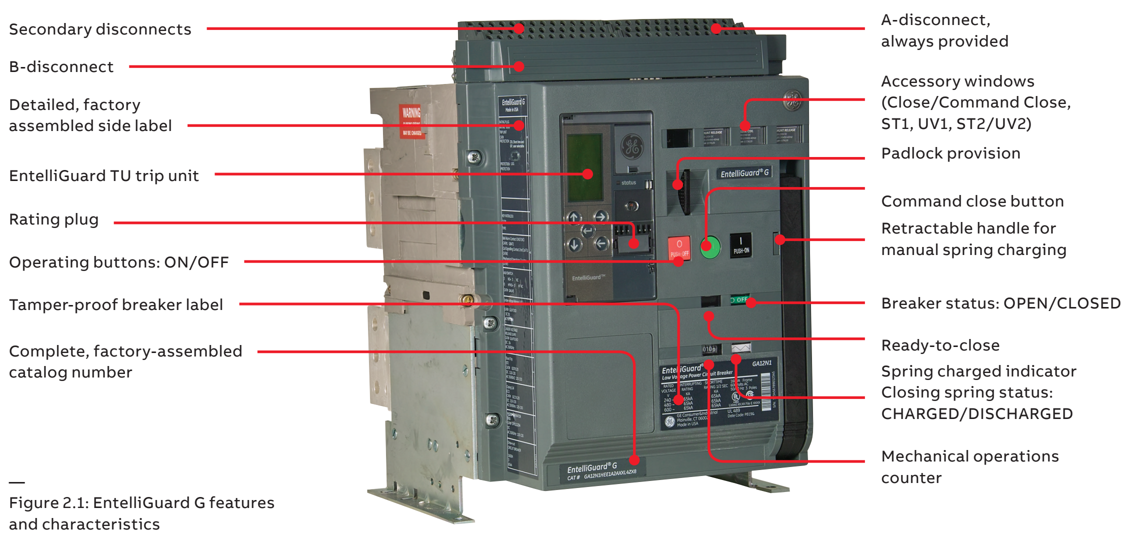

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Figure 2.1: EntelliGuard G features and characteristics

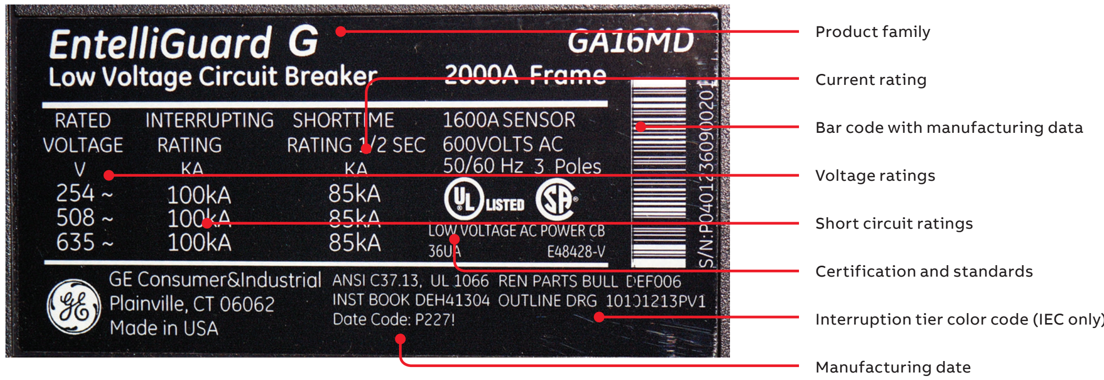

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Figure 2.2: Circuit breaker label

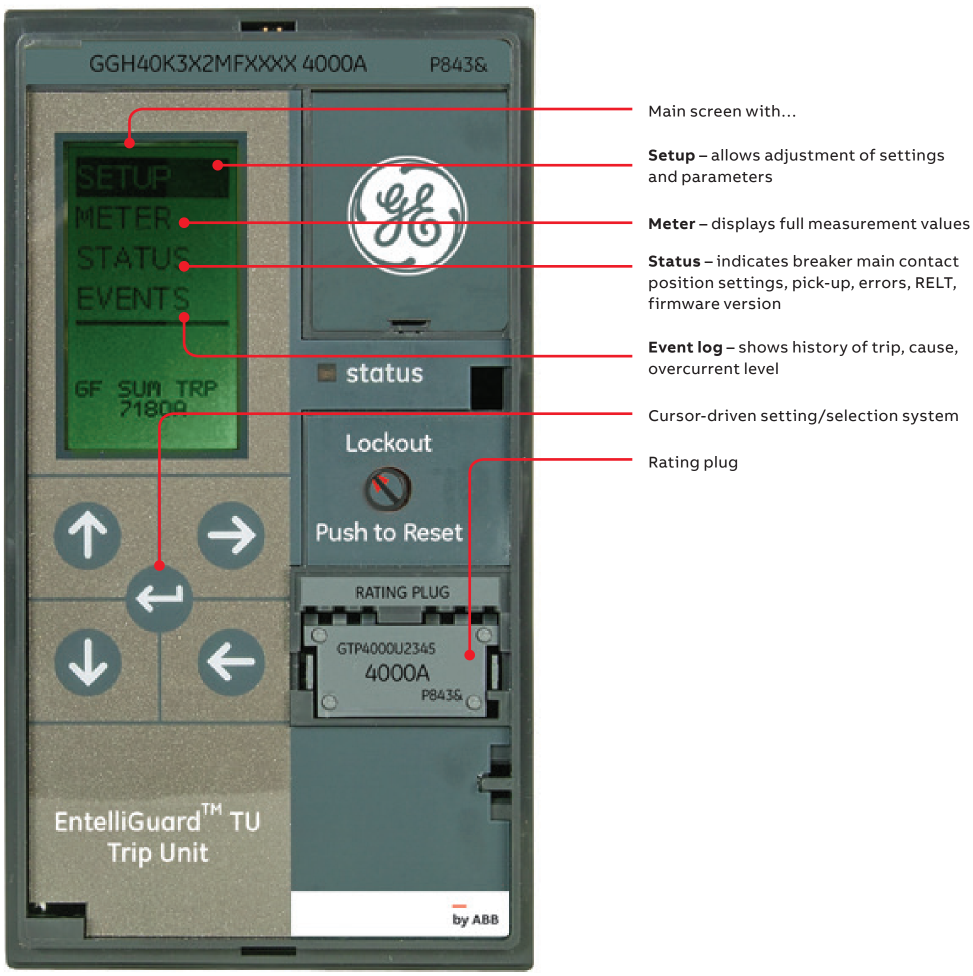

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Figure 2.3: EntelliGuard TU trip unit

Standard and optional features

Short time rating
Up to 100 kA for 1/2 sec. Types B and L.

Short circuit/high interruption rating
150 kA at 600 V. Types B and L.

Thermal performance
ANSI C37 designs are 100% rated up to 40ºC when applied in recommended enclosure sizes.

Reverse feed
EntelliGuard G devices can be fed from top or bottom terminals.

Two-step stored energy mechanism
EntelliGuard G operates via stored energy mechanisms that can be manually charged (MO) or electrically charged (EO) by the Spring Charging Motor. Closing time is less than five cycles. Closing and opening can be initiated remotely or via the front cover pushbuttons. An Open-Close-Open cycle is possible without recharging. The breaker operating mechanism is a trip-free mechanism and is furnished with an integrated anti-pumping system.

Field-installable trip units and accessories
Field-installable accessories are common to all breaker envelopes and frames.

Coils (optional)
EntelliGuard G breakers have provisions for four accessory operating coils. The four positions can be filled as shown in Table 2.5. The Command Closing Coil (CCC) can accept a low-level signal (such as a PLC output) or a Modbus Command to close the breaker. Network Interlock is used to mechanically enable or block closing the circuit breaker by momentarily energizing the SET or RESET coils. Optional coil signaling contacts for the Shunt Trip, Close Coil, and UV accessory coils provide coil status (energized/de-energized) via the secondary disconnects and trip unit Modbus registers.

Table 2.5: Breaker accessory coil combinations

Accessory coil position, left-to-right			
1	2	3	4
Shunt Trip	UV	CC/CCC	Shunt Trip #2
Shunt Trip	UV	CC/CCC	UV #2
Network Interlock		CC/CCC	Shunt Trip

- Shunt Trip, UV, CC, CCC are continuously rated
- Network Interlock coils are momentary rated
- CC/CCC include anti-pump function
- CCC includes electrical close PB on breaker escutcheon
- UV time delays:
  - 50 msec, down to 50% sensed voltage
  - 20 msec, less than 50% sensed voltage
  - Up to 3 sec with separate Time Delay Module

Breaker/main contact status (standard)
OPEN/CLOSED, ON/OFF indication is provided on the front cover.

Motor operator (optional)
Heavy-duty motor/gearbox unit; easily accessible.

Ready-to-close indicator (standard)
Provides visible indication of readiness for close operation.

Auxiliary switches (standard and optional)
Four designs available:
- Power rated (3NO+3NC) – standard;
- Power rated (3NO+3NC) + low signal (Hi-Fi) (2NO+2NC);
- Power rated (8NO+8NC);
- Power rated (4NO+4NC) + low signal (Hi-Fi) (4NO+4NC).

Table 2.6: Auxiliary switch ratings

AC Ratings		
AC	220/240 V	10 A
	110/120 V	15 A
DC Ratings		
DC	240 V	5 A (6 contacts in series)
	125 V	10 A (3 contacts in series)
	24 V	15 A

Interlocks (Standard)
Standard interlocks include:
- **Drawout breaker:** prevents the breaker from being closed unless it is in the TEST or CONNECT positions;
- **Drawout breaker/Main contacts:** prevents withdrawal/removal of the breaker unless the main contacts are OPEN. Access to the drawout mechanism racking screw is blocked when the breaker is CLOSED;
- **Spring discharge interlock:** Automatically discharges the closing springs when the breaker is moved from the DISCONNECT to the WITHDRAWN position. This prevents withdrawing a breaker from the cubicle with energy stored in the closing springs.

Breaker status indicators (standard)
Standard indicators include:
- The breaker status indicator shows the condition of the main contacts as OPEN or CLOSED;
- The status of the closing springs is indicated as CHARGED or DISCHARGED;
- The draw-out position indicator on the cassette displays whether the breaker is in the CONNECT, TEST, or DISCONNECT position;
- The breaker also includes a switch that provides main contact status indication to the POWER LEADER™ Power Management System;
- The optional Reduced Energy Let-Through (RELT) is provided with an ON/OFF contact closure to positively indicate whether or not the RELT function is active.

Rejection feature (standard)
A factory-installed rejection feature prevents mismatching breakers and cassettes/substructures to prevent:
- Inserting a breaker with a lower interrupting rating into a higher rated cassette/substructure;
- Inserting a higher current rated breaker into a lower rated cassette/substructure.

Closed-door racking (standard)
The breaker racking mechanism is accessible through the front of the cassette and permits safely connecting and disconnecting the circuit breaker without opening the door and exposing personnel to live parts during the process.

Padlocking devices (standard)
The padlocking device is standard on breakers and allows up to three padlocks with 1/4" to 3/8" diameter shanks to secure the breaker in the OPEN/TRIP FREE position. The front panel of the cassette/substructure permits locking the breaker drawout mechanism with up to three padlocks.

Key interlock (optional)
Switchgear applications utilize a Kirk key interlock mounted in the cassette. A maximum of two key interlocks may fit in the cassette.

Shutters (optional)
Shutters may be installed in any cassette. Shutters are padlockable in the closed position.

Carriage position switch (optional)
This optional cassette/substructure device permits local or remote indication of the circuit breaker drawout status (CONNECTED or TEST/DISCONNECTED), 6NO/6NC singlepole, double-throw contacts are available.

Lifting spreader (standard)
Furnished standard with all switchgear lineups. Used to attach lifting mechanism (hoist) cable to the breaker for insertion/removal.

Mechanical counter (optional)
Provides a local record of the cumulative number of complete breaker closing operations.

Bell alarm contact (optional)
Provided with a mechanical lockout feature, the bell alarm operates whenever the breaker trips due to a protective function (electrical fault).

Racking handle (standard)
Furnished with each switchgear lineup. Moves the drawout breaker through the CONNECT, TEST, and DISCONNECT positions.

EntelliGuard TU trip unit
For more detail on the EntelliGuard TU trip unit system on EntelliGuard G breakers, refer to publication DET-653, EntelliGuard G Circuit Breaker Application Guide.

Introduction
The EntelliGuard TU trip unit offers optimum circuit protection and optimum system reliability simultaneously with little or no compromise to either of these critical functions. Reliability and arc flash protection, in one package, at the same time, all the time. EntelliGuard TU series trip units are available as the standard controller for new production EntelliGuard G ANSI/UL1066 circuit breakers.

Reliability without compromising protection
Reliable protection of circuits and equipment has always been the circuit breaker's primary mission. Providing appropriate protection of the conductors, while preserving selective coordination, has been the primary focusof most system designers.

Modern economic reality, coupled with strict regulatory requirements, demand optimal system performance with increased sensitivity to the inherent power system hazards that face operating and maintenance personnel. Safety agencies, local authorities and owner-operators demand better personnel protection and state-of-the-art capabilities to minimize hazards while simultaneously preserving critical loads and system capabilities. These requirements often seem to be, and sometimes are, in conflict, pitting the speed and sensitivity required to improve arc flash protection against the delays and deliberate decision making required to maximize power system reliability. EntelliGuard TU, along with the EntelliGuard family of circuit breakers, offers flexible solutions for demanding circuit protection and circuit preservation environments. The EntelliGuard TU is designed to provide the utmost in system protection and reliability simultaneously, with little or no compromise.

Arc flash and the EntelliGuard TU trip unit
Reducing arc flash hazards should be the primary concern when designing power systems. The EntelliGuard TU, especially in conjunction with the EntelliGuard G circuit breaker, provides significant flexibility towards solving arc flash hazard problems without excessive sacrifice of system reliability, in terms of selectivity. One way to lower potential incident energy is to ensure that circuit breakers are able to interrupt using their Instantaneous trips for all expected arcing faults.

The IEEE standard's calculations predict a wide range of possible arcing currents. The actual arcing currents may be lower or higher when consideration is given to the potential error in short circuit calculations, fault current data provided by the utility company, and variance in the actual arcing gap or enclosure's geometry where the arc occurs. Of particular concern should be the lower end of the possible range of current that may fall below the Instantaneous pickup of a circuit breaker or the current limiting threshold of a fuse. Dangerous incident energy may quickly increase when interruption time increases from a few cycles to a few seconds, even for low arcing current.

Terminology
- **I_n:** Trip plug rating in amperes. This is the current rating of the rating plug installed in the trip unit. This is the maximum Long Time pickup a trip unit can have with a specific plug installed. A sensor can usually be applied with plugs between 37.5% or 40% to 100% of the sensor rating. Plugs are labeled in amperes;
- **X:** X is a multiplier that may be applied in front of any rating value to denote a fraction of that rating. For example, the Long Time Pickup may be set at 0.5X of In;
- **HSIOC:** High Set Instantaneous Overcurrent, also known as the Override. This is an Instantaneous protection setting applied near the circuit breaker's withstand rating required to clear high magnitude faults quickly. In UL489 circuit breakers this is fixed; in UL1066 CBs the override may vary, if present at all;

- **MCR:** Making Current Release. A setting provided with each trip unit, based on the specific circuit breaker size, used to protect the circuit against closing on high magnitude faults. The MCR function immediately trips/opens the circuit breaker if high magnitude fault current is sensed at the instant the circuit breaker is closed;
- **I_{cw}:** Short Circuit Withstand Rating of a particular circuit breaker in amperes. The withstand rating is defined differently within different standards, but it is always the value of current that a circuit breaker can withstand for some period of time without interrupting;
- **I_{cu}:** Short Circuit Interrupting Rating (ISC), or ultimate interrupting rating (ICU) in IEC terms. The maximum shortcircuit interrupting rating of a circuit breaker in amperes.

Long time protection

EntelliGuard TU offers two different shapes for Long Time protection curves. Each type of curve is available with 22 different time delays. The shapes may be described as circuit breaker-type characteristics and fuse-type characteristics. The nominal Long Time pickup is computed from the trip rating plug value (In) multiplied by the Long Time pickup setting. Long Time pickup setting multipliers are user adjustable, ranging from 0.5 to 1.0 in increments of 0.05.

Thermal long time overcurrent (circuit breaker-type characteristic)

The thermal I^2t shape is similar to the typical curve of a thermal magnetic circuit breaker and matches the shape of many overcurrent devices used in industry today. The typical shape and range of settings may be seen in DES-090 (Figure 2.6).

Fuse-shaped steep long time overcurrent

The steeper fuse characteristic is a straight line shape for application in systems where fuses and circuit breakers are used together. Twenty-two different time bands are available in each trip unit. Refer to DES-091 for timecurrent characteristics (Figure 2.7).

Thermal memory

The Long Time and Short Time pickup algorithm also includes a cooling cycle that keeps track of current if it oscillates in and out of pickup range. This Thermal Memory is also active in case the circuit breaker trips on Long Time or Short Time to account for residual heating in conductors. If a circuit breaker is closed soon after a Long Time trip or Short Time trip, a subsequent trip may happen faster than indicated by the time current curve due to the residual cable Thermal Memory effect. In trips without control power, the Thermal Memory is powered from the Trip Unit battery. The cooling algorithm requires up to 14 minutes to fully reset to zero.

Short time protection

Short time pickup

EntelliGuard TU provides a wide range of Short Time pickup settings, I2t slope characteristics, and time bands to optimize selectivity while not unnecessarily sacrificing clearing time. Short Time pickup settings range from 1.5 to 12 times the Long Time pickup setting for the EntelliGuard G circuit breakers in Envelopes 1 and 2. The maximum Short Time pickup for Envelope 3 is 10.

Short time bands

EntelliGuard TU comes with a wide range of adjustable Time Delay Bands, ranging from a minimum of 25 msec (clears in 80 msec) to 417 msec (clears in 472 msec). The bands are specially designed to pickup above various circuit breakers and trip systems to provide required selectivity while not sacrificing any more clearing time than required to provide the best possible arc flash protection. Refer to DES-092 for time-current characteristics (Figure 2.8).

Short time I^2t slopes

EntelliGuard Trip Unit offers three different Short Time I^2t characteristics to allow optimized settings for selectivity and fast protection whenever possible. The position of the I^2t slopes varies with the Long Time pickup of the respective circuit breaker. The intersection of the Short Time pickup and the Short Time delay band with the I^2t slope varies with the Short Time pickup and time delay band.

Ground fault protection

EntelliGuard TU trip unit offers the ultimate in Ground Fault protection. Each trip unit may be provided with the ability to accept a neutral sensor signal and generate an internal Zero Sequence phasor for Ground Fault protection. It may also be equipped with the ability to accept a Zero Sequence phasor signal from an external Zero Sequence CT or residual summation scheme using current transformers. Either Ground Fault method may be used to provide Ground Fault trip or Ground Fault alarm.

Internal residual summation

EntelliGuard TU trip unit uses internal air core sensors for current sensing, and the signals are residually summed using advanced digital electronics. A neutral sensor may be located remotely and connected to the trip unit.

External zero sequence input

EntelliGuard TU trip unit is able to accept input from an externally calculated Ground Fault current. The Ground Fault current may be derived using a single Zero Sequence CT or multiple phase CTs connected in a residual summation scheme. Applications for this capability include sensing at the ground return connection for a transformer or generator, as well application in multiple-source grounded systems.

Ground fault pickup settings

All UL1066 circuit breakers are limited to a maximum nominal pickup setting of 1200 A per the National Electrical Code or 60% of the sensor size, whichever is lower. The minimum setting is 20% of sensor size. Refer to DES-093 (Figure 2.9) for time-current characteristics.

Instantaneous protection

EntelliGuard TU trip unit may provide several types of Instantaneous protection, depending on the circuit breaker in which it is installed.

The different types of Instantaneous protection are as follows:
- Adjustable Selective Instantaneous;
- Extended Range Adjustable Selective Instantaneous;
- High Set Instantaneous Overcurrent Trip;
- Making Current Release (MCR);
- Reduced Energy Let-Through Instantaneous Trip.

Each of these Instantaneous trips provides optimum protection, selectivity, or both as required for different applications. Refer to DES-094 for time-current characteristics (Figure 2.10).

Adjustable selective instantaneous

EntelliGuard TU uses an exclusive algorithm to recognize the wave shape of fault current within a cycle. With the improved analysis of the fault current wave shape, the trip unit allows the circuit breaker to trip immediately yet provide superior selectivity when used above current limiting circuit breakers or fuses. In many cases, the trip unit’s Instantaneous pickup may be set quite low yet allow for complete selectivity up to the circuit breaker’s full withstand level.

The Adjustable Selective Instantaneous will clear a fault in three cycles when used in 60 Hz or 50 Hz applications. Zone Selective Interlocking (ZSI) may be used with this Instantaneous function, allowing several breakers with overlapping Instantaneous protection to be selective with each other. Because each circuit breaker is set to trip instantaneously for faults within their respective zones of protection, fast protection and selectivity are achieved simultaneously.

EntelliGuard TU trip unit can be furnished with one of two Instantaneous adjustment ranges. The standard adjustable range may be as high as 15X the trip plug value. An optional Extended Range Adjustable Selective Instantaneous, as high as 30X, may be provided. LVPCBs allow for this adjustable Instantaneous trip to be turned off.

High set instantaneous overcurrent (HSIOC)
EntelliGuard TU trip unit's HSIOC pickup is similar to the fixed override used by other trip units and circuit breakers in the industry. In EntelliGuard G, the HSIOC setting is changed automatically by the trip unit if the normal adjustable Instantaneous is turned off.

When the adjustable instantaneous setting is turned OFF, the HSIOC nominal setting becomes 98% of the circuit breaker's Short Time Withstand rating, Square-rated breakers (breakers where the interrupting and Short Time Withstand ratings are the same) do not require the use of HSIOC.

Making current release (MCR)
This form of Instantaneous protection is provided on all EntelliGuard G circuit breakers. The MCR provides very fast protection when the circuit breaker is closed and for the first six cycles thereafter. After the six cycles hove elapsed, the MCR is turned off and the circuit breaker reverts to its adjustable Instantaneous pickup and HSIOC, if provided. The MCR will pick up for currents exceeding 78% of the breaker close and latch rating (see Table 2-3) and will clear the fault in 40 msec or less.

Reduced energy let-through (RELT) Instantaneous Trip EntelliGuard TU trip unit provides an optional second, useradjustable, RELT Instantaneous trip. This trip provides an alternate setting that temporarily gives the circuit breaker more sensitive pickup to provide better Instantaneous protection, only when better protection is needed and some selectivity may be sacrificed.

The RELT pickup is adjustable from 1.5X to 15X of plug rating, independent of the normal adjustable selective Instantaneous. It may be set higher or lower than the selective Instantaneous. When EntelliGuard TU trip unit has the RELT Instantaneous pickup enabled, the trip unit provides a positive feedback signal via an optically isolated dry contact and serial communication. This positive feedback indicates that the trip unit has received and processed the RELT input and the Instantaneous settings have been changed. EntelliGuard TU trip unit's RELT capability provides the ultimate in user flexibility for wiring and controlling an alternate Instantaneous setting for temporary use to reduce personnel hazard. The RELT Instantaneous pickup clears fault current in 42 msec or less at 60 Hz.

Reduced energy let-through switch wiring
The RELT switch may be connected to a manually operated two-position switch, a remote sensor, or both simultaneously. The EntelliGuard TU trip unit provides positive feedback directly from the trip unit so that the user is able to verify that the signal was received by the trip unit and the settings have changed. A light may be connected to the source to indicate that control power is available to change the setting (Figure 2.4). When RELT is turned ON, the backlight on the trip unit display will flash. When the RELT input is removed to turn RELT OFF, the backlight will continue to flash for 15 seconds, allowing an operator to exit the arc flash boundary before the trip unit returns to its normal selective trip settings.

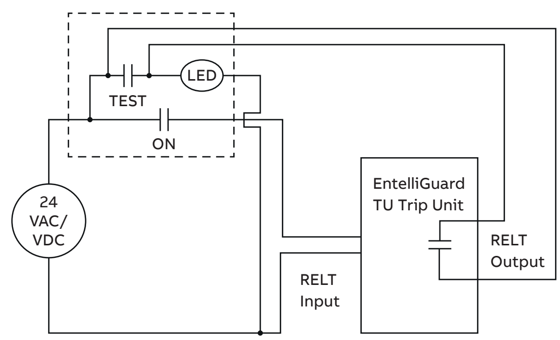

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Figure 2.4: Integrated Switch and LED. Spring Return from TEST to OFF, maintained in ON*

* This configuration provides positive indication that the trip unit has received and processed the RELT ON signal. It also provides a control power check.

Caution: It is recommended that RELT Output be wired to an appropriate annunciation when remote activation control of RELT is used.

Zone selective interlocking (ZSI)
EntelliGuard TU trip unit's fast ZSI system is able to interlock Ground Fault, Short Time and Instantaneous. When the feeder's in-zone protection must be slowed to be selective with a branch protector, the main can be set faster than the feeder without a sacrifice in selectivity between the main and feeder.

Each circuit breaker in a ZSI scheme allows separate user settings for the restrained (backup) and unrestrained (in-zone protections) for Ground Fault and Short Time protection. Instantaneous protection may also be interlocked such that all circuit breakers above the one whose zone has the fault will shift from Instantaneous clearing to a 0.058 msec time band.

Rating plugs
The EntelliGuard TU trip system is composed of trip units and trip rating plugs along with the sensors and wiring provided in the EntelliGuard G circuit breaker to support the trip. Rating plugs are used to lower the Long Time adjustment range of the sensor provided in the circuit breaker. The EntelliGuard TU trip rating plugs are unique in that they can be used with multiple trip units and circuit breakers within a specific sensor range, rather than with only a single specific sensor.

The trip rating plug catalog number, shown in Figure 2.5, identifies the rating as well as the minimum and maximum sensor rating the plug may be used with. Table 2.7 lists trip rating plugs available for each sensor. Table 2.8 lists the two-digit codes used within the trip rating plug catalog numbers and the sensor current ratings to which they are mapped.

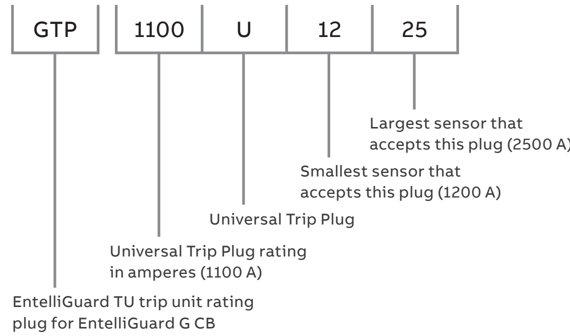

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Figure 2.5: EntelliGuard TU trip unit rating plug catalog number guide

Table 2.7: Trip rating plug specifications

Trip plug catalog number	Plug rating	May be used with	
		Minimum sensor	Maximum sensor
GTP0150U0104	150 A	150 A	400 A
GTP0200U0204	200 A	200 A	400 A
GTP0225U0306	225 A	400 A	600 A
GTP0250U0407	250 A	400 A	630 A
GTP0300U0408	300 A	400 A	800 A
GTP0350U0408	350 A	400 A	800 A
GTP0400U0410	400 A	400 A	1000 A
GTP0450U0612	450 A	600 A	1200 A
GTP0500U0613	500 A	600 A	1250 A
GTP0600U0616	600 A	600 A	1600 A
GTP0700U0816	700 A	800 A	1600 A
GTP0750U0820	750 A	800 A	2000 A
GTP0800U0820	800 A	800 A	2000 A
GTP0900U1020	900 A	1000 A	2000 A
GTP1000U1025	1000 A	1000 A	2500 A
GTP1100U1225	1100 A	1200 A	2500 A
GTP1200U1232	1200 A	1200 A	3200 A
GTP1500U1640	1500 A	1600 A	4000 A
GTP1600U1640	1600 A	1600 A	4000 A
GTP1900U2050	1900 A	2000 A	5000 A
GTP2000U2050	2000 A	2000 A	5000 A
GTP2200U2550	2200 A	2500 A	6400 A
GTP2400U2564	2400 A	2500 A	6400 A
GTP2500U2564	2500 A	2500 A	6400 A
GTP3000U3064	3000 A	3000 A	6400 A
GTP3200U3264	3200 A	3200 A	6400 A
GTP3600U4064	3600 A	4000 A	6400 A
GTP4000U4064	4000 A	4000 A	6400 A
GTP5000U5064	5000 A	5000 A	6400 A
GTP6000U6064	6000 A	6000 A	6400 A

Table 2.8: Trip rating plug codes

Sensor designation	Sensor rating
04	400 A
06	600 A
07	630 A
07	800 A
10	1000 A
12	1200 A
13	1250 A
16	1600 A
20	2000 A
25	2500 A
30	3000 A
32	3200 A
40	4000 A
50	5000 A
60	6000 A
64	6400 A

Universal spare trip unit

EntelliGuard G circuit breakers will accept a Universal Spare Trip Unit. This unique trip unit may be used in any EntelliGuard G circuit breaker regardless of frame size, sensor size, or short circuit rating. Should any circuit breaker's trip unit fail to operate for any reason, this one universal trip unit may be used as a replacement.

Once an EntelliGuard TU trip unit, including the Universal Spare Trip Unit, is associated with a specific EntelliGuard G circuit breaker, it may be used only with that specific circuit breaker. If exchange between EntelliGuard G circuit breakers is required, a trip unit may be interchanged only between circuit breakers with equal sensor ratings, short circuit ratings, and standard listing. Universal Trip Units may be ordered with a limited set of options. It is suggested that they be ordered with the widest range of options used within a facility, as any unnecessary functions can always be disabled or turned off (except for Ground Fault) during setup. Configurable options for the Universal Trip Unit are listed in Table 2.9.

Protective relays

EntelliGuard TU offers various protective and alarm relay functions that may be displayed on the LCD screen, assigned contact outputs or communicated serially (Table 2.10).

Table 2.9: Universal Spare Trip Unit options (userselected)

Feature	#	Option
Long Time	1	Standard
	2	Standard and fuse
Instantaneous	1	Standard
	2	Extended range
Ground Fault*	1	None
	2	Standard
	3	Ground input
Arc Flash Protection	1	No RELT
	2	RELT
Zone Selective Interlocking	1	Short Time and Ground fault
	2	Short Time, Ground fault, and Instantaneous
Communications	1	None
	2	Modbus
	3	Profibus
Metering	1	Standard (ammeter)
	2	Advanced (A, V, E and P)
	3	Diagnostic (Advanced and WFC)

* Mains and ties in solidly grounded multiple source substations will usually require ground input type Ground Fault Protection. Feeders will use standard internal ground fault protection.

Protective relays may be set by the user to alarm, trip the circuit breaker, or both. Alarms and trips are displayed on the local LCD trip and communicated serially. Alarms may also be assigned to one of two output contacts. The Trip and Alarm settings are independently set for each relay function.

Trip logic inputs

The trip unit is able to receive two hardwired input signals (Table 2.10). Either can be a 24 Vac or Vdc signal. The inputs can be assigned to two main functionalities:

- Reduced Let Thru Energy (RELT) Instantaneous protection “ON”;
- Breaker “TRIP”.

Table 2.10: Relay functions available in EntelliGuard G circuit breakers with EntelliGuard TU trip units

Functions		Trip	Alarm	Display	Output contact[2]	Serial comm.	Output[3][4]		
							1	2	Dedicated
Protective	Voltage unbalance	Yes	Yes	Yes	Yes	Yes			-
	Under voltage	Yes	Yes	Yes	Yes	Yes			-
	Over voltage	Yes	Yes	Yes	Yes	Yes			-
	Current unbalance	Yes	Yes	Yes	Yes	Yes			-
	Power reversal	Yes	Yes	Yes	Yes	Yes			-
Status	Current level alarm, 2 settings available	No	Yes	Yes	Yes	Yes			-
	Health indication (bad)	No	No	Yes	Yes	Yes			-
	Health indication (good)	No	No	Yes	Yes	Yes			-
	RELT ON Status3	No	No	Yes	Yes	Yes			-
	Ground fault alarm status	No	No	Yes	Yes	Yes			-
	ZSI output	No	No	Yes	No	No	-	-	
Diagnostics	Trip target	No	No	Yes	No	Yes	-	-	-
	Trip information	No	No	Yes	No	Yes	-	-	-
	Trip counter	No	No	Yes	No	Yes	-	-	-
	Event logging (Trips, alarms, I/O)	No	No	Yes	No	Yes	-	-	-
	Waveform Capture	No	No	No	No	Yes	-	-	-
Metering	Current (Phases A, B, C, N)	No	No	Yes	No	Yes	-	-	-
	Voltage (Phase A, B, C)[1]	No	No	Yes	No	Yes	-	-	-
	Energy (kWh, Total)	No	No	Yes	No	Yes	-	-	-
	Real power (watts, per phase and total)	No	No	Yes	No	Yes	-	-	-
	Apparent power (VA, per phase and total)	No	No	Yes	No	Yes	-	-	-
	Reactive power	No	No	Yes	No	Yes	-	-	-

1. User set to PH-N or PH-PH.
2. Output contacts are low signal (Hi-Fi).
3. When trip unit has RELT, output 1 is dedicated to RELT ON status.
4. When breaker requires fans, output 2 is dedicated to the Fan control circuit.

Outputs for EntelliGuard TU trip units
EntelliGuard TU trip units have two outputs, which are relay contact outputs to secondary disconnects. Each output can be configured per Table 2.11.

Waveform capture
The Waveform Capture option in the advanced trip unit can track and visualize any fault event. The device tracks eight cycles, four before and four after the event, with resolution of 48 samples per cycle at 60 Hz, and stores the results in memory. It registers events in all three phases and the neutral.

After the event, the waveform is stored in COMTrade format and can be accessed by using the waveform client module of the Enervista software. (The PMCS system must be connected and running at the time of the event to capture waveform information.) When the upload into this software is complete, the trip unit will reset this function and be available to register the next event.

6000A AKD-20 and 5000A AKD-20 AR(Arc Res) breakers require the use of cooling fans to maintain temperatures within standards. The Relay output 2 is used to control an external contactor that switches power to the fan. Details of the automatic fan controls can be found in DEH-41472D or DEH-41304.

EntelliGuard trip unit summary
Table 2.13 provides an overview of the trip unit features, characteristics, specifications, and accuracy.

Table 2.11: Input assignments possible

Input	Assignment	Summary description
1	OFF	No action taken
	TRIP	Will cause the circuit breaker to trip
	RELT	Input causes the unit to use the RELT set-point as long as input is active
2	OFF	No action taken
	TRIP	Will cause the circuit breaker to trip

Table 2.12: Output configuration

Assignment	Summary description
GF alarm	Closes when GF alarm is activated. Relay 1 or 2.
Overcurrent trip (GF, INST, LT, ST)	Overcurrent trip closes the relay. Relay 1 or 2.
RELT on	Closes relay when Reduced Let Through Energy Instantaneous pickup setting is enabled. Relay 1.
Any protective relay	Closes relays when protective relay is in pickup. Relay 1 or 2.
Current alarm 1	Exceeding current alarm Pickup closes relay. Relay 1 or 2.
Current alarm 2	Exceeding current alarm Pickup closes relay. Relay 1 or 2.
Health status. NO or NC may be assigned to Health OK via serial communication	Relay contact will change state when the Health Monitoring algorithm senses a change. Relay 1 or 2.

Notice: Relay 1 may be used for the RELT function and not available for customer use. Relay 2 may be used when fans are required for a breaker and not available customer use.

