POWER/VAC®
Application Guide

GENERAL ELECTRIC

POWER/VAC®
Metalclad Switchgear
Application Guide

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West Burlington, Iowa

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Sections

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Section 1
Power/Vac Switchgear Concepts

POWER/VAC Switchgear Concepts

USE OF APPLICATION GUIDE

This *Application Guide* provides information necessary to help plan and specify medium-voltage power system switchgear, using General Electric's POWER/VAC® vacuum metalclad switchgear application procedure in an orderly, step-by-step manner. Since it is intended to be a workbook, only the data necessary to choose applicable switchgear is included.

Complete specifications can be written for most switchgear applications using this publication. Guidance is given in developing a system one-line diagram, calculating short circuit currents, and references to appropriate literature is presented. This technical information goes beyond the usual scope of an application guide. General Electric, under special contract agreements, will perform power system studies, including the necessary calculations and comparisons.

The topics discussed in the first five sections of this guide are of a general nature, applicable to any type of medium-voltage metalclad switchgear. Information is provided relating to one-line diagrams, circuit breaker ratings and selection, control power requirements, basic circuit protections considerations, and specific recommendations for protection, instrumentation, and control for basic switchgear circuits.

The remainder of the application guide explains the application and specification of General Electric POWER/VAC metalclad switchgear. The concepts of modular construction and device package structuring are basic to POWER/VAC switchgear and are introduced and illustrated through application details covering the use of POWER/VAC switchgear and are introduced and illustrated through application details covering the use of POWER/VAC breakers in basic circuit applications. Auxiliary unit and power conductor compartment structuring are also included. Following the selection of individual units, an optimum lineup configuration can be developed using the guidelines given. Finally, a specification procedure, complete with Guide Form Specifications, is suggested to facilitate the documentation of POWER/VAC metalclad switchgear requirements. This approach to metalclad switchgear application is typical and its use is recommended. Where practical, begin with Section 2 and work through the guide in a step-by-step fashion. The guide's structure is based on extensive engineering experience and will service as a checklist which will aid in preparing complete specifications.

Since the application of POWER/VAC metalclad switchgear is the underlying purpose of this guide, a brief introduction of POWER/VAC will serve as useful starting point to begin the application procedure.

POWER/VAC METALCLAD SWITCHGEAR

POWER/VAC metalclad switchgear is designed for applications on 5-kV, 8.25V, and 15-kV power systems with available short-circuit capacities from 250 through 1500 MVA nominal. A typical lineup of indoor POWER/VAC switchgear is shown in Figure 1-1.

Figure 1-1. Typical lineup of indoor POWER/VAC switchgear.

POWER/VAC circuit breakers are rated per ANSI C37.06-1979, Table 3.1.1. Available ratings are shown on page 3-3 of this application guide.

POWER/VAC switchgear is designed, built, and tested to the applicable industry standards shown in Table 1-1.

POWER/VAC equipment is furnished in five basic types; indoor, outdoor weather proof (no aisle), protected-aisle outdoor, common-aisle outdoor (aisle shared by two facing lineups) and arc resistant. Figure 1-2 shows typical section outlines for each of the basic equipment types. Dimensions and weights are shown in Section 8.

Table 1-1. Applicable Industry Standards

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) 1430 Broadway New York, New York 10018		NATIONAL ELECTRICAL MANUFACTURERS ASS'N (NEMA) 2101 L St. NW, Suite 300 Washington, D.C. 20037	
Standard No.	Description	Standard No.	Description
C37.04	AC Power Circuit Breaker Rating Structure	SG-2	High-voltage Fuses
C37.06	Preferred Ratings of Power Circuit Breakers		
C37.09	Test Procedure for Power Circuit Breakers	SG-4	Power Circuit Breakers
C37.010	Application Guide for Power Circuit Breakers	SG-5	Power Switchgear Assemblies
C37.11	Power Circuit Breaker Control Requirements		
C37.20	Switchgear Assemblies and Metal-Enclosed Bus		
C37.100	Definitions for Power Switchgear		

Compliance with other National Standards (Must be reviewed with marketing Burlington, IA)

International Electrotechnical Commission Standards (IEC)

Power/Vac vacuum circuit breakers Type VB and Type VB1 comply with IEC ratings listed in Table 3.1.3

Underwriters Laboratories, Inc. (UL)

Power/Vac vacuum metalclad switchgear and associated circuit breakers are optionally available with UL labeling per UL standard 1670.

The requirement for UL labeling must be made known as a requirement in the bidding stage and agreed to by Switchgear Marketing, Burlington, Iowa. UL labeling under File No. E138019 category DLAI.

CAUTION: Not all medium voltage switchgear assemblies qualify for UL listing.

Canadian Standards Association (CSA)

Power/Vac metalclad switchgear and associated circuit breakers are optionally available with CSA markings and are in compliance with CSA C22.2 NO. 31.

Requirements for CSA marking must be made known as a requirement in the bidding stage and agreed to by Switchgear Marketing, Burlington, Iowa. CSA File NO. LL-95616-2.

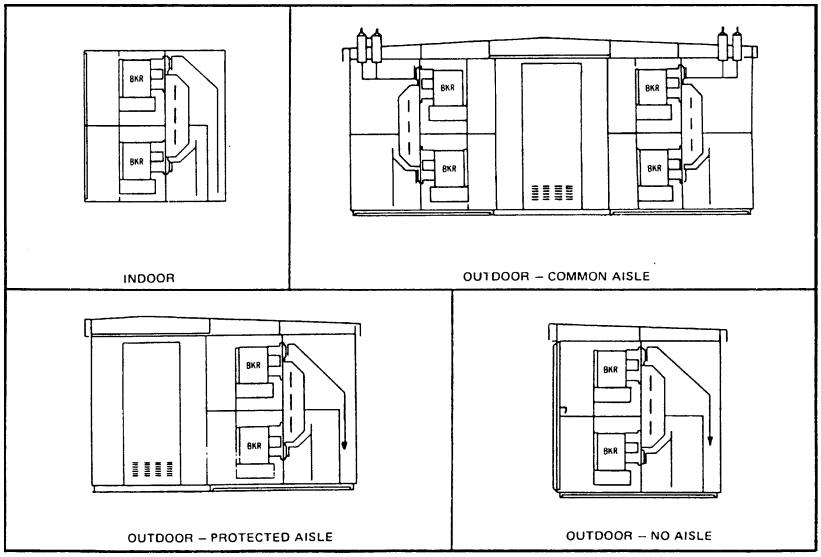
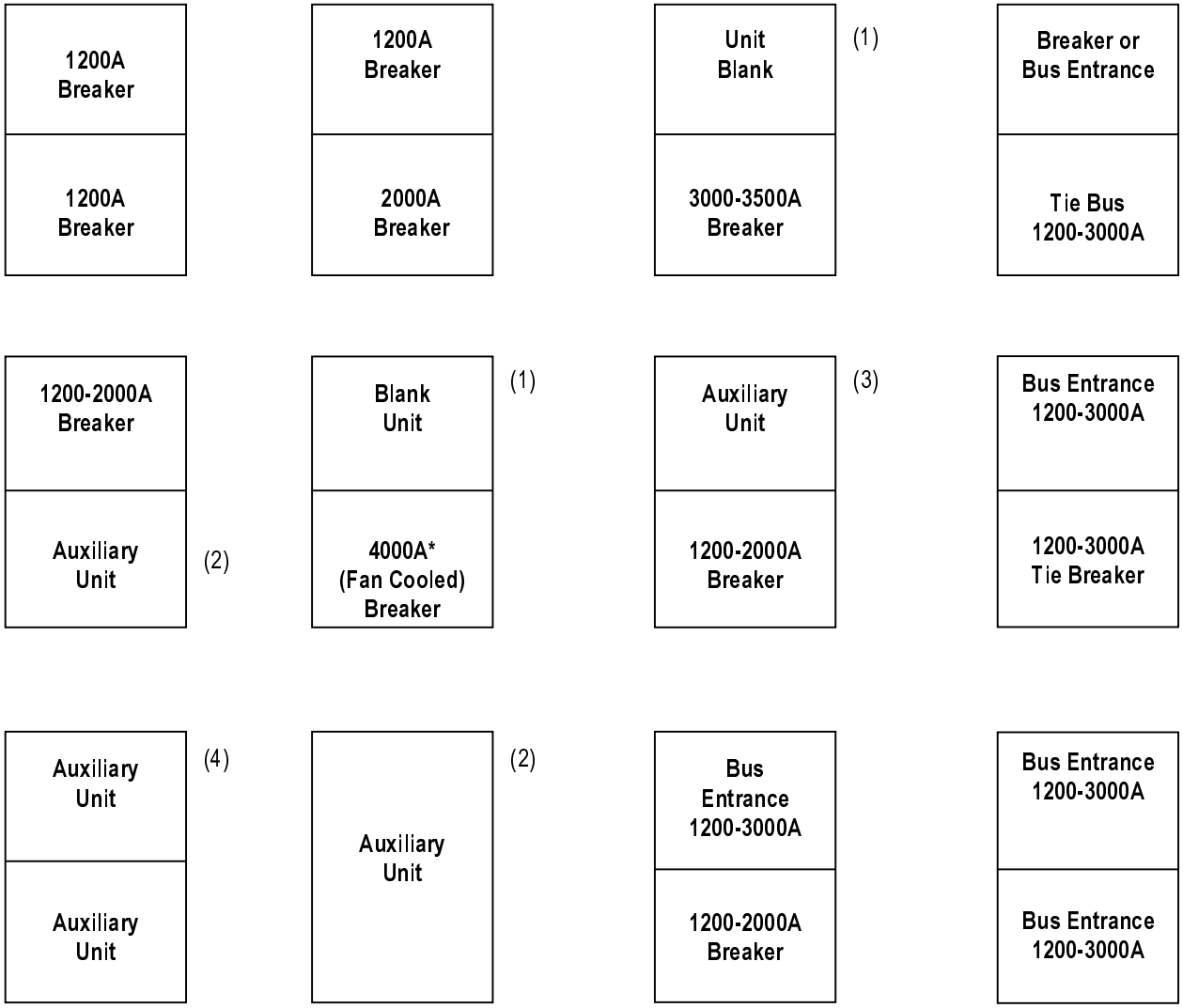


Figure 1-2. Typical section outlines

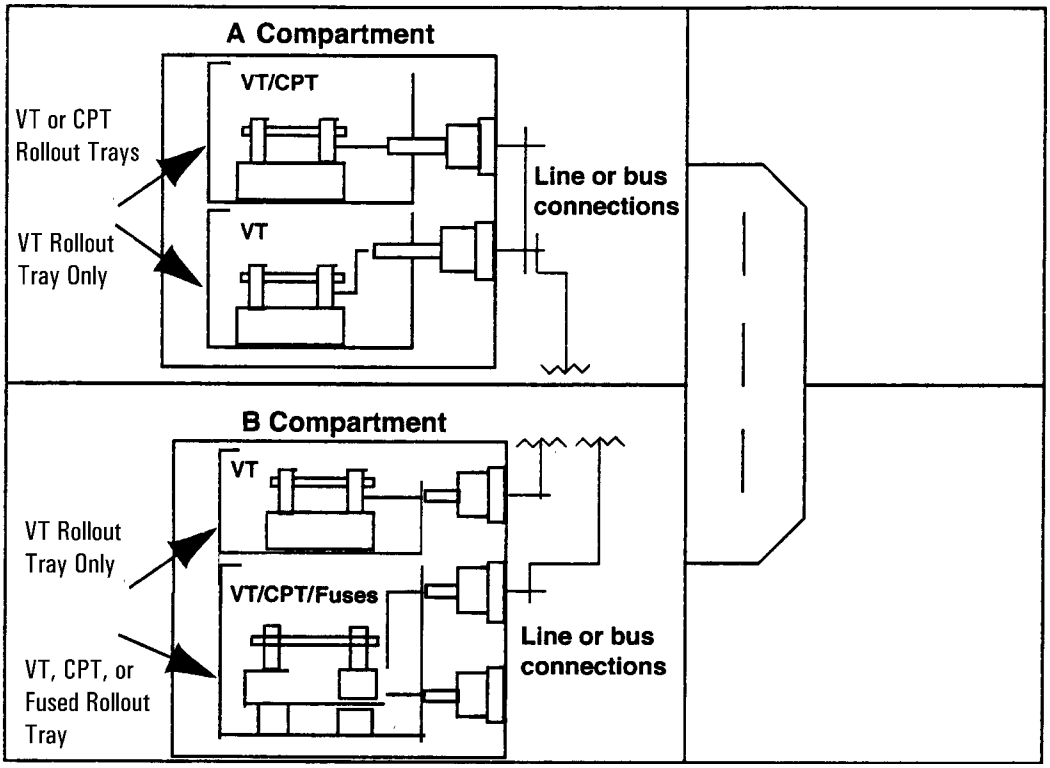
Available Unit Combinations



Note:
(1) Blank Unit (above 3000A, 3500A & 4000A breakers)—device mounting space in door.
(2) Auxiliary Unit: Adjacent to tie breaker for tie bus auxiliary. Can house 1 bus connected roll-out tray.
(3) Auxiliry Unit: Used for line or bus connected roll-out trays when located above or below a circuit breaker.
(4) Can house 2 rollouts in A and/or B compartment. See figure 1-5

Figure 1-4. Twelve standard combinations of upper and lower units

Rollouts



Devices	Ratings	Roll-out Unit	A Compartment		B Compartment	
			Lower	Upper	Lower	Upper
3-VT's (1)	5kV and 15kV	--	Yes	Yes	Yes	Yes
2-VT's (1)	5kV and 15kV	--	Yes	Yes	Yes	Yes
1-CPT (1)	5/10/15 kVA	--	No	Yes	Yes	No
1-CPT (2)	25kVA and 37.5kVA	--	No	No	No	No
CPT Fuses (3)	--	Fused Unit	No	No	Yes	No

Figure 1-5 Auxiliary Devices

(1) Fuses are an integral part of the device.
(2) CPT has to be installed in cable compartment. CPT fuses are installed in a key interlocked fused roll-out in Lower B or middle A drawer.
(3) Must have a key interlock for CPT secondary breaker.

Notes:

- In "A" Compartment: Upper and lower roll-out can be either bus or line connected as long as both roll-outs in a same compartment are connected in the same manner.
- In "B" Compartment: Only one roll-out can be installed in an auxiliary tie bus compartment.

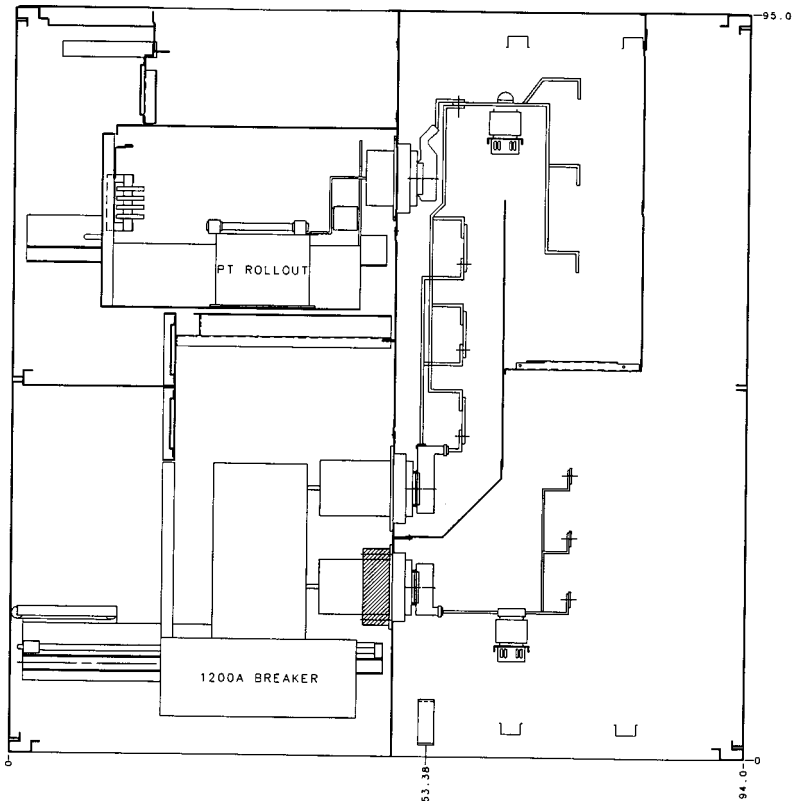


Figure 1-6
Breaker with PT Line Side Connected

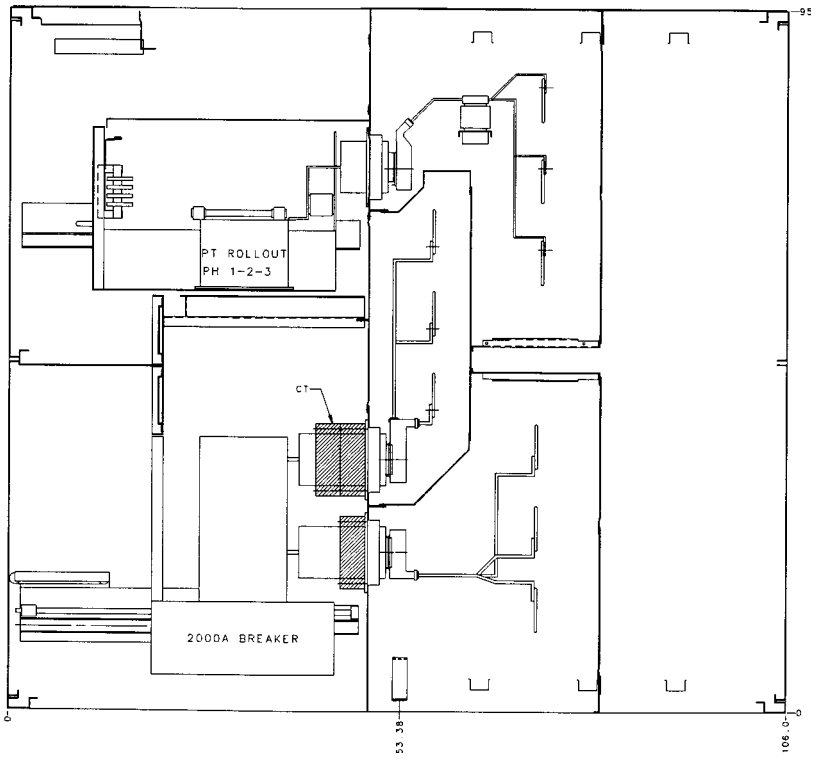
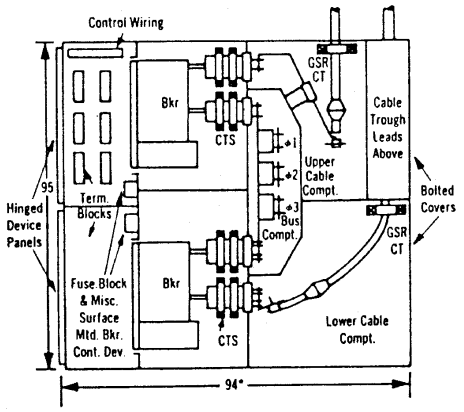


Figure 1-7
Breaker with PT Load Side Connected

POWER/VAC Switchgear Concepts

Typical Equipment Section Views

Typical 2 Bkr. Feeder Unit Clamp Type Term. For Cable Above

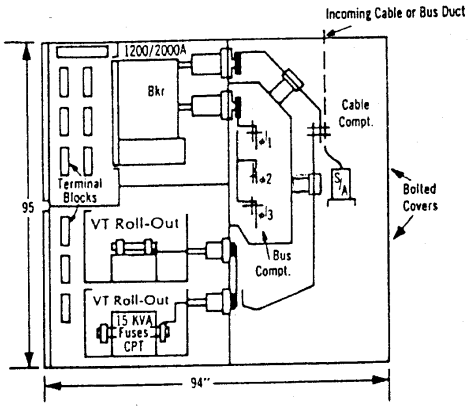


*STD. (82" Optional. See Note Under "Cable Compt.")

BUS COMPARTMENT

- 1200A and 2000A: Copper standard.
- 3000A bus and 3500A bus is copper only.
- Bus supports designed for 80,000A momentary.
- All joints connected with 2 bolts and booted.
- Bus support insulation system:
  Non-tracking polyester glass (std. 5kV & 15kV)
  Porcelain inserts (optional)
  Fluidized bed epoxy bus insulation.

Typical Incoming Line Unit With Main Breaker & CPT & VT Roll-outs in Same Unit



*STD. (82" Optional. See Below)

CABLE COMPARTMENT

- Designed for up to 2-750 MCM/ ∅ per breaker, cables above or below.
- CT's with greater than ANSI accuracy must be mounted in cable compartment and may limit such cases to one breaker per vertical section.
- Stress cone space of 21 inches is provided and use of preformed stress cones, such as GE Termimatic ™, is recommended.
- * Certain simple cable compartment configurations such as clamp type terminations for one moderate-sized cable per phase, with or without Ground Sensor, permit a unit depth of 82 inches on indoor units.

Figure 1-6. Possible combinations of upper and lower units.

PIC PACKAGES

Available PIC packages (Protection, Instrumentation, and Control) complement POWER/VAC structured equipment and breaker designs. A PIC package for application on a general-purpose feeder is shown in Figure 1-7. Structured PIC packages contain all door-mounted devices such as relays, switches, meters, and instruments, and all non-door-mounted devices such as fuses, current transformers, and voltage transformers that are required for proper circuit operation in a wide variety of basic switchgear applications. Because PIC packages are pre-engineered, the specific devices included in the materials list are provided. See Section 6 for frequently applied packages.

SUMMARY

In summary, POWER/VAC switchgear differs in design and construction from traditional single breaker, air-magnetic, and vacuum switchgear designs. From an electrical standpoint, however, the application procedures and guidelines for POWER/VAC are identical to those for other types of metalclad switchgear. This guide provides direction for proper application of POWER/VAC switchgear.

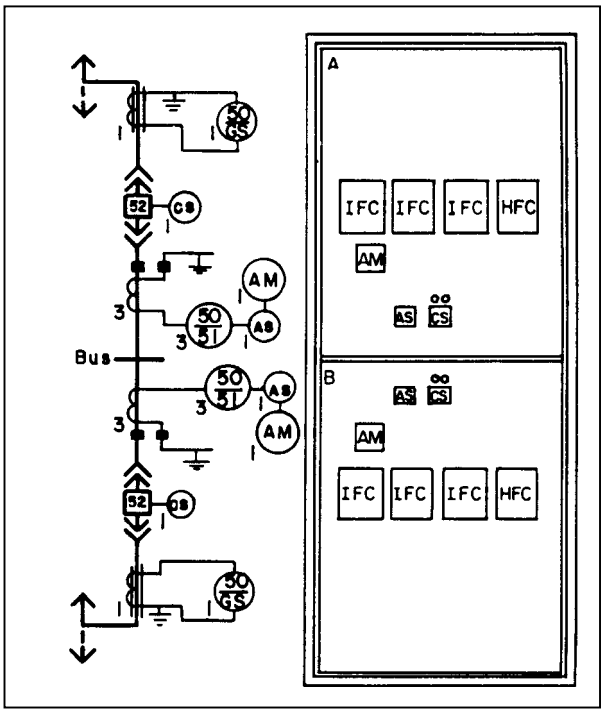


Figure 1-7. PIC package application on a general purpose feeder.

Contents

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Section 2
System One-Line Diagram

System One-Line Diagram

INTRODUCTION

The first step in preparing a specification for metalclad switchgear is to develop a one-line diagram. A one-line diagram (single unit) is "a diagram that shows, by means of single line and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein." (See Ref. 1 on Page 2-10.)

When preparing switchgear one-line diagrams, use graphic symbols in accordance with IEEE and ANSI standards listed in References 2 and 3 on page 2-10.

One-line diagrams employ device function numbers which, with appropriate suffix letters, are used to identify the function of each device in all types of partially automatic, fully automatic, and in many types of manual switchgear. A complete list of such device function numbers is published in C37.2.1979 and shown in Table 2-2.

DEVELOPING A ONE-LINE DIAGRAM

To illustrate the development of a one-line diagram, a typical resistance grounded system has been chosen. The same general procedures would apply to solidly grounded distribution systems.

Three steps are used in producing a one-line diagram: the preliminary diagram, followed by the partially developed diagram, and finishing with the developed diagram.

The abbreviations used for principal meters, instruments, and other devices (not including relaying, which is listed in Table 2-2), as found in the application guide, are listed in Table 2-1.

Each device in an automatic switching equipment has a device function number which is placed adjacent to or within the device symbol on all wiring diagrams and arrangement drawings so that its function and operation may be readily identified.

These numbers are based on a system which was adopted as standard for Automatic Switchgear by the American National Standards Institute and appear in ANSI C37.2-1979. (See Ref. 4 on page 2-10.)

Table 2-2 is a list of device numbers and functions as taken from this standard.

Table 2-1. Abbreviations

Abbr.	Description		Abbr.
AM	Ammeter	S	Synchronous motor
AS	Ammeter switch	S/A	Surge arrester
Aux	Auxiliary	SS	Synchronizing switch
Bkr	Breaker	SYN	Synchroscope
CO	Cut off switch	SYN BR	Synchronizing bracket
CPT	Control power transformer	TD	Test device
CS	Control switch	VAR	Varmeter (one-line)
CT	Current transformer	V ARM	Varmeter (device list)
FA	Field ammeter	VM	Voltmeter
FM	Frequency meter	VR	Voltage regulator
G	Generator	VS	Voltmeter switch
GS	Governor switch	WHM	Watthour meter
I	Induction motor	WHDM	Watthour demand center
VT	Voltage transformer	WM	Wattmeter

Table 2-2. ANSI Standard Device Function Numbers

Dev. No.	Function
1	Master Element
2	Time-Delay Starting or Closing Relay
3	Checking or Interlocking Relay
4	Master Contactor
5	Stopping Device
6	Starting Circuit Breaker
7	Anode Circuit Breaker
8	Control Power Disconnecting Device
9	Reversing Device
10	Unit Sequence Switch
11	Reserved for future application
12	Over-Speed Device
13	Synchronous-Speed Device
14	Under-Speed Device
15	Speed or Frequency Matching Device
16	Reserved for future application
17	Shunting or Discharge Switch
18	Accelerating or Decelerating Device
19	Starting-to-Running Transition Contactor
20	Electrically Operated Valve
21	Distance Relay
22	Equalizer Circuit Breaker
23	Temperature Control Device
24	Reserved for future application
25	Synchronizing or Synchronism-Check Device
26	Apparatus Thermal Device
27	Undervoltage Relay
28	Flame Detector
29	Isolating Contactor
30	Annunciator Relay
31	Separate Excitation Device
32	Directional Power Relay
33	Position Switch/Cell Switch
34	Master Sequence Device
35	Brush-Operating or Slip-Ring Short-Circuiting Device
36	Polarity or Polarizing Voltage Device
37	Undercurrent or Underpower Relay
38	Bearing Protective Device
39	Mechanical Condition Monitor
40	Field Relay
41	Field Circuit Breaker
42	Running Circuit Breaker
43	Manual Transfer or Selector Device
44	Unit Sequence Starting Relay
45	Atmospheric Condition Monitor
46	Reverse-Phase or Phase-Balance Current Relay
47	Phase-Sequence Voltage Relay
48	Incomplete Sequence Relay
49	Machine or Transformer Thermal Relay
50	Instantaneous Overcurrent or Rate-of-Rise Relay
51	AC Time Overcurrent Relay
52	AC Circuit Breaker
53	Exciter or DC Generator Relay
54	Reserved for future application
55	Power Factor Relay
56	Field Application Relay
57	Short-Circuiting or Grounding Device
58	Rectification Failure Relay
59	Overvoltage Relay
60	Voltage or Current Balance Relay
61	Reserved for future application
62	Time-Delay Stopping or Opening Relay
63	Pressure Switch
64	Ground Protective Relay
65	Governor
66	Notching or Jogging Device
67	AC Directional Overcurrent Relay
68	Blocking Relay
69	Permissive Control Device
70	Rheostat
71	Level Switch
72	DC Circuit Breaker
73	Load-Resistor Contactor
74	Alarm Relay
75	Position Changing Mechanism
76	DC Overcurrent Relay
77	Pulse Transmitter
78	Phase-Angle Measuring or Out-of-Step Protective Relay
79	AC Reclosing Relay
80	Flow Switch
81	Frequency Relay
82	DC Reclosing Relay
83	Automatic Selective Control or Transfer Relay
84	Operating Mechanism
85	Carrier or Pilot-Wire Receiver Relay
86	Locking-Out Relay
87	Differential Protective Relay
88	Auxiliary Motor or Motor Generator
89	Line Switch
90	Regulating Device
91	Voltage Directional Relay
92	Voltage and Power Directional Relay
93	Field-Changing Contactor
94	Tripping or Trip-Free Relay
95	Used only for specific applications in individual installations where none of the assigned numbered functions from 1-94 are suitable.
96	
97	
98	
99	

System One-Line Diagram

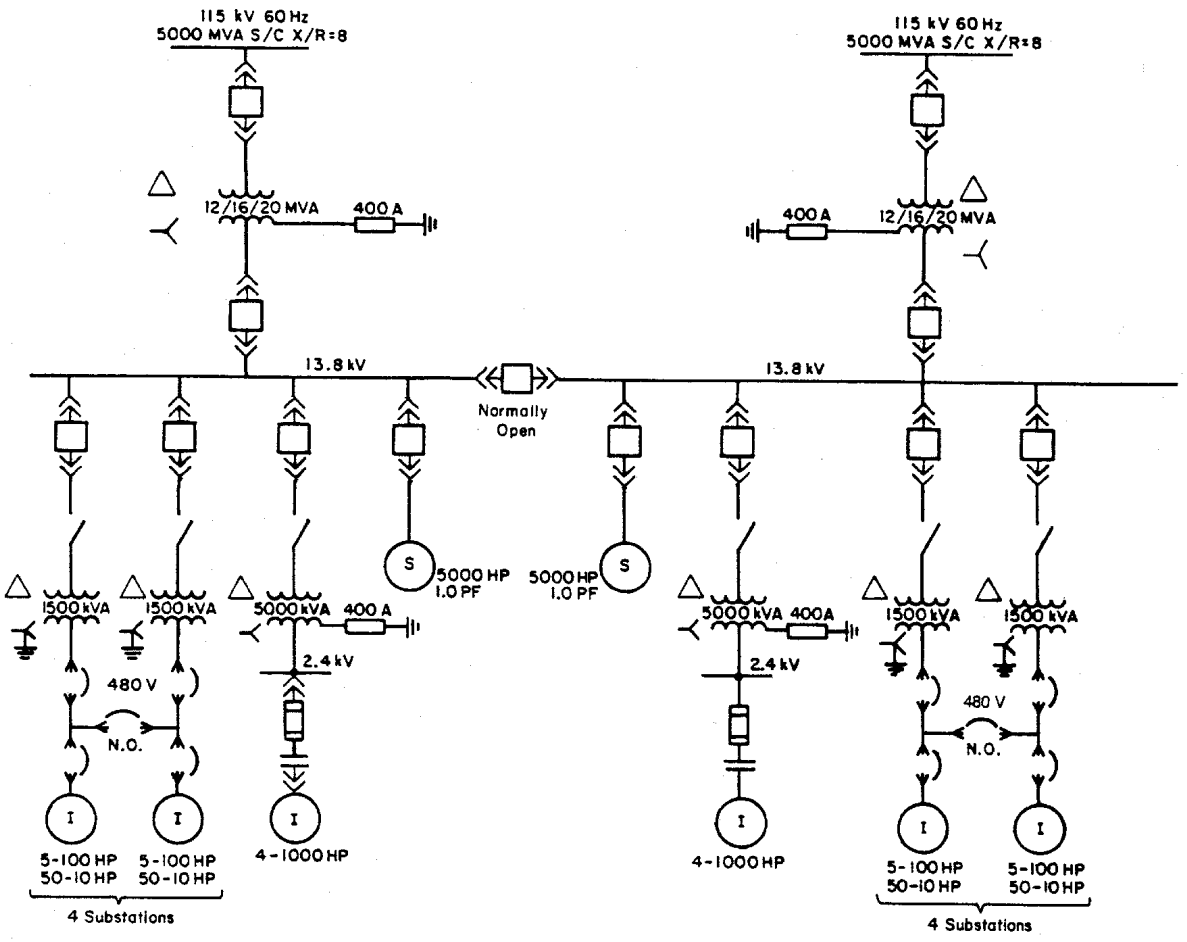


Figure 2-1. Preliminary one-line diagram

PRELIMINARY ONE-LINE DIAGRAM

On this diagram (Figure 2-1) show:

- System voltage and major component ratings.
- Major medium-voltage cable lengths, sizes, and construction. (Not shown in example.)
- Approximate number and ratings of all motors.
- Supply system available short-circuit capability in symmetrical MVA (plus X/R ratio) or per unit R+jX (on a given base).

Using data on the one-line diagram, perform short-circuit calculations:

- Compare the calculated "first cycle" (Momentary) asymmetrical current duty with the close and latch circuit breaker capability.
- Compare the calculated "1-1/2 to 4-cycle" (interrupting) current duty with the circuit breaker symmetrical interrupting capability. (See Ref. 3 on page 3-15.)
- Determine the applicable circuit breaker ratings.
- Compare the feeder cable short-circuit heating limit with the maximum available short-circuit current time K_t times K_o. (See Ref. 10 and 12 on page 3-15.)

Note that the calculations performed in accordance with Reference 5 (on page 3-15) determine only medium and high-voltage circuit breaker ratings. Perform short-circuit studies to determine relay operating currents in accordance with procedures outlined in Reference 6 (on page 3-15). For other than power circuit breakers, refer to the appropriate ANSI standard for short-circuit calculation procedure.

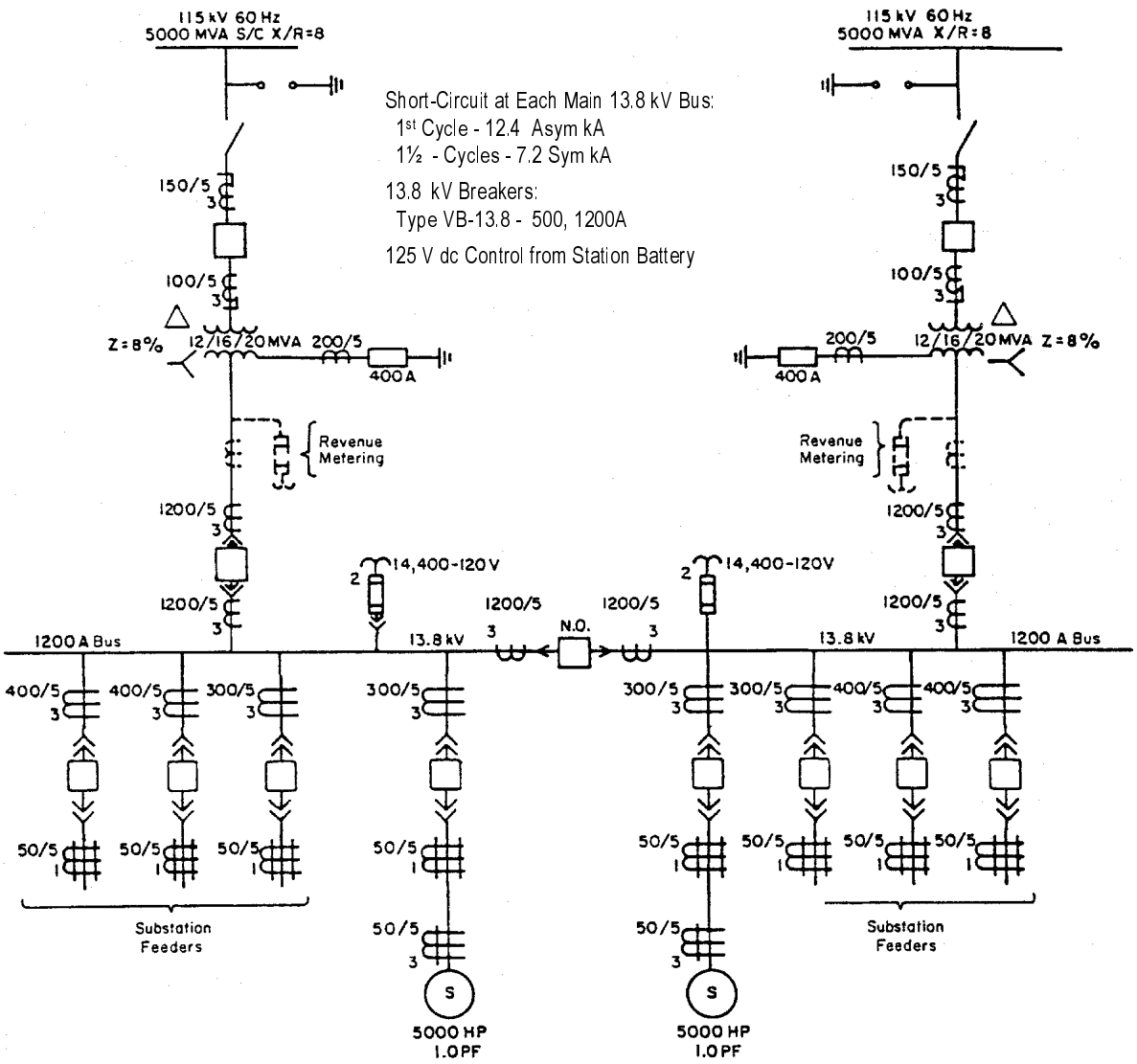


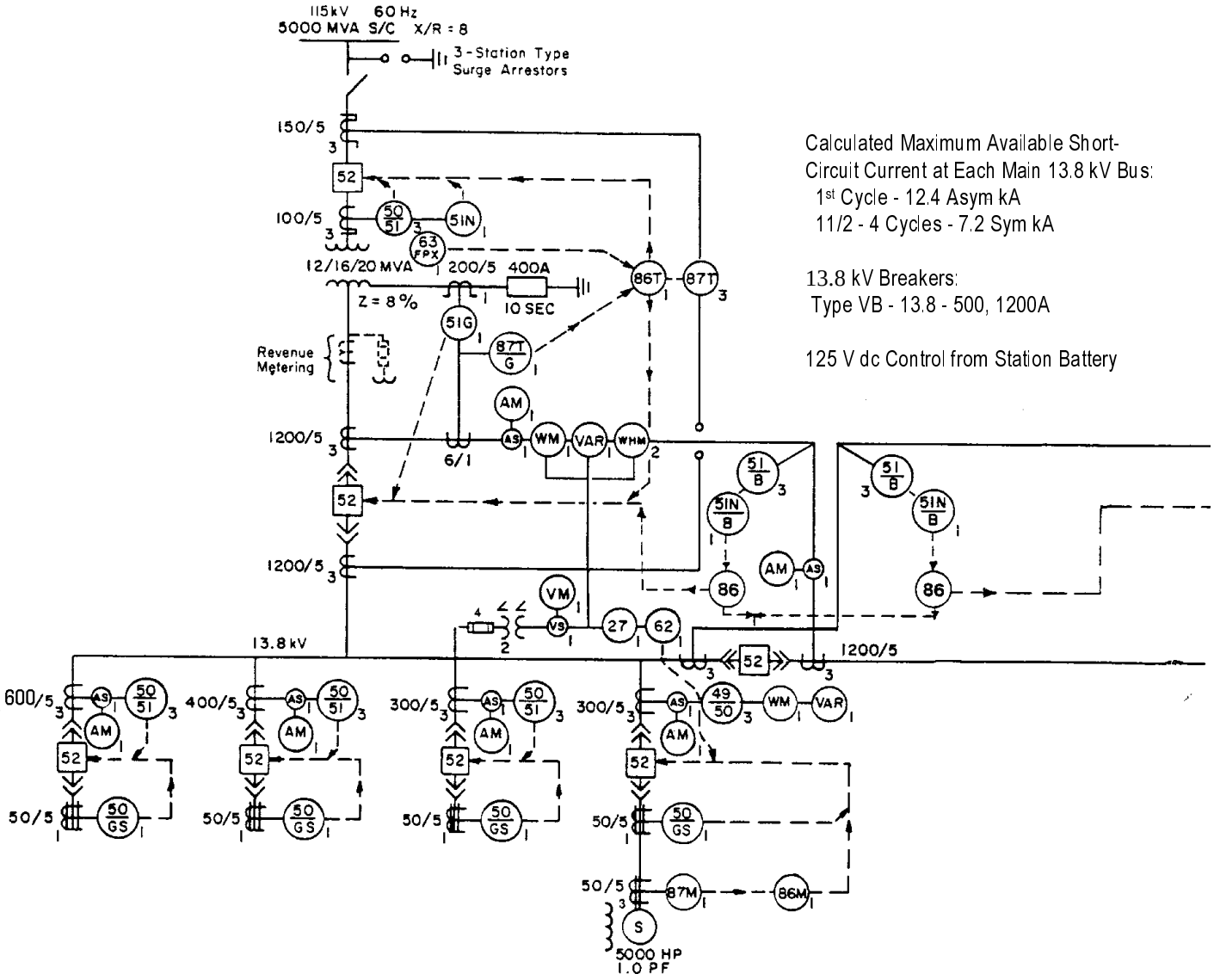
Figure 2-2. Partially developed one-line diagram.

PARTIALLY DEVELOPED ONE-LINE DIAGRAM

Using the sample system, a partially developed one-line diagram is shown in Figure 2-2. On this diagram, the specifier should:

- Show the results of the short-circuit calculations performed, using the preliminary one-line diagram and selected circuit breaker ratings.
- Show ratings selected for external devices, such as grounding resistors, control power transformers, considering the type of protective relaying instrumentation and metering required.
- Select tentative current transformer (CT) ratios in considering the maximum transformer rating, motor ratings, and ampacity of the circuits involved. (See Section 5.)
- Locate current transformers and voltage transformers, considering the type of protective relaying instrumentation and metering required.

System One-Line Diagram



Calculated Maximum Available Short-Circuit Current at Each Main 13.8 kV Bus:
1st Cycle - 12.4 Asym kA
11/2 - 4 Cycles - 7.2 Sym kA

13.8 kV Breakers:
Type VB - 13.8 - 500, 1200A

125 V dc Control from Station Battery

DEVELOPED ONE-LINE DIAGRAM

A developed one-line diagram for the system is shown in Figure 2-3. In addition to the information shown on the partially developed one-line diagram, the specifier should:

- Show all relaying, instrumentation, and metering.
- Select relaying, instrumentation, and metering using the information given in Sections 5 and 6 of this Application Guide.
- Confirm the selection of relay ratings and characteristics by performing a complete system short-circuit and coordination study. (See Ref. 7 through 10 on page 2-10.)
- Include in the study an examination of all circuits for compliance with applicable local and national codes. (See Ref. 11 on page 2-10.)
- Verify that all circuit conductors are applied within the conductor short-circuit heating limit. (See Ref. 10 on page 2-10.)

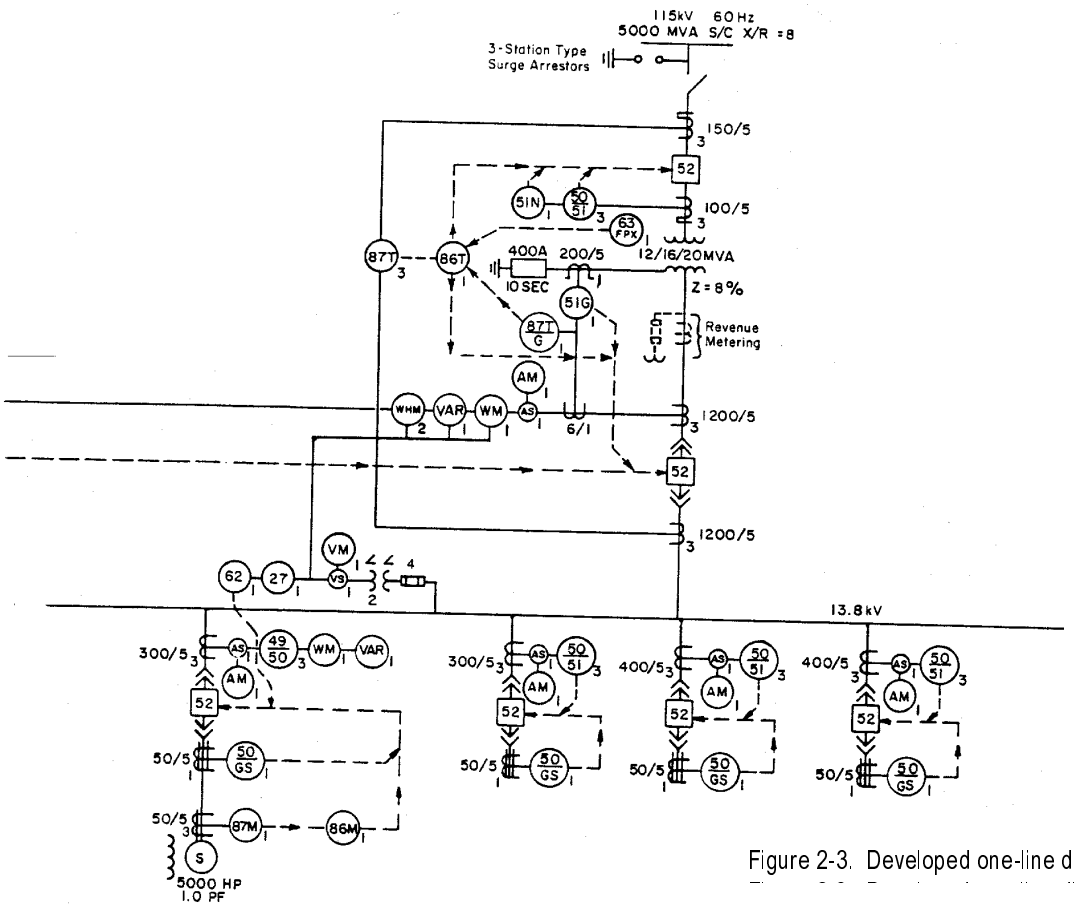


Figure 2-3. Developed one-line diagram

Protective Relays

50/51	Phase Time & Instantaneous Relay	87T/G	Transformer Ground Differential Relay
51N	Residually Connected Time Overcurrent Relay	86T	Transformer Lockout Relay
51G	Ground Time Overcurrent Relay	87M	Motor Differential Relay
50/GS	Ground Sensor Instantaneous Overcurrent Relay	86M	Motor Lockout Relay
51/B	Phase Time Overcurrent Relay	49/50	Motor Thermal & Instantaneous Relay
51N/B	Residually Connected Time Overcurrent Relay	27	Undervoltage Relay
87T	High Speed Transformer Differential Relay	62	Time (Typical) 0.5 to 5 seconds

ADAPTING ONE-LINE DIAGRAM TO EQUIPMENT

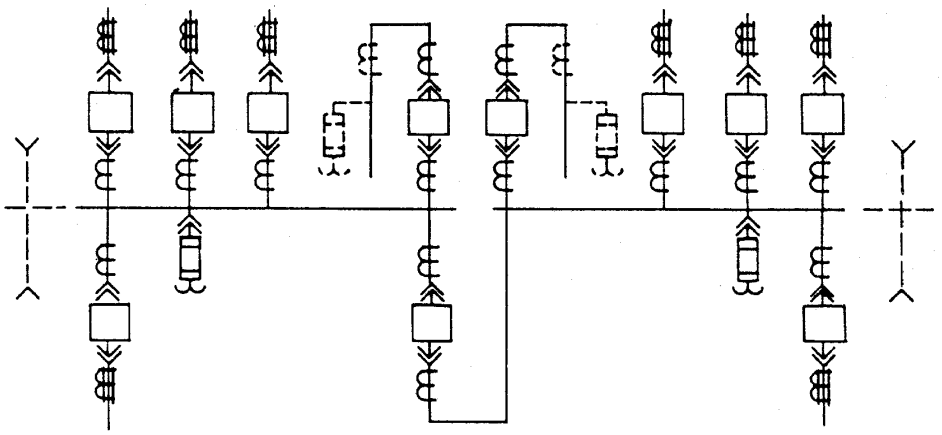
Figure 2-4 shows two possible arrangements of POWER/VAC metalclad switchgear as developed from the one-line diagram in Figure 2-2. Both save space when compared to air-magnetic metalclad switchgear, and both permit the addition of future units on either end.

The arrangements shown are not the only ones which can be developed to satisfy the conditions of the one-line diagram. Use the information in Section 6 to adapt the one-line diagram to the equipment and develop a suitable arrangement for the particular installation.

Refer to Section 15 for a Bill of Material, Front View Arrangement, and Floor Plan for "Arrangement 2" of Figure 2-4. The information in Section 15 is typical of proposal information supplied for POWER/VAC switchgear.

ARRANGEMENT 1

(FUTURE)	FEEDER	FEEDER	SYN. MOTOR FEEDER	REVENUE METER-ING	IN-COMING LINE	IN-COMING LINE	REVENUE METER-ING	SYN. MOTOR FEEDER	FEEDER	FEEDER	(FUTURE)
(FUTURE)	FEEDER	BUS VT'S	FIELD APPLI-CATION		TIE	TIE AUX-ILIARY		FIELD APPLI-CATION	BUS VT'S	FEEDER	(FUTURE)



ARRANGEMENT 2

(FUTURE)	REVENUE METER-ING	IN-COMING LINE	SYN. MOTOR FEEDER	FEEDER	FEEDER	FEEDER	FEEDER	SYN. MOTOR FEEDER	IN-COMING LINE	REVENUE METER-ING	(FUTURE)
(FUTURE)		BUS VT'S	FIELD APPLI-CATION	FEEDER	TIE	TIE AUX-ILIARY	FEEDER	FIELD APPLI-CATION	BUS VT'S		(FUTURE)

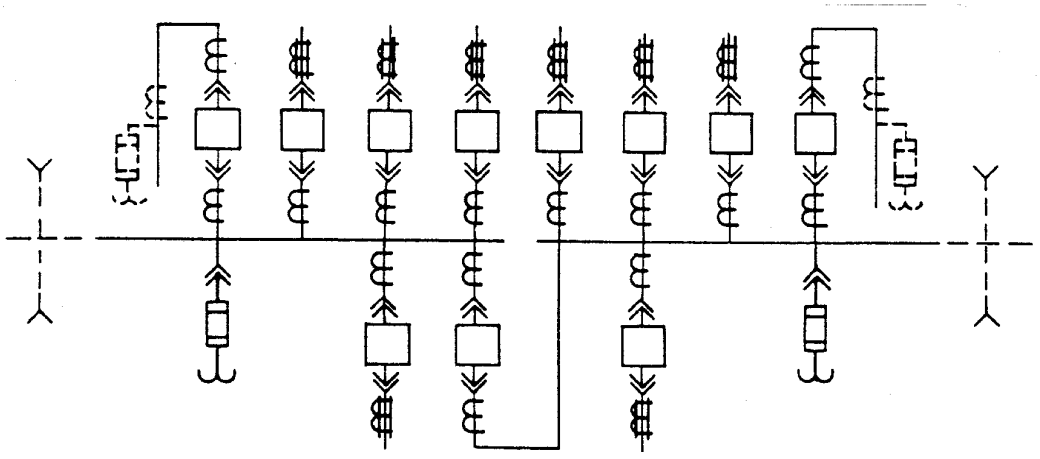


Figure 2-4. Two possible arrangements of POWER/VAC metalclad switchgear.

REFERENCES

Standards

	ANSI Standard	IEEE Standard	Title
1.	C42.100-1977	100-1977	IEEE Standard Dictionary of Electrical and Electrical Terms.
2.	Y32.2-1975	315-1975	Graphic Symbols for Electrical and Electronic Diagrams.
3.	Y14.15-1966 (R1973)	—	Electrical and Electronics Diagram.
4.	C37.2-1979	—	Electrical Power System Device Function.
5.	C37.010-1979	—	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
6.	C37.95-1974	357-1973	IEEE Guide for Protective Relaying of Utility-Consumer Interconnections.
7.	—	141-1969	Electric Power Distribution for Industrial Plants.
8.	—	142-1972	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.
9.	—	241-1974	IEEE Recommended Practice for Electrical Power Systems in Commercial Buildings.
10.	—	242-1975	IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

Books

11. Industrial Power Systems Handbook — D.L. Beeman, Editor McGraw-Hill Book Co., 1955.

Publications

12. GEA-10049F — POWER/VAC Metalclad Switchgear.

13. GET-6600E — POWER/VAC Application Guide.

Standards may be purchased from:

American National Standards Institute, Inc.
1430 Broadway
New York, NY 10018

Institute of Electrical and Electronics Engineers, Inc.
Service Center
445 Hoes Lane
Piscataway, NJ 08854

National Electrical Manufacturers Association
Publication Department
2101 L St. N.W. Suite 300
Washington, D.C. 20037

National Fire Protection Association
470 Atlantic Avenue
Boston, MA 02210

Contents

Section 3
Circuit Breaker Selection

3

Circuit Breaker Selection

INTRODUCTION

A circuit breaker's function and intended use are established in ANSI-C37. 100-1981, Definitions for Power Switchgear, which defines a circuit breaker as:

> "A mechanical switching device, capable of making, carrying, and breaking currents under normal circuit conditions and also, making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short-circuit."

In addition, it is noted that a circuit breaker is intended usually to operate infrequently, although some types are suitable for frequent operation.

A circuit breaker is applied generally to carry and switch load current and to interrupt short-circuit current when required. The application process is simple: each of the duty requirements is specified or calculated and is then compared to the corresponding capability of the circuit breaker. The fundamental rule for selection of the proper circuit breaker is that the ratings or related capabilities of the circuit breaker must equal or exceed each of the calculated or specified duty requirements of the circuit in which it is applied.

Circuit characteristics which must be defined and compared to the circuit breaker's capabilities (given in the various Table 3's) are:

- Circuit voltage
- System frequency
- Continuous current
- Short-circuit current
- Closing and latching current

In addition, certain special application conditions can influence circuit breaker selection. Special applications include the following:

- Repetitive switching duty (except arc furnaces)
- Automatic reclosing
- Arc furnace switching
- Reactor switching
- Capacitor switching
- Fast bus transfer
- Unusual service conditions

This section of the POWER/VAC *Application Guide* provides specific parameters and guidelines for circuit breaker selection and application. Specifically, those circuit parameters and special applications noted in the proceeding paragraph are addressed.

CIRCUIT BREAKER RATINGS

POWER/VAC circuit breaker ratings are shown in Table 3-1.1. Interrupting ratings are for 60-HZ and for 50-HZ applications are listed in Table 3-1.3. For more complete information concerning service conditions, definitions, and interpretation of ratings, tests, and qualifying terms, refer to the applicable ANSI and NEMA standards listed in Table 1-1, Sheet 1-3.

SELECTION CONSIDERATIONS

Application of the proper circuit breaker requires a definition of its duty requirements, which can then be compared with the choice of a circuit breaker with POWER/VAC ratings and capabilities shown in Table 3-1.1. It is recommended that ANSI Standard C37.010 (see Ref.2 of this section) be consulted for guidance in proper determination of duty requirements.

Circuit characteristics which must be considered are discussed in the following paragraphs.

CIRCUIT VOLTAGE

The nominal voltage classes of medium-voltage metalclad switchgear for ANSI standards are 4.16 kV, 7.2 kV and 13.8 kV. POWER/VAC switchgear may be applied at operating voltages from 2400 volts through 15,000 volts, provided the maximum circuit operating voltage does not exceed the POWER/VAC rated maximum voltage, see Table 3-1.1 Page 3-3.

Table 3-1.1 —POWER/VAC Power Circuit Breaker Characteristics (Symmetrical Rating Basis ANSI C37.06)

Symmetrical Rating Basis ANSI C37.06 (1987*)

Identification (6) & (7)*		Rated Values								Related Required Capabilities			
		Voltage		Insulation Level		Current					Current Values		
				Rated Withstand Test Voltage							Maximum Symmetrical Interrupting Capability (5)	3 Sec Short time Current Carrying Capability	
Normal rms Voltage Class (kV)	Normal 3-phase Class (MVA)	Rated Maximum rms Voltage (kV) (1)	Rated Voltage Range Factor, K (2)	Low Frequency rms Voltage (kV)	Crest Impulse Voltage (kV)	Continuous rms Current Rating at 60 Hz (amperes)	Short circuit rms Current Rating (at Rated Max kV) (kA) (3) (4)	Rated Interrupting Time (Cycles)	Rated Permissible Tripping Delay, Y (Seconds)	Rated Maximum rms Voltage Divided by K (kV)	K times Related Short-circuit rms Current		Closing and Latching Capability rms Current (kA)
											(kA)	(kA)	
4.16	250	4.76	1.24	19	60	1200	29	5	2	3.85	36	36	58
4.16	250	4.76	1.24	19	60	2000	29	5	2	3.85	36	36	58
4.16	250	4.76	1.24	19	60	3000	29	5	2	3.85	36	36	58
4.16	350	4.76	1.19	19	60	1200	41	5	2	4.0	49	49	78
4.16	350	4.76	1.19	19	60	2000	41	5	2	4.0	49	49	78
4.16	350	4.76	1.19	19	60	3000	41	5	2	4.0	49	49	78
4.16	350	4.76	1.19	19	60	3500	41	5	2	4.0	49	49	78
4.16	350	4.76	1.19	19	60	4000*	41	5	2	4.0	49	49	78
7.2	500	8.25	1.25	36	95	1200	33	5	2	6.6	41	41	66
7.2	500	8.25	1.25	36	95	2000	33	5	2	6.6	41	41	66
7.2	500	8.25	1.25	36	95	3000	33	5	2	6.6	41	41	66
7.2	500	8.25	1.25	36	95	3500	33	5	2	6.6	41	41	66
7.2	500	8.25	1.25	36	95	4000*	33	5	2	6.6	41	41	66
13.8	500	15	1.30	36	95	1200	18	5	2	11.5	23	23	37
13.8	500	15	1.30	36	95	2000	18	5	2	11.5	23	23	37
13.8	500	15	1.30	36	95	3000	18	5	2	11.5	23	23	37
13.8	750	15	1.30	36	95	1200	28	5	2	11.5	36	36	58
13.8	750	15	1.30	36	95	2000	28	5	2	11.5	36	36	58
13.8	750	15	1.30	36	95	3000	28	5	2	11.5	36	36	58
13.8	750	15	1.30	36	95	3500	28	5	2	11.5	36	36	58
13.8	750	15	1.30	36	95	4000*	28	5	2	11.5	36	36	58
13.8	1000	15	1.30	36	95	1200	37	5	2	11.5	48	48	77
13.8	1000	15	1.30	36	95	2000	37	5	2	11.5	48	48	77
13.8	1000	15	1.30	36	95	3000	37	5	2	11.5	48	48	77
13.8	1000	15	1.30	36	95	3500	37	5	2	11.5	48	48	77
13.8	1000	15	1.30	36	95	4000*	37	5	2	11.5	48	48	77
13.8 (6)	1500	15	1.00	36	95	1200	63	5	2	15.0	63	63	101
13.8 (6)	1500	15	1.00	36	95	2000	63	5	2	15.0	63	63	101
13.8 (6)	1500	15	1.00	36	95	3000	63	5	2	15.0	63	63	101
13.8 (6)	1500	15	1.00	36	95	3500	63	5	2	15.0	63	63	101
13.8 (6)	1500	15	1.00	36	95	4000*	63	5	2	15.0	63	63	101

Notes Applying to Table 3-1.1

(1) Maximum voltage for which the breaker is designed and the upper limit for operation.

(2) K is the ratio of rated maximum voltage to the lower limit of the range of operating voltage in which the required symmetrical and asymmetrical interrupting capabilities vary in inverse proportion to the operating voltage.

(3) To obtain the required symmetrical interrupting capability of a circuit breaker at an operating voltage between 1/K times rated maximum voltage and rated maximum voltage, the following formula shall be used:

$$\text{Required Symmetrical Interrupting Capability} = \text{Rated Short-circuit Current} \times \frac{\text{(Rated Max. Voltage)}}{\text{(Operating Voltage)}}$$

For operating voltages below 1/K times rated maximum voltage, the required symmetrical interrupting capability of the circuit breaker shall be equal to K times rated short-circuit current.

(4) With the limitation stated in 5.10 of ANSI-C37.04-1991, all values apply for polyphase and line-to-line faults. For single phase-to-ground faults, the specific conditions stated in 5.10.2.3 of ANSI-C37.04-1991 apply.

(5) Current values in this column are not to be exceeded even for operating voltages below 1/K times rated maximum voltage. For voltages between rated maximum voltage and 1/K times rated maximum voltage, follow (3) above.

(6) Note: 1500 MVA is not a listed rating according to ANSI C37.06 Table 2.1

(7) NOTE: GE reserves the right to improve the design and/or modify the specifications in this publication without notice.

*Fan cooled only.