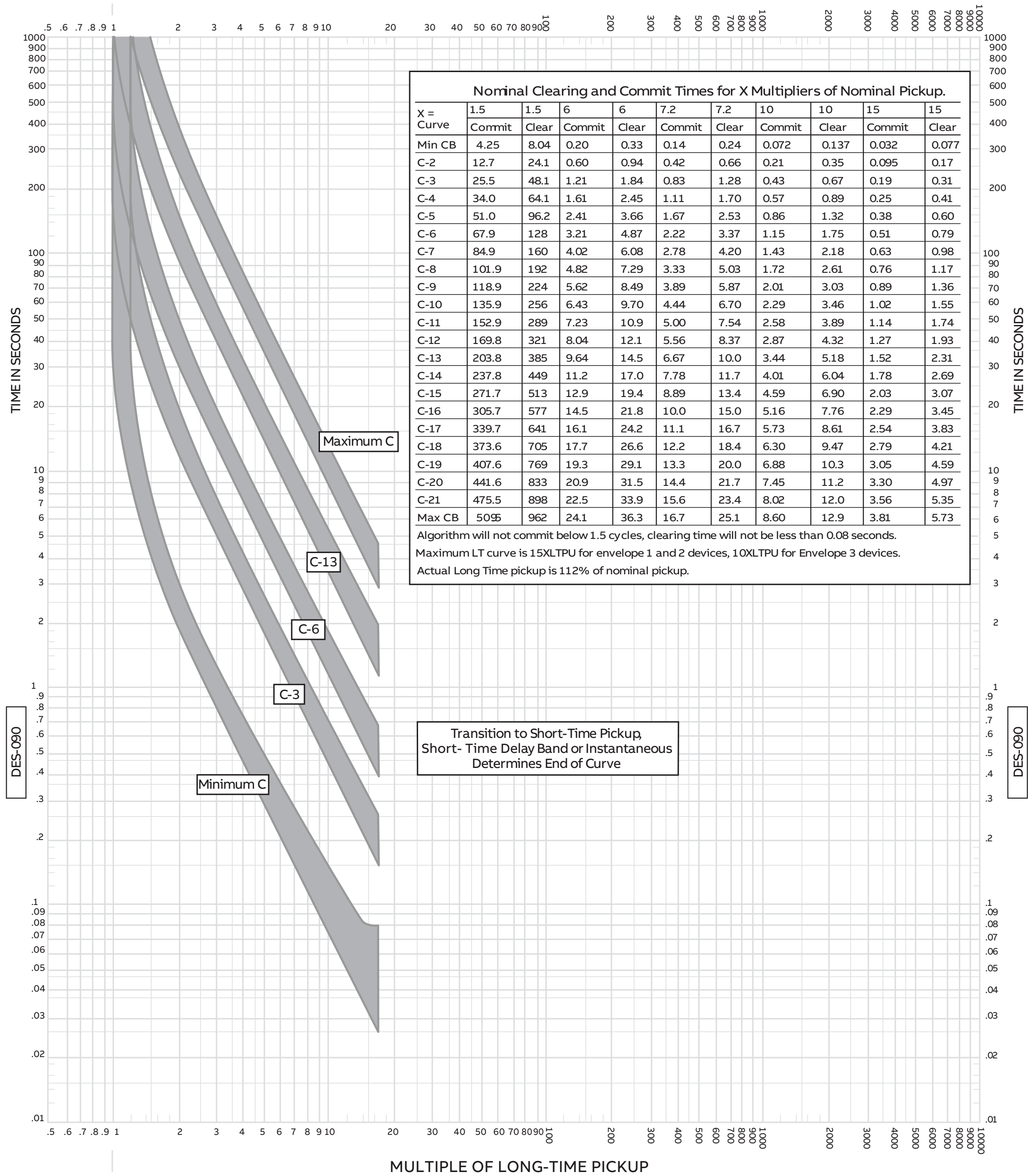
Table 2.13: EntelliGuard trip unit summary

Feature	Characteristic	Specification	Accuracy @100%
Long time pickup and delays (standard)	CB curves	22 (refer to Figure 2.6: DES-090)	-
	Fuse-type curves	22 (refer to Figure 2.7: DES-091)	-
	Pickup range	0.5–1.0 (.05 steps) x Rating Plug	-
	CB Curve delay band range @6X	0.5–22 sec	-
	Fuse-type curve delay band range @6X	0.004–3.09 sec	-
	Long time thermal memory	Switchable via Modbus	-
Short time pickup and delays (standard)	Pickup range	1.5–12 x LT Pickup (refer to Figure 2.8: DES-092 for max settings / breaker type)	-
	ST delay band range (commit time)	0.025 sec–0.417 sec and OFF	-
	Band width	55 msec	-
	ST delay bands	11	-
	I^2t slopes	3	-
Instantaneous Protection (standard except as noted)	Adjustable pickup range	2.0–15 x Rating Plug and OFF (refer to Figure 2.10: DES-094 for max settings / breaker type)	-
	Extended range adjustable pickup	2.0–30 x Rating Plug and OFF (refer to Figure 2.10: DES-094 for max settings / breaker type) – OPTIONAL	-
	Making current release	15X instantaneous, first six cycles after closing	-
	Override	Yes when ICW < ICU (30-cycle withstand is less than interrupting rating)	-
	Alternate pickup with remote enable	Yes (RELT Instantaneous), 1.5–15 x Rating Plug – OPTIONAL	-
	Selective instantaneous	Selective with current limiting MCCB, (selective with LVPCB and ICCB with unstantaneous ZSI)	-
Ground fault protection (optional)	Pickup range	0.2–0.6 x Sensor, up to 1200 A pickup max (refer to Figure 2-9: DES-093)	-
	External current sensor input	Yes, 63 mA = 1 per Unit	-
	Delay band range	0.047–0.91 sec	-
	Delay bands	14	-
	I^2t slopes	2	-
	I^4t slope	1	-
	GF alarm option	Yes	-
Zone Selective Interlocking (Optional)	Short time and/or Ground fault	User selectable restrained and unrestrained time delays	-
	Instantaneous	User selectable pickup	-

Feature	Characteristic	Specification	Accuracy @100%
Protective relays (optional except as noted)	Current unbalance	10–50% difference between highest and lowest phase compared to average	2%, +/- 0.1 sec on delay
		1% steps, 1–15 sec delay in 1 sec steps	
	Voltage unbalance	10 – 50% difference between highest and lowest phase compared to average	2%, +/- 0.1 sec on delay
		1% steps, 1–15 sec delay in 1 sec steps	
	Overvoltage	110–150% of sensed voltage	2%, +/- 0.1 sec on delay
		1% steps, 1–15 sec delay in 1 sec steps	
	Undervoltage	50–90% of sensed voltage	2%, +/- 0.1 sec on delay
		1% steps, 1–15 sec delay in 1 sec steps	
	Power reversal	Line-to-Load or Load-to-Line	2 %
		10–990 kW in 10 kW steps	
	High current alarm – STANDARD	2	-
		Independent pickup and drop-out settings for each alarm	-
Metering, diagnostics, and misc. functions (optional except as noted)	Current (A)	A, B, C–STANDARD	0000 Resolution, 2%
	Voltage (V)	A-B, B-C, C-A or A-N, B-N, C-N (single phase values for line-to-neutral PT connection)	0000 Resolution, 2%
	Real power (kW)	A, B, C, or Total (single phase values for line-toneutral PT connection)	000.000 Resolution, 4%
	Reactive power (kVar)	A, B, C, or Total (single phase values for line-to-neutral PT connection)	000.000 Resolution, 4%
	Apparent power (kVA)	A, B, C, or Total (single phase values for line-to-neutral PT connection)	000.000 Resolution, 4%
	Energy (kWh)	Total	000.000 Resolution, 4%
	Frequency (Hz)	Yes	00 Resolution, 1 Hz
	Real power demand (kW)	Total	000.000 Resolution, 4%
	Power factor (%)	A, B, C, or Total (single phase values for line-to-neutral PT connection)	00 Resolution, 4%
	Peak power demand (kW)	Total	000.000 Resolution, 4%
	Waveform capture	COMTrade file – requires PMCS	-
	Trip operations counter	Yes – STANDARD	-
	Event log	Last 10 events with Time and Date stamp – STANDARD	-
Serial communications (optional)	Open protocol	Modbus RTU, Profibus DP	-
	Front port for local comm	Yes – Standard	-
I/O – STANDARD	Programmable relays	2 Programmable Inputs, 2 Programmable Outputs	-
Flexibility	Universal rating plug	Yes	-
	Universal spare trip unit	Yes	-
	Interchangeable trip unit	Yes, breakers with equivalent ratings	-

Figures 2.6 to 2.10 show EntelliGuard G time curves:

Figure 2.6: DES-090, long time circuit breaker characteristics



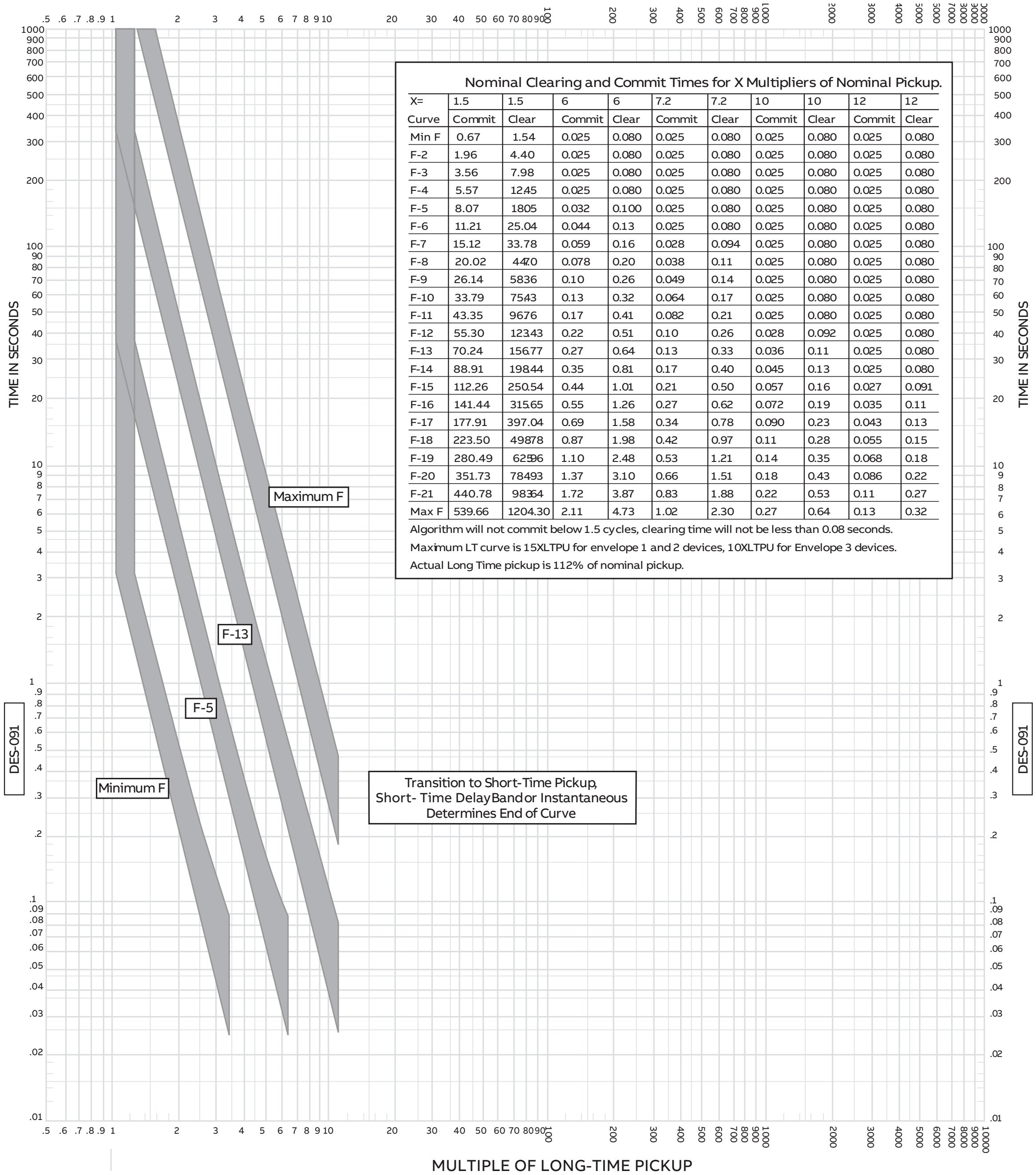
Nominal Clearing and Commit Times for X Multipliers of Nominal Pickup.

X =	1.5	1.5	6	6	7.2	7.2	10	10	15	15
Curve	Commit	Clear	Commit	Clear	Commit	Clear	Commit	Clear	Commit	Clear
Min CB	4.25	8.04	0.20	0.33	0.14	0.24	0.072	0.137	0.032	0.077
C-2	12.7	24.1	0.60	0.94	0.42	0.66	0.21	0.35	0.095	0.17
C-3	25.5	48.1	1.21	1.84	0.83	1.28	0.43	0.67	0.19	0.31
C-4	34.0	64.1	1.61	2.45	1.11	1.70	0.57	0.89	0.25	0.41
C-5	51.0	96.2	2.41	3.66	1.67	2.53	0.86	1.32	0.38	0.60
C-6	67.9	128	3.21	4.87	2.22	3.37	1.15	1.75	0.51	0.79
C-7	84.9	160	4.02	6.08	2.78	4.20	1.43	2.18	0.63	0.98
C-8	101.9	192	4.82	7.29	3.33	5.03	1.72	2.61	0.76	1.17
C-9	118.9	224	5.62	8.49	3.89	5.87	2.01	3.03	0.89	1.36
C-10	135.9	256	6.43	9.70	4.44	6.70	2.29	3.46	1.02	1.55
C-11	152.9	289	7.23	10.9	5.00	7.54	2.58	3.89	1.14	1.74
C-12	169.8	321	8.04	12.1	5.56	8.37	2.87	4.32	1.27	1.93
C-13	203.8	385	9.64	14.5	6.67	10.0	3.44	5.18	1.52	2.31
C-14	237.8	449	11.2	17.0	7.78	11.7	4.01	6.04	1.78	2.69
C-15	271.7	513	12.9	19.4	8.89	13.4	4.59	6.90	2.03	3.07
C-16	305.7	577	14.5	21.8	10.0	15.0	5.16	7.76	2.29	3.45
C-17	339.7	641	16.1	24.2	11.1	16.7	5.73	8.61	2.54	3.83
C-18	373.6	705	17.7	26.6	12.2	18.4	6.30	9.47	2.79	4.21
C-19	407.6	769	19.3	29.1	13.3	20.0	6.88	10.3	3.05	4.59
C-20	441.6	833	20.9	31.5	14.4	21.7	7.45	11.2	3.30	4.97
C-21	475.5	898	22.5	33.9	15.6	23.4	8.02	12.0	3.56	5.35
Max CB	509.5	962	24.1	36.3	16.7	25.1	8.60	12.9	3.81	5.73

Algorithm will not commit below 1.5 cycles, clearing time will not be less than 0.08 seconds.
Maximum LT curve is 15XLTPU for envelope 1 and 2 devices, 10XLTPU for Envelope 3 devices.
Actual Long Time pickup is 112% of nominal pickup.

- Long-Time Pickup Range: 0.5X-1.0X Trip Rating Plug
- Curves apply at 60 Hz and from -20 °C to 55 °C circuit breaker ambient temperature
- All Voltages: 600 Vac and below

Figure 2.7: DES-091, long time fuse-like characteristics



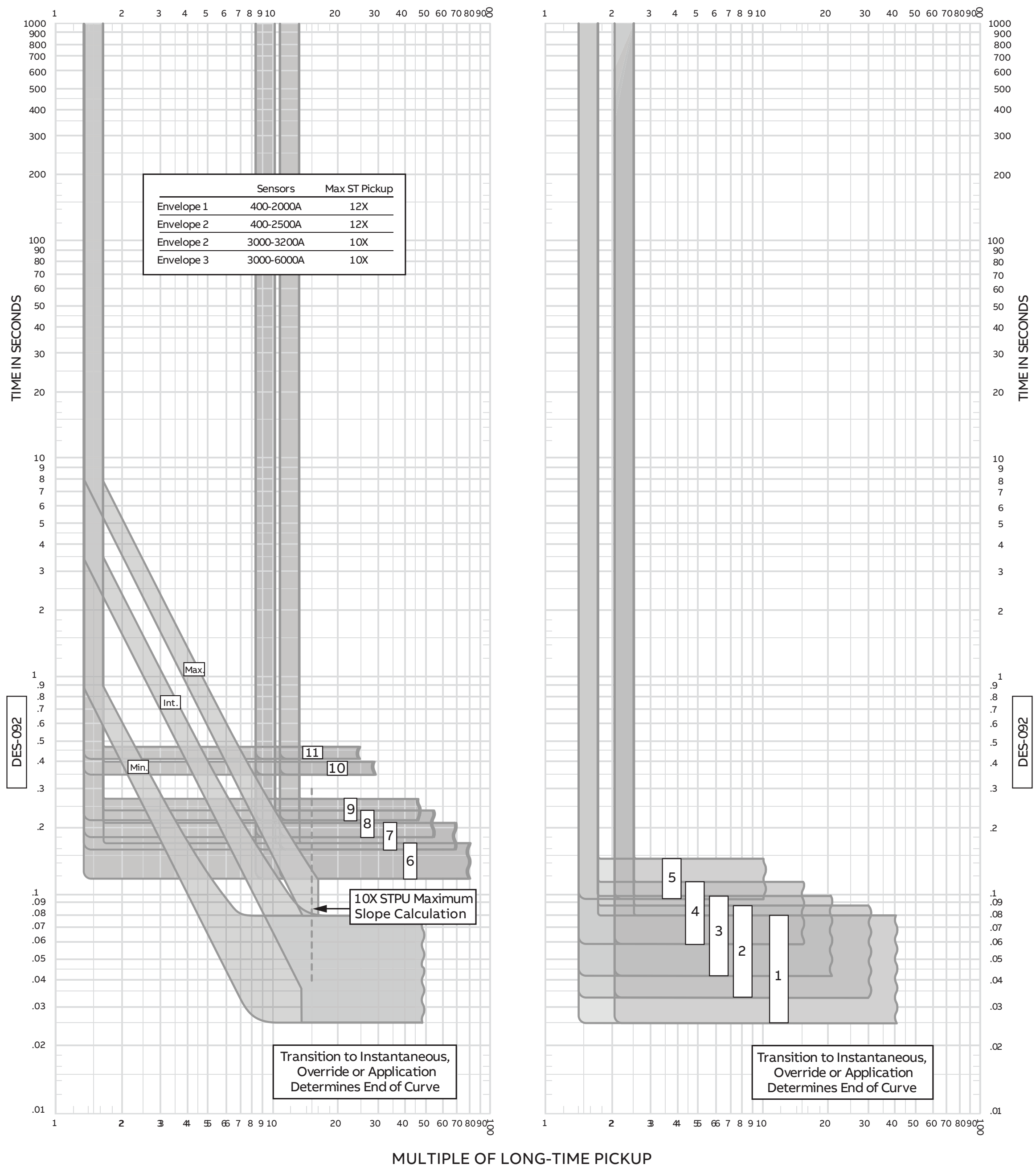
Nominal Clearing and Commit Times for X Multipliers of Nominal Pickup.

X=	1.5	1.5	6	6	7.2	7.2	10	10	12	12
Curve	Commit	Clear	Commit	Clear	Commit	Clear	Commit	Clear	Commit	Clear
Min F	0.67	1.54	0.025	0.080	0.025	0.080	0.025	0.080	0.025	0.080
F-2	1.96	4.40	0.025	0.080	0.025	0.080	0.025	0.080	0.025	0.080
F-3	3.56	7.98	0.025	0.080	0.025	0.080	0.025	0.080	0.025	0.080
F-4	5.57	12.45	0.025	0.080	0.025	0.080	0.025	0.080	0.025	0.080
F-5	8.07	18.05	0.032	0.100	0.025	0.080	0.025	0.080	0.025	0.080
F-6	11.21	25.04	0.044	0.13	0.025	0.080	0.025	0.080	0.025	0.080
F-7	15.12	33.78	0.059	0.16	0.028	0.094	0.025	0.080	0.025	0.080
F-8	20.02	44.70	0.078	0.20	0.038	0.11	0.025	0.080	0.025	0.080
F-9	26.14	58.36	0.10	0.26	0.049	0.14	0.025	0.080	0.025	0.080
F-10	33.79	75.43	0.13	0.32	0.064	0.17	0.025	0.080	0.025	0.080
F-11	43.35	96.76	0.17	0.41	0.082	0.21	0.025	0.080	0.025	0.080
F-12	55.30	123.43	0.22	0.51	0.10	0.26	0.028	0.092	0.025	0.080
F-13	70.24	156.77	0.27	0.64	0.13	0.33	0.036	0.11	0.025	0.080
F-14	88.91	198.44	0.35	0.81	0.17	0.40	0.045	0.13	0.025	0.080
F-15	112.26	250.54	0.44	1.01	0.21	0.50	0.057	0.16	0.027	0.091
F-16	141.44	315.65	0.55	1.26	0.27	0.62	0.072	0.19	0.035	0.11
F-17	177.91	397.04	0.69	1.58	0.34	0.78	0.090	0.23	0.043	0.13
F-18	223.50	498.78	0.87	1.98	0.42	0.97	0.11	0.28	0.055	0.15
F-19	280.49	625.96	1.10	2.48	0.53	1.21	0.14	0.35	0.068	0.18
F-20	351.73	784.93	1.37	3.10	0.66	1.51	0.18	0.43	0.086	0.22
F-21	440.78	983.64	1.72	3.87	0.83	1.88	0.22	0.53	0.11	0.27
Max F	539.66	1204.30	2.11	4.73	1.02	2.30	0.27	0.64	0.13	0.32

Algorithm will not commit below 1.5 cycles, clearing time will not be less than 0.08 seconds.
Maximum LT curve is 15XLTPU for envelope 1 and 2 devices, 10XLTPU for Envelope 3 devices.
Actual Long Time pickup is 112% of nominal pickup.

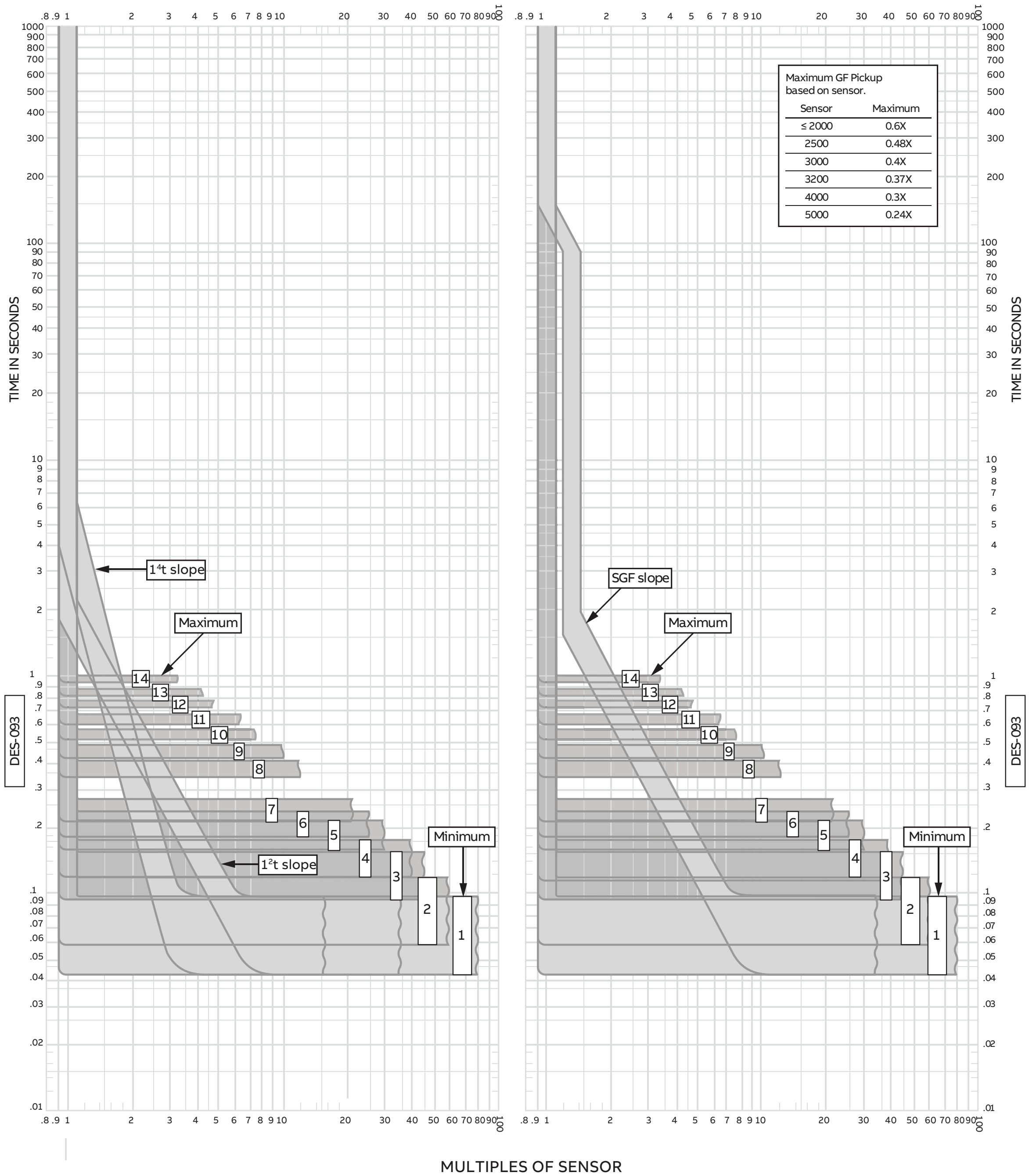
- Long-Time Pickup Range: 0.5X-1.0X Trip Rating Plug
- Curves apply at 60 Hz and from -20 °C to 55 °C circuit breaker ambient temperature
- All Voltages: 600 Vac and below

Figure 2.8: DES-092A, short time pickup and delay bands



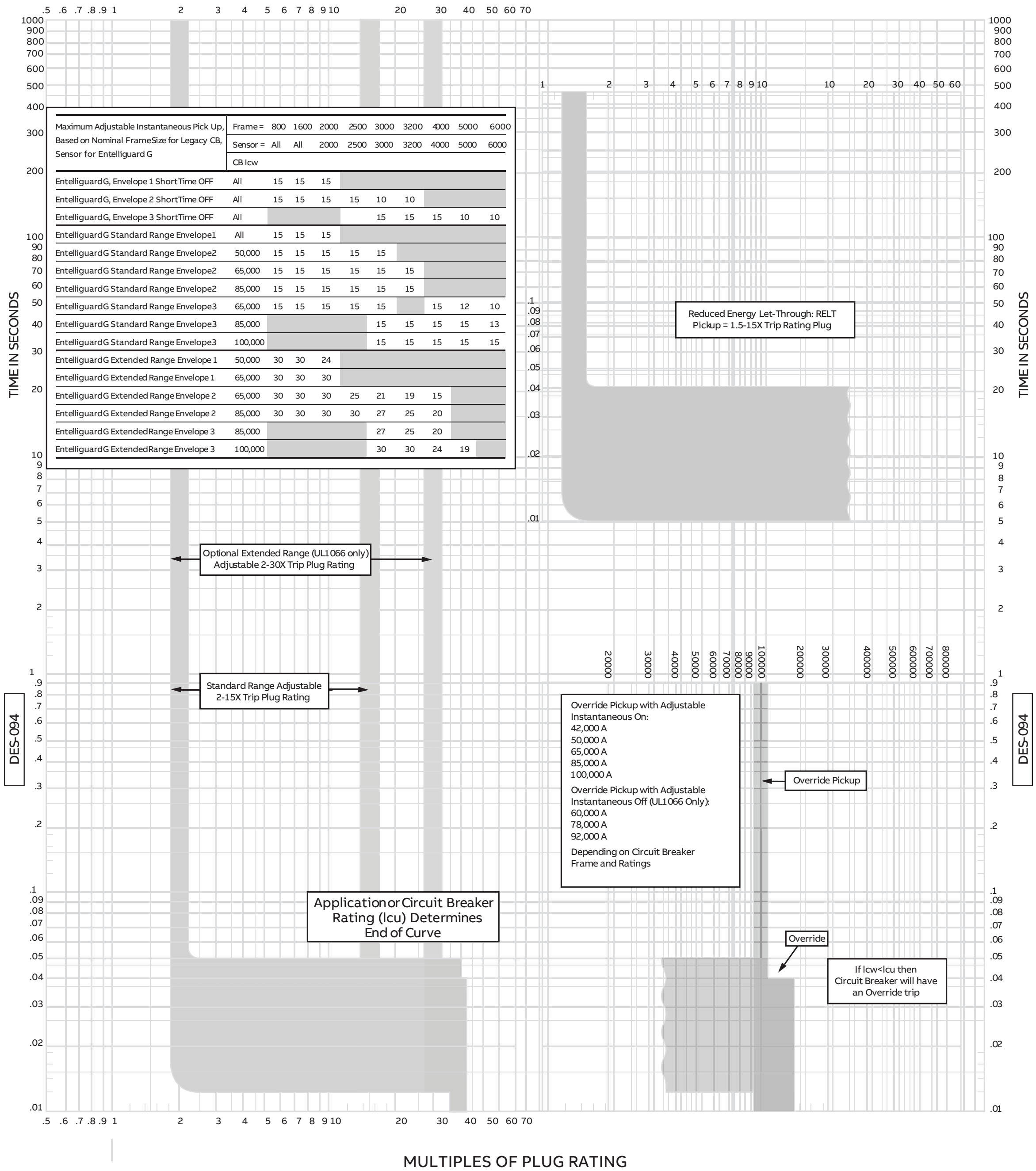
- Pickup range: 1.5X - 12X Long Time pickup
- Curves apply at 60 Hz and from -20 °C to 55 °C circuit breaker ambient temperature
- All Voltages: 600 Vac and below

Figure 2.9: DES-093A, ground fault characteristics



- Pickup range: 0.2X Sensor min.; 0.6x Sensor max.; not to exceed 1200 A
- Curves apply at 60 Hz and from -20 °C to 55 °C circuit breaker ambient temperature.All Voltages: 600 Vac and below

Figure 2.10: DES-094A, instantaneous, override (HSIOC) and reduced energy let-through instantaneous (RELT)



Maximum Adjustable Instantaneous Pick Up, Based on Nominal FrameSize for Legacy CB, Sensor for Entelliguard G	Frame =	800	1600	2000	2500	3000	3200	4000	5000	6000
	Sensor =	All	All	2000	2500	3000	3200	4000	5000	6000
	CB Icw									
EntelliguardG, Envelope 1 ShortTime OFF	All	15	15	15						
EntelliguardG, Envelope 2 ShortTime OFF	All	15	15	15	15	10	10			
EntelliguardG, Envelope 3 ShortTime OFF	All					15	15	15	10	10
EntelliguardG Standard Range Envelope1	All	15	15	15						
EntelliguardG Standard Range Envelope2	50,000	15	15	15	15	15				
EntelliguardG Standard Range Envelope2	65,000	15	15	15	15	15	15			
EntelliguardG Standard Range Envelope2	85,000	15	15	15	15	15	15			
EntelliguardG Standard Range Envelope3	65,000	15	15	15	15	15		15	12	10
EntelliguardG Standard Range Envelope3	85,000					15	15	15	15	13
EntelliguardG Standard Range Envelope3	100,000					15	15	15	15	15
EntelliguardG Extended Range Envelope 1	50,000	30	30	24						
EntelliguardG Extended Range Envelope 1	65,000	30	30	30						
EntelliguardG Extended Range Envelope 2	65,000	30	30	30	25	21	19	15		
EntelliguardG Extended Range Envelope 2	85,000	30	30	30	30	27	25	20		
EntelliguardG ExtendedRange Envelope 3	85,000					27	25	20		
EntelliguardG ExtendedRange Envelope 3	100,000					30	30	24	19	

- Pickup range: 2X-15X Trip Rating Plug standard; 2X-30X Trip Rating Plug extended range
- Maximum Pickup may be limited by CB AIC Rating or Withstand
- Curves apply at 60 Hz and from -20 °C to 55 °C circuit breaker ambient temperature
- All Voltages: 600 Vac and below

Accessories
A wide range of optional accessories are interchangeable across all EntelliGuard G power circuit breakers, regardless of nominal rating or envelope/frame size. As shown in Figure 2.11, each accessory incorporates easy-fit design features for quick installation.

—
Figure 2.11: Accessory mounting

Motorized spring charging unit
The unique motor/gearbox unit is specially designed to operate with the full range of EntelliGuard G breakers. After a breaker close operation, the unit automatically recharges the spring and makes it ready for immediate reclose, should the need arise. High-speed recharging ensures that the springs are fully charged within approximately three seconds following a release. All electrically operated (EO) ANSI/UL breakers are equipped with "Spring Charged" contact for status indication. Available charge motor control voltages shown in Table 2.15.

Spring charge contact is power rated only, as shown in Table 2.14:

Table 2.14

AC ratings		DC ratings	
Voltage	Amps	Voltage	Amps
110 V–130 V	AC21[1]-15 A	24 V	DC21[1]-15 A
	AC23[2]-10 A	110-130 V	DC21[1]-10 A
220 V–240 V	AC21[1]-10 A	250 V	DC21[1]-5 A
	AC23[2]-5 A	-	-

1. Resistive loads.
2. Inductive loads

Table 2.15: Motor operators

Envelope	Power consumption	Nominal control voltage	ANSI range	Cat no.
1	DC–300 W	24 Vdc/30 Vdc	-	GM0124DR
		48 Vdc	38 V – 56 V	GM01048DR
		60 Vdc	-	GM01060DR
		72 Vdc	-	GM01072DR
		110 Vdc/130 Vdc	100 V – 140 V	GM0111ODR
		250 Vdc	200 V – 280 V	GM01250DR
	AC–350 VA	48 Vac	-	GM01048AR
		120 Vac	104 V – 127 V	GM01120AR
		240 Vac	208 V – 254 V	GM01240AR
		277 Vac	-	GM01277AR
2 and 3	DC–480 W	24 Vdc/30 Vdc	-	GM0224DR
		48 Vdc	38 V – 56 V	GM02048DR
		60 Vdc	-	GM02060DR
		72 Vdc	-	GM02060DR
		110 Vdc/130 Vdc	100 V – 140 V	GM0211ODR
		250 Vdc	200 V – 280 V	GM02250DR
	AC–560 VA	48 Vac	-	GM02048AR
		120 Vac	104 V – 127 V	GM02120AR
		240 Vac	208 V – 254 V	GM02240AR
		277 Vac	-	GM02277AR

- Spring charge time = 3 sec max.
- Duty cycle = 2/min.
- Envelope 1 motors: running VA ~ 300 VA; inrush = 2 to 3 times.
- Envelope 2 and 3 motors: running VA ~ 450 VA; inrush = 2 to 3 times.

Circuit breaker closing coils – standard and command

Both closing coil options offer electrical remote release of the spring charged closing mechanism. Both options include a standard anti-pump safety feature ensuring that the close signal must be released before further close commands are allowed. The Command Close Coil additionally provides for local breaker electrical close and remote breaker close over communications via the EntelliGuard trip unit (Table 2.16).

Table 2.16: Closing Coil Characteristics

Type	Power consumption	Nominal control voltage	Catalog number
Closing coil	DC: 350 W, 20 W (sealed) AC: 350W (inrush), 20 W (sealed)	24 Vdc	GCCN024DR
		48 Vac/dc	GCCN048R
		60 Vdc–72 Vdc	GCCN060DR
		110 Vdc/ 130 Vdc/ 120 Vac	GCCN120R
		208 Vac	GCCN208AR
		220 Vdc/ 240 Vac	GCCN240R
		250 Vdc/ 277 Vac	GCCN277R
Command operated closing coil	DC: 350 W, 20 W (sealed) AC: 350W (inrush), 20 W (sealed)	24 Vdc	GCCC024DR
		48 Vac/dc	GCCC048R
		60 Vdc–72 Vdc	GCCC060DR
		110 Vdc/ 130 Vdc/ 120 Vac	GCCC120R
		208 Vac	GCCC208AR

- Duty cycle = 2/min.
- Closing coil inrush = 350 VA.

Command operation module

This module energizes the closing coil to cause the breaker to close whenever commanded from the breaker trip unit or breaker front panel pushbutton (electrical closing). Remoteelectrical closing is also possible with the Command Close Coil.

Shunt trip

Energizing the shunt trip (ST), via local or remote input, will instantaneously activate the circuit breaker mechanism, ensuring a rapid open operation (Table 2.17). The shunt trip is continuously rated and does not require an auxiliary switch in series with the coil.

Table 2.17: Extended range shunt trip for UL ground fault and ANSI DC rating applications

Nominal control voltage	Catalog number
24 Vdc	GSTG024DR
48 Vac/dc	GSTG048R
70 Vdc/72 Vdc	GSTG072DR
110 Vdc/125 Vdc/120 Vac	GSTG120R
208 Vac	GSTG208AR
240 Vac	GSTG240R
250 Vdc/277 Vac	GSTG250R

- Pickup range = 55%-110%.
- Duty cycle = 2/min.
- Inrush = 480 VA (ac), 480 W (dc).
- Holding = 60 VA (ac), 50 W (dc).

Status indication switch (coil signaling contact)

A plug-in module is available to provide status indication via the secondary disconnects and trip unit. Coil signaling contacts are available for closing coils, shunt trips and under voltage releases (Table 2.18). The contact is mounted on top of the accessory device. One of the lowsignal (Hi-Fi) contacts is always wired to the trip unit.

Table 2.18: Coil-signaling contact module

Type and configuration	Rating			Cat. no.
1 power rated + 1 low signal (Hi-Fi) (1NO contact each)	AC	120 Vac	6 A	GCSP1R
		250 Vac	6 A	
	DC	125 Vac	0.5 A	
		250 Vac	0.25 A	
	AC	125 Vac	0.1 A	
	DC	30 Vac	0.1 A	
2 low signal (Hi-Fi) (1NO contact each)	AC	125 Vac	0.1 A	GCSP2R

Undervoltage release (UVR)

The UVR instantaneously activates the circuit breaker trip mechanism when the source voltage drops below the low voltage threshold (Table 2.19). The UVR is also a simple, field-installable device.

Notice: The undervoltage release acts as a permissive; It is a no voltage/no close device. The circuit breaker cannot be closed (manually or electrically) unless the UVR coil is energized above the required threshold.

Table 2.19: UVR operating characteristics

Power consumption	Nominal control voltage	Catalog number
DC: 350 W AC: 350W (inrush)	24 Vdc	GUVT024DR
	30 Vdc	GUVT030DR
	40 Vdc; 48 Vac/dc	GUVT048R
	60 Vdc	GUVTO60DR
	110 Vdc/130 Vdc; 120 Vac	GUVT120R
	208 Vac	GUVT208AR
	220 Vdc/240 Vac	GUVT240R
	250 Vdc/277 Vac	GUVT277R

- 20 msec (1.2 cycles) delay at 0 V, 50 msec delay (3 cycles) at 50% V
- Inrush = 350 VA (ac), 350 W (dc)
- Holding = 60 VA (ac), 50 W (dc)

Time delay module (TDM) for UVR (externally mounted)

Operation of the Undervoltage Release can be delayed up to 3 seconds for applications where the breaker must be able to ride through momentary voltage interruptions. The Time Delay Module is mounted external to the circuit breaker and is connected between the voltage source and the breaker Undervoltage Release. Time delay is adjustable from 0 to 3 seconds. The time delay module starts its time delay at 50% of rated voltage (see Figure 2.12 and Table 2.19).

—
Figure 2.12: Time delay module

Table 2.20: TDM characteristics

Nominal control voltage	Catalog no.
48 Vdc	GTDM048D
48 Vac	GTDM048A
60 Vdc	GTDM060D
125 Vdc	GTDM120D
120 Vac	GTDM120A
208 Vac	GTDM208A
240 Vdc	GTDM240D
240 Vdc	GTDM240A
250 Vdc	GTDM250D
277 Vac	GTDM277A

Ready-to-close contact

These contacts, as shown in Table 2.21, indicate that the following conditions are met and the circuit breaker can be closed:

- The circuit breaker is open;
- The closing springs are charged;
- The circuit breaker in not locked/ interlocked in the open position;
- There is no standing closing signal;
- There is no standing opening signal.

Table 2.21: Ready-to-close contacts (1 NO)

Rating			Description	Catalog number
AC	120 Vac	6 A	high fidelity/ secondary disconnect	GRTC2R
	250 Vac	6 A		GRTC2R
DC	125 Vac	0.5 A	power rated/ secondary disconnect	GRTC1R
	250 Vac	0.25 A	high fidelity/ trip unit	GRTC3R

Auxiliary switches

Auxiliary switches indicate breaker main contact position. They change their state in the same time sequence as the breaker main contacts. See Table 2.22 and Table 2.23 for available combinations and ratings.

Table 2.22: Auxiliary switches

Nominal control voltage	Catalog no.
Power rated (3NO+3NC)	GAUX3R
Power rated (3NO+3NC) + low signal (Hi-Fi) (2NO+2NC)	GAUX5R
Power rated (8NO+8NC)	GAUX6R
Power rated (4NO+4NC) + low signal (Hi-Fi) (4NO+4NC)	GAUX8R

Table 2.23: Auxiliary switch ratings and secondary disconnect points

Contact configuration	Power rated	Hi-Fi	Cat. no.
Power rated (3NO+3NC)	A14 – A25	-	GAUX3R
Power rated (3NO+3NC) + low signal (Hi-Fi) (2NO+2NC)	A14 – A25	B10 – B13, B23 – B26	GAUX5R
Power rated (8NO+8NC)	A14 – A25, B4 – B13, B17 – B26	-	GAUX6R
Power rated (4NO+4NC) + low signal (Hi-Fi) (4NO+4NC)	A14 – A25, B12 – B13, B25 – B26	B4 – B11, B17 – B24	GAUX8R

- High Fidelity refers to gold-plated contacts. Use for signal level outputs (10 mA min. to 100 mA max., 8 Vdc to 30 Vdc, 125 Vac).
- Power-rated contacts – 15 A/440 V.

Key interlocks and door interlocks

EntelliGuard G breakers may be key-interlocked so that the breaker is held in a trip-free condition when the key is removed from the interlock. Key interlocks can be used on main and generator breakers or on main and tie breakers to prevent paralleling sources. Main circuit breakers may also be key-interlocked with transformer primary switches such that the secondary main breaker must be open before the primary switch can be operated. One or two key interlocks can be mounted in the cassette.

The key interlock also locks access to the racking mechanism when the breaker is locked open (Figure 2-13). Proper breaker position (CONNECT, TEST, or DISCONNECT) must be selected before engaging the key interlock.

An optional defeatable door interlock may also be incorporated into the cassette. This interlock is intended to prevent access to the breaker cubicle when the breaker is racked into the CONNECT position. The door interlock will latch the breaker cubicle door closed unless the breaker is racked out to the TEST or DISCONNECT position. If the breaker is in the CONNECT position and the door is closed, the door interlock can be manually overridden through a small hole in the breaker cubicle door. The door interlock does not trip the circuit breaker if the door is opened. Table 2.24 shows key and door interlock catalog numbers.

—
Figure 2.13: Cassette-mounted Key Interlock

Table 2.24: Key interlocks and door interlocks

Description	Catalog no.
Mechanism for Kirk key cassette interlock (cassette mounted) – key interlock ordered separately	GCKRKR
Door interlock (left side)	GLHD
Kirk lock for cassette – extended	KCAMXXX10S*
Kirk lock for cassette – withdrawn	KCAMXXX11S*

* S indicates that the key designation (A,B,etc.) is stamped on the lock and key.

Carriage position switch (TOC)

Available as an option and mounted on the side of the cassette/substructure, the carriage position switch provides six single-pole, double-throw (SPDT) contacts for local or remote electrical indication of the circuit breaker drawout status.

- GCPS2R provides two sets of contacts for each drawout breaker position: CONNECT – TEST – DISCONNECT;
- GCPS3R provides six sets of contacts that change when the breaker is moved between the TEST and CONNECT positions.

See Table 2.25 for configurations and ratings.