Circuit Breaker Selection

Table 3-1.2 Non-Standard-High Close and Latch Capability Circuit Breakers (these ratings exceed ANSI-C37.06)

Identification (6) & (7)		Rated Values								Related Required Capabilities			
		Voltage		Insulation		Current					Current Values		
				Rated Withstand Test Voltage							Maximum Symmetrical Interrupting Capability (5)	3 Sec Short time Current Carrying Capability	
Normal rms Voltage Class (kV)	Normal 3-phase Class (MVA)	Rated Maximum rms Voltage (kV) (1)	Rated Voltage Range Factor K (2)	Low Frequency rms Voltage (kV)	Crest Impulse Voltage (kV)	Continuous rms Current Rating at 60 Hz (amperes)	Short circuit rms Current Rating (at Rated Max kV) (kA) (3) (4)	Rated Interrupting Time (Cycles)	Rated Permissible Tripping Delay, Y (Seconds)	Rated Maximum rms Voltage Divided by K (kV)	K times Related Short-circuit rms Current (kA)	(kA)	Closing and Latching Capability rms Current (kA)
4.16	250	4.76	1.24	19	60	1200 2000 3000 3500 4000*	29	5	2	3.85	36	36	78
7.2	500	8.25	1.25	36	95	1200 2000 3000 3500 4000*	33	5	2	6.6	41	41	78
13.8	500	15	1.30	36	95	1200 2000 3000 3500 4000*	18	5	2	11.5	23	23	58
13.8	750	15	1.30	36	95	1200 2000 3000 3500 4000*	28	5	2	11.5	36	36	77

* Fan Cooled Only

Table 3-1.3 PowerVac Power Circuit Breaker Characteristics* Ratings Basis on 50 Hertz per IEC

		Insulation Level					
Circuit Breaker Type	Rated Voltage kV	Power Frequency	Impulse Withstand	Rated Normal Current Amps	Rated Short Circuit Breaking Current kA rms sym. (1) (2)	Short-time Current kA rms 3sec.	Short Circuit Making Current kA peak
3.6VBI-25	3.6	20	60	1250, 2000	25	25	63
3.6VBI-40	3.6	20	60	1250, 2000	40	40	100
7.2VBI-25	7.2	20	60	1250, 2000	25	25	63
7.2VBI-40	7.2	20	60	1250, 2000	40	40	100
12.0VBI-25	12.0	28	75	1250, 1600, 2000	25	25	63
12.0VBI-40	12.0	28	75	1250, 1600, 2000	40	40	100
13.8VBI-25	13.8	36	95	1250, 2000	25	25	63
13.8VBI-40	13.8	36	95	1250, 2000	40	40	100
13.8VBI-63	15.0	36	95	1250, 2000	63	63	170

* *Does not apply to Switchgear*

(1) Rated operating sequence (duty cycle) CO + 15 sec. + CO

(2) Interrupting time 5 cycles at 50 Hz.

SYSTEM FREQUENCY

The frequency rating of POWER/VAC metalclad switchgear should coincide with the nominal frequency of the power system. Standard POWER/VAC is available in 60-Hz (Table 3-1.1) and 50-Hz ratings (Table 3-1.3), but other frequency ratings are available. Special applications should be referred to the nearest General Electric Sales Office.

SHORT-CIRCUIT CURRENT

Quick interruption of short-circuit current is usually considered the primary function of a circuit breaker. The fault-current interrupting capability of POWER/VAC circuit breakers is stated in three-phase, symmetrical, rms ac amperes. Accordingly, calculation of the maximum available fault duty of a circuit breaker assumes a three-phase bolted fault.

After calculation of short-circuit current duty, choose a POWER/VAC breaker which has a short-circuit current capability that equals or exceeds the expected duty, and remember to consider the circuit operating voltage when evaluating the circuit breaker's interrupting capability. For example: at 4160 volts, a 4.16 kV— 350 MVA-class circuit breaker with a rated short-circuit current of 41 kA at a maximum rated voltage of 4.76 kV has an interrupting capability of kA x $\frac{4.76\ \text{kV}}{4.16\ \text{kV}}$ = 47 kA symmetrical rms current. But at 2.4 kV, the interrupting capability is 49 kA, the maximum symmetrical interrupting capability listed in the rating tables, because 2.4 kV is less than 4.76 kV/"k" = 4.76/1.19 = 4.0 kV. (See footnote No. 5, Table 3-1.1).

CLOSING AND LATCHING CURRENT

Circuit breakers are designed to stay latched, or to close and latch, against a first-cycle maximum asymmetrical rms current of 1.6 times the maximum symmetrical rms interrupting capability of the circuit breaker. Ordinarily this close and latch capability is satisfactory for most applications (Table 3-1.1). There are some applications, however, in which the calculated[2] rms value of first-cycle asymmetrical short-circuit current exceeds the closing and latching capability of the circuit breaker (Table 3-1.2). Applications which include a large motor load are a typical example. In these cases, breaker selection may depend on closing and latching capability rather than symmetrical short-circuit capability. The breaker selected might have the next-higher short-circuit current capability or it might have a higher-than-standard closing and latching capability.

CONTINUOUS CURRENT

Feeder and main breaker loading determine required continuous current duty. For continuous loads, select a POWER/VAC breaker with rated continuous current (defined at 60-Hz) equal to or greater than load current.

Note that circuit breakers have no continuous overload rating. When considering circuit breaker application with a generator, a motor, a transformer, or other apparatus having a long-time overload rating, the circuit breaker (and switchgear equipment) must have a continuous-current rating at least equal to the overload rating of the served apparatus. When applied with a forced-cooled transformer, the switchgear continuous-current rating must equal or exceed the transformer forced-cooled current rating.

Circuit breakers may be operated, for short periods, in excess of rated continuous current. This covers such operations as starting motors or energized cold loads.

RATED INTERRUPTING TIME

POWER/VAC circuit breaker interrupting time is 5-cycles, as stated in Table 3-1.1.

As an option, 3-cycle POWER/VAC breakers are available. For additional information contact your General Electric Company Sales Engineer or Medium Voltage Switchgear, 510 East Agency Road, West Burlington, Iowa 52655.

SPECIAL SWITCHING APPLICATIONS

Application of power circuit breakers for switching duty may require derating of the circuit breaker or increased maintenance. Particular attention should be given to breakers intended for use in any of the following switching applications:

- Repetitive switching (except arc furnace)
- Automatic reclosing
- Arc furnace switching
- Reactor switching
- Capacitor switching
- Fast bus transfer

For these applications, the usual practice is to first select a circuit breaker based on the criteria provided under "SELECTION CONSIDERATIONS" of this section. Then consider the switching duty and, if necessary, redetermine the circuit breaker capabilities (continuous-current rating, interrupting rating, etc.), and factor in any modified operating or maintenance requirements. Recheck the circuit breaker's evaluation capabilities against all the basic duty requirements under "SELECTION CONSIDERATIONS."

If the circuit breaker selected initially, and as derated (or otherwise modified), no longer meets the duty requirements of the application, choose the next-higher rated breaker. Repeat the derating or rating adjustment process to confirm that the new breaker has adequate capability.

REPETITIVE SWITCHING (EXCEPT ARC FURNACE)

POWER/VAC circuit breakers can be applied on most power circuits without attention to frequency of operation, since highly repetitive switching duty is uncommon. Typical switching duties include motor starting, switching of distribution circuits, transformer magnetizing current, and other miscellaneous load-current switching. While magnitude of current switched in these applications can vary from very light load to the maximum permissible for a particular circuit breaker, switching is generally infrequent; thus, no derating is required.

Standard POWER/VAC circuit breakers may be operated as often as 20 times in 10 minutes or 30 times in one hour without derating for switching duty. Further frequency of operation capabilities are given in Table 3-2.

When operated under usual service conditions and for other than arc furnace switching, standard POWER/VAC circuit breakers are capable of operating the number of times shown in the table. Operating conditions, servicing requirements and permissible effects on the breakers are specified in Table 3-2.

ARC FURNACE SWITCHING

Arc furnace switching duty is more repetitive than normal switching duty. The circuit breaker is applied on the primary side of a relatively high-impedance transformer and the usual duty is frequent switching (50 to 100 times per day) of the transformer magnetizing current. Switching is required when the transformer is de-energized for tap changing, when taking melt samples, or when adding alloys. In addition to this switching duty, transformer through-faults must occasionally be interrupted

This heavy-duty application requires circuit breaker capabilities and maintenance schedules different from those required for other switching duty.

POWER/VAC circuit breakers designed for arc furnace switching are capable of operating the number of times given in Table 3-3, providing they are operated under usual service conditions. Operating conditions, servicing requirements, and permissible effects on the breakers are given in the table.

REACTOR SWITCHING

Standard POWER/VAC circuit breakers with ML-17 mechanisms are capable of switching reactive load current up the full continuous current rating of the breaker.

Consult the nearest GE Sales Office for information on reactor switching.

AUTOMATIC RECLOSING

When POWER/VAC circuit breakers are used for automatic reclosing duty to maintain service continuity, they must be derated in accordance with standard capability factors. These apply to all high-voltage circuit breakers rated up to 72.5 kV.

All POWER/VAC circuit breakers may be used for reclosing duty. Automatic reclosing is normally used only on overhead distribution circuits of electric utilities. Breakers serving rotating machines are not reclosed when tripped by protective relays.

Capability factors for POWER/VAC circuit breakers used in automatic reclosing duty applications are shown in Figures 3-1 and 3-2. To ensure proper determination of POWER/VAC circuit breaker capabilities in reclosing applications, use this step-by-step calculating procedure.

When automatic reclosing duty is specified, it is recommended that dc control voltager be supplied. A capacitor trip device is not recommended in connection with breaker control when automatic reclosing of the breaker is to be employed.

Automatic reclosing relays available are GE type DFP100, DFP200, and SR 760.

Calculation of Reclosing Capabilities

- A duty cycle shall not contain more than five opening operations.
- All operations within a 15-minute period are considered part of the same duty cycle.
- The circuit breaker may be applied, at the determined operating voltage and duty cycle, to a circuit for which the calculated short-circuit current does not exceed the symmetrical interrupting capability, as determined by the following procedure.
- If the X/R ratio for the circuit exceeds 15, refer to ANSI-C37.010 for guidance.

Procedure

Step 1 — Determine the breaker symmetrical interrupting capability at the operating voltage from Table 3-1.1 (Note 3).

Step 2 — Determine the factor d_1 from the reclosing capability curve in Figure 3-1.1 for the current value determined in Step 1.

Step 3 — Determine the factor D from the following equation:

$$D = d_1 (n-2) + \frac{d_1 (15-t_1)}{15} + \frac{d_1 (15-t_2)}{15} + \ldots + \frac{d_1 (15-t_n)}{15}$$

where:

D = total reduction factor (in percent).

d_1 = calculating factor for D in percent of breaker symmetrical interrupting capability at operating voltage.

n = total number of openings in duty cycle.

t_1 = duration (in seconds) of first time interval between operations that is less than 15 seconds.

t_2 = duration (in seconds) of second time interval between operations that is less than 15 seconds.

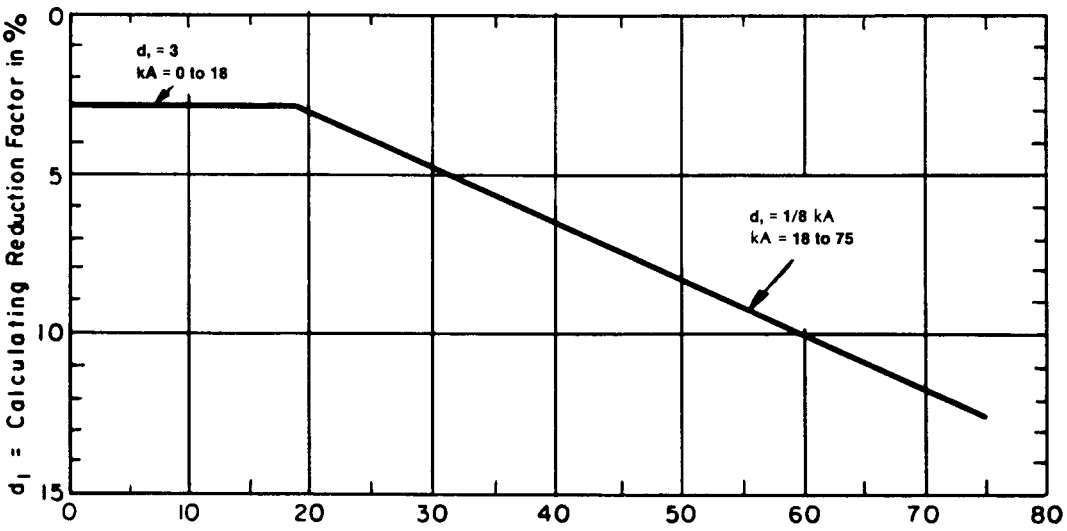
t_n = duration of n^{th} time interval...

Step 4 — Calculate the reclosing capability factor (R) in percent where:

R = 100 minus D

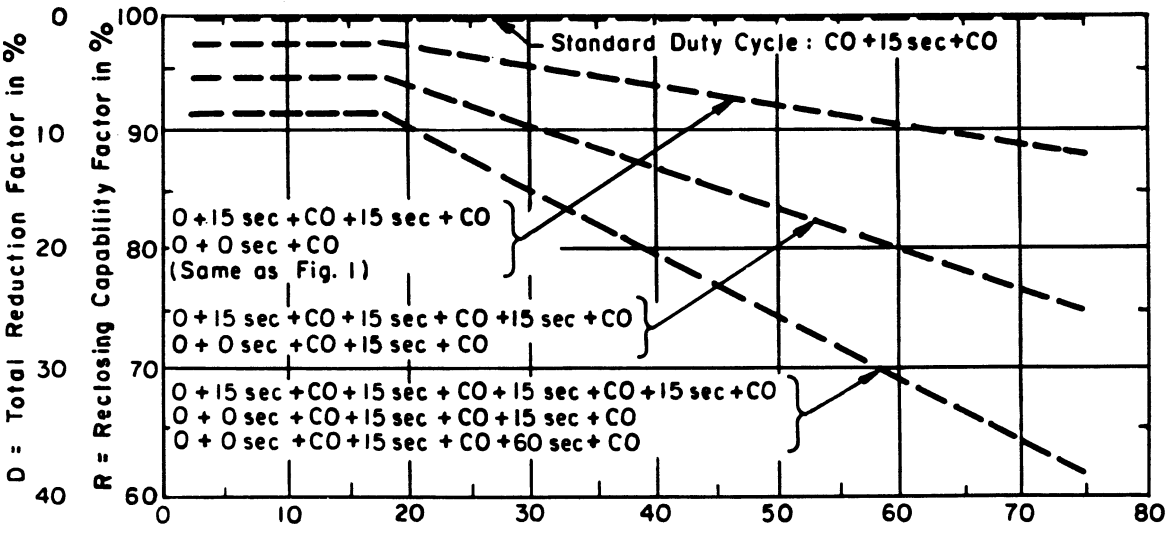
For some typical duty cycles, R can be determined directly from the appropriate curves in Figure 3-2.

Step 5 — The revised symmetrical interrupting capability of the circuit breaker for the operating voltage and duty cycle desired is now determined by multiplying the Step 1 symmetrical interrupting capability by R, as determined in Step 4.



Breaker Symmetrical Interrupting Capability in Kiloamperes at Operating Voltage
(Step 1 Value)
REF. (ANSI C37.06-1979, PAGE 32)

Figure 3-1. Reclosing capability curve for determining d_1.



Breaker Symmetrical Interrupting Capability in Kiloamperes at Operating Voltage
(Step 1 Value)
REF. (ANSI C37.010-1979 PAGE 26)

Figure 3-2. Reclosing capability factor curves for typical duty cycles.

Table 3-2 — Repetitive Duty and Normal Maintenance for POWER/VAC Breakers used in Mild Environments other than for Arc Furnace Switching

BREAKER		MAXIMUM NO. OF OPERATIONS BEFORE SERVICING	NUMBER OF OPERATIONS (EACH = 1 CLOSE PLUS 1 OPEN OPERATION)		
TYPE	CONTINUOUS RATING - AMPS		NO-LOAD MECHANICAL	CONTINUOUS CURRENT SWITCHING	INRUSH-CURRENT SWITCHING
COLUMN 1		COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5
		A. Servicing consists of adjusting, cleaning, lubrication, changing parts, as recommended by the Company. The operations listed are on the basis of service in a mild environment.	B. Close and trip, no-load. E. Rated control voltage. F. Frequency of operation not more than 20 in 10 minutes or not more than 30 in 1 hour. G. Servicing at intervals given in Column 2. H. No parts replacement. I. Breaker meets all current, voltage , interrupting current ratings.	C. Close and trip within rated current, rated maximum voltage and 80% PF or greater. E. Applies F. Applies G. Applies H. Applies I. Applies J. At the first servicing interval, the amount of vacuum interrupter contact erosion should be used to estimate the additional life at that continued duty. K. After 15 full short circuit faults check the contact erosion.	D. Closing 600% of rated current of less at no less than 30% PF. Otherwise, same as C. E. Applies F. Applies G. Applies H. Applies I. Applies J. Applies K. Applies
All	All	10,000 or 10 years	10,000 minimum	10,000	10,000

Table 3-3 — Repetitive Duty and Maintenance Requirements for POWER/VAC Circuit Breakers Applied to Arc Furnace Switching

BREAKER		ARE FURNACE FULL-LOAD RATING (AMPERES)	MAXIMUM NUMBER OF OPERATIONS BETWEEN SERVICING	NUMBER OF OPERATIONS	
TYPE	CONTINUOUS RATING (AMPERES)			NO-LOAD MECHANICAL	SWITCHING AND INTERRUPTING
COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6
			A. Servicing consists of adjusting, cleaning, lubrication, tightening, changing parts, as recommended by the Company. The operations listed are on the basis of service in a mild environment. H. If the weighted average of the currents interrupted during load and secondary furnace cave-ins is equal to the breaker continuous current, this column applies. I. After 15 full short circuit faults check the contact erosion.	B. When closing and opening no-load. C. Within 90 to 100% of rated control voltage. D. Frequency of operation not more than 20 in 10 minutes or not more than 30 in 1 hour. E. Servicing at no greater interval than shown in Column 4. F. No parts replacement. G. Breaker meets all current, voltage, interrupting current ratings.	C. Applies D. Applies E. Applies F. Applies G. Applies I. Applies J. At the first servicing interval, the amount of vacuum interrupter contact erosion should be used to estimate the additional life at that continued duty.
All	All	All	10,000 or 10 years	10,000 minimum	

Circuit Breaker Selection

CAPACITOR SWITCHING

Capacitor banks are generally applied on both utility and industrial power systems to improve voltage regulation and system stability. POWER/VAC circuit breakers with ML-17 Mechanism are applicable to shunt-capacitor-bank switching in accordance with the capabilities listed in Table 3-4B.

POWER/VAC circuit breakers with ML-18 mechanism are applicable to shunt-capacitor-bank switching in accordance with Table 3-4A.

Shunt-bank capacitor switching means one breaker feeding one 3-phase capacitor bank. If this circuit is closely paralleled by another switched capacitor bank, Table 3-4A will not apply. These situations require evaluation of such factors as local high-frequency equalizing currents flowing between the separated, switched capacitor banks.

Table 3-4A — VB1 POWER/VAC Circuit Breaker (ML-18 and ML-18H Mechanism) General Purpose Capacitor Bank Switching Capability for 1200 and 2000 Continuous Current Rated POWER/VAC Circuit Breakers

SYSTEM VOLTAGE	BREAKER AMPS		MAXIMUM NAMEPLATE CAPACITOR BANK RATING-MVAR		
		(2)	UNGROUNDED BANK MVAR	(2)	GROUNDED BANK MVAR
2400	1200	400	1.3	400	1.2
	2000	400	1.3	400	1.2
4160	1200	400	2.3	400	2.1
	1200	665	3.8	665	3.5
	2000	400	2.3	400	2.1
	2000	665	3.8	665	3.5
	2000	1350	7.8	1350	7.2
7200	1200	190	2.3	190	1.8
	1200	630	8.8	630	5.8
	2000	190	2.3	190	1.8
	2000	630	8.8	630	5.8
	2000	1350	13.5	1350	12.5
12470	1200	250	4.3	250	4.0
	2000	250	4.3	250	4.0
	2000	1350	23.3	1350	21.6
13800	1200	250	4.8	250	4.4
	1200	262	5.0	262	4.6
	2000	340	6.5	340	6.0
	2000	630	12.0	630	11.1
	2000	1350	25.8	1350	23.9
	3000	653	12.5	653	11.5

Footnote: The capacitor -bank rating is subject to the following conditions:

1. Application guide rounds-off the bank MVAR ratings.
2. Capacitor switching currents.
3. The transient voltage from line to ground shall not exceed 3 times maximum design line-to-ground crest voltage measured at the breaker terminals.
4. The number of restrikes or reignitions shall not be limited as long as the transient voltage to ground does not exceed the value given in Footnote 1.
5. The capacitor bank rating applies only to single bank switching as noted herein.
6. Interrupting time is in accordance with the rated interrupting time of the circuit breaker.
7. For capacitor switching capability of breakers having Definite-Purpose capacitor Switching capability (higher than General Purpose rating and for Back-to-Back Switching) please see TABLE 3-4B.

Table 3-4B — POWER/VAC Circuit Breaker VB with ML-17 Mechanism Capacitor Switching Capability for Single Banks and Back-To-Back Switching

SYSTEM VOLTAGE	BREAKER AMPS	MAXIMUM NAMEPLATE CAPACITOR BANK RATING -MVAR			
		(2)	UNGROUNDED BANK MVAR	(2)	GROUNDED BANK MVAR
2,400	1,200	1200	4	1200	4
	2,000	1806	6	1806	6
	3,000	2950	10	2950	9
4,160	1,200	1042	6	1042	5
	2,000	1910	11	1910	10
	3,000	2952	17	2952	16
7,200	1,200	1104	11	1104	10
	2,000	1906	19	1906	18
	3,000	2910	29	2910	27
12,470	1,200	1159	20	1159	19
	2,000	1970	34	1970	32
	3,000	2607	45	2607	42
13,800	1,200	1151	22	1151	20
	2,000	1570	30	1570	28
	3,000	1570	30	1570	28

NOTES:

1. Application guide rounds-off the bank MVAR ratings.
2. Capacitor switching currents.
3. POWER/VAC breaker has a definite purpose rating per Table 2A, ANSI C37.06-1979 except the allowable capacitor currents for POWER/VAC may be higher than given in Table 2A.
4. Bank inrush currents are to be limited to 15kA at 2000 Hz or to 30kA-kHz if the inrush current is less than 15kA.
5. Surge suppressors are not required for switching transient voltages.
6. Interrupting time is in accordance with the rated interrupting time of the circuit breaker.
7. Cap Bank = $\frac{\text{System Volts (KV) x Cap. Swithching current rating x } \sqrt{3}}{\text{Rating KVAR}}$ 1.25 (for ungrounded banks) or 1.35 (for grounded banks)

FAST BUS TRANSFER

Fast bus transfer is normally used for transferring from a normal power source bus to an emergency or alternate power source within a maximum of 3 cycles. ((50 milliseconds) upon failure of the normal source of power or vice-versa. It is needed for serving essential loads including nuclear applications.

During this transfer, it is essential that bus “dead time” be as short as possible to prevent loss of downstream critical auxiliary functions, such as contactors and relays. It is important that the main and alternate breakers are not closed at the same time since the sources may not be synchronous or even if they are, some short circuit conditions may result in the loss of both sources, if they are both closed at the same time. Also, when both are closed at the same time, system short circuit currents can exceed the feeder breaker rating.

In order to provide the utmost assurance that one breaker will be open before the other is closed, accepted practice requires that the first breaker must be on the way open before the second breaker is given a closing signal. "Fast" transfer means there is no intentional time delay in the transfer of a bus or load from one source of power to another.

The amount of dead time depends upon whether the POWER/VAC breaker is standard or is provided with an early "b" (faster) contact and special closing coil.

In use of the ML-17 mechanism, the preferred circuit breaker operation sequence used to achieve fast transfer consists of giving a trip signal to the opening breaker. Then an early "b" contact (open when the breaker contacts are closed) which closes 3 milliseconds after the vacuum interrupter main contacts open on the opening breaker initiates a closing of the second breaker. Then the other breaker, Tie, or Incoming breaker has a special coil that closes the main interrupter contact in 50 milliseconds.

An ML-18 mechanism does not require an early "b" contact. The standard "b" contact is already sufficiently fast - approximately 20 milliseconds from main contact part to "b" contact close and a special close coil which reduces closing time to 40 milliseconds.

Typical dead times for fast bus transfer, using standard and special POWER/VAC breakers for the ML-17 and the ML-18 mechanism is 60-62 milliseconds. See Table 3-5. Fast bus transfer with 3 cycle dead time will be offered only for 1200, 2000 and 3000 ampere breakers having 125 vdc and 250 vdc control voltages.

POWER/VAC circuit breakers with the various stored-energy mechanisms meet the critical requirements for fast bus transfer. Fast bus transfer breakers must be specified when placing an order.

Table 3-5 — Typical Dead-Times for Fast Transfer Using POWER/VAC Circuit Breakers

Power/Vac Breakers	Mechanism	Control Voltage (volts) (1)	Nominal Dead Bus Times (Milliseconds) Trip then close using:					
			early "b" contact & special closing coil (2)		standard "b" contact special closing coil (3)		Standard "b" contact	
			No Arcing (3)	With Arcing (4)	No Arcing (3)	With Arcing (4)	No Arcing (3)	With Arcing (4)
All Rating	ML-17	125/250 DC	62	50			90	78
All Rating	ML-18	125/250 DC			60	48	70	58

Footnotes:
(1) Control voltage at rated value.
(2) Tolerances are minus.
(3) Main contact parting to main contact making.
(4) End of arcing to main contact making.

AUTOMATIC TRANSFER

Main and transfer bus arrangements are employed when the user desires the ability to maintain feeder circuit breakers while continuing to supply the load without taking a service interruption. The normal mode of operation is to have the mains and three feeder breakers closed, and the bus tie breaker open. The typical transfer scheme (see Section 6, page **75**) is intended for application to a set of three circuit breakers, two of which, (Incomers 1 and 2) connect separate power sources to two busses which can be paralleled through the bus tie breaker. Normal configuration of the system is with both incoming breakers closed and the bus tie breaker open.

The transfer scheme is used to minimize the effect of outages on one of the incoming supplies by opening the incoming breaker connected to that supply, and then re-energizing the dead bus by closing the bus ties breaker to transfer the dead bus to the live source. To protect against damage to motors connected to the dead bus, the bus tie breaker is not allowed to close, after a transfer has been initiated until the decaying voltage on the bus has decayed to a safe level.

After the lost source has been reestablished, the scheme provides two methods to restore the system to normal configuration. If the sources cannot be synchronized, the bus tie breaker must be manually opened before the open incomer can be manually closed. In this procedure the incomer will only be allowed to close if the incoming source (line VT) voltage is above a 'live' threshold and the load (bus VT) voltage is below a 'dead' threshold value. If the sources are synchronized, it is possible to manually close the open incomer with synchrocheck supervision to parallel all three breakers; the scheme will then automatically open a breaker which had been previously selected to trip if all breakers become closed, in this instance the bus tie breaker.

In addition to a relay required for each of the three circuit breakers, it is required to connect one contact from a three-position switch to each relay. This switch (device 43/10) is used to select the breaker that will trip after all breakers are closed. It is generally recommended that a two-position switch (device 43/83) with three contacts, be connected to each relay as an "Auto-Off" transfer scheme selector.

Because a relay is required for each the three circuit breakers, it allows bus-splitting operation. This is accomplished by setting the time overcurrent elements in the relay on the bus tie breaker to trip faster than the incomers, opening the bus tie before an incomer when operating from only one source.

SERVICE CONDITIONS

POWER/VAC metalclad switchgear ratings and capabilities are based on operation under certain defined service conditions, defined as "usual." Conditions other than usual are called "unusual." Factors used to classify service conditions are altitude, ambient temperature, and a variety of others, such as the presence of atmospheric contaminants, unusual storage conditions, and requirements for tamper-resistance. These factors are specified for circuit breakers in ANSI-C37.04-1979 (Circuit Breaker Rating Structure) and for equipment in ANSI-C37.20-1974 (Switchgear Assemblies), and are summarized here for application guidance.

Application of POWER/VAC circuit breakers under conditions other than "usual" may require significant derating, special construction or use of special protective features.

USUAL SERVICE CONDITIONS

POWER/VAC circuit breakers (and switchgear assemblies) are suitable for operation at their standard nameplate ratings:

- Where ambient temperature is not above 40° C or below -30° C (104° F and -22° F)

- Where the altitude is not above 1000 meters (3300 feet).

NOTE: For switchgear assemblies (breakers and housings combined) there is one additional stipulation:

- Where the effect of solar radiation is not significant. (See Ref. 5 on page 3-15.) Where radiation is significant the user is responsible for specifying the cooling/ventilation required to limit the temperature rise.

UNUSUAL SERVICE CONDITIONS

Abnormal Temperature

The planned use of POWER/VAC circuit breakers or switchgear outside the normal ambient temperature range (+40° C to -30° C) shall be considered as special. Reference should be made to ANSI C37-20.2, Table 11. Example: Per ANSI a 50° C ambient temperature will require the switchgear to be derated by 8% per Table 11. Such applications of increased temperature should be referred to the nearest General Electric Sales Office for evaluation.

Temperature Rise

The temperature rise, above ambient outside enclosure, of buses and connections in an enclosed assembly will not exceed C, and that of connections to insulated cables will not exceed 75° when operated at reated continuous current in rms amperes at rated frequency.

The maximum usual ambient temperature is 40° C. The temperature of the air surrounding all devices in an enclosed switchgear assembly, considered in conjunction with their standard rating and loading as used, will not cause these devices to exceed their maximum allowable temperature when the switchgear assembly is surrounded by air at the maximum average ambient temperature of 40°C.

The average temperature of the air surrounding outgoing insulated cables in any compartment of an enclosed switchgear assembly will not exceed 65° C when the assembly is equipped with the maximum rated current devices for which it is designed.

High Altitude

Medium voltage metal-clad switchgear is designed and tested in conformance to ANSI Standards. Inherent is these standards is the use of air as a heat transfer and dielectric medium. In the Application of metalclad switchgear at high altitudes there are two characteristics which degrade at altitudes above 1000 meters (3300ft). They are the continuous current ability and the dielectric withstand capability which may result in excessive corona at operating voltages and an inability to operate due to the dielectric breakdown of the air insulation by the loss of the air density.

POWER/VAC circuit breakers and switchgear assemblies utilize air for an insulating and cooling medium. Operation at altitudes above 1000 meters (3300 ft) will result in a higher temperature rise and lower dielectric withstand capability because the air is thinner at the higher altitudes. For applications at higher altitudes, the rated 1 minute power-frequency withstand voltage, the impulse withstand voltage, and continuous current rating of the switchgear should be multiplied by the correction factors listed in Table 3-6 to obtain the modified ratings. Thus, certain circuit breakers and switchgear capabilities must be corrected to adjust for high-altitude operation.

When the **Voltage Correction Factor** is applied to the maximum designed voltage rating of 13.8 kV and 4.16 kV metal-clad switchgear, the deration will not permit the equipment to be installed at altitudes above 1000 meters at their respective nominal system voltages. Since it is more realistic to apply these correction factors to the actual BIL rating (impulse withstand voltage) of the switchgear. An acceptable option** may be to apply the equipment at their rated nominal voltages, with no change in clearances, by the addition of lighting arrresters. Hence, apply the Voltage Correction Factor to the BIL level of the equipment and then provide surge protection on the load side of the switchgear and station type lightning arrester (Aluguard arrester) protection such that the maximum sparkover voltage of the arrester is about 20% less than the modified impulse voltage rating of the switchgear.

The **Current Correction Factor** is applied to the continuous current rating of the equipment only. It is necessary to derate because switchgear assemblies which depend on the air for cooling will have a higher temperature rise when operated at altitudes above 1000 meters. The short-time and interrupting current ratings are not affected by altitude. Since the Current Correction Factor is small and the actual continuous current duty is usually less than the equipment rating, current correction is not as serious a consideration as the voltage correction.

Consideration of **Corona Performance** for medium voltage metal-clad switchgear is not covered in the ANSI Standards...The Canadian standards do specify a corona level but no mention is made of altitude. Thus, Corona performance is not addressed in technical depth and there is no published research on high altitude performance of the equipment. Any statement on high-altitude corona performance of medium voltage switchgear must be based on deductive logic and the equipment may not actually perform in service in the manner anticipated.

NOTE: The recommendations are subject to modification depending on the actual system conditions.

Table 3-6 — Altitude Correction Factors for POWER/VAC Circuit Breakers and Switchgear

Altitude (feet / meters)	Rating Correction Factors*		
	Rated Continuous Current	Rated Voltage	Basic Insulation Level**
3300ft - 1000m	1.00	1.00	1.00
4000ft - 1200m	0.99	0.98	1.00
5000ft - 1500m	0.99	0.95	1.00
7000ft - 2100m	0.98	0.89	1.00
10000ft - 3000m	0.96	0.80	1.00
12000ft - 3600m	0.95	0.75	1.00

** Standard Power/Vac corrected to the rated BIL

Application of metal-clad switchgear above 1000 meters (3300 ft) should be referred to Application Engineering. It should be cautioned that the correction factors of power transformers are different than those for switchgear.

Besides abnormal temperature and high altitude there are other unusual service conditions which may require special protecting features or affect construction. Some of these are:

- Exposure to corrosive atmosphere, explosive fumes, excessive dust (e.g., coal dust) or particular contamination, salt spray, steam, dripping water, and other similar conditions.

- Exposure to abnormal vibration, shock, unusual transportation, or special storage conditions.
- Installations accessible to the general public.
- Duty/operating requirements of equipment.

BREAKER MOUNTED ACCESSORIES

POWER/VAC circuit breakers can be furnished with a redundant tripping circuit, dual trip coils, including the addition of a shunt trip coil. It is designed specifically for use on utility breakers and on breakers applied in nuclear power-station switchgear applications. This feature is seldom used in normal applications since the standard trip circuit is extremely reliable.

POWER/VAC circuit breakers can also be provided with a direct-acting undervoltage trip device. The device is a factory installed unit which is an integral part of the breaker mechanism. Its function is to monitor the trip control voltage and to trip the breaker if that control is lost. (See page 4-4.) Refer to GEK 105393

An optional stationary mounted auxiliary switch is available with 6 stage / 12 contacts (6 “a” and 6 “b”, or a 3 stage / 6 contacts (3 “a” and 3 “b”), and/or 10 stage / 20 contacts (10 “a” and 10 “b”).

The breaker stationary-mounted position switch is normally operated in the breaker “Test” and “Connect” positions. It may also be supplied to operate in “Test” and/or “Connect” positions only.

LIFT TRUCK

GE offers two styles of lift trucks for handling Power/Vac circuit breakers, ground and test devices, roll-out transformers and fuse roll-outs. The first is a double masted truck that is available with two swivel casters in the rear and two straight wheels in the front. This truck is compatible with indoor switchgear and provided as a standard with every order. However, to reach the top rollout drawer in an “A” compartment, a single masted truck is required. The dimensions of the double masted truck carriage are width of 47 inches and a total width of 50 inches with the winch handle installed, the depth with arms extended is 46 inches, and the standing height is 86 inches. This style of truck can not be used with outdoor aisle-less switchgear.

The second style is a single-masted truck that is available with two swivel casters and two straight wheels. This truck is compatible with outdoor switchgear and is required to reach the upper “A” compartment rollout on indoor equipment. The maximum handle load is 15 lb. with a 850 lb. load. The dimensions of the single masted truck are width 36.5 inches, the depth is 47 inches and with arms extended 55.5 inches, and the standing height is 79.5 inches extendible to 137.5 inches. The legs at the base of the lift truck are adjustable in width from 31.5 inches to 58 inches. This allows the legs to be narrowed to the width of the breaker for moving through door ways. Caution; while lowering the breaker from the cubicle to the floor the width of the legs must maintain a minimum width of 44 inches.

The single-mast lift truck can be collapsed for storage. The width is 39 inches with arms and legs collapsed, the depth is 29 inches and the height is 77 inches.

Both style of lift trucks are provided with interlocks to retain the device being handled and to lock the lift truck to the switchgear while a device is being inserted or removed. The carriage which lifts a device is raised or lowered by means of a winch and cable. When the winch handle is released the carriage is held in that position by means of a clutch-brake internal to the winch. Two arms are attached to the carriage for engaging the track rollers on the sides of each device.

The lift trucks are functional for both the upper and lower compartments of Power/Vac provided the equipment is mounted on no more than a three inch pad.

Minimum working access requirements for the lift trucks of indoor switchgear is a 66 inch front aisle space with an 18 inch right side and a 12 inch left side clearance. Outdoor switchgear requires a 66 inch front aisle space with a 36 inch right side and a 18 inch left side clearance required as standard minimum space. Smaller front aisles may be used if the required right side space is available but the factory must be consulted for an engineering evaluation.

REFERENCES

1. ANSI Standard C37.06-1979, Schedules of Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

2. ANSI Standard C37.010-1979, Application Guide for AC High Voltage Circuit Breakers.

3. ANSI Standard C37.04-1979, Circuit Breaker Rating Structure.

4. ANSI Standard C37.20-1974, Switchgear Assemblies.

5. ANSI Standard C37.24-1971, Guide for Evaluating the Effect of Solar Radiation on Outdoor Metalclad Switchgear.

6. ANSI Standard C37.100-1972 Definitions for Power Switchgear.

7. POWER/VAC* Manual Ground and Test Device Instruction Book, GEK-39686.

8. POWER/VAC* Electrical Ground and Test Device Instruction Book, GEK-39684.

Contents

Section 4
Control Power Equipment

4

Control Power Equipment

INTRODUCTION

This section of the Application Guide addresses specific control power requirements and provides guidance in selecting the proper type of control power equipment.

CONTROL POWER REQUIREMENTS

Equipment necessary to provide control power for POWER/VAC switchgear must have sufficient capacity to deliver the maximum power required, at the proper voltage, under any operating condition.

The most important consideration in selecting a control power source is that it must provide tripping power for the circuit breakers during protective relay operation. Also, it should be capable of closing the breakers without direct manual operation. Other requirements can include:

DC	AC
Indicating lamps	Indicating lamps
Emergency lights	Equipment heaters
Emergency motors	Equipment lights and convenience outlets
Excitation power (brushless motors, etc.)	Excitation power (brushless motors, etc.)
	Equipment ventilating fans
	Remote lights (on structures, etc.)

All of these requirements must be considered in determining the type and rating of the control power source.

Sources of control power for POWER/VAC metalclad switchgear are storage batteries (with charger) for dc control, and transformers for ac control. When ac is used for closing, the tripping power must be obtained from capacitors fed from rectified ac, or from a "tripping only" battery. The choice between these alternatives depends on factors such as the size of the switchgear installation, the need to operate breakers simultaneously, the degree of reliability required, expansion plans, the expected environmental conditions, maintenance support availability, and the economics related to these considerations.

CLOSING AND TRIPPING

Successful operation of POWER/VAC metalclad switchgear depends on a reliable source of control power which will, at all times, maintain a voltage at the terminals of electrically operated devices within the rated operating voltage range. In general, the operating voltage range of a switchgear equipment is determined by the rated operating voltage range of the circuit breaker. These ranges, as established by ANSI C37.06 standards, for Control Voltage and operating currents for POWER/VAC circuit breakers are given in Table 4-1 and 4-2.

Table 4-1
ML-17 & ML17H

Control Voltage Source	Closing Range	Tripping Range	Closing Coil Current		Tripping Coil Current		Motor Inrush Current	Motor Windup Current	Fuse Size Close CKT. Protection	
			W/O FBT	With FBT	5 Cycle	3 Cycle			W/O FBT	With FBT
48 VDC	38-56	28-56	9.6	-	26.5	26.5	29	12.3	30	-
125 VDC	100-140	70-140	6.0	32	10.2	6.0	18.3	3.7	20	30
250 VDC	200-280	140-280	3.0	12	5.2	5.2	9.9	2.3	15	20
240 VAC	208-254	• 295-360 VDC	10.3	16	2.3	2.3	7.2	3.0	20	30
120 VAC	104-127	• 295-360 VDC	8.0	-	2.3	2.3	13.6	4.9	20	-

• Capacitor Trip, 120/240 VAC requires the capacitor trip to operate a 340 VDC trip coil.
- Approximate Spring Charge Time: ML17=8 sec, ML18=2 sec.
- Fuses for tripping circuit should have ampere rating of at least 2 times the tripping current and not less than 35 amperes.
- Tripping Circuit Fuse is 35A except for 240 VAC with Capacitor Trip - Use 10A

Table 4-2
ML-18 & ML-18H

Control Voltage Source	Closing Range	Tripping Range	Closing Coil Current		Tripping Coil Current		Motor Inrush Current	Motor Windup Current	Fuse Size Close CKT. Protection	
			W/O FBT	With FBT	5 Cycle	3 Cycle			W/O FBT	With FBT
48 VDC	38-56	28-56	13.7	-	24	24	34	17	30	-
125 VDC	100-140	70-140	6.0	35.7	6.1	10.5	23	8.0	20	30
250 VDC	200-280	140-280	2.4	12.0	5.0	10.8	18	3.8	15	20
240	208-254	• 295-360 VDC	2.4	-	3.7	14.7	20	6.0	20	30
120 VAC	104-127	• 295-360 VDC	6.0	-	3.7	14.7	35	15	20	-

• Capacitor Trip, 120/240 MAC requires the capacitor trip to operate a 340 trip coil.
- Approximate Spring Charge Time: ML17=8 sec, ML18=2 sec.
- Fuses for tripping circuit should have ampere rating of at least 2 times the tripping current and not less than 35 amperes .
- Tripping Circuit Fuse is 35A except for 240 VAC with Capacitor Trip - Use 10A

Breaker Tripping

POWER/VAC circuit breakers are provided with means for manual tripping (push button) and for electrically actuated tripping (trip coil). Electrically actuated tripping devices are used for two functions:

- As a means of opening the breaker in the process of normal switching operations initiated by an operator, or
- As a means of automatically opening the breaker for circuit protective purposes, under abnormal conditions.

Electrical tripping is accomplished when external power, from a battery or from a rectified ac source (with capacitor), is directed into the breaker trip coil. Normal switching tripping uses an operator control switch. Automatic tripping occurs when a contact on a protective relay closes, actuated by power circuit instrument transformers.

When deciding between dc battery trip and ac capacitor trip, the following points must be considered:

- For a single breaker, or a few breakers, the capacitor trip device has lower cost than a battery, but a trip device is required for each breaker.
- A battery source is more reliable, but requires more maintenance than a capacitor trip device.
- If a battery is used for tripping, dc closing power can also be obtained for little additional cost.

DC BATTERY TRIP — When properly maintained, a battery bank offers the most reliable tripping source. It requires no auxiliary tripping devices, and uses single-contact relays which directly energize a single trip coil in the breaker. Power circuit voltage and current conditions during time of faults do not affect a battery-trip supply; therefore, it is considered the best source for circuit breaker tripping. Additional advantages are that, usually, only one battery bank is required for each location, and it may be used to operate other equipment such as high-voltage circuit breakers or protective grounding switches.

Once a battery bank has been selected for tripping purposes, it can, after proper evaluation of additional loads, also be used for breaker closing power. For indoor applications, if the battery bank can be located close to the switchgear, a 48-volt battery operating level is usually suitable. For more general use, a 125-volt battery is recommended, but 250-volt batteries can be used if other conditions require that voltage. In outdoor locations, space considerations in the switchgear usually restrict the battery bank to a 48-volt rating.

General requirements for battery bank sizing of a 48 vdc bank is one 36 inch Power/Vac stack. A 125 vdc bank will require two 36 inch wide Power/Vac stacks.

Long service can be obtained from batteries when they receive proper maintenance, are kept fully charged, and when the electrolyte is maintained at the proper level. For equipment in outlying locations where periodic battery maintenance would be difficult, the capacitor trip device may offer overall advantages.

Control Power Equipment

POWER/VAC AUTO-CHARGE CAPACITOR TRIP DEVICE— The "auto-charge" trip device consists of the "simple" device, plus voltage amplifier, a battery, and a battery charger. Under normal conditions, with 230-volt ac power used for breaker closing, the single cell, sealed, rechargeable, nickel-cadmium battery is maintained at full charge by the small charger connected to the 230-volt ac source.

Upon loss of ac power, the voltage amplifier steps up the low battery voltage to the higher voltage needed to maintain charge on the capacitor for seventy-two hours. The transfer to the standby charging battery is completely automatic.

Should the battery be removed or become discharged, the device will continue to function as a conventional capacitor trip unit. The battery itself is the size of a flashlight battery and can be replaced temporarily by one in an emergency. A push-button and indicating lamp provide a means for checking the presence of tripping potential across the capacitor.

The "auto-charge" capacitor trip device is provided on POWER/VAC switchgear whenever ac trip or capacitor trip is specified. In capacitor trip applications, the breaker trip coil is 325-volts dc and the output tripping range is 295-360 vdc.

DIRECT ACTING UNDERVOLTAGE TRIP— POWER/VAC circuit breakers can be provided with a direct acting undervoltage trip device. The undervoltage trip device is a factory-installed unit which is an integral part of the breaker mechanism. Its function is to monitor the trip control voltage and to trip the breaker if that control voltage is lost.

NEMA Standard Publication No. SG4-1975 paragraph 3.12 requires the dropout range of undervoltage trip devices to be 30 to 60 percent of the rated voltage. The POWER/VAC undervoltage device trips the breaker in the range of 15 to 60 percent of the nominal tripping control voltage.

Control Voltage	Tripping Range
48 VDC	7-29 VDC
125 VDC	19-75 VDC
250 VDC	38-150 VDC

Specifications which require that tripping occur at some voltage higher than 15 percent should be provided with a voltage sensing relay to remove trip control voltage from the undervoltage trip device to assure breaker tripping at the desired voltage.

Breaker Closing

Closing power availability should be independent of voltage conditions on the power system associated with the switchgear. Accordingly, a 125-volt or 250-volt dc battery bank is normally considered to be the most reliable auxiliary power source. Nevertheless, in many instances, the storage battery bank or other independent power source necessary to achieve this goal may require an investment which is considered too high for the advantages gained. This is particularly true for small line ups, consisting of only a few circuit breaker units.

Generally, the choice between dc closing power derived from a battery and ac closing power derived from a control power transformer is an economic one, dictated by desired system reliability. There are other factors, however, which also influence this choice. These are:

- Need to close breakers with the power system de-energized.
- Availability of housing space for a battery and its associated charging equipment.
- Estimated lowest ambient temperature and its effect on battery capability.
- Maintenance requirements for a battery and battery charger.
- Expected future equipment additions which may affect the present choice of closing-power source.

The POWER/VAC stored-energy operating mechanism can use the closing arrangements shown in Figures 4-1A through 4-1D.

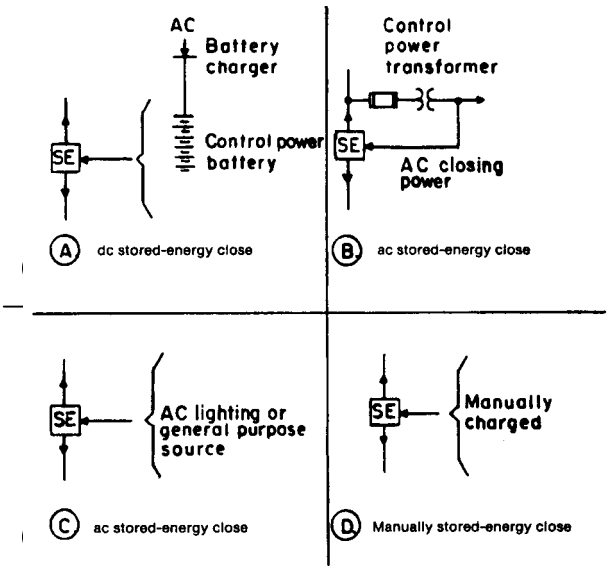


Figure 4-1. Closing mechanism arrangements.

When the mechanism is operated from alternating current, the current required is such that it can be taken from a control power transformer or a general-purpose or lighting source, as shown by Figures 4-1B and 4-1C. The energy for the next operation is stored in the springs as soon as the breaker is closed. To permit control switch or automatic initiation of closing, the ac source must also be present at the time of breaker closing to energize the spring-release solenoid; however, at attended locations, a somewhat less reliable ac control source may be permissible where an operator can manually release the closing springs if necessary. The POWER/VAC breaker mechanism is also suitable for manual operation (Figure 4-1D), both for charging the springs and for releasing them to close the breaker.

For any control power source used for breaker closing, the maximum closing load should be calculated using Table 4-1 and 4-2 values. Usually, only one breaker will be closed at a time, but the possibility of simultaneous closing of two or more breakers must be examined. This possibility will depend on the type of application and any special control requirements, such as load restoration. Simultaneous closing of two breakers could occur with multiple-breaker, motorstarting equipment, or with automatic reclosing breakers. Also, on large installations, with several different control points, different operators could cause simultaneous manual operations.

INDICATING LAMPS

Position indicating lamps for each circuit breaker are operated from the trip fuses with dc closing power, or the closing fuses on either ac control or a "tripping only" battery. These lamps are a small — but steady — load, which is of concern particularly in dc applications. The total load is the sum of:

- One indicating lamp per breaker.
- Lamps used to supervise fuses of lockout relays, etc.
- Additional lamps — if any —used for remote indication in parallel with switchgear lamps.

Burden is usually 0.035 amperes per lamp, regardless of voltage, and is assumed to be carried (by the battery) for not more than eight hours.

EQUIPMENT HEATERS

On outdoor designs, moisture condensation is minimized through the use of Calrod heating elements. A 75-watt output heating element is located in each breaker or auxiliary compartment and each cable compartment with a total of 300 watts per vertical section. Heaters are applied at half-voltage for extended life and are protected by perforated metal guards to prevent inadvertent contact with the heater element.

Heaters should be energized at all times to guard against condensation caused by wide ambient temperature excursions. Accordingly, no switch or thermostat is provided in the heater circuit.

Heaters are supplied on indoor designs only if specified by the purchaser.

COMFORT HEATING

Comfort heaters for use in outdoor aisle-type POWER/VAC installations must be supplied by the Purchaser. A grounding-type receptacle, rated 250 volt ac, 20 amperes, is provided at each end of the aisle for portable comfort heaters.

When sizing the ac control power source, allow for 5000 VA ac load at 230 volts for each heater receptacle intended for use.

RELAYING

With dc control power, allowance must be made for simultaneous tripping of two or more breakers. Requirements for simultaneous tripping depend, first, on the number of breakers on the dc source, and, second, on the kind of relaying. Based on probability considerations, a guide to the possible number of simultaneous tripping is given in Table 4-3.

Table 4-3
Simultaneous Breaker Tripping

Number of Breakers in lineup	1	2	3-5	6-10	Above 10
Breakers Tripped By:	**Probable Maximum Number of Breakers Tripping Simultaneously**				
Time delay fault protection	1	1	2	3	(a)
Instantaneous fault protection	1	2	3	4	(a)
Undervoltage or bus differential (b)	1	2	All	All	All

(a) Depends upon operating conditions.
(b) Use of single undervoltage or bus differential relay for tripping all breakers.

Lockout relays, when present, as in differential relay circuits, require special treatment:

- With ac operation, a capacitor trip device must be included for operation of each lockout relay.
- With dc operation, the relay coil current must be added to the simultaneous breaker demand, since the relay does not cut itself off until after the breaker coils have been energized. A guide to this current is:

Operating voltage (volts)	48 V	125 V	250 V
HEA relay coil current (amperes)	10.7 V	5.5 A	2.4 A

FANS

Outdoor aisle-type POWER/VAC switchgear is available with roof fans for aisle ventilation. The standard fan uses a 1/3 hp single-phase motor, for operation from 120-volts ac only; provide 333 VA per fan.

Substation transformers associated with switchgear sometimes include fans. When energized for the switchgear control power source, the fan load must be included in the total burden on the source. Usually this is a 230-volt, single-phase load; from one to several kVA per transformer.

LIGHTS

Outdoor POWER/VAC switchgear, both aisle and non-aisle types, is provided with receptacles for 120-volt incandescent lamps. The control power allowance for these should be 100 Watts per vertical section.

Other lighting loads, such as outside floodlights, must be factored into the ac control power load based on actual requirements.

CONVENIENCE OUTLETS

In outdoor POWER/VAC switchgear, 115-volt duplex grounding convenience outlets are provided. With aisle-less design, one outlet is provided per vertical section. With aisle-type construction, one outlet is located at each end of the aisle.

Control power allowance should be a nominal 500 Watts for each duplex outlet.

EXCITATION POWER

When synchronous motors with brushless field excitation are controlled directly for the switchgear, power for the exciter field source is frequently required from the switchgear control power source.

This excitation demand varies with the machine, from 1 to perhaps 8 amperes dc, usually at approximately 100 volts. With rectified ac supply to the field, the ac equivalent of the dc field current must be included the total CPT loading. (As a first approximation, multiply the dc amperes by 1.15 and convert to VA by multiplying this product by 125 volts.) When the exciter field is fed directly from the battery, the field demand — as a nominal 8-hour load — must be included in the dc steady load total.

Generators with static regulators usually require a separate transformer on the incoming leads of the generator breaker. This transformer is of the same epoxy-cast coil, dry type, as the switchgear CPT, but is located in its own rollout tray. Such dedicated transformers are not part of the regular control power loading.

BREAKER REMOTE RACKING

When the usual manual racking means is supplemented by a remote racking device with a motor, the load on the control power source is the same as for the breaker spring-charging motor; see Table 4-1 and 4-2.

OTHER LOADS

With dc control, when the charger is supplied from the switchgear ac control power transformer, the charger load must be included in the total ac demand. Using charger dc ampere rating as a base, some ratios of equivalent ac load at different supply and battery voltages are tabulated in Table 4-4.

Table 4-4

AC Supply Voltage	Ac load factor for charger Battery Voltage	
	48 V	125 V
115 V	75 %	230%
230 V	38%	115%

For example, a 6-ampere charger, fed 115 volts, and supplying a 125-volt battery bank, has an ac load of approximately 13.8 amperes (6 A x 230%) at full output, or 1590 VA (13.8 A x 115 V). While this would be an intermittent condition, with the normal load being about 0.5 to 1.0 amperes dc, the ac control source must be sized to handle the 13.8 ampere load.

With automatic control schemes, some relays will be energized continuously after the first breaker is closed. The amperes drawn by these relays must be totalled and included with the indicating lamp load, etc., to arrive at the total steady load.

Emergency loads on switchgear batteries, such as room lights or dc pump motors, usually result in a much larger battery bank than required for the switchgear alone. Lights are usually assumed to be used for three hours, and then extinguished. Motor load duration must be specified by the user.

CONTROL POWER SOURCE SELECTION

For a particular station, selection of a control power source may require sizing of a battery, a control power transformer, or — sometimes — both. The first step is to establish the size of each load of the various kinds enumerated. Second, for batteries, the short-time loads, such as breaker tripping, and the steady load, such as lamps, must be converted to a common rate base.

With the relatively small demands placed on the control power source by individual breakers, as detailed in Table 4-1 and 4-2, other loads must be evaluated carefully, since they may represent the major demand. Particularly with batteries, long-time loads must have a time period stated, since a battery bank, with the charger “off”, is not a “continuous” source.

DC CONTROL POWER EQUIPMENT

GE Switchgear Operations in Burlington does not design, manufacture or test storage batteries. The principal function of the Medium Voltage Switchgear Operations is to select and furnish batteries and their charger as specified by the customer and in accordance with the requirements of the switching devices and the over-all station operation.

A dc control power source consists of a storage battery bank and an associated charger. The battery bank is connected to the dc control power bus and the charger at all times. Large momentary loads are supplied from the battery bank, but it otherwise does very little work in normal operating situations.

The basic requirements of a storage battery are it must be capable of being trickle charged so that under normal conditions the battery is always fully charged and its terminal voltage held substantially constant. The trickle charge voltage must be less than the upper voltage limits of lamps and continuously energized coils and should not fall below a specified minimum voltage during maximum normal momentary discharge. This is to insure adequate closing voltage at the breaker mechanism terminals after making allowances for voltage drop in connections between the battery bank and the breaker mechanism.

Two types of batteries are used with switchgear that have the characteristics which meet the requirments for closing and tripping functions: lead-acid or nickel-cadmium. Several classes of each type are produced, each with different costs and with different ratios between short-time and long-time capacities. The exact type and class must be established before performing the conversion of loads to a common rate base.

Lead-acid Batteries

Listed, in order of increasing cost, are several classes of lead-acid batteries.

- Pasted plate, with lead-antimony grids.
- Lead-calcium; a pasted-plate construction with calcium replacing antimony as the additive for grid strength.

Pasted plate, lead antimony, is the basic lead-acid battery, familiar in another form as the automobile battery. For control work (compared to auto batteries), thicker plates and lower gravity of acid provide longer life and allow long-time trickle or “float” charging. With different plate thicknesses, expected life is from 6 to 14 years.

Lead-calcium construction has longer expected life (up to 25 years) than lead-antimony — at a rather small increase in cost. The “pure lead” electrochemical characteristics, compared to the other classes, require slightly different (higher) charging voltages.

The tubular-positive class evolved from electric battery truck service; hence, it is most suitable for large stations with considerable emergency lighting and/or motor loads, etc.

Plant— batteries are long-life cells, with 20 to 25 years of expected life. Increased manufacturing time for the pure-lead positive plates, compared to pasted plates, leads to higher prices. Electrically, short-time rates are somewhat higher, and ampere-hours slightly less, for a given cell size, than in pasted-plate construction.

Nickel-cadmium Batteries

Nickel-cadmium batteries are more expensive than lead-acid, in general, but have some advantages. Maintenance is less, life is somewhat longer, low-temperature discharge currents are higher for a given size, and they can be charged more rapidly.

Pocket-plate cells are the normal construction used with switchgear; they are made in three different plate thicknesses. The thickest plates are not suitable for short-time applications. Medium or thin-plate cells are used with switchgear; the choice depending upon the relative amounts, respectively, or long- or short-time load.

Sintered-plate construction, which is relatively new, is used mostly in "cordless" appliances, seldom in switchgear.

Battery Capacity and Sizing

The capacity of a storage battery is usually expressed in ampere-hours (one amp for one hour, or the product of amperes output multiplied by hours of discharge, with the basic rate being eight hours). Battery capacity, however, may be expressed at many time-rates other than the eight-hour rate.

For switchgear short-time loads, such as breaker tripping, the one minute rate per cell — discharging to 1.75 volts for lead, or 1.14 volts for nickel-cadmium — is used. The one minute rate does not exhaust the battery completely; rather, it is the rate which causes the terminal voltage to drop to the stated value early in the discharge period.

Further, the actual value of discharge capacity of a storage battery may vary over a wide range with battery temperature. Published data is for cells at 25° C (77° F), and battery rating factors must be reduced when the battery is at a lower temperature. For capacity rating factors refer to IEEE worksheets.

Generally the effect of high temperatures for every 15° F above 77° F the lead acid battery loses 50% of its useful life and for the same temperature decrease, the nickel-cadmium loses 20% of its useful life. The one-minute rating at -10° C (15° F), for instance is half the 25° C rating.

In calculating the battery loads you must consider three types of loads: Continuous loads are those that are energized for the duration of the duty cycle. These have a major effect of battery capacity. Non-continuous loads are energized for only a portion of the duty cycle. If the inception of the load is known, but the end is not or reverse then you must consider it as the known portion of the duty cycle. Last are momentary loads which are very short in duration, they can be a fraction of a second, but you must treat it as lasting one full minute.

- Direct use of specification sheets, or software programs, etc. from battery makers.
- Referral of data to battery manufacturers.
- Referral of calculated data to switchgear manufacturers.

For direct calculation, the battery is assumed to have carried its steady loads for eight hours, and then — as the worst case — subject to the maximum load involving the one-minute rate.

Indoor locations assume that the battery is at 25° C (77° F); outdoor locations at -10° C (15° F). A minimum size limit of cell is suggested to allow for unknowns: 20 ampere-hours for lead-acid, or 15 ampere hours for nickel-cadmium.