Table 2.25: Carriage position switch configurations

Switch catalog # and configuration	Wire #	Switch function	Wire color	Switch contact #	Plug Connector #	Contact status and breaker drawout position	
						OPEN	CLOSED
GCPS3R 6 NO/NC switches for CONN / TEST position (normal application)	1	CONNECT common	YELLOW	D11	J1-1 and J1-4	-	-
	2	CONNECT NC	BROWN	D12	J1-2 and J1-5	CONN	TEST/DISC
	3	CONNECT NO	PURPLE	D14	J1-3 and J1-6	TEST/DISC	CONN
	4	CONNECT common	YELLOW	D31	J3-1 and J3-4	-	-
	5	CONNECT NC	BROWN	D32	J3-2 and J3-5	CONN	TEST/DISC
	6	CONNECT NO	PURPLE	D34	J3-3 and J3-6	TEST/DISC	CONN
	7	CONNECT common	YELLOW	D51	J2-7 and J2-10		
	8	CONNECT NC	BROWN	D52	J2-8 and J2-11	CONN	TEST/DISC
	9	CONNECT NO	PURPLE	D54	J2-9 and J2-12	TEST/DISC	CONN
	10	CONNECT common	YELLOW	D21	J2-1 and J2-4	-	-
	11	CONNECT NC	BROWN	D22	J2-2 and J2-5	CONN	TEST/DISC
	12	CONNECT NO	PURPLE	D24	J2-3 and J2-6	TEST/DISC	CONN
	13	CONNECT common	YELLOW	D41	J1-7 and J1-10	-	-
	14	CONNECT NC	BROWN	D42	J1-8 and J1-11	CONN	TEST/DISC
	15	CONNECT NO	PURPLE	D44	J1-9 and J1-12	TEST/DISC	CONN
	16	CONNECT common	YELLOW	D61	J3-7 and J3-10	-	-
	17	CONNECT NC	BROWN	D62	J3-8 and J3-11	CONN	TEST/DISC
	18	CONNECT NO	PURPLE	D64	J3-9 and J3-12	TEST/DISC	CONN
GCPS2R 2 NO/NC switches per position (special application)	1	DISCONNECT common	YELLOW	D11	J1-1 and J1-4	-	-
	2	DISCONNECT NC	BROWN	D12	J1-2 and J1-5	DISC	TEST/DISC
	3	DISCONNECT NO	PURPLE	D14	J1-3 and J1-6	TEST/DISC	DISC
	4	TEST common	YELLOW	D31	J3-1 and J3-4	-	-
	5	TEST NC	BROWN	D32	J3-2 and J3-5	DISC	TEST/DISC
	6	TEST NO	PURPLE	D34	J3-3 and J3-6	TEST/DISC	DISC
	7	CONNECT common	YELLOW	D51	J2-7 and J2-10		
	8	CONNECT NC	BROWN	D52	J2-8 and J2-11	DISC	TEST/DISC
	9	CONNECT NO	PURPLE	D54	J2-9 and J2-12	TEST/DISC	DISC
	10	DISCONNECT common	YELLOW	D21	J2-1 and J2-4	-	-
	11	DISCONNECT NC	BROWN	D22	J2-2 and J2-5	DISC	TEST/DISC
	12	DISCONNECT NO	PURPLE	D24	J2-3 and J2-6	TEST/DISC	DISC
	13	TEST common	YELLOW	D41	J1-7 and J1-10	-	-
	14	TEST NC	BROWN	D42	J1-8 and J1-11	DISC	TEST/DISC
	15	TEST NC	PURPLE	D44	J1-9 and J1-12	TEST/DISC	DISC
	16	CONNECT common	YELLOW	D61	J3-7 and J3-10	-	-
	17	CONNECT NC	BROWN	D62	J3-8 and J3-11	DISC	TEST/DISC
	18	CONNECT NO	PURPLE	D64	J3-9 and J3-12	TEST/DISC	DISC

- Position switch contact ratings – 0.5 A @125 Vdc, 0.25 A @250 Vdc, 10.0 A @120 Vac/240 Vac

Bell alarm with lockout

The Bell Alarm provides remote indication that the circuit breaker has opened because of an electrical fault. The Lockout feature is integral to the trip unit. In order to reclose the breaker after a fault, the Lockout button must be pushed in/reset on the trip unit (Table 2.26 and Table 2.27).

Table 2.26: Bell alarm switches

Switch Configuration	Catalog no.
One single-pole, double-throw switch (1-Form C contact)	GBAT1R

Table 2.27: Bell alarm contact ratings

Ratings		
AC	120 Vac	6 A
	250 Vac	6 A
DC	125 Vdc	0.5 A
	250 Vdc	0.25 A

Charging spring status indicator

Factory-installed on the motor, this auxiliary switch indicates that the circuit breaker is charged (Table 2.28); it comes standard with the spring-charging motor.

Table 2.28: Spring-charged contact (1 NO)

Ratings			Catalog number
AC	120 Vac	6 A	GSCC1R
	250 Vac	6 A	
DC	125 Vdc	0.5 A	
	250 Vdc	0.25 A	

Secondary-disconnects (Factory-installed/ Field- installable)

Inputs and outputs to the circuit breaker are wired through secondary disconnects located on the top of the breaker. The plug-style secondary disconnects engage mating disconnects in the breaker cubicle when the breaker is in the TEST or CONNECT position. Up to 78 points are available so that all breaker accessories can be wired to a dedicated disconnect point (Table 2.29). Block B is ordered separately for cassettes, Cat. No. GSDWTR.

Table 2.29: Wiring schematic nomenclature definitionsand breaker wiring diagrams

Ratings	Nomenclature	
A1	Motor	power input to
A2	Motor	motor operator
A3	SPR NO/RTC NO	spring charge status contact/
A4	SPR NO/RTC NO	ready to close signaling contact
A5	ST1	power input to shunt trip 1
A6	ST1	
A7	UV1	under voltage release 1
A8	UV1	
A9	CC COM	closing coil neutral, wire-common(CC or CCC), closing coil (CC),
A10	CC IMM	continuous control power (CCC), closing coil close signal (CCC)
A11	CC CMD	
A12	ST2/UV2	power input to shunt
A13	ST2/UV2	trip 2/undervoltage
A14	NC3	normally closed contact 3
A15	NC3	
A16	NC2	normally closed contact 2
A17	NC2	
A18	NC1	normally closed contact 1
A19	NC1	
A20	NO3	normally open contact 3
A21	NO3	
A22	NO2	normally open contact 2
A23	NO2	

Ratings	Nomenclature	
A24	NO1	normally open contact 1
A25	NO1	
A26	-	-
A27	O/P1a	relay output 1 from trip unit
A28	O/P1b	relay output 1 from trip unit
A29	O/P2a	relay output 2 from trip unit
A30	O/P2b	relay output 2 from trip unit
A31	24 V+	auxiliary power supply
A32	24 V-	to trip unit
A33	BA NC	bell alarm switch
A34	BA NO	
A35	BA COM	
A36	N-RC	neutral Rogowski coil
A37	N-RC+	
A38	Eleg-CT	earth leg CT (multi-source ground fault)
A39	Eleg-CT	
B1	Input 1	relay input to trip unit
B2	Input 2	
B3	I/P COMc	
B4	ST1 NO/NC8	shunt trip 1 signaling contact/normally closed contact 8
B5	ST1 COM/NC8	
B6	UV1 NO/NC7	undervoltage release 1 signaling contact/normally closed contact 7
B7	UV1 COM/NC7	
B8	NC6	normally closed contact 6
B9	NC6	
B10	NC5	normally closed contact 5
B11	NC5	
B12	NC4	normally closed contact 4
B13	NC4	
B14	-	-
B15	-	-
B16	-	-
B17	CC NO/NO8	closing coil signaling contact/normally open contact
B18	CC COM/NO8	
B19	ST2 NO/UV2 NO/NO7	shunt trip 2 signaling contact/under voltage release 2 signaling contact/
B20	ST2 COM/UV2 COM/NO7	normally open contact 7
B21	NO6	normally open contact 6
B22	NO6	
B23	NO5	normally open contact 5
B24	NO5	
B25	NO4	normally open contact 4
B26	NO4	
B27	ZSI out+	GF zone selective interlock output
B28	ZSI out-	
B29	ZSI in+	GF zone selective interlock input
B30	ZSI in-	
B31	ISO GND	trip unit communication
B32	5V Iso	Modbus and Profibus
B33	TX EN 1	
B34	RX	
B35	TX	
B36	Voltage Input GND	-
B37	Volt-A	system phase voltage signals
B38	Volt-B	
B39	Volt-C	

Pages 46-49 show how to build an EntelliGuard catalog number based on available options.

Figure 2.14: Order guide: Catalog options

Circuit breaker family	Device and type	Current sensor	Short circuit and interrupting rating	Mounting type/# of poles	Spring charging motor
G	**N**	**16**	**P**	**D**	**H**

Digit 1 - Breaker family	**Code**
EntelliGuard G breaker or switch	**G**

Digit 2 - device and type ANSI/UL1066 circuit breaker	**Code**
Envelope 1	**N**
Envelope 2 AND 3	**A**

Digit 3 and 4 - Current sensor rating	**Code**
400	**04**
800	**08**
1200	**12**
1600	**16**
2000	**20**
3200	**32**
4000	**40**
5200	**52**
6000	**60**

Digit 6 - Mounting type, # of poles	**Code**
Drawout/3-pole	**D**

Digit 7 - Spring charging motor[1][2]		**Code**
AC	24/30 Vdc	**A**
	48 Vdc	**B**
	60 Vdc	**C**
	72 Vdc	**D**
	110/130 Vdc	**E**
	250 Vdc	**F**
DC	48 Vac	**G**
	120 Vac	**H**
	240 Vac	**J**
None	Manually Operated	**X**

Digit 5 - short circuit and interrupting rating (Amps)								**Envelope 1**	**Envelope 2**		**Envelope 3**		
254 V	**508 V**	**635 V**	**30 Cycle Withstand**	**HSIOC**	**Override No INST**	**Override with INST**	**Code**	**400 A – 1200 A**	**400 A – 2000 A**	**3200 A**	**400 A – 3200 A**	**3200 A**	**4000 A – 6000 A**
65000	65000	65000	50000	50000	49000	53500	S		-	-	-	-	-
65000	65000	65000	65000	-	-	-	N	-			-	-	-
85000	85000	85000	65000	65000	63700	69500	H	-		-	-	-	-
100000	100000	100000	65000	65000	63700	69500	P	-		-	-	-	-
85000	85000	85000	85000	-	-	-	E	-	-	-		-	-
100000	100000	100000	85000	85000	83800	90950	M	-	-	-		-	
100000	100000	100000	100000	-	-	-	B	-	-	-	-		
150000	150000	150000	100000	100000	98000	107000	L	-	-	-	-		

1. Spring Charge Contact, GSCC1, supplied with all motor operators.
2. Electrically operated breakers require Closing Coil (Digit 8) and Shunt Trip Coil (Digit 9).
3. Both CC and CCC include anti-pump feature and manual close button.
4. CCC includes a local electrical close pushbutton on the breaker escutcheon.
5. Extended range shunt trip is required for external ground fault relaying applications.
6. Pickup range is 55-110% of the shunt trip coil voltage.
7. Fixed time delay, 50 msec @50% Volts, 20 msec @<50% Volts.
8. External UVR time delay module available for 1-3 sec delay.

Figure 2.14 (cont'd): Order guide: Catalog options

Closing device
E

Shunt trip 1
F

Undervoltage release (UVR)
5

2nd shunt tripor UVR
5

Digit 8 - Closing device(3)(4)		**Code**
Closing coil (CC)	24 Vdc	**A**
	30 Vdc	**B**
	48 Vac/Vdc	**C**
	60–72 Vdc	**D**
	110/130 Vdc; 120 Vac	**E**
	208 Vac	**F**
	220 Vdc; 240 Vac	**G**
	250 Vdc; 277 Vac	**H**
Command-operated close coil (CCC)	24 Vdc	**M**
	30 Vdc	**N**
	48 Vac/Vdc	**P**
	60–72 Vdc	**Q**
	110/130 Vdc; 120 Vac	**R**
	208 Vac	**S**
	220 Vdc; 240 Vac	**T**
None		**X**

Digit 9 - Shunt trip 1: Extended range(5)(6)	**Code**
24 Vdc	**M**
48 Vac/Vdc	**P**
70-72 Vdc	**Q**
110/125 Vdc; 120 Vac	**R**
208 Vac	**S**
220 Vdc; 240 Vac	**T**
250 Vdc; 277 Vac	**V**
None	**X**

Digit 10 - Undervoltage release(7)(8)	**Code**
24 Vdc	**1**
30 Vdc	**2**
48 Vac/Vdc	**3**
60–72 Vdc	**4**
110/130 Vdc; 120 Vac	**5**
208 Vac	**6**
220 Vdc; 240 Vac	**7**
250 Vdc; 277 Vac	**8**
None	**X**

Digit 8 - Closing device(3)(4)		**Code**
Closing coil (CC)	24 Vdc	**1**
	30 Vdc	**2**
	48 Vac/Vdc	**3**
	60–72 Vdc	**4**
	110/130 Vdc; 120 Vac	**5**
	208 Vac	**6**
	220 Vdc; 240 Vac	**7**
	250 Vdc; 277 Vac	**8**
Command-operated close coil (CCC)	24 Vdc	**M**
	48 Vac/Vdc	**P**
	70–72 Vdc	**Q**
	110/125 Vdc; 120 Vac	**R**
	208 Vac	**S**
	220 Vdc; 240 Vac	**T**
	250 Vdc; 277 Vac	**V**
None		**X**

Figure 2.14 (cont'd): Order guide: Catalog options

Auxiliary switch	Bell alarm/trip annunciation	Breakermounted keylock	Mechanical interlock
4	**A**	**X**	**X**

Digit 13 - Bell Alarm/Trip Annunciation	Code
Bell alarm contact (1NO/1NC) with lockout (BACL)	A
Mechanical operations counter (MOC)	B
Bell alarm contact (1NO/1NC) with Lockout and MOC	C
RTC power-rated contacts on Sec Disc	1
RTC signal-rated (Hi-Fi) contacts on Sec Disc	2
RTC signal-rated (Hi-Fi) contacts through trip unit	3
BACL and RTC power-rated contacts on Sec Disc	D
BACL and RTC signal-rated (Hi-Fi) contacts on Sec Disc	E
BACL on Sec Disc, RTC signal-rated (Hi-Fi) contacts through TU	F
BACL and RTC power-rated contacts on Sec Disc, MOC	G
BACL and RTC signal-rated (Hi-Fi) contacts on Sec Disc, MOC	H
BACL on Sec Disc, RTC signal-rated (Hi-Fi) contacts through TU, MOC	J
RTC power-rated contacts on Sec Disc, MOC	K
RTC signal-rated (Hi-Fi) contacts on Sec Disc, MOC	L
RTC signal-rated (Hi-Fi) contacts through trip unit, MOC	M
None	X

Digit 14 - Key interlock: breaker mounted	Code
None	X

Key interlocks for drawout breakers in AKD-20 switchgear are mounted in the cassette

Digit 15 - Mechanical interlocks (Cable)	Code
None	X

- BACL = Bell Alarm contact with Lockout
- BACL contacts are always power-rated Bell alarm and trip unit options do not apply to non-auto switches (Digit 2)
- Hi-Fi = High Fidelity (low signal)
- MOC = Mechanical Operations Counter
- RTC = Ready-To-Close contact

Digit 12 - Auxiliary switch - Contact configuration		Code
Aux Sw, 3NO/3NC (power rated) Std / Included		4
Aux Sw, 8NO/8NC (power rated)		6
Aux Sw, 3NO/3NC (power rated) + 2NO/2NC Low Signal (Hi-Fi)		8
Aux Sw, 4NO/4NC (power rated) + 4NO/4NC Low Signal (Hi-Fi)		4
Aux Sw, 3NO/3NC (power rated)	CSC, pwr Rated, (1NO on Sec Disc) - close coil or CCC	A
	CSC, Hi-Fi via trip unit - close coil or CCC	B
	CSC, pwr rated, (1NO on sec disc) - shunt trip 1	C
	CSC, Hi-Fi via trip unit - shunt trip 1	D
	CSC, Pwr Rated, (1NO on Sec Disc) - UVR 1	E
	CSC, Hi-Fi via Trip Unit - UVR 1	F
	CSC, pwr rated, (1NO on Sec Disc) - shunt trip 2 or UVR 2	G
	CSC, Hi-Fi via trip unit - shunt trip 2 or UVR 2	H
Aux Sw, 3NO/3NC (power rated) + 2NO/2NC low signal (Hi-Fi)	CSC, pwr rated, (1NO on Sec Disc) - close coil or CCC	J
	CSC, Hi-Fi via trip unit - close coil or CCC	K
	CSC, pwr rated, (1NO on Sec Disc) - shunt trip 1	L
	CSC, Hi-Fi via trip unit - shunt trip 1	M
	CSC, pwr Rated, (1NO on Sec Disc) - UVR 1	N
	CSC, Hi-Fi via trip unit - UVR 1	P
	CSC, pwr rated, (1NO on Sec Disc) - shunt trip 2 or UVR 2	Q
	CSC, Hi-Fi via trip unit - shunt trip 2 or UVR 2	R
Aux Sw, 3NO/3NC (power rated)	CSC, pwr rated, (1NO on Sec Disc) - All installed devices	S
	CSC, Hi-Fi via trip unit - All installed devices	T
Aux Sw, 3NO/3NC (power rated) + 2NO/2NC low signal (Hi-Fi)	CSC, pwr rated, (1NO on Sec Disc) - All installed devices	U
	CSC, Hi-Fi via trip unit - All installed devices	V

- CCC - command operated close coil
- CSC - coil signaling contact
- Hi-Fi - High fidelity (low signal) gold-plated contact, 10mA min, 100mA max, 5-30Vdc, 125Vac
- 3NO/3NC Aux switch contacts are wired to Sec Disc "A". All other aux switch options require Sec Disc "B"
- CSC via the TU requires a communications option on the TU (Digit 19)
- Non-automatic breakers cannot have CSC via the trip unit
- CSC selection is not valid if there are no accessory coils on the breaker (close, shunt trip, UV)

Figure 2.14 (cont'd): Order guide: Catalog options

Trip unit	Zone - selective interlocking	Advanced features and communications	Rating plug
L4	**T**	**2**	**V**

Digit 16 and 17 - Trip unit uharacteristics		**Code**
Standard range adjustable instantaneous	LSI	**L3**
	LSIG	**L4**
	LSIGA	**L5**
	LSIC	**L6**
	LSICA	**L7**
	LSIGDA*	**L8**
	LSIGCDA*	**L9**
Extended range adjustable instantaneous	LSH	**LC**
	LSHG	**LD**
	LSHGA	**LE**
	LSHC	**LF**
	LSHCA	**LG**
	LSHGDA*	**LH**
	LSHGCDA*	**LK**
None-non-auto switch		**XX**

Digit 18 – Zone-selective interlocking	**Code**
ZSI - Short time and GF	**Z**
ZSI - ST, GF, INST	**T**
Interlocking	**X**

- A = Ground fault alarm, internal or external GF
- C = External GF sensing - used for multi-source GF
- D = Defeatable GF (not UL Listed)
- G = Internal GF sensing, 3 or 4 wire, internal summing
- H = Extended Range Instantaneous (up to 30X)
- I = Standard Adjustable Instantaneous (up to 15X)
- L = Long Time (Breaker I2t and Fuse I4t curves)
- S = Short Time
- CA = External GF - Alarm only
- GA = Internal GF - Alarm only
- GDA, GCDA = GF Trip and GF Alarm (switchable, not UL Listed)
- * = Indicates the function combination is not UL Listed

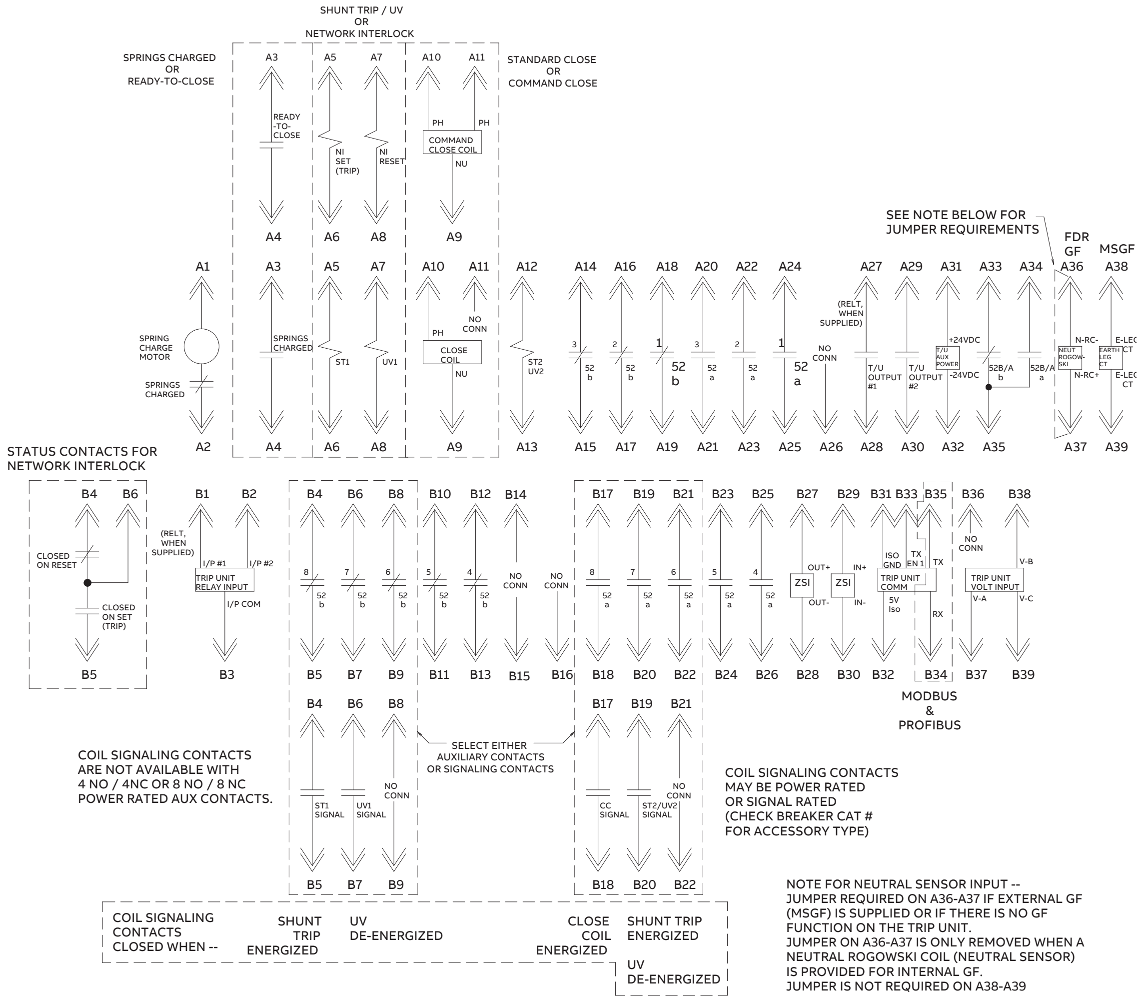
Digit 19 - Advanced features and communications	**Code**
Reduced energy let-Thru (RELT)	**1**
Modbus and RELT	**2**
Profibus and RELT	**3**
Metering and RELT, no comm	**4**
Metering and Prot Relay and RELT	**5**
Metering, WF capture, Modbus, RELT	**6**
Metering, WF capture, Profibus, RELT	**7**
Metering, WF capture, Prot relay, Modbus, RELT	**8**
Metering, WF capture, Prot relay, Profibus, RELT	**9**
None - Non-auto switch only	**X**

Coil signaling contacts (Digit 12) via trip unit and RTC (Digit 13) via trip unit requires communications option

Digit 16 and 17 - Trip unit characteristics

Rating	**Min. sensor**	**Max. sensor**	**Code**
150	150	400	**B**
200	200	400	**C**
225	225	600	**D**
250	400	630	**E**
300	400	800	**F**
350	400	800	**G**
400	400	1000	**H**
450	600	1200	**I**
500	600	1250	**J**
600	600	1600	**K**
700	800	1600	**M**
750	800	2000	**N**
800	800	2000	**O**
900	1000	2000	**P**
1000	1000	2500	**Q**
1100	1200	2500	**R**
1200	1200	3200	**S**
1500	1600	4000	**U**
1600	1600	4000	**V**
1900	2000	5000	**W**
2000	2000	5000	**Y**
2200	2000	5000	**Z**
2400	2500	6400	**1**
2500	2500	6400	**2**
3000	3000	6400	**3**
3200	3200	6400	**4**
3600	4000	6400	
4000	4000	6400	**6**
5000	5000	6400	**7**
6000	6000	6400	**8**
None (Non-Auto Sw)			**X**

Internal wiring diagram of EntelliGuard G breaker



AUXILIARY SWITCH CONTACTS

POWER RATED -- (CAN HAVE COIL SIGNALING CONTACTS)
3NO / 3NC -- A14-A25

POWER RATED -- (CANNOT HAVE COIL SIGNALING CONTACTS)
8NO / 8NC -- A14-A25, B4-B13, B17-B26

POWER RATED & HIGH FIDELITY (SIGNAL RATED) -- (CAN HAVE COIL SIGNALING CONTACTS)
3NO / 3NC -- A14-A25 (POWER RATED)
2NO / 2NC -- B10-B13, B23-B26 (SIGNAL RATED)

POWER RATED & HIGH FIDELITY (SIGNAL RATED) -- (CANNOT HAVE COIL SIGNALING CONTACTS)
4NO / 4NC -- A14-A25, B12-B13, B25-B26 (POWER RATED)
4NO / 4NC -- B4-B11, B17-B24 (SIGNAL RATED)

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Figure 2.15: EntelliGuard G Breaker – Internal Wiring

Typical control circuit for EntelliGuard G breaker

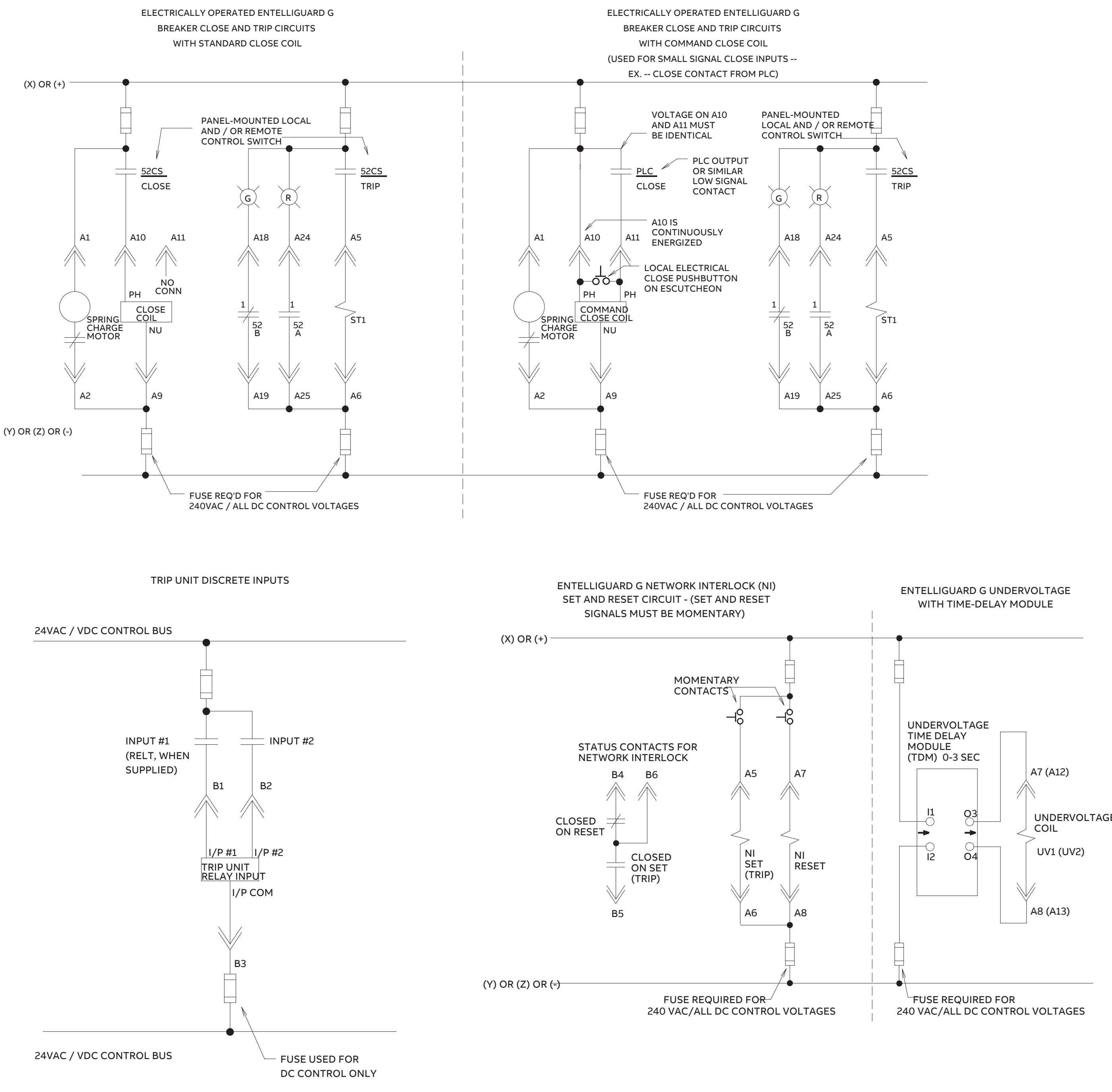

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Figure 2.16: EntelliGuard G Breaker – Typical control circuits

Ground fault

EntelliGuard TU trip unit has provisions for two types of ground fault protection – internal sensing and external sensing. Internal ground fault sensing uses three-phase sensors plus a neutral sensor (Rogowski coil – see Table 2.30) for summation of the phase and neutral currents. If the summation of the phase and neutral currents exceeds the trip unit ground fault pickup and delay settings, the breaker will trip or the trip unit can provide a ground fault alarm. Internal ground fault sensing is typically applied to feeder breakers (3-wire or 4-wire) and to main breakers (3-wire only).

External ground fault sensing uses a single current sensor input as the ground fault signal. AII summations of currents are performed external to the trip unit. Examples of external ground fault sensing are multisource ground fault on 4-wire systems and ground-return sensing. External ground fault sensing pickup settings are based on the rating of the phase sensors on the breaker.

The input from the external current sensors must be scaled such that 63 mA corresponds to 1 per unit of current.For example, the external current sensor used with a 4000 A breaker would be scaled so that 63 mA from the external current sensor would equal 4000 A.

The external ground fault sensors (5 amp relay-class current transformers) must have a primary rating that matches the phase sensor rating on the breaker. A summing and auxiliary CT sums and scales the secondary current from the ground fault sensors before providing the ground fault signal to the trip unit. Table 2.31 lists the summing and auxiliary CTs for external ground fault sensing. A more detailed description of external ground fault applied to multiple-source systems (double-ended substations) is provided in pages 55-77.

Table 2.30: Neutral Rogowski CTs (encased with terminal screws)

Envelope	Current rating	Cat. no.
1	400 A	G04HNRCE
	800 A	G08HNRCE
	1200 A/1500 A	G13HNRCE
	1600 A	G16HNRCE
	2000 A	G20HNRCE
2	400 A	G04MNRCE
	800 A	G08MNRCE
	1600 A	G16MNRCE
	2000 A	G20MNRCE
	3200 A	G32HNRCE
3	3000 A/3200 A (1600 A x 2)	G32LNRCE
	4000 A (2000 A x 2)	G32LNRCE
	5000 A (2500 A x 2)	G50LNRCE

Table 2.31: EntelliGuard G summing and auxiliary CT

Summing/Aux. CT catalog number 0173B4934____	Ground fault CT ratio	Summing CT input	Summing CT output	Summing CT turns ratio	Auxiliary CT ratio
P002	1200:5	5+5+5+5	0.1515 A	132:1	0.60:1
P003	1600:5		0.2000 A	100:1	0.79:1
P004	2000:5		0.2500 A	80:1	0.99:1
P007	3200:5		0.4167 A	48:1	1.65:1
P008	4000:5		0.5000 A	40:1	1.98:1
P009	5000:5		0.6250 A	32:1	2.47:1
P010	6000:5		1.0 A	20:1	3.97:1

Mechanical operations counter

Used with either manual or motor charged circuit breakers, the counter provides an accurate record of the cumulative number of complete breaker closing operations (Table 2.32).

Table 2.32: Operations counter

Description	Cat.no.
Mechanical operations counter	GMCNR

Table 2.33: Wiring schematic for block-a (three layer secondary disconnect with basic GTU and basic accessories)

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**	**A13**
	Motor	**Motor**	**Spr NO/ RTC NO**	**Spr NO/ RTC NO**	**ST1**	**ST1**	**UV1**	**UV1**	**CC COM**	**CC IMM**	**CC CMD**	**ST2/ UV2**	**ST2/ UV2**
Max. current (I)	14.8A	14.8A	10A	10A	1.9A	1.9A	1.9A	1.9A	1.9A	1.9A	1.9A	1.9A	1.9A
Max. voltage (V)	440V	440V	240V	240V	440V	440V	440V	440V	440V	440V	440V	440V	440V
	A14	**A15**	**A16**	**A17**	**A18**	**A19**	**A20**	**A21**	**A22**	**A23**	**A24**	**A25**	**A26**
	NC3	NC3	NC2	NC2	NC1	NC1	NO3	NO3	NO2	NO2	NO1	NO1	-
Max. current (I)	15A	15A	15A	15A	15A	15A	15A	15A	15A	15A	1A	15A	-
Max. voltage (V)	440V	440V	440V	440V	440V	440V	440V	440V	440V	440V	440V	440V	-
	A27	**A28**	**A29**	**A30**	**A31**	**A32**	**A33**	**A34**	**A35**	**A36**	**A37**	**A38**	**A39**
	O/P1a	O/P1b	O/P2a	O/P2b	24V+	24V-	BA NC	BA NO	BA COM	N-RC-	N-RC+	Eleg-CT	Eleg-CT
Max. current (I)	1A	1A	1A	1A	<500 mA	<500 mA	10A	10A	10A	<50 mA	<50 mA	5A	5A
Max. voltage (V)	30Vdc/ 25Vac	30Vdc/ 25Vac	30Vdc/ 25Vac	30Vdc/ 25Vac	30V	30V	240V	240V	240V	480mV	480mV	2V	2V

Table 2.34: Wiring schematic for block-b (three layer secondary disconnect to be added for GTU with full I/O and additional accessory ignals)

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13
	INPUT1	**INPUT2**	**I/P COM**	**ST1 NO/ NC8**	**ST1 COM/ NC8**	**UV1 NO/ NC7**	**UV1 COM/ NC7**	**NC6**	**NC6**	**NC5**	**NC5**	**NC4**	**NC4**
Max. current (I)	<50mA	<50mA	<50mA	10A/ 15A	10A/ 15A	10A/ 15A	10A/ 15A	15A	15A	15A	15A	15A	15A
Max. voltage (V)	30Vdc/ 25Vac	30Vdc/ 25Vac	30Vdc/ 25Vac	240V/ 440V	240V/ 440V	240V/ 440V	240V/ 440V	440V	440V	440V	440V	440V	440V
	B14	**B15**	**B16**	**B17**	**B18**	**B19**	**B20**	**B21**	**B22**	**B23**	**B24**	**B25**	**B26**
	-	-	-	CC NO/ NO8	CC COM/ NO8	ST2 NO/ UV2 NO/ NO7	ST2 COM/ UV2 COM/ NO7	NO6	NO6	NO5	NO5	NO4	NO4
Max. current (I)	<50mA	<500mA	-	10A/ 15A	10A/ 15A	10A/ 15A	10A/ 15A	15A	15A	15A	15A	15A	15A
Max. voltage (V)	5V	0.1V	-	240V/ 440V	240V/ 440V	240V/ 440V	240V/ 440V	440V	440V	440V	440V	440V	440V
	B27	**B28**	**B29**	**B30**	**B31**	**B32**	**B33**	**B34**	**B35**	**B36**	**B37**	**B38**	**B39**
	ZSI out+	ZSI out-	ZSI in+	ZSI in-	ISO GND	5V ISO	TX EN 1	RX	TX	GND Volt-IN	Volt-A	Volt-B	Volt-C
Max. current (I)	<50mA	<50mA	<50mA	<50mA	<500 mA	<500 mA	<50mA	<50mA	<50mA	<500 mA	<50mA	<50mA	<50mA
Max. voltage (V)	28Vdc	28Vdc	30Vdc	30Vdc	0.1V	5V	5V	5V	5V	0.1V	1.76V	1.76V	1.76V

Table 2.35: Electronic interlock

Network interlock connections						Network interlock status switch
A5	A6	A5	A8	B4	B5	B6
NI TRIP	NI TRIP	NI RESET	NI RESET	NI NC	NI NO	NI COM
1.9A	1.9A	1.9A	1.9A	10A	10A	10A
240V	240V	240V	240V	240V	240V	240V

Application data

EntelliGuard G power circuit breaker selection tables

The tables on the following pages can be used to help determine the correct EntelliGuard G breaker frame sizes and interrupting ratings based on the system voltage, transformer kVA rating, transformer overload ratings, and transformer impedance. The tables also provide arc flash incident energy values at the feeder sections based on the noted assumptions and the calculation methods provided in IEEE 1584. Main breakers are sized based on either the transformer base kVA or the transformer full load current with fan cooling. The main breaker short circuit rating is based on the transformer base kVA rating, minimum transformer impedance, and the system voltage.

Recommended feeder breakers are listed in two columns. Feeder breaker short circuit rating is determined by the combined short circuit current available from the transformer and any contribution from connected motor loads.

The first feeder breaker column provides the breaker designation based on the required short circuit interrupting rating. The breaker in this column has a short time withstand rating less than or equal to the breaker interrupting rating. The second feeder breaker column lists the feeder circuit breaker with a short time withstand rating equal to its interrupting rating or a “square-rated” breaker. The EntelliGuard G circuit breaker application guide discusses breaker short time withstand versus interrupting ratings and the use of the various instantaneous trip functions to achieve the required interrupting ratings while maintaining selectivity. To determine the transformer full load current based on the transformer type, kVA, temperature rise, andfan cooling, see Table 3.1.

Table 3.1: Transformer full-load current

Transformer type	Self-cooled kVA	Percent increase with fans
Liquid filled 65 °C rise	750-2000	15%
	2500-5000	25%
Liquid filled 55 °C/ 65 °C rise	750-2000	15% (fans) + 12% (65 °C)
	2500-5000	25% (fans) + 12% (65 °C)
Ventilated dry	750-2500	33%
Cast coil	500-2500	40%
	3000-5000	25%

Table 3.2 shows the first five characters in the breaker catalog number, which define the breaker current and interrupting rating. These breaker designations are used in the following breaker selection tables.

Table 3.2: Breaker catalog number description for breaker selection table[1]

ACB family	Code
EntelliGuard G	G

ANSI/UL1066 (breaker/vassette Size)	Code
Envelope 1	N
Envelopes 2 and 3	A

Current Rating (Max Sensor)	Code	Breaker/ Cassette Size	AIC Rating Code[2]
800 A	08	1	S/N/H/P
		2	E/M
1200 A	12	1	S
1600 A	16	1	N/H/P
		2	E/M
2000 A	20	1	N/H/P
		2	E/M
3200 A	32	2	E/M
		3	B/L
4000 A	40	3	M/B/L
5000 A	50	3	M/B/L
64000 A	60	3	M/B/L

1. Example: GA16E is EntelliGuard G, 1600 A, 85 kA interrupting, 85 kA withstand, Envelope 2.
2. Refer to Table 2.3: ANSI/UL1066 LVPCB interrupting ratings.