A small station, for example, with the battery located indoors, might have three breakers, with closing and tripping duty, and no steady load except the switchgear indicating lamps. Two of the breakers have instantaneous attachments on their overcurrent relays, so that — per Table 4-3 — simultaneous tripping of these two breakers might occur. Steady lamp load, thus, is 0.035 A x 3 = 0.105 amperes. Maximum short-time loads, given for both 48-volt and 125-volt dc to illustrate procedure, are:

Table 4-5
Battery Sizing Information

Control Voltage	125 VDC		48 VDC	
Battery System Voltage Range	105-140 VDC		42-56 VDC	
Breaker Mechanism Type	ML-18	ML-17	ML-18	ML-17
Breaker Quantity				
Breaker Close Current	6.0 Amps	6.0 Amps	13.7 Amps	9.6 Amps
Breaker Close Time	5 Cycles	5 Cycles	5 Cycles	5 Cycles
Breaker Trip Current	6.1 Amps	10.2 Amps	24 Amps	26 Amps
Breaker Trip Time	5 Cycles	5 Cycles	5 Cycles	5 Cycles
Spring Charge Inrush Current	23 Amps	18.3 Amps	34 Amps	29 Amps
Spring Charge Windup Current	8 Amps	3.7 Amps	17 Amps	12.3 Amps
Breaker Spring Charge Time	2 Seconds	3 Seconds	2 Seconds	3 Seconds

Since two breakers can trip at once, maximum current from this load is either 19A x 2, or 10A x 2, respectively, 38 or 20 amperes at 48 or 125 volts. Comparing this with charging motor current, we see that the trip current is larger, so trip current will be used in the next step as illustrated in Table 4-5.

Table 4-6

Battery Type:	Lead-acid		Nickel-cadmium	
Control voltage (volts)	**45**	**125**	**48**	**125**
Maximum 1-minute demand (amperes)	38	20	38	20
8-hr. equiv. Of 1-min. demand (Max. demand divided by conversion factor*) (ampere-hours)	25.3	13.3	13.1	7.0
Lamp load (0.105A x 8 hrs.) (ampere-hours)	0.84	0.84	0.84	0.84
Total ampere-hours (8 hr. rate)	26.14	14.14	13.94	7.84

* Conversion factors to convert to "common rate base" (i.e., from one-minute rate to eight-hour rate) are: 1.5 for the lead-acid batteries (pasted plate); 2.9 for the nickel-cadmium batteries (thin plate or high rate). Please note that conversion factors vary by cell size; therefore, the factors used in this example are not applicable for batteries of other sizes.

Analyzing these totals, the lead-acid battery at 48 volts with a nominal ampere-hour rating of 30AH will be required. As an alternate the minimum 20AH lead-acid battery at 125 volts will be sufficient. The minimum nickel-cadmium battery of 15AH will be sufficient at 48 volts and at 125 volts.

In addition, since the total ampere-hours required in each case is less than the ampere-hour capacity of the selected cell, reserve capacity is available. The matter of reserve capacity is largely related to how long the charger may be off. This no-charge condition has been known to last for several days. Thus, a "dc low-voltage alarm" option in the charger may be desirable to warn of such conditions.

For the same station, with the battery at outdoor temperatures, the one-minute demand must be doubled before converting to ampere-hours. The eight-hour rate needs a smaller increase of about 30 percent. Note that these conversion ratios generally decrease as cell size increases; hence, the approximate size of cell being considered must be determined before the conversion factors can be determined.

In arriving at the actual size of the battery bank, care must be taken to review the calculated amp-hours or cell requirement and then take into account the recommended design factor of 10% times the calculated values and then an aging factor of 25% times the calculated values. The combined sum of these calculations will provide the actual size of the battery bank.

Battery Chargers

Battery chargers have been built both as unregulated or "trickle" chargers, and as voltage-regulated chargers. The latter type provides longer life for the battery, particularly if it is a lead-acid battery. Voltage-regulated chargers are considered standard for switchgear applications .

The charger must be selected with an ampere rating sufficient to satisfy the simultaneous demand of the following three functions:

- Self-discharge losses of the battery.
- Steady load of the station: indicating lamps, etc.
- Equalizing charges, or other high-rate output requirements.

The self-discharge or "trickle" current of a lead-acid battery starts at about 0.25 percent of the eight-hour rate, and increases with age to about 1.0 percent of that rate. Nickel-cadmium cells can be assigned a similar trickle current.

Steady load is made up of the long-time loads mentioned earlier in this section.

Equalizing charge is a monthly requirement for lead-acid batteries except for the lead-cadmium class. When the charger is first switched to the higher equalizing voltage, the battery demands current equal to about 20 percent of its eight-hour rate. Nickel-cadmium batteries do not require equalizing, but it is convenient to use the same numbers as for lead-acid in establishing the charger capacity to be used for occasional "boosting" of the nickel-cadmium battery.

In sizing the charger, the first number considered should be the steady load from the preceding battery calculations. Add to this load, the equalizing charge current. A quick way to find equalizing amperes is to divide the battery ampere-hour capacity (at the eight-hour rate) by 40. The sum of steady load and equalizing amperes is then compared with a list of battery charger ratings; select a charger with a rating that equals or exceeds this sum. The trickle current, unless known to be quite large, is usually covered by the margin between the standard charge rating and the sum of steady and equalizing loads.

Occasionally a battery is shipped "dry," with electrolyte added at its destination. Such batteries require a "conditioning" charge after filling; the amperes needed for this are 25 percent of the eight-hour rate, but with no other load connected.

AC CONTROL EQUIPMENT

Application

To minimize the possibility of inadvertent interruption of control power for ac-operated POWER/VAC switchgear, it is recommended that control power be derived from a separate transformer used only for control and other power requirements, which are directly associated with the performance of the switchgear. The transformer should be energized from that part of the main power system least likely to be de-energized.

Where the switchgear is energized from multiple sources of power, a control-power transformer is usually provided for each source, for operation of breakers associated with that source. Breakers such as feeder and bus-tie breakers not associated exclusively with any one source are supplied either from a transformer connected to the switchgear bus, or by selective relays embodied in the control power equipment, which automatically connect the control bus to an energized transformer.

Selection

If breaker tripping power, with ac control, is being obtained from capacitor-trip devices, its demand need not be included in the control power transformer section. Similarly, closing demand is relatively small, except for the breaker spring-charging motors. The principal caution regarding closing demand is to review for conditions where two or more spring-charging motors may be energized at the same time.

Other loads, such as those listed on page 4-2, must be totaled and evaluated to determine their demand on the control power transformer. The total load is then compared to the available sizes of control power transformers, and the next larger size selected.

As an example, consider an outdoor, protected-aisle station having five breakers and one auxiliary compartment (in four vertical sections). Control of breakers is from local control switches. No ventilating fan is used, but 400 Watts are needed for remote lights. As shown in Table 4-7, the load is approximately 8 kVA, so the next larger available transformer (10 or 15 kVA) is selected.

Table 4-7

Type of Load	Load (VA)
Indicating lamps (0.035A x 230V x 5 Breakers)	40
Equipment heaters (300 W x 4)	1200
Comfort heater (plug in)	5000
Equipment lights (100 W x 4)	400
Convenience outlets (500 W x 2)	1000
Remote lights	400
TOTAL	8040

GUIDE FOR ESTIMATING THE HEAT LOSS IN POWER/VAC SWITCHGEAR

When operating at name plate rating, POWER/VAC metalclad switchgear heat losses per vertical section may be obtained by adding the individual components of heat loss as indicated below.

Table 4-8

Breaker and Bus Work Per Vertical Section	Heat Loss In Watts
1-1200 AMP BKR	675
1-2000 AMP BKR	1335
1-3000 AMP BKR	2030
3500/4000 AMP BKR	2765
2-1200 AMP BKRS. STACKED	1220
1-1200 AMP & 1-2000 AMP BKR	1880

To the above figures add the following as they apply to the line-up.

Table 4-9

Each vertical section with simple relaying and control	150 watts
Each vertical section with complex relaying and control	330 watts
Each VT rollout	50 watts
Each CPT rollout up to 15KVA	600 watts
Equipment heaters if supplied	300 watts

To convert Watts to BTU'S:

Watts x 0.05688 = BTU'S per minute

Watts x 3.4128 = BTU'S per hour

Contents

Section 5
System and Equipment Protection

System and Equipment Protection

INTRODUCTION

This selection Guide covers some of the basic considerations used when selecting electrical-mechanical or microprocessor digital relays for the protection of Medium Voltage Power Systems. It is organized by protection packages according to the types of equipment generally encountered in medium voltage systems. Feeders, Incoming Lines, Bus, Transformers, Motors, Generators and Metering will be addressed.

Protection considerations can be provided by either single phase and multi-function three phase relays that include phase and ground directional, non-directional relays, overcurrent, differential, directional power, under-frequency and under-over voltage relaying.

Instrumentation, metering, current and voltage detection considerations include selection of scales as well as instrument transformer ratios.

Packages are based on traditional electrical-mechanical relays used on power system configurations. Introduction has been made to use the NEW multifunction digital relays. Multifunctional digital relays offer several benefits; expanded relay functions, digital metering, diagnostics, reduction in relay costs per function, reduction in wiring and increased panel space with the reduction in the quantity of relays. Relay product reference guides for electrical-mechanical and digital relays are GEZ 7723 and GEZ 8188.

Control considerations include a discussion of permissive control operation as well as supervision of trip coils by indicating lamps.

Since all ac power systems are subject to transient voltages, a discussion of surge protection is also included.

PROTECTION CONSIDERATIONS

BASIC SYSTEM PROTECTION

Phase-overcurrent Protection

Recommended phase over-current protection consists of one phase-overcurrent relay (50/51) in each phase operated from a current transformer in each phase. This arrangement provides complete circuit phase-overcurrent protection when one phase relay is removed from the circuit for testing; it also provides local backup if one of the three phase relays is inoperative. Minimum phase-overcurrent protection available for feeders, when ground protection is included, consists of two phase-overcurrent relays operating from current transformers in phases one and three. However, this minimum arrangement does not provide phase backup protection if one phase relay is removed from the circuit. If equipment is shut down for testing and local redundancy is not critical, three-phase protection (and possibly ground as well) may be provided in one unit.

Overcurrent relays are available with inverse, very inverse, or extremely inverse characteristic. In the absence of additional system information, for a single characteristic device the very inverse characteristic is most likely to provide optimum circuit protection and selectivity with other system protective devices. This characteristic is intended for application where the magnitude of fault current is determined primarily by the distance from the source to the fault. If selectivity with fuses and reclosers is a requirement, the extremely inverse characteristic is well suited for applications. The inverse characteristic is useful in those rare applications in which selectivity with other inverse or definite time relays is a concern. It is also useful on systems that have a multiplicity of local generators at the distribution voltage and where the magnitude of fault current is determined primarily by how many generators are in service at the same time. Some microprocessor-based relays have all the above characteristics field-selectable which would allow the specifier to select a relay with minimal information and select a characteristic when more complete information is available.

INCOMING LINES — Incoming line phase-over-current relays (51) of the electro-mechanical type are usually furnished without instantaneous attachments (50), while on digital multi-function relays the instantaneous is disabled but the functions stays available. This allows the relay to be selective with feeder relays having instantaneous attachments (50/51).

FEEDERS — Instantaneous phase-overcurrent relay (50) settings for radial *utility distribution feeders* are set usually as low as possible considering, among other things, “cold-load” pickup and other circuit requirements. Instantaneous phase-overcurrent relays for *industrial or commercial building radial circuits* are usually set high enough (but well below the available short-circuit current) to prevent false tripping for faults at the lower-voltage terminals of large transformer banks and to provide selectivity with groups of large motor starters. Instantaneous settings should be low enough so that the combination of time and instantaneous settings provides protection below the conductor short-circuit heating limit.

FEEDER TIES — For feeder-tie circuits to *downstream* distribution circuit-breaker lineups, selectivity is enhanced by disconnecting, disabling, or delaying (digital) the instantaneous element (50) of the phase-overcurrent relays and setting the time-overcurrent relay (51) element to trip at less than the short-circuit heating limit of the conductors.

BUS TIES — Bus-tie circuits, within the same lineup of switchgear including two incoming lines, are frequently specified without overcurrent-protective relays. When overcurrent protection is provided for this type of circuit, relays are connected in what is termed a "summation overcurrent" connection. The use of this connection provides the opportunity for selectivity between main or tie breakers and feeder breakers minimizing relay operating time delay. (See the one-line diagram on pages 2-6 and 2-7 for an example of this connection.)

TRANSFORMERS — Transformer-overcurrent protection criteria are specified in Section 450-3 of the 1996 National Electrical Code. Permissible short-circuit capabilities for transformers are specified in American National Standards Institute Standard C57.12-1979, Paragraph 10.1.1 Selection of transformer-overcurrent protection is governed by these criteria.

The NEC requirements determine the pickup of the time-overcurrent phase protective relays. The ANSI requirements and the connection of the transformer determine the time dial setting. The inrush and short-circuit current magnitudes determine the instantaneous setting of the phase-overcurrent protective relays.

GENERATORS — Overcurrent relays, applied on generator circuits, are used for feeder backup rather than overload protection. These overcurrent relays are voltage-restrained overcurrent relays (51V). They operate faster and are more sensitive for faults close to the generator than for faults remote from the generator. For complete protection using a digital multi-function relay refer to the GE Multilin-DGP relay or the SR 489 relay.

Ground-overcurrent Protection

Ground-overcurrent protection is provided by either time-overcurrent relays or instantaneous overcurrent relays. Sensitive ground-fault protection is desirable to minimize damage to circuit equipment and circuit conductors.

The three most commonly used connections for ground-overcurrent relays are the residual connection (51N), the ground-sensor (balanced-flux or zero-sequence) connection (50GS or 51GS), and the neutral current transformer connection (51G).

Residually connected ground-overcurrent relays (51N) are wired in the ground-return current transformer lead of three current transformers connected in wye. The relay detects the current in the ground fault by measuring the current remaining in the secondary of the three phases of the circuit as transformed by the current transformers. The minimum pickup of the relay is determined by the current transformer ratio. On systems with line-to-neutral connected loads, the ground-overcurrent relay (51N) pickup must be set above any expected maximum single-phase unbalanced load. If an instantaneous ground-overcurrent relay (50N) is used, it must be set above any expected unbalance due to unequal current transformer saturation on phase faults or transformer inrush currents. Residually connected ground-overcurrent relays are usually applied on solidly grounded systems.

Ground-sensor relaying schemes use an instantaneous (50GS) or time-delay (51GS) overcurrent relay connected to the secondary of a window-type current transformer through which all load current-carrying conductors pass. The relay detects the ground current directly from this current transformer, provided the equipment ground conductor and cable shielding bypass the current transformer. A 50:5 current transformer and 0.5A instantaneous or time-delay relay detects faults as low as 15 amperes in the primary circuit. Static relays with external power supplies and lower pickup may detect lower level faults. Ground-sensor relaying schemes are usually applied on low resistance grounded systems.

Neutral ground relaying uses a time-delay overcurrent relay (51G) connected in the secondary of the current transformer located in the neutral of a wye-connected transformer, wye-connected generator, or the neutral of a neutral-deriving transformer bank.

Some systems are designed with no intentional grounds. To detect the first ground on this type of system, a sensitive directional ground overcurrent device may be employed.

INCOMING LINES — Incoming line ground-over-current relay protection consists of either a residually connected relay (51N) or a relay (51G) connected to a current transformer in the transformer neutral ground connection. Ground-sensor relaying (51GS) on incoming lines is rarely applicable because of the size, number, or construction of the incoming line conductors.

For solidly grounded systems with remote-supply transformers, residually connected ground-overcurent relays (without instantaneous) are most applicable. Some utility users omit all incoming line ground relays on solidly grounded systems and rely on three phase-overcurrent relays to provide complete phase- and ground-fault protection.

For impedance-grounded systems with local supply transformers, a ground relay (51G) connected to a current transformer in the transformer neutral connection is most applicable. A typical current transformer ratio for the neutral current transformer is one-half to one-quarter the maximum ground-fault current, e.g., a 200:5 CT ratio is appropriate for the neutral CT in series with a 400A, 10-second neutral grounding resistor. This ratio permits sensitive settings of the ground relay and selective operation with downstream ground-sensor relays. The ground relay is the system backup relay for the medium-voltage system. It also provides ground-fault protection for the transformer and its secondary conductors. If a transformer primary circuit breaker is used, the secondary ground-overcurrent relay (51G) in the transformer neutral connection should trip both the transformer primary and secondary circuit breaker.

FEEDERS — Ground-sensor (zero-sequence) relay arrangements use instantaneous-overcurrent relays (50GS) or time-overcurrent relays (51GS) and are appropriate for both impedance and solidly grounded systems. These arrangements provide sensitive ground-fault protections for both branch circuits and feeder-distribution circuits. Good selectivity can be obtained for a distribution system incorporating this type of relaying on all branch and feeder distribution circuits; however, a feeder breaker with ground-sensor relaying usually cannot be made selective with downstream feeders using residual ground relaying. In addition, ground-sensor relaying is not applicable to circuits with metal-enclosed conductors because of the impracticability of passing the phase conductors through a single current transformer. Ground-sensor relaying is rarely applied to circuits terminated with potheads because of the special installation procedures required for mounting the potheads.

Residual-ground relaying (51N or 50/51N) is suitable for feeders on solidly grounded systems or impedance grounded systems with available ground-fault currents greater than about twice the maximum current transformer rating. It is also required for feeders which must be selective with downstream feeders, which have residual-ground overcurrent relaying.

TRANSFORMERS AND GENERATORS — Ground-overcurrent relaying for wye-connected transformers, wye-connected generators and neutral-deriving transformers usually employs neutral-ground relaying, as discussed previously under “Incoming Lines.” This provides system backup ground relaying. Settings, however, are normally too high to provide good ground-fault protection for the apparatus. Ground-fault protection is better obtained by using a scheme of differential relaying which is described later in this section.

Directional Phase-overcurrent Protection

Directional phase-overcurrent relays (67) operate for current flow in only one pre-determined direction. Incoming lines, operating in parallel from separate sources, require directional phase-overcurrent relay protection to provide sensitive operation and to assure selectivity between incoming-line breakers for phase faults on the source side of one of the breakers. This directional phase-overcurrent protection is furnished by using relays, polarized to operate on current flowing toward the source. The directional-overcurrent relay without instantaneous function is appropriate for most applications. The pickup of this relay should be set at a value slightly below full-load current. The time dial can be set to permit selectivity with upstream feeder breaker or line instantaneous relays.

Occasionally a directional-overcurrent relay (67) with directional instantaneous function is applied to incoming lines fed by long ”dedicated” service lines, the instantaneous directional unit is set to operate for faults located approximately 80 to 90 percent of the distance from the incoming line to the source. For large local transformers, the instantaneous unit on a high side directional overcurrent relay is set slightly above the low-voltage symmetrical rms amperes contributed through the transformer to a fault on the higher voltage side of the transformer.

Directional phase-overcurrent relays can be voltage polarized from bus VT's connected in open-delta, delta-delta or wye-wye. Polarization is necessary to establish the current phase relationships between voltage and current to determine the direction of current flow.

Electromechanical directional-overcurrent relays are usually available only in single phase units having one time-current characteristic. Digital multi-functional versions are available in three-phase (and ground, if desired) packages with inverse, very inverse, and extremely inverse (and possibly other) characteristics field-selectable.

Directional Ground-overcurrent Protection

Incoming lines operated in parallel from separate grounded sources require directional-ground-overcurrent relays (67N) to assure selectivity between incoming-line breakers for ground faults on the source side of each of the incoming-line breakers. For solidly grounded systems and many impedance-grounded systems, multi-functional digital relay usually is appropriate. This relay is set at a low pickup to permit selectivity with the other incoming-line non-directional ground-overcurrent relaying.

All directional-ground relays must be polarized. For systems with local, grounded supply transformers, the current transformer located in the transformer neutral-ground connection may be used for polarizing. For systems with remote-supply transformers, a set of local wye-broken delta connected voltage transformers (or wye-wye VTs with wye-broken delta auxiliary transformers) may be used for polarization. On occasion, dual polarization may be desirable.

As mentioned in the phase units above, electromechanical directional ground-overcurrent relays are usually available only in stand-alone units having one time-current characteristics. Static versions are available in packages with inverse, very inverse, and extremely inverse (and possibly other) characteristics field-selectable. This function (67N) may also be packaged in with all three phases of directional phase overcurrent.

High Impedance Ground Fault Detection

Many distribution system faults do not include enough current to be detected by traditional overcurrent protection. These faults frequently result from a broken conductor falling in contact with a poor conducting surface or an object having relatively high impedance. A high percentage of arcing downed conductors may be detected by a special digital relay specifically designed for that purpose.

Differential Protection

Differential Protection is a method of apparatus protection in which an internal fault is identified by comparing electrical conditions at all terminals of the apparatus. By virtue of the connection and settings, this protection only operates for faults in the apparatus being protected. Hence differential protection does not need to coordinate with devices protecting other downstream conductors and equipment. Differential protection considerations for a specific apparatus will be discussed in the later section related to the apparatus.

BUS PROTECTION — Bus-differential relays should be applied to generator buses, buses with high available short-circuit current, and buses which, if faulted, create system disturbances which could lead to system instability in other portions of the system if the fault is not rapidly isolated. This type of relaying uses equally rated phase-current transformers of like characteristics in each circuit connected to or from the bus to be protected. Bus-differential relays (87B), Type PVD, are high-speed relays sensitive to both phase and ground faults or for multiple bus arrangements use BUS1000 relay.

TRANSFORMER PROTECTION — Transformer-differential relays (87T), Type STD, are high-speed relays with harmonic restraint. These relays use current transformers of different ratios and connections and compensating relay taps. Liquid-filled transformers, larger than approximately 5000 kVA, are protected usually with both differential and fault-pressure relays (63FP) and occasionally with gas-detector relays.

Differential relays protect the transformer circuit, including conductors, bushings and windings. Digital SR745 relays are normally applied since slower-induction-disc differential relays are no better than conventional overcurrent protection and must be desensitized against transformer inrush currents. Fault-pressure relays provide excellent internal tank-fault protection for liquid-filled transformers, but do not include the entire circuit in the protected zone.

Transformers connected delta-wye, with the secondary neutral grounded through resistance, frequently require ground-fault as well as phase-fault differential protection because the pickup of phase-differential relays may not be low enough to detect secondary ground faults. This results from the large CT's necessary to carry transformer lead currents at forced ratings. For such systems, a differentially connected SR745 ground-overcurrent relay with a very inverse characteristic, and with restraint coils, can be used to complete the protection.

MOTORS — Motor differential relays are usually applied to motor circuits for motors 1500 hp and larger. Motor-differential three-phase relays (87M), SR269 or SR469 used for this application employ the balanced-current principle. This type of protection provides for detecting motor-fault currents as small as 15 amperes. An example for a typical application is shown in the one-line diagram in Section 2. In some applications, differential relay schemes are used to protect both the motor and its feeder cable. These schemes use three CT's on each side of the motor.

LINES — Line-differential protection for short lines and important tie lines between medium-voltage switchgear lineups is obtained by using Type SPD (87L) pilot-wire relays. These relays compare the currents at each end of a two-terminal line. These high-speed relays are sensitive to both phase and ground faults. Pilot wire supervision and transfer tripping employ Type SPA relays in conjunction with the pilot-wire relays.

GENERATORS — All generators should be protected with differential relaying. Generator-differential relays (87G) can be Type DGP and functions as high-speed relays sensitive to phase faults and many ground faults. These relays compare the currents in and out of generators using three CT's on each side of the generator. For small generators, SR489, balanced-current-differential relaying may be used. This type of relaying is described under "Differential Protection — Motors".

Open-phase Protection (Negative-sequence Voltage)

Incoming line open-phase operation occurs when one conductor is opened due to either a single fuse melting or a single-line conductor or circuit breaker pole opening. System protection for either of these events for systems without local generation consists of a negative-sequence voltage unbalanced relay (60). To avoid tripping on system transient disturbances, this relay should operate through a timer usually set form 2 to 4 seconds. For systems subject to harmonics, apply a harmonic filter to the input to this relay. The negative-sequence voltage function (60) may also be incorporated in a multi-function motor protection system.

Automatic Reclosing

Radial feeders supplying overhead lines, with or without line sectionalizing, sometimes employ automatic reclosing for better service continuity. Relaying for this type of application is used for open-wire overhead circuits which are prone to develop non-persistent faults. A series of three of four attempts to close a breaker at variable times may either be programmed with an immediate initial reclosure or an initial time-delay reclosure. A multi-shot automatic reclosure option is applied for this function. The use of the immediate initial reclosure option is not recommended on feeders serving large motors or on feeders originating on a generator bus. Frequently, the automatic reclosing relay is used to block an instantaneous overcurrent relay (50 or 50N) after the initial trip for part or all of the reclosing schedule. This function may also be incorporated as part of a multi-function microprocessor-based protection system which is directional or non-directional.

Directional Power, Underfrequency, and Undervoltage Protection

Systems with local generation or large motors require relaying to detect fault conditions on the utility tie circuit or to detect loss of the utility source. Relays used to detect these circumstances should be high-speed to trip the utility tie prior to any automatic reclosing operations and to promptly initiate any programmed load shedding. Complete protection for these circumstances is provided by a combination of relays including and underfrequency relay (81); a sensitive directional-power relay (32); and an undervoltage relay (27). For some applications where the 32 and 27 are instantaneous, a timer is also used which is set at about 0.2 second. The directional-power relay may be connected to current transformers either in the incoming line circuit or in a large motor circuit depending on the application. A study of the specific system is required to select the appropriate relays and connections for this type of protection.

In addition, protection for these circumstances is provided by multi-function Type SR469G or DFP200 relays using a combination of relay functions including an underfrequency relay (81), sensitive directional-power relay (32), undervoltage relay (27) and a timer.

BASIC EQUIPMENT PROTECTION

Circuit Breaker Control and Control Power Protection

Basic circuit breaker control consists of a control switch, located at the breaker to close and trip the breaker. Associated with the control switch are two indicating lamps, one red and one green. The red lamp indicates a closed breaker and supervises the trip coil integrity. The green lamp indicates an open breaker. This lamp is connected through a breaker "b" contact.

Each breaker trip circuit is individually protected by a two-pole 60-amperes pullout fuse-block with 35-ampere NEC fuses. The same type of pullout fuse block rated 30 amperes is used with selected fuses for each individual closing circuit. For capacitor trip devices a 10-ampere fuse is used for trip circuit.

An optional white "breaker disagreement" lamp is available. This lamp is by-passed by a slip contact of the control switch and connected to a "b" contact of the breaker and provides indication of a breaker opening not initiated by the control switch. An alternate option for this white lamp is to provide indication of the circuit breaker spring-charged condition.

For switchgear applications requiring remote control, a permissive control function is available. This function provides local or remote control of a circuit breaker under certain defined conditions, and is available in three schemes as shown in Table 5-1.

Scheme C is recommended for remote control, since it provides maximum operating flexibility. When a local "trip" operation is initiated, the breaker cannot be closed remotely until the local switch handle is returned to the "NORMAL AFTER CLOSE" position. When the breaker is in the "TEST" position, closing and tripping can only be done locally.

Table 5-1. Remote Control Schemes

Control Location		Local				Remote				Devices Required (in addition to remote CS)
Breaker Operation		Close		Trip		Close		Trip		
Breaker Position		Conn	Test	Conn	Test	Conn	Test	Conn	Test	
Remote Control Scheme†	A			X	X	X	X	X	X	Local permissive sw (69) in lieu of control sw (CS)
	B		X		X	X		X		Local control sw (CS), plus bkr position sw
	C*		X	X	X	X		X		Local control sw (CS), plus bkr position sw

X = This manually initiated operation is possible.

* = This scheme uses same devices as scheme B, but different wiring.

† = This basic control scheme provides only local control, as follows

Basic Control	X	X	X	X					Control sw (CS)

Instrumentation, Current, and Voltage Transformers.

INSTRUMENTS — Basic current indication in POWER/VAC switchgear uses a 240-degree scale taut-baud, Type AB-40, indicating ammeter with one percent accuracy at full scale, plus a transfer switch. An optional substitution of three ammeters instead of an ammeter and switch may be made. Also, Lincoln thermal demand ammeters with instantaneous attachment are available as an option.

Optional voltage indication can be maintained using a Type AB-40 indicating voltmeter and transfer switch.

Optional wattmeters and varmeters Type AB-40 are available for most equipment.

Metering is provided in all the multi-function relays including voltage, current, watts, vars, frequency and all the demand functions.

SCALES, CURRENT TRANSFORMER, AND VOLTAGE TRANSFORMER RATIOS — The ammeter scale is determined by the CT ratio. Current transformer ratings are normally selected to exceed slightly the ampacity of the feeder circuit conductors. Current transformer ratios selected in this manner permit settings of circuit overcurrent-protective relays which provide good selectivity and protection. For a properly designed circuit, operating at full load, this means a maximum scale reading of between half and three-quarter scale. For a circuit which provides for substantial future expansion, lower scale readings will indicate initial-load conditions.

The voltmeter scale, determined by the voltage transformer ratio, is 125 percent of the nominal line-to-line VT rating.

Wattmeter and varmeter scales are determined by the CT and VT ratios.

CURRENT TRANSFORMERS AND VOLTAGE TRANSFORMERS — Basic window-type current transformers for phase conductors listed in Device Table 7-33 are available in ratios ranging from 150:5 to 4000:5 amperes. The basic ground-sensor window-type CT ratio is 50:5 amperes, with a 71/4 inch window, and is listed in Table 7-34. An optional current transformer with a 12-inch window is available for circuits with a large number of conductors. Low current wound primary CT's are listed in Table 7-35.

Excitation characteristics and accuracy classes are given in Tables 7-33, 7-34, 7-35A, and 7-35B.

Basic voltage transformers are listed in Tables 7-37 and 7-38, along with the appropriate volt-ampere burden characteristics.

Instrument transformer metering accuracy's are of concern for billing metering applications. Current transformer relaying accuracy's and excitation characteristics are particularly important when considering lower-rated current transformers on systems with high available short-circuit currents and for all differential relay applications.

CONTROL AND TRANSFER SWITCHES — G.E. Co. Type SB control and transfer switches are furnished as required.

Metering and Test Blocks

Optional two-element watthour meters or two-element watthour demand meters are available. These devices are for application on circuits with line-to-line connected loads. If two-element meters are applied on circuits with line-to-neutral connected loads, the amount of load unbalance between phases can cause a proportional inaccuracy in the meter reading. For these applications, a two and one-half or three-element meter is more appropriate. The basic demand interval is 15 minutes. Basic meters are secondary reading utilizing a multiplier equal to the current transformer ratio times the voltage transformer ratio.

Four-pole Type PK test blocks and plugs can be furnished to facilitate circuit testing, using portable instruments and meters. The current test block is arranged so that the current circuit is maintained when the plug is removed from the block.

SURGE PROTECTION

Every medium voltage ac power system is subject to transient voltages in excess of the normal operating voltages. There are many sources of transient voltages.

The most prominent ones are:

- Lightning
- Physical contact with a higher voltage system
- Resonant effects in series inductive-capacitive circuits.
- Repetitive restrike (intermittent grounds).
- Switching surges.

To mitigate the effects of these transient voltages, both surge arresters and, where appropriate, surge capacitors should be used. Surge arresters limit the crest voltage of a voltage surge; surge capacitors reduce the steepness of the voltage wave which reaches the protected equipment.

Surge capacitors, to be most effective, should be located as close to the protected equipment (usually motors) as possible with minimum inductance connections.

Surge arresters can be supplied with certain POWER/VAC units (namely, SSIL, DSIL, BE and GEN) to limit the peak magnitude of transient voltage at loads to values below the rated BIL level of connected utilization equipment.

Those structured units (for other than electric utility distribution substations) which do not include surge arresters as a standard option are supplied with surge suppressors. For equipment with surge suppressors, the peak transient line-to-ground voltages which can appear across the load side of the breaker during the application of a 200-ampere switching surge to the surge suppressors, are those shown in Table 5-2.

Table 5-2. Peak Transient Line-to-Ground Voltages

System Voltage (kV)	Switchgear Equipment BIL (kV)	Maximum Line-to Ground Voltage (kV)
4.16	60	11
7.2	95	23
13.8	95	38

SURGE SUPPRESSORS

The application of surge suppressors on all outgoing feeders controlled by Power/Vac circuit breakers has been a policy of GE Switchgear Operations since 1980.

Surge suppressors are manufactured with zinc oxide (MOV) disc. These discs are a ceramic material with special voltage limiting properties. These discs are manufactured by GE and have superior characteristics to similar products manufactured by others. The device is called a surge suppressor because we do not hold the narrow protective level required by standards for a surge arrester. The goal is to provide a bank of protective levels which is below the BIL levels of rotating machines and ventilated dry-type transformers.

The discs used in the surge suppressor are approximately two inches in diameter and one and one-quarter inches thick. Mechanically and thermally they are very strong.

The typical representation $\blacktriangle I = \blacktriangle V^{26}$ shows that over a wide current range the voltage remains within a narrow bank. The material is not subject to deterioration by repeated surges. Its current when energized line-to-ground is a few microamperes.

Tests on surge suppressors indicated that switching surges rarely produced a 200 ampere surge through the surge suppressor . For this reason the surge suppressor is rated at a protective level at 200 amperes.

The surge suppressor 200 ampere rating and characteristics are shown in Table 5-3 for machine voltages in these voltage classifications, to illustrate the margin of protection. The BIL's of ventilated dry-type transformers are above the machine characteristics shown and are relatively insensitive to front time in contrast to the motor characteristic. Note that steep front transient may be above the machine characteristics at fast front times.

Table 5-3 Surge Suppressor Ratings

Nominal System Voltage - kV	Test Voltage	200 IR kV	10,000 IR kV
4.16	4.76	9.25 - 10. 9	13.9 - 15.6
7.2	8.25	17.2 - 23.0	25.9 - 33.0
13.8	15.0	32.1 - 38.0	48.3 - 54.5

Section 6
Power/Vac Switchgear Equipment

POWER/VAC Switchgear Equipment

INTRODUCTION

This section contains detailed information covering structured device packages for POWER/VAC® metalclad switchgear equipment. With this information, complete specifications for a lineup of metalclad switchgear can be developed.

The first part of this section contains basic equipment specifications for the protection, instrumentation, and control portions of the equipment. Fifteen basic circuits are shown in detail, complete with the type of the basic equipment and devices for these commonly used configurations. For each circuit, a discussion of options is included with illustrations of some of the optional arrangements. Following the specifications for each of the circuits are option tables for substitutions, omissions, and additions to the basic structured equipment. A series of tables giving arrangements of power conductor and auxiliary compartments follows this data. The last part of this section shows a sample lineup developed from the preceding information.

Section 7 of this guide contains a device list giving the ratings and characteristics of the devices included in Section 6 and 6-1.

Devices illustrated in Section 6 utilize an 125V dc control voltage. (Devices with optional control voltages are given in Section 7.)

To use Section 6, proceed in the following manner:

- Determine the type of each circuit in the one-line diagram (developed in accordance with procedures outlined in Section 2).
- Select from the 15 basic circuit specifications the circuits which meet the requirements of the installation.
- Study the discussion on selection of options for each circuit for which options may be required. Refer to the device list in Section 7 for the description, ratings, and characteristics of any device included in the basic equipment or optional equipment.
- Select from the option tables those options desired for the protection, instrumentation, and control portion of each circuit.
- Determine the requirements for auxiliary compartments to house voltage transformers or control power transformers.
- Determine the incoming and outgoing circuit conductor configurations required for each circuit.
- Select the equipment configurations necessary for each circuit and auxiliary compartment from the part of this section covering Power Conductor and Auxiliary Compartments (pages 6-45 to 6-53).

The basic equipment and options in this section constitute a structured line of metalclad equipment. Some lineups, however, may require devices and circuit arrangements other than those included in this section. These items are considered custom fabricated items. Custom requirements are discussed in Section 9.

To obtain the maximum benefits of prompt engineering service, consistency of circuit and device arrangement, and minimum number of equipment variations, specify as much of a lineup as possible from Section 6.

BASIC EQUIPMENT APPLICATIONS

DEFINITION

A brief definition of each of the 15 basic equipment circuits is given in the following paragraphs.

GENERAL PURPOSE FEEDERS

General purpose feeder (GPF) equipment is metalclad equipment controlling and protecting a set of conductors supplying one or more secondary distribution centers, one or more branch-circuit distribution centers, or any combination of these two types of equipment. A general purpose feeder usually includes circuit overcurrent protection, circuit current indication, and circuit control.

BREAKER BYPASS FEEDERS

Breaker bypass feeder (BBF) equipment is metalclad equipment similar to a general purpose feeder, except two breaker units are connected in parallel to feed a common load. Phase current transformers for both circuit breakers are connected in parallel to a common set of phase relays and instruments. This arrangement is used when a means to bypass a feeder circuit breaker is desired. Every breaker bypass vertical section has positions for two circuit breaker removable elements. It is not necessary to include a circuit breaker removable element in each breaker bypass position. One spare circuit breaker removable element per lineup or bus section is usually considered sufficient for each equipment lineup.

TRANSFORMER PRIMARY FEEDERS

Transformer primary feeder (TPF) equipment with differential relays is similar to a general purpose feeder except the entire load is one transformer, and the entire circuit is protected with transformer differential relays. Liquid transformers of the rating to justify differential protection for the circuit are usually equipped with fault-pressure relays for additional internal protection. Both the differential and fault-pressure relays trip a hand reset lockout relay which trips the primary and secondary transformer circuit breaker.

SINGLE-SOURCE INCOMING LINES

Single source incoming line (SSIL) equipment is metalclad equipment for a circuit to a main power distribution bus from the only source of power supplying the bus. A system with this type of incoming line is called a radial system. A system with two or more incoming lines supplying distribution buses sectionalized by normally open bus-tie circuit breakers requires the same type of protection, instrumentation, and control as single source incoming lines, with the possible exception of the connection of the overcurrent relays.

DUAL SOURCE INCOMING LINES

Dual source incoming line (DSIL) equipment is metalclad equipment for a circuit to a main power distribution bus from one or two sources of power supplying the main bus. The other source of power may be either another incoming line or a local generator. Both sources supply a common distribution bus with or without a normally closed bus-tie circuit breaker .

BUS TIES

Bus-tie (BT) equipment is metalclad equipment connecting two power distribution buses with a tie breaker. Such equipments are usually not equipped with overcurrent relays because of the difficulty of obtaining selective system operation with bus-tie overcurrent relays.

BUS ENTRANCES

Bus entrances (BE) equipment is a metalclad vertical section in which one of the compartments contains incoming conductors which are connected directly to the main bus. No incoming breaker is used. This arrangement applies to lineups of switchgear, without main circuit breakers, which connect the incoming line to the main bus. It also applies to subfeeds, from a lineup of switchgear without circuit breakers, which connect the outgoing conductors to the main bus.

SMALL INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START LESS THAN 1500 HP

These metalclad feeder (IMF1) equipments are used for controlling and protecting full-voltage-start motors of less than 1500 hp and are designated as motor "branch circuit" protective equipment.

*LARGE INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START 1500 HP AND LARGER

These metalclad feeder (IMF2) equipments are used for controlling and protecting full-voltage-start motors of more than 1500 hp and are designated as motor "branch circuit" protective equipment. These equipments include differential protection.

*Motors above 4500 hp should be reviewed with POWER/VAC sales and customer engineers.

BASE UNIT (BASIC UNIT)

These metalclad feeder (BU) equipments are designed to allow for future expansion. The base unit is furnished with bus, power circuit breaker, control switch, and indicating lights.

FUTURE (BASIC UNIT)

These metalclad feeder (FU) equipments are identical to the basic unit (BU) equipments except the breaker is future. Provisions are made to receive a breaker of known rating.

It is important to equip these base units with the breaker stationary auxiliary switch and breaker position switch if the active feeders are so equipped. This minimizes field installation and adjustment procedures when the application of this base unit is determined.

The selected relays may be added to the door when the circuit application is determined, or a new door may be purchased with relays and devices completely wired.

SYNCHRONOUS MOTOR FEEDERS, FULL-VOLTAGE-START, LESS THAN 1500 HP

These metalclad feeder (SMF1) equipments are used for controlling and protecting full-voltage-start synchronous motors of less than 1500 hp and are designated as motor "branch circuit" protective equipment.

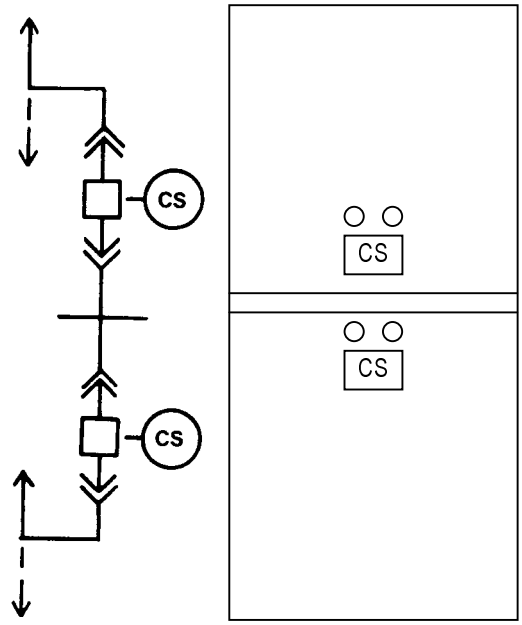
*SYNCHRONOUS MOTOR FEEDERS, FULL-VOLTAGE-START, 1500 HP AND LARGER

These metalclad feeder (SMF2) equipments are used for controlling and protecting full-voltage-start synchronous motors of more than 1500 hp and are designated as motor "branch circuit" protective equipment. These equipments include differential protection.

GENERATORS

These metalclad generator (GEN) equipments control and protect a synchronous generator driven by a gas turbine or diesel engine.

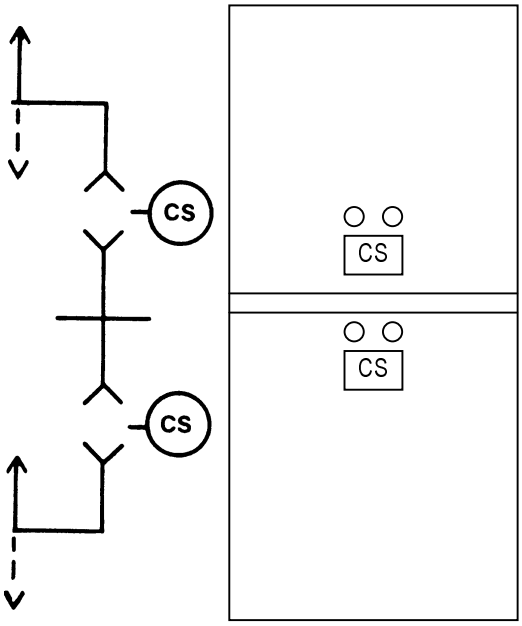
MATERIAL LIST — BASE



MATERIAL LIST-BASE
(unit A or Unit B)

Qty	Description	Device No. or abbreviation
1	Metalclad Stationary Unit, (Unit A or Unit B)	
1	Bus, 3-phase, 3-wire, 1200 Amperes or same as breaker rating when specified	
1	Power Circuit Breaker Removable Element, POWER/VAC, Type VB with Electrical Operating Mechanism arranged for cd close and dc trip	52
1	Switch, Breaker Control, Type SB-1	CS
2	Indicating Lamps, Breaker Close-Open, Type ET-16	RIL GIL
1	Breaker Closing, Fuse Blocks, Pull-Out Type, 2-pole 30A (15A Fuses)	FU
1	Breaker Tripping, Fuse Blocks, Pull-Out Type, 2-pole, 60A (35A Fuses)	FU
1	Cable Termination Provisions (NEMA drilling for 2-750 MCM cables per phase)	

MATERIAL LIST — FUTURE



MATERIAL LIST - FUTURE
(Unit A or Unit B)

Qty	Description	Device No. or abbreviation
1	Metalclad Stationary Unit, (Unit A or Unit B)	
1	Bus, 3-phase, 3-wire, 1200 Amperes or same as breaker rating when specified	
1	Switch, Breaker Control, Type SB-1	CS
2	Indicating Lamps, Breaker Close-Open, Type ET-16	RIL GIL
1	Breaker Closing, Fuse Blocks, Pull-Out Type, 2-pole 30A (15A Fuses)	FU
1	Breaker Tripping, Fuse Blocks, Pull-Out Type, 2-pole, 60A (35A Fuses)	FU
1	Cable Termination Provisions (NEMA drilling for 2-750 MCM cables per phase)	

GENERAL PURPOSE FEEDERS

DEFINITION

A general purpose feeder equipment (GPF) is a metalclad equipment controlling and protecting a set of conductors supplying one or more branch-circuit distribution centers, one or more branch-circuit distribution centers, or any combination of these centers.

BASIC EQUIPMENT SELECTION

GPF-1 Use this type of feeder for systems which are impedance or solidly grounded and for which selectivity is not required with downstream residually connected ground relays.

This type of feeder equipment includes three Type IFC phase-overcurrent relays (50/51) and one Type HFC ground-sensor instantaneous overcurrent relay (50GS).

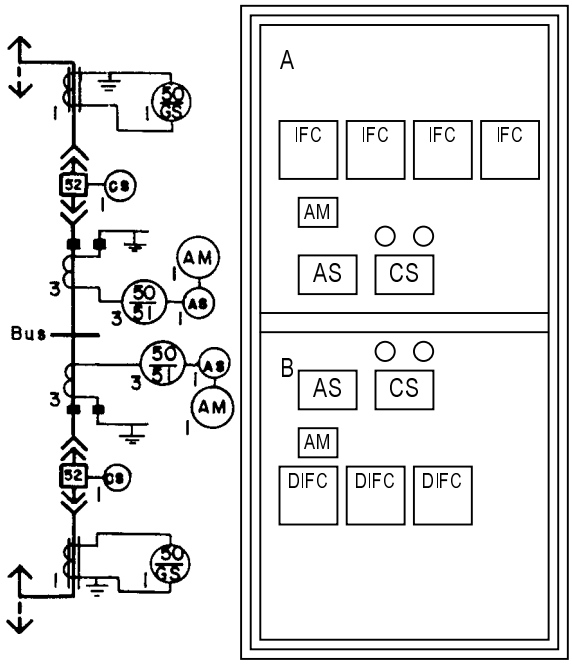
GPF-2 Use this type of feeder for systems which are impedance or solidly grounded and for which selectivity is required with downstream residually connected ground relays.

This type of feeder equipment includes one Type MDP phase-overcurrent (50/51) and residually connected time-overcurrent ground relay (51N).

GPF-3 Use this type of feeder for ungrounded or solidly grounded systems for which no ground relays are desired.

This type of feeder equipment includes one Type DFP100 phase-overcurrent relay (50/51) and no ground relays.

GENERAL PURPOSE FEEDER‡ (GPF-1)

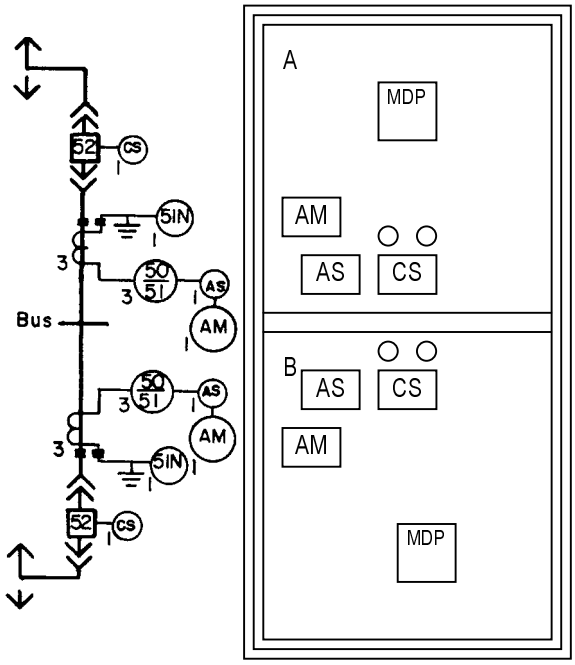


DEVICE LIST FOR GPF-1
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relays	‡50/51	3	121IFC or DIFC
Ground Sensor Relay	‡50GS	1	12HFC
Current Transformers	CT	3	ITI(___/5A)
Current Transformer	GSCT	1	INSTR. TRANS. INC.
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1 OR SBM
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡Ground CT connection

GENERAL PURPOSE FEEDER‡ (GPF-2)

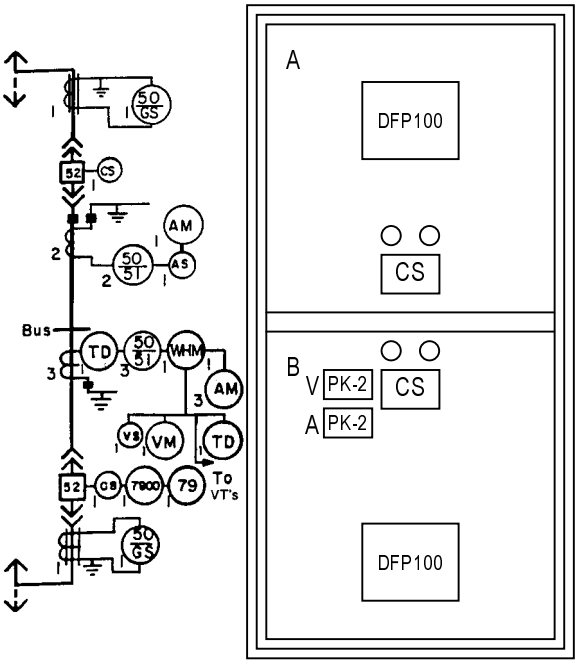


DEVICE LIST FOR GPF-2
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relays	‡51N	1	MDPO
Current Transformers	CT	3	ITI(___/5A)
Current Transformer	GSCT	1	INSTR. TRANS. INC.
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1 OR SBM
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡Residual ground CT connection

GENERAL PURPOSE FEEDER‡ (GPF-3)



DEVICE LIST FOR GPF-3
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent	50/51	1	DFP100
Current Transformers	CT	3	ITI(___/5A)
Current Transformer	GSCT	1	INSTR. TRANS. INC.
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Voltage Test Block			One PK-2
Current Test Block			One PK-2
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡No ground relays

OPTIONAL EQUIPMENT SELECTION

Protection

OVERCURRENT RELAY CHARACTERISTIC — For systems requiring very inverse time-overcurrent relays for phase relays (50/51) and residually connected ground relays (51N), substitute multifunction relays with the desired characteristic from page 7-2. Including systems requiring time-delay ground sensors (51G).

AUTOMATIC RECLOSING — For open-wire over-head distribution circuits on which this feature is desired, use multifunction DFP100 relay with automatic-reclosing relay (79) and cutoff switch (79CO).

Current Transformers for Remotely Located Differential Relays.

For a feeder included in a bus-differential-protected zone, add a separate set of three current transformers located on the outgoing side of the feeder included in a transformer-differential-protected zone, add a separate set of three current transformers located on the bus side of the feeder circuit breaker.

Indication

INSTRUMENTATION AND METERING — For circuits requiring the indication or metering of additional electrical quantities, indicating voltmeter, three phase ammeters plus transfer switch, watthour meter or watthour demand meter, as appropriate use a multi-function digital relay with metering functions.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and voltage test blocks. The basic current test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP — For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

CONTROL VOLTAGE — For equipment other than those with circuit-breaker control from a 125-volt dc station battery, substitute the appropriate available control voltage. For ac control, include a control power transformer connected to the incoming line in each lineup, plus an auto-charged, capacitor-trip device for each circuit breaker in the lineup.

REMOTE CONTROL — For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-7 of this guide). From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the “test” position; and local trip with the breaker in the “connected” or “test” position.

GPF OPTIONS

Device	Device No.	Qty	Description or Type
Interposing Relay		2	12HGA
Reclosing Relay	79	1	12SLR
Reclosing Cut-off Switch	79C/O	1	JBT
Multi-ratio CT's		1	BP
CT High accuracy 5kV		1	JKS-3
or 15KV		1	JKS-5
Ammeter		3	AB-40
Voltmeter		1	SBI or SBM
Voltmeter		1	AB-40
Wattmeter		1	AB-40
Watthour Meter or		1	DS
Watthour Demand Meter		1	DSM
Permissive Switch	69	1	16SB1 or SBM
Sta. Aux. Switch (3, 6, or 10 stages)	52-STA	1	SB-12
Breaker Pos. Sw. (3 or 6 stage)	52-POS	1	SB-12
Test Block-Current		1	PK-2
Test Block-Voltage		1	PK-2
Lincoln Thermal Demand Ammeter		1	ADF7
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		1	ST-230

BREAKER BYPASS FEEDERS

DEFINITION

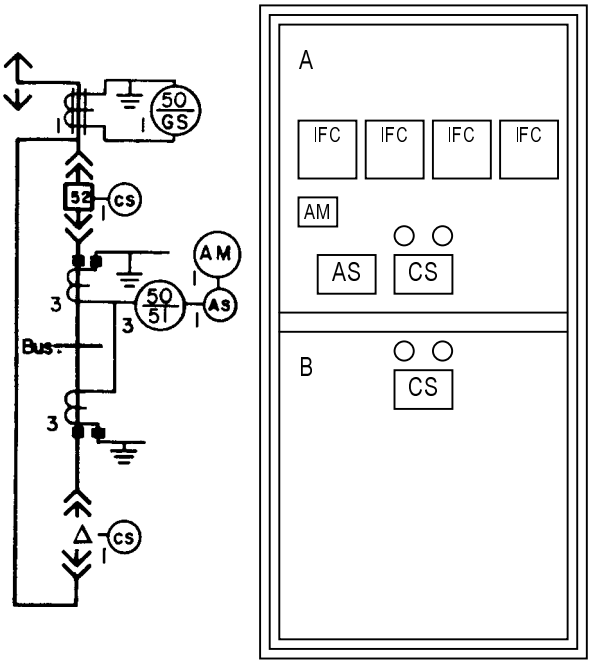
A breaker bypass feeder (BBF) equipment is a metalclad equipment similar to a general purpose feeder, except two breaker units are connected in parallel to feed a common load. A complete vertical section (Unit A and Unit B) is required for each breaker bypass feeder circuit. The purpose of this arrangement is to allow removal of the normal service breaker for maintenance without interrupting service on the feeder. Previously, this type of service required either a main and transfer bus arrangement or feeder tie switches.

A lineup utilizing this arrangement of feeders may be specified with only one bypass position breaker element for the lineup since only one feeder circuit breaker is bypassed at a time.

BASIC EQUIPMENT SELECTION

Basic devices included in a breaker bypass feeder are the same as those included in a general purpose feeder. Select BBF-1, BBF-2, or BBF-3 on the same basis as GPF-1, GPF-2, or GPF-3.

BREAKER BYPASS FEEDER‡ (BBF-1)

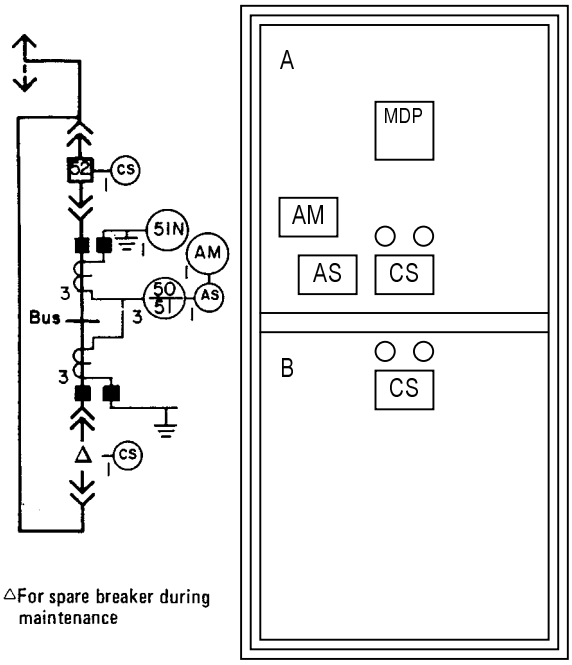


DEVICE LIST FOR BBF-1
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker †	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relays	‡50/51	3	121IFC
Ground Sensor Relay	‡50GS	1	12HFC
Current Transformers	CT	6	BP(___/5A)
Current Transformer	GSCT	1	INSTR. TRANS. INC.
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1 OR SBM
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

† For bypass operation, one additional breaker is required per lineup
Ground CT connection

BREAKER BYPASS FEEDER‡ (BBF-2)



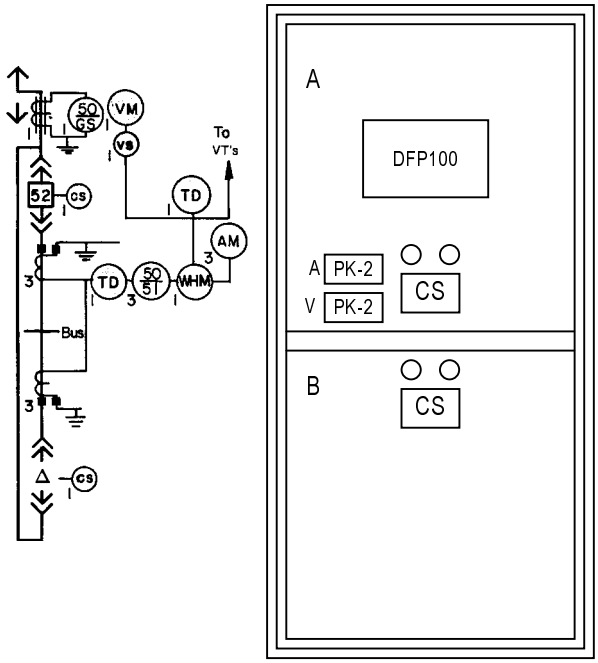
△For spare breaker during maintenance

DEVICE LIST FOR BBF-2
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker †	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relays	‡51NS	1	MDPO
Current Transformers	CT	6	IT(___/5A)
Breaker Control Switch	CS	2	16SB1 OR SBM
Indicating Lights	IL	4	ET-16, (2-R, 2-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1 OR SBM
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

† For bypass operation, one additional breaker is required per lineup
‡ Residual ground CT connection

BREAKER BYPASS FEEDER‡ (BBF-3)



DEVICE LIST FOR BBF-3
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker †	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	1	DFP100
Current Transformers	CT	6	BP(___/5A)
Current Transformer	GSCT	1	INSTR. TRANS. INC.
Breaker Control Switch	CS	2	16SB1 OR SBM
Indicating Lights	IL	4	ET-16, (2-R, 2-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
Voltage Test Block			One PK-2
Current Test Block			One PK-2
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

† For bypass operation, one additional breaker is required per lineup
‡ No ground relays

OPTIONAL EQUIPMENT SELECTION

Options for a breaker bypass feeder are the same as for a general purpose feeder. Select options for BBF-1, BBF-2, or BBF-3 on the same basis as for GPF-1, GPF-2, GPF-3.

BBF OPTIONS

Device	Device No.	Qty	Description or Type
Interposing Relay		2	12HGA
Reclosing Relay	79	1	12SLR
Reclosing Cut-off Switch	79C/O	1	JBT
Multi-ratio CT's		1	BP
CT High accuracy 5kV		1	JKS-3
or 15kV		1	JKS-5
Ammeter		3	AB-40
Voltmeter and Switch (SB-1)		1	AB-40
Voltmeter		1	AB-40
Wattmeter		1	AB-40
Watthour Meter or		1	DS
Watthour Demand Meter		1	DSM
Permissive Switch	69	1	16SB1 or SBM
Sta. Aux. Switch (3, 6, or 10 stages)	52-STA	1	SB-12
Breaker Pos Sw (3 or 6 stage)	52-POS	1	SB-12
Test Block-Current		1	PK-2
Test Block-Voltage		1	PK-2
Lincoln Thermal Demand Ammeter		1	ADF7
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		1	ST-230

TRANSFORMER PRIMARY FEEDERS

DEFINITIONS

A transformer primary feeder (TPF) equipment with differential relays Type STD or DTP digital relay (87T), is similar to a general purpose feeder except the entire load is one transformer, and the circuit is protected with transformer differential relays.

If transformer differential protections is not required, use a General Purpose Feeder.

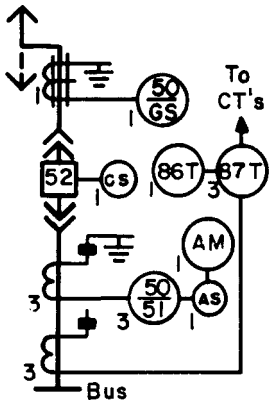
BASIC EQUIPMENT SELECTION

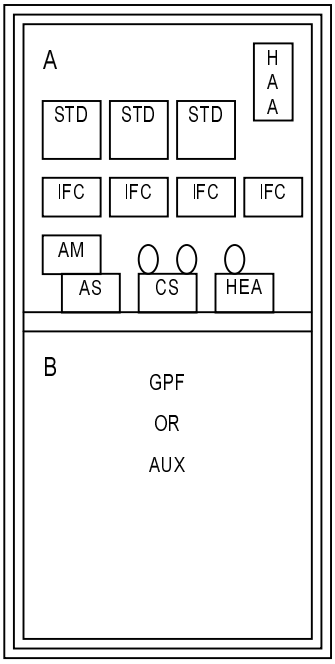
Basic devices included in a transformer primary feeder are the same as those included in a general purpose feeder plus six current transformers, one Type DTP high-speed transformer differential relay (87T)with a transformer fault-pressure auxiliary relay (63PX) included and a HEA lockout relay (86T).