Table 3.3: System voltage @600 V – Nominal transformer Z (%) = 5.75 ±7.5%; Minimum transformer Z (%) = 5.32

Voltage Rating: 600 V

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Arc flash incident energy[(6)(7)] (cal/cm2)	Main breaker [(1)(2)(3)] $I_{CW}>I_{SC}$	Feeder breaker[(5)] $I_{CW}\leq I_{CU}$	Feeder breaker[(5)] $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
500	481 with fans: 674	50	1.00	7128	7614	1925	9539	1.47	GA08E (GA08E)	GN08S	GN08N
		100	0.50	7698	8269		10193	1.57			
		150	0.33	7909	8512		10437	1.60			
		250	0.20	8086	8086		10643	1.63			
		500	0.10	8224	8879		10803	1.66			
		750	0.07	8271	8934		10858	1.67			
		Unlimited	0.00	8367	9046		10970	1.68			
750	722 with fans: 1010	50	1.50	9954	10584	2887	13471	2.05	GA08E (GA16E)	GN08S	GN08N
		100	0.75	11103	11892		14779	2.25			
		150	0.50	11547	12403		15290	2.32			
		250	0.30	11929	12844		15731	2.39			
		500	0.15	12232	13197		16083	2.44			
		750	0.10	12337	13318		16205	2.46			
		Unlimited	0.00	12551	13569		16456	2.50			
1000	962 with fans: 1347	50	2.00	12416	13148	3849	16997	2.58	GA16E (GA16E)	GN08S	GN08N
		100	1.00	14256	15228		19077	2.88			
		150	0.67	14996	16077		19926	3.01			
		250	0.40	15646	16826		20675	3.12			
		500	0.20	16172	17436		21285	3.21			
		750	0.13	16356	17649		21498	3.24			
		Unlimited	0.00	16735	18092		21941	3.30			
1500	1443 with fans: 2021	50	3.00	16496	17351	5774	23124	3.48	GA16E (GA20E)	GN08S	GN08N
		100	1.50	19909	21168		26941	4.03			
		150	1.00	21383	22843		28616	4.28			
		250	0.60	22730	24386		30160	4.50			
		500	0.30	23857	25689		31462	4.69			
		750	0.20	24258	26154		31928	4.76			
		Unlimited	0.00	25102	27137		32911	4.76			
2000	1925 with fans: 2694	50	4.00	19738	20652	7698	28350	4.24	GA20E (GA32N)	GN08S	GN08N
		100	2.00	24832	26295		33993	5.06			
		150	1.33	27169	28931		36629	5.44			
		250	0.80	29382	31453		39151	5.80			
		500	0.40	31293	33652		41350	6.12			
		750	0.27	31986	34456		42154	6.23			
		Unlimited	0.00	33470	36183		43881	6.48			

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Arc flash incident energy[(6)(7)] (cal/cm2)	Main breaker [(1)(2)(3)] $I_{cw}>I_{sc}$	Feeder breaker[(5)] $I_{cw}\leq I_{cu}$	Feeder breaker[(5)] $I_{cw}=I_{cu}$ or $I_{cw}>I_{sc}$
		50	5.00	22378	23313		32936	4.90			
		100	2.50	29159	30767		40390	5.98			
		150	1.67	32435	34438		44060	6.51			
2500	2406 with fans: 3368	250	1.00	35639	38071	9623	47694	7.03	GA32N (GA40M)	GN08N	GN08N
		500	0.50	38490	41343		50965	7.50			
		750	0.33	39545	42562		52184	7.67			
		Unlimited	0.00	41837	45229		54852	8.05			
		50	6.00	24568	25504		37051	5.50			
		100	3.00	32991	34702		46249	6.82			
		150	2.00	37248	39443		50990	7.50			
3000	2887 with fans: 4041	250	1.20	41536	44284	11547	55831	8.19	GA32N (GA50M)	GA08E	GA08E
		500	0.60	45461	48773		60320	8.83			
		750	0.40	46939	50479		62026	9.08			
		Unlimited	0.00	50204	54275		65822	9.62			
		50	7.50	27234	28150		42583	6.29			
		100	3.75	37984	39790		54224	7.96			
		150	2.50	43739	46151		60585	8.87			
3750	3608 with fans: 5052	250	1.50	49772	52919	14434	67353	9.83	GA40M (GA50M)	GA08E	GA08E
		500	0.75	55514	59459		73893	10.76			
		750	0.50	57735	62014		76448	11.12			
		Unlimited	0.00	62755	67844		82278	11.95			
		50	10.00	30548	31408		50653	7.45			
		100	5.00	44756	46626		65871	9.62			
		150	3.33	52968	55608		74853	10.90			
5000	4811 with fans: 6736	250	2.00	62081	65739	19245	84984	12.33	GA50B	GA32B	GA32B
		500	1.00	71278	76142		95387	13.80			
		750	0.67	74981	80383		99628	14.39			
		Unlimited	0.00	83674	90458		109703	15.81			-

1. Main breaker sized for transformer base kVA. (Larger main breaker is sized for transformers with dual temperature rise and/or forced air cooling.)
2. Main breaker is Envelope 2 or 3 to accommodate ground fault CTs for 4-wire multi-source ground fault protection.
3. Main breaker has 30 cycle withstand rating (ICW) greater than transformer maximum short circuit current (ISC).
4. Equipment ANSI short circuit rating is based on the breaker (main or feeder) with the lowest short circuit rating (ICU).
5. ICW = 30 cycle withstand current rating; ICU = maximum short circuit interrupting rating; ISC = available short circuit current.
6. Arc flash incident energy calculated at fault current based on minimum Z% and full motor contribution. 600 V, resistance grounded or floating system, arc in a box, 32 mm arcing gap and 18" working distance. Circuit breaker clearing time is 3 cycles (instantaneous).
7. Arc flash incident energy may be calculated using different assumptions. IEEE 1584 has been used as the guide for the above calculated incident energy values.

Table 3.4: System voltage @480 V – Nominal transformer Z (%) = 5.75 ±7.5%; Minimum transformer Z (%) = 5.32

Voltage Rating: 480 V

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Arc flash incident energy[(6)(7)] (cal/cm2)	Main breaker[(1)(2)(3)] $I_{cw}>I_{sc}$	Feeder breaker[(5)] $I_{cw}\le I_{cu}$	Feeder breaker[(5)] $I_{cw}=I_{cu}$ or $I_{cw}>I_{sc}$
		50	1.00	8910	9518		11923	1.48			
		100	0.50	9623	10336		12741	1.57			
	601	150	0.33	9886	10640		13046	1.61			
500	with fans: 842	250	0.20	10108	10898	2406	13303	1.63	GA08E (GA16E)	GN08S	GN08S
		500	0.10	10280	11099		13504	1.66			
		750	0.07	10339	11167		13573	1.66			
		Unlimited	0.00	10459	11307		13713	1.68			
		50	1.50	12443	13230		16838	2.02			
		100	0.75	13879	14865		18473	2.20			
	902	150	0.50	14434	15503		19112	2.26			
750	with fans: 1263	250	0.30	14911	16055	3608	19664	2.32	GA16E (GA16E)	GN08S	GN08S
		500	0.15	15290	16496		20104	2.37			
		750	0.10	15421	16648		20256	2.39			
		Unlimited	0.00	15689	16961		20569	2.42			
		50	2.00	15520	16435		21246	2.49			
		100	1.00	17819	19036		23847	2.76			
	1203	150	0.67	18745	20096		24907	2.87			
1000	with fans: 1684	250	0.40	19558	21033	4811	25844	2.97	GA16E (GA20E)	GN08S	GN08S
		500	0.20	20215	21795		26606	3.05			
		750	0.13	20444	22062		26873	3.08			
		Unlimited	0.00	20918	22615		27426	3.14			
		50	3.00	20620	21689		28905	3.29			
		100	1.50	24886	26460		33677	3.77			
	1804	150	1.00	26729	28553		35770	3.98			
1500	with fans: 2526	250	0.60	28413	30483	7217	37700	4.18	GA20E (GA32N)	GN08S	GN08S
		500	0.30	29822	32111		39328	4.34			
		750	0.20	30323	32693		39909	4.40			
		Unlimited	0.00	31378	33922		41139	4.52			
		50	4.00	24673	25815		35437	3.95			
		100	2.00	31040	32869		42492	4.65			
	2406	150	1.33	33962	36163		45786	4.97			
2000	with fans: 3368	250	0.80	36727	39316	9623	48938	5.28	GA32N (GA40M)	GN08S	GN08N
		500	0.40	39116	42066		51688	5.55			
		750	0.27	39983	43070		52692	5.64			
		Unlimited	0.00	41837	45229		54852	5.85			

Transformer KVA	Full load current (A)	Primary short sircuit[4] (MVA)	System Z (%)	Available SC Curr. (A), Nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Arc flash incident energy[(6)(7)] (cal/cm2)	Main breaker [(1)(2)(3)] $I_{CW}>I_{SC}$	Feeder breaker[(5)] $I_{CW}\leq I_{CU}$	Feeder breaker[(5)] $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
		50	5.00	27972	29141		41170	4.52			
		100	2.50	36449	38459		50487	5.43			
	3007	150	1.67	40544	43047		55075	5.87			
2500	with fans: 4210	250	1.00	44549	47589	12028	59617	6.31	GA32N (GA50M)	GN08H	GA08E
		500	0.50	48113	51678		63706	6.70			
		750	0.33	49431	53202		65230	6.84			
		Unlimited	0.00	52296	56536		68565	7.15			
		50	6.00	30710	31880		46314	5.03			
		100	3.00	41239	43377		57811	6.14			
	3608	150	2.00	46561	49304		63738	6.70			
3000	with fans: 5052	250	1.20	51920	55355	14434	69789	7.27	GA40M (GA50M)	GN08H	GA08E
		500	0.60	56826	60966		75400	7.79			
		750	0.40	58674	63098		77532	7.99			
		Unlimited	0.00	62755	67844		82278	8.43			
		50	7.50	34042	35187		53229	5.70			
		100	3.75	47479	49737		67779	7.08			
	4511	150	2.50	54673	57689		75731	7.82			
3750	with fans: 6315	250	1.50	62214	66149	18042	84191	8.61	GA50M	GN08P	-
		500	0.75	69393	74324		92366	9.36			
		750	0.50	72169	77517		95560	9.65			
		Unlimited	0.00	78444	84805		102847	10.31		GA32L	

1. Main breaker sized for transformer base kVA. (Larger main breaker is sized for transformers with dual temperature rise and/or forced air cooling.)
2. Main breaker is Envelope 2 or 3 to accommodate ground fault CTs for 4-wire multi-source ground fault protection.
3. Main breaker has 30 cycle withstand rating (ICW) greater than transformer maximum short circuit current (ISC).
4. Equipment ANSI short circuit rating is based on the breaker (main or feeder) with the lowest short circuit rating (ICU).
5. ICW = 30 cycle withstand current rating; ICU = maximum short circuit interrupting rating; ISC = available short circuit current.
6. Arc flash incident energy calculated at fault current based on minimum Z% and full motor contribution. 480 V, resistance grounded or floating system, arc in a box, 32 mm arcing gap and 18" working distance. Circuit breaker clearing time is 3 cycles (instantaneous).
7. Arc flash incident energy may be calculated using different assumptions. IEEE 1584 has been used as the guide for the above calculated incident energy values.

Table 3.5: System voltage @240 V – Nominal transformer Z (%) = 5.75 ±7.5%; Minimum transformer Z (%) = 5.32

Voltage Rating: 240 V

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Arc flash incident energy[6][7] (cal/cm2)	Main breaker [1][2][3] $I_{CW}>I_{SC}$	Feeder breaker[5] $I_{CW}\leq I_{CU}$	Feeder breaker[5] $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
		50	1.00	17819	19036		21441	1.52			
		100	0.50	19245	20671		23077	1.61			
	1203	150	0.33	19772	21281		23687	1.64			
500	with fans:	250	0.20	20215	21795	2406	24201	1.67	GA16E (GA20E)	GN08S	GN08S
	1684	500	0.10	20561	22197		24603	1.69			
		750	0.07	20679	22335		24740	1.69			
		Unlimited	0.00	20918	22615		25020	1.71			
		50	1.50	24886	26460		30068	1.96			
		100	0.75	27757	29730		33338	2.12			
	1804	150	0.50	28868	31007		34615	2.18			
750	with fans:	250	0.30	29822	32111	3608	35719	2.24	GA20E (GA32N)	GN08S	GN08S
	2526	500	0.15	30580	32991		36600	2.28			
		750	0.10	30841	33296		36904	2.29			
		Unlimited	0.00	31378	33922		37530	2.32			
		50	2.00	31040	32869		37681	2.33			
		100	1.00	35639	38071		42882	2.57			
	2406	150	0.67	37490	40191		45003	2.66			
1000	with fans:	250	0.40	39116	42066	4811	46877	2.75	GA32N (GA40M)	GN08S	GN08N
	3368	500	0.20	40431	43590		48401	2.81			
		750	0.13	40889	44123		48934	2.84			
		Unlimited	0.00	41837	45229		50040	2.88			
		50	3.00	41239	43377		50594	2.91			
		100	1.50	49772	52919		60136	3.31			
	3608	150	1.00	53458	57107		64324	3.49			
1500	with fans:	250	0.60	56826	60966	7217	68183	3.64	GA40M (GA50M)	GN08H	GA08E
	5052	500	0.30	59644	64221		71438	3.77			
		750	0.20	60646	65385		72602	3.82			
		Unlimited	0.00	62755	67844		75061	3.92			
		50	4.00	49346	51630		61252	3.36			
		100	2.00	62081	65739		75361	3.93			
	4811	150	1.33	67924	72327		81950	4.19			
2000	with fans:	250	0.80	73454	78631	9623	88254	4.43	GA50B	GN08P	GA32B
	6736	500	0.40	78232	84131		93754	4.63			
		750	0.27	79965	86140		95762	4.71			
		Unlimited	0.00	83674	90458		100081	4.87			-

1. Main breaker sized for transformer base kVA. (Larger main breaker is sized for transformers with dual temperature rise and/or forced air cooling.)
2. Main breaker is Envelope 2 or 3 to accommodate ground fault CTs for 4-wire multi-source ground fault protection.
3. Main breaker has 30 cycle withstand rating (ICW) greater than transformer maximum short circuit current (ISC).
4. Equipment ANSI short circuit rating is based on the breaker (main or feeder) with the lowest short circuit rating (ICU).
5. ICW = 30 cycle withstand current rating; ICU = maximum short circuit interrupting rating; ISC = available short circuit current.
6. Arc flash incident energy calculated at fault current based on minimum Z% and 50% motor contribution. 240 V, resistance grounded or floating system, arc in a box, 32 mm arcing gap and 18" working distance. Circuit breaker clearing time is 3 cycles (instantaneous).
7. Arc flash incident energy may be calculated using different assumptions. IEEE 1584 has been used as the guide for the above calculated incident energy values.

Table 3.6: System voltage @208 V – Nominal transformer Z (%) = 5.75 ±7.5%; Minimum transformer Z (%) = 5.32

Voltage Rating: 208 V

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Arc flash incident energy[(6)(7)] (cal/cm2)	Main breaker[(1)(2)(3)] $I_{CW}>I_{SC}$	Feeder breaker[(5)] $I_{CW}\leq I_{CU}$	Feeder breaker[(5)] $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
500	1388 with fans: 1943	50	1.00	20561	21964	2776	24740	1.22	GA16E (GA20E)	GN08S	GN08S
		100	0.50	22206	23852		26627	1.29			
		150	0.33	22814	24555		27331	1.31			
		250	0.20	23325	25148		27924	1.33			
		500	0.10	23724	25612		28388	1.35			
		750	0.07	23860	25771		28546	1.35			
		Unlimited	0.00	24137	26094		28869	1.36			
750	2082 with fans: 2915	50	1.50	28714	30530	4164	34694	1.56	GA20E (GA32N)	GN08S	GN08S
		100	0.75	32028	34303		38467	1.69			
		150	0.50	33309	35777		39941	1.73			
		250	0.30	34410	37051		41214	1.77			
		500	0.15	35285	38067		42231	1.81			
		750	0.10	35586	38418		42582	1.82			
		Unlimited	0.00	36205	39141		43304	1.84			
1000	2776 with fans: 3886	50	2.00	35816	37926	5551	43478	1.84	GA32E (GA40M)	GN08N	GN08N
		100	1.00	41122	43928		49480	2.03			
		150	0.67	43258	46375		51926	2.10			
		250	0.40	45134	48537		54089	2.17			
		500	0.20	46651	50296		55848	2.22			
		750	0.13	47179	50911		56463	2.24			
		Unlimited	0.00	48273	52187		57739	2.27			
1500	4164 with fans: 5829	50	3.00	47584	50051	8327	58378	2.29	GA50B	GN08P	GA32B
		100	1.50	57429	61061		69388	2.60			
		150	1.00	61683	65893		74220	2.73			
		250	0.60	65568	70346		78673	2.85			
		500	0.30	68820	74102		82429	2.95			
		750	0.20	69976	75444		83771	2.99			
		Unlimited	0.00	72410	78281		86608	3.06			

1. Main breaker sized for transformer base kVA. (Larger main breaker is sized for transformers with dual temperature rise and/or forced air cooling.)
2. Main breaker is Envelope 2 or 3 to accommodate ground fault CTs for 4-wire multi-source ground fault protection.
3. Main breaker has 30 cycle withstand rating (ICW) greater than transformer maximum short circuit current (ISC).
4. Equipment ANSI short circuit rating is based on the breaker (main or feeder) with the lowest short circuit rating (ICU).
5. ICW = 30 cycle withstand current rating; ICU = maximum short circuit interrupting rating; ISC = available short circuit current.
6. Arc flash incident energy calculated at fault current based on minimum Z% and 50% motor contribution. 240 V, resistance grounded or floating system, arc in a box, 32 mm arcing gap and 18" working distance. Circuit breaker clearing time is 3 cycles (instantaneous).
7. Arc flash incident energy may be calculated using different assumptions. IEEE 1584 has been used as the guide for the above calculated incident energy values.

EntelliGuard G low voltage circuit breakers – watts lost

Breaker watts loss values (Table 3.7) are shown for 100% current values. To convert watts loss to BTU/hour, multiply watts by 3.42. Breaker watts loss for lower current values may be estimated by the following formula:

$$W_e = W_{FL}\ (I/I_{FL})^2$$

where:
We = estimated watts loss at load current
WFL = estimated watts loss at full load current (100% of frame rating, see Table 3.7)
I = load current
IFL = full load current (100% frame rating)

See the watts loss data in Table 3.8 for bus in vertical sections.

Table 3.7: EntelliGuard G LVPCB estimated watts loss (per breaker, 3-pole)

Breaker frame size	Breaker type	Breaker envelope	Watts loss
800	S/N/H/P	1	58
	E/M	2	45
1200	S	1	140
1600	N/H	1	230
	E/M	2	180
2000	N/H	1	360
	E/M	2	281
3200	N/E/M	2	558
	B/L	3	318
4000	M/B/L	3	498
5000	M/B/L	3	780
6000	M/B/L	3	1278

The signal from the neutral Rogowski coil is added to the trip unit summation circuit through the breaker secondary disconnect. Main and tie circuit breakers used on solidly grounded, 3-wire systems (no neutral bus for branch circuit loads) may also use the same summation ground fault protection system. Trip unit setup is under the heading of "GF SUM."

Table 3.8: Low voltage switchgear bussing estimated watts loss (per section, 3-phase)

Section Width (in.)	Main bus rating (A)	Watts loss
22	2000	743
	3200	1420
	4000	1893
	5000	2014
	6000	2163
	8000	2698
30	2000	802
	3200	1535
	4000	2044
	5000	2209
	6000	2413
	8000	3142
34	2000	831
	3200	1592
	4000	2120
	5000	2307
	6000	2538
	8000	3364
38	2000	499
	3200	1103
	4000	1597
	5000	2298
	6000	2931
	8000	3854

Ground fault protection

Several types of ground fault protection are available in AKD-20 switchgear using the EntelliGuard TU trip unit and current sensors. Solidly grounded systems will use either a simple current summation for individual branch feeder circuit breakers or a modified differential scheme for multiple source systems.

Ground fault for 3-wire branch circuits is accomplished by summing the phase currents from the integral current sensors on the circuit breaker. Branch circuit breakers serving 4-wire loads require the addition of a neutral current sensor (Rogowski coil) to monitor the load neutral current.

Multiple-source systems (or single-source systems with provisions for additional sources) with a neutral bus for branch circuit loads require the use of a modified differential ground fault scheme. The modified differential ground fault scheme, shown in Figure 3.1 for a typical double-ended substation configuration, accommodates neutral-to-ground bonding at each source. The scheme monitors all phase and neutral conductors on all source and tie circuit breakers and accounts for ground current flowing on the neutral bus due to the common neutral connection between sources.

The interconnection of the current sensors also accommodates any neutral load current that may appear on the ground bus. Each source and tie circuit breaker will have three standard 5 A relaying-type current transformers mounted in the breaker cassette and a similar current transformer mounted on the neutral conductor. The secondary of these four current transformers are connected to a summing CT in the breaker section.

For simplicity, the four phase and neutral current transformers and summing CT are represented by a single current transformer symbol on the three-line diagram (Figure 3.1). The secondary of the summing CTs are interconnected to allow unbalanced currents to circulate in the loop. Trip units for the source and tie breakers are connected to the summing CT loop through individual auxiliary current transformers. The summing and auxiliary current transformers are designed to allow a mixture of phase current transformer ratings for the source and tie breakers. For example, in the double-ended substation, below, one main circuit breaker may be rated 4000 A, the other main rated 3200 A and the tie circuit breaker may be rated 2000 A.

The summing and auxiliary CT ratios allow the use of phase and neutral current transformers that match the breaker frame rating rather than requiring all current transformers to have the same primary rating.

For ground faults on branch circuits, the multisource ground fault scheme will provide backup tripping for the feeder circuit breaker ground fault protection. The source and tie breakers that are connected to the bus with the ground fault will be signaled to trip should the feeder breaker fail to clear the ground fault. The same tripping response applies if the ground fault is ahead of the branch circuit breaker, within the switchgear, or on interconnecting cables or busway for multisource systems that are split into multiple lineups. The faulted bus section will be isolated by tripping the source and tie breakers connected to the bus. Trip unit setup is under the heading of "GF CT." All of the trip unit ground fault functions can be specified either to trip the circuit breaker or to provide an alarm when a ground fault is sensed. All ground fault tripping is self-powered and requires no shunt trip coil or control power source. Ground fault alarms require either a Modbus connection to the trip unit or use of the programmable contact on the trip unit and a powered alarm circuit.

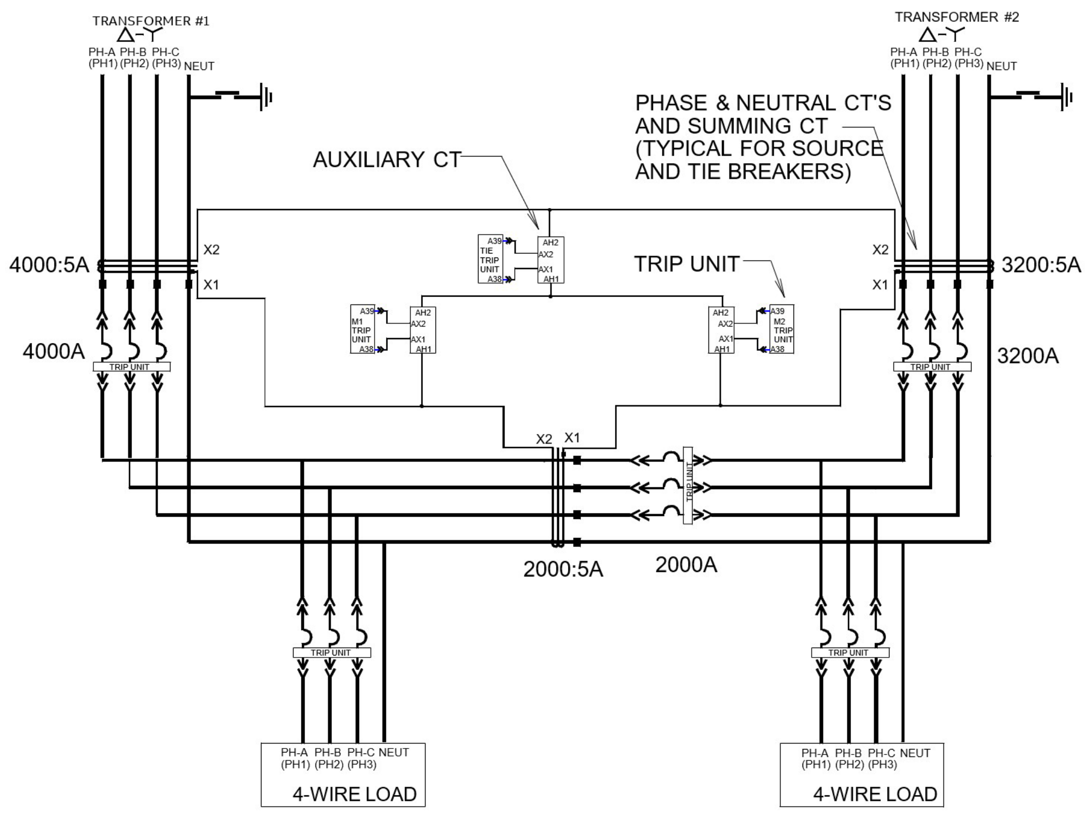

Figure 3.1: Example ground fault diagram

Ground detector considerations

High-resistance pulsing ground detection system
This system provides a means for grounding the neutral of a power system, utilizing the "high-resistance" method. It allows the switchgear to operate as an "ungrounded" system but eliminates the danger of high transient overvoltage during certain types of ground faults. For delta systems, a set of grounding transformers is provided for connection of the grounding resistor. Figure 3.2 shows a typical ground system visualization of the devices and operations in the switchgear.

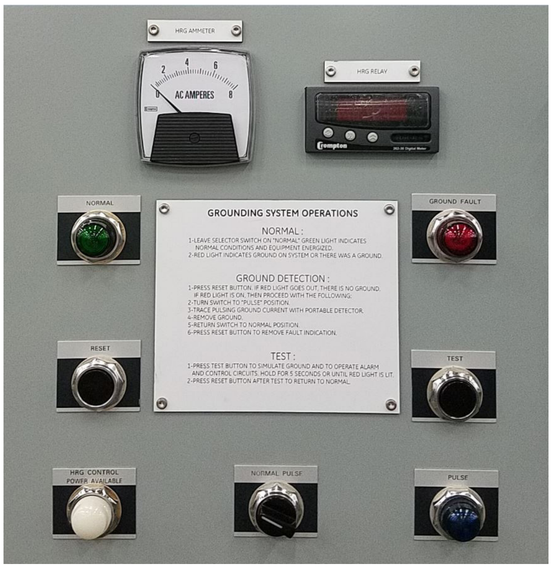

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Figure 3.2: Pulsing high-resistance ground detection interface

The pulsing high-resistance ground detection system uses a voltmeter relay with an adjustable set point to detect abnormal ground current through the grounding resistor.
A green indicating light shows normal conditions, and a red indicating light indicates the presence of a phase-toground fault. Alarm contacts allow remote indication of the ground condition.
The location of the fault is quickly determined using a pulsing current in conjunction with a sensitive clamp-on ammeter, which permits clearing of the ground fault before a second phase-to-ground fault causes an outage. After the fault is located and cleared, the system is reset and ready to detect the next ground fault. The pulsing high-resistance ground detection system can be enhanced by the addition of a current sensor on each feeder breaker, connected to individual ammeters on the switchgear front panel. The ammeter provides visual indication of the faulted feeder when the grounding resistor is being pulsed, avoiding the need for a clamp-on ammeter to detect the faulted feeder in the switchgear.

Ground detection on ungrounded systems
This system provides visual indication of the presence of a phase-to-ground condition on a delta ungrounded system. Ground detection on ungrounded systems consists of one set of three voltage transformers rated for full phase-tophase voltage on the primary winding and 120 V secondary winding. The primary is connected wye. The secondary connection is dependent on the type of ground indicators and alarm devices used. A loading or stabilizing resistor may be used in the voltage transformer primary connection to ground if ferroresonance with the distributed capacitance of the system is an issue. Ground indication and alarm can be accomplished as described in the following tables.

Caution: A combination of ground indication and metering or relaying on the same set of voltage transofrmers is not recommended. Metering not only may require different primary and/or secondary connections; It also increases the probability of faults in the secondary circuits with consequent false indications of grounds on the primary system.

Table 3.9: Operation with lights or voltmeters

Standard	Three 120 V indicating lights with clear lenses (one per phase). Voltage transformers with wye-connected secondaries.
Option	Three voltmeters instead of indicating lights. Voltage transformers with wye-connected secondaries.
Operational description	Assuming rated system voltage on the primary of the voltage transformers, the three lamps would glow about equally at subnormal brilliancy because the voltage across each lamp is 69.3 V. Similarly, each voltmeter would read 69.3 V. If one phase of the system becomes grounded, the voltage transformer on the grounded phase would be short-circuited, and the other two transformers would rise to approximately full phase-to-phase voltage. The lamp on the grounded phase would be dark, and the other two lamps would glow at normal brilliance. Similarly, the voltmeter on the grounded phase would read zero and the other two voltmeters would read 120 V.

Table 3.10: Operation with alarm relay

Option	An overvoltage relay coil rating of 199 V to 208 V, pickup range of 16 V to 64 V or 70 V to 140 V. Voltage transformers with broken delta-connected secondaries. Note that either indicating lights or voltmeters (Table 3-9) can be used as ground indicators with this option.
Operational description	Operation with the alarm relay is the same as described in Table 3-9, although the connections are different. Assuming rated system voltage on the voltage transformers' primary, the three secondary voltage vectors add up to zero, resulting in no voltage at the relay. If one phase of the system becomes grounded, the voltage transformer on the grounded phase would be short-circuited and the other two transformers would rise to full phase-to-phase voltage. The secondary voltages would also rise to the phase-tophase values (120 V). Because these two voltages are in series at an angle of 60° underground fault conditions, the voltage imposed on the relay is three times the voltage on each voltage transformer secondary under normal conditions (208 V).

Table 3.11: Operation with test switch

Option	Test switch (for either lamp test or test-forground).
Operational description	The lamp test feature is performed using the normally closed contact of the test switch. The test-for-ground feature is performed using the normally open contact. You must specify which test feature is to be furnished.

Breaker control systems

Accessories for the EntelliGuard G circuit breaker accommodate control schemes from the very simple to the complex. Electrical safety procedures emphasize the need for controlling breakers from a remote location or control station to keep electricians, operators, and maintenance personnel away from potential arc flash hazards. The need for continuity of service drives designs with multiple sources and automatic transfers to ensure loads remain energized from any available sources.

Switchgear lineups with multiple sources, either doubleended with two utility-fed transformers or a single utility with an emergency generator can be controlled so that a loss of one utility source will cause the main, tie, or generator breakers to open and close, maintaining power to the switchgear buses. Automatic breaker transfer schemes (auto-transfer) can be implemented with discrete relays and hard wiring between source and tie breakers or with programmable logic controllers (PLC) for more complex control sequences. While no single standard auto-transfer scheme will meet all customer needs, the AKD-20 switchgear and EntelliGuard G breakers provide flexible equipment configurations, sensing, and controls for almost any requirement. The basic set of components supplied with any auto-transfer scheme include:

- Electrically operated breakers;
- Voltage sensing on the source breakers;
- Lockout for overcurrent trips;
- Breaker position switches;
- Timers;
- An Auto/Manual control selector switch.

Depending on the specific application, additional components may be supplied for bus voltage sensing, synchronism check, generator start/stop signals, open or closed transition return to normal, test switches, and maintenance transfer selector switches.

As a starting point for sequences of operation and typical bills of material, consider 3-breaker (Main-Tie-Main) and 2- breaker (Main-Generator) auto-transfer schemes. Following are descriptions of the 3-breaker and 2-breaker automatic transfer schemes, including basic bills of material, transfer scheme options, sequences of operation, and single-line diagrams.

Main-tie-main (3-breaker) auto-transfer (Figure 3-3)

Basic bill of material:

- Electrically operated main and tie breakers with bell alarm/lockout, drawout position switch, breaker control switch, and indicating lights;
- Line-side voltage transformers on each main breaker;
- Voltage sensing relays on each main breaker – (1) three-phase voltage sensing relay, Device 27, and (1) phase loss/phase unbalance relay, Device 47N – all DIN rail mounted;
- Auto/Manual selector switch, Device 43;
- Electrical interlocking (hardwired) between main and tie breakers – with and without PLC control;
- Delayed auto-return to normal after utility voltage source returns with open transition (break-beforemake);
- Options for the basic auto-transfer scheme:
  - Manual transfer (return) to normal with open transition (break-before-make);
  - Delayed auto-return to normal with closed transition (make-before-break) and sync check relay, Device 25;
  - Bus-connected voltage transformers for residual voltage sensing;
  - Test switch to simulate loss of utility voltage;
  - Maintenance transfer trip selector switch (Device 10) to select breaker to trip when all 3 main and tie breakers are closed (system paralleled).

Additional bill of material for PLC/non-PLC control:

- Non-PLC-based transfer;
  - Auxiliary relays for voltage sensing (one per voltage relay), Device 27/47X;
  - Auxiliary relays for bell alarm (one per main and tie breaker), Device 86X;
  - Timers and auxiliary relays for delay on transfer, delay on return, Device 2, 62;
  - Auxiliary relay for sync check relay (when closed transition is required and sync check relay is provided), Device 25X;
- PLC-based transfer using intelligent platforms of PLC with non-volatile memory (NVM) and backup UPS;
  - Interposing close and trip relays for main and tie breakers (two per main and tie breaker), Device 94, 95;
  - Auxiliary relays for bell alarm (one per main and tie breaker), Device 86X;
  - Auxiliary relay for sync check relay (when closed transition is required and sync check relay is provided), Device 25X;
  - PLC alarm relay, Device 74;
- Option for PLC-based transfer;
  - Touch-screen interface for timer adjustment and system feedback.

Main-tie-main plc auto-transfer sequence of operations

1. Each utility has 3-phase undervoltage sensing and phase loss protection;
2. Closed transition return to normal (option) includes synchronism check relay;
3. PLC includes UPS for back-up control power for CPU and I/O;
4. Auto-transfer blocked when any main or bus tie breaker trips on overcurrent (overload, short circuit, ground fault) or when any main or bus tie breaker is racked out of the CONNECT position;
5. Hardwired electrical interlocking between main and bus tie breakers to prevent parallel operation (only 2 of 3 breakers can be closed at any time - standard), unless permitted by sync check relay (optional);
6. Return to normal (both mains closed, bus tie open) after a transfer and utility voltage has been restored will be automatic with time delay and open transition (break-before-make).

Initial Setup

1. Set Auto-Manual switch to Manual position;
2. Close Main1;
3. Close Main2;
4. Bus Tie remains open;
5. Set Auto-Manual switch to Auto position.

Loss of Utility1

1. After preset time delay, verify Utility2 is available;
2. Main1 will open;
3. Bus Tie will close.

Return of Utility1

1. After preset time delay, verify Utility1 is available;
2. Bus Tie will open;
3. Main1 will close (break-before-make).

Loss of Utility2

1. After preset time delay, verify Utility1 is available;
2. Main2 will open;
3. Bus Tie will close.

Return of Utility2

1. After preset time delay, verify Utility2 is available;
2. Bus Tie will open;
3. Main2 will close (break-before-make).

Option for closed transition return to normal (Make- before-break)

Return of Utility1
1. After preset time delay, verify Utility1 is available;
2. Verify Utility1 and Utility2 are in sync;
3. Close Main1;
4. After preset time delay Bus Tie will open (make-beforebreak).

Return of Utility2
1. After preset time delay, verify Utility2 is available;
2. Verify Utility1 and Utility2 are in sync;
3. Close Main2;
4. After preset time delay Bus Tie will open (make-beforebreak).

Option for closed transition maintenance transfer (Make-before-break)
In this configuration, Main1 and Main2 are closed, while the Bus Tie is open.

Transfer all loads to main1 (Bus1 and Bus2) without deenergizingload (bumpless transfer)
1. Set Trip Selector switch to Trip Main2;
2. Verify Utility1 and Utility2 are in synchronism;
3. Close Bus Tie;
4. After preset time delay, Main2 will open, transferring all loads to Main1 (Bus1 and Bus2).

Return loads to each bus
1. Set Trip Selector switch to Trip Bus Tie;
2. Verify Utility1 and Utility2 are in synchronism;
3. Close Main2;
4. After preset time delay, Bus Tie will open, transferring Bus2 loads back to Main2.

Transfer all loads to main2 (Bus1 and Bus2) without deenergizing load (bumpless transfer)
1. Set Trip Selector switch to Trip Main1;
2. Verify Utility1 and Utility2 are in synchronism;
3. Close Bus Tie;
4. After preset time delay, Main1 will open, transferring all loads to Main2 (Bus1 and Bus 2).

Return loads to each bus
1. Set Trip Selector switch to Trip Bus Tie;
2. Verify Utility1 and Utility2 are in synchronism.
3. Close Main1;
4. After preset time delay, Bus Tie will open, transferring Bus1 loads back to Main1.

Option for test switch to simulate utility failure
In this configuration, Main1 and Main2 are closed, and the Bus Tie open.
1. Transfer to Side2 – Simulates loss of Utility1 and executes automatic transfer as described in Loss of Utility1;
2. Normal – Returns Main1, Main2, and Bus Tie breakers to their normal position based on Open or Close Transition options;
3. Transfer to Side1 – Simulates loss of Utility2 and executes automatic transfer as described in Loss of Utility2.

Option for redundant bus tie breaker (Main-tie-tie-main, Figure 3.4)
1. Redundant bus tie breaker is normally closed and not operated by the PLC;
2. Drawout position switch and bell alarm are provided for inputs to PLC;
3. If redundant bus tie breaker is racked out of the CONNECT position or trips on overcurrent, then the auto transfer will be disabled.

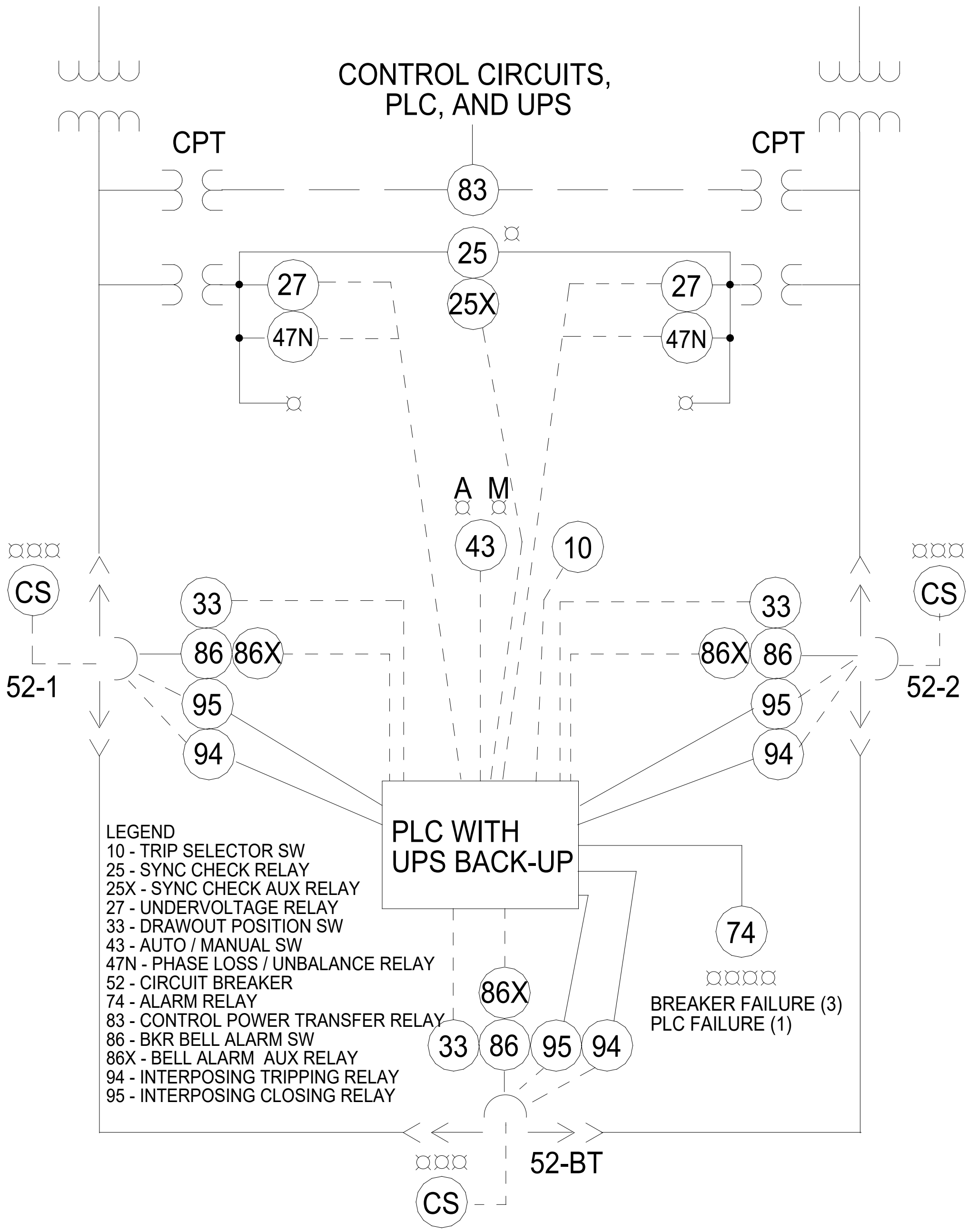

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Figure 3.3: Main-tie-main example single-line diagram

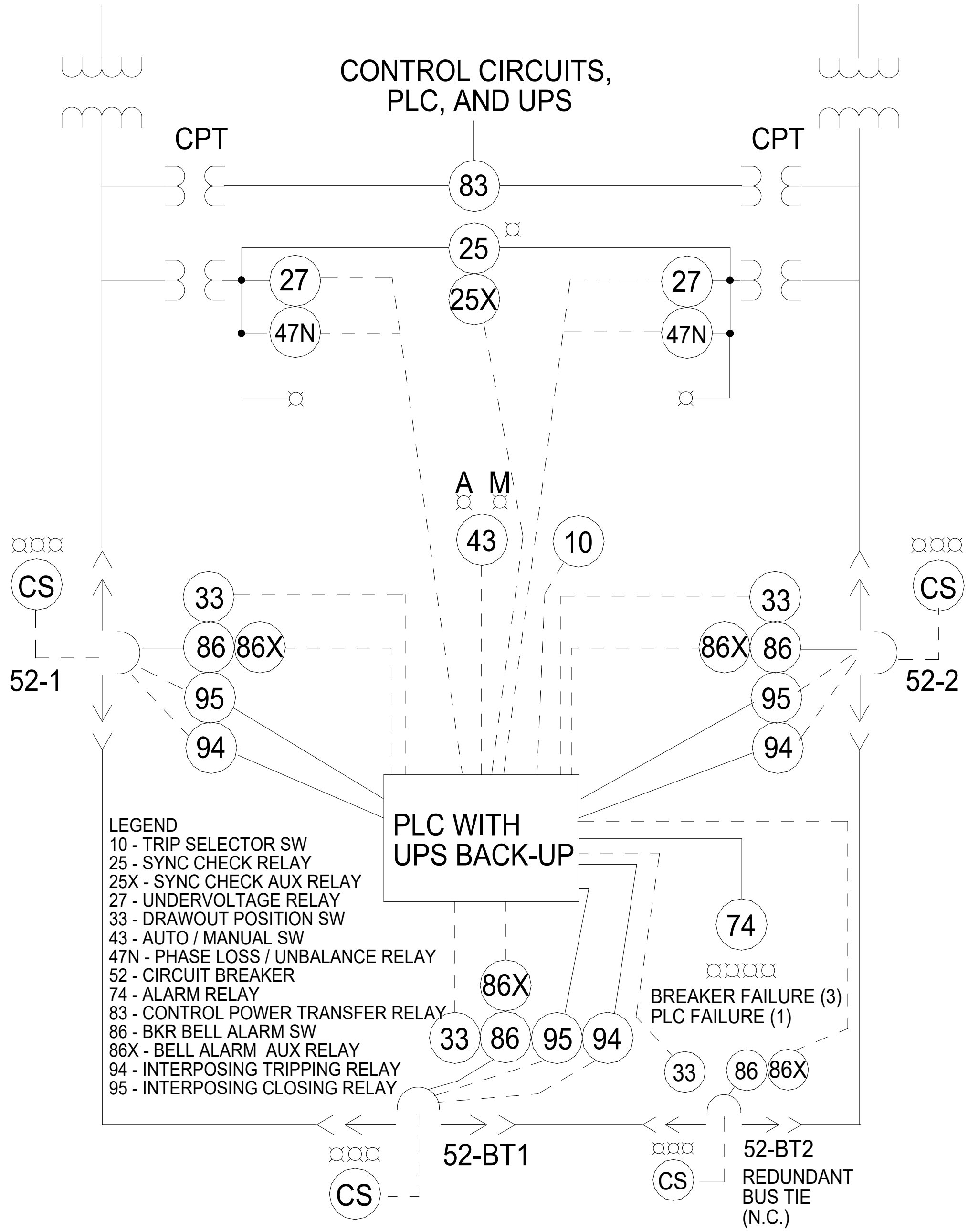

Figure 3.4: Main-tie-tie-main example single-line diagram

Main-generator (2-breaker) auto-transfer (Figure 3-5)

Basic bill of material:

- Electrically operated main and generator breakers with bell alarm/lockout, drawout position switch, breaker control switch, and indicating lights;
- Line-side voltage transformers on the main and generator breaker;
- Voltage sensing relays on the main breaker – (1) threephase voltage sensing relay, Device 27, and (1) phase loss/phase unbalance relay, Device 47N – all DIN rail mounted;
- Voltage and frequency sensing relays on the generator breaker – (1) three-phase voltage sensing relay, Device 27, and (1) single-phase over-/underfrequency relay, Device 81O/U – all DIN rail mounted;
- Auto/Manual selector switch, Device 43
- Electrical interlocking (hardwired) between main and generator breakers – with and without PLC control;
- Delayed auto-return to normal with open transition (break-before-make);
- Generator start/stop signal;
- Options for the basic auto transfer scheme:
  - Manual transfer (return) to normal after utility voltage source returns;
  - Delayed auto-return to normal with closed transition (make-before-break) and sync check relay;
  - Bus-connected voltage transformers for residual voltage sensing;
  - Test switch to simulate loss of utility voltage for generator no-load (start/stop) or full load test (autotransfer).

Bill of material for PLC/non-PLC control

- Non-PLC-based transfer;
  - Auxiliary relays for voltage and frequency sensing (one per voltage relay), Device 27/47X, 27/81X;
  - Auxiliary relays for bell alarm (one per main and generator breaker), Device 86X;
  - Timer and auxiliary relay for delay on transfer, delay on return, Device 2, 62;
  - Auxiliary relay for sync check relay (when closed transition is required and sync check relay is provided), Device 25X
- PLC-based transfer using intelligent platforms of PLC with non-volatile memory (NVM) and backup UPS;
  - Interposing close and trip relays for main and;
  - generator breakers (two per main and generator breaker), Device 94, 95;
  - Auxiliary relays for bell alarm (one per main and generator breaker), Device 86X;
  - Auxiliary relay for sync check relay (when closed transition is required and sync check relay is provided), Device 25X;
  - PLC alarm relay, Device 74;
- Option for PLC-based transfer;
  - Touchscreen interface for timer adjustment and system feedback.

Main-generator PLC auto transfer sequence of operations

1. Utility source has 3-phase undervoltage sensing and phase loss protection;
2. Generator source has 3-phase voltage sensing and single-phase frequency sensing;
3. Closed transition return to normal (option) includes synchronism check relay;
4. PLC includes UPS for backup control power for CPU and I/O;
5. Auto-transfer blocked when main or generator breaker trips on overcurrent (overload, short circuit, ground fault) or when main or generator breaker is racked out of the CONNECT position;
6. Hardwired electrical interlocking between main and generator breakers to prevent parallel operation (only 1 of 2 breakers can be closed at any time - standard), unless permitted by sync check relay (optional);
7. Return to normal (main breaker closed, generator breaker open) after a transfer and utility voltage has been restored will be automatic with time delay and open transition (break-before-make).

Initial Setup

1. Set Auto-Manual switch to Manual position;
2. Close Utility main breaker (52U);
3. Generator breaker (52G) remains open;
4. Set Auto-Manual switch to Auto position.

Loss of Utility

1. After preset time delay, send start signal to generator;
2. Check for proper voltage and frequency from generator source;
3. After preset time delay with proper voltage and frequency, 52U will open and 52G will close.

Return of Utility

1. Verify utility source is available for preset time delay;
2. 52G will open;
3. After preset time delay, 52U will close (break-beforemake);
4. Remove generator start signal.

Option for closed transition return to normal (Make- before-break)

Return of Utility

1. Verify utility source is available for preset time delay;
2. Verify utility source and generator source are synchronized;
3. 52U will close;
4. After preset time delay, 52G will open (make-beforebreak);
5. Remove generator start signal.

Option for test switch to simulate utility failure

In this configuration, 52U is closed and 52G is open.

1. No Load Test – Sends generator start signal;
2. Normal – Returns 52U and 52G breakers to their normal position based on Open or Close Transition options and removes generator start signal;
3. Full Load Test – Simulates loss of utility source and executes automatic transfer as described in Loss of Utility.

Option for generator cooldown

1. Apply preset time delay after 52G opens before generator start signal is removed.

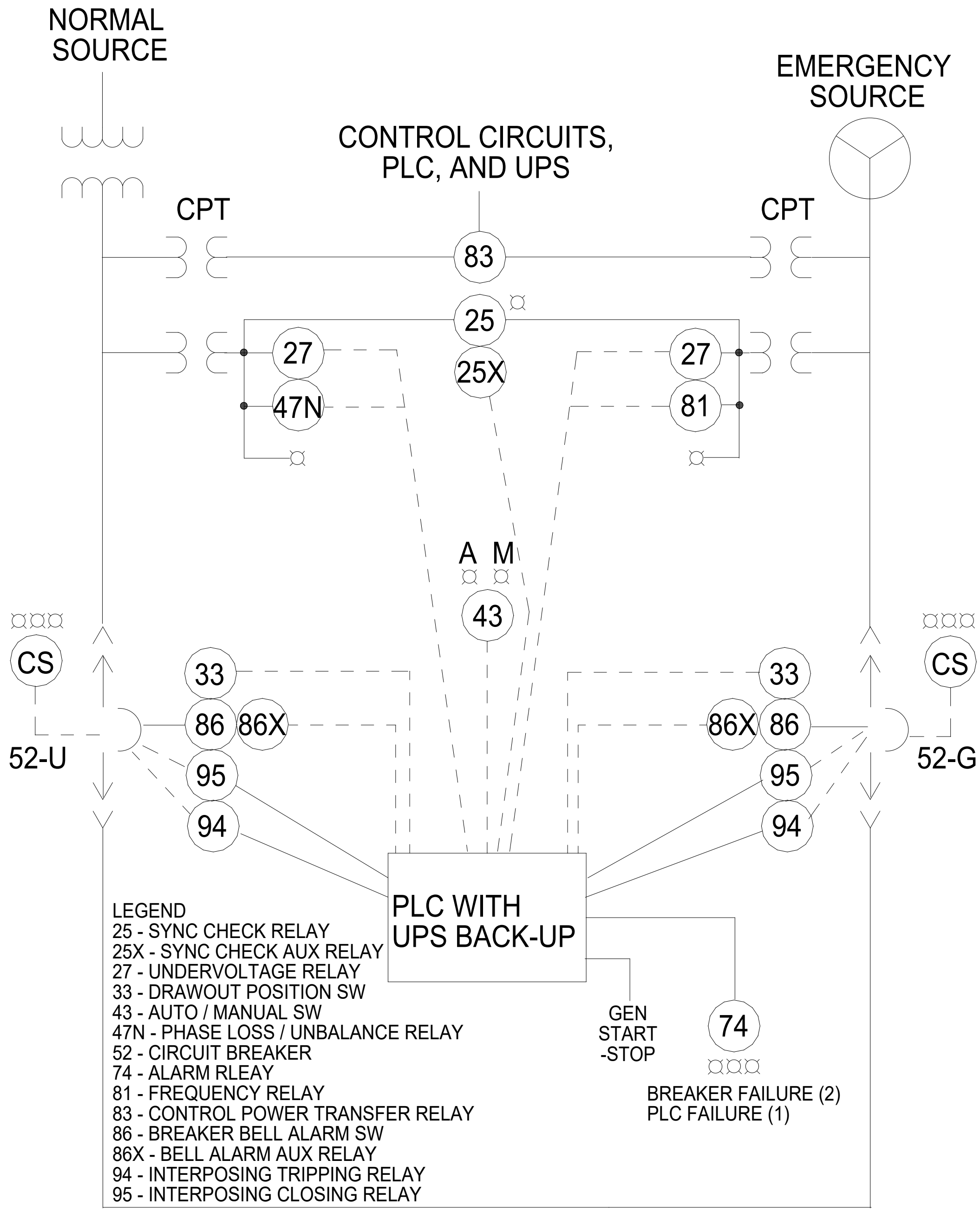

Figure 3-5: Main-Generator example single-line diagram

AKD-20 switchgear has numerous standard and optional features that can aid in reducing the energy associated with an arc flash or help mitigate the probability of an arc flash incident. Power system design, equipment design, operating procedures, electronics and communications, and new technologies can all be used to address the safety concerns associated with arc flash and shock. It may help if one considers mitigation of the hazards associated with electrical equipment from three perspectives:

- Exposure;
- Probability of an incident during exposure;
- The potential severity of an incident, should it occur.

Power system design

High resistance grounding (HRG) – limits ground fault current to a detectable level (approximately 5 amperes) while minimizing the possibility of the ground fault escalating to a serious phase to phase arcing fault. The neutral grounding resistor and sensing equipment can be located in the low voltage switchgear, and a pulsing circuit can be added to aid in determining the faulted feeder. HRG is widely considered to minimize the probability of serious faults.

Medium voltage interrupter – use of a circuit breaker or other controllable device that can be tripped in the event of an arcing fault between the transformer secondary terminals and the main secondary breaker. Relays, such as the Multilin F35, F60, T60 (and others), may be used for transformer primary and secondary protection and can accept inputs from CTs located on the transformer secondary. Implemented with Zone Selective Interlock signals from the low voltage trip unit, such a system can provide full selectivity and instant – or near-instant – protection, and arc flash protection for the conductors between the transformer secondary bushings and the main secondary breaker.

This type of protection can reduce the severity of an incident on the primary connections of the equipment or main bus if no secondary main is used.

Switchgear equipment design

Insulated/isolated bus – provides an epoxy coating on the horizontal main bus bars and phase isolation barriers in the vertical bus. The vertical bus system is enclosed with polyester-glass barriers. Bolted bus joints are enclosed with removable bus joint covers. Only cable or busway terminations are visible from the rear of the equipment.

The insulated/isolated bus option is available in sections with 800 A to 3200 A breakers (Envelopes 1 and 2) with main bus ratings up to, and including, 4000 A.

Bus compartment barriers – bus ratings above 4000 A and sections containing 3200 A to 6000 A (Envelope 3) breakers, can be supplied with bus compartment barriers. These polyester-glass barriers are attached to the switchgear frame and provide a separation between the bus compartment (horizontal and vertical buses) and the cable compartment.

As in the insulated/isolated bus option, the only exposed conductors in breaker sections are cable and busway terminations.

Section barriers – provide a combination of steel and polyester-glass barriers between vertical sections in the cable and bus area. Section barriers limit exposure to terminations in adjacent sections when performing maintenance or trouble-shooting work in the rear of a breaker section. Section barriers are particularly important between the section where a main circuit breaker is housed and sections where feeders are housed to ensure that arc plasma on the main bus does not create an arc on the line side of the main circuit breaker where protection may be much slower.

Shutters – provided as standard on source (main or generator) and tie breakers in multisource switchgear lineups. Shutters operate when the breaker is racked into or out of the cubicle. When the breaker is in the DISCONNECT or WITHDRAWN position, the shutters are closed over the primary disconnects. A padlocking feature allows the shutters to be locked in the closed position when the breaker is out of the cubicle. Optionally, shutters may be supplied on all breakers in the switchgear lineup. Shutters are strongly recommended on all circuit breaker cubicles.

IR windows – may be supplied on the rear doors of the switchgear for IR camera access. Thermal imaging cable terminations in the rear of each switchgear section do not require opening the rear door when the IR windows are supplied. IR windows are strongly recommended to minimize exposure during IR surveys of cable connections.

Operating the switchgear

Remote control and monitoring – moving operators away from the switchgear to perform monitoring or control functions. Specifying breakers with electric operators (E/O) and shunt trip allows the breaker to be controlled from a location outside the arc flash and arc blast boundaries.

Trip units specified with communication capability (Modbus or Profibus) can provide information about the circuit (metering data) and the circuit breaker (event information, open/close status, trip unit settings) from a safe location away from the front of the switchgear. A touchscreen monitor can be supplied in a switchgear auxiliary compartment or mounted on a wall and provide convenient single-point access to trip unit information for all breakers in the lineup without approaching each individual breaker cubicle.

Remote racking – inserting and withdrawing the circuit breaker from outside the arc flash boundary. After the circuit breaker has been opened via the remote control station and shunt trip on the breaker, the operator can attach the remote racking device to the front of the breaker cubicle. The operator then steps back, up to 30 feet away, from the front of the breaker, sets the controls on the remote racking controller, and proceeds to remotely draw out the breaker from the CONNECT position to the DISCONNECT position.

After the breaker has been removed from the cubicle and any maintenance performed on the breaker, the remote racking device can again be used to remotely rack the breaker back into the CONNECT position. After removing the remote racking device from the front of the breaker cubicle, the operator returns to the remote control station and closes the breaker – from a distance outside the flash and blast boundaries.

Trip unit electronics

Advances in trip unit technology have made it possible to provide enhanced protection while maintaining the selective tripping functions that switchgear has always been able to provide.

Zone-selective interlocking (ZSI) – digital communication between tiers of circuit breakers to provide increased protection while maintaining selectivity. ZSI allows individual time-delay settings for short time and/or ground fault for “in-zone” and “out-of-zone” faults. An in-zone fault would allow an “unrestrained” (faster) time delay for the upstream (main) breaker, providing better protection for equipment in the zone. An out-of-zone fault would allow the main breaker to operate with a “restrained” (slower) time delay, providing selectivity with the feeder breaker. The feeder breaker initiates the zone selective interlock signal for the out-of-zone fault and clears the fault with minimal service interruption.

ZSI can also be executed with breakers in switchboards or motor control centers, improving protection and selectivity for equipment located downstream of the switchgear.

A further enhancement to ZSI is the addition of Instantaneous ZSI, or I-ZSI, to the breaker trip units. I-ZSI allows an upstream breaker (a main breaker, for example) to trip instantaneously for a fault on the switchgear bus or in a breaker cubicle instead of with a delayed long time or short time trip. This provides vastly improved equipment protection by making the main breaker more sensitive to arcing faults, lowering incident energy levels by tripping the main breaker instantaneously while maintaining selectivity with feeder breakers, on a 7x24 basis. DET-760 (Guide to Instantaneous Selectivity) describes ABB instantaneous selective circuit breaker offering. Using this guide, it is possible to design a power distribution system, rated up to 100kA at 480 V that is 100% selective and provides 100% instantaneous protection at arcing current levels, 7x24. Using MV relays such as Multilin F35, F60, or T60, selective instantaneous protection can be extended to the first MV CB ahead of the substations transformer for 100% selective instantaneous protection of your substation, motor control centers, and panels.

Reduced energy let-through (RELT) – provides a separate, adjustable instantaneous trip function that is enabled by an external Modbus command or remote dry contact. RELT instantaneous trip can be enabled whenever an operator must approach the switchgear or any downstream equipment. RELT on the main breaker provides instantaneous overcurrent protection for the switchgear. RELT on a feeder breaker provides instantaneous overcurrent protection for downstream equipment connected to the feeder. The RELT instantaneous function is ½ cycle faster than the normal instantaneous function and can be adjusted as low as 1.5X of the trip unit rating plug. RELT can affect selectivity so it is normally used only during times when an operator must be in the arc flash boundary.

New technologies

Arc vault – a remotely activated system that, when triggered by current and voltage signals, will create a secondary arc fault within a containment dome to divert the energy from the arc flash and provide a trip signal to an upstream breaker to clear the fault. The secondary arc fault in the containment dome has a lower impedance than the arcing fault and is therefore able to extinguish the arc fault within 7 msec of the initial event.

When applied to a 480 Volt system with 65 kA available fault current, the Arc Vault is able to reduce incident energy from the arc event to less than 1.2 cal/cm2 (IEEE 1584, 18 inch working distance), even with the breaker cubicle door open. The Arc Vault section is connected to the protected switchgear lineup via a 2000 A cable connection and can be located up to 50 feet (maximum total cable length) from the switchgear.

Arc flash relay – For applications of Arc Flash systems by ABB or other manufacturers, contact your ABB Application Engineer.

Entellisys switchgear

We invite you to explore the world of Entellisys low voltage switchgear. Entellisys is a protection and control system that is integrated into the basic AKD-20 structure. In addition to the rugged and time-tested construction of AKD-20, Entellisys low voltage switchgear is the first system to provide the power of knowledge about the entire switchgear lineup. This knowledge can be used by the engineer to improve protection, by the installing contractor to shorten installation time, by the operator to stay out of the arc flash zone, by the maintenance personnel to save maintenance time and money, and by the owner to adapt the equipment to the dynamic needs of the facility. Entellisys helps to reduce costs, shorten schedules, and increase reliability throughout the process of designing, installing, maintaining, and owning your low voltage power distribution switchgear. Figure 4.1 shows the Entellisys architecture.

Arc flash mitigation

Easy to add or modify functionality
Information that can impact the power system design is constantly changing. Entellisys' firmware-based architecture makes it easy for the engineer to modify functionality during almost any portion of the design and build phase without impacting the schedule. This translates to dollars saved. A change in options can be made easily with updated software. And, this flexibility is inherent over the lifetime of the equipment, allowing the owner to continue to meet the changing needs of the facility over time.

Finally, a holistic approach to low voltage switchgear dynamics
Traditional switchgear trip systems can react only to what they know – the current magnitude and time for one particular circuit. Entellisys is the first circuit-protection technology that overcomes this limitation.

The Entellisys "Single Processor Concept" bases control of every circuit breaker in the switchgear upon what is best for the entire lineup under the exact conditions in the system at that moment. With Entellisys, each circuit breaker is controlled with full information about every current, voltage, and circuit breaker in the switchgear.

Don't trade selectivity for protection
Entellisys knows the magnitude and the location of a fault. As a result, when Zone Selective Interlocking and Bus Differential are applied, you achieve both fast protection (detection as fast as 0.25 ms) and selectivity. You can now have the best of both worlds: fast protection while minimizing outage potential.

Installation and startup

Fast installation
Entellisys-streamlined architecture minimizes wiring and shipping split terminations by reducing the amount of wiring in equipment – in some cases up to 70 %. Consequently, it is efficient and fast to install the Entellisys equipment.

Faster startup using diagnostics for troubleshooting
The sequence of event logs in Entellisys provides a detailed history of the system dynamics with a resolution of 0.5 ms. Instead of guessing at what might be occurring, personnel can quickly discern exactly what is happening and quickly remedy the situation.

Streamlined interface to communication systems
Traditional switchgear using discrete devices forces the integrator to interface with many devices within each switchgear lineup. Entellisys streamlines the integration process in a number of ways. Only one interface is required for the entire lineup. That means, instead of interfaces for each type of devices, one interface to the Modbus register map provides access to thousands of registers for data collection as well as control.

System Operation

Increased reliability

Since power distribution systems provide continuity of service, Entellisys architecture provides increased reliability when compared to traditional switchgear.

Traditional switchgear has many devices for monitoring, protection, and control over miles of wire. Entellisys has one set of hardware to provide the entire range of possible needed functionality. This simplicity (fewer components, less wiring) increases reliability. Traditional switchgear almost always has a single level of device functionality. Entellisys features redundant central processing units, communication buses, and UPSs as standard.

Traditional switchgear doesn't necessarily know that a function is not working until it is called upon to act. Entellisys is continuously monitoring the health of the system components and, should something not be functioning properly, the instance is identified by the system health screen, the event log, or can be configured as an alarm. The alarms can be emailed to as many as four addresses, providing immediate feedback that attention is needed.

Increase system availability

What matters to you is that your switchgear is performing as needed providing the protection, monitoring and control for your facility. With the redundant systems and system health monitoring, you are notified should something need to be addressed. Due to the redundant architecture, it is possible to service the system-level devices and maintain service – not something you typically even know about in traditional switchgear, let alone resolve in a nonintrusive manner.

Decrease downtime using low voltage switchgear diagnostics

Power systems are dynamic, and – prior to Entellisys – it was very hard to determine what exactly had occurred during a disturbance. In traditional systems you may have some trip type indication, possibly a waveform on a circuit or two, and some type of time-stamping that may not be synchronized across devices. Entellisys provides a detailed log of all of the system's protection functions (pick-up, drop-out, etc.), as well as detailed fault reports providing the current and voltage for every EntelliGuard E circuit breaker at the time of the event. An industry first, Entellisys' waveform capture records the current and voltage waveforms for every EntelliGuard E circuit breaker, as well as the open and close commands and actions. All of the events, data, and waveforms are synchronized to within 0.5 ms, providing you with a detailed chronological log of system dynamics. This is a powerful tool in determining exactly what occurred during a disturbance. Entellisys also provides various information as well as protective alarm settings to provide warnings of possible unfavorable conditions, allowing you to take action and prevent an outage. There are real-world examples of how Entellisys identified issues that prevented an outage, as well as provided information to root-cause system conditions.

Reduced arc-flash hazard

Entellisys offers advanced protection modes known as zone-based protection, which includes bus differential, dynamic zone-selective interlocking, and multi-source ground fault protection. This protection enables fast (as fast as 25 ms) detection of arcing faults in the equipment while maintaining selectivity. Consequently, the energy letthru from a fault is significantly reduced across the entire range of perspective fault magnitudes. This reduction can mean less cumbersome personal protective equipment (PPE) for the operators, as well as less potential damage to downstream equipment.

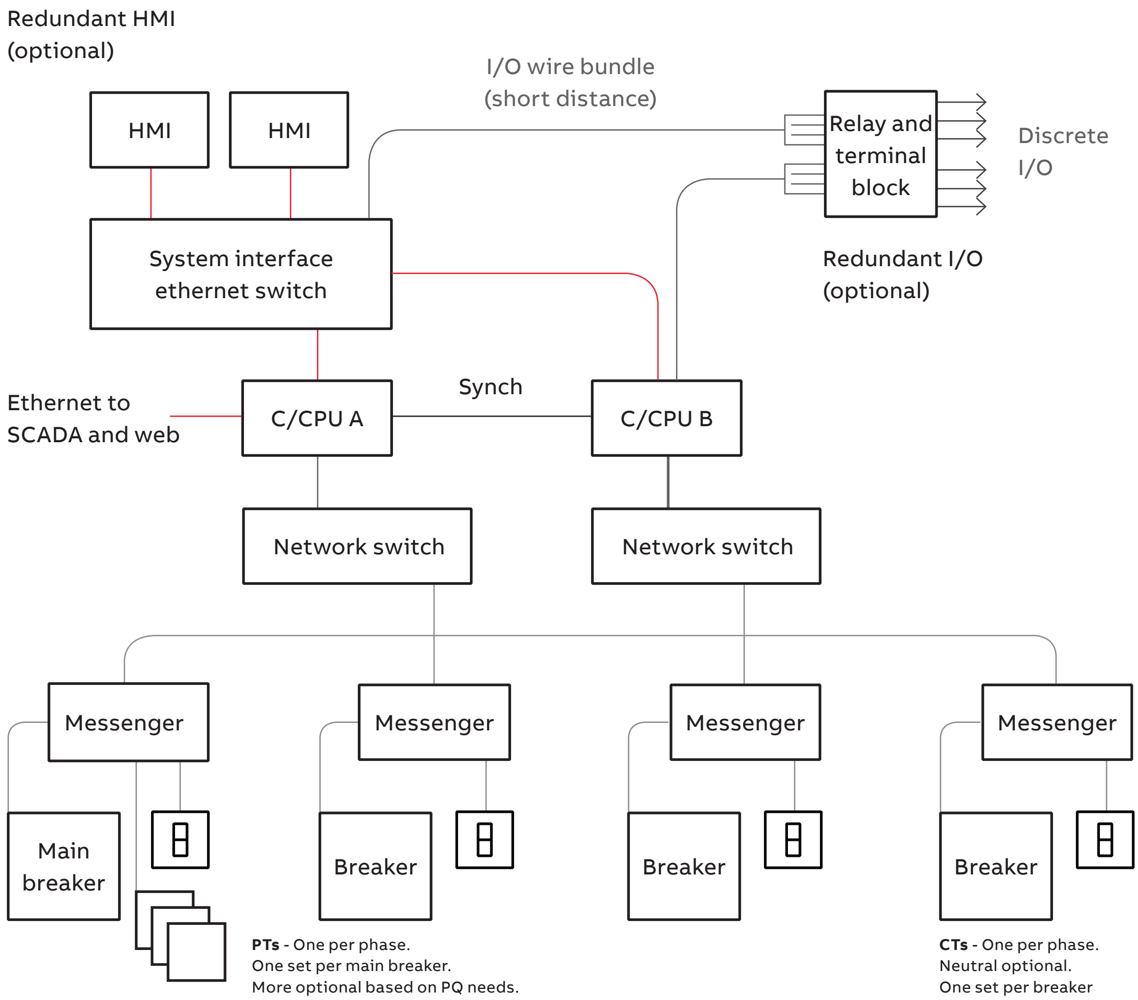

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Figure 4.1: Entellisys architecture overview

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Move operators outside the flash protection boundary
The Control Stack allows for the complete interaction with the Entellisys System. The touchscreen display can be placed outside the Flash Protection Boundary. The operator can fully interact with the Entellisys system, view all parameters, and open and close circuit breakers without being in front of live equipment.

Move operators away from the gear during Rack-in/Rack-out operations
Entellisys' remote racking device eliminates the need for operators to stand in front of a moving circuit breaker during racking-out or racking-in of an EntelliGuard circuit breaker.

Efficient remote communications
Entellisys provides enhanced communication capabilities for the operator. Alarms can be easily configured and can be emailed to up to four different email addresses. Entellisys communicates all status data, alarms, metering, event logs, etc., digitally over Modbus TCP/IP. The amount of information available, all synchronized, is unprecedented.

System operation

Streamlined circuit breaker testing
The Entellisys architecture of circuit hardware (current sensors and messengers) located in the equipment and not on the circuit breaker translates to efficient maintenance procedures for testing. Traditional low voltage power circuit breaker testing requires high-current injection testing. This was a time consuming process, which also increased the probably of damage or an arcing fault due to the movement and handling of the circuit breaker in and out of the gear. Entellisys changes this. The current sensors integrity can be determined by simply reading the metering information on the HMI for each circuit (Figure 4.2). Using the Entellisys test kit, automated or customized test cases are performed with the breaker still in the cubicle. Consequently, EntelliGuard circuit breakers do not require high-current injection testing, saving time and resources while providing comprehensive testing.

Predictive maintenance information
Entellisys provides circuit breaker operating data so you can improve your maintenance timing. For each circuit breaker, Entellisys tracks the number of various types of operations as well as the date of the last circuit breaker operation. Entellisys also calculates the percentage of the total load life that has been used, both mechanically and electrically. Entellisys can activate alarms and associated emails for various stages during mechanical and electrical life. Now you have data to determine the maintenance required instead of just a time-based system.

Entellisys is the preferred solution in critical applications such as medical center, data centers, water/wastewater plants, petrochem facilities, and airports around the world. State-of-the-art protection, monitoring, and control make it the intelligent choice to provide reliable power distribution now and in the future.

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Figure 4.2: Entellisys remote HMI

AKD-20
Sizing and dimensional data

AKD-20 switchgear has numerous standard configurations with and without optional features. Figures 5.1 through 5.11, show the layouts for these configuration arrangements and dimensions.