OPTIONAL EQUIPMENT SELECTION

Options for a transformer primary feeder are the same as for a general purpose feeder except that automatic reclosing is not used. Select options for TPF-1, TPF-2, or TPF-3 on the same basis as for GPF-1, GPF-2, or GPF-3.

TRANSFORMER PRIMARY FEEDER‡ (TPF-1)



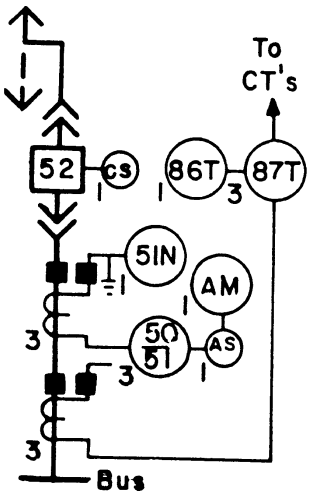


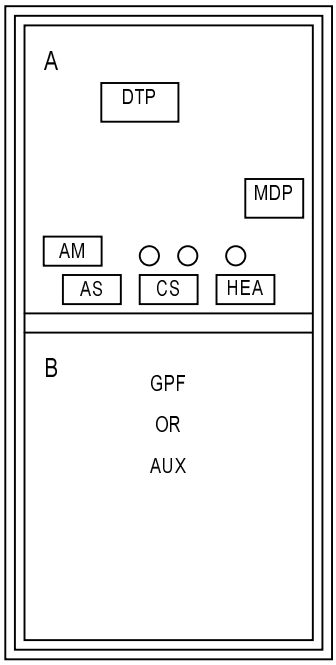
DEVICE LIST FOR TPF-1
(Unit A only)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker †	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent	‡50/51	3	121IFC
Ground Sensor Relay	‡50GS	1	12HFC
Transformer Differential Relays	87T	3	12STD
Lockout Relay	86T	1	12HEA
Fault Pressure Auxiliary Relay	63FPX	1	12HAA
Circuit Current Transformers	CT	3	BP(___/5A)
Differential Current Transformer	CT	3	BP(___/5A)
Ground Sensor Current Transformer	CT	1	INSTR. TRANS, INC
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	3	ET-16, (1-R,1-G,1-W)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping & L.O. Fuse Pullouts	FU	2	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1 OR SBM
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ Ground CT connection

TRANSFORMER PRIMARY FEEDER‡ (TPF-2)





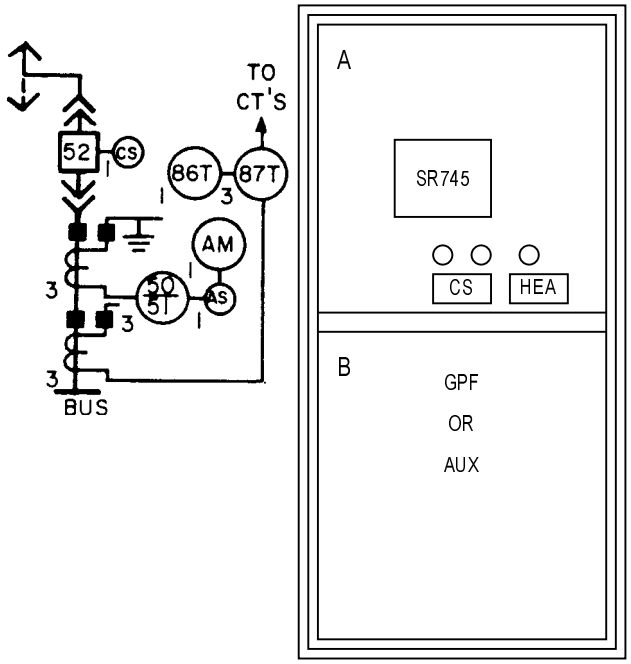
DEVICE LIST FOR TPF-2

(Unit A only)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Transformer Differential	87T	1	DTP
Phase Overcurrent	50/51	3	MDP
Residual Overcurrent	‡51		
Fault Pressure Auxiliary Relay	63FPX		
Lockout Relay	86T		
Circuit Current Transformers	CT	3	BP(___/5A)
Differential Current Transformer	CT	3	BP(___/5A)
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	3	ET-16, (1-R,1-G,1-W)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping & L.O. Fuse Pullouts	FU	2	2P-60A (35A Fuses)
Ammeter (Scale to Match CT)	AM	1	AB-40
Ammeter Switch	AS	1	16SB1 OR SBM
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ Residual ground CT connection

TRANSFORMER PRIMARY FEEDER‡ (TPF-3)



DEVICE LIST FOR TPF-3
(Unit A only)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent	50/51	1	SR745
Transformer Differential	87T		
Fault Pressure Auxiliary Relay	63FPX		
Metering		1	
Lockout Relay	86T	1	12HEA
Circuit Current Transformers	CT	3	BP(___/5A)
Differential Current Transformers	CT	3	BP(___/5A)
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	3	ET-16, (1-R,1-G,1-W)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping & L.O. Fuse Pullouts	FU	2	2P-60A (35A Fuses)
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ No ground relays

TPF OPTIONS

Device	Device No. or Abbr.	Qty	Description or Type
Interposing Relay		2	12HGA
Multi-ratio CT's		1	BP
CT High accuracy 5kV		3	JKS-3
or 15kV		3	JKS-5
Ammeter		3	AB-40
Voltmeter and Switch (SB-1)		1	AB-40
Voltmeter		1	AB-40
Wattmeter		1	DS-40
or Watthour Demand Meter		1	DSM
Permissive Switch	69	1	16SB1 OR SBM
Sta. Aux. Switch (3, 6, or 10 stages)	52-STA	1	SB-12
Breaker Pos Sw (3 or 6 stage)	52-POS	1	SB-12
Test Block - Current		1	PK-2
Test Block - Voltage		1	PK-2
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		2	ST-230

SINGLE SOURCE INCOMING LINES
(or dual source with normally open tie breakers)

DEFINITION

A single source incoming line (SSIL) equipment is a metalclad equipment for a circuit to a main power distribution bus from the only source of power supplying the bus.

A system with two or more incoming lines which supply distribution buses sectionalized by normally open bus-tie breakers, requires essentially the same type of protection, instrumentation, and control for each incoming line as a single source incoming line.

BASIC EQUIPMENT SELECTION

SSIL-1 Use this type of incoming line for an impedance or solidly grounded system fed from a local wye-connected transformer with a current transformer in the transformer neutral connection.

This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and one Type IFC ground-over-current relay (51G) to be connected to the neutral current transformer of a local power transformer feeding the incoming line.

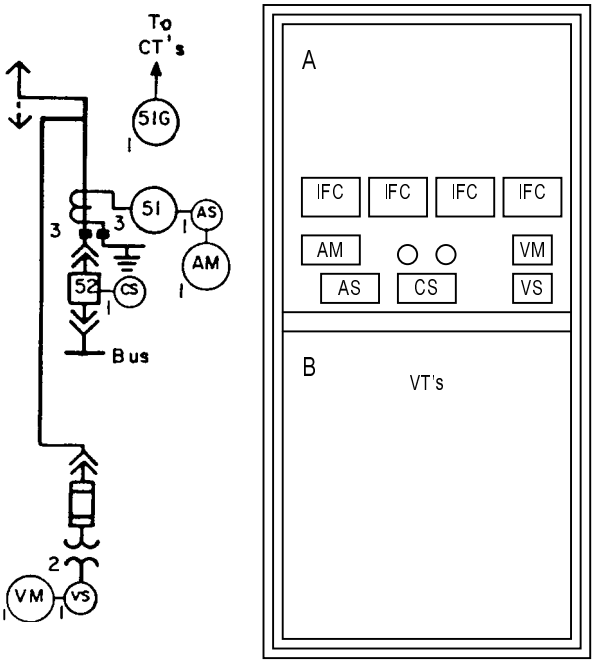
SSIL-2 Use this type of incoming line for and impedance or solidly grounded system fed from a remote wye-connected transformer, or a local wye-connected transformer with no current transformer in the transformer neutral connection .

This type of incoming line equipment includes a Type MDP phase-overcurrent (51) and residually connected ground-overcurrent relay (51N0.

SSIL-3 Use this type of incoming line for ungrounded or solidly grounded systems for which no ground relays are desired.

This type of incoming line equipment includes three Type DFP100 phase-overcurrent (51) and ground relays.

SINGLE SOURCE INCOMING LINES‡ (SSIL-1)

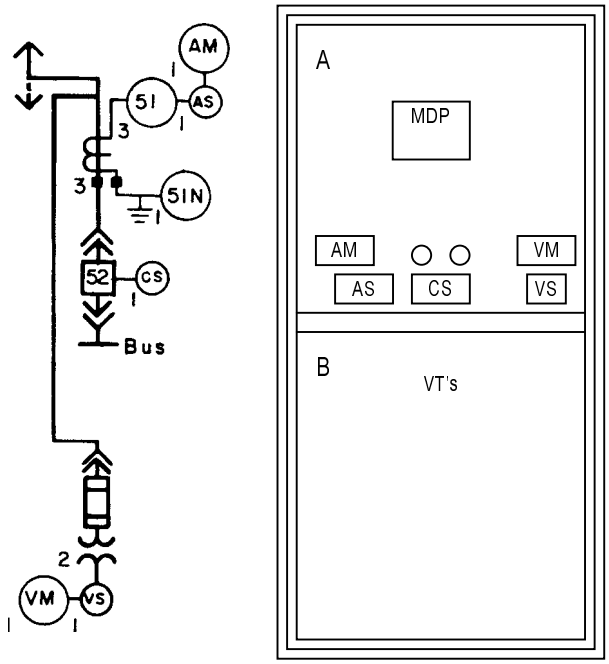


DEVICE LIST FOR SSIL-1
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relays	51	3	121IFC or DIFC
Ground Overcurrent Relay	‡51G	1	121FC
Current Transformers	CT	3	BP(__/5A)
Voltage Transformers	VT	2	JVM (__/120V)
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	2	2P-60A (35A Fuses)
VT Fuses	FU-VT	4	EJ-1
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale Match VT)	VM	1	AB-40
Ammeter Switch	AS	1	16SB1 OR SBM
Voltmeter Switch	VS	1	16SB1 OR SBM
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ Ground CT connection

SINGLE SOURCE INCOMING LINES‡ (SSIL-2)



DEVICE LIST FOR SSIL-2

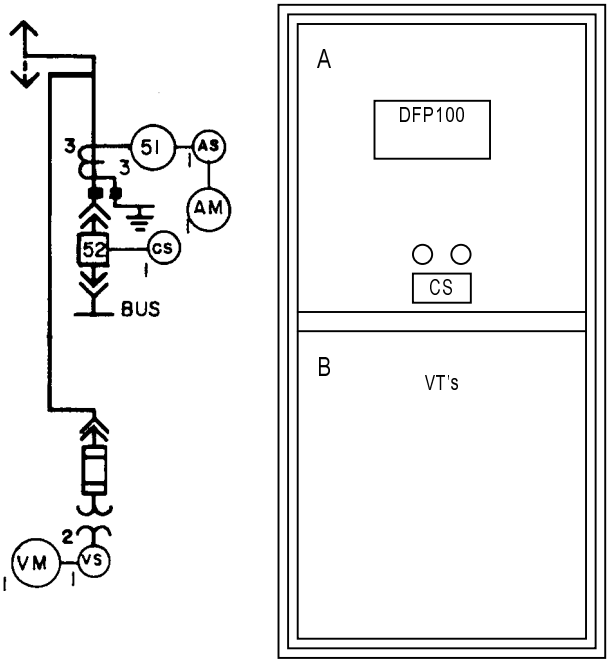
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent	51	1	MDP
Residual Overcurrent	‡51N		
Current Transformers	CT	3	BP(__/5A)
Voltage Transformers	VT	2	JVM (__/120V)
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	2	2P-60A (35A Fuses)
VT Fuses	FU-VT	4	EJ-1
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale Match VT)	VM	1	AB-40
Ammeter Switch	AS	1	16SB1 OR SBM
Voltmeter Switch	VS	1	16SB1 OR SBM
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ Residual ground CT connection

SINGLE SOURCE INCOMING LINES‡ (SSIL-3)

Note: For 3000A & 3500A breaker, locate breaker in Unit B and potential transformers elsewhere.



DEVICE LIST FOR SSIL-3

(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent	51/50	1	DFP100
Current Transformers	CT	3	BP(__/5A)
Voltage Transformers	VT	2	JVM (__/120V)
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	2	2P-60A (35A Fuses)
VT Fuses	FU-VT	4	EJ-1
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ No ground relays

OPTIONAL EQUIPMENT SELECTION

Protection

OVERCURRENT RELAY CHARACTERISTICS — Time current characteristics for overcurrent relays are determined by system studies. After the time current characteristic has been established, refer to Table 7-1, page 7-2 for the model no. of the overcurrent relay that will satisfy the application.

OVERCURRENT RELAY QUANTITY — For incoming lines, including ground-overcurrent protection, and for which minimum protection is acceptable, omit one Type IFC phase-overcurrent relay (51) from phase 2, and omit the associated current transformer.

CURRENT SUMMATION CONNECTION — For line-ups containing bus-tie breakers, specify the incoming line overcurrent relays to be wired for current summation. Add a lockout relay (86) and a set of three tie breaker CT's for each set of relays to be wired this way.

OPEN-PHASE PROTECTION — For incoming lines fed from transformers with fused primaries or sources subject to single-phase operation, add one negative-sequence voltage relay Type NBV (60) and timer (62). If the system is subject to harmonics, specify a harmonic filter for the Type NBV relay.

TRANSFORMER DIFFERENTIAL PROTECTION — For incoming lines fed from transformers with a means to trip a primary breaker and for which differential protection is desired, add one DTP or three Type STD transformer differential relays (87T), one Type HEA lockout relay (86T), one Type HAA fault pressure auxiliary relay (63FPX), and a set of three current transformers. For impedance grounded systems with larger transformers and for which transformers differential relaying is not sensitive enough to detect secondary ground faults, add a Type IFD ground differential relay (87TG) and an auxiliary current transformer.

BUS DIFFERENTIAL PROTECTION — For systems requiring bus differential protection, add three Type PVD high-speed bus differential relays (87B) and one Type HEA hand reset lockout relay (86B). For multiple bus arrangements use a BUS1000 solid state differential protection relay.

CURRENT TRANSFORMERS FOR REMOTLEY LOCATED DIFFERENTIAL RELAYS — For incoming lines included in bus or transformer differential zones for which relays are not mounted on the incoming line equipment, add a separate set of three current transformers for each differential function.

DIRECTIONAL POWER, UNDERFREQUENCY, AND UNDERVOLTAGE PROTECTION — To detect utility tie circuit fault conditions prior to automatic reclosing and to initiate programmed load shedding, add, either singly or in combination, Type CCP directional relay (32), Type SFF underfrequency relay (81), undervoltge relay (27) and timer (62). This applies for systems with local generation or large motors. A study of each system is required to assure proper selection and circuit location of these relays.

AUTOMATIC THROWOVER — For lineups with a normally open tie breaker or a normally open alternate incoming line breaker, add automatic throwover equipment if desired. This consists of two Type NGV undervoltage relays (27), two Type HFA auxiliary relays (27X), two timers (2 and 62), two Type HGA auxiliary relays (2X and 62X), and one Type SB-1 manual-automatic switch (43). Automatic throwover equipment requires an additional auxiliary compartment, custom designed for each application. For digital applications, add three SR750 relays with HEA lockout relays.

Indication

INSTRUMENTATION AND METERING — For incoming lines for which voltage indication and a relay voltage source are not required, omit the voltmeter, voltmeter switch, and two voltage transformers. For circuits requiring the indication or metering of additional electrical quantities, add indicating varmeter, wattmeter, watthour meter, or watthour demand meter as appropriate. For simultaneous continuous indication of all three phases of current, substitute three ammeters for an ammeter and switch.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and voltage test block. Basic test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP — For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

CONTROL VOLTAGE — For equipments other than those with circuit breaker control from a 125-volt dc station battery, substitute the appropriate available control voltage. For ac control, include a control power transformer connected to the incoming line in each line-up bus, plus an auto-charged capacitor trip device for each circuit breaker in the line-up; omit Type STD relays (87T) and add Type BDD relays (87T). For dual source with normally open-tie circuit breaker and ac control, add secondary throwover contactor.

REMOTE CONTROL — For circuit breakers controlled from a remote location, choose the remote control scheme for those listed in Table 5-1 (page 5-7 of this guide). From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch in conjuction with the breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the "connected" position; local close with the breaker in the "test" position; and local trip with the breaker in the "connected" or "test" position.

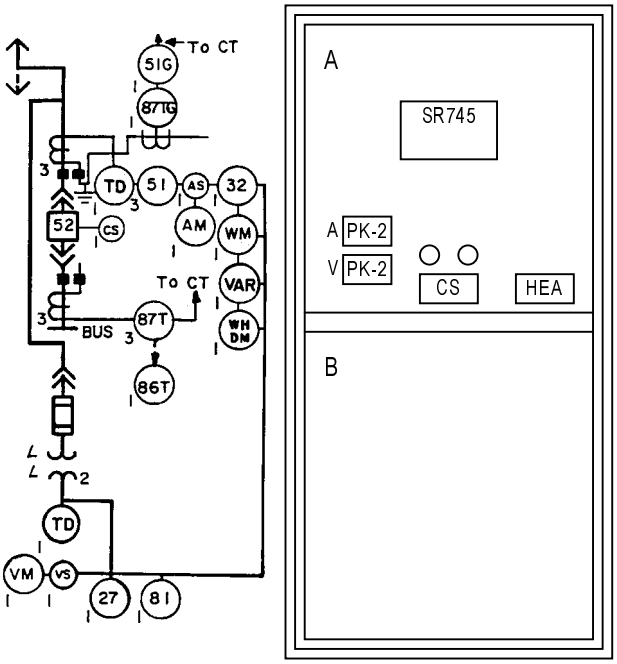
Location of Optional Devices

If several optional devices are added to an incoming line equipment, there may not be sufficient space to mount them all. In this case, specify excess relays to be mounted on the tie-breaker vertical section or on an adjacent auxiliary compartment. This makes the vertical section a custom section.

SSIL OPTIONS

Device	Device No.	Qty	Description or Model No.
Bus Differential Relay	87B	3	12PVD
Transf Differential Relay	87T	3	12STD
Transf Ground Relay with CT	87TG	1	12IFC
Lockout Device for 86, 86B, 86T	86T	1	12HEA
Fault Pressure Aux Relay	63-FPX	1	12HAA
Power Directional Relay	32	1	12CCP
Time Delay Aux Relay for 32	62-32	1	7012
Auxiliary Relay for 32	32X	1	12HGA
Undervoltage Relay	27	1	12NGV
Phase Sequence and UV Relay	47	1	121RC
Underfrequency Relay	81	1	12SFF
Interposing Relay		2	12HGA
Lockout Relay for Sum ckt		1	12HGA
Pilot Wire Basic		1	12SPD
Pilot Wire-Send/Receive		1	12SPA
Multi-ratio CTs		1	750X10G5
CT High accuracy 5kV		3	JKS
15kV		3	JKS
Ammeter		3	AB
Voltmeter and Switch (SB-1)		1	AB
Voltmeter		1	AB
Wattmeter		1	AB
Watthour Meter		1	DS
or Watthour Demand Meter		1	DSM
Permissive Switch	69	1	16SB1
Sta Aux Sw (3, 6, or 10 stage)	52-STA	1	SB-12
Breaker Pos Sw (3 or 6 stage)	52-POS	1	SB-12
Test Block-Current		1	PK-2
Test Block-Voltage		1	PK-2
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		2	ST-230-3
Trans Diff (used with Cap trip)	87T	3	12BDD
Bus Differential	87B	3	12PVD
Voltage Unbalance	60	1	12NBV
Man/Auto Switch		1	16SB1

SINGLE SOURCE INCOMING LINES (SSIL-4)



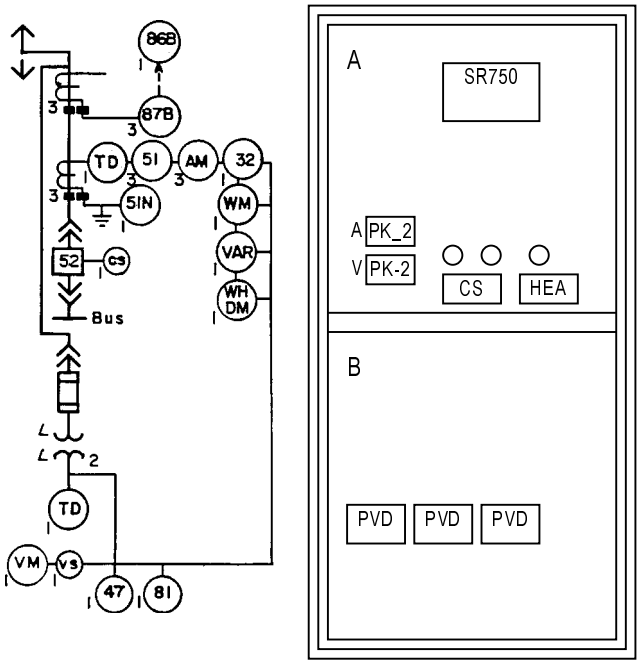
DEVICE LIST FOR SSIL-4

(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent	51	1	SR745
Residual Overcurrent	‡51N		
Current Transformers	CT	3	BP(__/5A)
Voltage Transformers	VT	2	JVM (__/120V)
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	2	2P-60A (35A Fuses)
VT Fuses	FU-VT	4	EJ-1
Transformer Differential Relays		1	87T
IFC Transformer Ground Differential Relay		1	
HEA Lockout Relay		1	86T
Voltage Test Block		1	PK-2
Current Test Block		1	PK-2
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ Residual ground CT connection

SINGLE SOURCE INCOMING LINES (SSIL-5)



DEVICE LIST FOR SSIL-5

(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent	51/50	1	SR750
Current Transformers	CT	3	BP(__/5A)
Voltage Transformers	VT	2	JVM (__/120V)
Differential Bus Relays		3	PVD
Breaker Control Switch	CS	1	16SB1 OR SBM
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A
Breaker Tripping Fuse Pullout	FU	2	2P-60A (35A Fuses)
VT Fuses	FU-VT	4	EJ-1
Voltage Test Block		1	PK-2
Current Test Block		1	PK-2
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ No ground relays

DUAL SOURCE INCOMING LINES

DEFINITION

Dual source incoming line equipment (DSIL) is metalclad equipment for a circuit to a main power distribution bus from one of two sources of power supplying the main bus. The other source of power may be either another incoming line or a local generator. Both sources supply a common distribution bus, with or without a normally closed bus-tie breaker.

BASIC EQUIPMENT SELECTION

DSIL-1 Use this type of incoming line for an impedance or solidly grounded system fed from a local wye-connected power transformer, with a current transformer in the transformer neutral connection.

This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and three Type JBC directional phase-overcurrent relays (67). It includes one Type IFC ground-overcurrent relay, (51G) connected to the neutral CT of a local power transformer feeding the incoming line and one residually connected Type IBCG directional ground-overcurrent relay (67N), polarized from the power transformer neutral CT.

DSIL-2 Use this type of incoming line for an impedance or solidly grounded system fed from a remote wye-connected power transformer.

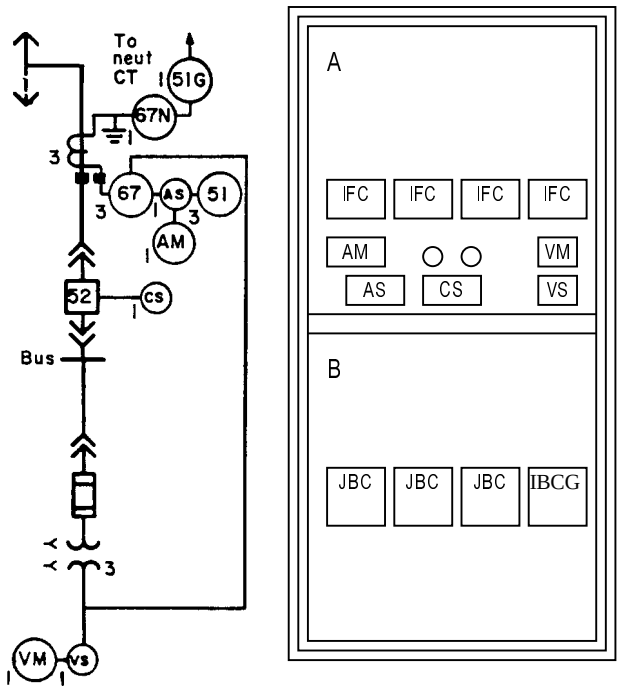
This type of incoming line equipment includes a SR750 relay covering phase-overcurrent (51) and directional phase-overcurrent (67). It also includes residual connected ground-overcurrent (51G) and residually connected directional ground-overcurrent (67N) polarized from a wye-broken delta auxiliary VT connected to a set of wye-wye VT's.

DSIL-3 Use this type of incoming line for ungrounded systems only.

This type of incoming line equipment includes DFP200 relay covering phase-overcurrent (51) and directional phase-overcurrent relays (67). There are additional functions available as required.

DUAL SOURCE INCOMING LINES‡ (DSIL-1)

~~NOTE: For 3000A, 3500A and 4000A breakers, locate breaker~~ in Unit B.



DEVICE LIST FOR DSIL-1
(Unit A **AND** Unit B)

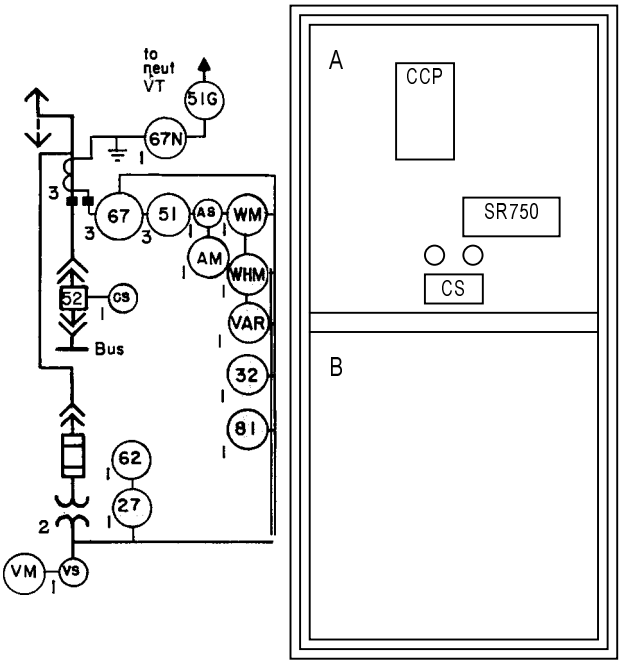
Local transformers -
No tie or normally closed tie

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Directional Phase Overcurrent Relays	67	3	12JBC
Directional Ground Overcurrent Ground	67N	1	12IBCG
Phase Overcurrent Relay	51	3	12IFC
Ground Overcurrent Relay	51G	1	12IFC
Current Transformers	CT	3	BP(__/5A)
Voltage Transformers	VT	2	JVM (__/120V)
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	2	2P-60A (Fuses)
VT Fuses	FU-VT	3	2E
Ammeter (Scale to Match CT)	AM	1	AB
Voltmeter (Scale to Match VT)	VM	1	AB
Ammeter Switch	AM	1	16 SBM or SB1
Voltmeter Switch	VS	1	16 SBM or SB7
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ Ground CT connection

DUAL SOURCE INCOMING LINES‡ (DSIL-2)

NOTE: For 3000A, 3500A and 4000A breakers, locate breaker in Unit B and potential transformers elsewhere.



DEVICE LIST FOR DSIL-2

(Unit A **AND** Unit B)

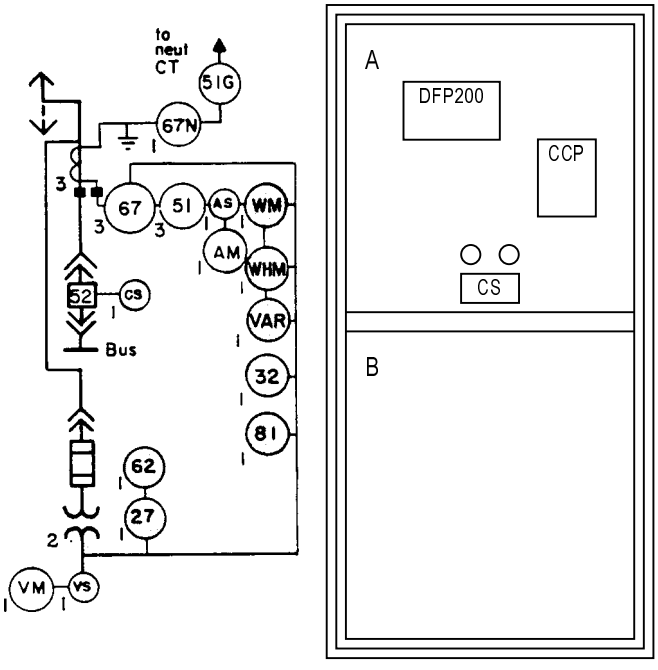
Local transformers - No tie or normally closed tie

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Multifunction Digital Relay	67	1	**SR750**
Current Transformers	CT	3	ITI(__/5A)
Voltage Transformers	VT	3	JVM (__/120V)
Auxiliary Voltage Transformer	AUX-VT	1	9T56Y
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	2	2P-60A (Fuses)
VT Fuses	FU-VT	4	2E
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ Residual ground CT connection

DUAL SOURCE INCOMING LINES‡ (DSIL-3)

NOTE: For 3000A, 3500A and 4000A breakers, locate breaker in Unit B and potential transformers elsewhere.



DEVICE LIST FOR DSIL-2

(Unit A **AND** Unit B)

Local transformers - No tie or normally closed tie

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Multifunction Digital Relay	67	1	**DFP200**
Current Transformers	CT	3	ITI(__/5A)
Voltage Transformers	VT	3	JVM (__/120V)
Auxiliary Voltage Transformer	AUX-VT	1	9T56Y
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	2	2P-60A (Fuses)
VT Fuses	FU-VT	4	2E
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

‡ Residual ground CT connection

OPTIONAL EQUIPMENT SELECTION

Protection

OVERCURRENT RELAY CHARACTERISTICS — For systems requiring other than very inverse Type IFC53, JBC53, or IBC53 time-overcurrent relays, substitute relays with the desired characteristic from page 7-2

OVERCURRENT RELAY QUANTITY — For incoming lines, including ground-overcurrent protection, and for which minimum protection is acceptable, omit one Type IFC phase-overcurrent relay (50/51) and one Type JBC directional phase-overcurrent relay (67) from phase 2. The phase 2 current transformer may not be omitted since it is necessary for the directional ground relay residual connection.

OPEN-PHASE PROTECTION — For incoming lines fed from transformers with fused primaries or sources subject to single-phase operation, add one negative-sequence voltage relay Type NBV (60) and timer (62), as well as three Type IJC current-balance relays (60C), to distinguish which incoming line has single-phase operation. If the system is subject to harmonics, specify a harmonic filter for the Type NBV relay.

TRANSFORMER AND BUS DIFFERENTIAL PROTECTION — Add relays and current transformers to obtain this protection, using the same considerations as for single source incoming lines.

DIRECTIONAL POWER, UNDERFREQUENCY, AND UNDERVOLTAGE PROTECTION — Add relays to obtain this protection using the same considerations as for single source incoming lines.

Indication

INSTRUMENTATION AND METERING — For circuits requiring the indication or metering of additional electrical quantities, add indicating varmeter, watt-meter, watthour meter, or watthour demand meter as appropriate. For simultaneous continuous indication of all three phases of current, substitute three ammeters for an ammeter and switch.

TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and voltage test block. Basic test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP - For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

Optional feature involving control voltage and permissive control switch are the same as for single-source incoming line equipments.

Location of Optional Devices

If several optional devices are added to an incoming line equipment, there may not be sufficient space to mount them all. In this case, specify excess relays to be mounted on the tie-breaker vertical section, or on an adjacent auxiliary compartment. This makes the vertical section a custom section.

DSIL OPTIONS

Device	Device No.	Qty	Description or Model No.
Bus Differential Relay	87B	3	12PVD
Tranf Differential Relay	87T	3	12STD
and Transf Ground Relay with CT	87TG	1	12IFC
Lockout Device fro 86, 86B, 86T	86T	1	12HEA
Fault Pressure Aux Relay	63-FPX	1	12HAA
Power Directional Relay	32	1	12CCP
Time Delay Aux Relay for 32	62-32	1	7012
Auxiliary Relay for 32	32X	1	12HGA
Undervoltage Relay	27	1	12NGV
Phase Sequence and UV Relay	47	1	121RC
Underfrequency Relay	81	1	12SFF
Interposing Relay		2	12HGA
Lockout Relay for Sum ckt		1	12HGA
Pilot Wire Basic		1	12SPD
Pilot Wire - Send/Receive		1	12SPA
Multi-ratio CTs		1	750X10G5
CT High accuracy 5kV		3	JKS
15kV		3	JKS
Ammeter		3	AB
Voltmeter and Switch (SB-1)		1	AB
Voltmeter		1	AB
Wattmeter		1	AB
Watthour Meter		1	DS
or Watthour Demand Meter		1	DSM
Permissive Switch	69	1	16SB1
Sta Aux Sw (3, 6, or 10 stage)	52-STA	1	SB
Breaker Pos Sw (3 or 6 stage)	52-POS	1	SB
Test Block-Current		1	PK-2
Test Block-Voltage		1	PK-2
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		2	ST-230-3
Trans Diff (used with Cap trip)	87T	3	12BDD
Bus Differential	87B	3	12PVD
Voltage Unbalance	60	1	12NBV
Man/Auto Switch		1	16SB1

BUS TIES

DEFINITION

A bus-tie is metalclad equipment connecting two power distributions buses with a tie breaker. Such equipment is specified frequently without overcurrent relays because of the difficulty of obtaining selective system operation when using bus-tie over-current relays.

BASIC EQUIPMENT SELECTION

Basic bus-tie equipment is located in the bottom compartment of each of two vertical sections. The top compartment of either or both vertical sections can be used as either an auxiliary compartment or a feeder compartment.

The basic equipment included in a bus-tie is a circuit breaker control switch and indicating lights.

OPTIONAL EQUIPMENT SELECTION

Protection

OVERCURRENT PROTECTION - For systems requiring overcurrent protection relays for bus-tie equipment, specify incoming line Type MDP overcurrent relay (50/51) to be wired for a summation current connection. If residually connected ground-overcurrent relays (51N) are required with an incoming line, the equipment may be wired also for a summation current connection. Specify a second set of three current transformers for a second incoming line.

BUS-DIFFERENTIAL PROTECTION - For systems requiring bus-differential protection, mount such equipment in bus-tie vertical sections. Each set of bus-differential protection includes three Type PVD high-speed bus-differential relays (87B), one Type HEA hand-reset lockout relay (86B), and three current transformers. For multiple bus configurations use a BUS1000 relay system.

AUTOMATIC THROWOVER - For systems with a normally open bus-tie circuit breaker that require automatic throwover, add equipment listed under “Single Source Incoming Line Options” in a custom-designed auxiliary compartment above one of the bus-tie compartments. The control panel for automatic throwover of CPTs can be placed on a swinging auxiliary panel, above a bus-tie, behind the front door of an auxiliary compartment.

Indication

INSTRUMENTATION - For indication of current, add three current transformers, an ammeter, and an ammeter switch. For simultaneous continuous indication of all three phases of current, substitute three ammeters for and ammeter and switch.

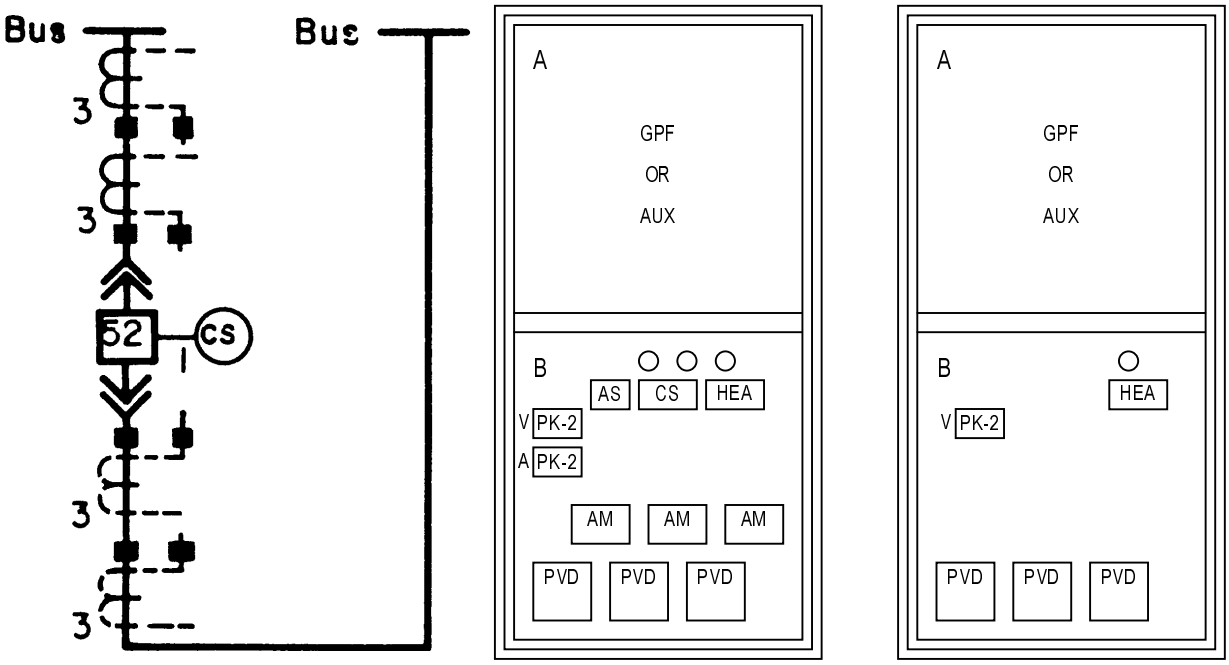
TEST BLOCKS - For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and voltage test blocks. Basic current test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP - A white indicating lamp is added to circuits requiring a circuit breaker disagreement or spring-charged indication function,

Control

Optional features involving control voltage and a permissive control switch are the same as for single source incoming line equipment. For circuit breakers where ac control is specified, include a secondary automatic-throwover contactor for control power.

BUS TIES (BT-1)



DEVICE LIST FOR BT-1

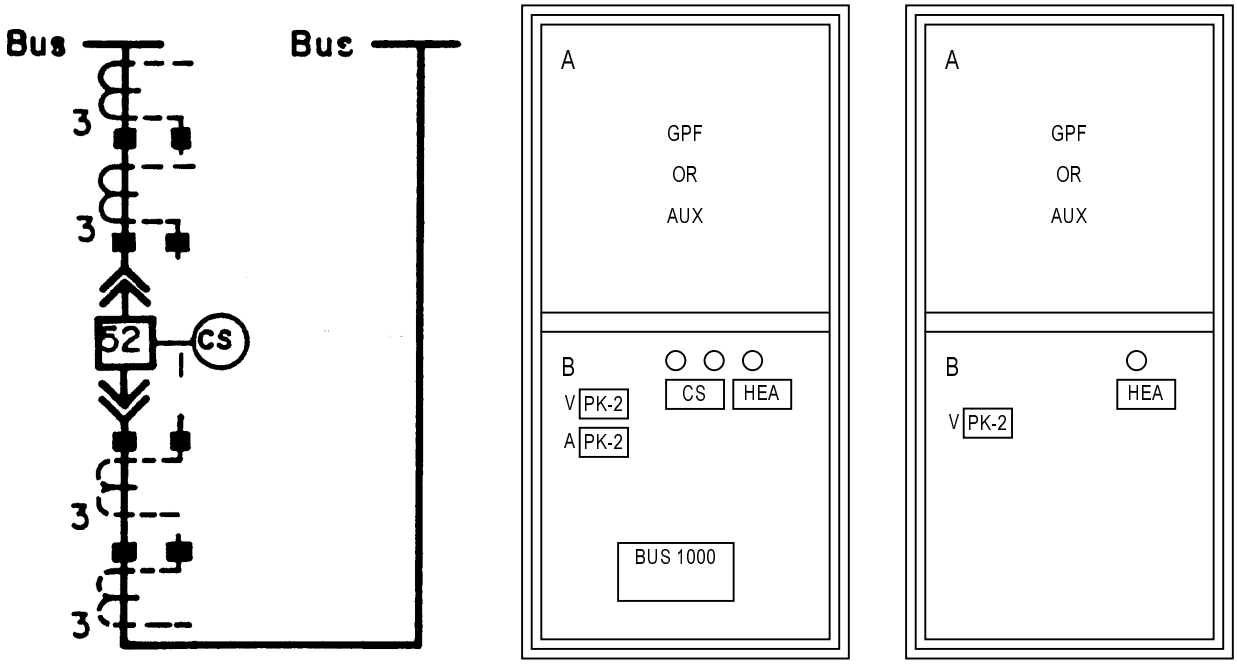
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	2	2P-60A (Fuses)

BT OPTIONS

Device	Device No. or Abbr.	Qty	Description **or** Type
Interposing Relay		2	12HGA
Bus Diff Relay	87B	3	12PVD
Lockout Relay for 87B	86B	1	12HGA
Ammeter and Switch (SB-1)		1	AB
Ammeter		3	AB
Permissive Switch	69	1	16SB1
Sta. Aux. Sw. (3, 6, or 10 stage)	52-STA	1	SB-12
Breaker Pos Sw (3 or 6 stage)	52-POS	1	SB-12
Lincoln Thermal Demand Ammeter		1	
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		1	ST-230-3
Bus Conn VT's		1	JVM(__/120V)
		1	JVM(__/120V)

BUS TIES (BT-2)



DEVICE LIST FOR BT-2

(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	2	2P-60A (Fuses)

BT OPTIONS

Device	Device No. or Abbr.	Qty	Description **or** Type
	87B	1	BUS1000
Lockout Relay for 87B	86B	1	12HGA
Permissive Switch	69	1	16SB1
Sta. Aux. Sw. (3, 6, or 10 stage)	52-STA	1	SB-12
Breaker Pos Sw (3 or 6 stage)	52-POS	1	SB-12
Lincoln Thermal Demand Ammeter		1	
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		1	ST-230-3
Bus Conn VT's		1	JVM(__/120V)
		1	JVM(__/120V)

BUS ENTRANCES

DEFINITION

Bus-entrance equipment is a metalclad vertical section in which one of the compartments contains incoming conductors which connect directly to the main bus without the use of a circuit breaker.

BASIC EQUIPMENT SELECTION

Select this type of equipment as a means to connect either incoming or outgoing conductors directly to the bus for circuits that require no circuit breakers. The top compartment of a vertical section is used for basic bus-entrance equipment rated at 1200 amperes and 2000 amperes. The bottom compartment is used for equipment rated at 3000, 3500 and 4000 amperes.

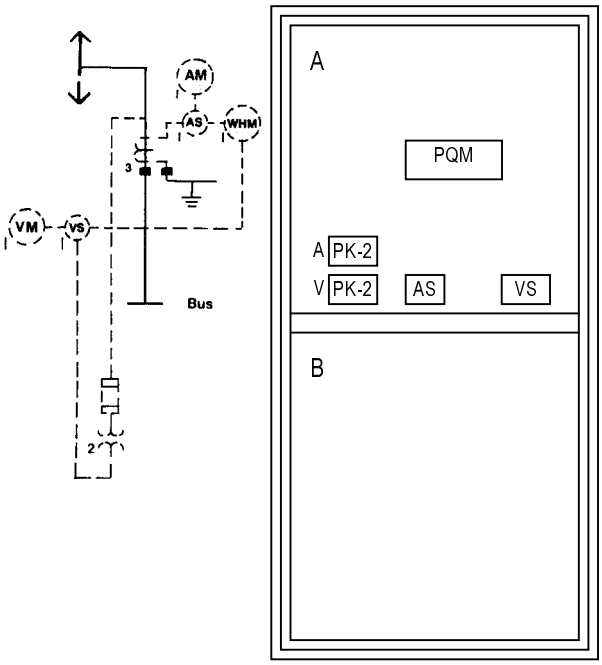
OPTIONAL EQUIPMENT SELECTION

Indication

INSTRUMENTATION AND METERING - For circuits requiring the indication or metering of electrical quantities, add two or three current transformers and two voltage transformers. Arrangements are shown under "Power Conductor and Auxiliary Compartments" (pages 6-45 to 6-53). Select instrumentation and metering required from option tables in this section.

TEST BLOCKS - For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and voltage test blocks. Basic current block is wired to maintain the circuit when the test plug is removed.

BUS ENTRANCES (BE-1)



DEVICE LIST FOR BE
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase
PQM System		1	
ADD:			
Current Transformers		3	BP(__/5A)
Voltage Transformers	Type JVM	2	(__/120V)
VT Fuses		4	
Current Test Block		1	PK-2
Voltage Test Block		1	PK-2

SMALL INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START, (For Motors Less than 1500 HP)

DEFINITION

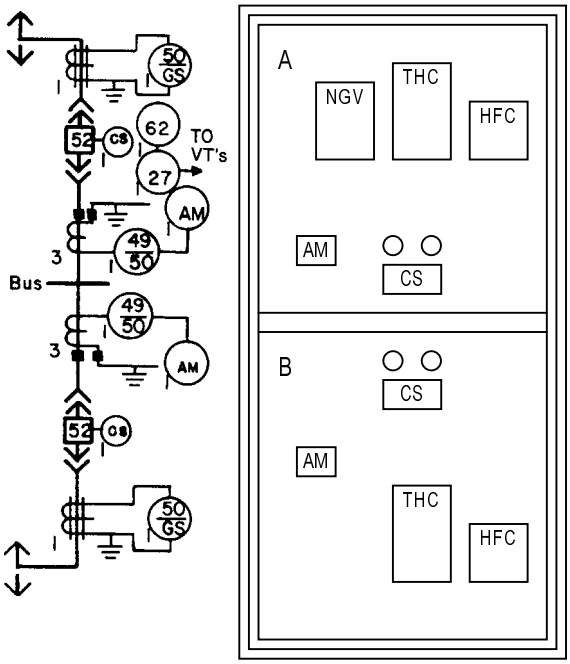
These metalclad feeder equipments (IMF1) are used for controlling and protecting full-voltage-start motors of less than 1500 hp and are designated as "branch circuit" protective equipment. Economics usually preclude protecting a motor smaller than 1500 hp with a device package as complete as that used for larger motors.

BASIC EQUIPMENT SELECTION

Basic equipment for and IMF1 includes one three-phrase Type THC relay for running overload, locked rotor, and short-circuit protection (49/50); one Type NGV relay and timer for undervoltage protection (27, 62) (only one required per lineup); one Type HFC relay for ground-fault protection (50GS); and an ammeter in phase 2. The overcurrent relays operate from a total three CT's, one in each phase, and a ground-sensor CT.

The equipment is specified for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-34) for modifications of this equipment for use on systems with other types of grounding.

INDUCTION MOTOR FEEDER (IMF1)



DEVICE LIST FOR IMF1
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
3-Phase Thermal Overcurrent Relay	49/50	1	12THC__A, 3 Element
Ground Sensor Relay	50GS	1	12HFC
Undervoltage Relay*	27	1	12NGV
Timer, Agastat*	62	1	0.5-5 sec
Current Transformers	CT	3	BP(__/5A)
Current Transformer	CT	1	ITI G.S.
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (Fuses)
Ammeter (Scale to Match CT)	AM	1	AB
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

* One required per lineup

LARGE INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START, (For Motors 1500 HP and Larger)

DEFINITION

These metalclad feeder equipments (IMF2) are used for controlling and protecting full-voltage-start motors of more than 1500 hp and are designated as "branch circuit" protective equipment. These equipments include differential protection.

BASIC EQUIPMENT SELECTION

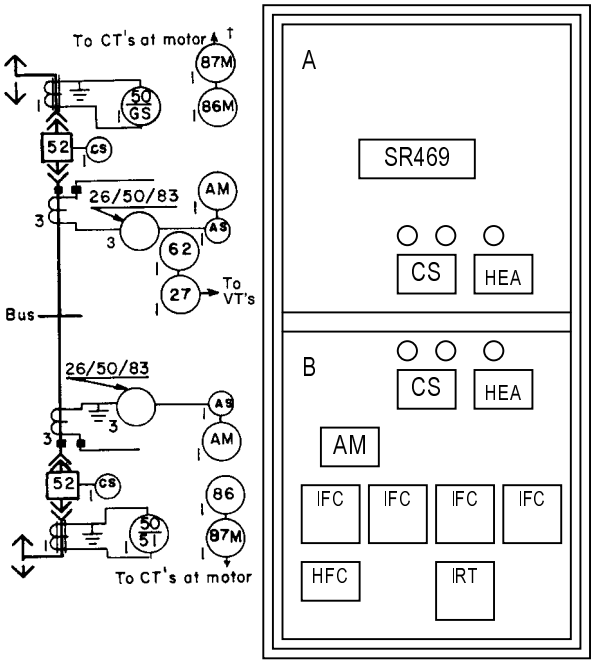
Basic equipment for an IMF2 is a SR469 digital motor protection relay (26/50/83) for locked rotor and short-circuit protection; temperature relay (49); undervoltage and timing relay (27, 62); 3-element self-balancing differential relay (87M); ground-sensor relay (50GS); and an ammeter in all three phases.

The equipment is specified for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-34) for modifications of this equipment for use on systems with other types of grounding.

MOTOR DIFFERENTIAL PROTECTION

The CT's located at the motor, used for the motor differential (87M) circuit, are designated by "†" below. The purchaser should request the motor manufacturer to supply these CT's; they are not supplied with the switchgear.

INDUCTION MOTOR FEEDER (IMF2)



DEVICE LIST FOR IMF2
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Digital motor protection	26/50/83	1	SR469
Lockout Relay	86M	1	12HEA
Current Transformers	CT	3	BP(__/5A)
Current Transformers†	CT	3	BP(__/5A) Remote
Current Transformer	CT	1	ITI G.S.
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R, 1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (Fuses)
Provisions for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

* One required per lineup

INDUCTION MOTOR FEEDERS, FULL-VOLTAGE-START, ESSENTIAL SERVICE, ALL RATINGS

DEFINITION

These metalclad feeder equipments (IMFE) are used for controlling and protecting full-voltage-start, essential-service motors and are designated as motor "branch circuit" protective equipment. Such motor feeders sound an alarm only for motor overload, and trip the circuit breaker for locked rotor and short-circuit conditions.

BASIC EQUIPMENT SELECTION

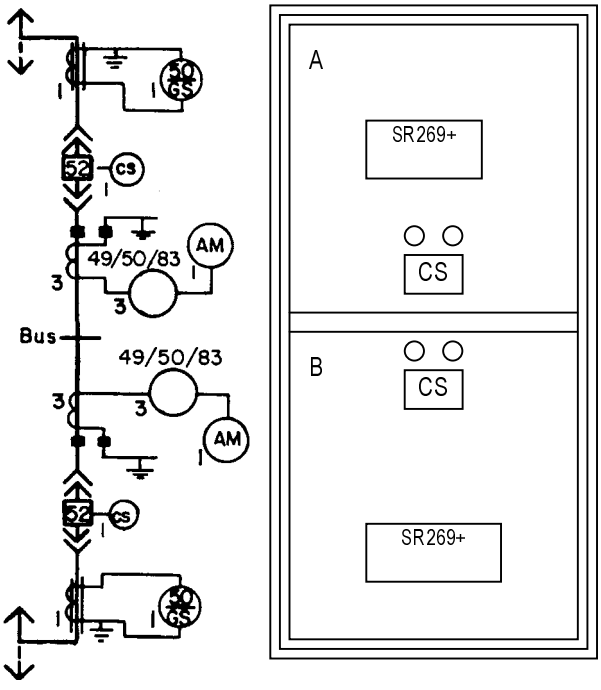
IMFE basic equipment includes three single-phase Type IFC relays for overload indication, locked-rotor tripping, and short-circuit tripping (49/50/83), a Type HFC relay (50GS) for ground-fault protection and an ammeter for phase 2. No undervoltage protection is included. These relays operate from three current transformers, one in each phase, and a ground sensor CT.

The equipment specified is for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-34) for modifications of this equipment for use in systems with other types of grounding.

OPTIONAL EQUIPMENT SELECTION

Options for IMFE are discussed on page 6-34.

INDUCTION MOTOR FEEDER (IMFE)



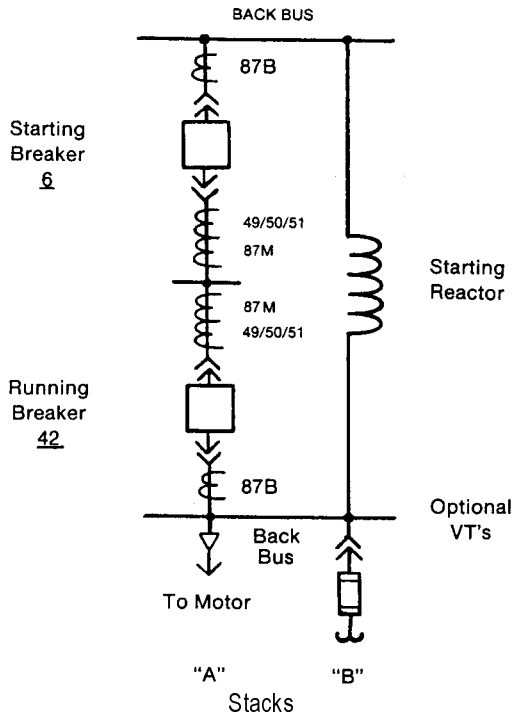
DEVICE LIST FOR IMFE
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Digital motor Relay	49/50/83	1	SR469†
Current Transformers	CT	3	BP(__/5A)
Current Transformer	CT	1	ITI G.S.
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R, 1-G)
Auxiliary Over-Temperature Alarm Relay	49X	1	12HGA
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	2	2P-60A (Fuses)
Ammeter	AM	1	AB
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

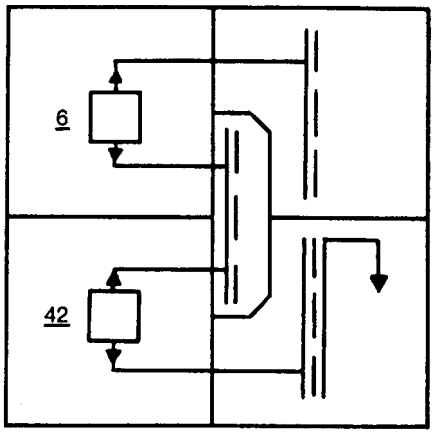
INDUCTION MOTOR FEEDER, REDUCED-VOLTAGE-START

REACTOR START

Power distribution system voltage regulation requirements sometimes require reduced current starting. Inserting a reactor and then bypassing it as the motor comes up to speed is one method of accomplishing this objective.



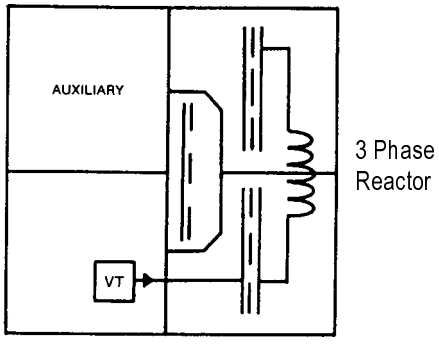
Stacks



Stack "A" Side Elevation

Notes:
1. Add metering, instrumentation control, and additional relaying as required. (See pages 59 & 60).
2. Starting reactor must fit in available space. The main bus must penetrate reactor cubicle. If these conditions are not met the reactor must be housed separately.

POWER/VAC CONFIGURATION



Stack "B" Side Elevation

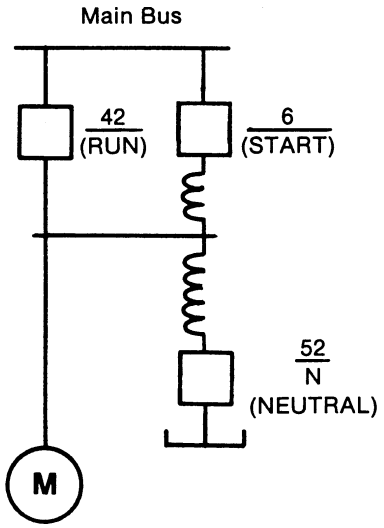
Note: In all cases of reduced-voltage-starting, the starting torque varies as the square of the applied voltage, (e.g., one-half rated voltage results in one-quarter rated starting torque.)

INDUCTION MOTOR FEEDER, REDUCED-VOLTAGE-START

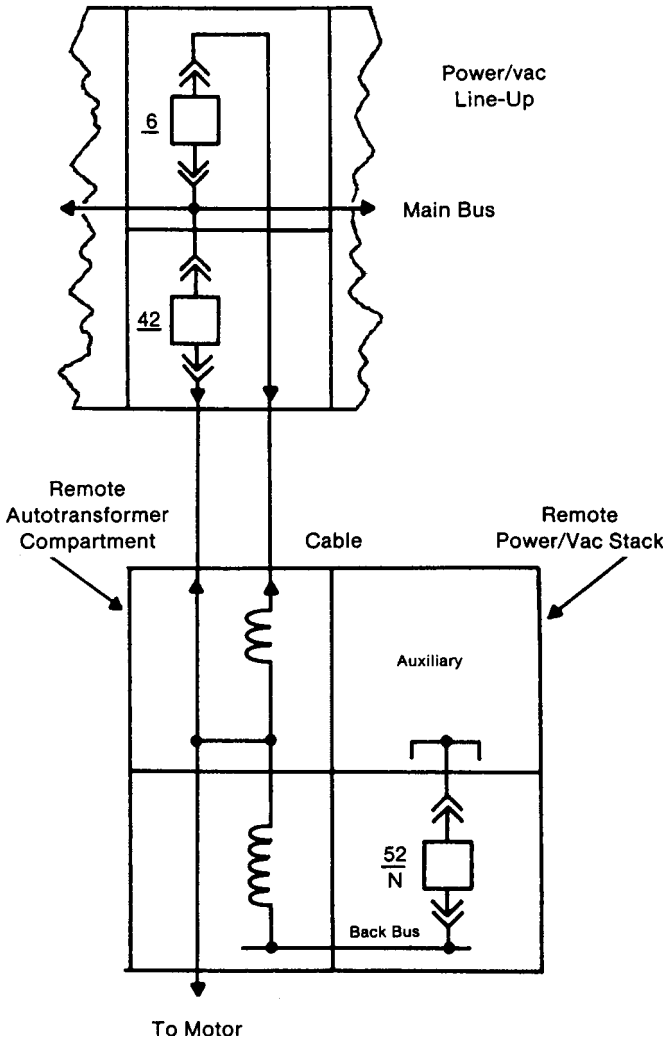
AUTO TRANSFORMER START

An autotransformer connection is an alternate method of reduced voltage starting. This method applies a reduced voltage via the autotransformer which is shorted out as the motor comes up to speed.