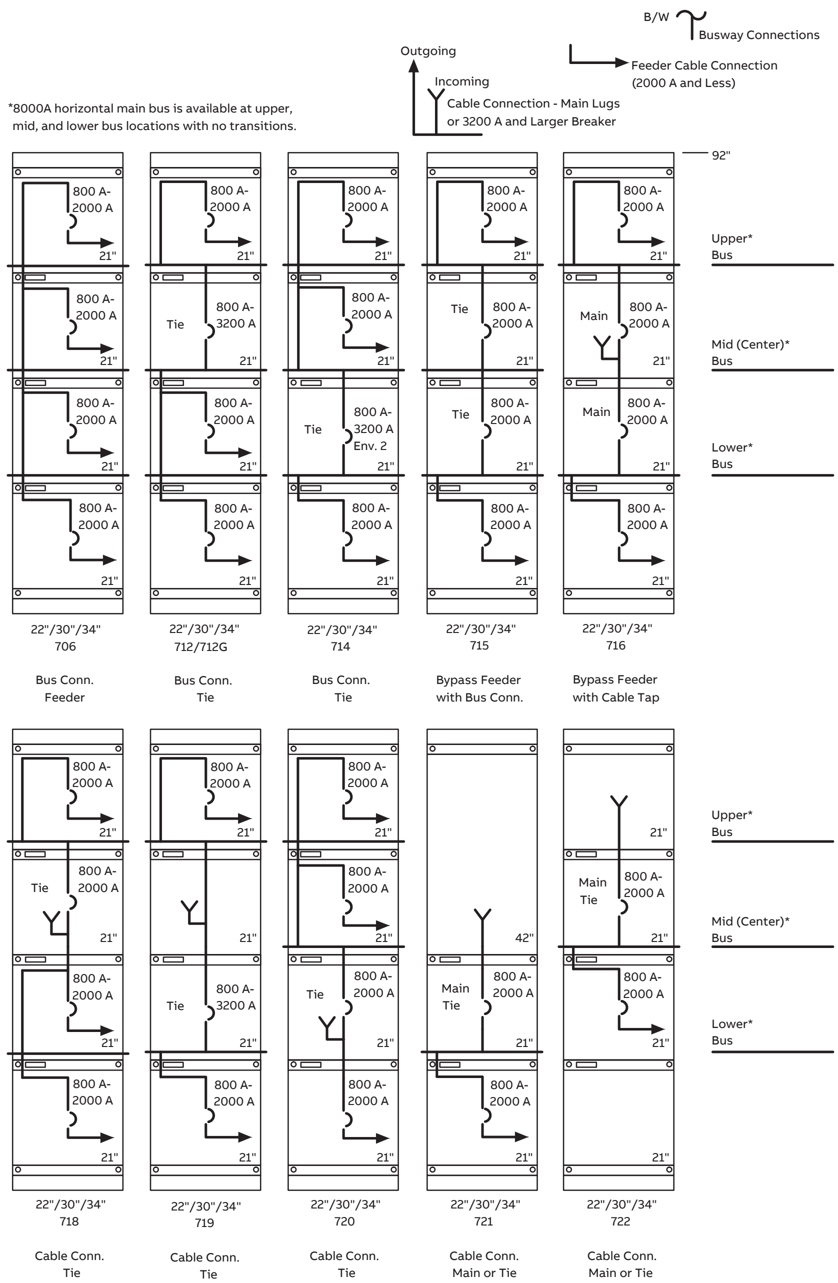

Figure 5.1: Switchgear layout and sizing: 22", 30", and 34" sections

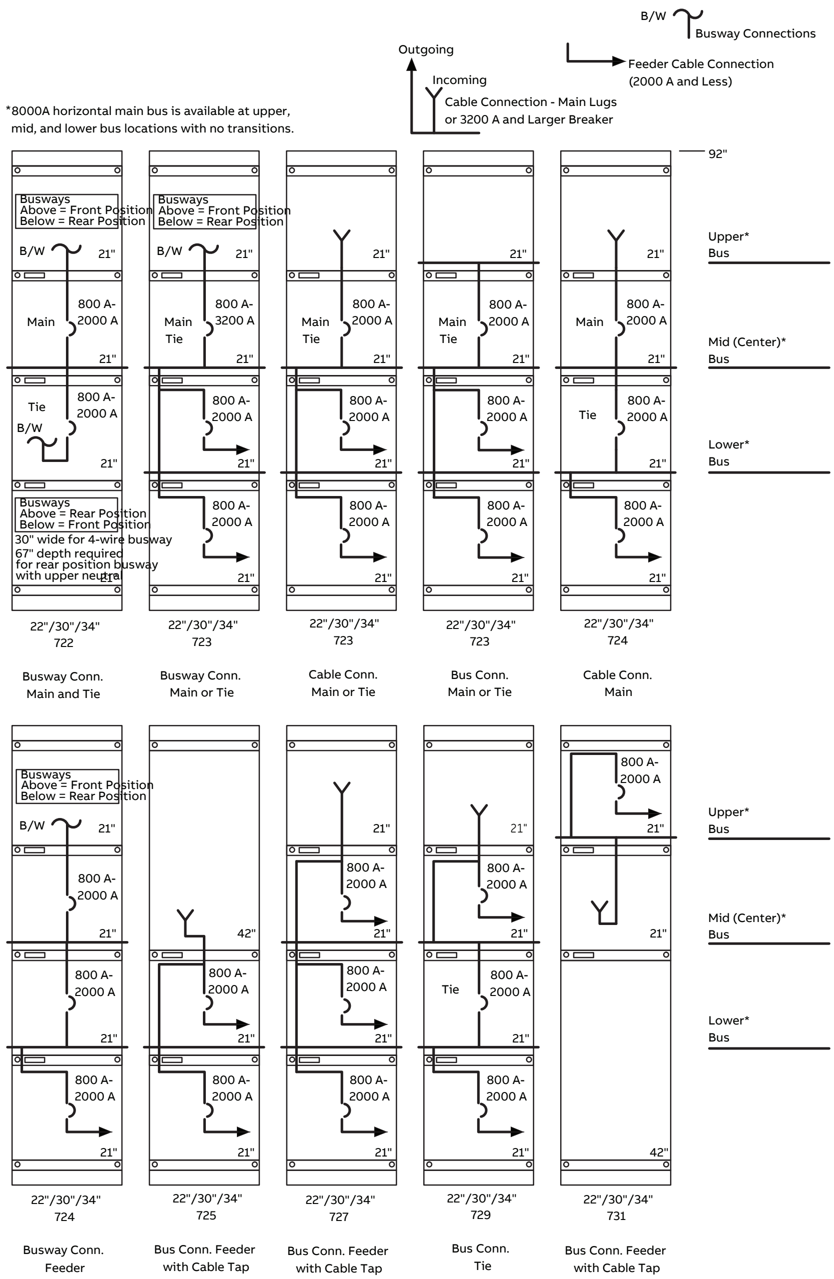

Figure 5.2: Switchgear layout and sizing: 22", 30", and 34" sections

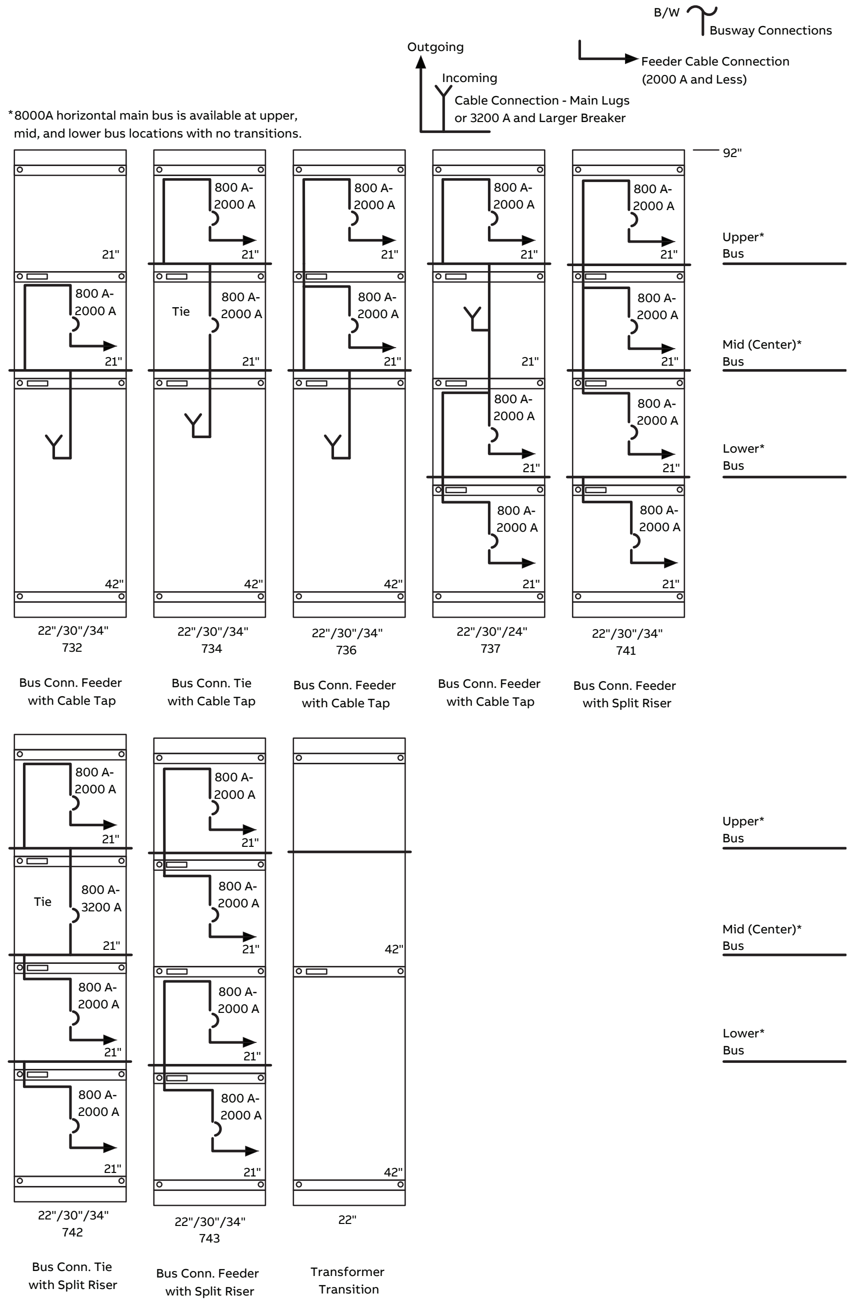

Figure 5.3: Switchgear layout and sizing: 22”, 30”, and 34” sections

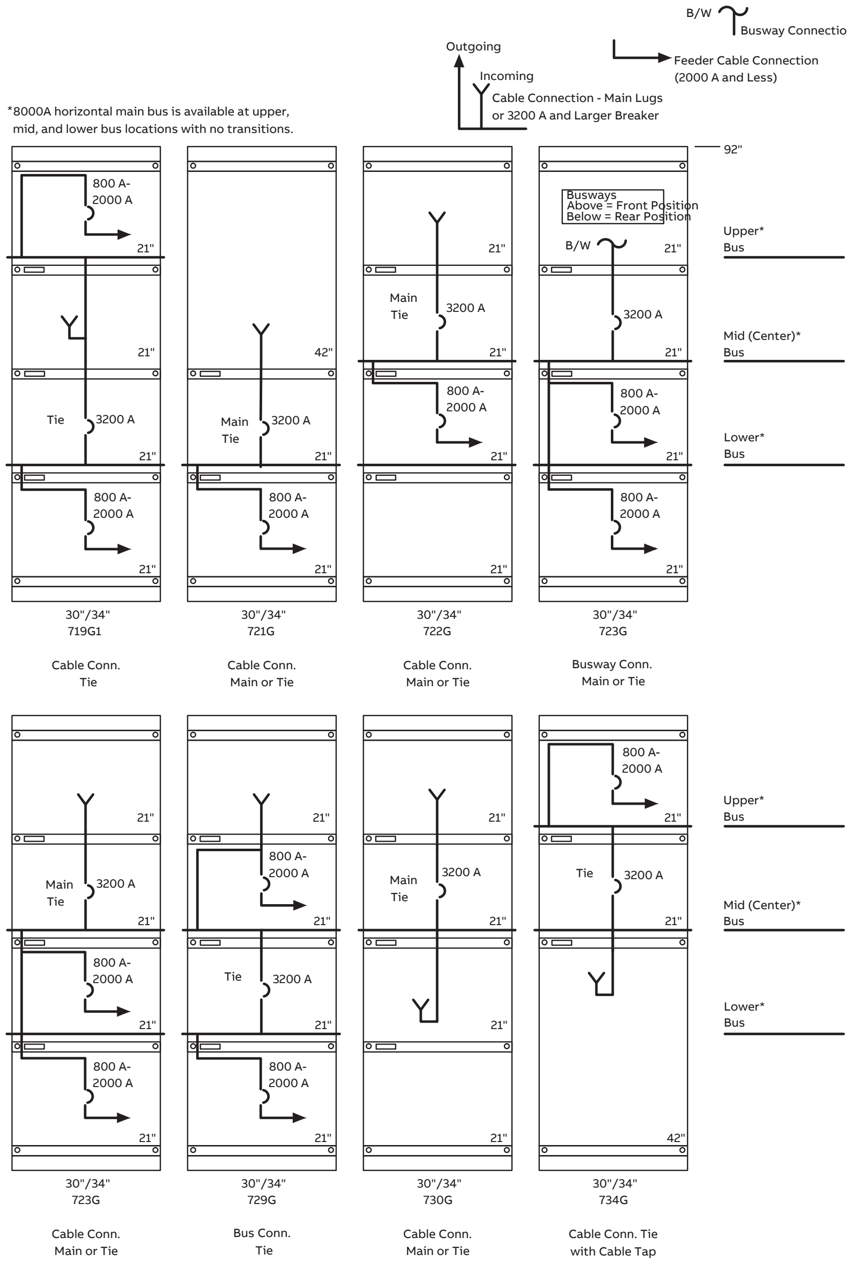

Figure 5.4: Switchgear layout and sizing: 30” and 34” sections

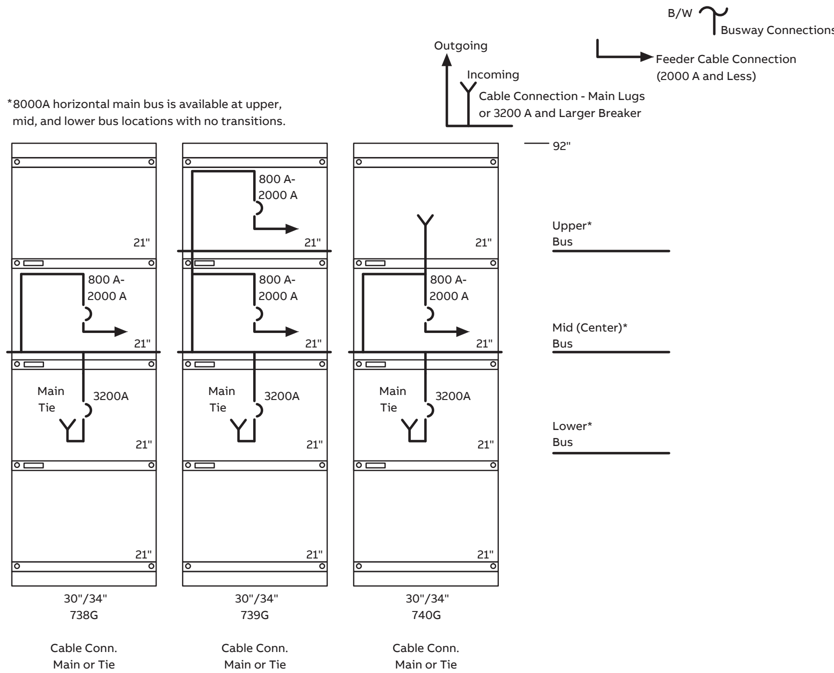

Figure 5.5: Switchgear layout and sizing: 30” and 34” sections

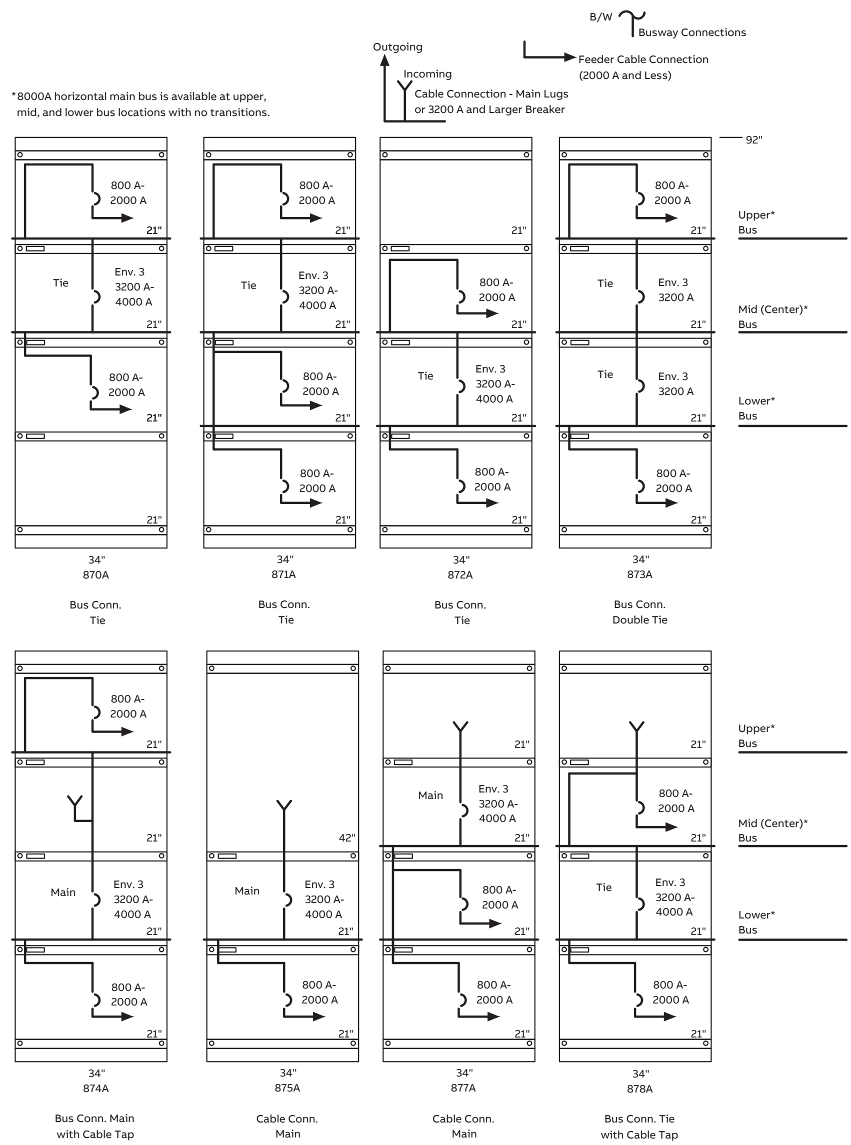

Figure 5.6: Switchgear layout and sizing: 34” sections

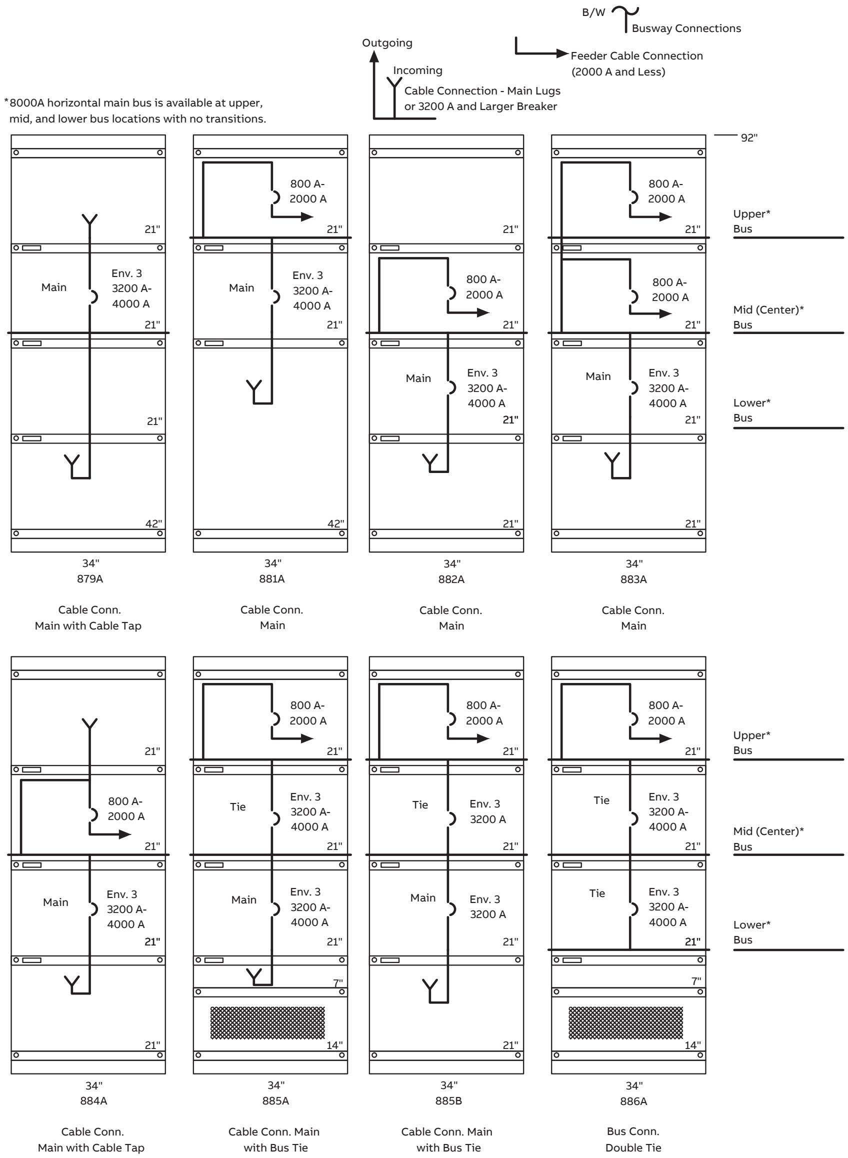

Figure 5.7: Switchgear layout and sizing: 34” sections

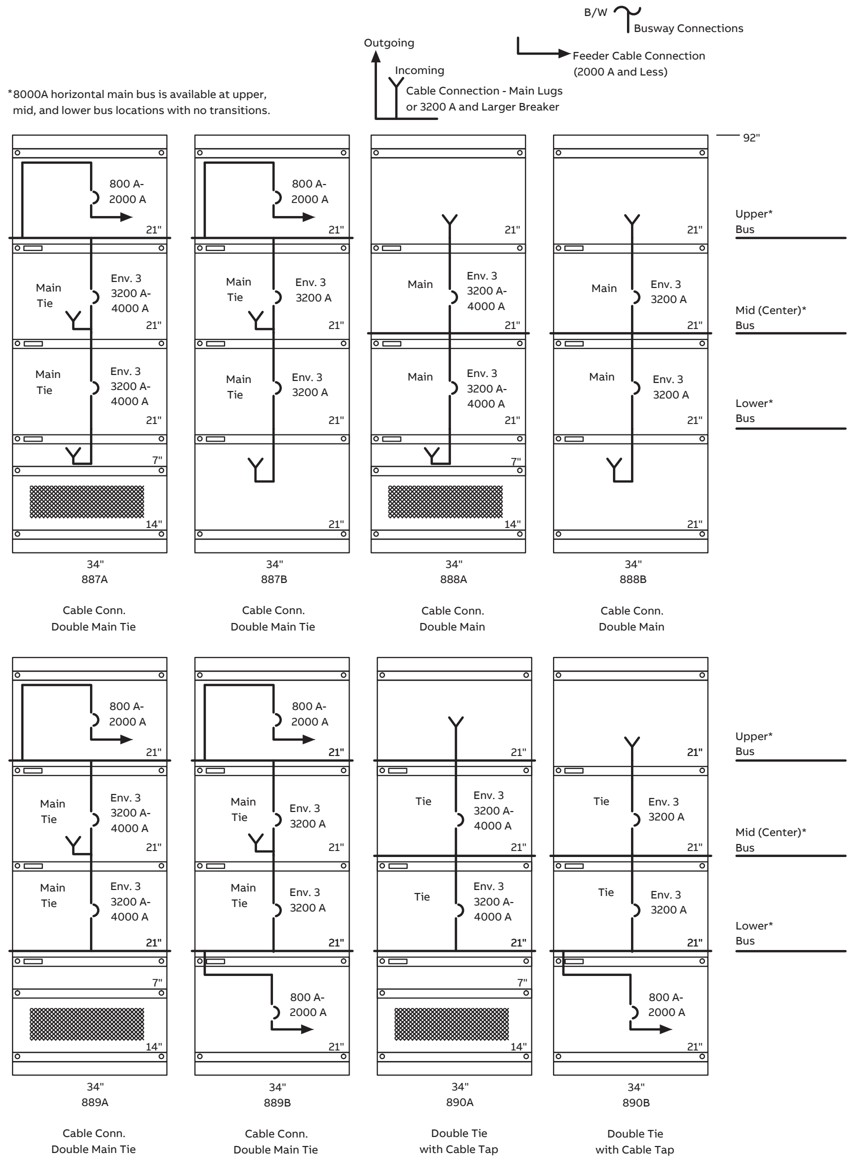

Figure 5.8: Switchgear layout and sizing: 34” sections

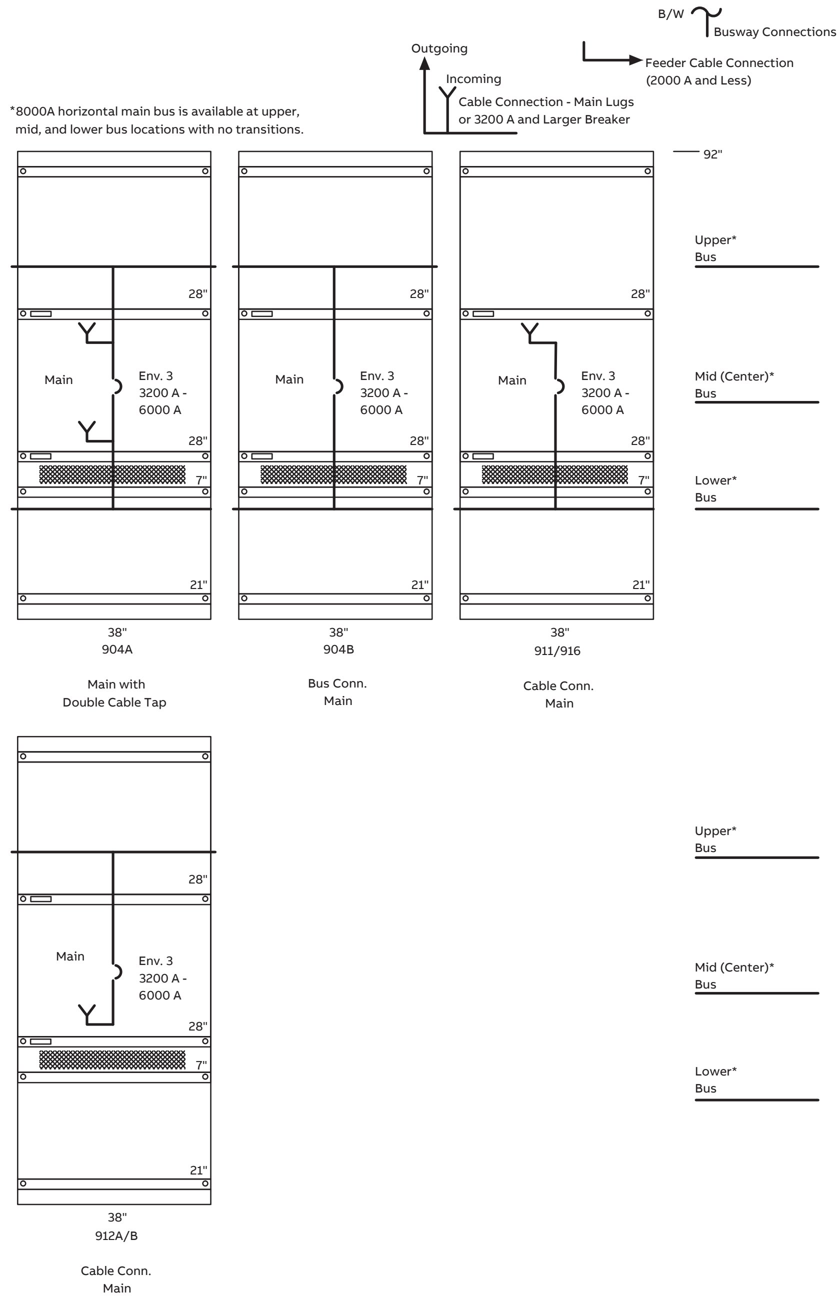

Figure 5.9: Switchgear layout and sizing: 38” sections

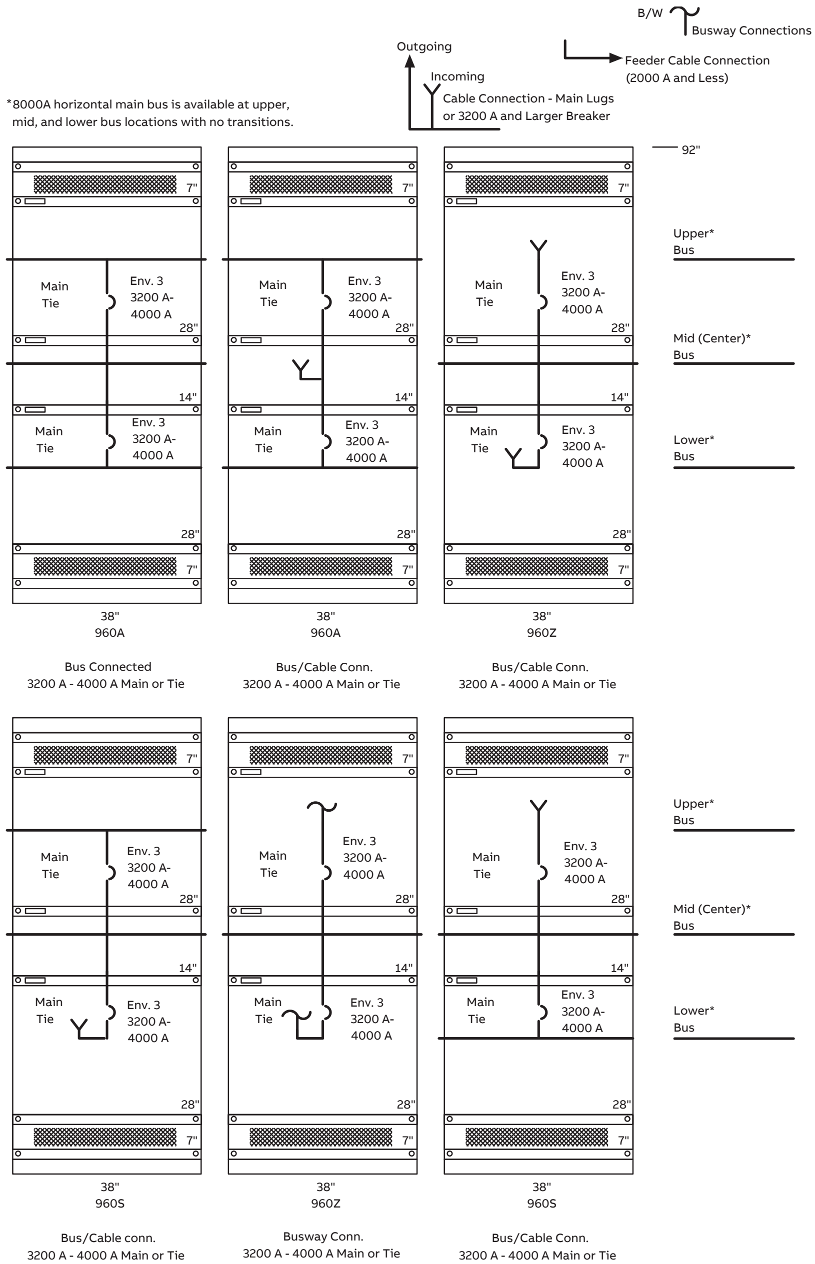

Figure 5.10: Switchgear layout and sizing: 38” sections

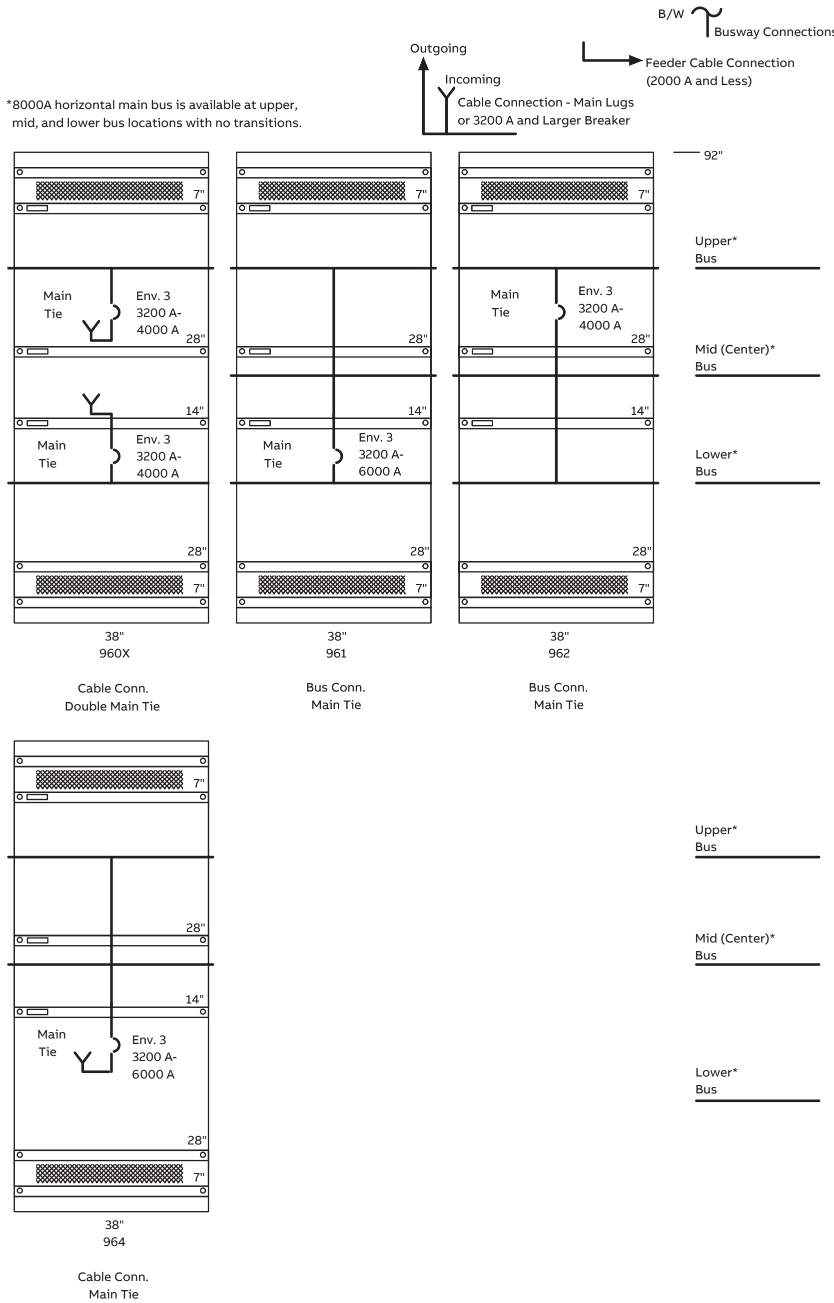

Figure 5.11: Switchgear layout and sizing: 38” sections

Section views and cable lug landings for feeder breakers and main cable feeds

Cable terminations
Cables used for low voltage power circuit breaker terminations in AKD-20 (with the exception of non-AR breakers rated 2000A or less) must have minimum 90°C insulation while the cable ampacity will be based on a 75°C rating. This meets the requirements of ANSI C37.20.1, UL1558 and the National Electrical Code. Refer to the example for typical cable ampacities (derating factors that may apply are not shown). Figure 5.12 shows four-high feeder breaker sections and runback locations with and without optional 45° lug adapters for cables above or below.

Cable Size	90°C rating (ref.)	75°C rating (of 90°C cable)
500kcmil	430 Amps	380 Amps
600kcmil	475 Amps	420 Amps

Example(from NEC table 310.16)

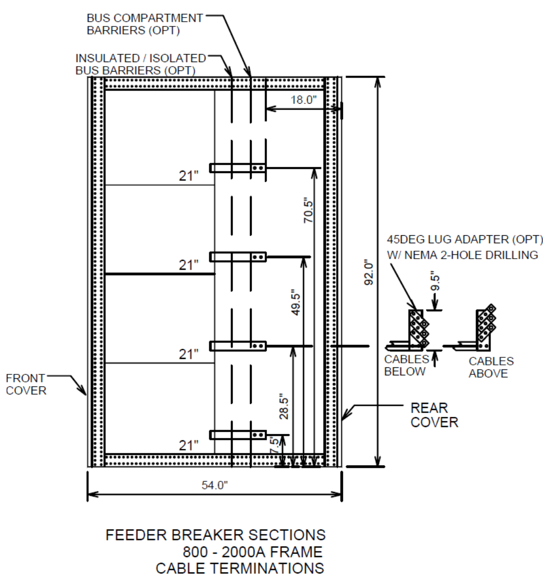

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Figure 5.12: Feeder breaker cable termination sections: 800 A – 2000 A breaker

Figure 5.13 shows a 2000 A main breaker cable feed with cables to the upper primary disconnects and main bus to the lower primary disconnects. The main bus is in the mid or lower bus position.

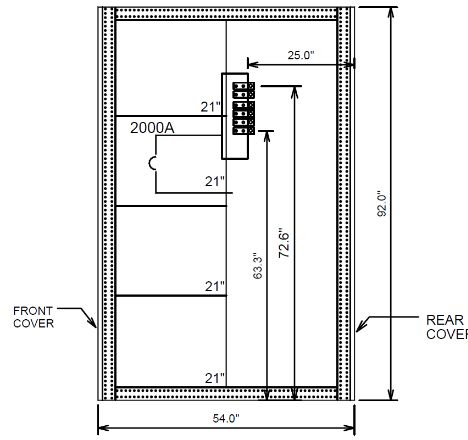

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Figure 5.13: Main-Tie breaker cable termination sections: 800 A – 2000 A breaker, mid or lower bus

Figure 5.14 shows a 2000 A main breaker cable feed with cables to the upper primary disconnects and main bus to the lower primary disconnects. The main bus is in the lower bus position.

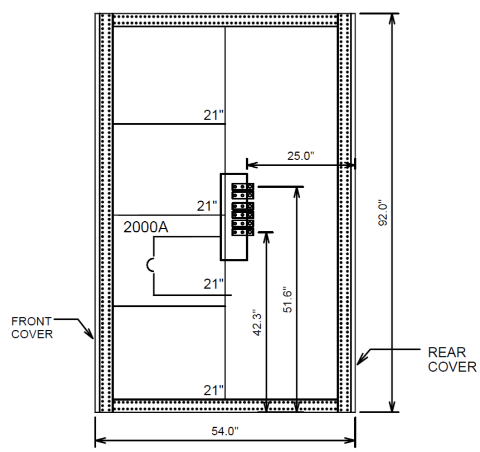

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Figure 5.14: Main-Tie breaker cable termination sections: 800 A – 2000 A breaker, lower bus

Figure 5.15 shows a 3200 A or 4000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the lower bus position. Cables to the lower primary disconnect, main bus in the upper or mid bus position.

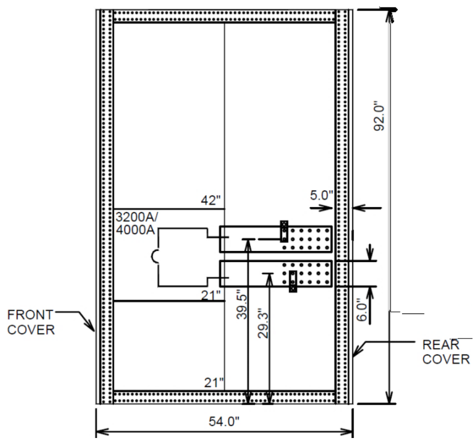


Figure 5.15: Main-Tie breaker cable termination sections: 3200 A/4000 A breaker

Figure 5.17 shows a 3200 A or 4000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the lower bus position. Cables to the lower primary disconnect, main bus in the upper bus position.

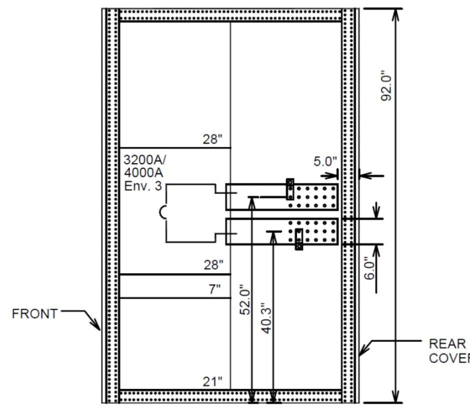


Figure 5.17: Main-Tie breaker cable termination sections: 3200 A/4000 A breaker

Figure 5.16 shows a 3200 A or 4000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the mid or lower bus position. Cables to the lower primary disconnect, main bus in the upper bus position.

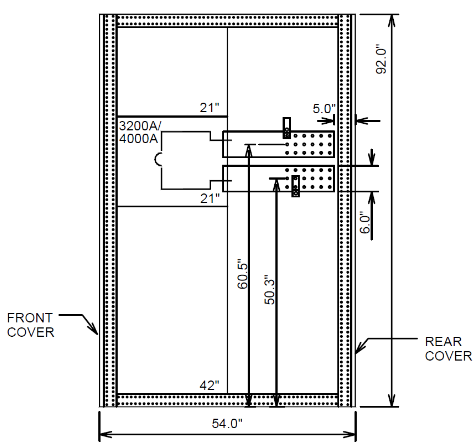


Figure 5.16: Main-Tie breaker cable termination sections: 3200 A/4000 A breaker

Figure 5.18 shows a 5000 or 6000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the lower bus position. Cables to the lower primary disconnect, main bus in the upper bus position.

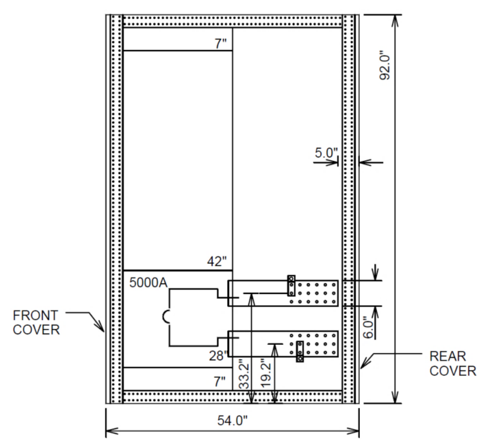


Figure 5.18: Main-Tie breaker cable termination sections: 5000 - 6000 A breaker

Figure 5.19 shows a 5000 - 6000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the lower bus position. Cables to the lower primary disconnect, main bus in the upper bus position. Minimum depth is 74“.

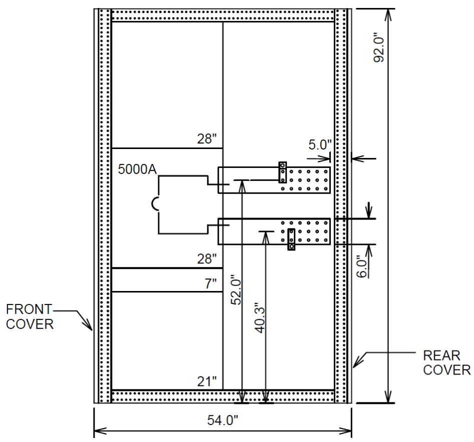


Figure 5.19: Main-Tie breaker cable termination sections: 5000 - 6000 A breaker

Table 5.1: Feeder breaker cable termination provisions (refer to Figure 5.12)*

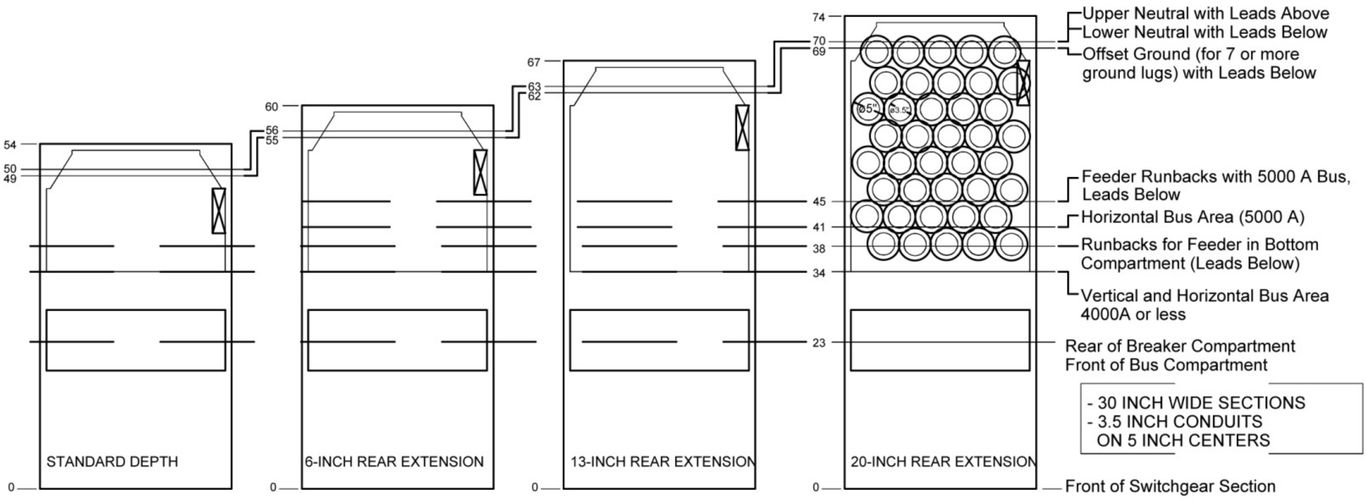
Breaker ampere frame	Compression lugs 600 kcmil and smaller NEMA 2-Hole drilling				Clamp (screw) lugs 600 kcmil and smaller NEMA 2-Hole drilling			
	A,B,C-COMP'T		D-COMPT		A,B,C-COMP'T		D-COMPT	
	45° Lug adapter	90° Lug adapter	45° Lug adapter	90° Lug adapter	45° Lug adapter	90° Lug adapter	45° Lug adapter	90° Lug adapter
800 A 1600 A 2000 A	8	8	6	8	8	8	3	5

* Maximum quantity of lugs shown. Adapter bars are provided for customer-specified quantity of lugs per breaker.

Table 5.2: Main cable feed and bus tap-off (refer to Figure 5.13 through Figure 5.19)

Breaker frame/ cable tapoff	Compression lugs 600 kcmil and smaller NEMA 2-Hole drilling			Clamp (screw) lugs 600 kcmil and smaller NEMA 2-Hole drilling		
	Cable feed/Tapoff location			Cable feed/Tapoff location		
	Top	Center	Bottom	Top	Center	Bottom
2000 A	6 (22") 9 (30")	6 (22") 9 (30")	6 (22") 9 (30")	6 (22") 9 (30")	6 (22") 9 (30")	6 (22") 9 (30")
3200 A	12	12	12	11	11	11
4000 A	12	-	12	11	-	11
5000 A	14	-	14	14	-	14
6000 A	14	-	14	14	-	14

Figures 5.21 through 5.34 show various layouts for conduit and cable position depending on the section depth and close-coupling options available.



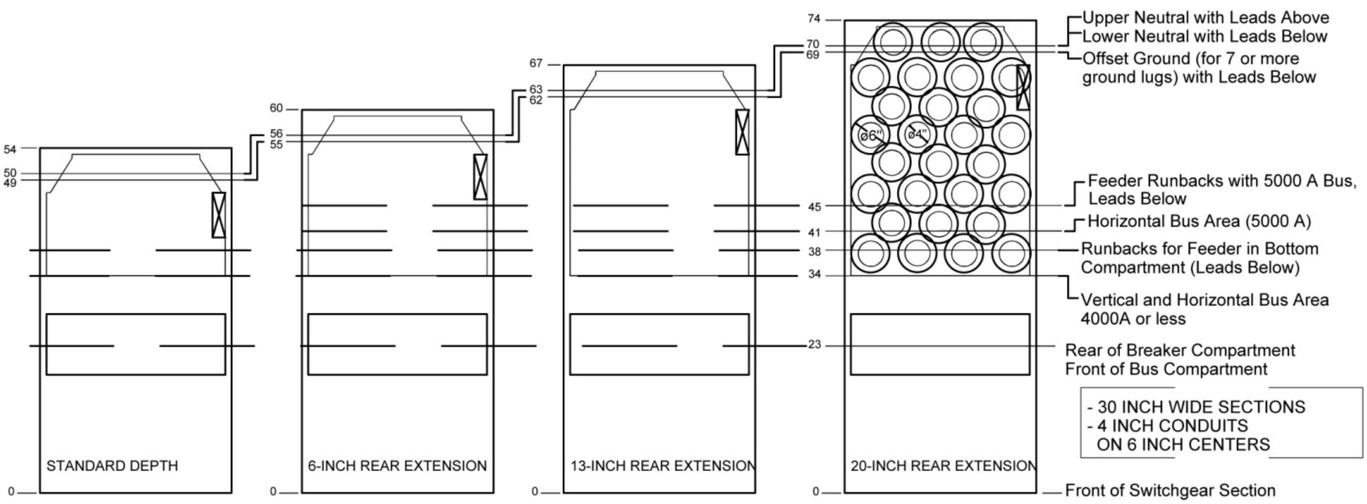


Figure 5.21: Conduit layout: 30” sections

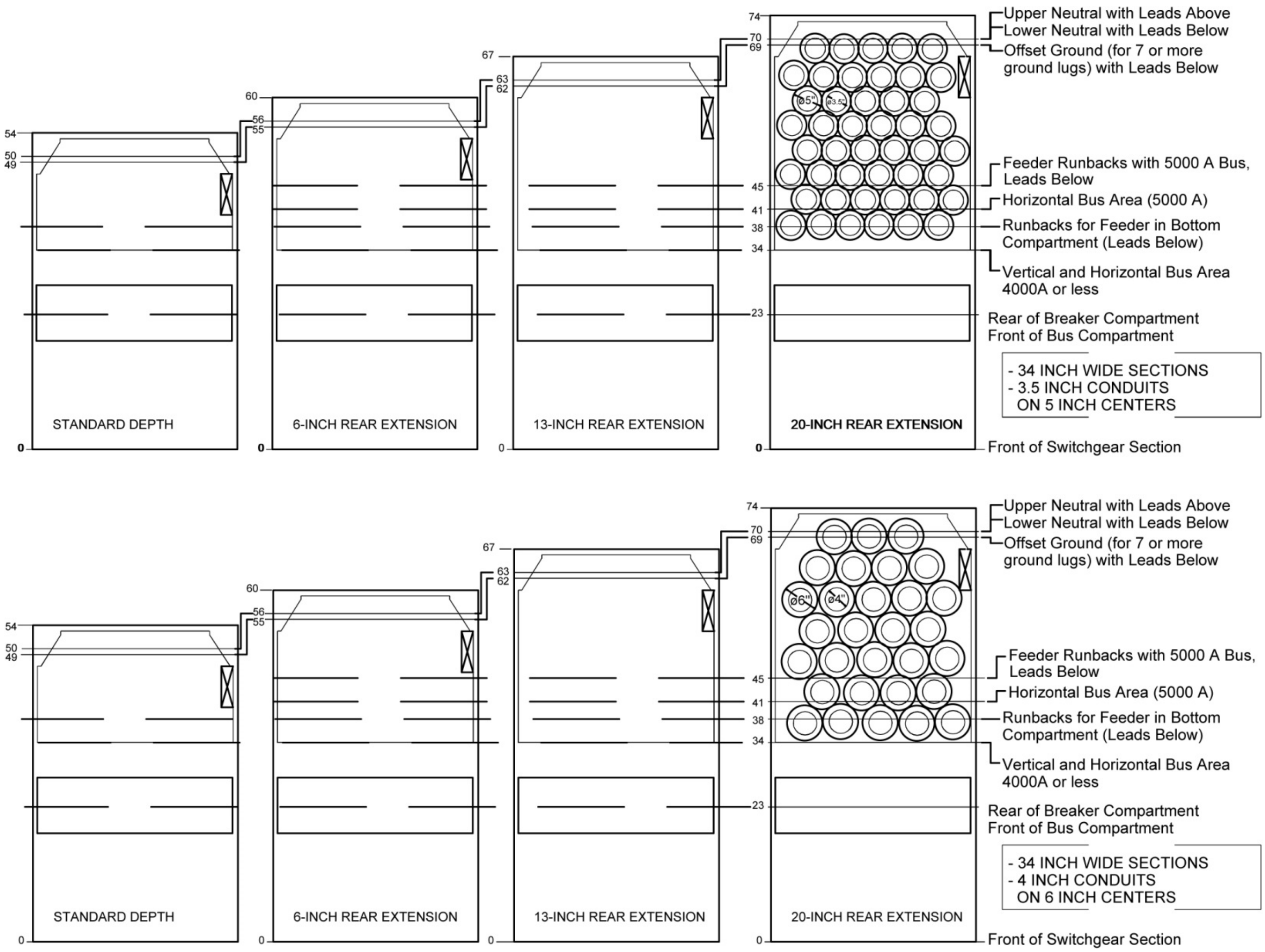


Figure 5.22: Conduit layout: 34” sections

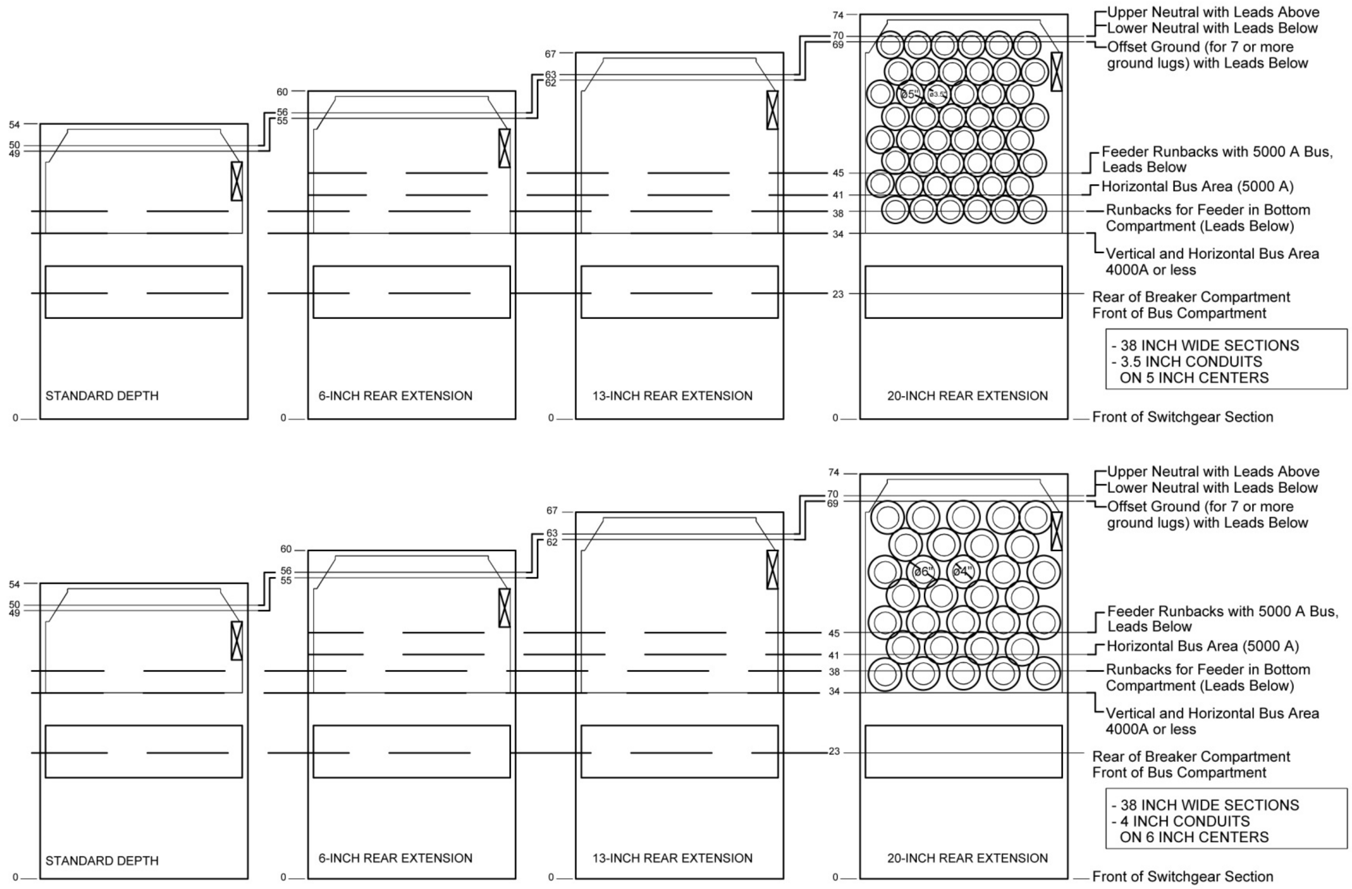
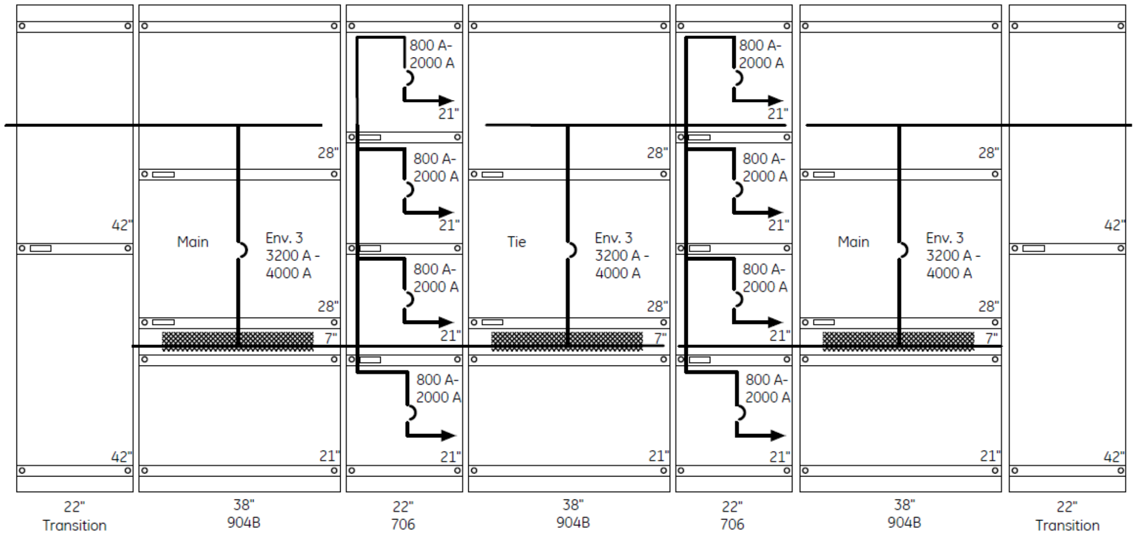


Figure 5.23: Conduit layout: 38” sections

Main-tie-main / Close-coupled to transformer / With transition / Additional feeder sections as required



Main-tie-main / Close-coupled to transformer / With transition / Additional feeder sections as required

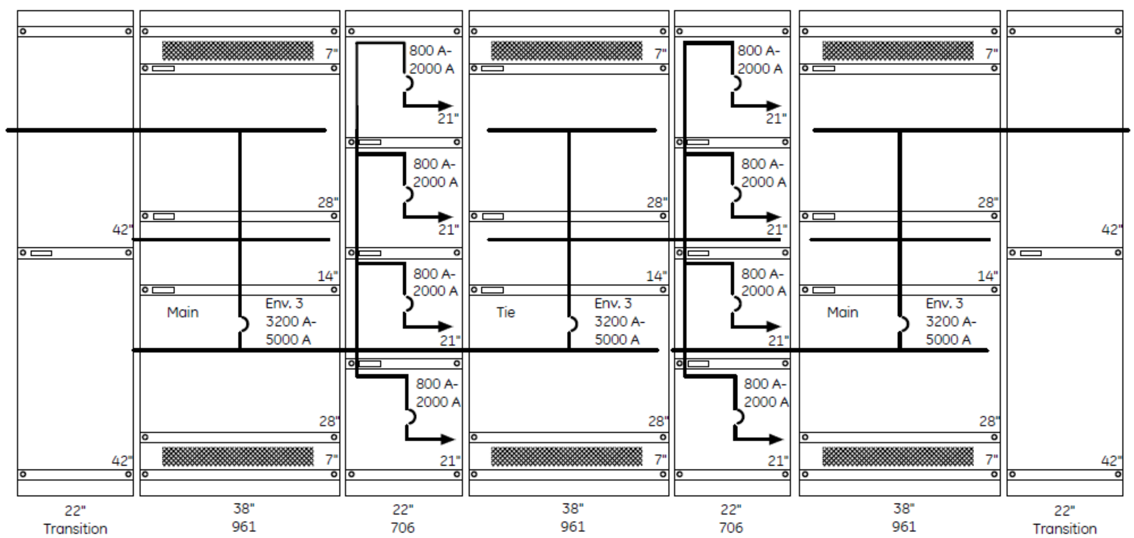


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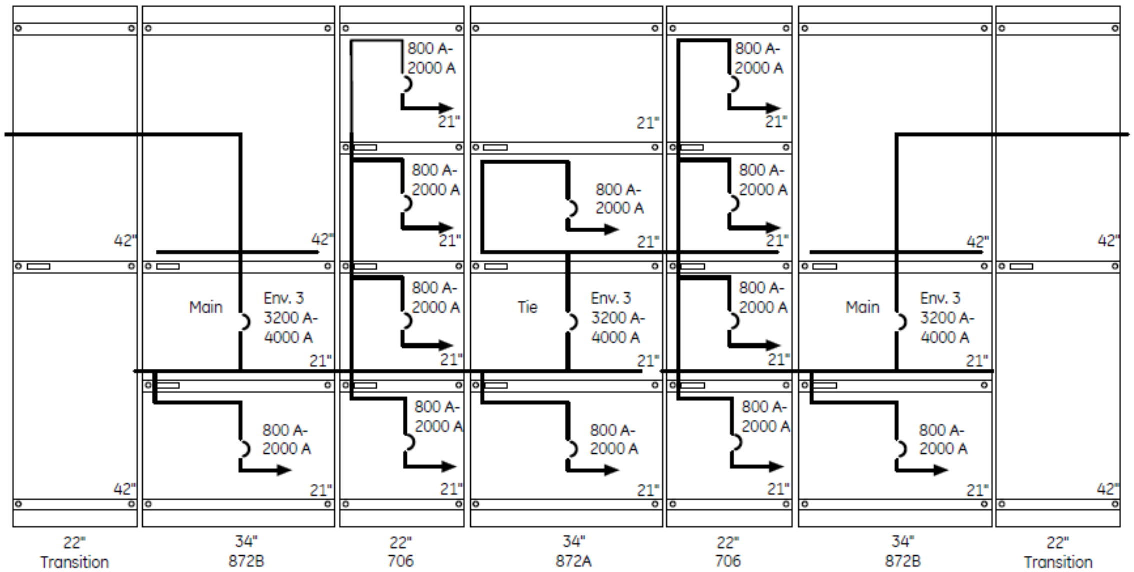
Figure 5.24: Close-coupled to transformer with transition section: Main-Tie-Main

Notes:

1. All auxiliary compartments have shallow depths. Device-mounting space on door and rear barrier only.
2. Transition to transformer required with liquid-filled transformed and recommended with dry type transformers. If transition is not used, then space must be provided in the breaker sections for auxiliary devices (PT, CPT, fuses, meters, etc.).

Main-tie-main / close-coupled to transformer /
With transition / additional feeder sections as required



Main-tie-main / Close-coupled to transformer /
With transition / Additional feeder sections as required

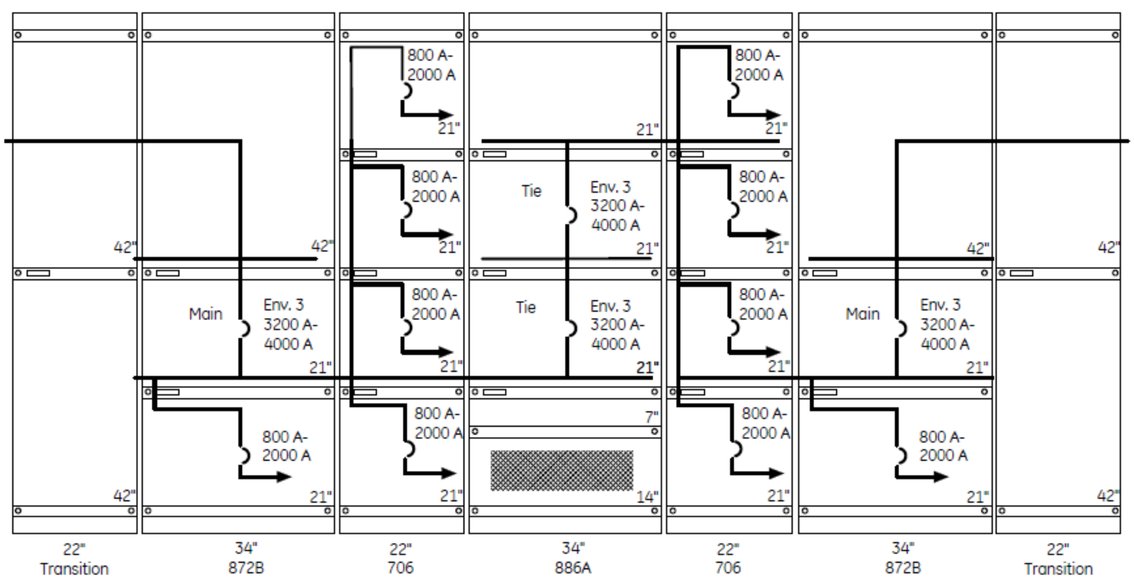


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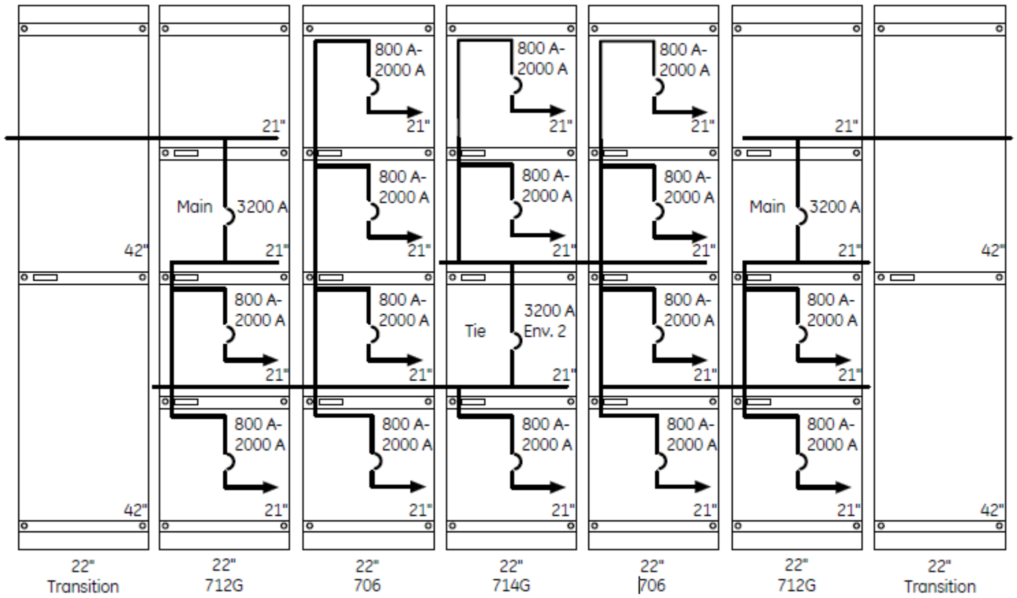
Figure 5.25: Close-coupled to transformer with transition section: Main-Tie-Main and Main-Tie-Tie-Main

Notes:
1. All auxiliary compartments have shallow depths. Device-mounting space on door and rear barrier only.
2. Transition to transformer required with liquid-filled transformed and recommended with dry type transformers. If transition is not used, then space must be provided in the breaker sections for auxiliary devices (PT, CPT, fuses, meters, etc.).

**Main-tie-main / Close-coupled to transformer /
With transition / Additional feeder sections as required**



**Main-tie-main / close-coupled to transformer /
With transition / Additional feeder sections as required**

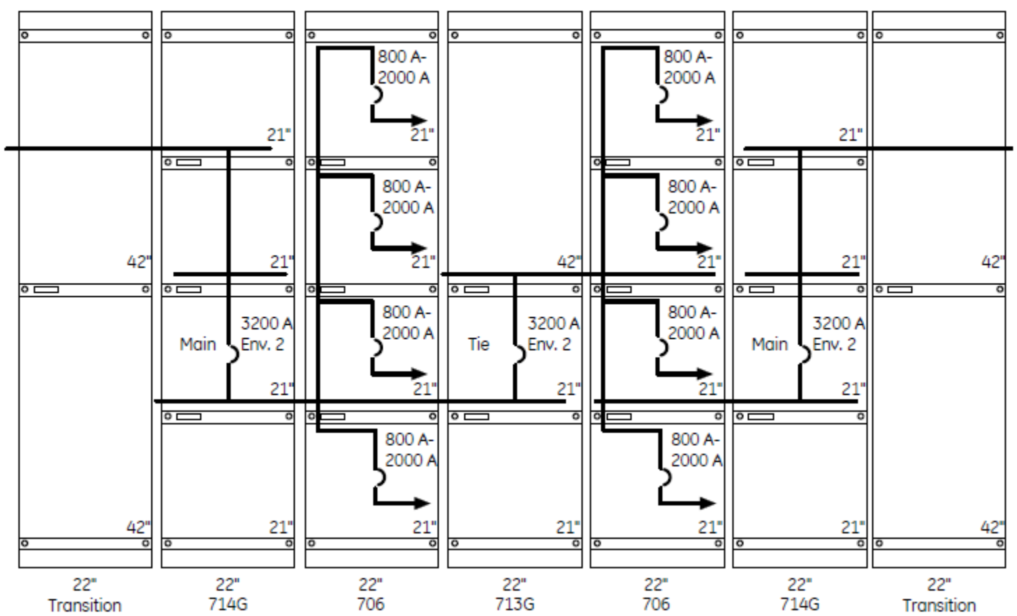
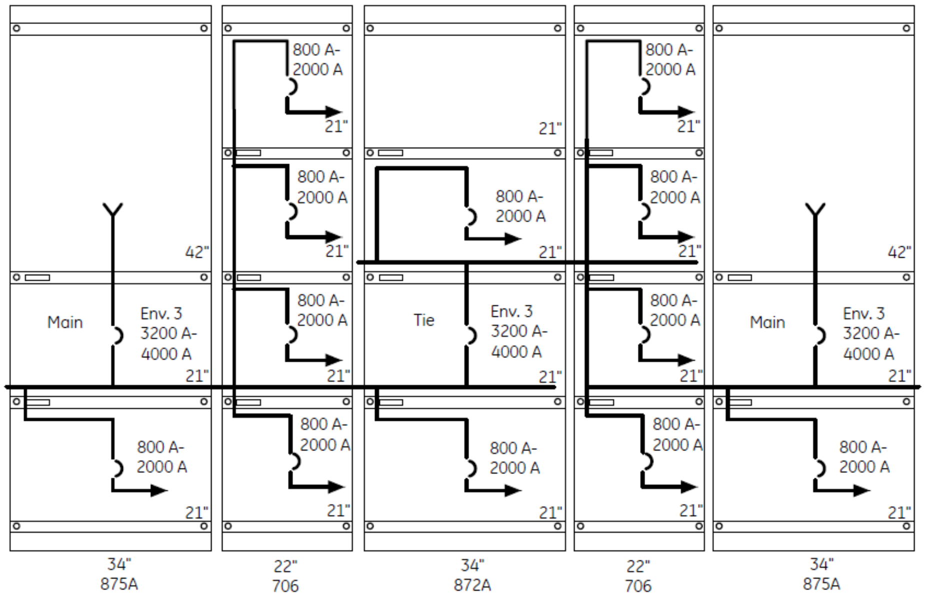


Figure 5.26: Cable or busway connected: Main-Tie-Main

Notes:

1. All auxiliary compartments have shallow depths. Device-mounting space on door and rear barrier only.
2. Transition to transformer required with liquid-filled transformed and recommended with dry type transformers. If transition is not used, then space must be provided in the breaker sections for auxiliary devices (PT, CPT, fuses, meters, etc.).

**Main-tie-main / Close-coupled to transformer /
With transition / Additional feeder sections as required**



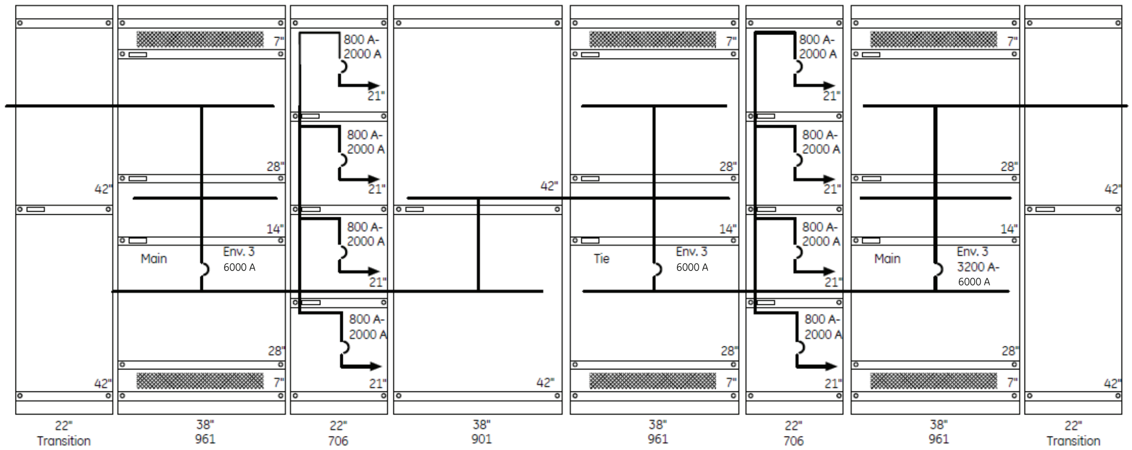
**Main-tie-main / Close-coupled to transformer /
With transition / Additional feeder fections as required**

Figure 5.27: Cable or busway connected: Main-tie-tie-main

Notes:

1. All auxiliary compartments have shallow depths. Device-mounting space on door and rear barrier only.
2. Transition to transformer required with liquid-filled transformed and recommended with dry type transformers. If transition is not used, then space must be provided in the breaker sections for auxiliary devices (PT, CPT, fuses, meters, etc.).

**Main-tie-main / Close-coupled to transformer /
With transition / Additional feeder sections as required**



**Main-tie-main / Close-coupled to transformer /
With transition / Additional feeder sections as required**

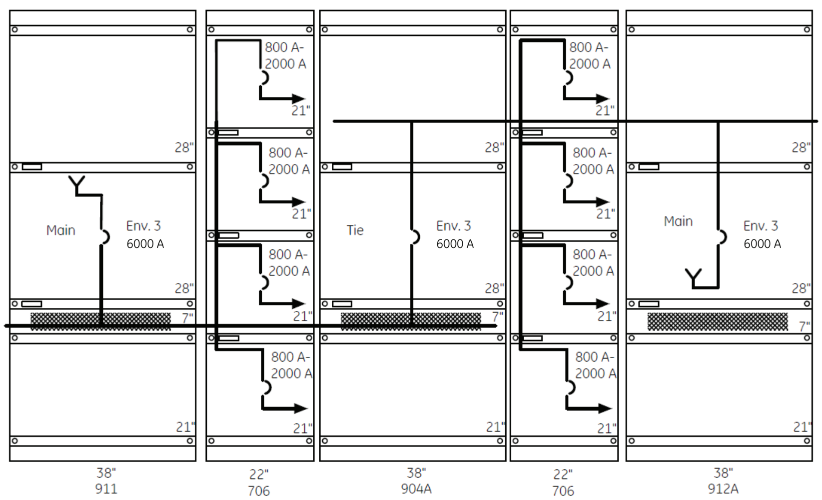


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Figure 5.28: 5000 A, Main-tie-main

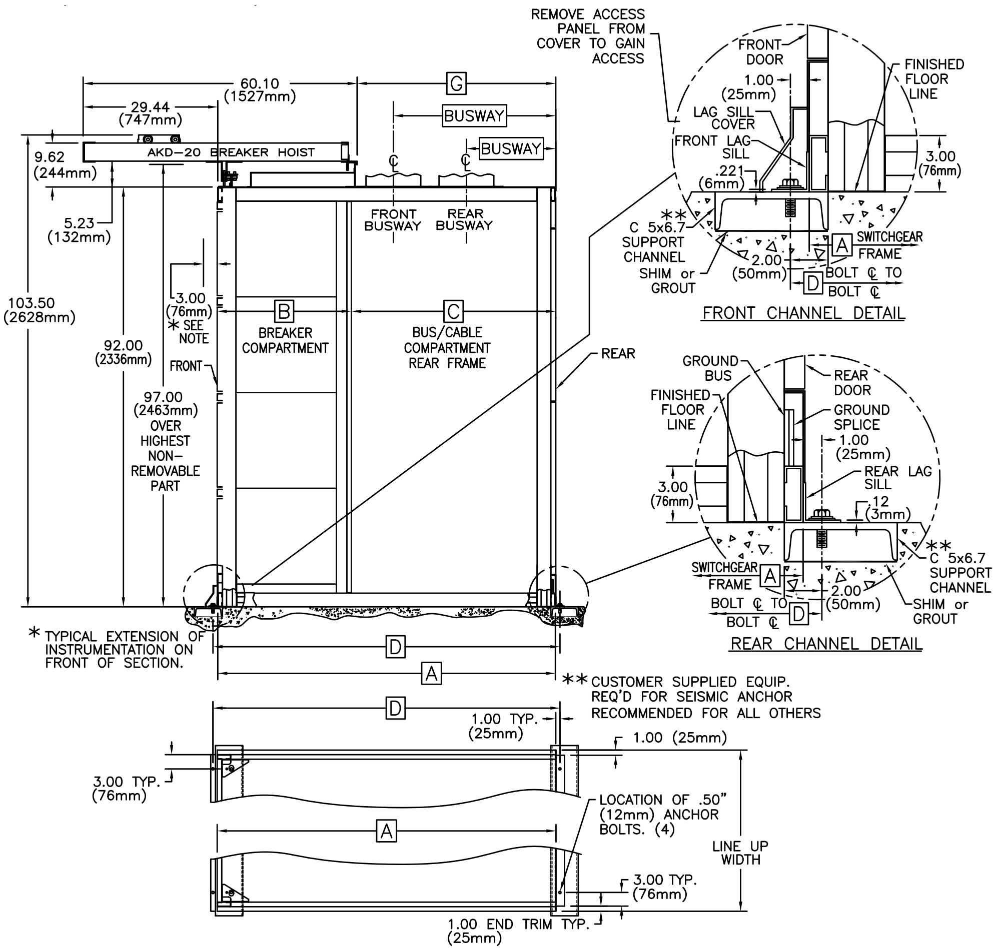


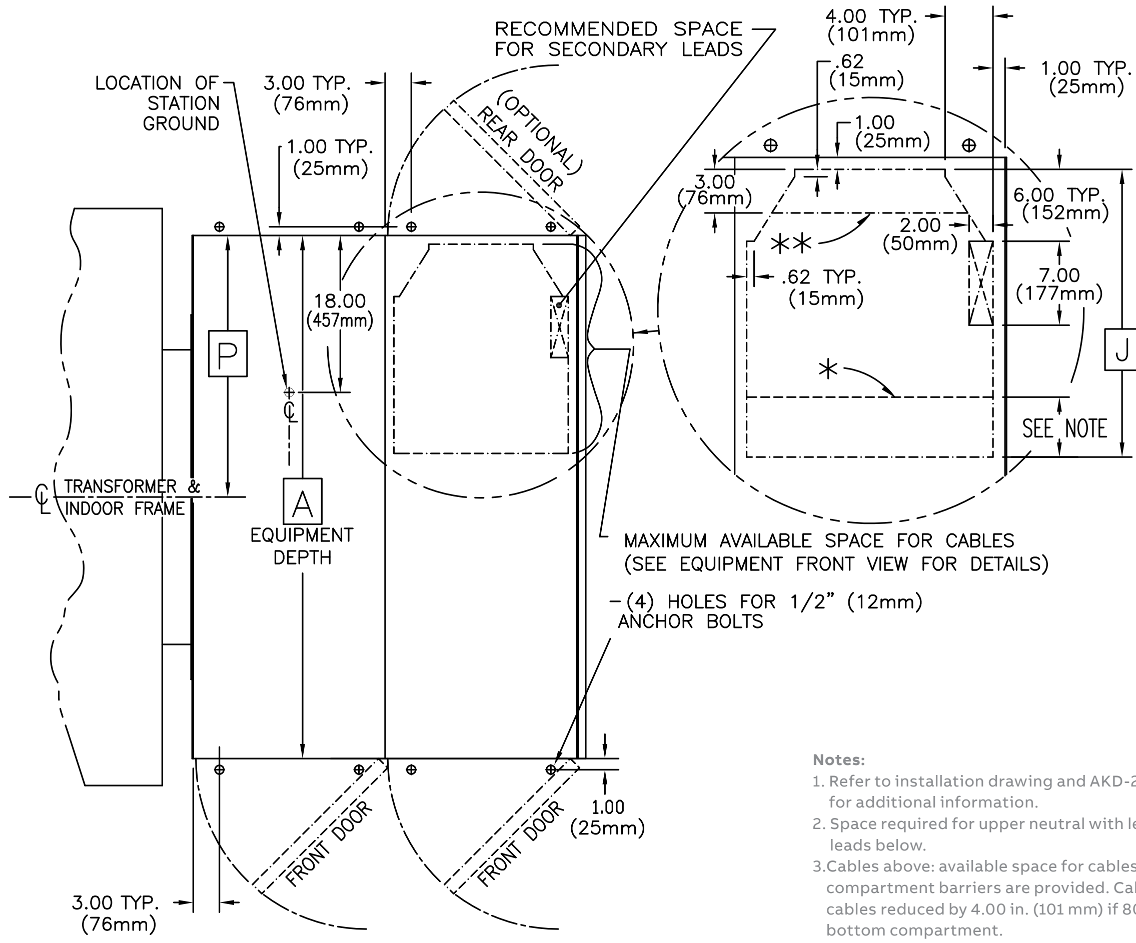
Figure 5.29: NEMA 1 indoor side view and anchoring details[1] – in. (mm)

Busway section width required

Type and amp rating	Min. section width
Spectra 800 A - 3200 A	22.00 in (558 mm)
Spectra 4000 A	30.00 in (762 mm)
Spectra 5000 A	38.00 in (965 mm)
NSP 1200 A - 2500 A	22.00 in (558 mm)
NSP 3200 A	30.00 in (762 mm)
NSP 4000 A – 5000 A	38.00 in (965 mm)

										Busway locations
							Front			Rear
A Equipment depth	B Breaker compartment	D Anchor bolt spacing	G Back of hoist to rear frame	Spectra 800 A - 4000 A NSP 1200 A - 3200 A	NSP 4000 A	Spectra 5000 - 6000A	Spectra 800 A - 4000 A	NSP 1200 A -4000 A	Spectra 5000 A	NSP 5000 A
54.00 in (1372 mm)	17.00 in (432 mm)	56.00 in (1422 mm)	23.34 in (593 mm)	12.50 in (317 mm)	12.50 in (317 mm)	-	-	-	-	-
60.00 in (1524 mm)	17.00 in (432 mm)	62.00 in (1575 mm)	29.34 in (745 mm)	21.50 in (546 mm)	19.50 in (495 mm)	23.50 in (596 mm)	9.50 in (241 mm)	12.50 in (317 mm)	11.50 in (292 mm)	-
67.00 in (1701 mm)	17.00 in (432 mm)	69.00 in (1752 mm)	36.34 in (923 mm)	28.50 in (723 mm)	26.50 in (673 mm)	30.50 in (774 mm)	16.50 in (419 mm)	12.50 in (317 mm)	18.50 in (470 mm)	15.88 in (403 mm)
74.00 in (1879 mm)	17.00 in (432 mm)	76.00 in (1930 mm)	43.34 in (1100 mm)	35.50 in (901 mm)	33.50 in (850 mm)	37.50 in (952 mm)	23.50 in (596 mm)	19.50 in (495 mm)	25.50 in (648 mm)	22.88 in (581 mm)

1. Refer to installation drawing and AKD-20 Installation Manual (DEH-41472) for additional information.
2. Customer-supplied equipment required for seismic anchor; recommended for all others.
3. Typical extension of instrumentation on front of section.
4. Uppermost breaker not available when used with a 4 in. subframe or housekeeping pad.



Notes:
1. Refer to installation drawing and AKD-20 Installation Manual (DEH-41472) for additional information.
2. Space required for upper neutral with leads above, or lower neutral with leads below.
3. Cables above: available space for cables reduced by 5.00 in. (127mm) if bus compartment barriers are provided. Cables below: available space for cables reduced by 4.00 in. (101 mm) if 800 A – 2000 A breaker is located in bottom compartment.

Figure 5.30: NEMA 1 indoor floor plan and cable space details(1) – in. (mm)

A Equipment depth	Direction of cables	J	Rear extension depth	P Transformer ℄ (center line) to rear of switchgear
54 in	Below	19.00 in (482 mm)	-	26.50 in (673 mm)
	Above	24.00 in (609 mm)		
60 in	Below	25.00 in (635 mm)	6.00 in (153 mm)	26.50 in (673 mm)
	Above	30.00 in (762 mm)		
67 in	Below	32.00 in (813 mm)	13.00 in (330 mm)	33.50 in (861 mm)
	Above	37.00 in (940 mm)		
74 in	Below	39.00 in (991 mm)	20.00 in (508 mm)	40.50 in (1029 mm)
	Above	44.00 in (1118 mm)		
67 in 5000A, 6000A, 8000A bus	Below	26.00 in (660 mm)	7.00 in (177 mm)	33.50 in (861 mm)
	Above	31.00 in (787 mm)		
74 in 5000A, 6000A, 8000A bus	Below	33.00 in (838 mm)	14.00 (356 mm)	40.50 in (1029 mm)
	Above	38.00 in (965 mm)		

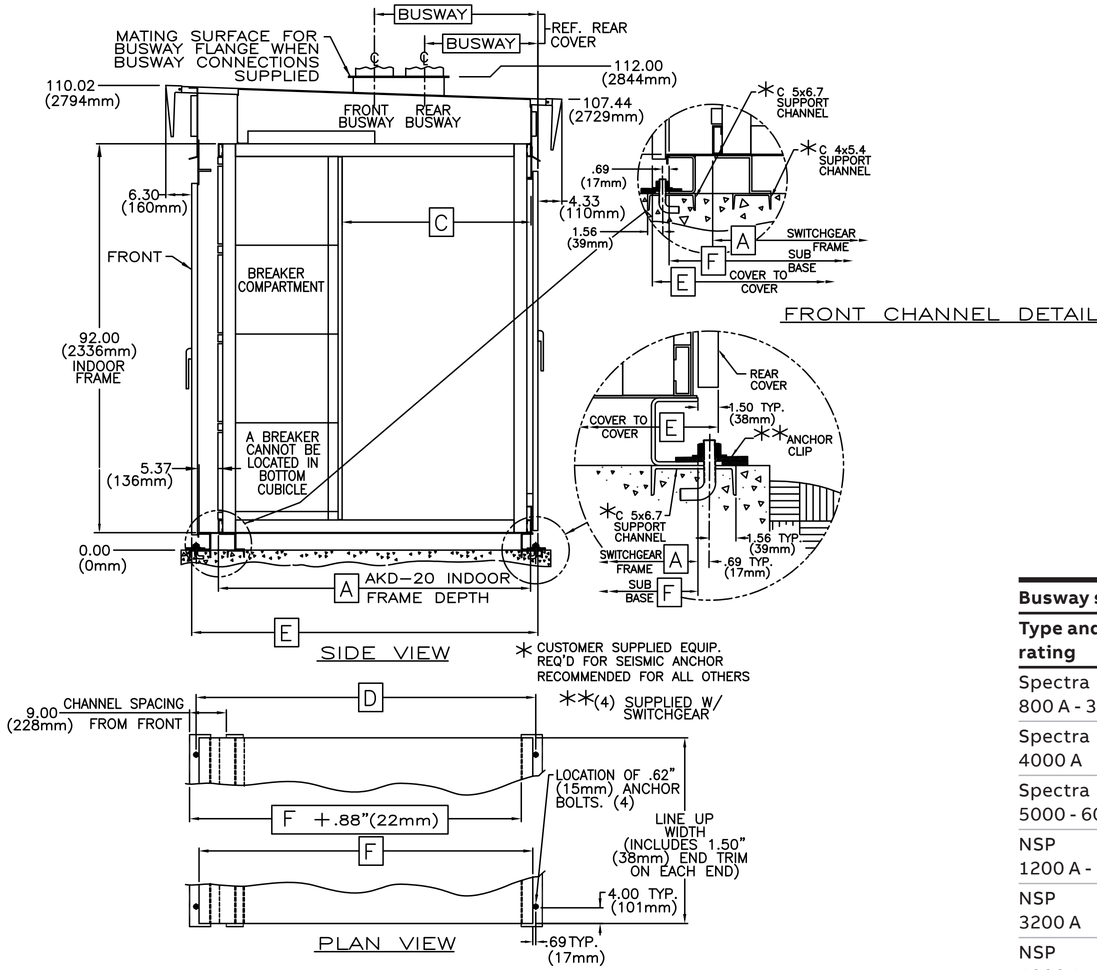


Figure 5.31: NEMA 3R outdoor non-walk-in side view and anchoring details[1] – in. (mm)

Busway section width required

Type and amp rating	Min. section width
Spectra 800 A - 3200 A	24.00 in (609 mm)
Spectra 4000 A	32.00 in (812 mm)
Spectra 5000 - 6000 A	40.00 in (1016 mm)
NSP 1200 A - 2500 A	24.00 in (609 mm)
NSP 3200 A	32.00 in (812 mm)
NSP 4000 A – 5000 A	40.00 in (1016 mm)

				Busway locations			
				Front			Rear
A Depth of indoor switchgear	D Anchor bolt spacing	E Depth of outdoor switchgear	F Sub base depth	Spectra 800 A - 4000 A NSP 1200 A - 3200 A	NSP 4000 A	Spectra 5000 - 6000 A	Spectra 800 A - 4000 A
60.00 in (1524 mm)	66.38 in (1686 mm)	68.37 in (1736 mm)	65.00 in (1651 mm)	23.00 in (584 mm)	21.00 in (533 mm)	-	11.00 in (279 mm)
74.00 in (1879 mm)	80.38 in (2041 mm)	82.37 in (2092 mm)	79.00 in (2006 mm)	37.00 in (940 mm)	35.00 in (889 mm)	32.00 in (812 mm)	25.00 in (635 mm)

1. Refer to installation drawing and AKD-20 Installation Manual (DEH-41472) for additional information.
2. Customer-supplied equipment required for seismic anchor; recommended for all others.
3. Four (4) anchor clips supplied with switchgear.
4. 5000 A busway to main bus only.
5. Uppermost breaker not available.
6. 800 A – 2000 A breaker may be installed in bottom compartment of 30 in. wide sections.