ONE-LINE DIAGRAM



POWER/VAC CONFIGURATION



Notes:

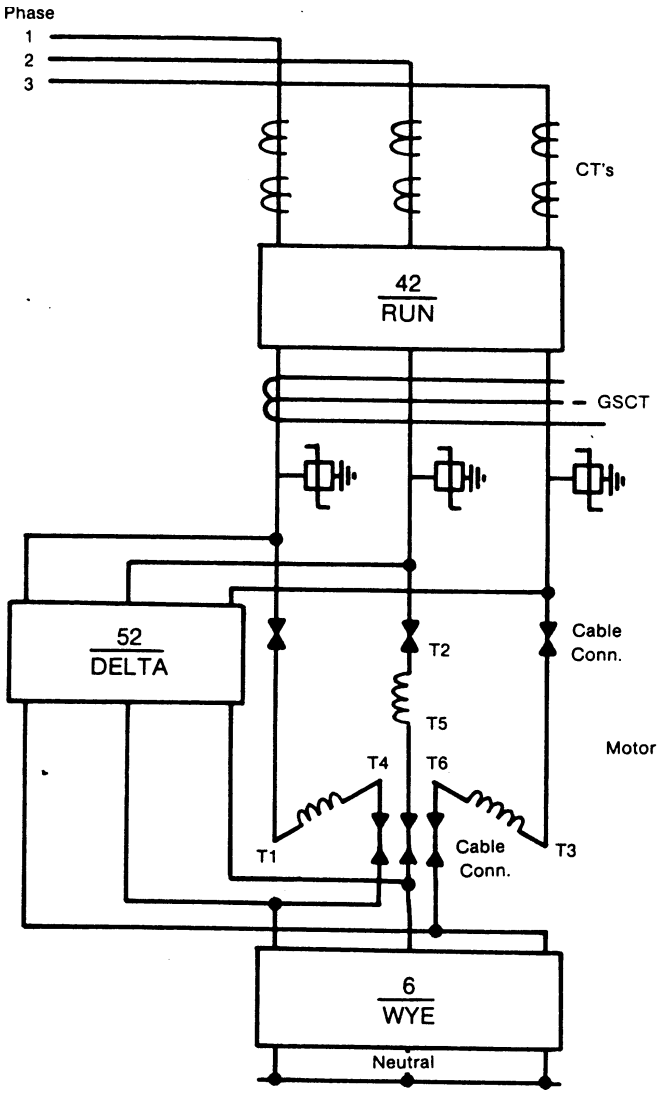
1. Starting Sequence
   a. Close #52/N
   b. Close #6
   c. Accelerate motor
   d. Open #52/N
   e. Close #42
   f. Open #6
2. Autotransformer and neutral breaker will usually be located at motor.
3. Protection, control and Instrumentation are tailored to specific application.

INDUCTION MOTOR FEEDER, REDUCED-VOLTAGE-START

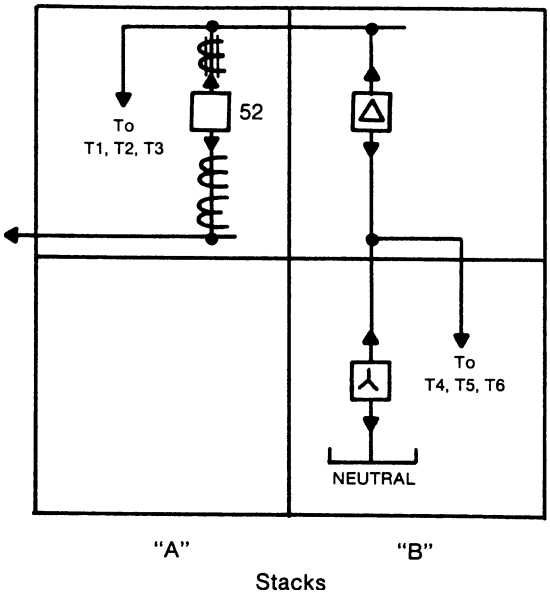
WYE-DELTA MOTOR STARTING

If the motor stator windings are normally designed for Delta connection at rated voltage, reconnection of the winding configuration to WYE on starting reduces the voltage applied to each phase and results in less starting current.

THREE-LINE DIAGRAM



BASIC POWER/VAC CONFIGURATION



Notes:

1. Stack "B" must be at the end of a line-up, or a separate stack at motor.
2. Add protection, indication and control as required.

Motor Delta Configuration:

Phase 1 connected to T1 and T6
Phase 2 connected to T2 and T4
Phase 3 connected to T3 and T5

OPTIONAL EQUIPMENT SELECTION (For IMFE, IMF1, IMF2)

Protection

For ungrounded systems, omit the ground-sensor overcurrent relay and the current transformer.

When equipment is used to feed more than one motor from the same bus, only one undervoltage relay and one timer are required; however, add Type HFA auxiliary relays (27X), with contacts for each additional motor.

For lineups with bus differential protection, add three current transformers.

Where economically justified, add one 3-element Type HFC instantaneous overcurrent relay operating from the three current transformers (mounted at the motor terminals) and connected for balanced-current motor differential protection (87M).

For small motors without RTDs, use THC phase-overcurrent relay (49/50) to provide overload protection. For larger motors with RTDs, use one Type IRT overtemperature relay (49) to provide running overload protection. Use one single-phase Type IFC-66K (26/50/83) to provide locked-rotor and short-circuit protection. For the other phases, use a three-element Type HFC instantaneous overcurrent relay (50) for protection.

Indication

INSTRUMENTATION AND METERING - For circuits requiring the indication or metering of additional electrical quantities, add PQM power quality meter which includes indication of all three phases of current.

TEST BLOCKS - For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and voltage test blocks. Basic current test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP - For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

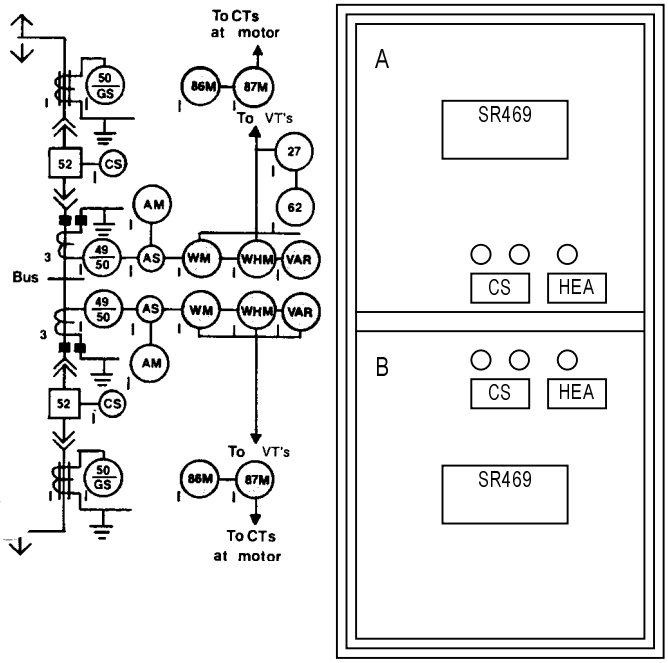
REMOTE CONTROL - For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-7 of this guide). From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker control switch to provide the permissive function. With Scheme C, remote close and trip is possible only with the breaker in the “connected” position; local close with the breaker in the “test” position; and local trip with the breaker in the “connected” or “test position.

In addition, remote control for motors requires a lockout relay (86), which prevents breaker closing (after a relay-initiated trip) until the lockout device is manually reset. (The 86 device furnished standard on IMF2 may be used for both 87M and remote control.)

Location of Optional Devices

If several optional devices are added to a motor feeder equipment, there may not be sufficient space to mount them all. In this case, specify that the excess relays are to be mounted on an adjacent auxiliary compartment. This makes the vertical section a custom section.

TYPICAL MODIFICATIONS OF IMFE, IMF1 AND IMF2



IMF OPTIONS

Device	Device No. or Abbr.	Qty	Description or Type
Digital motor Protection System	49/50/83	1	SR469
Interposing Relay		2	12HGA
Lockout Relay	86M	1	12HEA
Voltage Balance Relay	60V	1	12NBV
Permissive Switch	69	1	16SM1
Sta. Aux. Sw. (3, 6, or 10 stage)	52-STA	1	SB-12
Breaker Pos. Sw. (3 or 6 stage)	52-POS	1	SB-12
Breaker Disagree Light		1	ET-16
Test Block-Current		1	PK-2
Test Block-Voltage		1	PK-2
Multi-ratio CTs		1	750X10G5

DEVICE LIST
(Unit A **or** Unit B)
All IMF Devices
OMIT: None
ADD:
One DS Watthour Meter
One HFC Differential Relay
One AB Watthour
One AB Varmeter
One HEA Lockout Relay

SMALL SYNCHRONOUS MOTOR FEEDERS, FULL-VOLTAGE START, DIRECT-CONNECTED EXCITERS (For Motors Less than 1500 HP)

DEFINITION

These metalclad feeder equipments (SMF1) are used for controlling and protecting full-voltage-start synchronous motors of less than 1500 hp and are designated as motor "branch circuit" protective equipment. Economics usually preclude protecting a motor smaller than 1500 hp with a device package as complete as that used for larger motors.

BASIC EQUIPMENT SELECTION

Basic equipment can be supplied by SR469 digital relay or by a three-phase Type THC relay (49/50) for running overload, locked rotor, and short-circuit protection; A Type NGV relay and timer for undervoltage protection; A type HFC relay for ground-fault protection; and ammeter for current indication in phase 2; and field application equipment for a synchronous motor with collector ring excitation. The overcurrent relays operate from a total of three CT's, one in each phase, and a ground-sensor CT.

The equipment is specified for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (Page 6-34) for modifications of this equipment for use on systems with other types of grounding or having motors with other types of excitation.

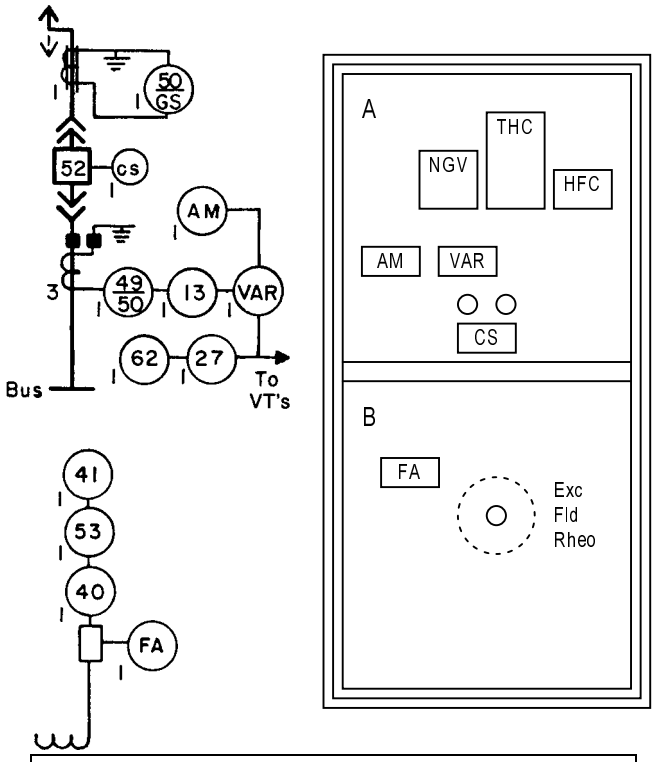
SYNCHRONOUS MOTOR FEEDER (SMF1)

DEVICE LIST FOR SMF1
(Unit A **AND** Unit B)

Local transformers -
No tie or normally closed tie

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
3-phase Thermal Overcurrent Relay	49/50/	1	12THC
Ground Sensor Relay	50GS	1	12HFC
Undervoltage Relay*	27	1	12NGV
Timer, Agastat	62	2	0.5-5 sec
Timer, Agastat	48	1	0.5-5 sec
Current Transformers	CT	3	BP(__/5A)
Current Transformer	CT	1	ITI G.S.
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (Fuses)
Drilling & Wiring for Exc. Fld. Rheo.		1	
Ammeter (Scale to Match CT)	AM	1	AB
Varmeter	VARM	1	AB
Field Ammeter	FA	1	DB
Field Shunt		1	
Provision for Power Conductor Terminations(NEMA Drilling Only)	_____	2	Per phase
FIELD APPLICATIONS DEVICES			
Exciter Relay	53	1	IC2820
Field Contactor	41	1	IC2812
Field Discharge Res.		1	

* One required per lineup



Field Forcing Res.		1	
Rotor Thermal Dev.	26	1	IC2820
Auxiliary Relay	41X	1	12HFA
Slip Guard Relay	55	1	IC3655
Field Discharge Res.	13, X, Y	1	0114C4063

LARGE SYNCHRONOUS MOTOR FEEDERS, FULL-VOLTAGE-START, DIRECT-CONNECTED EXCITERS (FOR Motors 1500 HP and Larger)

DEFINITION

These metalclad feeder equipments (SMF2) are used for controlling and protecting full-voltage-start synchronous motors of more than 1500 hp and are designated as motor "branch circuit" protective equipment. These equipments include differential protection.

BASIC EQUIPMENT SELECTION

The basic equipment includes the same devices as those listed for SMF1, plus the differential relay equipment described as optional equipment for the SMF1.

MOTOR DIFFERENTIAL PROTECTION

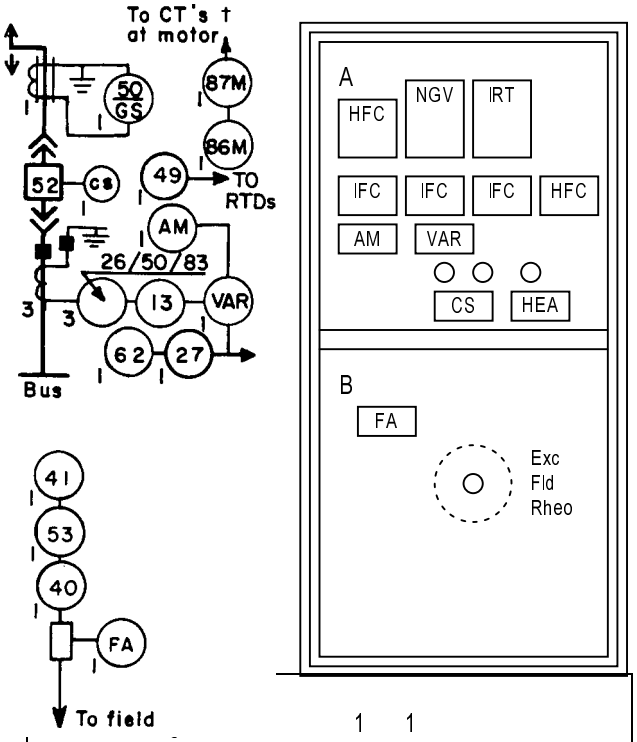
The CT's located at the motor, used for the motor differential (87M) circuit, are designated by "†" below. The purchaser should request the motor manufacturer to supply these CT's; they are not supplied with the switchgear.

SYNCHRONOUS MOTOR FEEDER (SMF2)

DEVICE LIST FOR SMF2
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relay	26/50/83	3	12IFC
Ground Sensor Relay	50GS	1	12HFC
Temperature Relay	49	1	12IRT
Differential Relay	87M	1	12HFC
Lockout Relay	86M	1	12HEA
Undervoltage Relay*	27	1	12NGV
Timer, Agastat	62	1	0.5-5 sec
Timer, Agastat	48	1	0.5-5 sec
Current Transformers	CT	3	BP(__/5A)
Current Transformer †	CT	3	BP(__/5A)Remote
Current Transformer	CT	1	ITI G.S.
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	2	ET-16, (1-R,1-G)
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (Fuses)
Drilling & Wiring for Exc. Fld. Rheo.		1	
Ammeter (Scale to Match CT)	AM	1	AB
Varmeter	VARM	1	AB
Field Ammeter	FA	1	DB
Field Shunt		1	
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase
FIELD APPLICATIONS DEVICES			
Exciter Relay	53	1	IC2820
Field Contactor	41	1	IC2812
Field Forcing Res.		1	
Rotor Thermal Dev.	26	1	IC2820
Auxiliary Relay	41X	1	12HFA
Slip Guard Relay	55	1	IC3655
Field Discharge Res.	13, X, Y	1	0114C4063

* One required per lineup



OPTIONAL EQUIPMENT SELECTION (For SMF1 and SMF2)

Protection

If six-CT machine differential relaying (87M) is desired, omit one three-phase Type HFC instantaneous relay and three CT's (supplied by motor manufacturer) at the machine terminals. Add three Type CFD differential relays and six CT's (three in machine neutral leads and three in metalclad switchgear.)

For ungrounded systems, omit the ground-sensor overcurrent relay (50GS) and the current transformer.

When equipment is used to feed more than one motor from the same bus, only one undervoltage relay and one timer are required; however, add Type HFA auxiliary relay (s) (27X), with contacts for each additional motor.

If the motor is part of a motor-generator set or drives a synchronous condenser, add one Type IAC60 extreme overload relay (51R).

Where economically justified, add one 3-element Type HFC instantaneous overcurrent relay operating from the three current transformers (mounted at the motor terminals) and connected for balanced-current motor differential protection (87M).

Excitation

For motors with collector ring excitation and for which solid-state field application equipment is desired for motors with brushless excitation, omit the field application equipment included in the basic equipment and add appropriate field application panel.

These two application panels are considered custom design.

Indication

INSTRUMENTATION AND METERING - For circuits requiring the indication or metering, add a PQM Power Quality meter, which includes indication of all three phases of current.

TEST BLOCKS - For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and voltage test blocks. Basic current test block is wired to maintain the circuit when the test plug is removed.

INDICATING LAMP - For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

REMOTE CONTROL - For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-7 of this guide). From this table, Scheme C is recommended, since it provides maximum operating flexibility. If requires the use of a breaker position switch in conjunction with the breaker control switch to provide the permissive function. With Scheme C. remote close and trip is possible only with the breaker in the “connected” position; local close with the breaker in the “test” position; and local trip with the breaker in the “connected” or “test” position.

In addition, remote control for motors requires a lockout relay (86), which prevents breaker closing (after a relay-initiated trip) until the lockout device is manually reset. (The 86 device furnished standard on SMF2 may be used for both 87M and remote control.)

Location of Optional Devices

If several optional devices are added to a motor feeder equipment, there may not be sufficient space to mount them all. In this case, specify that the excess relays are to be mounted on an adjacent auxiliary compartment. This makes the vertical section a custom section.

SMF OPTIONS

Device	Device No.	Qty	Description or Model No.
Inst Phase-overcurrent relay (3 el)	50	1	12HFC
Motor running Phase-Overcurrent Relay	51R	1	12IAC
Motor Phase-Overcurrent Relay	26/50/83	3	12IFC
Motor Diff Relay	87M	1	12HFC
Lockout Relay	86M	1	12HEA
High-speed Diff Relay	87M	3	12CFD
Voltage Balance Relay	60V	1	12NBV
Undervoltage Relay	27	1	12NGV
Timer, Agastat*	62	1	0.5-5 sec
Interposing Relay		2	12HGA
Temperature Relay	49	1	12IRT
Thermal Overcurrent Relay (3 el)	49/50	1	12THC
Aux. Overtemp Alarm Relay	49X	1	12HGA
Ammeter		1	AB
Field Ammeter (50A)		1	DB
Wattmeter		1	AB
Watthour Meter		1	DS
or Watthour Demand Meter		1	DSM
Permissive Switch	69	1	16SB1
Sta. Aux. Switch (3, 6, or 10 stage)	52-STA	1	SB-12
Breaker Pos Sw (3 or 6 stage)	52-POS	1	SB-12
Breaker Disagree Light		1	ET-16
Test Block-Current		1	PK-2
Test Block-Voltage		1	PK-2
Multi-ratio CT's		1	BP(__/5A)

* One required per lineup

Power Utilization - Brushless

Device	Device No.	Qty	Description or Model No.
Field Ammeter		1	DB
Field Disch Rect and dc Excitation Source		1	IN4529
Slip Guard Relay	55	1	IC3655
Slip Guard Aux Relay	55X	1	12HFA
Field Application Relay	41E	1	12HGA
Incomplete Sequence Relay, Agastat	48	1	5-50 sec
Field Application Relay, Agastat	13	1	0.5-5 sec
Volt-pac Variable Auto-trans		1	
Rect/Syntron Bridge		1	
Stabailizing Transformer		1	

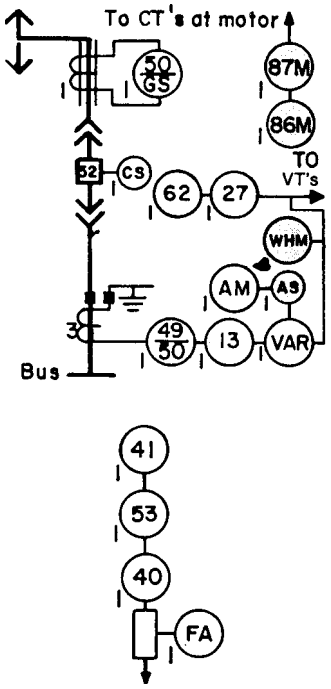
Power Utilization or M-G Set or Condenser Brush-type Direct Connected Exciter

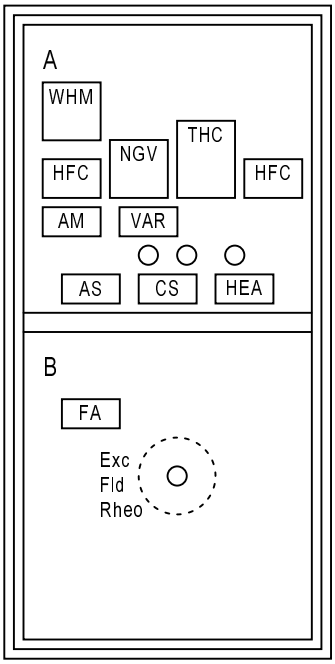
Device	Device No.	Qty	Description or Model No.
Synchronous Speed Device	13	1	12PJC
Synchronous Speed Device Aux.	13X	1	12HGA
Exciter Relay	53	1	IC2820
Field Failure Relay	40	1	IC2820
Field Contactor	41	1	IC2812
Field Ammeter		1	DB
Shunt for Field Ammeter		1	501400
Motor Field Discharge Resistor		1	
Field Rheostat		1	
Field Discharge Resistor		1	
Field Forcing Resistor		1	120LF
Incomplete Sequence Relay, Agastat	48	1	5-50 sec
Field Application Relay	13	1	IC2820
Rotor Thermal Device	26	1	IC2820
Auto Field Contactor	41X	1	
Slip Guard Relay	55	1	IC3655

Power Utilization or M-G Set or Condenser Brush-type Exciter Bus

Device	Device No.	Qty	Description or Model No.
Synchronous Speed Device	13	1	12PJC
Synchronous Speed Device Aux.	13X	1	12HGA
Exciter Relay		1	IC2820
Field Failure Relay	40	1	IC2820
Field Ammeter		1	DB
Shunt for Field Ammeter		1	501400
Motor Field Discharge Resistor		1	
Field Discharge Resistor		1	
Field Disconnect Switch	89F	1	
Field Disch Rect and dc Excitation Source		1	IN4529
Incomplete Sequence Relay, Agastat	48	1	
Rotor Thermal Device	26	1	IC2820
Field Application Relay	13	1	IC2820
Slip Guard Relay	55	1	IC3655

TYPICAL MODIFICATIONS OF SMF1 AND SMF2





DEVICE LIST
(Unit A **or** Unit B)

All SMF Devices
OMIT: None
ADD:
- One DS Watthour Meter
- One HFC Differential Relay
- One HEA Lockout Relay
- One SB-1 Ammeter Switch

GENERATORS

DEFINITION

Generator metalclad equipment (GEN) controls and protects a synchronous generator driven by a steam turbine, gas turbine, a diesel engine, a gasoline engine, a water-wheel turbine, or a motor. The generator may be operated as an isolated system source or in parallel with other power sources. The basic equipment specified here is adaptable to any of these circumstances with the addition of the proper optional equipment. Most generator equipments are custom.

BASIC EQUIPMENT SELECTION

The basic equipment includes no field control or voltage regulator equipment, since this equipment is normally supplied with the generator and located in a separate cubicle either adjacent to the generator or near the switchgear.

Field Control and Voltage Regulation

To obtain filed control for remote-mounted field equipment, add one motor-operated rheostat control switch and one field ammeter.

For generators with brushless exciters and without remote SC-VT regulators, add one metalclad equipment vertical section containing provision for mounting a voltage regulator, brushless exciter field control, mounting for an exciter field rheostat, and an exciter field ammeter. Add one or two VT's and one CT to the generator circuit breaker vertical section for use with the voltage regulator, if required.

Protection

STEAM-TURBINE GENERATORS - For generators requiring anti-motoring protection, add a Type GGP directional power relay (32).

OTHER THAN STEAM-TURBINE GENERATORS - For generators requiring ant-motoring protection, add one Type ICW directional power relay (32).

FOR GENERATORS ON GROUNDED SYSTEMS - Add one Type MIC ground overcurrent relay (51G).

FOR GENERATORS OPERATING IN PARALLEL WITH OTHER POWER SOURCES ON GROUNDED SYSTEMS - Add one Type DIFC ground relay (51GN). See GER-3011.

FOR LARGE GENERATORS (larger than 5000 kW) - Add one Type CEH loss-of-field relay (40), one Type INC or SGC negative sequence current relay (46), and one Type CFVB voltage-balance relay (60). Or consider one of the digital multifunction relay systems listed in GEZ8188A .

Synchronizing

To synchronize machine to bus, add a synchronizing bracket with two voltmeters, a frequency meter, a synchroscope, and two indicating lamps.

For automatic synchronizing, add a Type GES automatic synchronizing relay (25), a Type GTL speed-matching relay (15L & R), and a Type IJS cut-off relay (25A).

Isolated Systems

Omit the synchronizing switch and add one frequency meter and a voltmeter.

Current Transformers

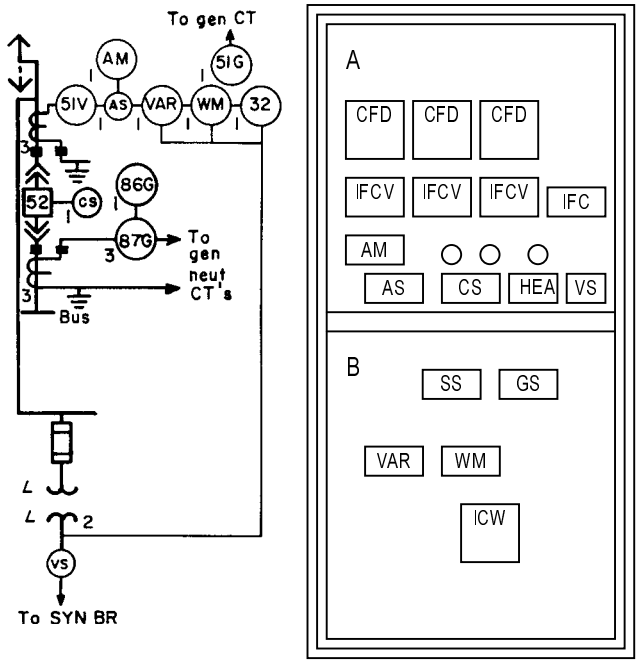
Add three current transformers for lineups that include bus differential protection.

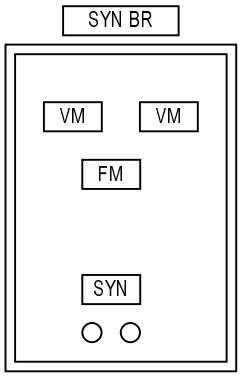
Indication and Metering

For generators requiring supplementary indication and metering, add one Type PQM meter and a transfer switch for monitoring three RTD's, one Type KT time meter, one Type DS-63 watthour meter, and Type PK-2 current or voltage test blocks.

GENERATOR (GEN)

NOTE: For 3000A breaker, locate breaker in Unit B and potential transformers elsewhere.





DEVICE LIST FOR GEN 1
(Unit A **AND** Unit B)

Device	Device No.	Qty	Description **or** Model No.
Power Circuit Breaker	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relay with Voltage Restraint	51V	3	12IFCV
Ground Overcurrent Relay	51G	1	12IFC
Generator Differential Relay	87G	3	12CFD
Lockout Relay	86G	1	12HEA61
Anti-motoring Relay	32	1	12ICW51
Current Transformers	CT	3	BP(__/5A)
Current Transformers	CT	3	BP(__/5A) (Diff)
Voltage Transformers	VT	2	JVM(__/120V)
Breaker Control Switch	CS	1	16SB1
Indicating Lights	IL	3	ET-16, (1-R,1-G,1-W)
Governor Switch	GS	1	16SB1
Voltmeter Switch	VS	1	16SB1
Synchronizing Switch	SS	1	16SB1
Breaker Closing Fuse Pullout	FU	1	2P-30A (Fuses)
Breaker Tripping Fuse Pullout	FU	1	2P-60A (Fuses)
VT Fuses	FU-VT	4	
Ammeter (Scale to Match CT)	AM	1	AB
Ammeter Switch	AS	1	16SB1
Varmeter	VARM	1	AB
Wattmeter	WM	1	AB
Provision for Power Conductor Terminations (NEMA Drilling Only)	_____	2	Per phase

DEVICE LIST FOR SYNCHRONIZING BRACKET

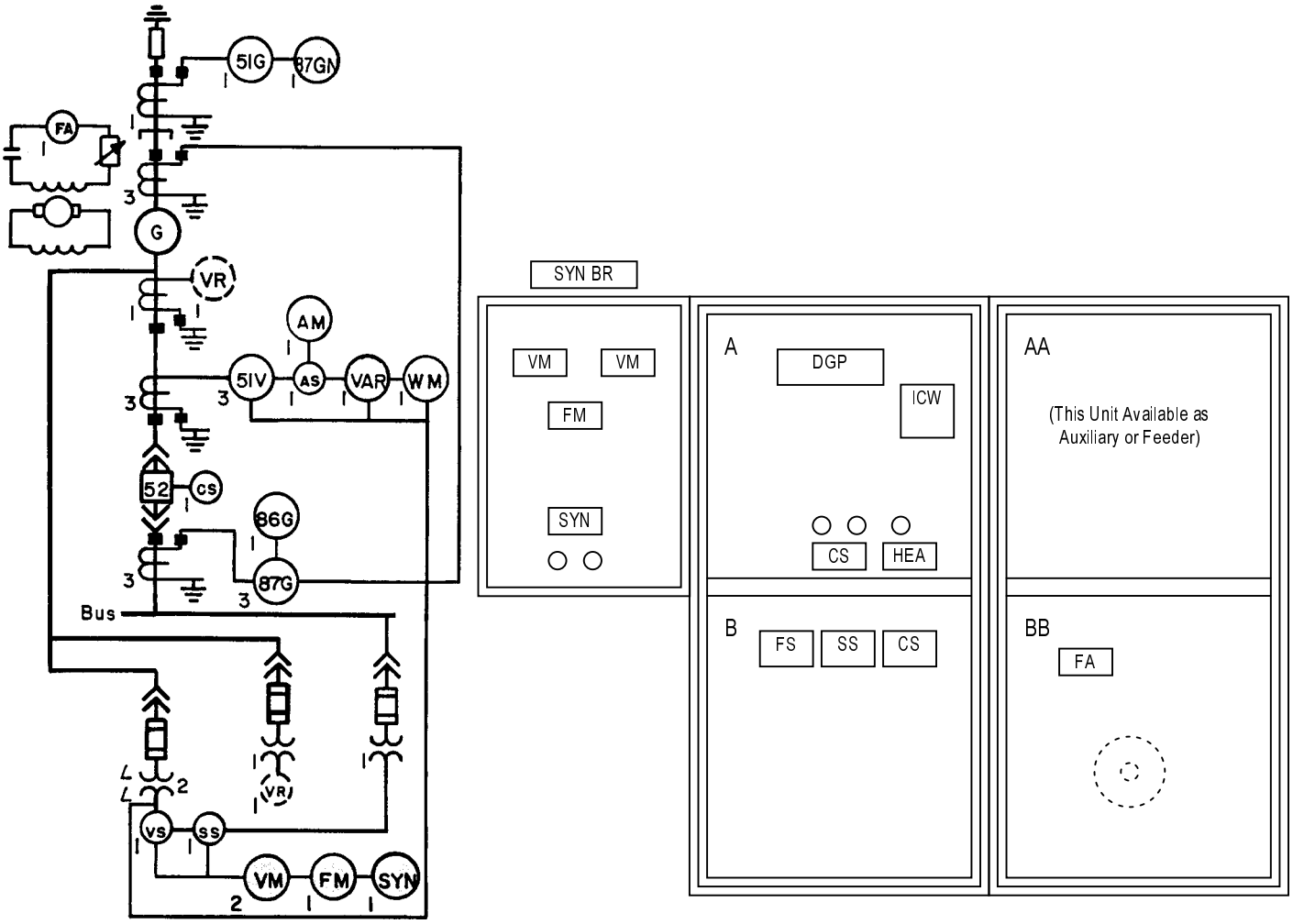
Device	Device No.	Qty	Description **or** Model No.
Voltmeter (Scale to Match VT)	VM	2	AB
Frequency Meter	FM	1	AB
Synchroscope	SY	1	AB

GEN OPTIONS

Device	Device No.	Qty	Description or Model No.
Voltage Balance Relay	60V	1	12CFVB
Loss of Excitation Relay	40	1	12CEH
Negative Sequence Relay (static)	46	1	12SGC
Digital Power Quality Meter		1	PQM
or			
Voltmeter and Switch (SB-1)	V	1	AB
Wattmeter	WM	1	AB
Watthour Meter	WHM	1	DS
or Watthour Demand Meter	WHDM	1	DSM
Frequency Meter	FM	1	AB
Temp Meter and Switch (SB-1)	TM	1	DB
Time Meter	TI	1	
Sta. Aux. Sw. (3, 6, or 10 stage)	52-STA	1	SB-12
Breaker Pos Sw (3 or 6 stage)	52-POS	1	SB-12
Synchronizing Switch	SS	1	16SB1
Governor Switch	GS	1	12SB!
Synch Trans Sw for GXS	43	1	16SB1
Synch Auto Trans Sw for GXS	43	1	16SB1
Breaker Disagree Light		1	ET
Synchroscope		1	AB
Auto-Sync Relay	25	1	12GES
or Auto-Sync Relay	25	1	12GXS
Speed Matching Relay	15	1	12GTL
Synch Check Relay	25	1	12IJS
Ground Relay	51GN	1	IFC
Bus Undervoltage Relay	27B	1	12HGA
Line Undervoltage Relay	27L	1	12HGA
Voltage Transformers	VT	2	JVM
Line and/or bus		2	
Multi-ratio CTs		1	BP(__/5A)

POWER/VAC Switchgear Equipment

GENERATOR (GEN2)



DEVICE LIST
(Unit A **or** Unit B)

All GEN Devices
Parallel Operation
(Larger Diesel Brushless Generator)
OMIT: None
ADD:
- One IFC53 Overcurrent Relay
- One Voltage Transformer
- One Field Control Switch
- One Aux. CT, ___:___ A

*See GER-3071

DEVICE LIST
(Unit AA **and** Unit BB)

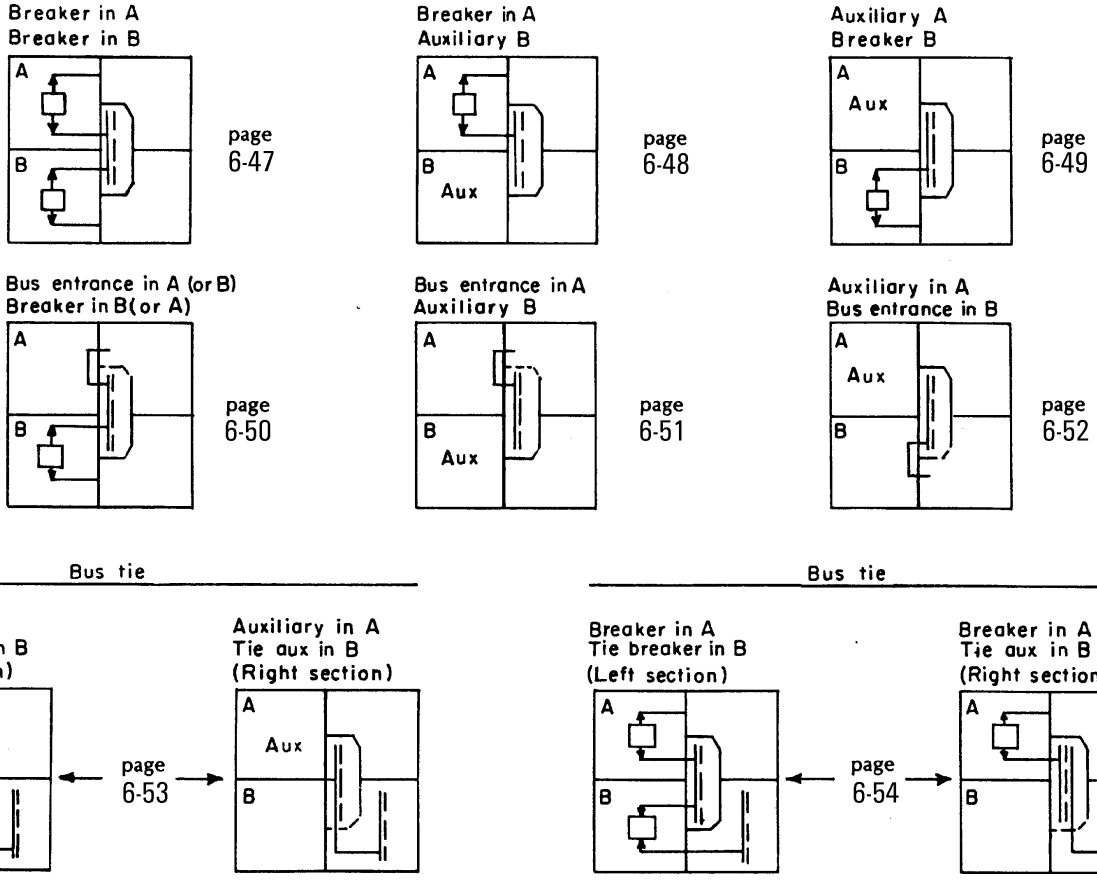
All GEN Devices
Parallel Operation
(Larger Diesel Brushless Generator)
OMIT: None
ADD:
- One Voltage Transformer
- One Field Ammeter
- Provision for Mounting Exciter Field Control
- Synchronizing Bracket Per Basic Specification

POWER CONDUCTOR COMPARTMENTS AND AUXILIARY UNITS

This section covers the arrangement of power conductor and auxiliary units in the vertical switchgear sections. Nine combinations of power conductor compartments are shown. For each combination, the basic arrangement is shown at the top of the page. Selection of one or more of the options determines the minimum depth of the indoor vertical section selected, as indicated in the option tables. (All outdoor units are 97 inches deep, plus depth of protected aisle, if specified.)

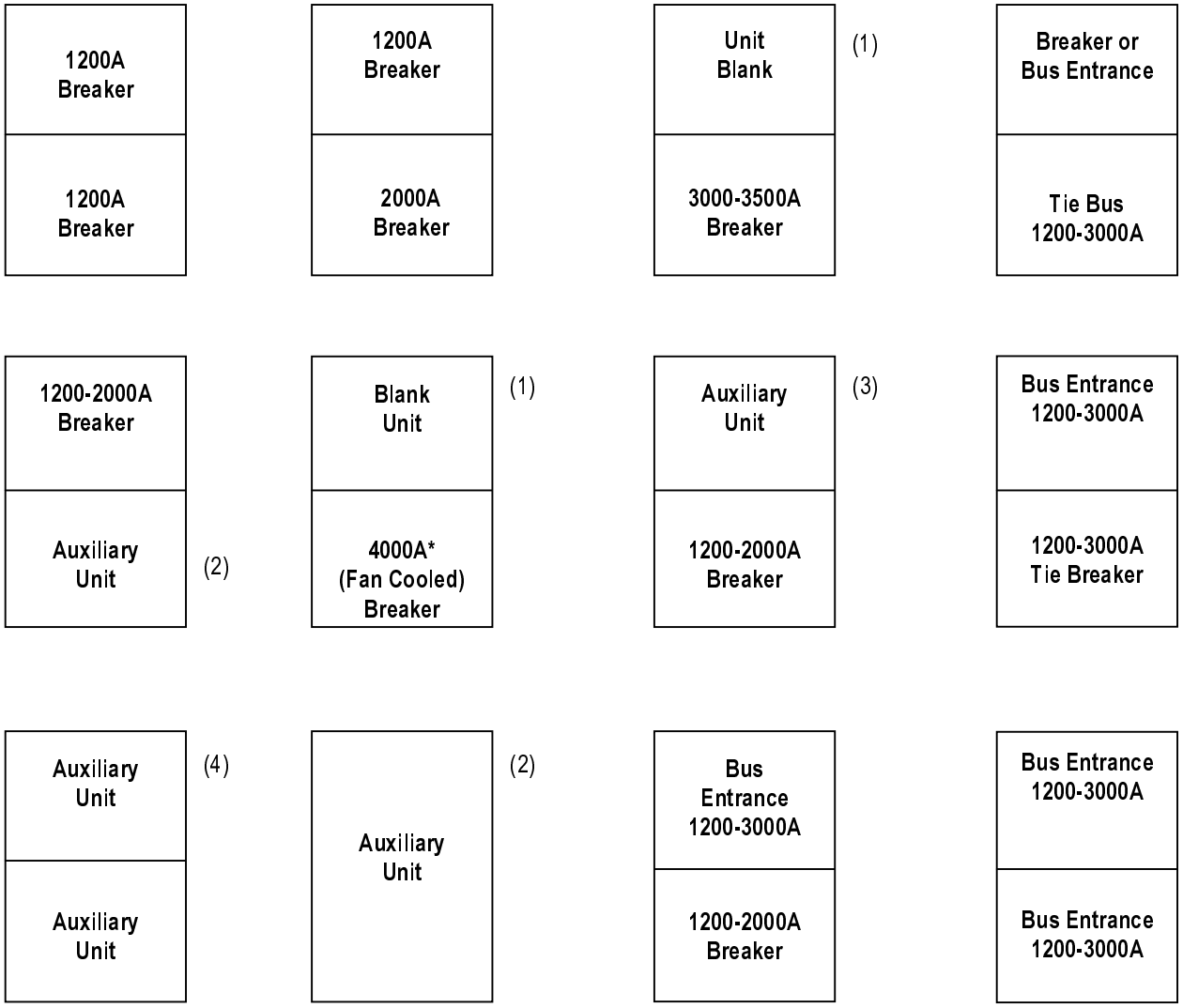
All indoor vertical sections are 95 inches high and 36 inches wide. Outdoor vertical sections are approximately 112 inches high.

Window-type phase CT's (up to two per breaker bushing) are mounted in the breaker compartment. See Table 7-33 for ratings.



POWER/VAC Switchgear Equipment

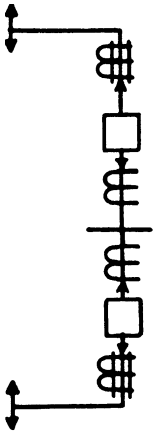
Available Unit Combinations

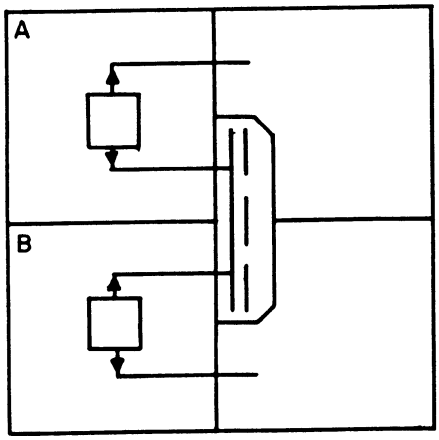


Note:

(1) Blank Unit (above 3000A, 3500A & 4000A breakers)—device mounting space in door.
(2) Auxiliary Unit: Adjacent to tie breaker for tie bus auxiliary. Can house 1 bus connected roll-out tray.
(3) Auxiliary Unit: Used for line or bus connected roll-out trays when located above or below a circuit breaker.
(4) Can house 2 rollouts in A and/or B compartment. See figure 1-5.

Breaker in A
Breaker in B

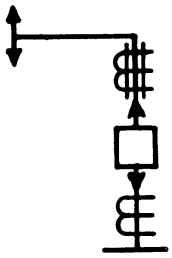


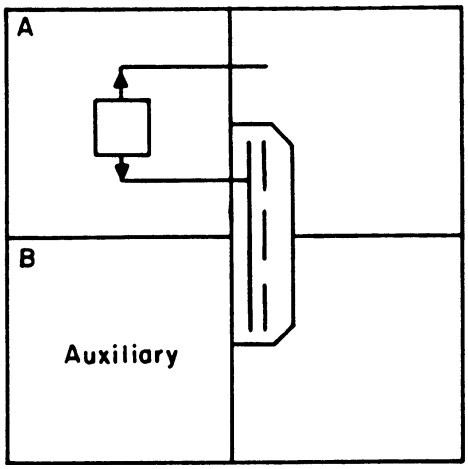


		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, 3000, or 3500 A	
	BREAKERS	Both 1200 A or top 1200 A / bottom 2000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	Top circuit from above and bottom circuit from below	
		Both circuits from below Both circuits from above	
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM for each circuit (21" allowed for stress cones)	

		OPTIONS	
CT's		Add small ground sensor (7" window) to either or both circuits	
		Add 2 or 3 wound type phase CT's per circuit to either or both circuits	
TERMINALS		Add Burndy Hylug terminals per Tables 7-45, 7-46 to either or both circuits	
		Add clamp type terminals per Tables 7-45, 7-46 to either or both circuits	
POTHEADS		Add 1-3/C or 3-1/C potheads per circuit to either or both circuits. No ground sensors or wound type CT's on either circuit.	
		Add 6-1/C potheads to either circuit (not both). No ground sensor or wound type CT's on either circuit.	
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings to top circuit (no ground sensor); bottom circuit out below	
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus from above to top circuit (no ground sensor); bottom circuit out above or below	
		Add termination for metal-enclosed bus from below to bottom circuit (no ground sensor); top circuit out above or below.	

Breaker in A
Auxiliary in B



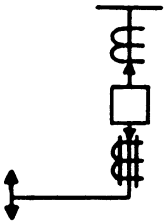


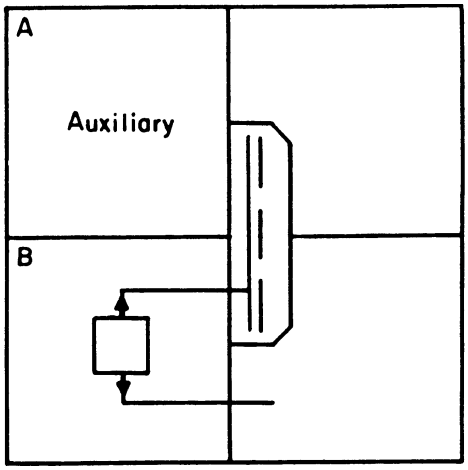
		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A	
	BREAKERS	1200 or 2000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below except above only when CPT mounted in bottom rear of Unit B	
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (21" allowed for stress cones)	

OPTIONS

CT's		Add small ground sensor (7" window)	
		Add large ground sensor (12" window)	
		Add 2 or 3 wound type phase CT's	
TERMINALS		Add provision for a totoal of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)	
		Add Burndy Hylug terminals per Tables 7-45, 7-46	
		Add clamp type terminals per Tables 7-45, 7-46	
POTHEADS		Add 1-3/C or 3-1/C potheads above or below; and 6-1/C or 2-3/C potheads above (no ground sensors). (Above only when CPT mounted in bottom power conductor compartments)	
		Add 6-1/C or 2-3/C potheads below (no ground sensors); (no CPT in bottom power conductor compartment)	
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings (no ground sensor)	
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus from above or below (from above only when CPT mounted in bottom near Unit B)	

Auxiliary in A
Breaker in B



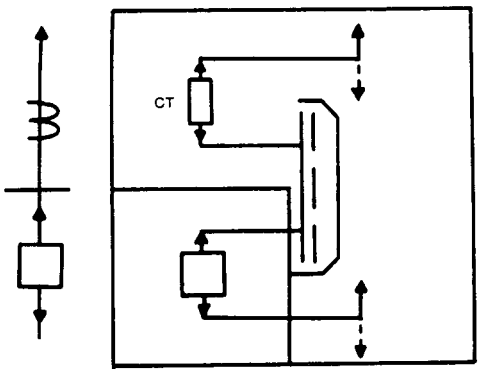


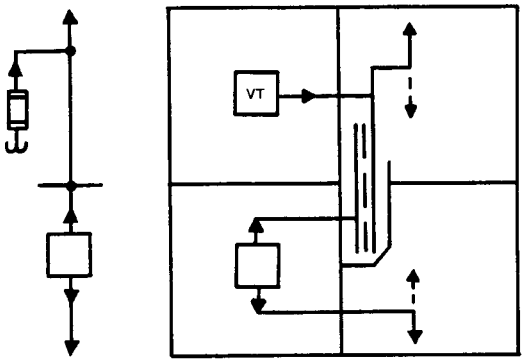
		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	3000 or 3500 A	
	BREAKERS	3000 or 3500 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below	
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (21" allowed for stress cones)	

OPTIONS

CT's		Add small ground sensor (7" window)	
		Add large ground sensor (12" window)	
		Add 2 or 3 wound type phase CT's	
TERMINALS		Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)	
		Add Burndy Hylug terminals per Tables 7-45, 7-46	
		Add clamp type terminals per Tables 7-45, 7-46	
POTHEADS		Add 1-3/C or 3-1/C potheads above or below; add 6-1/C or 2-3/C potheads above (no ground sensors)	
		Add 6-1/C or 2-3/C potheads below (no ground sensors)	
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings (no ground sensor)	
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus from above or below	

CT or VT in A
Breaker in B

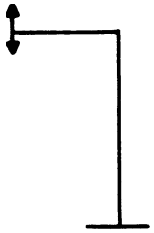


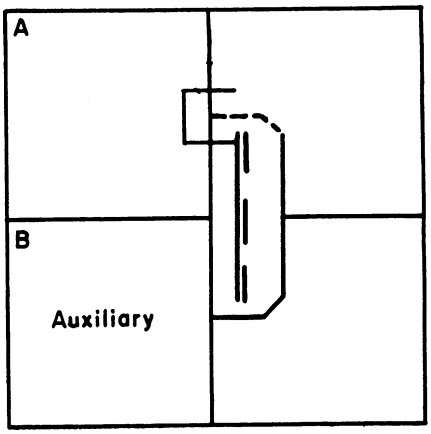


		94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A
	BREAKERS	1200 or 2000 A bus entrance, 1200 or 2000 A breaker
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable
	DIRECTION	Top circuit from above and bottom circuit from below
		Both circuits from below Both circuits from above
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM for each circuit (21" allowed for stress cones)

		OPTIONS
CT's		Add small ground sensor (7" window)
		Add large ground sensor (12" window) to breaker end
		Add 2 or 3 wound type phase CT's to Bus entrance or breaker circuit
TERMINALS		Add Burndy Hylug terminals per Tables 7-45, 7-46
		Add clamp type terminals per Tables 7-45, 7-46
		Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM for either or both circuits (25" allowed for stress cones)
VOLTAGE TRANSFORMER		Add standard V.T. Rollout per Figure 1-4
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings to top circuit (no ground sensor): bottom circuit out below
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus from above to top circuit (no ground sensor); bottom circuit out above or below
		Add termination for metal-enclosed bus from below to bottom circuit (no ground sensor); top circuit out above or below

Bus Entrance in A
Auxiliary in B



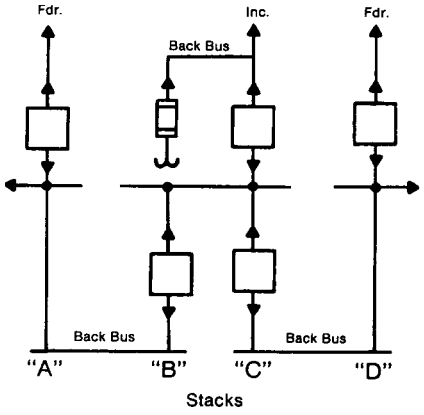


		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, 3000, or 3500 A	
	BREAKERS		
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below except above only when CPT mounted in bottom power conductor compartment	
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (21" allowed for stress cones)	

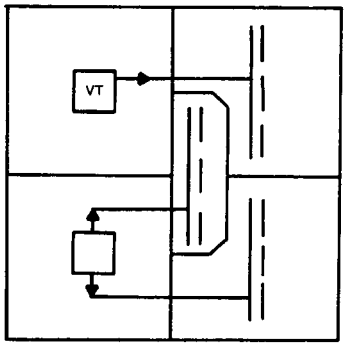
OPTIONS

CT's		Add 2 or 3 wound type phase CT's	
		Add window type phase CT's to top bus entrance compartment	
TERMINALS		Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)	
		Add Burndy Hylug terminals per Tables 7-45, 7-46	
		Add clamp type terminals per Tables 7-45, 7-46	
POTHEADS		Add 1-3/C or 3-1/C potheads above or below; add 6-1/C or 2-3/C potheads above (no ground sensors). (Above only when CPT mounted in bottom power conductor compartment)	
		Add 6-1/C or 2-3/C potheads below (no ground sensors); (no CPT in bottom power conductor compartment	
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings (no ground sensor)	
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus from above or below (from above only when CPT mounted in bottom power conductor compartment	

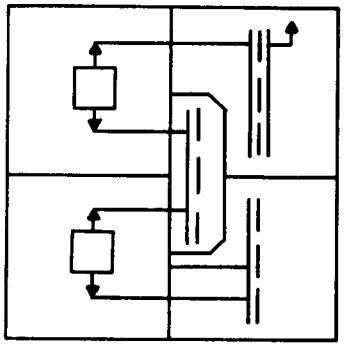
SSIL With Bus Tie To Separate Buses



Stacks



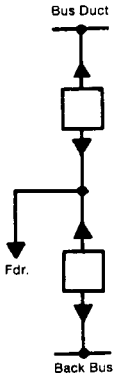
Stack "B"—Side Elevation

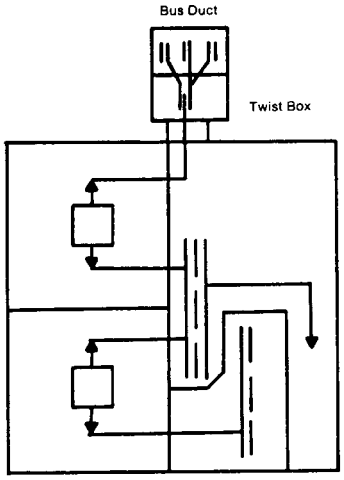

Stack "C"—Side Elevation

		94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, 3000, or 3500 A
	BREAKERS	1200, 2000 or 3000 A
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable
	DIRECTION	Incoming from above. Feeders from above or below if not larger than 2-500 MCM per phase.
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (21" allowed for stress cones)

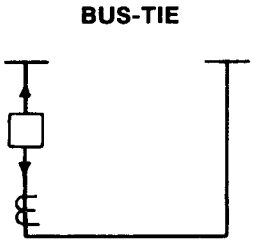
		OPTIONS
CT's		Add ground sensor CT to Feeders
TERMINALS		Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)
		Add Burndy Hylug terminals per Tables 7-45, 7-46
		Add clamp type terminals per Tables 7-45, 7-46
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings (no ground sensor)
METAL-ENCLOSED BUS		Add termination for metal-enclosed bus above or below

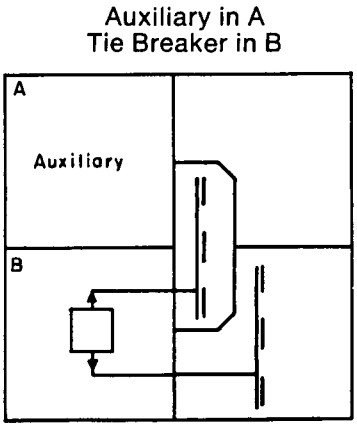
DOUBLE BUS DOUBLE BREAKER



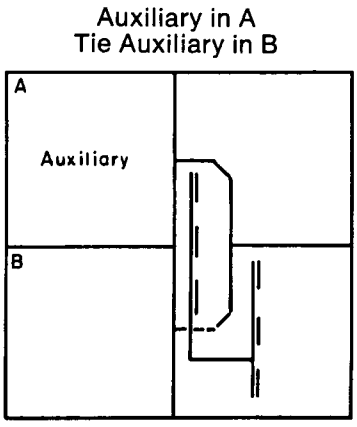


		94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, 3000, or 3500 A
	BREAKERS	1200, 2000 A (See Fig. 1-3)
FEEDER CABLE		Shielded, non-leaded cable



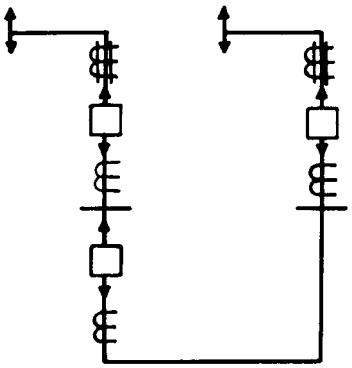


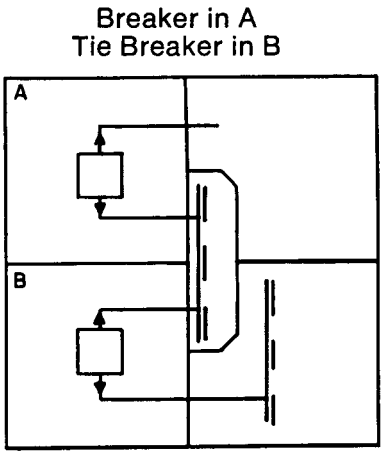
Left hand section



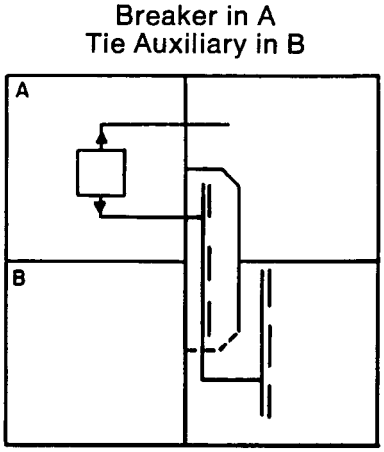
Right hand section

POWER/VAC Switchgear Equipment





Left hand section

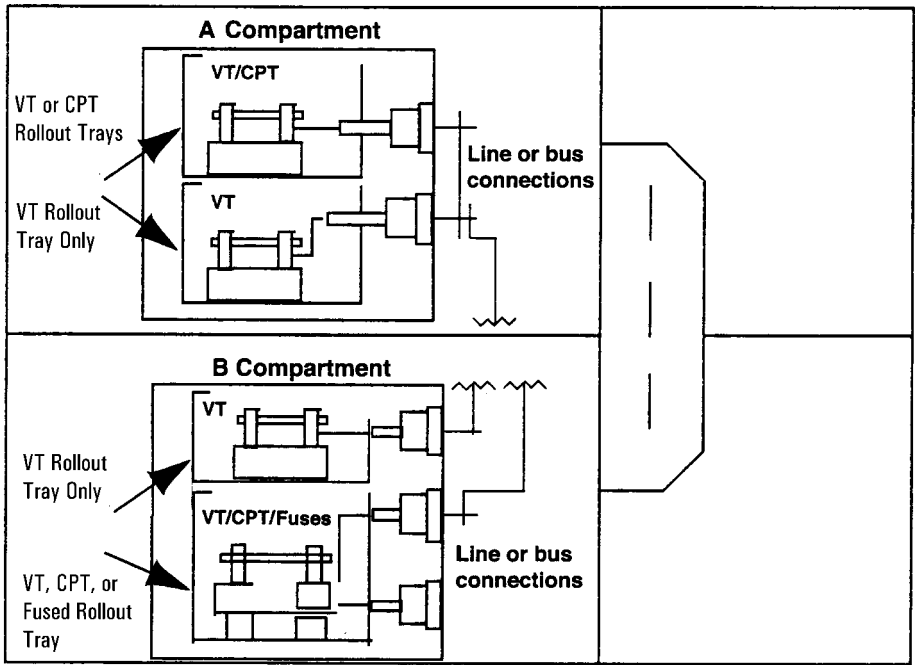


Right hand section

		94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, 3000, or 3500 A
	BREAKERS	1200, 2000, or 3000 A tie; 1200 A over tie for 1200 A or 2000 A tie;
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable
	DIRECTION	From above or below
	TERMINATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (21" allowed for stress cones)

		OPTIONS	
CT's		Add small ground sensor (7" window)	
		Add large ground sensor (12" window)	
		Add 2 or 3 wound type phase CT's	
		Add window type phase CT's in the breaker unit in breaker compartment	
TERMINALS		Add provision for a total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (25" allowed for stress cones)	
		Add Burndy Hylug terminals per Tables 7-45, 7-46	
		Add clamp type terminals per Tables 7-45, 7-46	
POTHEADS		Add 1-3/C or 3-1/C potheads above or below; add 6-1/C or 2-3/C potheads above; no ground sensor or wound type CT's	
		Add 6-1/C or 2-3/C potheads below; no ground sensor	
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings; no ground sensor	
METAL-ENCLOSED BUS		Add metal-enclosed bus above or below; no ground sensor	

Rollouts

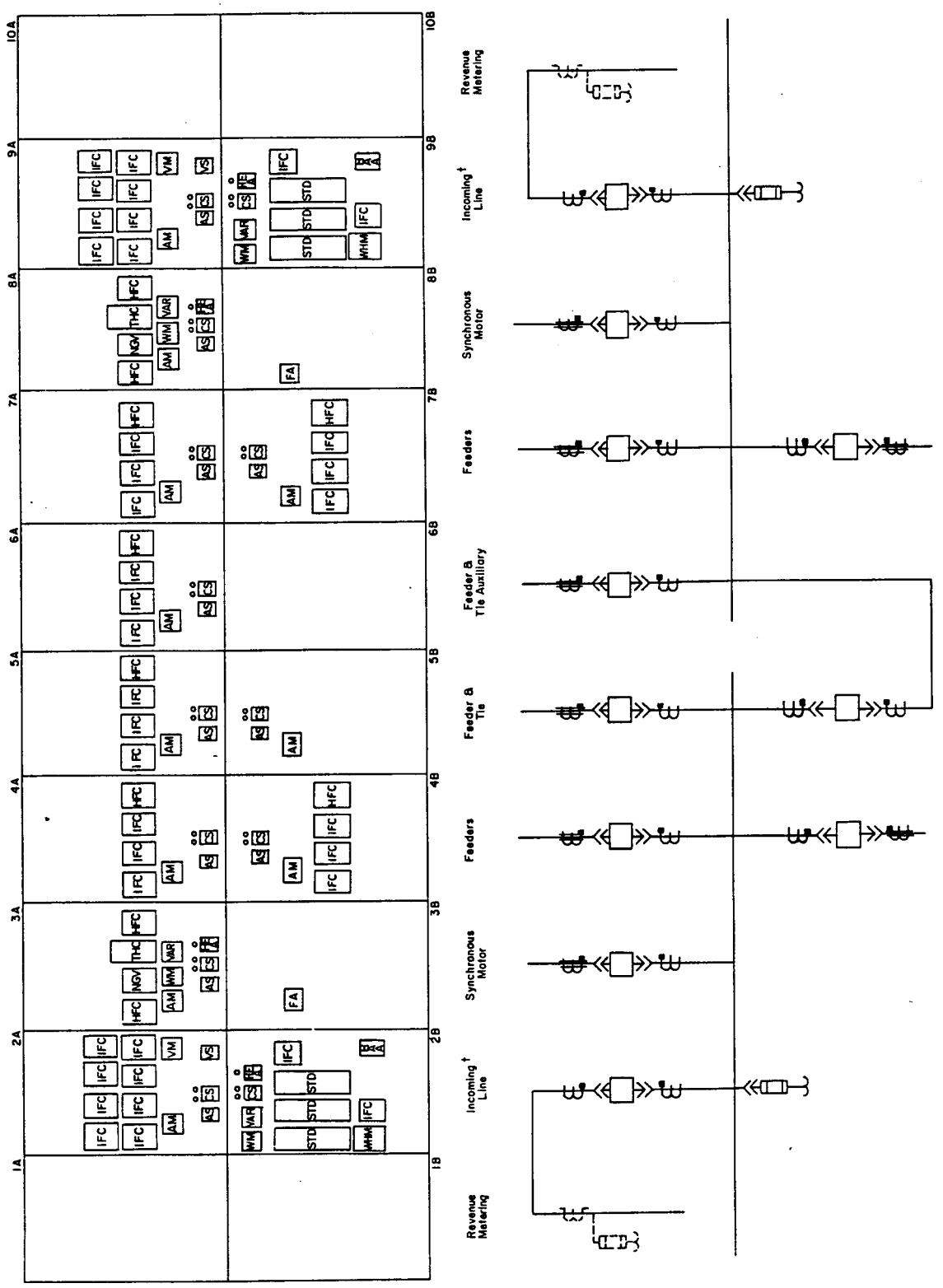


MAXIMUM VT's PER ROLLOUT	3 Fused VT's with 1 fuse each, rated 5000 V and 14,400 V or less, connected wye-wye (Unit A or bottom of Unit B) or 2 Fused VT's with 2 fuses each rated 5000 V and 14,400 V or less, connected in open data
MAXIMUM CPT PER ROLLOUT	1 Single-phase, 2-fuse CPT rated 5/10/15 kVA or less, with a non-automatic secondary breaker
MAXIMUM CPT IN REAR COMPARTMENT	1 25/37.5 kVA dry-tape, single-phase or 45 kVA dry-type, 3-phase. Bottom rollout used for fuses; second rollout space used for non-automatic stationary secondary breaker
MAXIMUM FUSE ON ROLLOUT	25E (size C only) fuse in bottom rollout for use with stationary remote mounted control power transformer
CPT SECONDARY RATINGS	115 / 230 V single-phase 208Y / 120 V three-phase 480Y / 277 V three-phase
CPT kVA RATINGS	Single-phase, dry on rollout; 5, 10, 15 kVA Single-phase, dry: 25, 37.5 kVA (only 25 kVA at 2400 V) Three-phase, dry: 30, 45 kVA (only 30 kVA at 2400V
CPT CONNECTIONS	Single-phase, CPT's connected from phase 1 to phase 2 or phase 1 to neutral; three-phase CPT's consist of 3 single-phase transformers with delta-connected primaries } Cable entry from above only

Notes:

- Upper and lower roll-out can be either bus or line connected as long as both roll-outs in a same compartment are connected in the same manner.
- Only one roll-out can be installed in an auxiliary tie bus compartment.