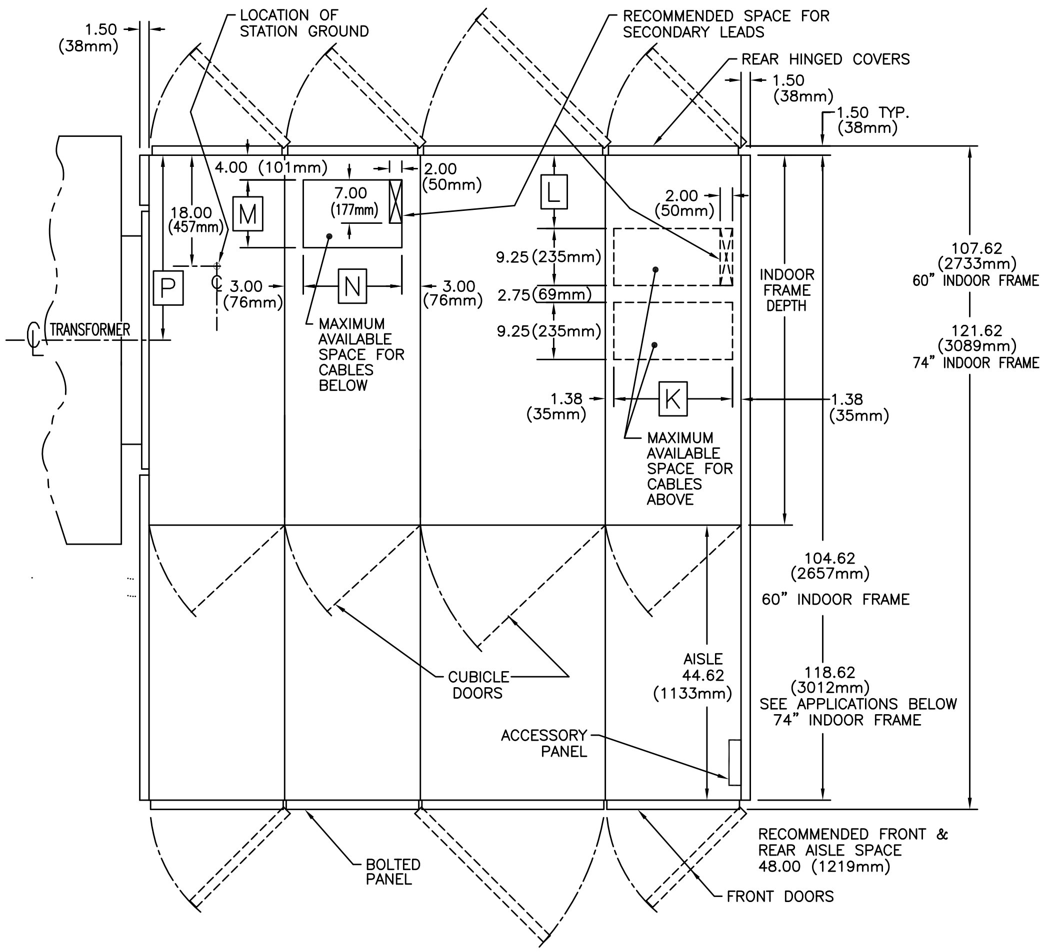


Figure 5.32: NEMA 3R outdoor non-walk-in floor plan and space details(1) – in. (mm)

Section width	K	N
24 in (609 mm)	19.25 in (489 mm)	16.00 in (406 mm)
32 in (812 mm)	27.25 in (692 mm)	24.00 in (609 mm)
40 in (1016 mm)	35.25 in (895 mm)	32.00 in (812 mm)

Indoor frame	L	M	P
60 in (1524 mm)	4.88 in (124 mm)	19.00 in (483 mm)	32.50 in (826 mm)
74 in (1879 mm)[2]	18.88 in (479 mm)	33.00 in (838 mm)	46.50 in (1181 mm)
74 in (1879 mm)[3]	18.88 in (479 mm)	26.00 in (660 mm)	40.50 in (1029 mm)

1. Refer to installation drawing and AKD-20 Installation Manual (DEH-41472) for additional information.
2. 14 in. rear extension. Main bus ≤ 4000 A.
3. 5000A, 6000A, and 8000A bus without 5000 or 6000 A breaker, 7 in. rear extension.

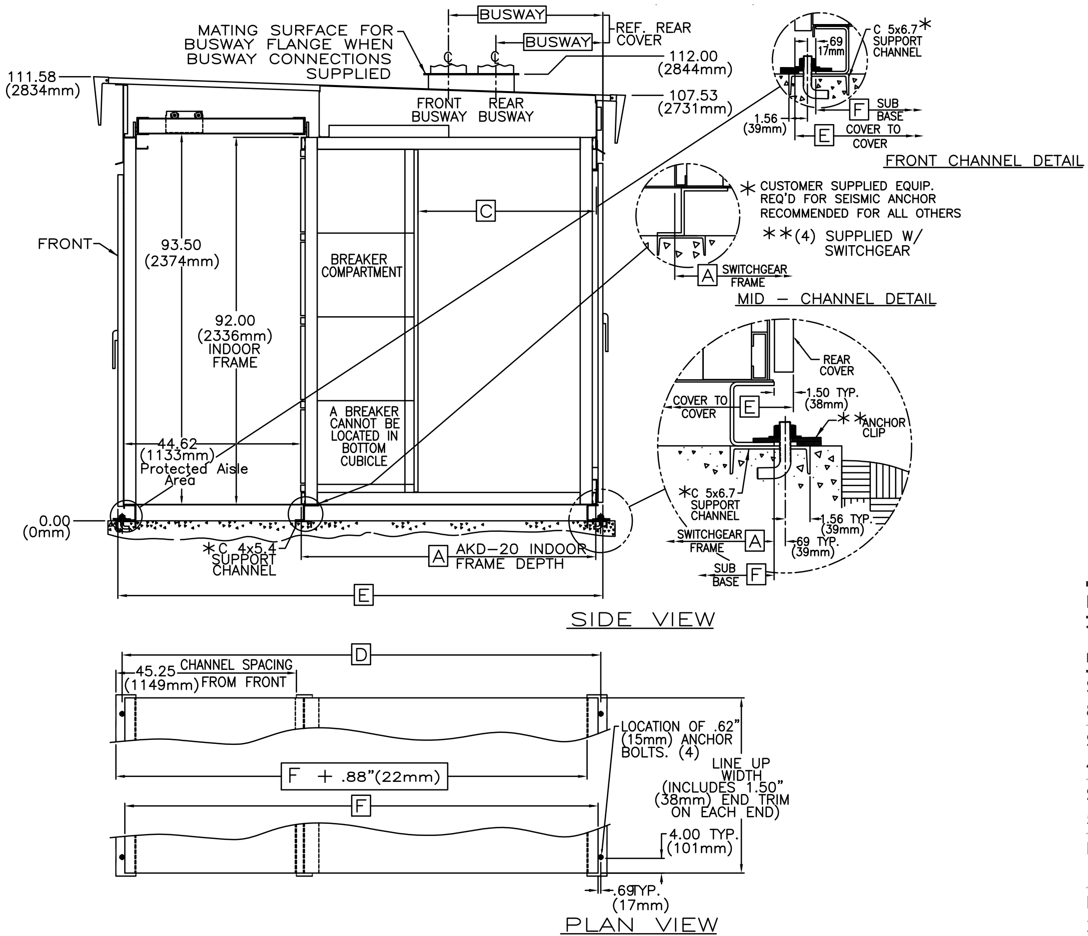


Figure 5.33: NEMA 3R outdoor walk-in protected aisle side view and anchoring details(1) – in. (mm))

Busway section width required

Type and amp rating	Min. section width
Spectra 800 A - 3200 A	22.00 in (558 mm)
Spectra 4000 A	30.00 in (762 mm)
Spectra 5000 - 6000 A	38.00 in (965 mm)
NSP 1200 A - 2500 A	22.00 in (558 mm)
NSP 3200 A	30.00 in (762 mm)
NSP 4000 A – 5000 A	38.00 in (965 mm)

A Depth of indoor switchgear	D Anchor bolt spacing	E Depth of outdoor switchgear	F Sub base depth	Main bus busway locations Front rear spectra	Busway locations			
					Front			Rear
					Spectra 800 A - 4000 A NSP 1200 A - 3200 A	NSP 4000 A	Spectra 5000 - 6000 A	Spectra 800 A - 4000 A
60.00 in (1524 mm)	106.00 in (2692 mm)	107.62 in (2733 mm)	104.62 in (2657 mm)	≤ 4000 A	23.00 in (584 mm)	21.00 in (533 mm)	-	11.00 in (279 mm)
74.00 in (1880 mm)	120.00 in (3048 mm)	121.62 in (3089 mm)	118.62 in (3012 mm)	≤ 4000 A	37.00 in (939 mm)	35.00 in (889 mm)	-	25.00 in (635 mm)
				5000 - 6000 A	37.00 in (939 mm)	35.00 in (889 mm)	37.50 in (952 mm)	25.00 in (635 mm)

1. Refer to installation drawing and AKD-20 Installation Manual (DEH-41472) for additional information.
2. Customer-supplied equipment required for seismic anchor; recommended for all others.
3. Four (4) anchor clips supplied with switchgear.
4. 800 A – 2000 A breaker may be installed in bottom compartment of 30 in. wide sections only.

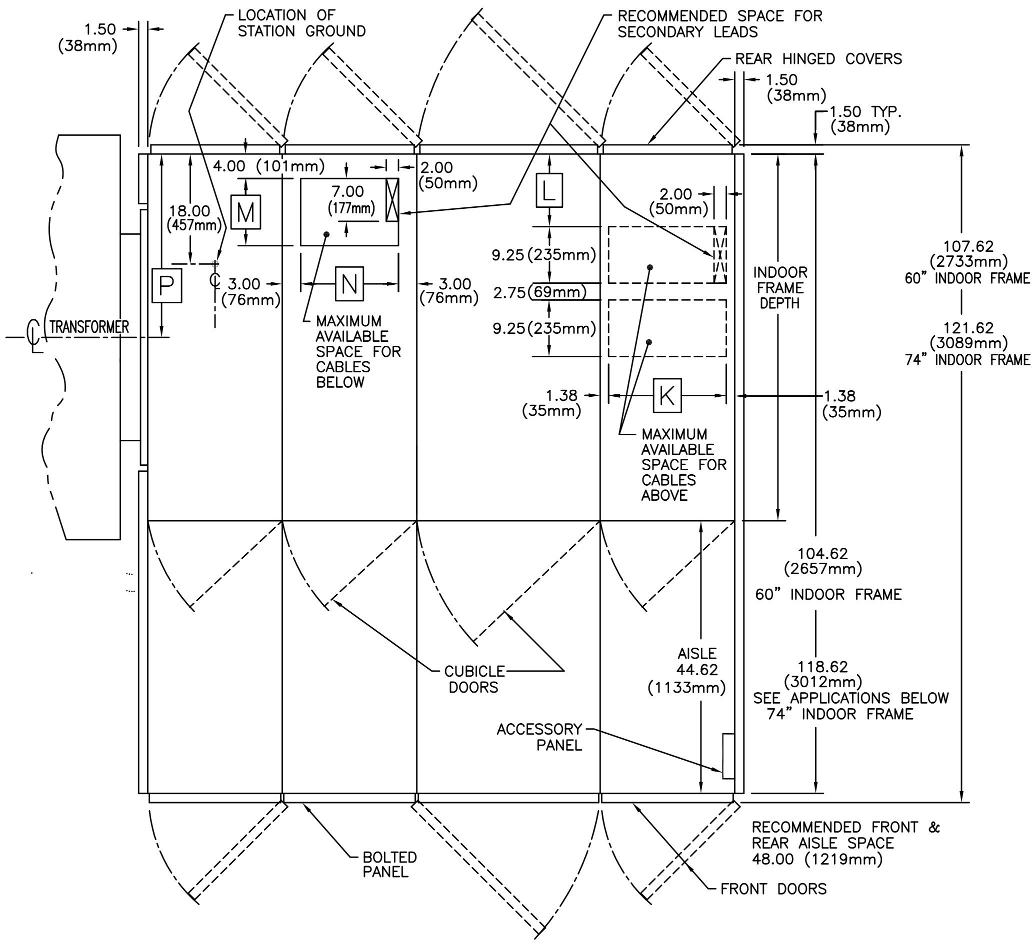


Figure 5.34: NEMA 3R outdoor walk-in protected aisle floor plan and cable space details[1] – in. (mm)

Section width	K	N
22.00 in (558 mm)	19.25 in (489 mm)	16.00 in (406 mm)
30.00 in (762 mm)	27.25 in (692 mm)	24.00 in (609 mm)
38.00 in (965 mm)	35.25 in (895 mm)	32.00 in (812 mm)

Indoor frame	L	M	P
60 in (1524 mm)	4.88 in (124 mm)	19.00 in (483 mm)	32.50 in (826 mm)
74 in (1879 mm)[2]	18.88 in (479 mm)	33.00 in (838 mm)	46.50 in (1181 mm)
74 in (1879 mm)[3]	18.88 in (479 mm)	26.00 in (660 mm)	40.50 in (1029 mm)

1. Refer to installation drawing and AKD-20 Installation Manual (DEH-41472) for additional information.
2. 14 in. rear extension. Main bus ≤ 4000 A.
3. 5000A, 6000A, and 8000A bus without 5000 or 6000 A breaker, 7 in. rear extension.

Arc-resistant switchgear

ABB AKD-20 and Entellisys arc-resistant (AR) switchgear solutions are for applications where an extra margin of safety is essential. They meet the IEEE C37.20.7 Type 2B AR standard which states that the equipment will provide arcresistance protection on the front, rear, and sides while opening designated low voltage compartments.

Designated compartments include front auxiliary, and instrumentation cubicles. AKD-20 AR and Entellisys AR are designed to contain and redirect the arc flash energy and exhaust gases through the plenum at the top of the enclosure and away from the operator. In the case of an arc flash event, normally open pressure activated flaps close shut to seal ventilation areas in the rear cable compartment.

The rugged dead front panels protect personnel from the explosive force of arc flash occurrences. The circuit breaker cubicle doors are provided with a reinforced escutcheon gasket, protecting operators from exhaust gases and other materials. Arc-resistant AKD-20 and Entellisys are designed with the safety of personnel and equipment in mind. AR is offered in the same shallower footprint as our traditional switchgear. Combine AR with unique GE Entellisys and ArcWatch technologies for even more advanced safety solutions against arc flash occurrences. Using interlocking systems, these two technologies increase protection while maintaining system uptime.

AR features
- Internal exhaust chimney and exhaust plenums with top, bottom, left, and right exit options
- Seismic construction
- Heavy-duty NEMA 1 enclosure
- Same footprint as standard AKD-20 and Entellisys
- Insulated/Isolated bus
- Bus compartment barriers
- Section barriers and shutters
- Push-to-latch circuit breaker cubicle doors
- Normally open pressure activated rear vent flaps
- Reinforced circuit breaker escutcheon gasket
- Plenum flange
- Full height hinged and bolted rear doors
- Floor plates in cable compartment
- ArcWatch compatible (ABB Pub DEA-565A)

Ratings
- System voltage nominal (max): 480 (508) V – 600 (635) V
- Main bus: 800 A – 5000 A (5000 A breakers require fan cooling)
- Enclosure type: Indoor NEMA 1
- Depths: 54”, 60”, 67”, and 74”
- Internal arc current: 65 kA (85 kA – consult factory) RMS at 0.5 sec
- Cable-connected or transformer close coupled main and cable-connected feeder breakers

Standards and approvals
- IEEE C37.20.7 – Type 2B
- ANSI C37.20.1
- UL 1558, UL1066

Additional reference publications
- DEH-41473 Installation and Maintenance Manual
- DEH-41474 Plenum Installation and Maintenance Manual

Additional options
- Infrared scanning window in rear doors
- Lockable T-Handles on circuit breaker cubicle
- Doors and rear doors
- Overhead circuit breaker lifting device

Additional options
AKD-20 or Entellisys Arc-resistant switchgear is provided in NEMA 1 indoor construction for electrical systems rated up to 5000 A, 600 V, 65 kA. AKD-20 or Entellisys Arc Resistant switchgear meets the requirements of the following IEEE and UL standards:

- IEEE C37.20.1 (2002) Metal-enclosed low voltage power circuit breaker switchgear;
- IEEE C37.20.7 (2007) Guide for testing metal-enclosed switchgear for internal arcing Faults (tested to Type 2B requirements);
- UL1558 Metal-enclosed low voltage power circuit breaker switchgear.

AKD-20 or Entellisys Arc-resistant switchgear is provided with a plenum flange on the top of each vertical section (refer to conduit/floorplan details provided in this document). The plenum flange at the end of our equipment mates with the owner-supplied plenum (Figure 6-11).

ABB will provide the following relative to the plenum:

1. Details on the minimum material thickness for the plenum;
2. Details on the minimum cross-section of the plenum (minimum ceiling height: 10 ft.);
3. Details on the mating plenum flange on the top of each vertical section;
4. Exhaust port with rodent screen and hinged flap for use on the exiting end of the plenum provided by ABB.

Cubicles with provisions for future circuit breakers are provided with a cover plate in the circuit breaker door cutout and a cassette barrier behind the door. All circuit breaker cubicle doors are provided with a “push-to-latch” mechanism, which eliminates the need for any additional motions to secure the circuit breaker door – a critical factor in maintaining the Type 2B arc-resistant rating of the equipment.

Arc-resistant type 2B – what does it mean?
Per IEEE C37.20.7-2007, clause 4.1, “Accessibility Type,” the Type designation refers to the placement of the cotton indicators used during testing of the equipment. Type 2 equipment is tested with cotton indicators placed on all four sides (front, back, left end, right end) of the test sample. Suffix “B,” as in Type 2B, is explained in IEEE C37.20.7-2007, Annex A.2 and is given to equipment “where normal operation…involves opening the door or cover of compartments specifically identified as lowvoltage control or instrumentation compartments.”

Annex A.2.1 reads,

Suffix B testing requires the placement of indicators directly in front of the low voltage control or instrument compartment(s) adjacent to the compartment in which the arc is initiated with the compartment cover/door(s) removed to evaluate entrance of ionized gases into those compartments.

The Type 2B designation does not imply that the switchgear can be operated with the breaker cubicle doors or the hinged rear doors for the cable and bus compartments opened or removed, nor that the switchgear can be operated continuously with the doors for the metering or auxiliary compartments open. Reference IEEE C37.20.7-2007 IEEE, “Guide for Testing Metal-enclosed Switchgear Rated up to 38 kV for Internal Arcing Faults,” for full details.

Cubicle doors - dead front construction
The circuit breaker cubicle doors are provided with a reinforced escutcheon gasket that protects operators by redirecting the arc flash energy and exhaust gases through the plenum at the top of the enclosure. Each circuit breaker compartment door is provided with two self-latching mechanisms with a single "T" shaped door handle (Figure 6.2).

Behind the circuit breaker compartment door is a dead front gasket (Figure 6-5). When the compartment door is closed, the combination of the dead front gasket and the breaker door gasket provides the necessary sealing for the arc-resistant rating (Figure 6.1).

—
Figure 6.1: Breaker compartment door (closed)

Warning: The breaker compartment door must be closed and latched to maintain the integrity of the arc resistant enclosure. The breaker compartment door should not be opened when the circuit breaker is closed and in the connected position when the equipment is energized.

Compartment handle
T-handles are standard on all cubicle doors. Key lockable handles (Figure 6.2) are optional. To open the door, rotate the handle clockwise to release the latch mechanisms and pull the door outward. Operating the handle is not necessary to close the door. Simply close the door and push on the door directly behind each latching mechanism (Figure 6.3). Confirmation of the door's being latched can be achieved by pulling on the T-shaped handle while not rotating the handle. If a circuit breaker is to be removed from its compartment for an extended period of time, it is strongly recommended that a future breaker door cover (Figure 6.4) and future breaker cassette barrier (Figure 6.5) be installed to keep any potential electrical arcing events contained within the equipment. Refer to DEH-41473 for future cassette and door covers.

—
Figure 6.2: Compartment T-handle

—
Figure 6.3: Breaker compartment door (open)

Breaker compartment for future circuit breakers
When specified, compartments may be supplied for future addition of circuit breaker elements. These compartments are fully equipped with drawout rails, primary disconnects, and ancillary devices as required (e.g., secondary disconnects, accessory devices, etc.). The opening in the breaker compartment door and the opening in the cassette of the compartment are closed with bolted-on steel plates to deter accidental contact with energized electrical circuits (i.e., primary disconnect stab tips) and provide the necessary structural barriers to achieve the arc resistant rating (Figure 6.4 and Figure 6.5).

—
Figure 6-4: Future breaker compartment door (closed)

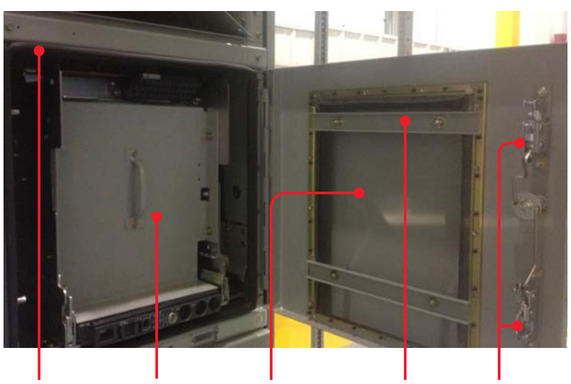


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Figure 6.5: Future breaker compartment door (open)

Rear doors
The standard full-height, hinged and bolted rear doors are shown in Figure 6.6. Doors are secured with bolts on both the hinge side and non-hinge side.

—
Figure 6.6: Bolted rear doors

Rear compartment features
Figure 6.7 and Figure 6.8 show the pressure-activated rear vent flaps for upper and lower vent openings. Normally held open by gravity, they seal the rear vent openings during an arcing fault. Insulated horizontal main bus, phase isolated vertical riser bus, and barriers between sections in the cable and bus compartments are optional design features. Insulated horizontal main bus, phase isolated vertical riser bus, and barriers between sections in the cable and bus compartments are optional design features.

—
Figure 6.7: Rear vent flaps (top)

—
Figure 6.8: Rear vent flaps (bottom)

Steel stiffeners as shown in in Figure 6.9 come standard on rear section doors wider than 30 in.

—
Figure 6.9: Rear door steel stiffene

Figure 6.10 shows the removable floor plates that are standard design for the cable compartment.

—
Figure 6.10: Floor plates

Plenum features

Figure 6.11, Figure 6.12, and Figure 6.13 depict a typical plenum system. The plenum at the top of the enclosure directs the arc flash energy and exhaust gases away from the operator.

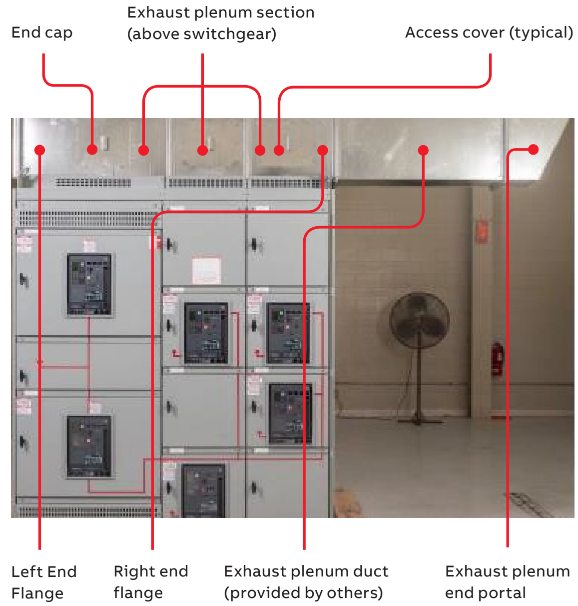

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Figure 6.11: Exhaust plenum system (front view)

Individual plenum sections extending beyond the end of the switchgear, and end caps are provided by a third-party vendor. Their design is based on ABB plenum specifications. Plenum requirements include 23-gauge min. zinc-plated or painted steel, 12” x 20” inside dimensions.

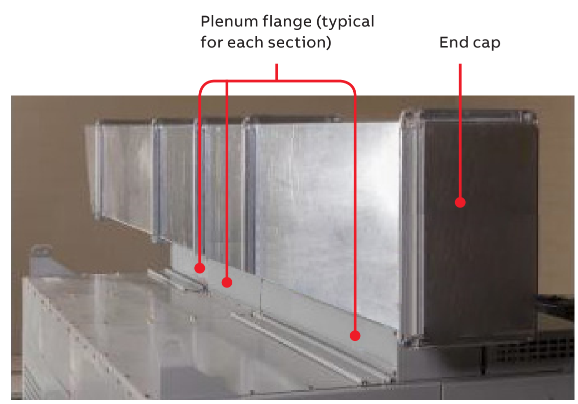

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Figure 6.12: Plenum end cap and flange

The vent flap is raised in Figure 6.13 to show the rodent screen built into the plenum exhaust end assembly.

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Figure 6.13: Plenum rodent screen

Each section (Figure 6.14) of plenum above the switchgear features a plenum flange and access panel for each vertical section.

Common plenum
A single plenum system can be used to connect multiple LV switchgear lineups, which allows for a single external exhaust vent, resulting in a simplified installation and reduced space requirements.

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Figure 6.14: Plenum rodent screen

Exhaust plenum end portal
The exhaust plenum end portal should be located on an exit wall and secured to this structure. If the exit point of the equipment is an exterior wall, the securing of the exhaust end portal must include methods to prevent water ingress between the portal and a structure wall. Care and consideration should be taken when selecting the exhaust end portal location. An area of at least 10 ft. in all directions from the exhaust end portal needs to be clear of obstructions and access to this area should be restricted for safety. The plenum exhaust end assembly with vent flap is furnished by ABB. Vent flap shown in the closed position in Figure 6.15.

—
Figure 6.15: Plenum vent

Portal
Construction of the exhaust plenum between the end flange on the switchgear and the exhaust end portal can vary upon the customer’s construction requirements. Care should be taken to ensure that minimum crosssectional area of the exhaust plenum interior volume be 12 in. by 20 in. The exhaust plenum should be constructed of a corrosionresistant metal with a material thickness of no less than 23 gauge.

Total length of the plenum has no restriction. Elevation changes and turns of no greater than 90° are acceptable, but should be kept to a minimum. Figures 6.16 through 6.17 show the front dimensional vier and cross-sectional view of AR low voltage switchgear.

Notice: The minimum unobstructed ceiling height,from the base of the switchgear is 10ft. to install the exhaust plenum system.

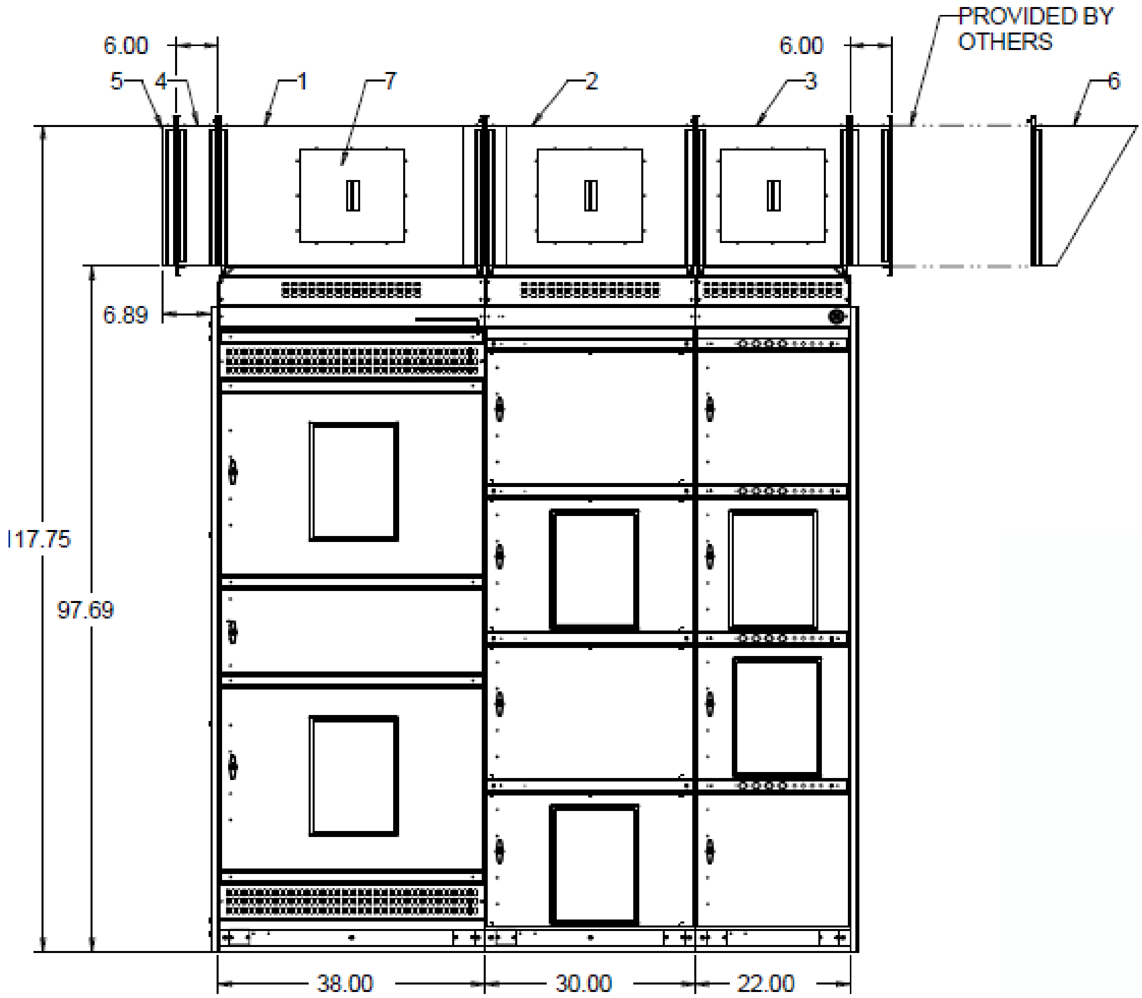

Figure 6.16: Outline of typical AR low voltage switchgear (front view, in inches)

1. Exhaust plenum section, 38 in. stack
2. Exhaust plenum section, 30 in. stack
3. Exhaust plenum section, 22 in. stack
4. Transition adaptor section (typical)
5. End cap
6. Exhaust plenum end portal
7. Exhaust plenum access cover (typical)

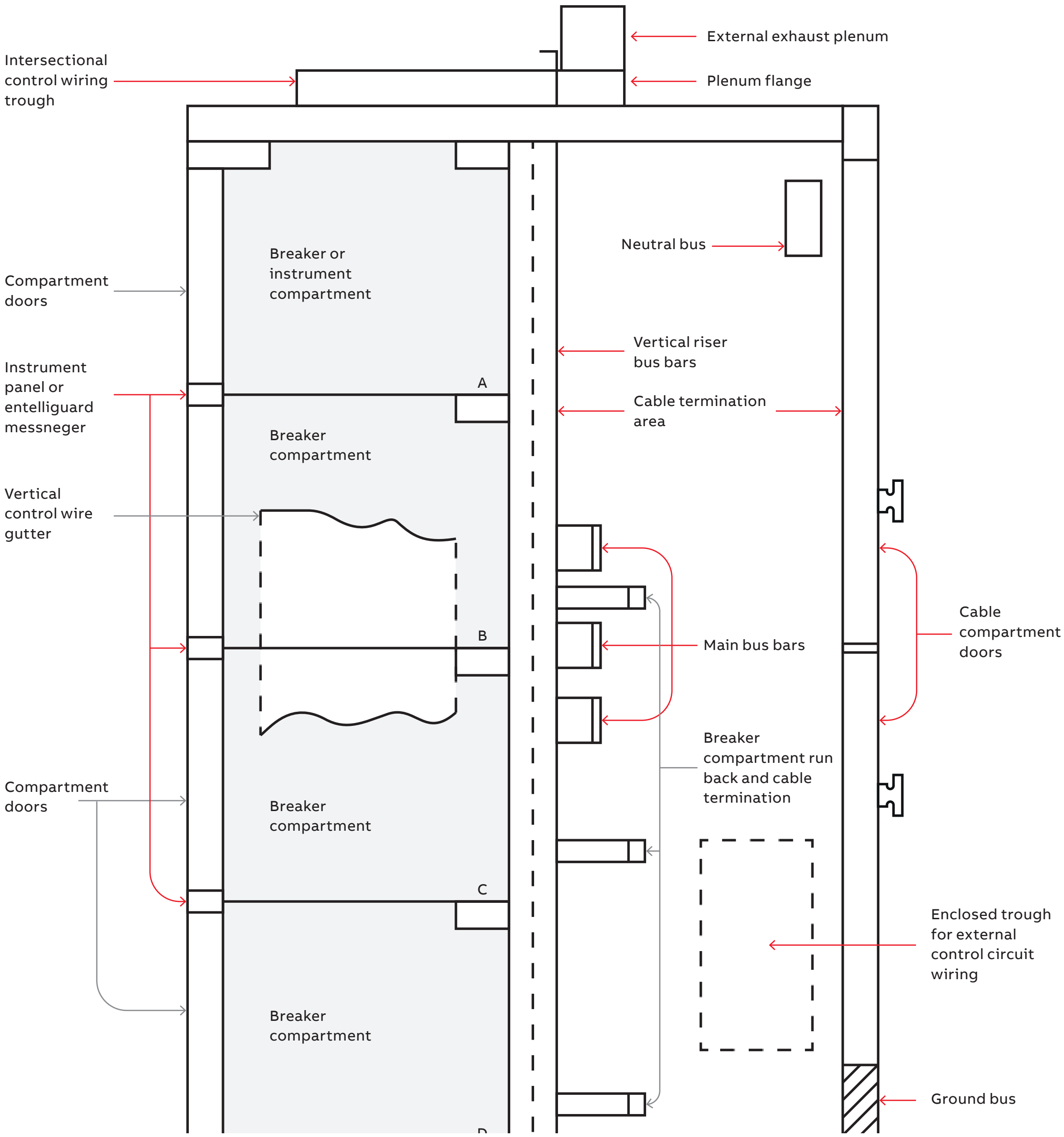

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Figure 6.17: Cross-sectional view of AR low voltage switchgear

Figure 6.18 shows a typical indoor enclosure floor plan and cable entry space. Table 6.1 shows the enclosure depths, cable direction, and cable space for AKD-20 AR and Entellisys AR.

- **Note 1: Offset ground bus**. If greater than six ground lugs are required in the same section, an offset ground bus is provided. When the offset ground bus and cable entry are located both bottom or above, it will reduce the available cable space.
- **Note 2: Neutral bus (optional, AKD-20AR only).** When this option is provided and the neutral bus and cable entry is located both at bottom or top, it will reduce the available cable space.
- **Note 3: Neutral bus (optional, Entellisys AR only).** When this option is provided and the neutral bus and cable entry are located both at bottom or top, it will reduce the available cable space.
- **Note 4: Cable direction below.** If the section does not have a circuit breaker in the "D" compartment, an additional 4 in. of cable space is available.
- **General:** Secondary control lead space may be required on left, right, or both sides of the cable compartment. Consult factory drawings for details.

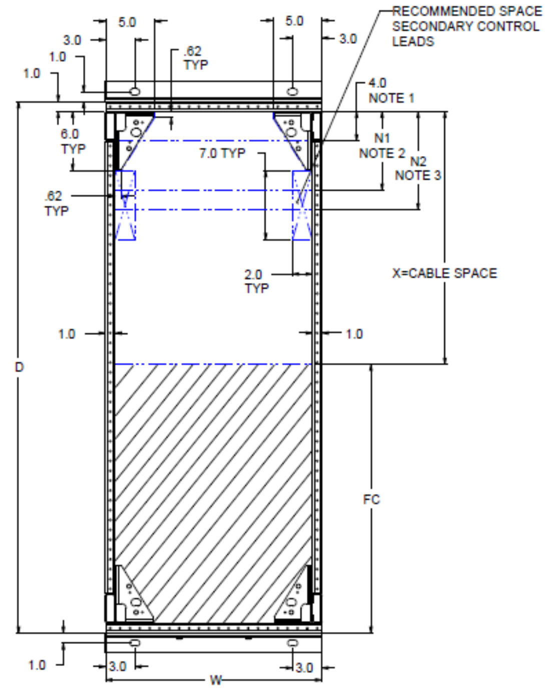

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Figure 6.18: Indoor enclosure floor plan and cable entry space (in inches)

Table 6.1: Indoor enclosure depth, cable direction, and cable space (in inches)

Section Width (W)	Section Width (D)	Front Compartment (FC)	Horizontal Bus Rating (Amperes)	Cable Direction (Note 4)	Cable Space (X)	AKD-20 AR Only (Note 1)	Entellisys AR Only (Note 2)
22, 30, 38	54	33	≤ 4000	Below	16	9	10.25
				Above	20		
	60	33	≤ 4000	Below	22		
				Above	26		
		40	≤ 5000	Below	15		
				Above	19		
	67	33	≤ 4000	Below	29		
				Above	33		
		40	≤ 5000	Below	22		
				Above	26		
	74	33	≤ 4000	Below	36		
				Above	40		
		40	≤ 5000	Below	29		
				Above	33		

Figures 6.19 and 6.20 show a typical side view of AKD-20 AR with reference Table 6.2 for dimensions. Figure 6.21 shows the outline of typical AR door features.

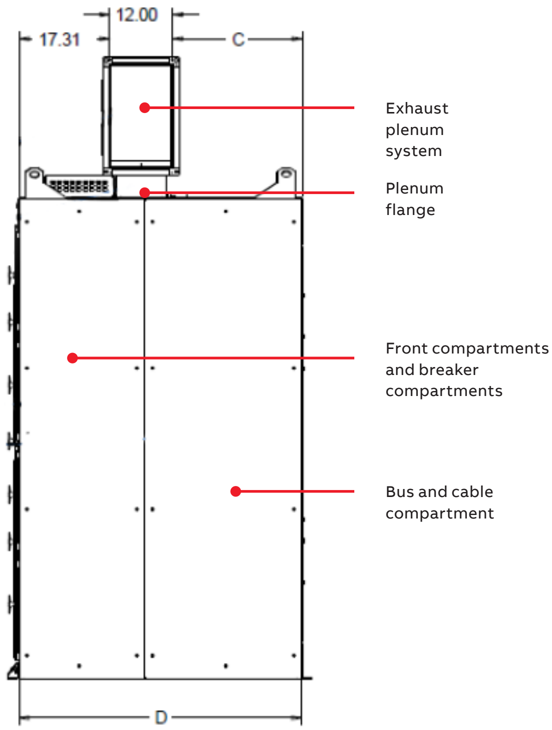

Figure 6.19: Outline of typical AR low voltage switchgear (side view)

Table 6.2: Arc-resistant low voltage switchgear assembly depths (in inches)

Dimension				Depth
C	24.74	24.74	37.74	44.74
D	54	60	67	74

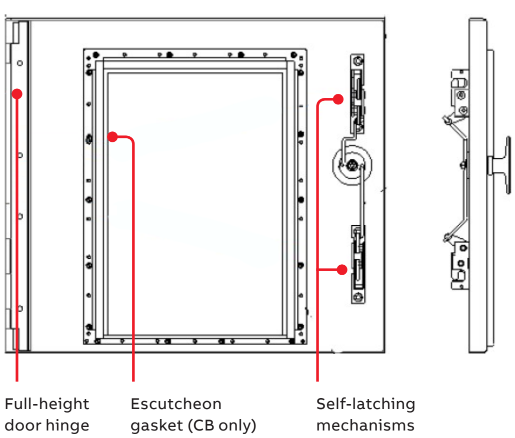

Figure 6.21: Outline of AR door features

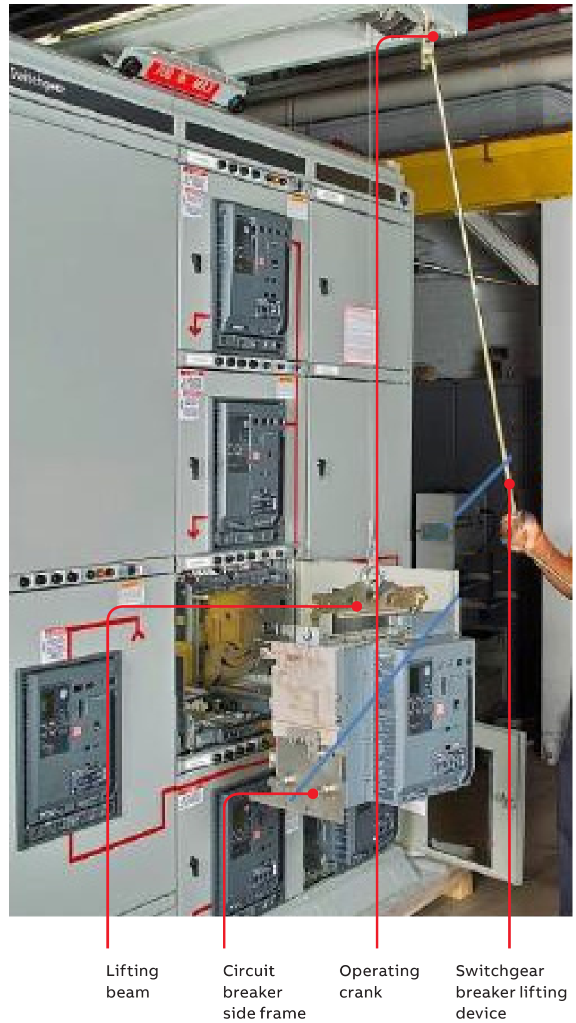

Figure 6.20: Outline of typical AR low voltage switchgear (side view)

Warning: The breaker compartment door must be closed and latched to maintain the integrity of the arc resistant enclosure. The breaker compartment door should not be opened when the circuit breaker is closed and in the connected position when the equipment is energized.

—

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DET-890 Rev B January 2020