POWER/VAC Switchgear Equipment



† This is a custom vertical section, because controls for the 115 kV primary breaker are located on this panel. (See Figure 2-2.)

Figure 6-1. Illustration of sample lineup discussed in Section 2 and documented in Section 15.

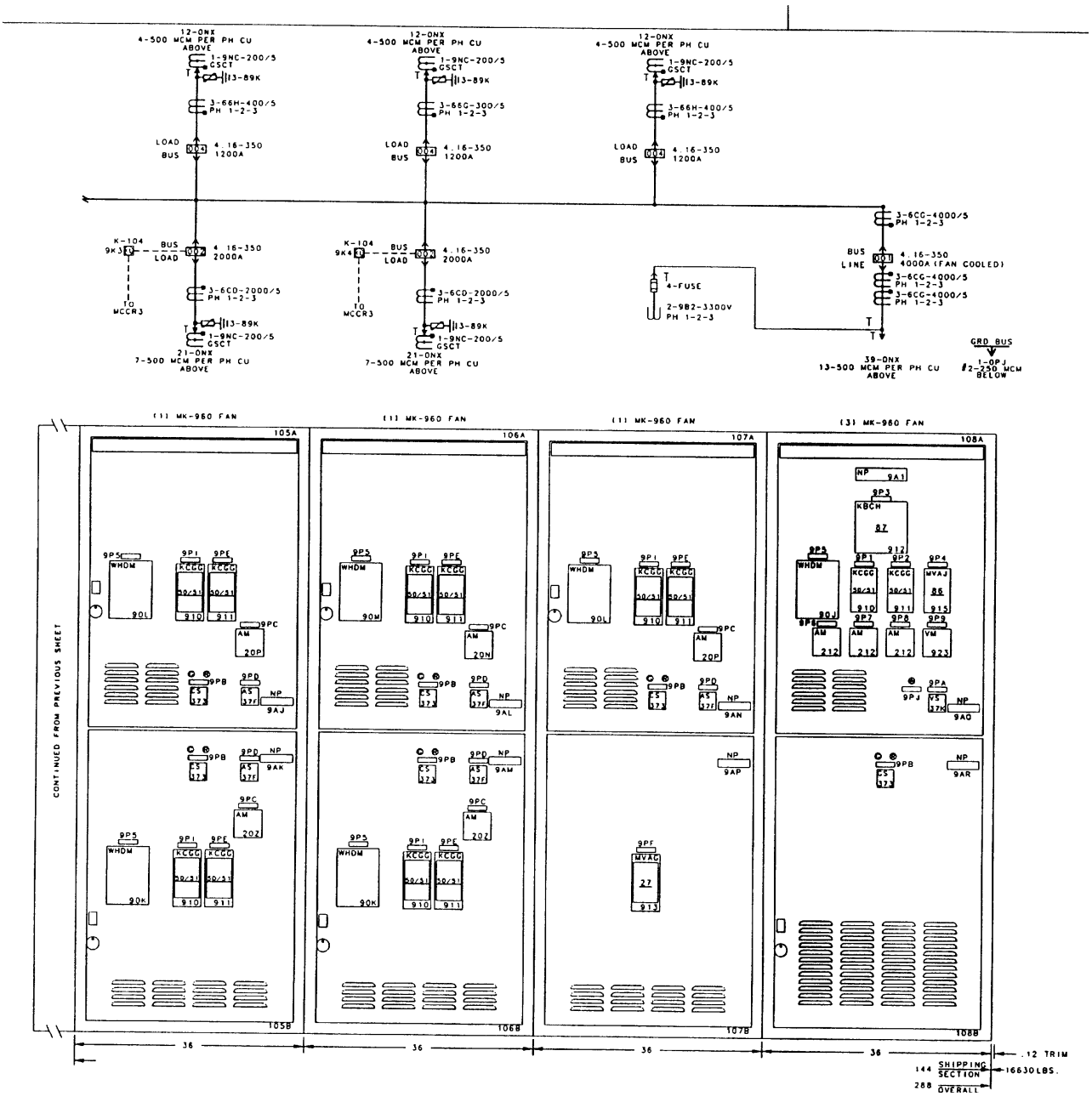


Figure 6-2. Illustration of a sample lineup

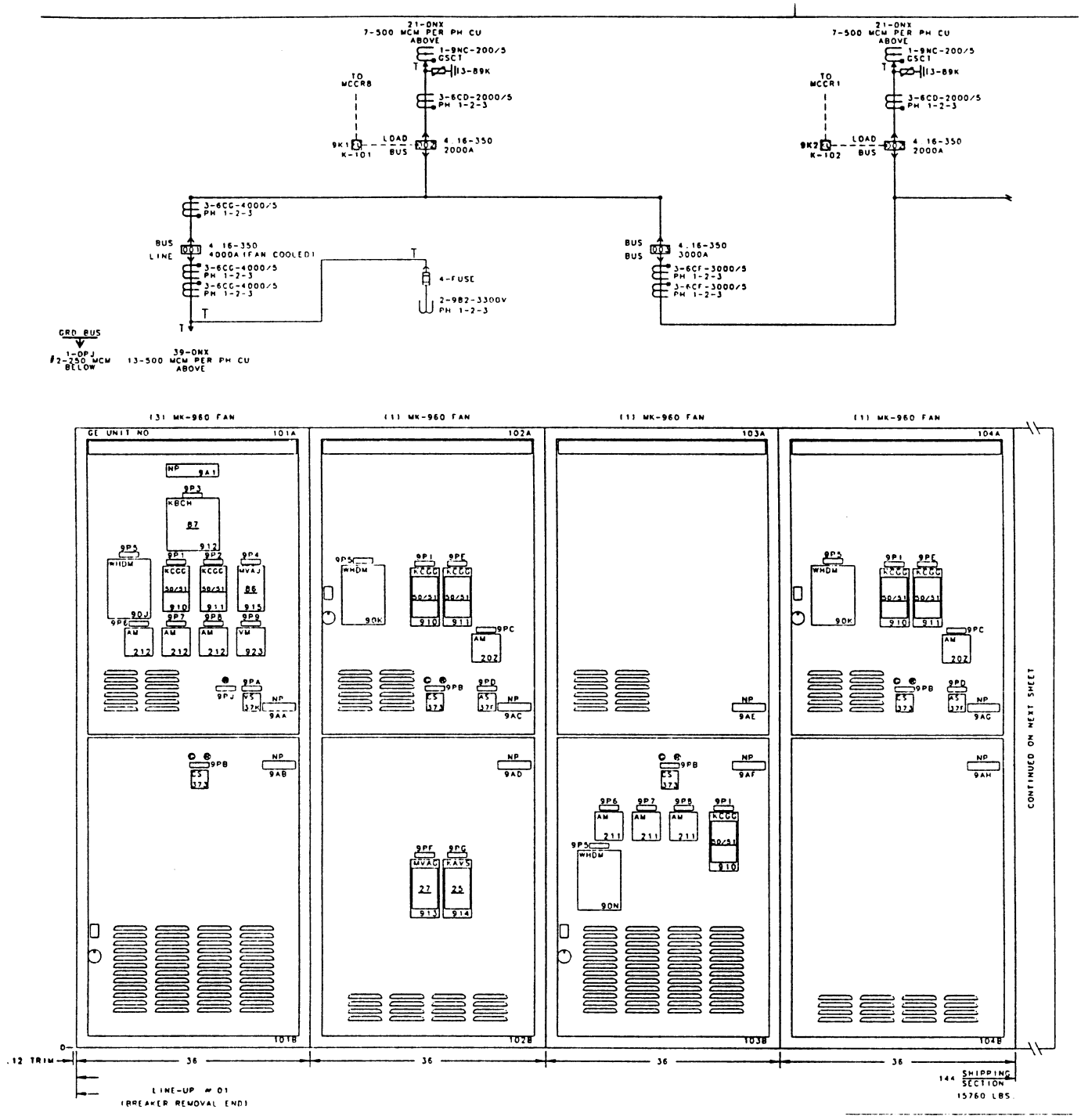


Figure 6-3. Illustration of a sample lineup - 4000 A main.

Device List For Vertical Sections

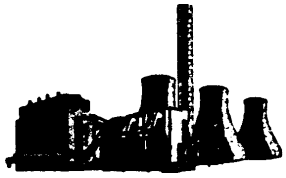
Vertical Section	Device	Dev. No.	Qty.	Description
1 A, B 10A, B	–	–	–	Provision for revenue meter CT's & VT's NEMA drilling for 2 terminals per phase to terminate 500-MCM cable from above
2A 9A	Power Circuit Breaker Phase Overcurrent Relays Residual Overcurrent Relay Phase Overcurrent Relays Residual Overcurrent Relay Circuit Current Transformers Differential Current Transformers Circuit Breaker Control Switch Indicating Lights Ammeter Ammeter Switch Voltmeter Voltmeter Switch Breaker Closing Fuse Pullout Breaker Tripping Fuse Pullout	52 51B 51N/B 50/51 51N CT CT CS IL AM AS VM VS FU FU	1 3 1 3 1 3 3 1 2 1 1 1 1 1 1	VB-13.8-500, 1200 A 12IFC53A1A 12IFC53A2A 12IFC53B1A 12IFC53B2A BP 1200/5A BP 1200/5A 16SB1B9X2 ET-16, 125V (1-R, 1-G) AB-40, 1200A Scale 16SB1CA15X2 AB-40, 18-kV Scale 16SB1CF11X2 2P-30A (15A Fuses) 2P-60A (35A Fuses)
2B 9B	Transfomer Differential Relays Transformer Ground Relay Transformer Fault Pressure Auxiliary Relay Hand Reset Lockout Relay Ground Overcurrent Relay Auxiliary Current Transformer Voltage Transformers Circuit Breaker Control Switch Indicating Lights Wattmeter Varmeter Watthour Meter	87T 87TG 63FPX 86T 51G CT VT CS IL WM VARM WHM	3 1 1 1 1 1 2 1 3 1 1 1	12STD15C5A 12IFC53 12HAA16B2 12HEA61B237X2 12IFC53B2A BP 5/0.833A JVM 14,400/120V 2E Fuses 16SM1B9X2 ET-16, 125V (1-R, 1-W, 1-G) AB-40, 30MW Scale AB-40, 15MVAR Scale DS-63
4A, B 5A, 6A 7A, B	Power Circuit Breaker Phase Overcurrent Relays Ground Sensor Relay Circuit Current Transformers Ground Sensor Current Transformer Circuit Breaker Control Switch Indicating Lights	52 50/51 50GS CT GSCT CS IL	1 3 1 3 1 1 2	VB-13.8-500, 1200A 12IFC53B1A 12HFC11B1A BP300/5A (5A, 6A) BP 400/5A (4A, 4B, 7A, 7B) ITI 50/5 16SB1B9X2 ET-16, 125V (1-R, 1-G)

Device List For Vertical Sections

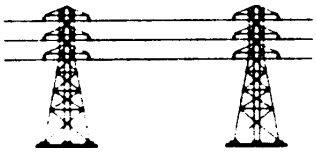
Vertical Section	Device	Dev. No.	Qty.	Description
	Breaker Closing Fuse Pulout	FU	1	2P-30A (15A Fuses)
	Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
	Ammeter	AM	1	AB-40, 300A Scale (5A, 6A) AB-40, 400A Scale (4A, 4B, 7A, 7B)
	Ammeter Switching	AS	1	16SB1CA15X2
	Provision for Feeder Cables	-	1	NEMA Drilling for 1 terminal per phase to terminate 500-MCM cable from above
5B, 6B	Power Circuit Breaker	52	1	VB-13.8-500, 1200 A
	Circuit Current Transformers	CT	6	BP 1200/5A
	Circuit Breaker Control Switch	CS	1	16SB1B9X2
	Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)
	Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
	Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
	Ammeter	AM	1	AB-40, 1200A Scale
	Ammeter Switch	AS	1	16SB1CA15X2
3A 8A	Power Circuit Breaker	52	1	VB-13.8-500, 1200A
	Phase Overcurrent Relay	49/50	1	12THC30A__A
	Ground Sensor Relay	50GS	1	12HFC11B1A
	Motor Differential Relay	87M	1	12HFC13B1A
	Hand Reset Lockout Relay	86M	1	12HEA61B235X2
	Undervoltage Relay	27	1	12NGV13B29A
	Timer, Agastat	62	1	7022PB, 0.5-5 sec
	Circuit Current Transformers	CT	3	BP 300/5A
	Ground Sensor Current	GSCT	1	ITI 50/5A
	Transformer	WM	1	AB-40, 7000kW Scale
	Wattmeter	VARM	1	AB-40, 3500kVAR Scale
	Varmeter	AM	1	AB-40, 300A Scale
	Ammeter Switch	AS	1	16SB1CA15X2
	Circuit Breaker Control Switch	CS	1	16SB1B9X2
	Indicating Lights	IL	3	ET-16, 125V (1-R, 1-W, 1-G)
	Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
	Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
	Provisions for Motor Cables	-	1	NEMA Drilling for 1 terminal per phase to terminate 500-MCM cable from above
3B 8B	Field Ammeter and Shunt	FA	1	DB-40 and Shunt
	Exciter Relay	53	1	IC2820A100BB
	Field Contactor	41	1	IC2812
	Resistors	RES	2	Field Discharge and Field Forcing
	Field Application Panel	13, X, Y	1	0114C4063

DIGITAL RELAY APPLICATION

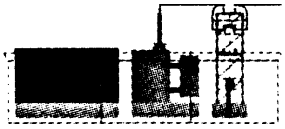
GENERATION



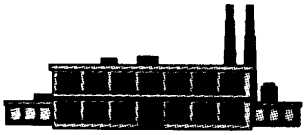
TRANSMISSION

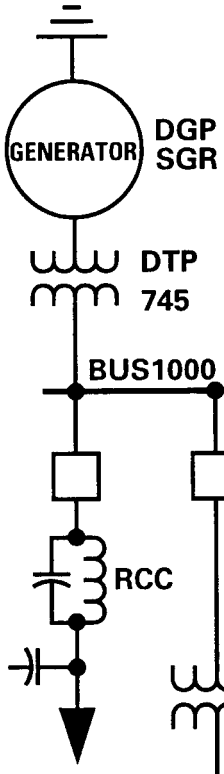


DISTRIBUTION



INDUSTRIAL

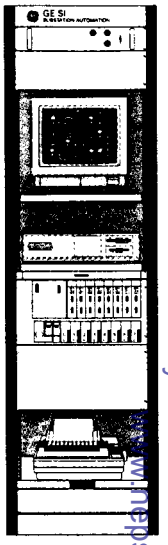




PRODUCTS

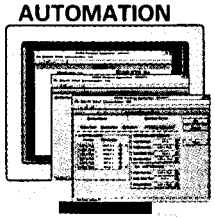
MODEL	DESCRIPTION
239	Small HP MV motor management relay
269 PLUS	Medium HP MV motor management relay
469	Large HP MV motor management relay with metering
489	Small/medium size generator relay
737/735	3 phase + ground feeder relay
745	Transformer management relay
760/750	Multifunction feeder relay
ALPS	High speed distance relay
BUS100	Bus protection relay
DBF	Breaker failure relay
DBT	Breaker coil/tripping circuit supervision relay
DDS	Integrated digital protection and control system
DFF	Frequency relay
DFM	Feeder monitor + hi impedance ground
DFP100	Multifunction feeder relay with reclose
DFP200	Multifunction feeder + hi impedance ground
DGP	Generator protection
DIAC	Time overcurrent relay
DIFC	Time overcurrent relay
DLPD	Distance relay
DTP	Transformer protection relay
EPM	Meter
GE-SI	Substation Integration system
MCP	Gapacitor bank protection
MDP	Modula protection system
MID	3 phase + ground feeder relay
MLP	Three pole tripping distance relay
MM2	Intelligent MCC controller
PMCS	Monitor and control system
PQM	Power quality meter
RCC	Relay communication channels
SGR	Stator ground relay
SPM	Synchronous motor controller
TS3	Transformer fan control

SUBSTATION AUTOMATION



GE-SI DDS

INDUSTRIAL AUTOMATION



PMCS

811817AV.CDR

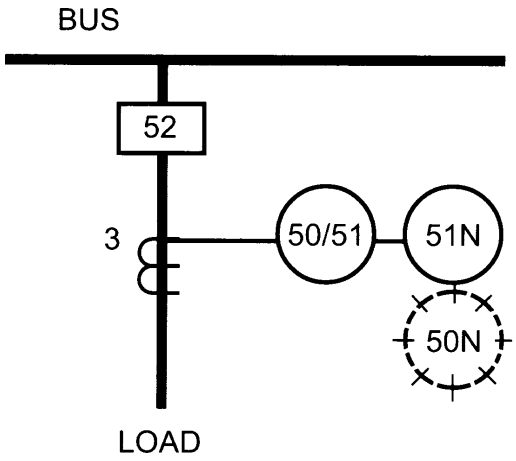
GE Relays Indexed by Device Function Number

Device Number	Description	GE Relay Type
2	Time-delay Starting or Closing Relay	SAM,IAV
8	Control Power Disconnecting Device	PK-2
15	Speed or Frequency Matching Device	GTL
21	Distance Relay	CEB, CEY, GCX, GCY, GXS, SLY, SLYG, CEYG, GCXG, GCXY
21(+)	Distance Relay System	DLP, TLS, TYS, SLS, PLS
24	Overexcitation Relay	STV
25	Synchronizing or Synchronism-Check Device	GES, IJS, SLJ, GXS
27	Undervoltage Relay	CFV, IAV, NGV, SLV, PJV, HGA, HMA, TOV
30	Annunciator Relay	HAA
32	Directional Power Relay	CAP, CCP, CFW, GGP, ICW, TCW
37	Undercurrent or Underpower Relay	CFW, HGC, ICW, PJC
38	Bearing Protective Device	IRT
40	Field Relay	CEH
46	Reverse-phase or Phase-balance Current Relay	IJC, SGC
46 (+)	Large Generator/Motor Relay System	DGP, DMP
47	Phase-sequence Voltage Relay	ICR, NBV
49	Machine or Transformer Thermal Relay	IRT, THC, TMC, MRC
49 (+)	Small Generator/Motor Relay Systems	MGC, MMC
50	Instantaneous Overcurrent or Rate-of-Rise Relay	CHC, HFC, PJC, SBC, BFC
51	AC Time Overcurrent Relay	BFC, IAC, IFC, IFCS, IFCV, SFC, DIAC, DIFC, DSFC
50/51	Instantaneous and Time Overcurrent Relay	IAC, IFC, SFC, TOC, DIAC, DIFC, DSFC
50/51 (+)	Overcurrent Relay System	DDP, MIC, MDP, MCP, DFM, DFP100, DFP200, SR750
52	AC Circuit Breaker	—
59	Overvoltage Relay	CFV, IAV, NGV, PJV, STV, SLV, TOV
60	Voltage or Current Balance Relay	CFVB, IJC, NBV
61	Machine Split Phase Current Balance	IFC, IAC, SFC, MDP
64	Ground Detector Relay	PJG, IAV, IFV
66	Notching or Jogging Device	—
67	AC Directional Overcurrent Relay	CFC, CJC, CJCG, CLPG, IBC, MOR, IBCG, IBCV, JBC, JBCG, JBCV, CAP, TCC, TCCV
68	Blocking Relay	CEB, SLY, SLYG
69	Permissive Control Device	—
74	Alarm Relay	HAA, HGA, HMA, NBT
76	DC Overcurrent Relay	PJC
78	Phase-Angle Measuring or Out-of-Step Protective Relay	CEX + GSY, OST, CEX + NAA
79	AC Reclosing Relay	HGA18, NLR, NSR, SLR, TRS, MRS, MOR
81	Frequency Relay	IJF, SFF
85	Carrier or Pilot-wire Receiver Relay	NAA, SCA, SPA
86	Lockout Relay	HEA, HFA, HAS
87	Differential Protective Relay	BDD, CFD, IFD, IJD, PVD, SBD, SPD, STD, NBD, BUS, TTS, DTP, SR745
87(+)	Differential Relay System	DLS, DGP, DTP, SR489, SR745, BUS1000
94	Tripping or Trip-free Relay	HFA, HGA, HMA, NGA, SBA
( )	Auxiliary Relay	HAA, HEA, HFA, HGA, HMA, HSA, NGA, SBA
( )	Timing Relay	SAM

FEEDER

Protective Relay Zone (FDR1)

Standard Non-directional circuit, residually connected ground relay:



Device list for FDR1

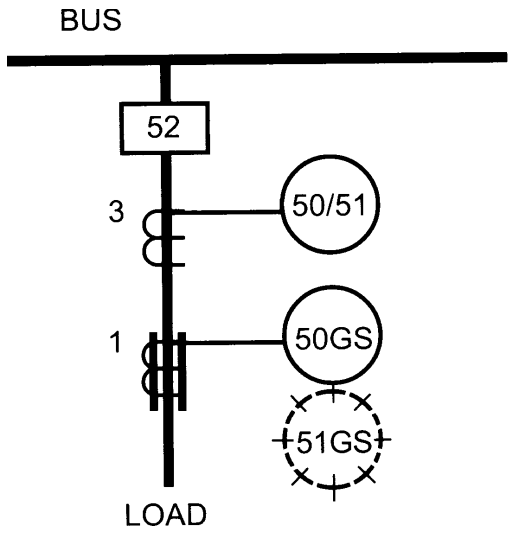
50/51 Phase overcurrent and short circuit
51N Time delay ground fault
50N Instantaneous ground fault

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	50/51/ 51N or 50N	3-Phase Digital Overcurrent, Short Circuit & Ground Fault Relay	MDP or SR735
		Alternate Package (Single Phase Units)	
3	50/51	Phase Overcurrent & Short Circuit Relay	DIFC or IFC53B
1	51N	Time Delay Ground Fault Relay	DIFC or IFC53A
	or 50N	Instantaneous Ground Fault Relay	DIFC or HFC21
		Second Alternate Package	
1		Multifunction microprocessor-based relay system including the following functions:	DFP100 or DFP200 or SR750
	27	Undervoltage	
	46	Negative Sequence Overcurrent (DFP100 & 200 only)	
	47	Negative Sequence Voltage (SR750 only)	
	51	Phase Overcurrent	
	51N	Residual Overcurrent	
	59	Overvoltage	
	74LM	High Impedance Ground (DFP200 only)	
	79	Recloser	
	81L/H	Frequency	
		Options	
	79	Recloser Relay	SLR12
1	81THD	Power Quality Monitoring	PQM

FEEDER

Protective Relay Zone (FDR2)

Standard Non-directional circuit, with ground sensor relay:



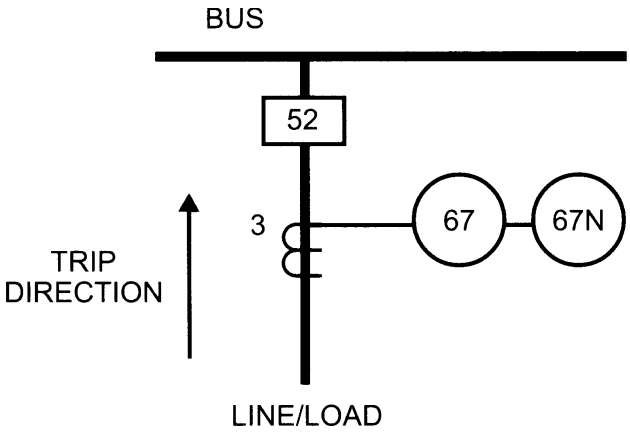
Device list for FDR2

50/51 Phase overcurrent and short circuit
50GS Instantaneous ground fault
51GS Time delay ground fault

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	50/51/ 51GS or 50GS	3-Phase Digital Overcurrent, Short Circuit & Ground Fault Relay	MDP / SR735
		Alternate Package (Single Phase Units)	
3	50/51	Phase Overcurrent & Short Circuit Relay	IFC53B / DIFCA
1	51GS or 50GS	Time Delay Ground Fault Relay Instantaneous Ground Fault Relay	IFC53A / DIFCA HFC21
		Second Alternate Package	
1		Multifunction microprocessor-based relay system including the following functions:	DFP100 or DFP200 or SR750
	27	Undervoltage	
	46	Negative Sequence Overcurrent (DFP100 & 200 only)	
	47	Negative Sequence Voltage (SR750 only)	
	51	Phase Overcurrent	
	51N	Residual Overcurrent	
	59	Overvoltage	
	74LM	High Impedance Ground (DFP200 only)	
	79	Recloser	
	81L/H	Frequency	
		Options	
1	79	Recloser Relay	SLR12

FEEDER

Protective Relay Zone (FDR3)
Standard Directional circuit:



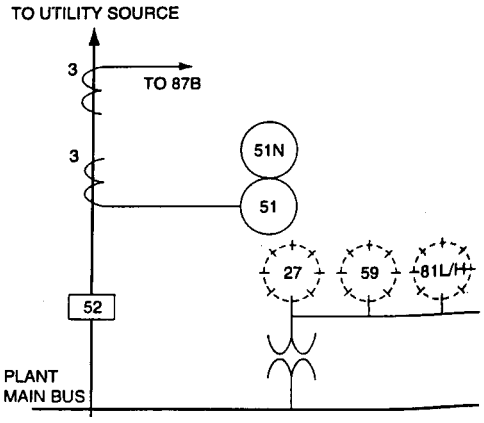
Device list for FDR3
67 Directional overcurrent and short circuit
67N Directional time delay and instantaneous ground fault

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	67/67N	Directional Phase & Ground Fault Relay (Optional recloser 79 function is included).	DFP100 or SR750 / SR760
		Alternate Package (Single Phase Units)	
3	67	Directional Overcurrent Relay	IBC53 or JBC53
1	67N	Directional Ground Fault Relay	IBCG53 or JBCG53
		Options	
1	79	Recloser Relay	SLR12

FEEDER

Protective Relay Zone (FDR4)

Single source incoming line (no internal generation):



Device list for FDR4

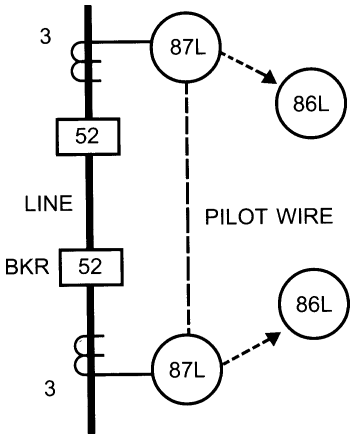
27	Undervoltage
51	Phase overcurrent
51N	Residual overcurrent
59	Overvoltage
81L/H	Frequency

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1		Multifunction Digital Protection System	**DFP100**
	46PT, 46PD	Negative Sequence TOC, Definite Time	
	51PT, 51NT	Phase/Ground TOC	
	50PL, 50NL	Phase/Ground Lowset IOC	
	50PH, 50NH	Phase/Ground Highset IOC	
	51PD, 51ND	Phase/Ground Definite Time	
	21P	mho Phase Distance	
	67N	Negative-sequence dir.	
	27	Undervoltage	
	59	Overvoltage	
	81U	Under-frequency	
	810	Over-frequency	
		Control & Monitoring	
		Metering	
		Cold Load Pickup	
		Breaker Health Monitor	
		Failure to Open/Close Detection	
		Demand Ammeter	
		Event Recording	
		Oscillography	
		Fault Reports	
		Multiple (6) Settings Groups	
		Phase Rotation Selection	
		Options	
1	79	Recloser, option	DFP100
1	81THD	Power Quality Monitoring	PQM

FEEDER

Protective Relay Zone (FDR5)

Long lines and critical short length lines:



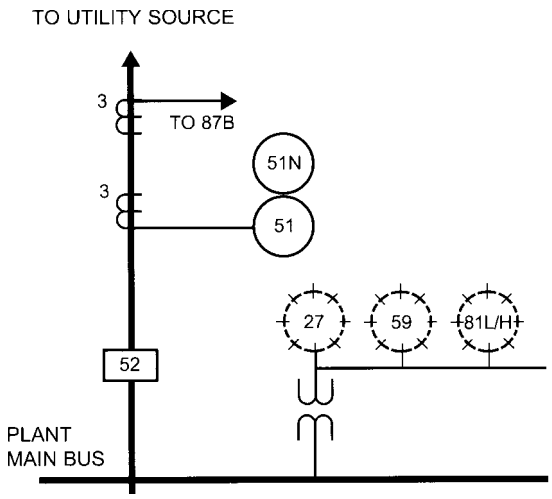
Device list for FDR5
87L Pilot wire line
86L Lockout auxiliary

Qty.	Device No.	Description	GE Model No.
		Basic Package	
2	87L	Pilot Wire Line Differential Relay	SPD11
2	86L	Lockout Auxiliary Relay	HEA61
		Options	
1	85LM	Pilot Wire Monitor Relay (sending end)	SPA11
1	85LM	Pilot Wire Monitor Relay (receiving end)	SPA12
		Alternate Package	
2	87L	Current Differential Relay	DLS3
2	86L	Lockout Auxiliary Relay	HEA61

INCOMING LINE

Protective Relay Zone (IL1)

Single source incoming line (no internal generation):



Device list for IL1

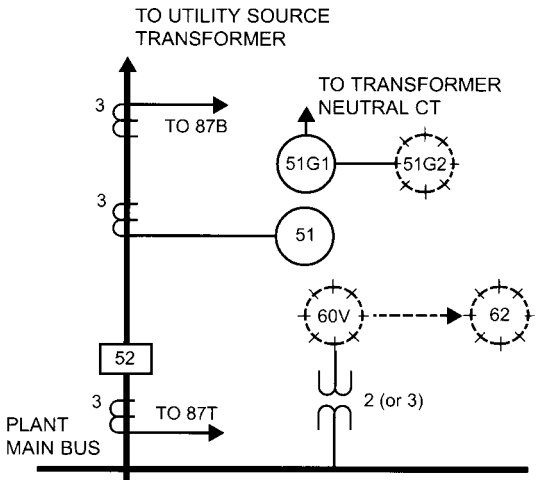
27	Undervoltage
51	Phase overcurrent
51N	Residual overcurrent
59	Overvoltage
81L/H	Frequency

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	51/51N	Phase Overcurrent & Ground Fault Relay	MDP
		First Alternate Package (Single Phase Units)	
1	51/51N 74LM	Phase & Ground Overcurrent Relay with High Impedance Ground Fault Detection (Power Quality Option)	DFM3
		Second Alternate Package	
1		Multifunction microprocessor-based relay system including the following functions:	DFP100 or DFP200 or SR750
	27	Undervoltage	
	46	Negative Sequence Overcurrent (DFP100 & 200 only)	
	47	Negative Sequence Voltage (SR750 only)	
	51	Phase Overcurrent	
	51N	Residual Overcurrent	
	59	Overvoltage	
	74LM	High Impedance Ground (DFP200 only)	
	81L/H	Frequency	
		Options (Single Phase Units)	
4	51, 51N	Phase/Ground Overcurrent Relays	DIFC or IFC53A
1	27	Undervoltage Relay	TOV or NGV
1	59	Overvoltage Relay	TOV or NGV
1	81L/H	Over and underfrequency Relay (add if upstream auto-reclosing is a concern)	SFF202B or MFF1
1	87B	Differential Relay (See Bus Protective Zone for Details)	

INCOMING LINE

Protective Relay Zone (IL2)

Single source incoming line via utility transformer (no internal generation):



Device list for IL2

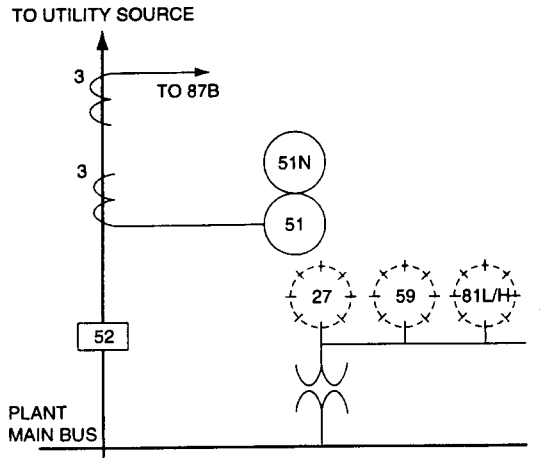
51	Phase overcurrent
51G-1	Ground overcurrent
51G-2	Ground overcurrent
60V	Voltage unbalance
62	Timer

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	51/51G	Phase Overcurrent & Ground Fault (Bus) Relay	MDP
		First Alternate Package (Single Phase Units)	
1	51/51G/ 74LM	Phase & Ground Overcurrent Relay with High Impedance Ground Fault Detection (Power Quality Option)	DFM3
		Second Alternate Package	
1		Multifunction microprocessor-based relay system including the following functions:	DFP100 or DFP200 or SR750
	27	Undervoltage	
	46	Negative Sequence Overcurrent (DFP100 & 200 only)	
	47	Negative Sequence Voltage (SR750 only)	
	51	Phase Overcurrent	
	51N	Residual Overcurrent	
	59	Overvoltage	
	74LM	High Impedance Ground (DFP200 only)	
	81L/H	Frequency	
		Options (Single Phase Units)	
4	51, 51N	Phase/Ground Overcurrent Relays	DIFC or IFC53A
1	60V	Voltage Unbalance Relay (add if high side fusing could result in single phase of motors)	NBV11
1	62	Timing Auxiliary Relay	SAM201 or IAV51M
1	51G2	Ground Fault (transformer secondary) Relay (add for two step trouble-shooting for transformer/bus grounds)	DIFC or IFC53A
1	87B and 87T	Differential Relay (See Bus and Transformer Protective Zone for Details) *(For additional options see IL1)*	

INCOMING LINE

Protective Relay Zone (IL3)

Single source incoming line (no internal generation):



Device list for IL3

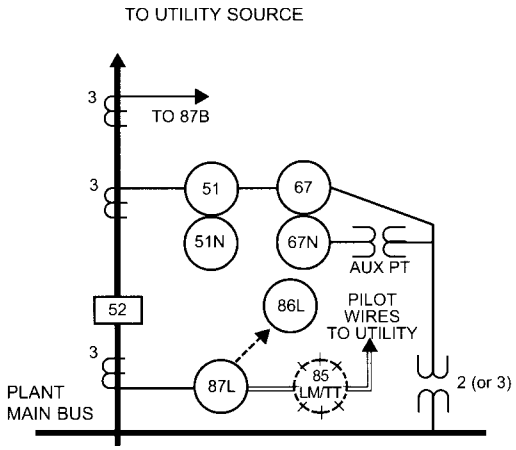
27	Undervoltage
51	Phase overcurrent
51N	Residual overcurrent
59	Overvoltage
81L/H	Frequency

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1		Multifunction Digital Protection System	DFP100
	46PT, 46PD	Negative Sequence TOC, Definite Time	
	51PT, 51NT	Phase/Ground TOC	
	50PL, 50NL	Phase/Ground Lowset IOC	
	50PH, 50HH	Phase/Ground Highset IOC	
	51PD, 51ND	Phase/Ground Definite Time	
	21P	mho Phase Distance	
	67N	Negative-sequence dir.	
	27	Undervoltage	
	59	Overvoltage	
	81U	Under-frequency	
	81O	Over-frequency	
		Metering	
		Cold-Load Pickup	
		Breaker Health Monitor	
		Failure to Open/Close Detection	
		Demand Ammeter	
		Event Recording	
		Oscillography	
		Fault Reports	
		Multiple (6) Settings Groups	
		Options	
1	79	Recloser, option	DFP100
1	81THD	Power Quality Monitoring	PQM

INCOMING LINE

Protective Relay Zone (IL4)

Single source incoming line with internal generation:



Device list for IL4

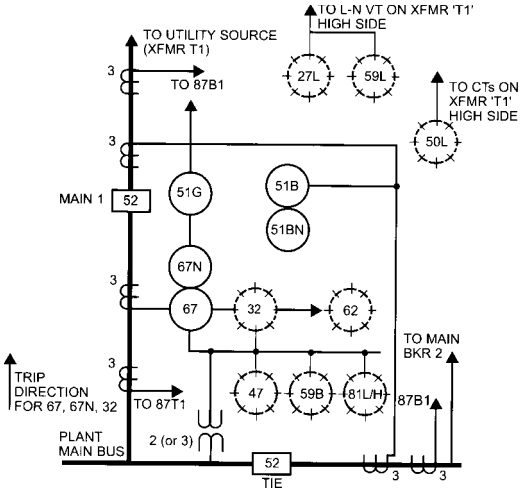
51	Phase overcurrent
51N	Residual overcurrent
67	Directional phase overcurrent
67N	Directional ground overcurrent
85LM/TT	Communication monitor
86L	Lockout auxiliary
87L	Differential

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	87L	Pilot Wire Line Differential Relay	SPD11*
1	86L	Lockout Auxiliary Relay	HEA61
1	67/67N	Directional Phase and Ground Overcurrent Relay	MOR3
1	51/51N	Phase Overcurrent and Ground Fault Relay	MDP
		Alternates	
1	87L/85LM/ 85TT	Line Differential & Channel Monitor & Transfer Trip Auxiliary Relay	DLS3*
3	67	Directional Phase Overcurrent Relay (Single Phase Units)	IBC53 or JBC53
1	67N	Directional Ground Overcurrent Relay (Single Phase Units)	IBC53 or JBCG53
4	51, 51N	Phase/Ground Overcurrent Relays (Single Phase Units)	DIFC or IFC53A
		Options	
1	85LM	Pilot Wire Monitor [different device at send and receive ends] Relay	SPA11A or 12A*
1	85LM/TT	Pilot Wire Monitor and Transfer Trip Auxiliary Relay [different device at send and receive ends]	SPA11B or 12B*
1	87B	Differential Relay (See Bus Protection Zones for Details) *(For additional alternates and options see IL1 and IL2)*	
	Notes:	*Must be selected in accordance with companion relay at opposite end of the line. Pilot wire protective auxiliaries may be required.	

INCOMING LINE

Protective Relay Zone (IL5)

Dual source incoming line (dual line with internal generation & via utility transformer):



Device list for IL5

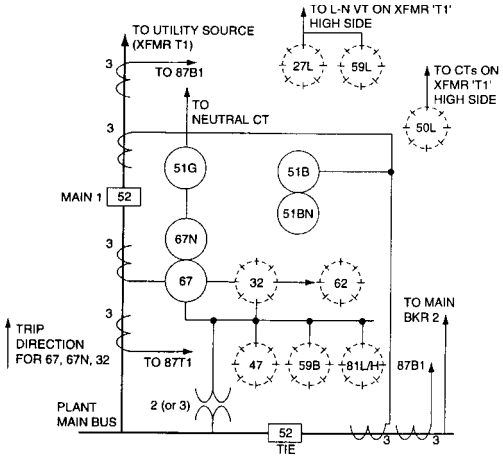
27L	Undervoltage
32	Power direction
47	Phase undervoltage and reverse phase sequence
50L	Instantaneous overcurrent
51B	Phase time overcurrent
51BN	Residual time overcurrent
51G	Ground overcurrent
59B	Overvoltage
59L	Overvoltage
62	Timer
67	Directional phase overcurrent
67N	Directional ground overcurrent
81L/H	Frequency

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	67/67N	Directional Phase and Ground Overcurrent Relay	MOR3
1	51B/51BN	Phase Overcurrent (Partial Differential) and Ground Fault Relay	MDP
1	51G	Ground Overcurrent (for transformer lowside) Relay	DIFC
		Options	
1	27L	Line Undervoltage (transformer highside) Relay	TOV5 or NGV
1	59L	Line Overvoltage (transformer highside) Relay (add 27L & 59L as a means of detecting Delta-Wye transformer highside ground fault after utility seperation.)	TOV5 or NGV
1	32	Power Directional Relay (detects tranf. magnetizing current)	CCP13E
1	62	Auxiliary Timing Relay (add 32 & 62 in lieu of 27L and 59L as alternate means of detecting system ground faults)	SAM201
1	47	Phase Undervoltage and Reverse Phase Sequence Relay (add if required for motor bus monitoring or intertie)	ICR53A
1	59B	Bus Overvoltage Relay (add if required for intertie)	TOV5 or NGV
1	81L/H	Over and Underfrequency Relay (add for intertie or load shedding requirements)	SFF202B or MFF1
1	50L	Instantaneous Overcurrent Relay (add if highside disconnect is not rated for fault interruption)	PJC11AV or CHC11A
1	87B and 87T	Differential Relay (See Bus and Transformer Protective Zones for Details) *(For additional alternates and options see IL1 and IL2)*	

INCOMING LINE

Protective Relay Zone (IL6)

Dual source incoming line (dual line with internal generation & via utility transformer):



Device list for IL6

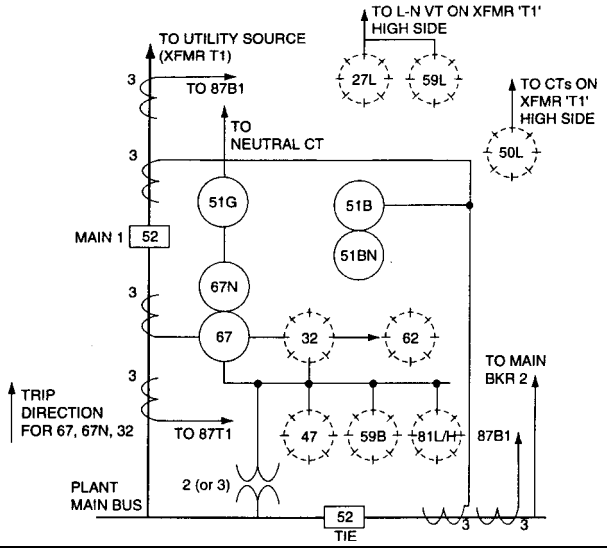
27L	Undervoltage
32	Power direction
47	Phase undervoltage and reverse phase seq.
50L	Instantaneous overcurrent
51B	Phase time overcurrent
51BN	Residual time overcurrent
51G	Ground overcurrent
59B	Overvoltage
59L	Overvoltage
62	Timer
67	Directional phase overcurrent
67N	Directional ground overcurrent
81L/H	Frequency

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1		Multifunction Digital Protection System	**DFP200**
	27	Bus/Line Undervoltage	
	47	Negative Sequence Voltage	
	50	Phase/Neutral/Ground/Neg Seq Loset Inst O/C	
	50	Phase/Neutral/Ground Hiset Inst O/C	
	51	Phase/Neutral/Ground/Neg Seq Time O/C	
	59	Bus/Line Overvoltage	
	67N/67P	Phase/Ground Directional Control	
	81	Over/Under Frequency	
	50	Phase/Neutral Current Level	
	55	Power Factor	
	62	Definite Time Overcurrent	
	46	Negative Sequence Overcurrent	
	50/62	Breaker Faliure	
		Metering, complete	
		Cold Load Pickup Feature	
		Breaker Operation Failure	
		Trip/Close Circuit Failure	
		Total Breaker Arcing Current	
		VT Failure	
		Demand (A, MW, Mvar, MVA)	
		Analog Input	
		Event Recording	
		Options	
1	79	Recloser, option	DFP200
1	81THD	Power Quality, option	DFP200
1	64HiZ	High impedance fault, option	DFP200
1	86	Lockout Relay	HEA61
1	87B and 87T	Differential Relay (See Bus and Transformer Protective Zones for Details)	
		(For additional alternates and options see IL1 and IL2)	

INCOMING LINE

Protective Relay Zone (IL7)

Dual source incoming line (dual line with internal generation & via utility transformer):



Device list for IL7

27L	Undervoltage
32	Power direction
47	Phase undervoltage and reverse phase sequence
50L	Instantaneous overcurrent
51B	Phase time overcurrent
51BN	Residual time overcurrent
51G	Ground overcurrent
59B	Overvoltage
59L	Overvoltage
62	Timer
67	Directional phase overcurrent
67N	Directional ground overcurrent
81L/H	Frequency

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1		Multifunction Digital Protection System	**SR750**
1	51G	Ground Overcurrent (for transformer lowside) Relay	IFC53A
	27	Bus/Line Undervoltage	
	47	Negative Sequence Voltage	
	50	Phase/Neutral/Ground Neg Seq Loset Inst O/C	
	50	Phase/Neutral/Ground Hiset Inst O/C	
	51	Phase/Neutral/Ground/Neg Seq Time O/C	
	59	Bus Overvoltage	
	67	Phase/Ground Directional Control	
	81	Bus Underfrequency	
	25	Synchrocheck	
	50	Phase/Neutral Current Level	
	55	Power Factor	
	81	Overfrequency	
		Breaker Open/Close	
		Trip/Close Circuit Failure	
		Total Breaker Arcing Current	
		VT Failure	
		Demand (A, MW, Mvar, MVA)	
		Event Recording	
		Options	
1	79	Recloser, option	SR760
1		Bus Transfer	SR750
1	81THD	Power Quality Monitoring	PQM
1	86	Lockout Relay	HEA61

INCOMING LINE

Protective Relay Zone (IL8)

Automatic transfer (throwover) equipment for medium voltage switchgear.

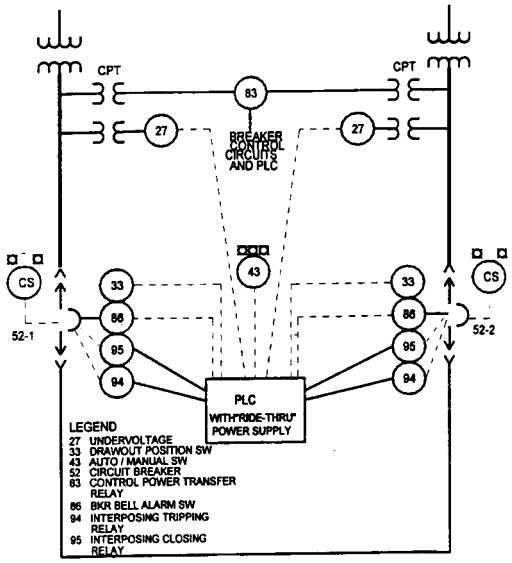
Relay and control equipment can be provided to maximize continuity of service to a switchgear load bus by detecting problems with power source (undervoltage, loss of phase, etc.) and transferring the load bus to an alternate or emergency source.

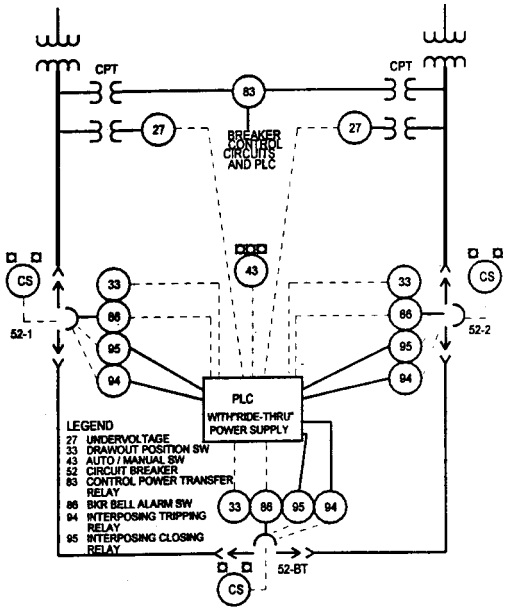
Typical two breaker auto throwover schemes are seen in applications were a main breaker losses voltage and an emergency breaker provides power to the lineup. Typical three breaker auto throwover schemes are seen on main-tie-main lineups.

Two/Three breaker automatic transfer scheme:

Single phase Basic Package:
Hardware relay (no PLC)
- 2-single phase (27) relays - NGV
- 4-Agastat timers
- 1-52 aux switch per M-T-M
- 2-Lockout (86) relays - HEA
- 1-Manual/automatic transfer switch (43)
- 2-Indicating lights and terminal blocks

Three phase Basic Package:
Hardware relay (no PLC)
- 2-NGV relay & 2 NBV relays
- 4-Agastat Timers
- 1-52 aux switch per M-T-M
- 2-Lockout (86) relays - HEA
- 1-Manual/automatic transfer switch (43)
- 2-Indicating lights and terminal blocks
- 1-CPT throwover
- 1-86 lockout to the tie breaker if tit has over current relays on it.





INCOMING LINE

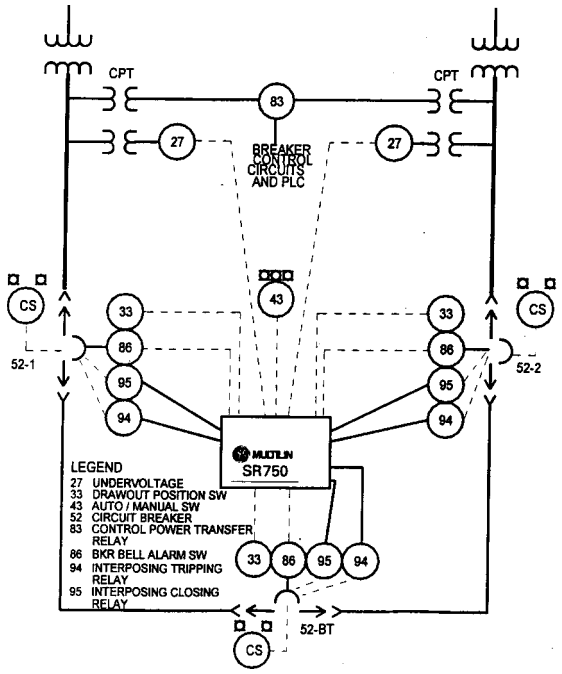
Protective Relay Zone (IL9)

Three breaker automatic transfer scheme w/MultiLin SR750 relays:

Basic Package:

Hardware relay (no PLC)
- 1-SR750 meter per main and tie breaker
- 1-52 aux switch 3 stage, each breaker
- 1-52 pos switch 3 stage, each breaker
- 1-HGA aux relay per main breaker
  - line pt's on each main breaker
  - bus pt's on each side of tie breaker
  - set of (3) ct's per breaker
- 1-CPT throwover

SR750 relays will require programming & wiring. The relay has step by step instructions to do this and has the capabilities as part of the standard relay offering.



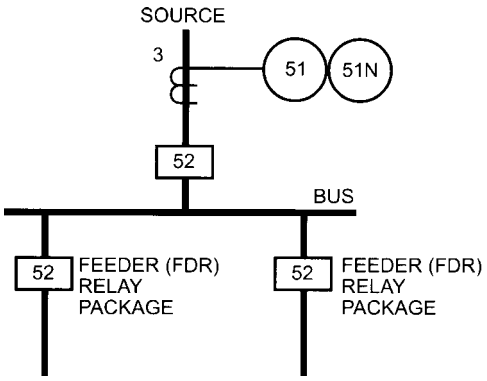
SR750 Relay System

ANSI	Protection / Control
27	Bus/Line Undervoltage
47	Negative Sequence Voltage
50	Phase/Neutral/Ground/Neg Seq Loset Inst O/C
50	Phase/Neutral/Ground Hiset Inst O/C
51	Phase/Neutral/Ground/Neg Seq Time O/C
59	Bus Overvoltage
67	Phase/Ground Directional Control
81	Bus Underfrequency
	Undervoltage Automatic Restoration
	Underfrequency Automatic Restoration
	Breaker Failure with Current Superv.
	Bus Transfer
	Programmable Logic Inputs
	Multiple Setpoint Groups
	Monitoring / Control
25	Synchrocheck
50	Phase/Neutral Current Level
55	Power Factor
79	Autoreclose (760 only)
81	Overfrequency
	Breaker Open/Close
	Manual Close Feature Blocking
	Cold Load Pickup Feature Blocking
	Breaker Operation Failure
	Trip/Close Circuit Failure
	Total Breaker Arcing Current
	VT Failure
	Demand (A, MW, Mvar, MVA)
	Analog Input
	Event Recording

BUS

Protective Relay Zone (BUS1)

Single source, radial configuration:



Device list for BUS1

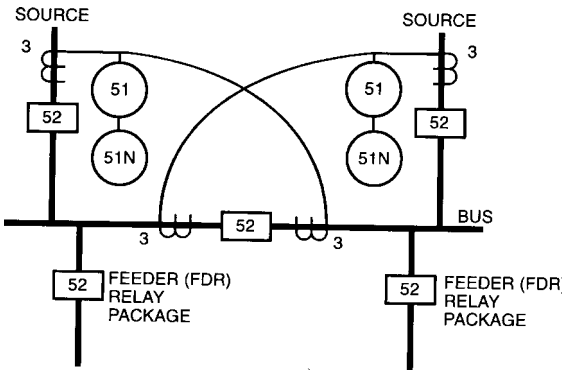
51 Phase overcurrent
51N Ground fault

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	51/51N	Phase Overcurrent and Ground Fault Relay	MDP or SR735
1	86B	Lockout Auxiliary Relay	HEA61
		Alternate Package (Single Phase Units)	
3	51	Phase Overcurrent Relay	DIFC or IFC53A
1	51N	Ground Fault Relay	DIFC or IFC53A
1	86B	Lockout Auxiliary Relay	HEA61
		Second Alternate Package	
1		Multifunction microprocessor-based relay system including the following functions:	DFP100 or DFP200 or SR750
	27	Undervoltage	
	46	Negative Sequence Overcurrent (DFP100 & 200 only)	
	47	Negative Sequence Voltage (SR750 only)	
	51	Phase Overcurrent	
	51N	Residual Overcurrent	
	59	Overvoltage	
	74LM	High Impedance Ground (DFP200 only)	
	81L/H	Frequency	
1	86B	Lockout Auxiliary Relay	HEA61
		Options	
1	64	Ground Fault Relay (ungrounded systems)	TCCV

BUS

Protective Relay Zone (BUS2)

Multiple sources with bus tie breaker:



Device list for BUS2

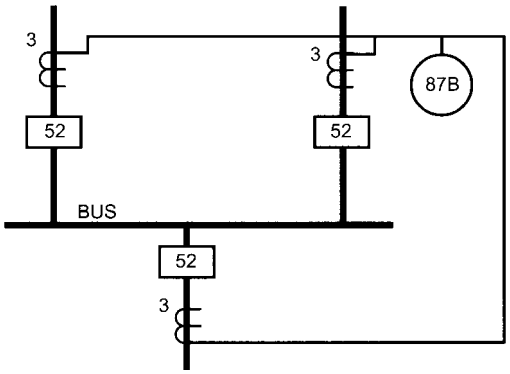
51 Phase overcurrent
51N Ground fault

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	51/51N	Phase Overcurrent and Ground Fault Relay	MDP or SR735
		Alternate Package (Single Phase Units)	
3	51	Phase Overcurrent Relay	DIFC or IFC53A
1	51N	Ground Fault Relay	DIFC or IFC53A
		Second Alternate Package	
1		Multifunction microprocessor-based relay system including the following functions:	DFP100 or DFP200 or SR750
	27	Undervoltage	
	46	Negative Sequence Overcurrent (DFP100 & 200 only)	
	47	Negative Sequence Voltage (SR750 only)	
	51	Phase Overcurrent	
	51N	Residual Overcurrent	
	59	Overvoltage	
	74LM	High Impedance Ground (DFP200 only)	
1	81L/H	Frequency	
		Options	
1	64	Ground Fault Relay (ungrounded systems)	TCCV
1	86B	Lockout Auxiliary Relay (as many as required)	HEA61

BUS

Protective Relay Zone (BUS3)

Single or multiple sources, with or without bus tie breakers:



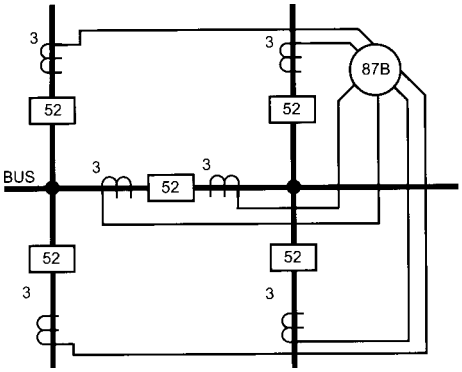
Device list for BUS3
87B Differential

Qty.	Device No.	Description	GE Model No.
		Basic Package	
3	87B	Differential Relay	PVD21 or SBD11
		Options	
1	86B	Lockout Auxiliary Relay (as many as required)	HEA61

BUS

Protective Relay Zone (BUS4)

Multiple sources, bus tie breakers, multi-ratio CT's



Device list for BUS4

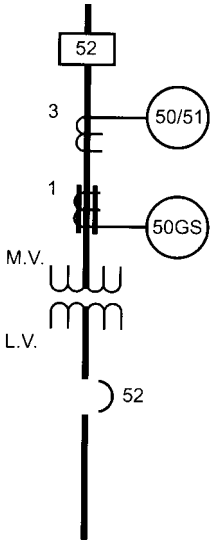
87B Differential

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	87B	Differential Relay	BUS1000
		Options	
1	86B	Lockout Auxiliary Relay (as many as required)	HEA61

TRANSFORMER (TR)

Protective Relay Zone (TR1)

Protection for transformers 2500KVA and below, medium and low voltage windings:



Device list for TR1

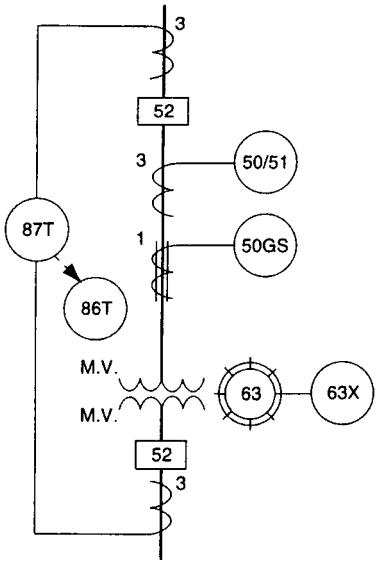
50/51 Overcurrent & short circuit
50GS Ground fault

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	50/51/50GS	Digital Overcurrent, Short Circuit & Ground Fault Relay	MDP or SR735
		Alternate Package (Single Phase Units)	
3	50/51	Overcurrent and Short Circuit Relay	DIFC or IFC53B
1	50GS	Ground Fault Relay	DIFC or HFC21
		Second Alternate Package	
1		Multifunction microprocessor-based relay system including the following functions:	DFP100 or DFP200 or SR750
	27	Undervoltage	
	46	Negative Sequence Overcurrent (DFP100 & 200 only)	
	47	Negative Sequence Voltage (SR750 only)	
	51	Phase Overcurrent	
	51N	Residual Overcurrent	
	59	Overvoltage	
	74LM	High Impedance Ground (DFP200 only)	
	81L/H	Frequency	
		Options	
1	86T	Lockout Auxiliary Relay	HEA61

TRANSFORMER (TR)

Protective Relay Zone (TR2)

Protection for transformers 2000KVA and above, medium voltage windings:



Device list for TR2

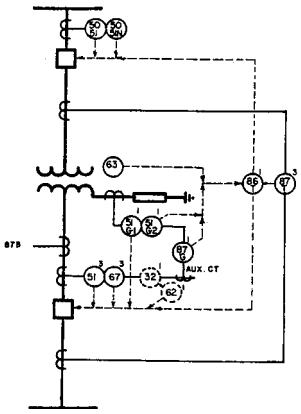
87T Differential
86T Lockout auxiliary
50/51 Overcurrent & short circuit
50GS Ground fault
63 Integral fault pressure
63X Fault pressure auxiliary

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	87T	Microprocessor Transformer Differential Relay	DTP1
X	86T	Lockout Auxiliary Relay (quantity as required)	HEA61
1	50/51/50GS	Overcurrent, Short Circuit and Ground Fault Relay	MDP0
1	63X	Fault Pressure Auxiliary Relay	HAA16B
		First Alternate Package	
1	87T	Differential Relay (Plus remaining devices listed in Basic Package)	TTS-0
		Second Alternate Package	
3	87T	Differential Relay (Plus remaining devices listed in Basic Package)	STD15C
		Third Alternate Package (E/M)	
3	87T	Differential Relay	BDD15B
X	86T	Lockout Auxiliary Relay (quantity as required)	HEA61
3	50/51	Overcurrent and Short Circuit Relay	IFC53B
1	50GS	Ground Fault Relay	HFC21
1	63X	Fault Pressure Auxiliary Relay	HAA16B

TRANSFORMER (TR)

Protective Relay Zone (TR3)

Protection for transformers 2500KVA and above, Large service:



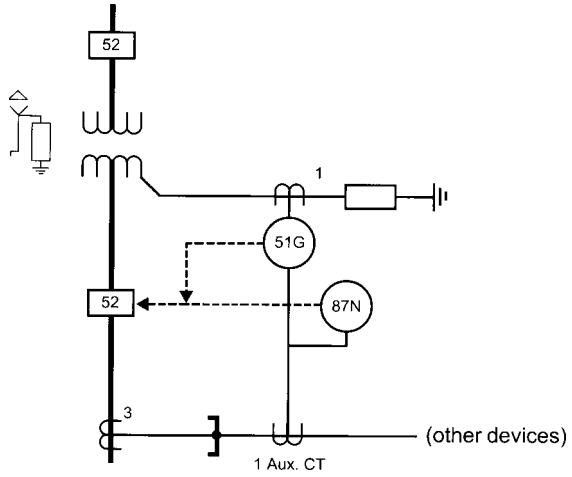
Device list for TR3

50/51	Time overcurrent relay/instantaneous
50/51	Time overcurrent relay/instantaneous
87T	Transformer differential relay
87G	Transformer ground differential relay
51	Time overcurrent relay
51G1 & 51G2	Time overcurrent relay
86T	Transformer hand reset lockout relay
63	Transformer fault pressure relay
67	Directional overcurrent relay instantaneous attachment
32	Reverse power relay
62	Auxiliary timing relay

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1		Microprocessor transformer differential relay	**SR745**
	87	Percent current differential	
		Percent restraint range (dual slope SR745)	
		Phase shift compensation	
		Harmonic restraint (harmonics)	
	87/50	Unrestrained differential IOC-highset	
		Operating time (cycles)	
		Applicable to transformers	
		CT ratio (5 A) matching tap range	
		Sampling rate (# sample/cycle)	
	50G, 50N, 50P	Instantaneous overcurrent	
	51G, 51N, 51P	Time overcurrent	
		TOC curve shapes	
	81U	Underfrequency & rate of change	
	46/50, 46/51	Negative sequence IOC & TOC	
	59/81	Overexcitation	
	87TG	Restricted Ground Fault	
	810	Overfrequency	
		Differential currents Ia, Ib, Ic	
		Demand interval Ia	
		Accuracy (percent full scale)	
		Fundamental RMS currents	
		Running and maximum current demand	
		Sequence of events (# events stored)	
		Oscillography (# events/ duration in cycles)	
		Fault reporting	
		Auto configuration of CTs	
		Waveform Capture and Playback	
		Relative cost	
		Options	
1	86T	Auxiliary Lockout relay (as many as required)	HEA61

TRANSFORMER (TR)

Additional Transformer Ground Protection



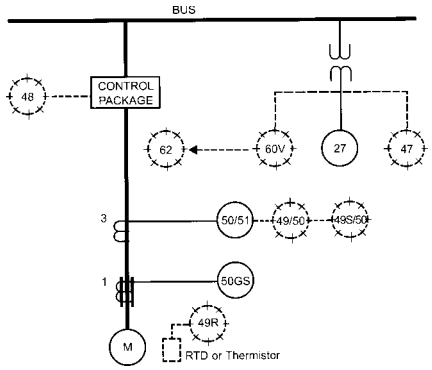
Device list for Additional Transformer Ground Protection
51G Time overcurrent
87N Ground differential

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1	51G	Time Overcurrent Relay	MIC5
		Alternate Package (Single Phase Units)	
1	51G	Time Overcurrent Relay	DIFC or IFC53A
1	87N	Ground Differential Relay	IFD51D
		**Note: The SR745 digital transformer relay includes 87N.*	

MOTOR (MTR)

Protective Relay Zone (MTR1)

Minimum protection for a small induction motor (below 1500HP):



Device list for MTR1

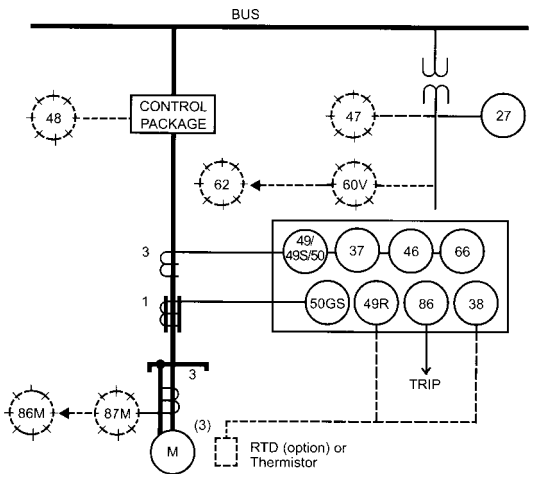
27	Time Undervoltage
47	Undervoltage and reverse phase sequence
48	Incomplete sequence timer
49/50	Thermal overcurrent
49R	Winding overtemperature (RTD)
49S/50	Time and instantaneous overcurrent (locked rotor)
50GS	Instantaneous overcurrent ground
50/51	Time and instantaneous overcurrent
60V	Voltage unbalance
62	Timer

Qty.	Device No.	Description	GE Model No.
		Basic Package (Multiphase Overcurrent)	
1	27	Undervoltage Relay	IAV54E or TOV5
1	50/51/50GS	Overload, Short Circuit and Ground Fault Relay	MDP0 or 735
		First Alternate Package (Single Phase Overcurrent)	
1	27	Undervoltage Relay	IAV54E or TOV5
3	50/51	Overload and Short Circuit Relay	IFC66B or DIFC
1	50GS	Ground Fault Relay	HFC21 or DIFC
		Second Alternate Package (Multiphase Overload)	
1	27	Undervoltage Relay	IAV54E or TOV5
1		Microprocessor-based Motor Relay including the following functions:	P4A
	46	Unbalance or Current-Reversal	
	49	Overload	
	49R	Winding Overtemperature	
	50GS	Ground Fault	
	66	Successive Starts Protection	
		Options	
1	38	Bearing Overtemperature Relay (RTD)	IRT51E
1	47	Three-phase Undervoltage and Reverse Phase Sequence Relay (in place of 27) (Requires open-delta or wye-wye voltage transformers)	ICR
1	48	Adjustable Time Delay Relay or Timer	-
1	49R	Winding Overtemperature Relay	IRT51E
1	49S/50	Stalled Rotor Relay	IFC66K
1	60V	Voltage Unbalance Relay (use with 62 and may require harmonic filter)	NBV11
1	62	Timing Auxiliary Relay	SAM201

MOTOR (MTR)

Protective Relay Zone (MTR1A)

Recommended protection for a more important small inductions motor (below 1500 HP):



Device list for MTR1A

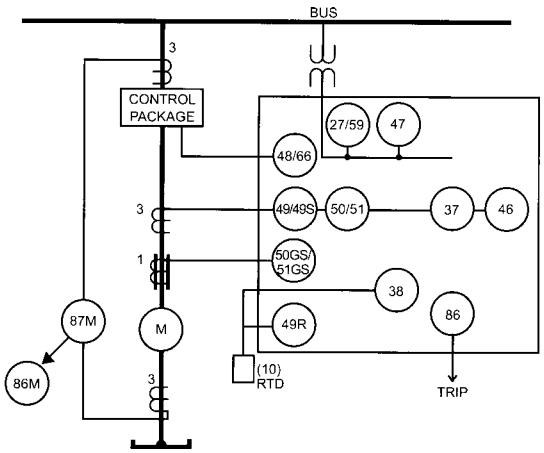
27	Undervoltage
37	Undercurrent
38	Bearing Overtemperature (RTD)
46	Unbalance or current-reversal
47	Three phase undervoltage and reverse phase sequence
48	Adjustable difinite time time device or timer
49	Overload
49R	Winding Overtemperature (Thermistor orRTD)
49S	Locked rotor
50	Short circuit
50GS	Ground fault
60V	Voltage unbalance
62	Timer
66	Successive starts
87M	Differential
86, 86M	Lockout Auxiliary

Qty.	Device No.	Description	GE Model No.
		Basic Package (Multiphase Overcurrent)	
1		Microprocessor-based Motor Relay including the following functions:	239 or MMC
	37	Undercurrent	IAV54E or TOV5
	38	Bearing Overtemperature (239 only)	
	46	Unbalance or Current-Reversal	
	49	Overload	
	49R	Winding Overtemperature (Thermistor or RTD) (239 only)	
	49S	Locked Rotor	
	50	Short Circuit	
	50GS	Ground Fault	
	66	Successive Starts	
	86	Lockout Relay (239 only)	
1	27	Undervoltage Relay	TOV5
		Options	
1	86M	Lockout Auxiliary Relay	HEA61
1	87M	Self-balance Differential Relay (Add if required and if possible to mount three 50/5A current transformers at the motor.)	HFC23
		or Percentage Differential Relay	CFD22A or DTP1
		(Add if required. See MTR2 figure for one-line representation)	
		(For additional options see MTR1)	

MOTOR (MTR)

Protective Relay Zone (MTR2)

Minimum protection for a small induction motor (1500 HP and above):



Device list for MTR2

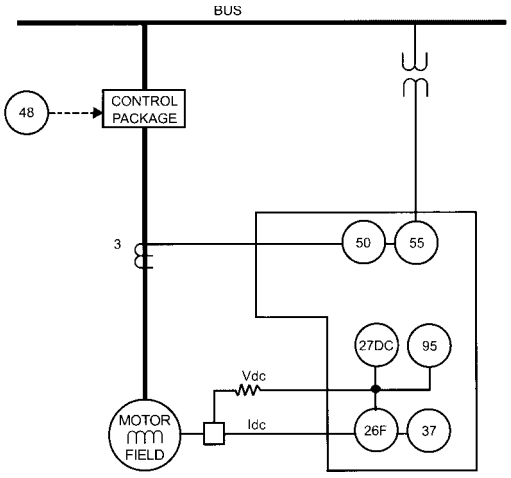
27/59	Under and overvoltage
37	Undercurrent
38	Bearing Overtemperature (RTD)
46	Current unbalance
47	Undervoltage and reverse phase sequence
48	Incomplete sequence
49	Overload
49R	Winding overtemperature (RTD)
49S	Locked rotor protection
50/51	Instantaneous & time overcurrent
50GS/ 51GS	Instantaneous & time overcurrent ground sensor
66	Successive starts
86,86M	Lockout Auxiliary
87M	Differential

Qty.	Device No.	Description	GE Model No.
		Basic Package (Multiphase Overcurrent)	
1		Digital Motor Relay including the following functions:	269 Plus
	27	Undervoltage (Meter Option)	
	37	Undercurrent	
	38	Bearing Overtemperature (RTD)	
	46	Current Unbalance	
	47	Voltage Phase Loss/Sequence (Meter Option)	
	48	Incomplete Sequence	
	49R	Winding Overtemperature	
	49S	Locked Rotor	
	49/51	Overload	
	50GS/51GS	Ground Fault	
	51R	Jam (Running)	
	59	Overvoltage (Meter Option)	
	66	Successive Starts	
	86	Lockout Relay	
1	87M	Differential Relay	CFD22A or DTP1
1	86M	Lockout Auxiliary Relay	HEA61
		Options	
		(See options for MTR1 and MTR1A)	

MOTOR (MTR)

Protective Relay Zone (MTR3)

Recommended protection for a synchronous motor in addition to that provided in preceding zones MTR1 through MTR2A:



Device list for MTR3

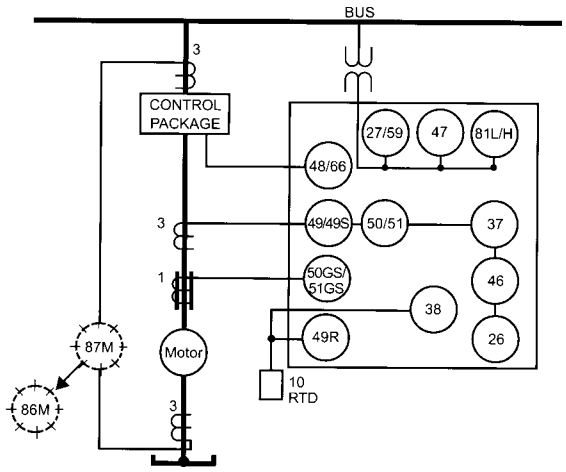
26F	Winding Overtemperatures
27DC	Undervoltage
37	Undercurrent
48	Incomplete sequence
50	Instantaneous overcurrent
55	Power factor
95	Reluctance Torque Sync./Re-Sync.

Qty.	Device No.	Description	GE Model No.
		Basic Package (Multiphase Overcurrent)	
1		Microprocessor-based Synchronous Motor Relay including the following functions:	SPM
	26F	Ammortisseur Winding Overtemperature (include if field is accessible)	
	27DC	Undervoltage Relay	
	37	Undercurrent	
	50	Short Circuit	
	55	Out of Step Protection/Power Factor	
	86	Lockout	
	95	Reluctance Torque Synchronizing and Re-Synchronizing	
	96	Autoloading/Unloading Relay	

MOTOR (MTR)

Protective Relay Zone (MTR2A)

Recommended protection for a more important large induction motor (1500 HP and above):



Device list for MTR2A

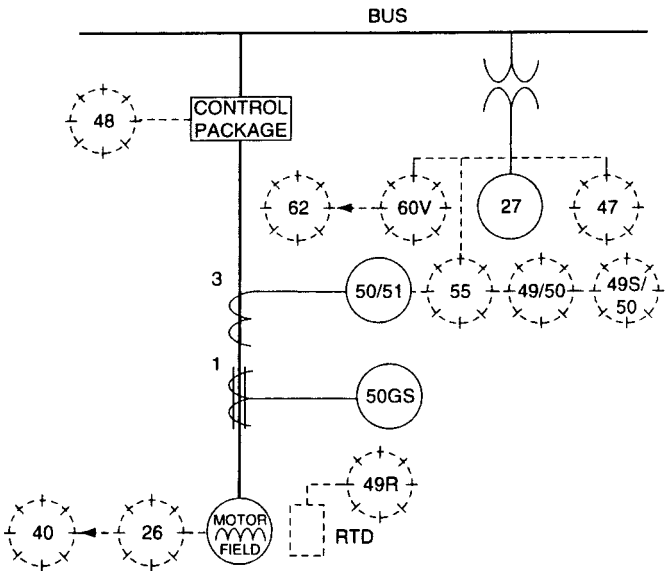
27/59	Under and overvoltage
37	Undercurrent
46	Current unbalance
47	Undervoltage/reverse phase sequence
48	Incomplete sequence
49	Overload
49R	Winding overtemperature (RTD)
49S	Locked rotor
50/51	Instantaneous & time overcurrent
50GS/	Instantaneous & time overcurrent
51GS	ground sensor
66	Successive starts
81L/H	Frequency
86M	Lockout Auxiliary
87M	Differential

Qty.	Device No.	Description	GE Model No.
		Basic Package (Multiphase Overcurrent)	
1		Digital Motor Relay including the following functions:	469
	27	Undervoltage	
	37	Undercurrent	
	38	Bearing Overtemperature (RTD)	
	46	Current Unbalance	
	47	Voltage Phase Loss/Sequence	
	48	Incomplete Sequence	
	49R	Winding Overtemperature	
	49S(26)	Locked Rotor	
	49/51	Overload	
	50	Short Circuit	
	50GS/51GS	Ground Fault	
	51R	Jam (Running)	
	59	Overvoltage (Meter Option)	
	66	Successive Starts	
	81L/H	Under-and Overfrequence	
	87M	Self-Balance Differential Relay (for connections see MTR1A figure)	
1	86M	Lockout Auxiliary Relay	HEA61
		Options	
1	87M	Differential Relay *(See options for MTR1 and MTR1A)*	CFD22A or DTP1

MOTOR (MTR)

Protective Relay Zone (MTR4)

Minimum protection for a small synchronous motor (below 1500 HP):



Device list for MTR4

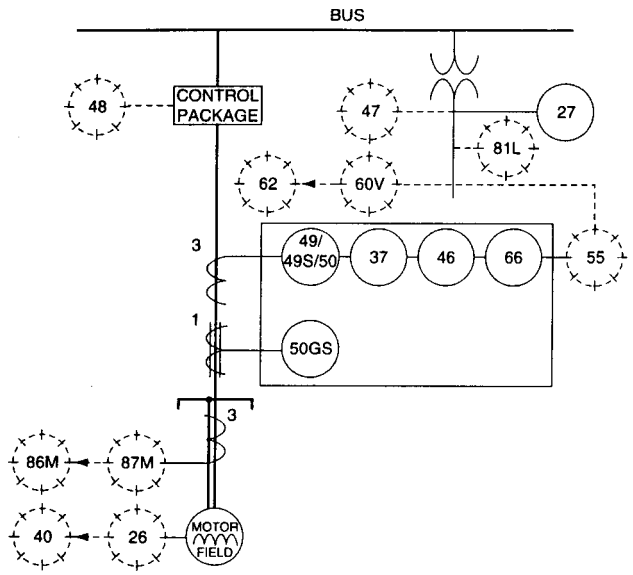
26	Apparatus thermal
27	Time undervoltage
40	Loss-of-field
47	Undervoltage and reverse phase sequence
48	Incomplete sequence timer
49/50	Thermal overcurrent
49R	Winding overtemperature (RTD)
49S/50	Time and instantaneous overcurrent (locked rotor)
50GS	Instantaneous overcurrent ground sensor
50/51	Time and Instantaneous Overcurrent
55	Power factor
60V	Voltage unbalance
62	Timing auxiliary

Qty.	Device	Description	GE Model No.
		Basic Package	
1	26	Ammortisseur Winding Protection (include if field is accessible and this function is not part of excitation/controls for motor)	-
1	27	Undervoltage Relay	IAV54E or TOV5
1	40	Loss-of-field Protection (DC undercurrent) (Include in place of 55 if field is accessible and the motor is part of motor/generator set and this function is not part of excitation/controls for motor.)	-
1	50/51/50GS	Overload, Short Circuit and Ground Fault Relay	MDP0
1	55	Out of Step Protection (include if not part of excitation controls for motor)	-
		First Alternate Package	
1	27	Undervoltage Relay	IAV54E or TOV5
3	50/51	Overload and Short Circuit Relay	IFC66B
1	50GS	Ground Fault Relay (Plus remaining devices listed in Basic Package.)	HFC21
		Second Alternate Package	
1	27	Undervoltage Relay	IAV54E or TOV5
1	49/50	Overload and Short Circuit Protection	THC30
1	50GS	Ground Fault Relay (plus remaining devices listed in Basic Package.)	HFC21
		Options	
		(See options for MTR1 and MTR2)	

MOTOR (MTR)

Protective Relay Zone (MTR5)

Recommended protection for a more important small synchronous motor (below 1500 HP) and minimum protection for a large synchronous motor (1500 HP and above):



Device list for MTR5

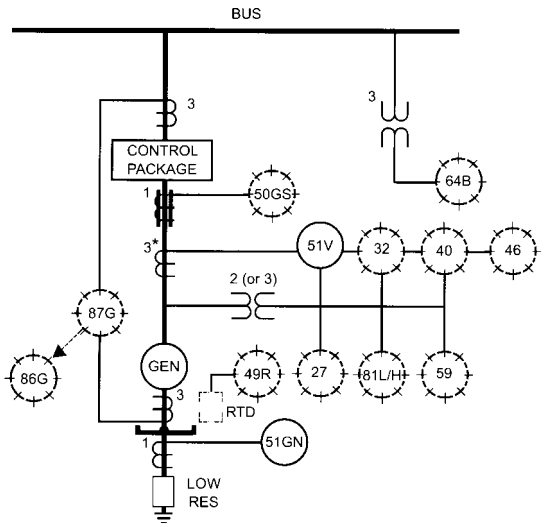
26	Locked rotor
27	Undervoltage
37	Undercurrent
40	Loss of field
46	Current unbalance
47	Undervoltage/reverse phases eq.
48	Incomplete sequence
49	Overload
49S	Overload
50	Instantaneous overcurrent
50GS	Instantaneous overcurrent ground
51GS	Time overcurrent ground
55	Power factor
60V	Voltage unbalance
62	Timing auxiliary
66	Successive starts
81L	Underfrequency
86M	Lockout auxiliary
87M	Differential

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1		Microprocessor-based Motor relay including the following functions:	**MMCI**
	37	Undercurrent	
	46	Unbalance or Current reversal	
	49	Overload	
	50	Short circuit	
	50GS	Ground Fault	
	66	Successive Start	
1	27	Undervoltage Relay	TOV5
1	55	Out of Step Protection (Include if not part of excitation/controls for motor)	—
1	26	Ammortiseur Winding Protection (Include if field is accessible and this function is not part of excitation/controls for motor)	—
1	40	Loss-of-Field Protection (DC undercurrent) (Include in place of 55 if field is accessible and the motor is part of motor/generator set and this function us not part of excitation/controls for motor)	—
		Options	
1	51R	Extreme Overload Relay	IAC60A
1	81L	Underfrequency Relay (add to bus if automatic reclosing is possible for motor bus to source) (*For additional options see MTR1 and MTR2)*	SFF201
1	86M	Lockout Auxiliary Relay	HEA61
1	87M	Differential relay	CFD22A

Generator (GEN)

Protective Relay Zone (GEN1)

Minimum protection for a small machine with low resistance grounding:



Device list for GEN1

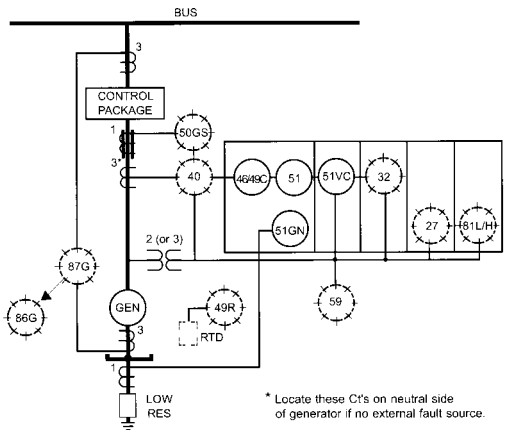
27	Undervoltage
32	Power Direction
40	Loss of Excitation
46	Current Unbalance
49R	Overload (RTD)
50GS	Instantaneous Overcurrent Ground
51GN	Time Overcurrent Ground
51V	Time Overcurrent (V Restraint)
59	Overvoltage
64B	Bus Ground Detection
81L/H	Frequency
86G	Lockout Auxiliary
87G	Differential

Qty.	Device	Description	GE Model No.
		Basic Package	
3	51V	Voltage-restrained Time Overcurrent Relay	IFCV51AD
1	51GN	Neutral Ground Overcurrent Relay	DIFC or IFC53A
		Options	
1	27	Undervoltage Relay	TOV5 or IAV54
1	32	Reverse Power Relay (detects losses over 5%) or Reverse Power Relay (detects losses below 5%)	ICW51A
1	40	Loss-of-excitation Relay	CEH51A
1	46	Negative Sequence Relay	SGC21C
1	49R	Stator Overtemperature Relay (RTD input)	IRT51E
1	50GS	Ground Sensor Overcurrent Relay (in place of 51GN where system ground is not generator neutral)	DIFC or HFC21
3	51VC	Voltage-controlled Overcurrent Relay (in place of 51V)	IFCS51AD
1	59	Overvoltage Relay	TOV5 or IFV71AD
1	64B	Generato4 Ground Overvoltage Relay (in place of 51GN where generator is ungrounded)	TOV5 or IFV51DD
1	81L/H	Under/Overfrequency Relay	SFF202B
1	86G	Lockout Auxiliary Relay	HEA61
1	87G	Self-balancing Current Differential Relay (for connections see MTR1A figure) or Percentage Current Differential Relay	MDP or CFD22A

Generator (GEN)

Protective Relay Zone (GEN1A)

Alternate protection for a small machine with low resistance grounding:



Device list for GEN1A

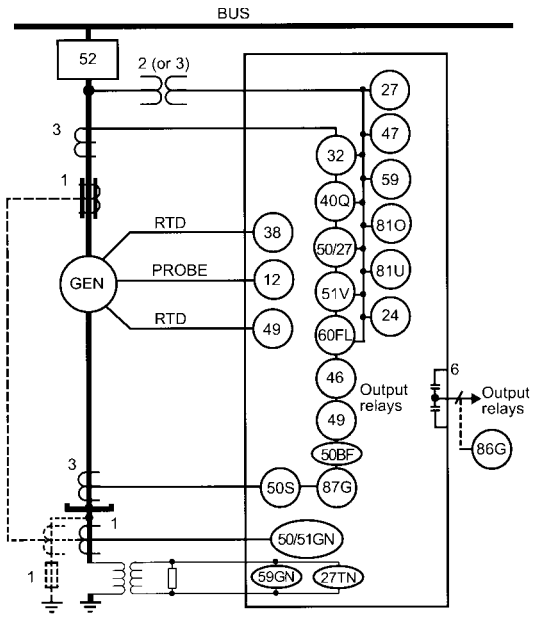
27	Undervoltage
32	Power Direction
40	Loss of Excitation
46	Current Unbalance
49R	Overload (RTD)
50GS	Instantaneous Overcurrent Ground
51GN	Time Overcurrent (Ground)
51VC	Time Overcurrent (V Control)
59	Overvoltage
81L/H	Frequency
86G	Lockout Auxiliary
87G	Differential

Qty.	Device No.	Description	GE Model No.
		Alternate Package	
1		Multifunction analog relay system containing the following modules:	**MID100**
		Multifunction Module with functions:	MGC
	46	Negative Sequence	
	49C	Thermal Image	
	51	Definite Time Overcurrent	
	51GN	Neutral Ground Overcurrent	
	51VC	Voltage-controlled overcurrent Modules	MIC7/TOV4
		Options	
1	27	Undervoltage Module (into MID100 system)	TOV5
1	32	Reverse Power Module (into MID100 system)	TCW
1	81L/H	Under/Overfrequency Module (into MID100 system)	MFF
		(For additional options, see GEN1 package)	

Generator (GEN)

Protective Relay Zone (GEN2)

Recommended protection for a small machine with low/high resistance grounding:



Device list for GEN2

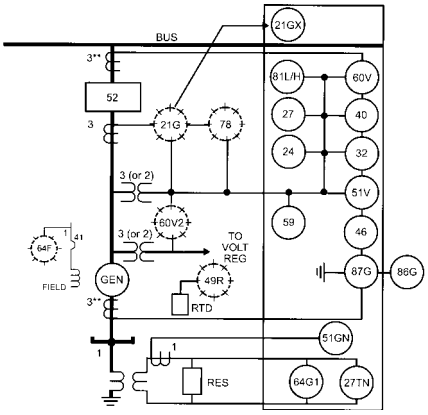
12	Overspeed
24	Overexcitation, Volts/Hz
27	Undervoltage
50/27	Inadvertent generator energization
32	Reverse power for anti-motoring
38	Bearing overtemperature
39	Bearing vibration (analog inputs)
40Q	Loss of field
46	Negative Sequence Overcurrent (I_2^2t)
47	Voltage phase reversal
49	Stator thermal (RTD and thermal model)
50BF	Breaker failure detection
50S	Instantaneous overcurrent (during startup)
50/51GN	Instantaneous or definite time overcurrrent
51V	Voltage restrained phase overcurrent
59	Overvoltage
59GN/ 27TN	100% stator ground
60FL	VT fuse failure detection
81	over and underfrequency
87G	Phase differential
86G	Lockout Auxiliary

Qty.	Device	Description	GE Model No.
		Basic Package	
1	51V	Multifunction microprocessor-based protection including the following functions:	SR489
	12	Overspeed	
	24	Overexcitation, Volts/Hz	
	27	Undervoltage	
	50/27	Inadvertent generator energization	
	32	Reverse power for anti-motoring	
	38	Bearing overtemperature	
	39	Bearing vibration (analog inputs)	
	40Q	Loss of field	
	46	Negative Sequence Overcurrent (I_2^2t)	
	47	Voltage phase reversal	
	49	Stator thermal (RTD and thermal model)	
	50BF	Breaker failure detection	
	50S	Instantaneous overcurrent (during startup)	
	50/51GN	Instantaneous or definite time overcurrent)	
	51V	Voltage restrained phase overcurrent	
	59	Overvoltage	
	59GN/27TN	100% stator ground	
	60FL	VT fuse failure detection	
	81	Over and underfrequency	
	87G	Phase differential Sequential tripping logic Trip coil supervision	
		Options	
1	86G	Lockout Relay	HEA61
		(For additional options, see GEN1 package)	

Generator (GEN)

Protective Relay Zone (GEN3)

Minimum protection for a large machine with high resistance grounding:



Device list for GEN3

21G	Distance	51V	Time Overcurrent (V Restraint)
21GX	Aux to 2G	59	Overvoltage
24	Overexcitation	60V	Voltage Balance
27	Undervoltage	64F	Ground (field)
27TN	Undervoltage (Third Harmonic)	64G	Ground (stator)
32	Power Direction	78	Out-of-Step
40	Loss of Excitation	81L/H	Frequency
46	Current Unbalance	86G	Lockout Auxiliary
49R	Overload (RTD)	87G	Differential
51GN	Time Overcurrent (Ground)		

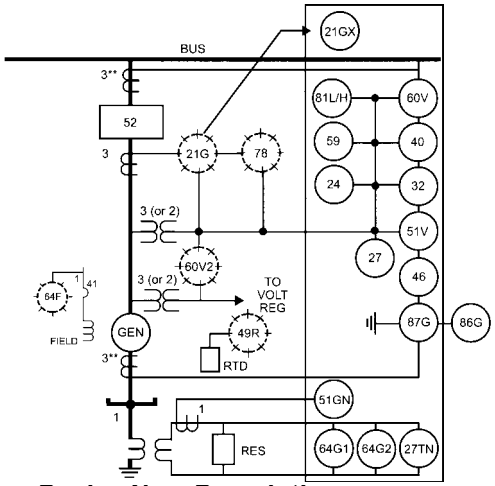
** If no external fault source exists, exchange connections of protection from line side CT's to neutral side CT's and vice versa.

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1		Multifunction microprocessor-based relay system	DGP-BA 0005
	21GX	Aux to 2G	
	24	Overexcitation	
	27	Undervoltage	
	27TN	Undervoltage (Third Harmonic)	
	32	Power Direction	
	40	Loss of Excitation	
	46	Current Unbalance	
	51GN	Time Overcurrent (Ground)	
	51V	Time Overcurrent (V Restraint)	
	59	Overvoltage	
	64G	Ground (stator)	
	81L/H	Frequency	
	87G	Differential	
		Accidental energization protection	
		Trip circuit monitoring	
		Personal computer communications interface, event time tagging, fault data capture	
		Oscillography capture, time standard I/F	
1	86G	Lockout Auxiliary Relay	HEA61
		Options	
1	21G	System Backup Distance Relay (in place of 51V)	SLY92/SLY82
1	49R	Stator Overtemperature Relay (RTD)	IRT51E
1	60V2	Voltage Balance Relay	CFVB11
1	64F	Field Ground Relay	PJG12
1	78	Out-of-Step Relay	OST1000
		(For additional options see GEN1 Options)	

Generator (GEN)

Protective Relay Zone (GEN4)

Recommended protection for a more important large machine with high resistance grounding:



Device list for GEN4

21G	Distance	51V	Time Overcurrent (V Restraint)
21GX	Aux to 2G	59	Overvoltage
24	Overexcitation	60V	Voltage Balance
27	Undervoltage	64F	Ground (field)
27TN	Undervoltage (Third Harmonic)	64G	Ground (stator)
32	Power Direction	78	Out-of-Step
40	Loss of Excitation	81L/H	Frequency
46	Current Unbalance	86G	Lockout Auxiliary
49R	Overload (RTD)	87G	Differential
51GN	Time Overcurrent (Ground)		

** If no external fault source exists, exchange connections of protection from line side CT's to neutral side CT's and vice versa.

Qty.	Device No.	Description	GE Model No.
		Basic Package	
1		Multifunction microprocessor-based relay system	DGP—CA
	24	Overexcitation	
	27	Undervoltage	
	27TN	Undervoltage (Third Harmonic)	
	21GX	Timing Auxiliary to External 21G	
	32	Power Direction	
	40	Loss of Excitation	
	46	Current Unbalance	
	51GN	Time Overcurrent (Ground)	
	51V	Time Overcurrent (V Restraint)	
	59	Overvoltage	
	64G	Ground (stator)	
	81L/H	Frequency	
	87G	Differential	
		Accidental energization protection	
		Trip circuit monitoring	
		Personal computer communications interface, event time tagging, fault data capture	
		Oscillography capture, time standard I/F	
1	86G	Lockout Auxiliary Relay	HEA61
		(For options see GEN1 and GEN3 Options)	

METERING

Power Quality Metering and Monitoring

EPM

Electronic Power Meter

Application

- Energy and demand billing meter
- Three or four-wire 3 phase systems

Metering and Monitoring

- Up to 51 display options
- Accurate metering includes:
  actual A V W var VA PF Wh varh
  frequency
  demand A W var VA
  peak A W var VA
- 15 to 60 minute demand interval
- V & I sampled 480 times per second
- Display updated every 3 seconds
- Wye-Wye or open-delta
- Self-test at power up

User Interface

- 2 line LCD display
- 3 button keypad
- Programming security code
- ModBus® RTU protocol (optional)

Features

- Pulse initiation (optional)
- Easy retrofit
- Drawout S1 case

PQM

Applications

- Metering of distribution feeders, transformers, generators, capacitor banks and motors
- Medium and low voltage systems
- Commercial, industrial, utility
- Flexible control for demand load shedding, power factor, etc.
- Power quality analysis

Metering / Control

- A V W var VA varh Wh PF Hz unbalance
- A W var VA demand
- Load shedding
- Power factor control
- Pulse input totalizing
- Pulse output based on kWh, kvarh or kVAh

Monitoring

- Harmonic analysis through 63rd with THD and TIF
- Event recorder
- Waveform capture
- Data logger
- Triggered trace memory

Communications

- Ports: RS232 front, dual RS485 rear
- ModBus® RTU protocol
- Mini RTU: digital 4 in / 4 out
- Analog 1 in / 4 out
- Local/remote display of all values

Contents

Section 7
Basic and Optional Device Lists

Basic and Optional Device Lists

INTRODUCTION

This section contains tabulated device lists of both basic and optional devices included in POWER/VAC metalclad switchgear. Individual model numbers are given, along with their pertinent characteristics. Use these tables when selecting options, as well as when investigating the characteristics of basic items.

Model numbers other than those listed in this section are available as custom items.

All listed devices are 60-Hz unless otherwise noted.

RELAYS - ELECTORO-MECHANCAL

Table 7-1
Overcurrent Relays

Time Current Characteristics	Pickup Current Range (Amperes) Time	Pickup Current Range (Amperes) Instantaneous	Model No.	Device No.
Inverse	1-12	None	12IFC51A1A	51
	0.5-4	None	12IFC52A2A	51N, 51G, 51GS
	1-12	6-150	12IFC51B1A	50/51
	0.5-4	2-50	12IFC51B2A	50/51N
Very Inverse	1-12	None	12IFC53A1A	51
	0.5-4	None	12IFC53A2A	51N, 51G, 51GS
	1-12	6-150	12IFC53B1A	50/51
	1-12	2-50	12IFC53B3A	50/51
	0.5-4	2-50	12IFC53B2A	50/51N
Extremely Inverse	1-12	None	12IFC77A1A	51
	0.5-4	None	12IFC77A2A	51N, 51G, 51GS
	1-12	6-150	12IFC77B1A	50/51
	1-12	2-50	12IFC77B3A	50/51
	0.5-4	2-50	12IFC77B2A	50/51N
Long Time	2.5-7.5	6-150	12IFC66KD1A	26/50/83 or 49/50/83
Inverse-torque Controlled	4-16	None	12IAC60A111A	51R
Instantaneous				
1-Element	None	0.5-4	12HFC21B1A	50GS
2-Element	None	0.5-4	12HFC22B1A	50
2-Element	None	2-50	12HFC22B2A	50
3-Element	None	0.5-4	12HFC23C1A	87M
3-Element	None	2-50	12HFC23C2A	50

Table 7-2
Directional Overcurrent Relays
(Voltage rating 120 volts)
(60 Hz)

Time-current Characteristics	Pickup Current Range (Amperes) Time	Pickup Current Range (Amperes) Instantaneous	Model No.	Device No.
Inverse	2-6	None	12IBC51M1A	67
	2-6	6-150	12IBC51M1Y1A	67
Very Inverse	1.5-12	None	12IBC53M1A	67
	1.5-12	6-150	12IBC53M1Y1A	67
Inverse	2-16	None	12IBCG51M2A	67N
	0.5-4	6-150	12IBCG51M1Y1A	67N
Very Inverse	1.5-12	None	12IBCG53M2A	67N
	0.5-4.0	6-150	12IBCG53M1Y1A	67N
Very Inverse	1.5-12	10-80	12JBC53M1A	67

Table 7-3
Voltage-restrained Overcurrent Relays
(Device No. 51V)
(60 Hz)

Time-current Charac-teristics	Pickup Current Range (Amperes)	Voltage Range (Volts)	Model No.
Very Inverse	2-16	120	12IFCV51ADIA
Very Inverse w/inst	2-16	120	12IFCV51BD1A

Table 7-4
Temperature Relays
(Device No. 49)

Temperature-Range Rating	Voltage Range (Volts)	Model No.
80-160C	120/240	12IRT51E1A

RTD=10 ohms-Also available in 100 and 120 ohm RTD's

Table 7-5
Thermal Overcurrent Relay
(Device No. 49/50)

Heater Current (Amperes)	Instantaneous (Amperes)	Model No.
2.63	10-40	12THC30A2A
2.93	10-40	12THC30A3A
3.16	10-40	12THC30A4A
3.58	10-40	12THC30A5A
4.24	20-80	12THC30A6A
4.73	20-80	12THC30A7A

Table 7-6
Differential Relays

Description	Taps (Amperes)	Model No.	Device No.
TRANSFORMER			
48/125/250V dc control, 2-restraint 15/25/40% slope	2.9-8.7	12STD15C5A	87T
48/125/250V dc control, 3-restraint 15/25/40% slope	2.9-8.7	12STD16C5A	87T
0.5A minimum pick-up		12IFC53 (See GER03071)	51TN
BUS			
150V, 0.2/2A target and seal-in	87L 75-300V 87H 2-50A	12PVD21D1A	87B
MOTORS (6 CT DIFFERENTIAL)			
0.2A minimum pickup, 0.2A target and holding coil	-	12CFD22B2A	87M

Table 7-7
Agastat Timers
(Device No. 62)

Description	Model No.
Time-delay Pickup	
48V dc, 0.5-5 sec.	7012 NB
120V dc, 0.5-5 sec.	7012 PB
250V dc, 0.5-5 sec.	7012 SB
110V ac, 0.5-5 sec.	7012 AB
220V ac, 0.5-5 sec.	7012 BB
Time-delay Dropout	
48V dc, 0.5-5 sec.	7022 NB
120V dc, 0.5-5 sec.	7022 PB
250V dc, 0.5-5 sec.	7022 SB
110V ac, 0.5-5 sec	7022 AB
220V ac, 0.5-5 sec.	7022 BB

Basic and Optional Device List

Table 7-8
Lockout Relay
(Device No. 86)

Contacts		Voltage Ratings	
N.O.	N.C.	(Volts)	Model No.
3	3	125V dc	12HEA61A223x2
5	5	125V dc	12HEA61B235x2
7	3	125V dc	12HEA61B237x2
9	7	125V dc	12HEA61C239x2
7	7	125V dc	12HEA61V37x2
11	3	125V dc	12HEA61V41x2
13	3	125V dc	12HEA61C243x2
3	3	48V dc	12HEA61A233x2
5	5	48V dc	12HEA61B255x2
7	3	48V dc	12HEA61B257x2
9	7	48V dc	12HEA61C259x2
7	7	48V dc	12HEA61V57x2
11	3	48V dc	12HEA61V61x2
13	3	48V dc	12HEA61C263x2
3	3	250V dc	12HEA61A213x2
5	5	250V dc	12HEA61B215x2
7	3	250V dc	12HEA61B217x2
9	7	250V dc	12HEA61C219x2
7	7	250V dc	12HEA61V17x2
13	3	250V dc	12HEA61C223x2
3	3	230V vac	12HEA61A303x2
5	5	230V vac	12HEA61B375x2
7	3	230V vac	12HEA61B377x2
13	3	230V vac	12HEA61C363x2

Table 7-9
Target Relays
(Device No. 63FPX)

Description	Model No.
48V dc, Seal-in	12HAA16B1F
125V dc, Seal-in	12HAA16B2F
250V dc, Seal-in	12HAA16B3F

Table 7-10
Auxiliary Relays
(Device No. 27X, 62X, X)

Description	Model No.
250V dc	12HGA11J51
125V dc	12HGA11J52
48V dc	12HGA11J54
62.5 dc	12HGA14AF53
115V dc	12HGA11J70
230V dc	12HGA11J71
115V ac	12HGA14AF70
250V dc	12HFA51A51
125V dc	12HFA51A52
48V dc	12HFA51A53

Table 7-11
Undervoltage Relays
(Device No. 27)

Description	Model No.
120V ac. 2A Target (Instantaneous)	12NGV13B29A
(Device No. 47)	
Undervoltage Phase Sequence	12ICR53A1A

Table 7-12
Power Directional Relays
(Device No. 32)

Description (5A, 115V)		Model No.
Target Coil	Minimum Pickup	
0.2/2.0	0.004	12CCP13E1A
Voltage Range (Volts)	**Power Range (Watts)**	**Model No.**
120	25-100	12ICW51A2A
208	50-200	12ICW51A11A

Table 7-13
Loss of Excitation Relay
(Device No. 40)

Description	Model No.
5A-115V ac 125/250V dc, Control	12CEH51A1A

Table 7-14
Voltage Unbalance Relay
(Negative-phase Sequence)
(Single Phase-Blown Fuse Protection)
(Device No. 60)
(Also order 60 Hz Harmonic Filter)

Rating and Description	Model No.
120V ac, No Target	12NBV11A1A
208V ac, No Target	12NBV11A3A

Table 7-15
Voltage Unbalance Relay
(Blown VT Fuse Protection)
(Device No. 60V)

Rating and Description	Model No.
120V ac	12CFVB11B1A

Table 7-16
Current Balance Relay
(Device No. 60C)

Rating and Description	Model No.
5A	121JC5B3A

Table 7-17
Reclosing Relay
(Device No. 79)

Reclosing Cycle	Control Voltage	Model
To be set by user (One instantaneous and 3 time-delay reclosure maximum)	48/125 240V ac	12SLR12A1A 12SLR12B1A

Table 7-18
Reclosing Cut-off (Culter-Hammer) Switch
(Device No. 79CO)

Type	Description	Model No.
JBT	DPST with locking ring	ST50K

Table 7-19
Underfrequency Relays
(Device No. 81)

Description	Model No.
44.0 Hz min- 60.98 Hz max; 120V; 0.07-1.3 seconds time day	12SFF31C1A

INSTRUMENTS

Table 7-20
Type AB-40 Ammeters
(5-ampere movement, 40-70 Hz)

Scale (Amperes)	Model No.
5	103131LSLS7
50	103131LSNT7
75	103131LSPB7
100	103131LSPK7
150	103131LSPZ7
200	103131LSRL7
250	103131LSRS7
300	103131LSRX7
400	103131LSSC7
450	LATER
500	103131LSSF7
600	103131LSSJ7
800	103131LSSN7
900	103131LSSR7
1000	103131LSSS7
1100	LATER
1200	103131LSSV7
1500	103131LSTC7
1600	103131LSTE7
2000	103131LSTM7
2200	LATER
2500	103131LSTV7
3000	103131LSUA7
4000	103131LSUE7

Type AB-40 Voltmeters
(150-volt movement, 40-70 Hz)

Scale	Model No.
3000V	103021PZUA7
5250V	103021PZUL7
6000V	103021PZUP7
9000V	103021PZUY7
10.5KV	103021PZWM7LDR
15KV	103021PZWZ7
18KV	103021PZXE7

Table 7-21

Basic and Optional Device List

Table 7-22
Type AB-40 Wattmeters
(5A, 120V, 50/60 Hz)

Wattmeter scales are determined by current transformer and voltage transformer ratios. (CT ratio x VT ratio = TR). Catalog number of the instrument is a root number plus a suffix for the scale.

TR	Scale kW	Suffix 103221A
	3-PHASE, 3-WIRE Root number for zero left scales = 50-103221A	
100	100	103221ARBU7CAC
120	120	103221ARBU7CCC
160	150	103221AXAG7CEC
175	175	103221ARBU7GGC
200	200	103221ARBU7CGC
210	200	103221AXGJ7CGC
240	250	103221ARDR7CJC
280	300	103221ARET7CKC
300	300	103221ARBU7CKC
320	320	103221ARBU7CLC
350	350	103221ARBU7CMC
360	350	103221ARAS7CMC
400	400	103221ARBU7CNC
480	500	103221ARDR7CRC
500	500	103221ARBU7CRC
525	500	103221AXGJ7CRC
600	600	103221ARBU7CTC
700	700	103221ARBU7CWC
720	700	103221ARAS7CWC
800	800	103221ARBU7CYC
900	900	103221ARBU7CZC
960	1000	103221ARDR7DAC
1000	1000	103221ARBU7DWC
1050	1000	103221AXGJ7DAC
1200	1200	103221ARBU7DCC
1400	1400	103221ARBU7DDC
1500	1500	103221ARBU7DEC
1600	1500	103221AXAG7DEC
1750	1750	103221ARBU7HGC
1800	1800	103221ARBU7DFC
2000	2000	103221ARBU7DGC
2100	2000	103221AXGJ7DEC
2400	2500	103221ARDR7DJC
2800	3000	103221ARET7DKC
3000	3000	103221ARBU7DKC
3200	3000	103221AXAG7DKC
3500	3500	103221ARBU7DMC
3600	3500	103221ARAS7DMC
4000	4000	103221ARBU7DNC
4200	4000	103221AXGJ7DNC
4800	5000	103221ARDR7DRC

TR	Scale kW	Suffix 103221A
5000	5000	103221ARBU7DRC
5600	6000	103221ARET7DTC
6000	6000	103221ARBU7DTC
6400	6500	103221ARCP7DUC
7000	7000	103221ARBU7DWC
7200	7000	103221ARAS7DWC
8000	8000	103221ARBU7DYC
8400	8000	103221AXGJ7DYC
	Scale MW	
9600	10	103221ARDR7BAD
10000	10	103221ARBU7BAD
10500	10	103221AXGJ7BAD
11200	12	103221ARET7BCD
12000	12	103221ARBU7BCD
12800	12.5	103221ARAU7FCD
14000	15	103221ARET7BED
14400	15	103221ARDR7BED
16000	16	103221ARBU7FED
17500	17.5	103221ARBU7FGD
18000	18	103221ARBU7BFD
19200	20	103221ARDR7BGD
20000	20	103221ARBU7BGD
21000	20	103221AXGJ7BGD
22400	24	103221ARET7BHD
24000	25	103221ARDR7BJD
28000	28	103221ARBU7FKD
28800	30	103221ARDR7BKD
30000	30	103221ARBU7BKD
32000	32	103221ARBU7BLD
36000	35	103221ARAS7BMD
38400	40	103221ARDR7BND
40000	40	103221ARBU7BND
48000	50	103221ARDR7BRD
50000	50	103221ARBU7BRD
60000	60	103221ARBU7BTD
72000	70	103221ARAS7BWD
80000	80	103221ARBU7BYD
96000	100	103221ARDR7CAD

Table 7-22 Wattmeters (Cont'd)

TR	Scale kW	Suffix 103251A
3-PHASE, 4-WIRE Root number for zero left scales = 50-103251A		
100	200	103251ARBU7CGC
120	240	103251ARBU7CHC
160	300	103251AXAG7CKC
200	400	103251ARBU7CNC
240	450	103251AXAG7CPC
300	600	103251ARBU7CTC
320	600	103251AXAG7CTC
350	700	103251ARBU7CWC
360	700	103251ARAS7CWC
400	800	103251ARBU7CYC
420	800	103251AXGJ7CYC
480	1000	103251ARDR7DAC
560	1200	103251ARET7DCC
600	1200	103251ARBU7DCC
700	1400	103251ARBU7DDC
800	1600	103251ARBU7HEC
900	1800	103251ARBU7DFC
1000	2000	103251ARBU7DGC
1050	2000	103251AXGJ7DGC
1200	2500	103251ARDR7DJC
1400	3000	103251ARET7DKC
1600	3000	103251AXAG7DKC
1800	3500	103251ARAS7DMC
2000	4000	103251ARBU7DNC
2100	4000	103251AXGJ7DNC
2400	4500	103251AXAG7DPC
2800	5500	103251ARAX7DSC
3000	6000	103251ARBU7DTC
3200	6000	103251AXAG7DTC
3500	7000	103251ARBU7DWC
3600	7000	103251ARAS7DWC
4000	8000	103251ARBU7DYC
4200	8000	103251AXGJ7DYC

TR	Scale kW	Suffix 103251A
4800	10	103251ARDR7BAD
5600	12	103251ARET7BCD
6000	12	103251ARBU7BCD
6400	12.5	103251ARAS7FCD
7000	14	103251ARBU7BDD
7200	14	103251ARAS7BDD
8000	16	103251ARBU7FED
8400	17.5	103251ARDR7FGD
9600	20	103251ARDR7BGD
10000	20	103251ARBU7BGD
11200	24	103251ARET7BHD
12000	25	103251ARDR7BJD
12800	25	103251ARAU7BJD
14000	28	103251ARBU7FKD
14400	30	103251ARDR7BKD
16000	30	103251AXAG7BKD
16800	35	103251ARDR7BMD
18000	35	103251ARAS7BMD
19200	40	103251ARDR7BND
20000	40	103251ARBU7BND
21000	40	103251AXGJ7BND
22400	45	103251ARBX7BPD
24000	50	103251ARDR7BRD
28000	55	103251ARAX7BSD
30000	60	103251ARBU7BTD
32000	60	103251AXAG7BTD
35000	70	103251ARBU7BWD
36000	70	103251ARAS7BWD
42000	80	103251AXCJ7BYD
48000	90	103251AXAG7BZD

Basic and Optional Device List

Table 7-23
Type AB-40 Varmeters
(5A, 120V, 50/60 Hz)

Varmeter scales are determined by current transformer and voltage transformer ratios. (CT ratio x VT ratio = TR). Catalog number of the instrument is a root number plus a suffix for the scale. Scales are zero center: "in" at left, "out" at right. Cross-phase connections used.

Three-phase, three-wire, cross-phase, three current coils on opendelta voltage transformers.
Coil rating 5 ampere, 120 volt, 50/60 Hz, connections 2634K26.
Root number = 50-103742A.

TR	Scale kvar	Suffix Model # 103812A
100	50	TAJH7BRC
120	60	TAJ7BTC
160	80	TAJ7BYC
175	90	UBC7BZC
200	100	TAJ7CAC
210	100	RDH7CAC
240	120	TAJ7CCC
280	150	WGG7CEC
300	150	TAJ7CEC
320	160	TAJ7GEC
350	175	TAJ7GGC
360	175	SAJ7GGC
400	200	TAJ7CGC
480	250	UFJ7CJC
500	250	TAJ7CJC
525	250	RDH7CJC
600	300	TAJ7CKC
700	350	TAJ7CMC
720	350	SAJ7CMC
800	400	TAJ7CNC
900	450	TA57CPC
960	500	UFJ7CRC
1000	500	TAJ7CRC
1050	500	RDH7CRC
1200	600	TAJ7CTC
1400	700	TAJ7CWC
1500	750	TAJ7CXC
1600	800	TAJ7CYC
1750	900	UBC7YZ
1800	900	TAJ7CZC
2000	1000	TAJ7DAC
2100	1000	RDH7DAC
2400	1200	TAJ7DCC
2800	1400	TAJ7DCC
3000	1500	TAJ7DEC
3200	1600	TAJ7HEC
3500	1750	TAJ7HGC
3600	1750	SAJ7HGC
4000	2000	TAJ7DGC
4200	2000	RDH7DGC
4800	2500	UFJ7DJC
5000	2500	TAJ7DJC
5600	3000	WGG7DKC
6000	3000	TAJ7DKC
6400	3000	PJB7DKC
7000	3500	TAJ7DMC
7200	3500	SAJ7DMC
8000	4000	TAJ7DNC
8400	4000	RDH7DNC
9600	5000	UFJ7DRC
10000	5000	TAJ7DRC
10500	5000	RDH7DRC
11200	5500	SEE7DSC
12000	6000	RAJ7DTC
12800	6000	PJB7DTC
14000	7000	TAJ7DWC
14400	7000	SAJ7DWC
16000	8000	TAJ7DYC
17500	9000	UBC7DZC
18000	9000	TAJ7DZC

TR	Scale Mvar	Suffix 103812A
19200	10	UFJ7BAD
20000	10	TAJ7BAD
21000	10	RDH7BAD
24000	12	WGG7BCD
28000	14	TAJ7BCD
28800	15	TAJ7BDD
		UFJ7BED
30000	15	TAJ7BED
32000	16	TAJ7FED
36000	17.5	SAJ7FGD
38400	18	PJB7BFD
40000	20	TAJ7BGD
48000	25	UFJ7BJD
50000	25	TAJ7BJD
60000	30	TAJ7BKD
72000	35	SAJ7BMD
80000	40	TAJ7BND
96000	50	UFJ7BRD

Three-phase, three-wire, cross-phased, Wye-wye voltage transformers, 208-volt voltage coils
Root number = 50-103742B.

TR	Scale kvar	Suffix Model # 103742B
100	100	AWP7CAC
120	120	AWP7CCC
160	160	AWP7GEC
200	200	AWP7CGC
240	250	BTX7CJC
300	300	AWP7CKC
320	300	KSC7CKC
350	350	AWP7CMC
360	350	ANS7CMC
400	400	AWP7CNC
420	400	KWE7CNC
480	500	BTX7CRC
560	600	CPL7CTC
600	600	AWP7CTC
700	700	AWP7CWC
800	800	AWP7CYC
900	900	AWP7CZC
1000	1000	AWP7DAC
1050	1000	KWE7DAC
1200	1200	AWP7DCC
1400	1400	AWP7DDC
1600	1600	AWP7HEC
1800	1800	AWP7DFC
2000	2000	AWP7DGC
2100	2000	KWE7DGC
2400	2500	BTX7DJC
2800	3000	CPL7DKC
3000	3000	AWP7DKC
3200	3000	KSC7DKC
3500	3500	AWP7DMC
3600	3500	ANS7DMC
4000	4000	AWP7DNC
4200	4000	KWE7DNC
4800	5000	BTX7DRC
5600	5500	ARS7DSC
6000	6000	AWP7DTC
6400	6500	BMR7DUC
7000	7000	AWP7DWC
7200	7000	ANS7DWC
8000	8000	AWP7DYC
8400	8000	KWE7DYC

TR	Scale Mvar	Suffix 103742B
9600	10	BTX7BAD
10000	10	AWP7BAD
11200	12	CPL7BCD
12000	12	AWP7BCD
12800	12	KSC7BCD
14000	14	AWP7BDD
14400	14	ANS7BDD
16000	16	AWP7FED
16800	17.5	BTX7FGD
18000	18	AWP7BFD
19200	20	BTX7BGD
20000	20	AWP7BGD
21000	20	KWE7BGD
22400	24	CPL7BHD
24000	24	AWP7BHD
28000	30	CPL7BKD
30000	30	AWP7BKD
32000	30	KSC7BKD
35000	35	AWP7BMD
36000	35	ANS7BMD
38400	35	BTW7BND
42000	42	KWE7BND
48000	50	BTX7BRD

Table 7-24
Type DB-40 Temperature Meter

Rating	Model No.
20-140C, 120V 50/60 Hz (one way lead resistance 0.21-0.40 ohm)	50-103502CAAB7

Table 7-25
Type SB-1 Temperature Meter Switch

Stage	Description	Model No.
4	3 RTD's and test position 2-wire RTD connection	16SB1CE28X2

Table 7-26
Type AB-40 Frequency Meter

Description	Model No.
120V - 55-65 Hz scale	50-103372-ANAN7
120V - 45-55 Hz scale	50-103372-AGAG7

Table 7-27
Synchroscope

Type	Description	Model No.
AB-16	120V 60 Hz 120V 50 Hz	50-120452-AAA7 50-120452-ABAA7
AB-40	120V 60 Hz 120V 50 Hz	50-106452-AAAA7 50-106452-A3AA7

METERS

Table 7-28
Watthour and Watthour Demand Meters (120V, 2.5A) Secondary Reading (Multiplier Specified on Nameplate)

Description	Type	Demand Interval	Model No.
3-phase, 3-wire 2-element, watthour	DS63	--	700X563004
3-phase, 3-wire, 2-element, watthour demand	DSM63	15 min.	700X564001

Table 7-29
Type KT Time Meter

Description	Model No.
120 V ac, Register (in hrs.)	50-240711AAAD7

Table 7-30
Capacitor Trip

Rating & Description	Model No.
Basler* Energy Storage Device 120 or 240 VAC Input 50/60 Hz 330-450 VDC Output	ESD-201
Basler *1 Non-energy Storage Device 208 or 240 VAC Input 50/60 Hz	ESD-202
GE Energy Storage Device 190/250 VAC Input 50/60 Hz 360-380 VDC Output	ST-230-3

* UL & CSA Recognized

Note *1: No battery support - retains charge for minimum of 12 seconds.

Basic and Optional Device List

Table 7-31
Control Switches

Description	Stages	Positions	Model No.
Type SBM			
Circuit Breaker control or Permissive	3	(C) (NAC) (NAT) (T)	165BM10AA106
Governer Switch	2	(RAISE) (LOWER)	B3A04S1A2P1
Type SB-12			**Catalog No.**
Breaker	3		006353570G002
Position Switch	6		006353570G001
Stationary	3		006353570G002
Auxiliary Switch*	6		006353570G001
	10		006353570G012

*Operate in "TEST" or "CONNECT" positions, or in both positions. 1 "a" and 1 "b" contact per stage

Table 7-32
Type SBM Transfer Switches

Description	Stages	Positions	Model No.
Ammeter Switch (Middle of Circuit)	5	(1) (2) (3) (OFF)	16SBM10AA093
Voltmeter Switch (3-phase, 3-wire)	2	(OFF) (1-2) (2-3) (3-1)	16SBM10AA004
Voltmeter Switch (phase neutral)	2	(OFF) (IN) (2-N) (3-N)	16SBM10AA003
Voltmeter Switch (3-phase, 4-wire)		(OFF) (1-2) (2-3) (3-1) (OFF) (1) (2) (3)	16SBM10AA006
Voltmeter Switch (Removable Handle)	2	(OFF) (1-2) (2-3) (3-1)	16SBM10AA069
Synchronizing Switch (Removable Handle)	3	(OFF) (ON)	16SBM10AA070

Current Transformers

Table 7-33
Type SR Window-type Phase Current Transformers

Ratio	Model No.	Accuarcy Class	Drawing Number
100:5	0144D26846	C10	G001
150:5	0144D26846	C20	G002
200:5	0144D26846	C20	G003
250:5	0144D26846	C20	G004
300:5	0144D26846	C20	G005
400:5	0144D26846	C50	G006
500:5	0144D26846	C50	G007
600:5	0144D26846	C50	G008
800:5	0144D26846	C100	G009
1000:5	0144D26846	C100	G010
1200:5	0144D26846	C100	G011
1500:5	0144D26846	C200	G012
1600:5	0144D26846	C200	G013
2000:5	0144D26846	C200	G013
2500:5	0144D26846	C200	G014
3000:5	0144D26846	C200	G015
4000:5	0144D26846	C200	G016
5000:5	0144D26846	C200	G017

Table 7-34
Ground-sensor Current Transformers

Type	Rating 5A	Excitation Curve	Model No.
Instr. Transf. Inc	50	5121A00886	143500
JCG-O	50	H-9689241-46B	750X061101
JCB-O	50	H-9689241-271	750X011001

Table 7-35-A
Type JKS-3 Wound Primary Current Transformers (5kV Single Secondary)

Ratio	Model No.	Accuracy Class Metering			Relay-ing	Saturation Curve
		B=0.1	B=0.5	B=2.0		
50:5	753X001006	0.6	1.2	—	T10	C145325
75:5	753X001007	0.6	1.2	—	T20	C145325
100:5	753X001008	0.3	0.6	—	T20	C145325
150:5	753X001009	0.3	0.6	—	T50	C145325
200:5	753X001010	0.3	0.3	1.2	T50	C145325
250:5	753X001011	0.3	0.3	1.2	T50	C145325
300:5	753X001012	0.3	0.3	1.2	T50	C145325
400:5	753X001013	0.3	0.3	0.3	T100	C145325
500:5	753X001014	0.3	0.3	0.3	T100	C145325
600:5	753X001015	0.3	0.3	0.3	T100	C145325

Table 7-35-B
Type JKS-5 Wound Primary Current Transformers (15kV Single Secondary)

Ratio	Model No.	Accuracy Class Metering			Relay-ing	Saturation Curve
		B=0.1	B=0.5	B=2.0		
50:5	755X001007	0.6	2.4	—	T10	C-5453777
75:5	755X001008	0.6	1.2	—	T20	C-5453777
100:5	755X001009	0.3	0.6	—	T20	C-5453777
150:5	755X001010	0.3	0.3	2.4	T50	C-5453777
200:5	755X001011	0.3	0.3	1.2	T50	C-5453777
250:5	755X001012	0.3	0.3	1.2	T50	C-5453777
300:5	755X001013	0.3	0.3	1.2	T50	C-5453777
400:5	755X001014	0.3	0.3	1.2	T50	C-5453777
500:5	755X001015	0.3	0.3	0.3	T100	C-5453777
600:5	755X001016	0.3	0.3	0.3	T100	C-5453777
800:5	755X001017	0.3	0.3	0.3	T100	C-5453777

NOTE: —Window-type current transformers are preferred, since wound-type transformers are more expensive and require more space.
—Wound-type current transformers are used when better accuracy (than offered by BP current transformers) is required for metering.

Table 7-36
Type JKM-0 Auxiliary Current Transformers

NOTE: 5A winding connected in residual circuit for ground differential relay.

Ratio	Catalog No.	Relaying Accuracy Class	Saturation Curve
10:5	750X41G1	T-50	H-9689241-554
15:5	750X41G2	T-50	H-9689241-554
20:5	750X41G3	T-50	H-9689241-554
25:5	750X41G4	T-50	H-9689241-554
30:5	750X41G5	T-50	H-9689241-554
50:5	750X41G7	T-50	H-9689241-554
75:5	750X41G8	T-50	H-9689241-554
100:5	750X41G9	T-50	H-9689241-554

Basic and Optional Device List

VOLTAGE TRANSFORMERS

Table 7-37
Voltage Transformers (Line-to-Line)

Type	Rating	Ratio	BIL	Model No.
JVM-3	2400V-200VA	20:1	60	763X21G41
JVM-3	4200V-200VA	35:1	60	763X021026
JVM-5	4800V-400VA	40:1	95	765X021040
JVM-5	7200V-400VA	60:1	95	765X011039
JVM-5	8400V-400VA	70:1	95	765X011034
JVM-5	12000V-400VA	100:1	95	765X011035
JVM-5	14400V-400VA	120:1	95	765X011036

Table 7-38
Voltage Transformers (Line-to-Neutral)

Type	Rating V	Rating VA	System kV	Ratio	BIL	Model No.
JVM-3	2400	50	2.4	20:1	60	763X21G643
	2400	50	2.4	20:1	60	643X88
	2400	200	4.16	20:1	60	763X021034
	4200	200	4.2	35:1	60	763X021035
JVM-5	4800	200	4.8	40:1	110	765X021040
	7200	200	7.2	60:1	110	765X021039
	8400	200	8.4	70:1	110	765X021034
	12000	200	12.0	100:1	110	765X021035
	14400	200	14.4	120:1	110	765X021036
	4800	400	8.3	40:1	110	765X21G703
	7200	400	12.5	60:1	110	670X43
	8400	400	14.4	70:1	110	670X44

CONTROL POWER TRANSFORMERS

Table 7-39
Control Power Transformers

kVA	Volts Primary	Volts Secondary	Primary Taps %	BIL kV	GC Model No. 9T28	ITI % Cat. No.
5	2400	120/240	1 ± 7½	60	Y5600	CPT3-60-5-242A
	4160	120/240	1 ± 7½	60	Y5601	CPT3-60-5-4161A
	4800	120/240	1 ± 7½	95	Y1040G20	CPT5-95-5-482A
	7200	120/240	1 ± 7½	95	Y1040G21	CPT5-95-5-722A
	8400	120/240	1 ± 7½	95	Y1040G22	CPT5-95-5-842A
	12000	120/240	1 ± 7½	95	Y5604	CPT5-95-5-123A
	13300	120/240	1 ± 7½	95	Y5605	CPT5-95-5-1332A
10	2400	120/240	1 ± 7½	60	Y5610	CPT3-60-10-242A
	4160	120/240	1 ± 7½	60	Y5611	CPT3-60-10-4161A
	4800	120/240	1 ± 7½	95	Y1041G20	CPT5-95-10-482A
	7200	120/240	1 ± 7½	95	Y1041G21	CPT5-95-10-722A
	8400	120/240	1 ± 7½	95	Y1041G22	CPT5-95-10-842A
	12000	120/240	1 ± 7½	95	Y5614	CPT5-95-10-123A
	13300	120/240	1 ± 7½	95	Y5625	CPT5-95-10-1332A
15	2400	120/240	1 ± 7½	60	Y5620	CPT3-60-10-242A
	4160	120/240	1 ± 7½	60	Y5621	CPT3-60-10-4161A
	4800	120/240	1 ± 7½	95	Y1042G20	CPT5-95-15-482A
	7200	120/240	1 ± 7½	95	Y1042G21	CPT5-95-15-722A
	8400	120/240	1 ± 7½	95	Y1042G22	CPT5-95-15-842A
	12000	120/240	1 ± 7½	95	Y5624	CPT5-95-15-123A
	13300	120/240	1 ± 7½	95	Y5625	CPT5-95-15-1332A
25	2400	120/240	1 ± 7½	60	Y5430	CPT3-60-25-242A
	4160	120/240	1 ± 7½	60	Y5431	CPT3-60-25-4161A
	4800	120/240	1 ± 7½	95	Y1042G20	CPT5-95-25-482A
	7200	120/240	1 ± 7½	95	Y1042G21	CPT5-95-25-722A
	8400	120/240	1 ± 7½	95	Y1042G22	CPT5-95-25-842A
	12000	120/240	1 ± 7½	95	Y5434	CPT5-95-25-123A
	13300	120/240	1 ± 7½	95	Y5435	CPT5-95-25-1332A
37.5	4160	120/240	1 ± 7½	60	Y1223G2	CPT3-60-37.5-4161A
	7200	120/240	1 ± 7½	75	Y1233	CPT5-95-37.5-722A
	12470	120/240	1 ± 2½	95	Y1243G14	CPT-95-37.5-1242A
	13200	120/240	1 ± 2½	95	Y1243G3	CPTN595-37.5-1322A

FUSES, TEST BLOCKS AND INDICATING LAMPS

Table 7-40
Pull-out Control Fuse Blocks

Description (Two-pole)	Catalog No.
30A	0673D0515421 G01
60A	0673D0515422 G01

Table 7-41
Type PK-2 Test Blocks and Plug

Description	Pole	Model No.
Current Block	4	0133C8576 G006*
Voltage Block	4	0133C8576 G001
Plug	4	006129533 G001

* Through-type block

Table 7-42
Indicating Lights

Type	Volts	Color	Model No.
ET-16 IND. LTS. (1835 incandescent bulb)	48V 200Ω	---------	0116B6708 G002
	125V 2000Ω	---------	0116B6708 G003
	250V 5100Ω	---------	0116B6708 G004
	120V 1900Ω	---------	0116B6708 G005
	240V 4800Ω	---------	0116B6708 G006
ET-16 COLOR CAPS	----------	Red	0208A3768 P009
	----------	Green	0208A3768 P008
	----------	White	0208A3768 P005
	----------	Clear	0208A3768 P001
	----------	Amber	0208A3768 P007
	----------	Blue	0208A3768 P006
	----------	Yellow	0208A3768 P004

LED BULBS (Starled) For Use in ET-16 FIXTURES	120/240VAC, 125VDC @	Red	0282A4651 P007
	120/240VAC, 125VDC @	Green	0282A4651 P008
	120/240VAC, 125VDC @	Yellow	0282A4651 P009
	48VDC #	Red	0282A4651 P010
	48VDC #	Green	0282A4651 P011
	48VDC #	Yellow	0282A4651 P012
	250VDC @, *	Red	0282A4651 P013
	250VDC @, *	Green	0282A4651 P014
	250VDC @, *	Yellow	0282A4651 P015

Order lamp & color cap separately
48 VDC used 1900 ohm resistor
* designed to operate to 288VDC
@ 120 VAC uses 1900 ohm resistor
240 VAC uses 4800 ohm resistor
125 VDC uses 2000 ohm resistor
250 VDC uses 5100 ohm resistor

Basic and Optional Device List

TERMINATIONS

Description	Catalog
No Standard	QA1C-BTN
1 AWG	QA26-BTN
3 AWG	QA28-2NTN
250-350 MCM	QA31-2NTN
400-500 MCM	QA34-2NTN
600-800 MCM	QA40-2NTN
850-1000 MCM	QA44-2NTN

Description	Catalog
1 AWG	YA25-2N
2 AWG	YA26-2N
3 AWG	YA27-2N
4 AWG	YA28-2N
250 MCM	YA29-2N
300 MCM	YA30-2N
350 MCM	YA31-2N
500 MCM	YA34-2N
750 MCM	YA39-2N
1000 MCM	YA442N

Description	Catalog
1 AWG	YA25A7
2 AWG	YA26A3
3 AWG	YA27A5
4 AWG	YA28A5
250 MCM	YA29A3
300 MCM	YA30A3
350 MCM	YA31A3
500 MCM	YA34A3
750 MCM	YA39A5
1000 MCM	YA44A3

Description	Catalog
No 1 AWG	NAR25A-2N
1 AWG-250 MCM	NAR29A-2N
250-400 MCM	NAR32A-2N
350-600 MCM	NAR36A-2N
600-900 MCM	NAR42A-2N
900-1250 MCM	NAR45A-2N
1250-1600 MCM	NAR46A-2N
1500-2000 MCM	NAR48A-2N

Table 7-45
Shielded-conductor
(15kV)

Type M

Description	Catalo
(Right-Sleeve)	X5471SUV-LH-M
(Right-Sleeve)	X64571SUV-LH-M
(Right-Sleeve)	X64771SU-LH-M
(Right-Sleeve)	X64871SU-LH-M
(Right-Sleeve)	X65971SU-LH-M
(Right-Sleeve)	X65X71SU-LH-M
fitting	54271SUV-LH-M
fitting	64571SUV-LH-M
fitting	64771SU-LH-M
fitting	64871SU-LH-M
fitting	65971SU-LH-M
fitting	65X71SU-LH-M

Table 7-46
(15kV)

Type M

Description	Catalo
(Left-Sleeve)	X5471SUV-LHB
(Left-Sleeve)	X64571SUV-LHC
(Left-Sleeve)	X64771SU-LHD
(Left-Sleeve)	X64871SU-LHE
(Left-Sleeve)	X65971SU-LH
(Left-Sleeve)	X65X71SU-LH
fitting	54217SUV-LHB
fitting	64571SUV-LHC
fitting	64771SU-LHD
fitting	64871SU-LHE
fitting	65971SU-LH
fitting	65X71SU-LH

Table 7-47
(15kV)

Type M

Description	Catalo	
2/0 CM *		0152C5409G021
3/0 CM *		0152C5409G022
4/0 CM *		0152C43096023
250 CM *		0152C5409G024

* Use with fitting

Table 7-48
(15kV)

Type M

Description	Catalo	
2/0 CM *		0152C5409G017
3/0 CM *		0152C5409G018
4/0 CM *		0152C4309G019
250 CM *		0152C5409G020

* Use with fitting

Table 7-49
Shielded

Type M

Conductor Diameter (Inches)	Size	Catalo
1.94	4	RSQ-4-OD1.94
2.00	4	RSQ-4-OD2.00
2.06	4	RSQ-4-OD2.06
2.13	4	RSQ-4-OD2.13
2.19	4	RSQ-4-OD2.19
2.25	4	RSQ-4-OD2.25
2.31	4	RSQ-4-OD2.31
2.38	4	RSQ-4-OD2.38
2.44	4	RSQ-4-OD2.44
2.50	4	RSQ-4-OD2.50
2.56	4	RSQ-4-OD2.56
2.62	4	RSQ-4-OD2.62
2.69	4	RSQ-4-OD2.69
2.75	4	RSQ-4-OD2.75
2.81	4	RSQ-4-OD2.81
2.88	4	RSQ-4-OD2.88
2.94	5	RSQ-4-OD2.94
3.00	5	RSQ-4-OD3.00
3.06	5	RSQ-4-OD3.06
3.13	5	RSQ-4-OD3.13
3.19	5	RSQ-4-OD3.19
3.25	5	RSQ-4-OD3.25
3.31	5	RSQ-4-OD3.31
3.38	5	RSQ-4-OD3.38
3.44	5	RSQ-4-OD3.44
3.50	5	RSQ-4-OD3.50
3.56	5	RSQ-4-OD3.56
3.62	5	RSQ-4-OD3.62
3.69	5	RSQ-4-OD3.69
3.75	5	RSQ-4-OD3.75
3.81	5	RSQ-4-OD3.81
3.88	5	RSQ-4-OD3.88

Basic and Optional Device List

Table 7-50
Wiping Sleeves For Potheads

Type : PLM

Description	Catalog No.
Base Size 4	WS-4
Base Size 5	WS-5

Table 7-51
Adapters For Potheads

Description	Base Size	Catalog No.
Three conductor	4	006273645P001
Three conductor	5	006216909P001
Single conductor	5	0722D0350P016

Table 7-52
PLM Fittings For Potheads

Pothead Description	Outside Diameter (Inches) Min.	Max.	Catalog No.
Single conductor	1.38	1.58	ACS16F4
Single conductor	1.57	1.75	ACS18F4
Single conductor	1.76	1.94	ACS20F4
Single conductor	1.95	2.13	ACS22F4
Single conductor	2.14	2.32	ACS24F4
Single conductor	2.33	2.51	ACS26F4
Single conductor	2.52	2.70	ACS28F4
Single conductor (B/S 5)	2.9	1.75	ACS30F5
Single conductor (B/S 5)	3.09	1.75	ACS32F5
Single conductor (B/S 5)	3.28	1.75	ACS34F5
Single conductor (B/S 5)	3.47	1.75	ACS36F5
Single conductor (B/S 5)	3.66	1.75	ACS38F5
Single conductor (B/S 5)	3.85	1.75	ACS40F5
Single conductor	1.38	1.56	ACS16F
Single conductor	1.57	1.75	ACS18F
Single conductor	1.76	1.94	ACS20F
Single conductor	1.95	2.75	ACS22F
Single conductor	2.14	2.75	ACS24F
Single conductor	2.33	2.75	ACS26F
Single conductor	2.52	2.75	ACS28F
Single conductor	2.71	2.75	ACS30F
Single conductor	2.91	3.75	ACS32F
Single conductor	3.10	3.75	ACS34F
Single conductor	3.29	3.75	ACS36F
Single conductor	3.48	3.75	ACS38F
Single conductor	3.67	3.75	ACS40F

SURGE ARRESTERS

Table 7-53
Surge Arresters

Rating (KV)	System Nominal kV and grounding Solid Grd	Ungrd	Model No.
3	4.16	2.4	9L12PPB003 *
5.1	4.8	4.16	9L12PPB005 *
7.5	8.3	4.8	9L12PPB007 *
9	12.47	7.2	9L12PPB009 *
10	13.8	8.3	9L12PPB010 *
15	-	12.47	9L12PPB015 *
18	-	13.8	9L12PPB018 *
3	4.16	2.4	9L11XPB003
5.1	4.8	4.16	9L11XPB005
7.5	8.3	4.8	9L11XPB007
9	12.47	7.2	9L11XPB009
10	13.8	8.3	9L11XPB010
15	-	12.47	9L11XPB015
18	-	13.8	9L11XPB018

* Polymer Arresters

Contents

Section 8
Equipment and Installation Information

Equipment and Installation Information

INTRODUCTION

This section of the Application Guide provides basic construction information for POWER/VAC vacuum metalclad switchgear; a standard equipment specification, weights and dimensions, floor plan details, and installation details for floor, pad, or pier mounting.

Since POWER/VAC is a highly structured design, one basic floor plan detail, with three sets of dimensions, provides complete floor plan information, regardless of rating. Control and power conduit entrances remain in one specified location for all units in a lineup. In addition, anchor bolt locations are the same for each unit. These benefits of product design structuring simplify layout planning, sited construction, and equipment installation.

STANDARD EQUIPMENT SPECIFICATION

GENERAL

This specification describes standard General Electric POWER/VAC vacuum metalclad switchgear rated 5, 8.25 and 15 kV, 250 MVA through 1500 MVA. For definition of standard options (not described in this specification), see Section 6 of this guide.

DOCUMENTATION

Standard documentation consists of the following computer-generated diagrams and documents:

- Device summary
- Elementary diagram (power and control circuits showing each wire and terminal point)
- Connection diagram (shows physical location of devices and wiring connection points)
- Interconnection diagram (shows interunit wiring)
- Arrangement drawing (includes one-line diagram, front view, side views, and floor plan)
- Also included are side views of the individual sections

Standard documentation does **not** include special drawing formats, special nomenclature for terminal points, special location or sequencing of customer terminal points, or preparation of composite drawings showing equipment other than the switchgear and essential customer connections.

INDUSTRY STANDARDS

POWER/VAC metalclad switchgear is designed, built and tested in accordance with applicable ANSI, IEEE and NEMA standards.

SERVICE CONDITIONS

POWER/VAC metalclad switchgear assemblies are suitable for operation at their standard nameplate ratings (See ANSI-C37.20):

- Where ambient temperature is not above 40°C or below -30°C (104°F and -22°F)
- Where the altitude is not above 1000 meters (3300 feet)
- Where the effect of solar radiation is not significant

CONSTRUCTION

Indoor Equipment

Indoor POWER/VAC switchgear consists of one or more vertical sections mounted side by side, and connected electrically and mechanically to form a complete switching equipment.

Each vertical section is a self-supporting structure including a formed steel frame, bolted together, (with reinforcing gussets) to which front doors and top, side and rear covers are assembled. External covers and doors are 11 gauge steel (or equivalent thickness if cover consists of two sheets).

A vertical section will accommodate a maximum of two circuit breakers or four VT/CPT fuse rollout trays, or certain combinations. Now available—two upper compartment ("A" compartment) VT/CPT, roll out trays, or certain combinations of these as defined in Section 6 of this guide.

Breakers are removable from the equipment by means of a portable lifting device. As a breaker is removed, grounded metal safety shutters isolate the primary contacts from the rest of the compartment and are fronted by a glastic safety barrier.

Primary compartments of each circuit are isolated by grounded metal barriers having no intentional openings. Primary compartments are the breaker compartment, main bus compartment, power termination compartment, and auxiliary compartment. In addition, each breaker and rollout tray is furnished with a 1/8-inch thick front plate that isolates the control from the primary compartment. Secondary control circuit wires will be armored where they pass through primary compartments.

Power termination compartments are located at the rear of the equipment, accessible through bolted covers. Barriers and a cable pass-through box are furnished to separate the two termination compartments in each vertical section when required. (See Section 6 for typical power-conductor compartment arrangements.)

Two front doors are mounted on each vertical section with each door provided with a full-length hinge, a door stop, and two hex-knob closing screws. Each breaker door will mount only those control, instrumentation and protection devices associated with the breaker in that compartment. Fuse blocks, terminal blocks and other surface-mounted accessories will be mounted in locations dedicated for that purpose within the associated breaker compartment.

Ventilation is provided by inlet openings through slots in the bottom flange of each front door and louvres in the rear covers. Exhaust is through "basket weave" openings in the top covers (not used for power control cable entry). Top exhaust vents are equipped with dust guards to keep dirt from entering the top of the switchgear.

Indoor Drip Proof Construction

The indoor drip proof construction has the same design as the standard indoor construction, but with the addition of a sloped roof. This type of design is used to prevent dripping liquids from entering the top of the switchgear.

Outdoor Equipment

Weatherproof construction begins with basic indoor equipment and is partly provided by gasketing the end covers and rear covers, adding filters to ventilation louvres and adding a sloped weatherproof roof. In addition, weatherproof doors or a maintenance aisle are added to the front. A three-inch box frame is provided under each vertical section and the equipment is painted for outdoor service.

Convection air flow is assisted by heaters, applied at half voltage for long life which provide 75 watts for each breaker and cable compartment (total 300 watts per vertical section). These are to remain energized at all times (no switch or thermostat is provided) to guard against internal condensation when wide ambient temperature excursions occur.

AISLELESS CONSTRUCTION - For aisleless construction, full-height, gasketed, padlockable doors are provided on the front of the basic weatherproofed equipment to protect the device doors. Grounded 120-volt convenience outlets are provided on each lower device door. In addition, a light socket and switch (120-volt, 100-watt) for an incandescent lamp is mounted on the inside of each unit.

PROTECTED-AISLE CONSTRUCTION - A preassembled weatherproof aisle of 11-gauge steel is added to the basic weatherproofed equipment to provide protected-aisle convenience. Doors with padlocks and panic latches are located at each end of the aisle. Space (full vertical section-sized) is provided at the left end of the lineup to allow for device door swing of the left-end units and can be used for a work area, batteries and battery charger, or for equipment storage.

Inlet ventilation openings for the aisle are louvred, equipped with filters, and located on the aisle doors. Exhaust is through screened openings designed into the roof overhang.

A grounding-type receptacle, rated 250 volts ac, 20 amperes, is provided at each end of the aisle for portable comfort heaters. (Comfort heaters to be furnished by Purchaser.) A 120-volt grounding, duplex convenience outlet and a three-way switch for ceiling lights are also provided at each end of the aisle. Ceiling-mounted light sockets for 120-volt, 100-watt, incandescent bulbs are furnished (one per vertical section).

COMMON-AISLE CONTRUCTION - To provide common-aisle construction, the aisle between facing lineups of weatherproofed gear is spanned by a weatherproof roof. Space is proved at the left end of each lineup to allow for device-door swing. Otherwise, all construction details are the same as those for protected-aisle construction.

For Protected-Aisle and Common-Aisle Switchgear, allow 36 inches clearance at the left end of the lineup to provide space for the door swing with 18 inches clearance on the right side for additional space. Recommended aisle extends minimum space for the front aisle is 75 inches.

In outdoor protected-aisle and common-aisle construction, as noted above, a 36 inch extension is needed on the left side of the switchgear and a 24 inch extension is needed on the right side to accommodate the cubicle door swing and the lift truck access.

EXTERNAL BUSHING

As an option, outdoor switchgear can be provided with roof entrance bushing. The outdoor bushing extend the height of the switchgear by the following; 1200 ampere bushing, 13-16 inches, 2000 ampere bushing, 14-17 inches, 3000 ampere bushing, 16 inches.

HARDWARE

All standard hardware will be high tensile-strength steel (SAE grade 5) which is zinc plated and bronze iridescent chromate conversion coated to resist corrosion.

BREAKER COMPARTMENT

Each POWER/VAC circuit breaker rolls on horizontal guide rails and has self-coupling primary and secondary contacts. A manually* operated jackscrew racking mechanism is provided in each breaker compartment to move the breaker between the "connected" and "test/disconnected" positions. The equipment is of closed-door-drawout design, to allow the breaker to be racked between positions with the front door closed.

Grounded-metal safety shutters are actuated to cover the stationary primary disconnects when the breaker is moved from the connected position.

A direct roll-in breaker is offered as an option in a one-high vertical section.

An optional motor operator is available for racking the breaker in and out of the cubicle.

AUXILIARY COMPARTMENT

Rollout trays are provided in primary auxiliary compartments for mounting voltage transformers (VT's), control power transformers (CPT's) or CPT fuses. Two roll-out trays can be accommodated in the bottom primary auxiliary compartment and two in the top compartment.

Voltage transformers are General Electric Type JVM-3 and JVM-5, mounted three per tray for single-fused voltage transformers and two per tray for double-fused voltage transformers.

Control power transformers are GE and ITI epoxy-cast, dry-type transformers. A rollout tray can accommodate up to one single-phase 15-kVA control power transformer maximum.

Larger control power transformers are stationary-mounted in the power termination compartment and only the fuses are mounted on a rollout tray. Transformer size in the rear termination compartment is limited to one 75 KVA single-phase transformer or a 75 KVA three-phase transformer using three individual 25 KVA transformers.

TRANSITIONS

Transition sections between motor control equipment and Power/Vac is handled in the following manner. The metalclad switchgear bus is extended out the side 10 inches. The motor starting equipment factory provides the transition section, usually 24 inches in width. It is full height and full depth lining up to the metalclad on one side and the limit-amp motor control on the other side.

Transition to a transformer is very similar. The transition is provided by the transformer vendor and Burlington provides a 6" throat welded to the switchgear end sheet which then can be bolted to the transformer transition section.

SAFETY INTERLOCKS

POWER/VAC switchgear is provided with mechanical interlocks to:

- Inhibit moving the breaker to or from the "connected" position when the breaker contacts are in the "closed" position;
- Oppose closing the breaker unless the primary disconnects are fully engaged or the breaker is in the test/disconnect position.
- Automatically discharge the closing springs when the breaker is moved between the "connected" and "test" positions or when it is inserted into or withdrawn from the compartment.

In addition, the breaker racking mechanism is a jackscrew type which positively holds the breaker when it is in either the "connected" or "test/disconnected" position. Finally, control power transformer primary fuses, whether located on the CPT or on the separate rollout trays, are not accessible unless the CPT primary and secondary circuits are open.

Additional safety design features include:

- The rating interference plate which allows only a breaker of the correct type and rating to be inserted into any specific breaker compartment;

- Closed-door drawout design which allows breaker racking to and from the "connected" position with the front door closed;
- Grounded metal shutters which automatically close to cover the stationary primary disconnects when the breaker is moved from the "connected" position.
- An additional safety barrier is installed in front of the metal shutters.

MAIN BUS

The main bus is completely enclosed by grounded, metal barriers and feeds both the upper and lower compartment in a vertical section. Standard main bus materials are copper ASTM B187 for 1200-ampere rating (3/16-inch by 6-inch bar) and 2000-ampere rating (3/8-inch x 6-inch bar), and ASTM B187 Type ETP copper for the 3000 ampere rating has (2 - 0.38" x 6.0" bars) and the 3500 and 4000 ampere rating has (2 - 0.50" x 6.0" bars). All main bus joints and bus are tin plated and utilize at least two ½-inch zinc-plated, bronze iridescent chromate conversion coated steel bolts per joint. Maximum main bus length without a splice is 34.5 inches. Provision for future extension of the main bus is standard.

Bus bars are mounted edgewise on 11-inch centers and are insulated with flame retardant, track-resistant epoxy applied by the fluid-dip process to a thickness that withstands the dielectric tests specified in ANSI-C37.20. The bus bars are supported on track-resistant, molded-polyester-glass supports which also serve as interstack bus barriers. Bus supports have strength suitable to withstand the forces caused by a peak short-circuit asymmetrical current of 80,000 amperes, (50,000 symmetrical amperes). An enhanced 63,000 amperes symmetrical bracing is also available. All bus joints are insulated with pre-formed vinyl boots secured by nylon hardware as a standard practice.

Porcelain insulation to ground is optional for 15-kV main bus. This includes porcelain inserts in the bus-support barriers, porcelain standoff insulators where required, and porcelain sleeves for the stationary primary disconnects.

SECONDARY CONTROL

Door-mounted Devices

Protection, instrumentation, and control devices, which provide indication or manual control, are mounted on the enclosure front doors.

The devices required for a particular breaker are mounted only on the compartment door associated with that breaker. For cases in which all devices cannot be accommodated on the breaker compartment door, the additional devices are mounted on the auxiliary compartment door in the same vertical section. (Only one breaker is furnished in a vertical section in such cases.)

Typical door-mounted devices are relays, meters, instruments, control switches indicating lights, and test blocks. Standard POWER/VAC switchgear utilizes pre-engineered door-mounted device packages (called PIC packages) with specified available options for all basic circuit-protection schemes and uses preassigned locations on the door for these devices.

Equipment-mounted Devices

Secondary control devices which are not door-mounted are surface-mounted in their predesignated locations in the equipment. Included in this class are fuse blocks, terminal blocks, some auxiliary relays, and stationary auxiliary switches. Terminal blocks are one-piece, molded General Electric Type EB-25. All control circuits are properly protected using General Electric deadfront drawout mounted fuses.

Ring-type current transformers are mounted over the stationary primary disconnect bushings and are accessible through the front of the breaker compartment. Wound primary CT's, when required, are mounted in the power termination compartment. Voltage transformers, and their associated fuses, are mounted on rollout trays.

Two "a" and three "b" contacts are wired from the breaker-mounted auxiliary switch for the Purchaser's use.

Wiring

Secondary control wiring is No. 14, extraflexible, stranded, tinned-copper control wire, Type SIS (Vulkene), rated 600 volts, except for some specific circuits for which a larger wire size is required. Crimp-type, uninsulated spade terminals are furnished on all wire ends, except where non-insulated ring terminals are used to connect to fuse blocks, instrument studs or terminal block points which have two or more wire connections. Secondary control wires are armored or enclosed in grounded metal troughs where they pass through primary compartments.

POWER TERMINATION COMPARTMENT

Cable termination compartments for incoming and load cables are located at the rear of the equipment and are accessible through bolted rear covers. Barriers and cable pass-through boxes of 11-gauge steel are provided to isolate the circuit terminations in the event there are two cable termination compartments in the same vertical section. Each termination compartment can accommodate up to two 750 MCM stress cones (or two potheads) per phase as standard. With the addition of a rear extension, various combinations can be accommodated up to six 1000 MCM cables maximum.

New roof entrance bushings and connections to General Electric metal-enclosed bus are also available.

As required, the power-termination compartment will be used for mounting stationary CPT's, wound-primary CT's, ground-sensor CT's surge arrestors, and other auxiliary devices.

Standard POWER/VAC switchgear includes only NEMA drilling for terminations. Terminal lugs are not included.

GROUND BUS

The standard ground bus matches the rating of the main bus and is ¼-inch by 2-inch copper up to a rating of 1000 MVA, which equates to 50 kA symmetrical 2 second rating. For the special 1500 MVA applications, the ground is 0.40-inch by 2-inch to achieve a 63 KA symmetrical 2 second rating.

The ground bus extends throughout the lineup with connections to each breaker grounding contact and each cable compartment ground terminal. All joints are made with at least two 3/8-inch zinc-plated, bronze iridescent chromate conversion coated steel bolts per joint. Station ground connection points are located in each end section.

EQUIPMENT HEATERS

Indoor equipment does not include space heaters and thermostats as standard equipment. They may be supplied as an option. The heaters are rated 75 watts each at 120 VAC. We install 4 heaters per vertical section - 2 front and 2 rear.

On outdoor designs, moisture condensation is minimized through the use of Calrod® heating elements. A 75-watt heating element is located in each breaker or auxiliary compartment and each cable compartment with a total of 300 watts per vertical section. Heaters are applied at half-voltage for extended life and are protected by perforated metal guards to prevent inadvertent contact with the heater element.

Heaters should be energized at all times to guard against condensation caused by wide ambient temperature excursions; accordingly, no switch or thermostat is provided in the heater circuit.

Heaters are supplied as standard on outdoor designs.

FINISH AND PAINT

Indoor switchgear enclosure parts are protected with a cathodic electrodeposition of ANSI 61, gray epoxy after pretreatment of the metal. This process results in high corrosion resistance, uniform and thorough paint coverage which is more attractive, exceptionally hard yet exhibits greater flexibility and impact resistance than former painting methods.

Outdoor switchgear is given the same “E Coat” process as indoor equipment followed with an additional coat of Light Gray (ANSI 61) acrylic enamel. Other options include Dark Gray (ANSI 24), Sky Gray (ANSI 70) or Berkshire Medium Green (ANSI 45).

UNIT NAMEPLATES

Provided on each unit door is a 4-3/8-inch by 1-inch lamicoid nameplate. Either black on white or white on black will be furnished, as specified (white on black if not specified by Purchaser), with the designated customer unit name engraved on the nameplate in 3/6-inch letters, two lines and sixteen letters per line, maximum. A blank nameplate will be provided if unit designations are not specified.

INSTALLATION INFORMATION

Layout planning and installation information for POWER/VAC switchgear equipment is detailed in Table 8-1 and Figures 8-1, 8-2 and 8-3. Typical weights and dimensions are given in Table 8-1. Shown in Figure 8-2 and 8-3 are floor plan details, including anchor bolt locations and power conductor and conduit entrance locations. Equipment anchoring information is provided in Figure 8-7.

SHIPPING SPLITS

Most metalclad switchgear lineups require many vertical sections, or stacks. These lineups are broken down into shipping splits of four stacks or fewer after the lineup is assembled and tested at the factory. The four shipping sections would be approximately 14 feet long, 8 feet high and 9 feet deep, weighing 16,000 pounds. These shipping sections must be reassembled, in the correct order, when received at the job site.

TABLE 8-1 Rating, Weights and Dimensions

Breakers			Indoor Equipment						Outdoor Equipment								Indoor & Outdoor			Arc Resistant	
			Breaker Vertical Section (less Breakers)				Auxiliary Vertical Section (No Trays)		Breaker Vertical Section (less Breakers)				Auxiliary Vertical Section (No Trays)		For Protected Aisle, Add to Each Vertical Section		Roll-out Tray (VT- CPT)	Required Clearance		Breaker Vertical Section (Less Breaker)	
Breaker Type	Current Rating (Amps)	Breaker Weights	Height	Depth (1)	Width	Weight (4)	Width	Weight	Height (2)	Depth (3)	Width	Weight	Width	Weight	Depth	Weight	Weight	Front Aisle Min.- (5)	Rear Aisle Min. (6)	Width	Weight
VB-4.16 250	1200	550	95	94	36	3100	36	3100	111 OR 112	109 OR 181 OR 272	36	3600	36	3600	75	1100	500	66	26	36	4100
	2000	650																			
	3000	780																			
VB-4.16 350	1200	550																			
	2000	650																			
	3000	780																			
	3500	850																			
	4000	860																			
VB-7.2 500	1200	550																			
	2000	650																			
	3000	780																			
	3500	850																			
	4000	860																			
VB-13.8 500	1200	550																			
	2000	650																			
	3000	780																			
	3500	850																			
	4000	860																			
VB-13.8 750	1200	550																			
	2000	650																			
	3000	780																			
	3500	850																			
	4000	860																			
VB-13.8 1000	1200	550																			
	2000	650																			
	3000	780																			
	3500	850																			
	4000	860																			
VB-13.8 1500	1200	550																			
	2000	650																			
	3000	780																			
	3500	850																			
	4000	860																			

(1) An optional 82" depth is available for some applications if limited to one breaker per vertical section.
(2) 111" for standard outdoor construction; 112" for protected and common aisle construction.
(3) 109" for standard outdoor; 181" for protected aisle; 272" for common aisle construction.
(4) For common aisle construction, add 1500 pounds to weights of 2 indoor vertical sections.
(5) 66" minimum front aisle space available for indoor.
(6) For slit or bolted covers. For hinged doors, 35" minimum is required on 36" wide sections.

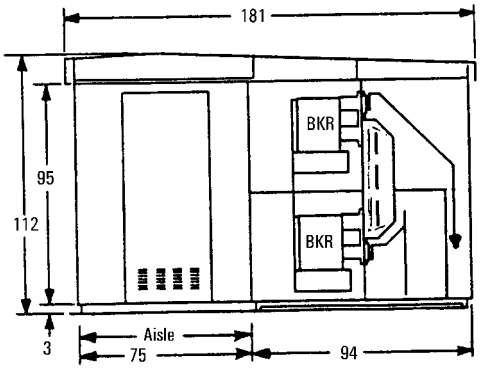


Figure 8-1. Typical Section Dimensions—Outdoor Protected Aisle Equipment (All dimensions in inches)

1. Indoor Construction (Standard)

- NEMA 1 Construction
- Non-Gasketed (Gasketed indoor construction may be available for some Power/Vac equipment arrangements—contact factory for details.)

2. Indoor Drip Proof Construction

- Indoor Design with sloped roof
- Used to prevent dripping liquids from entering from the top of indoor switchgear.

Figure 8-2 Indoor Constructions

1. Outdoor Construction (Standard)

- Similar to NEMA 3R Construction
- Not Protected Aisle

2. Outdoor Construction Protected Aisle

Includes:

- Incandescent lights with 3-way switch at each end.
- 120Vac Convenience Outlet
- Panic door hardware on doors at each end.

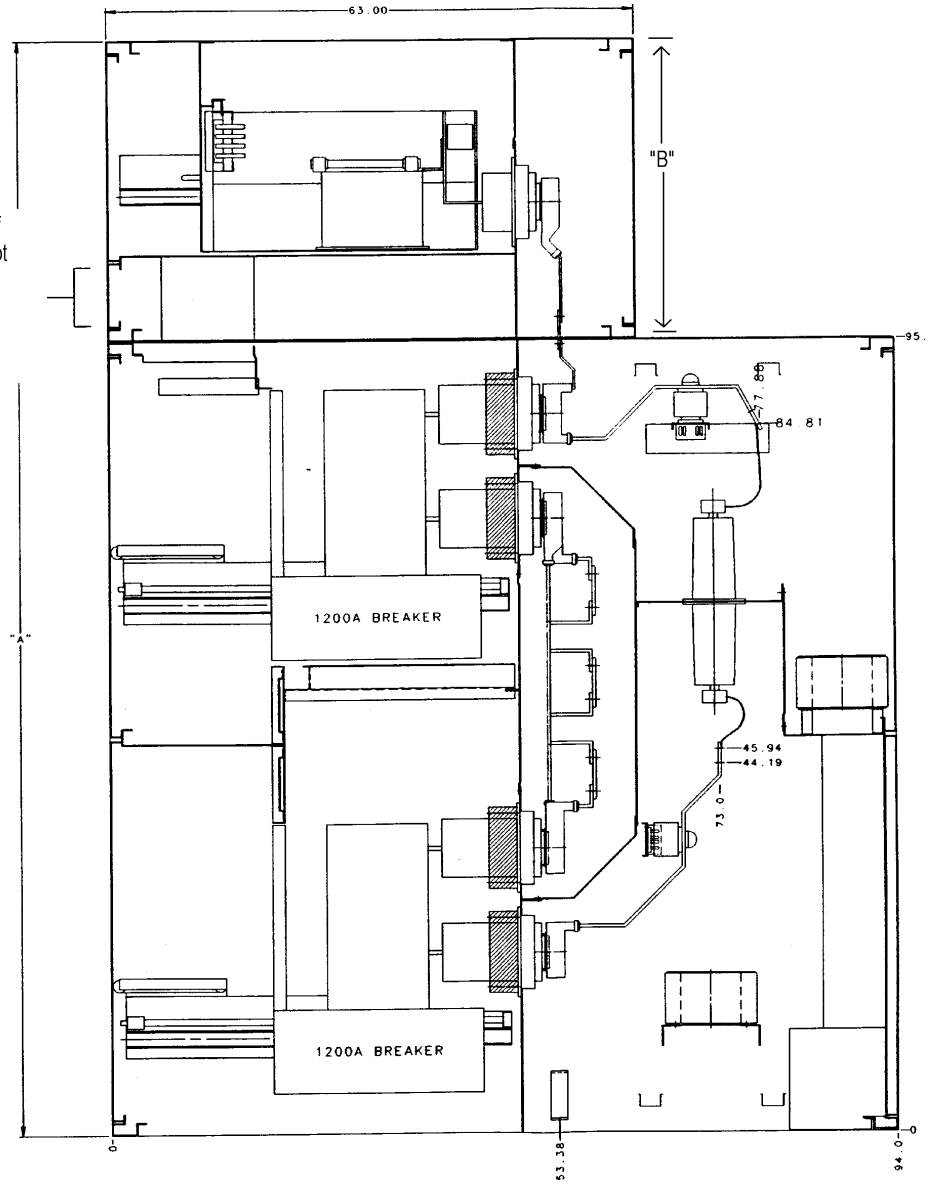
NOTE: All outdoor equipment should be mounted on solid and level pad. Refer to page 8-12 and 8-13 for details

3. Outdoor Common Aisle Construction

- Two outdoor lineups facing each other with a connected covered 6 foot aisle.
- Field assembled

Figure 8-3 Outdoor Constructions

This space provided for ventilation of breaker compartments below - Do not reduce or restrict air flow in this area.



Type of Rollout	"A"	"B"
PT/VT	131.0	36.0
CPT *	137.0	42.0

* Not Pictured

Rollout tray may be same as any of our standard configurations. With breaker located in the "A" compt., Rollout must be line conn.

Placement of additional rollout structure on top of unit only available on indoor equipment.

Special lift truck required to remove tray from structure on top of unit - 0144D2911G005

Rollout structure is removed for shipment.

Figure 8-4. Top Hat (PT/CPT) for Power/Vac Switchgear

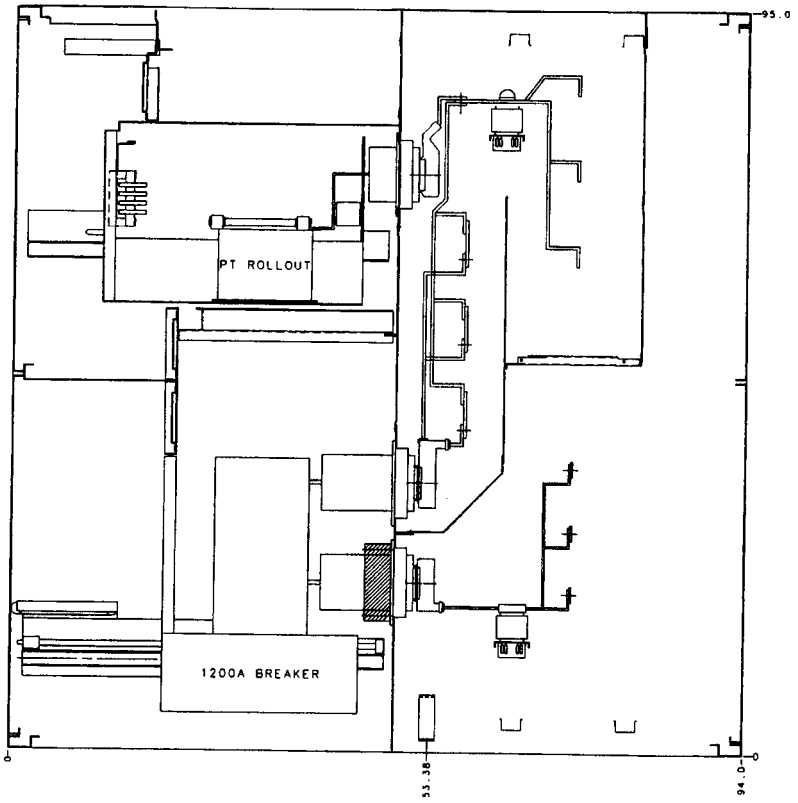


Figure 8-5
Breaker with PT Line Side Connected

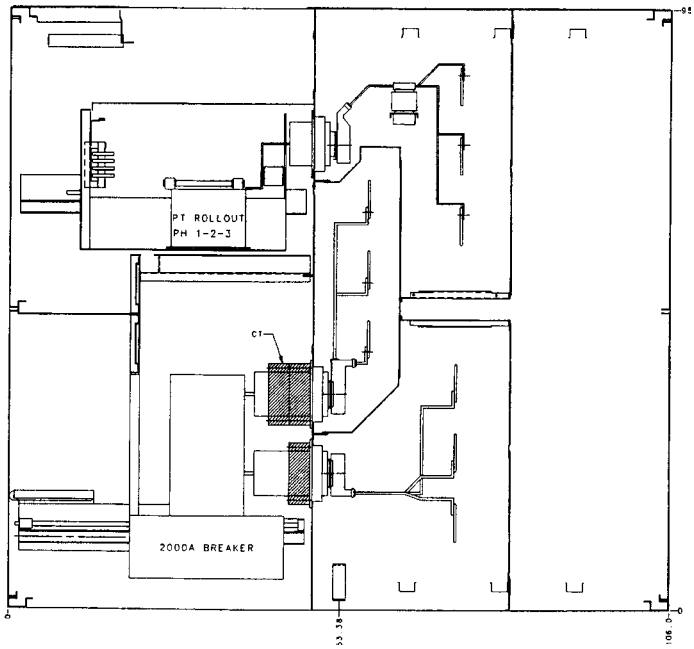


Figure 8-6
Breaker with PT Load Side Connected

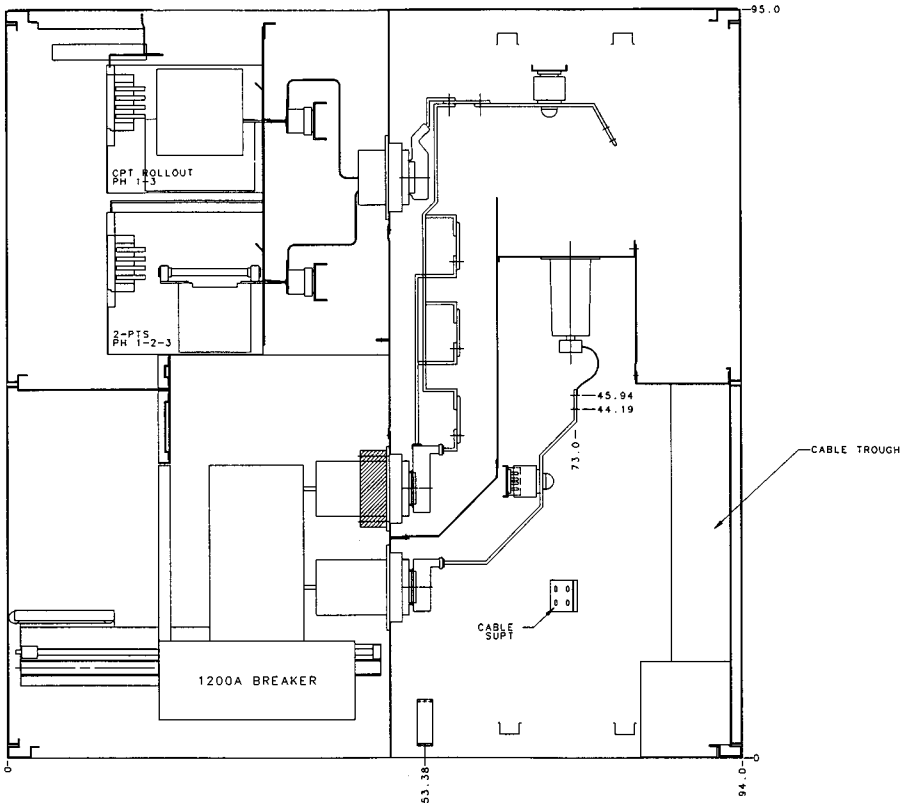


Figure 8-7
Indoor Switchgear with PT & CPT
Line Side Connected

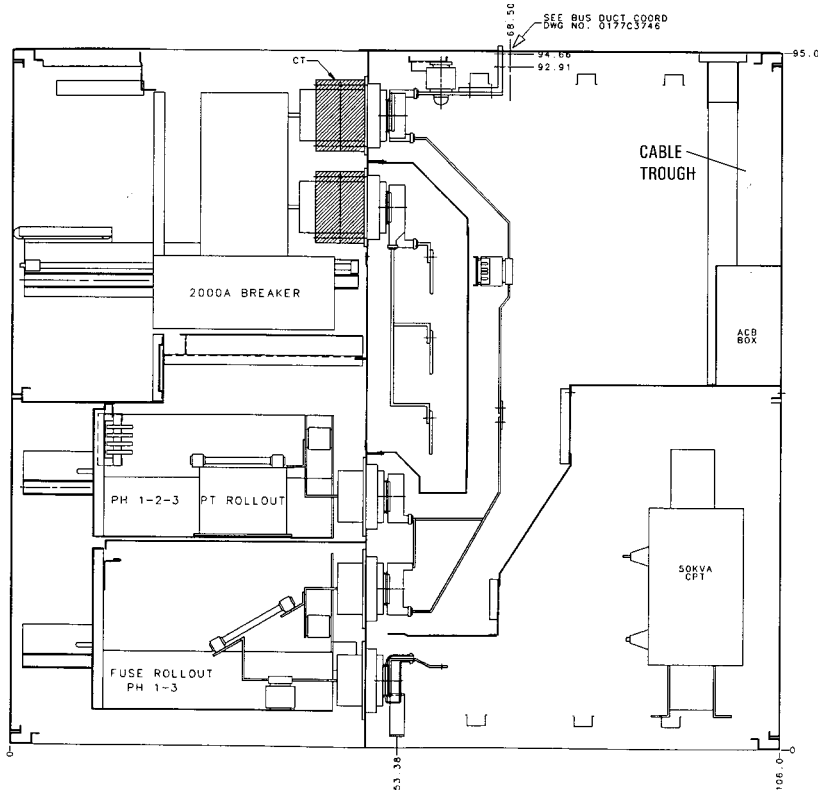


Figure 8-8
Indoor Switchgear

- PT Load Side Connected
- CPT Mounted in Cable Compartment
- CPT Fused Rollout in "B" Compartment

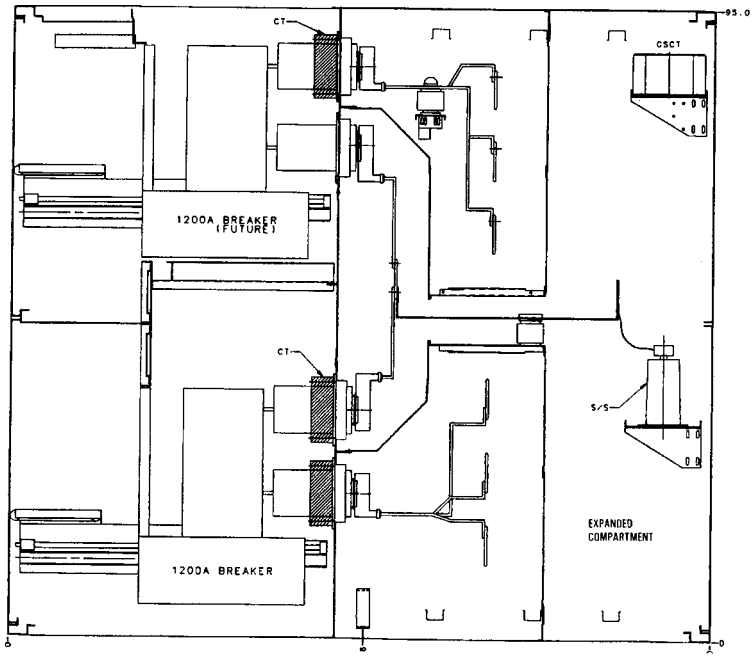
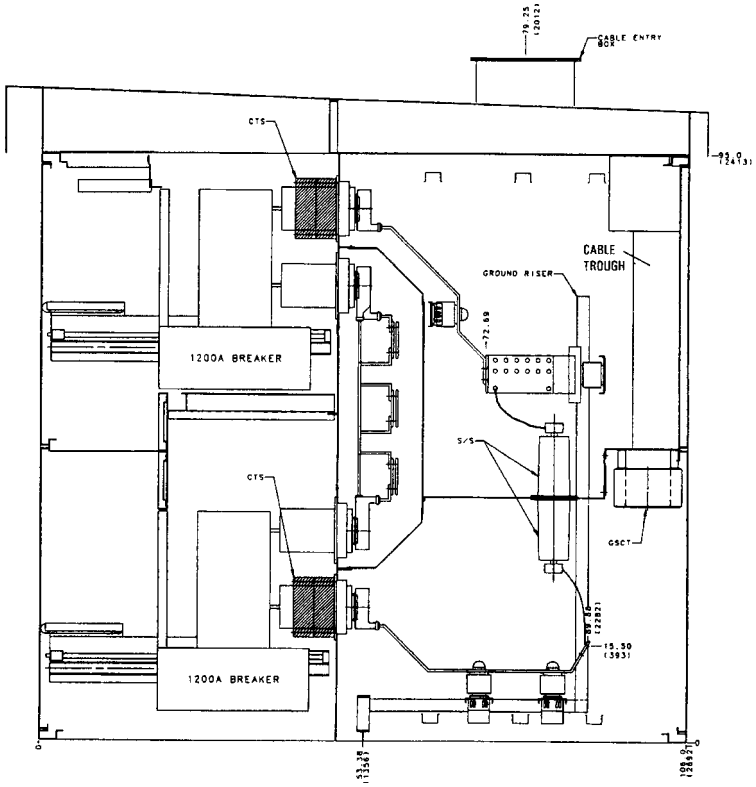


Figure 8-9
Two High Breaker Indoor Switchgear with Expanded Compartment

Figure 8-10
Outdoor No-Aisle Switchgear
- Two-high breakers
- Top Cable Entrance
- Cable Isolation to cover compartment
- Multi-cable connection



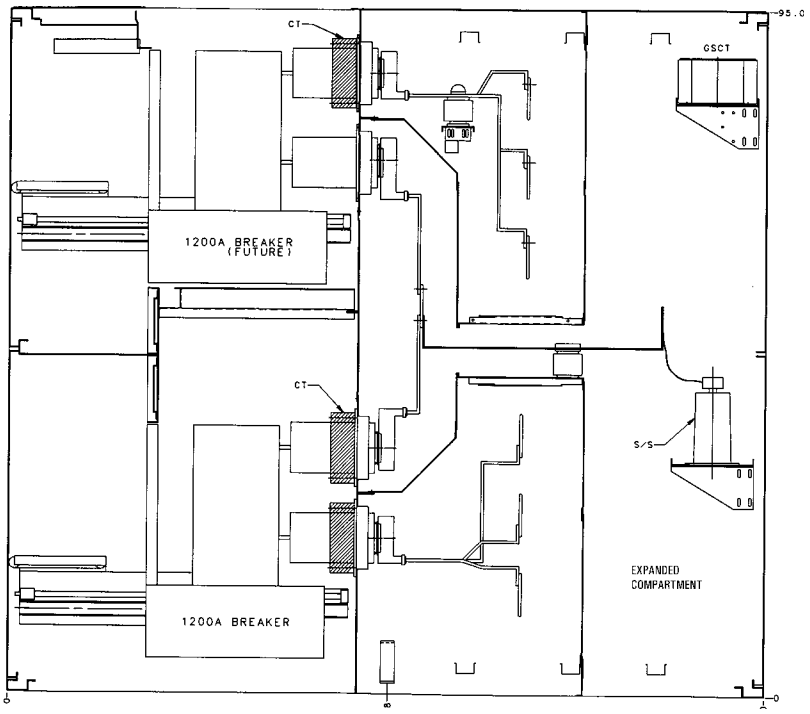


Figure 8-11
Two High Breaker Indoor Switchgear with Expanded Compartment

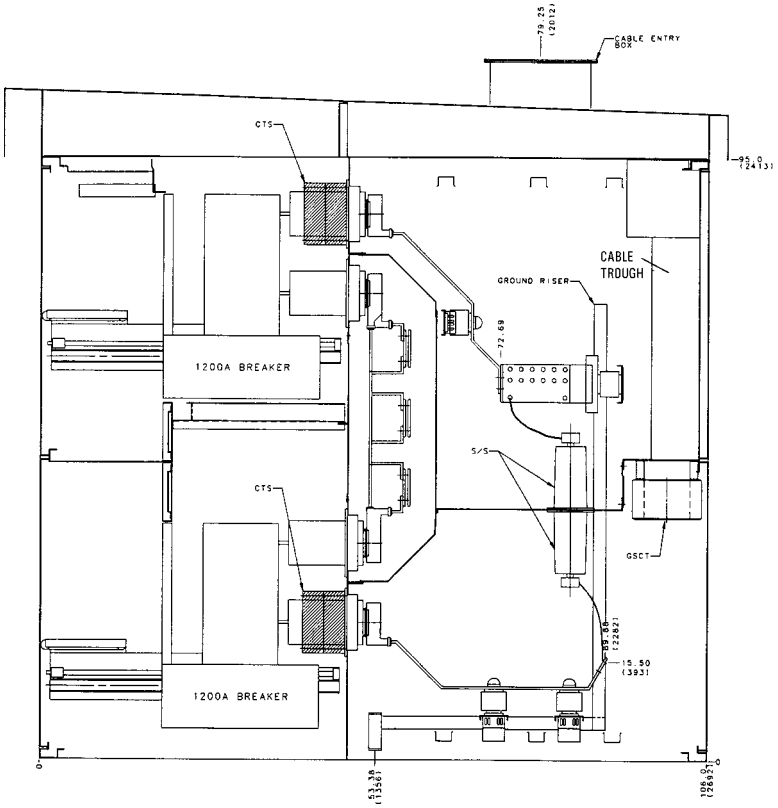
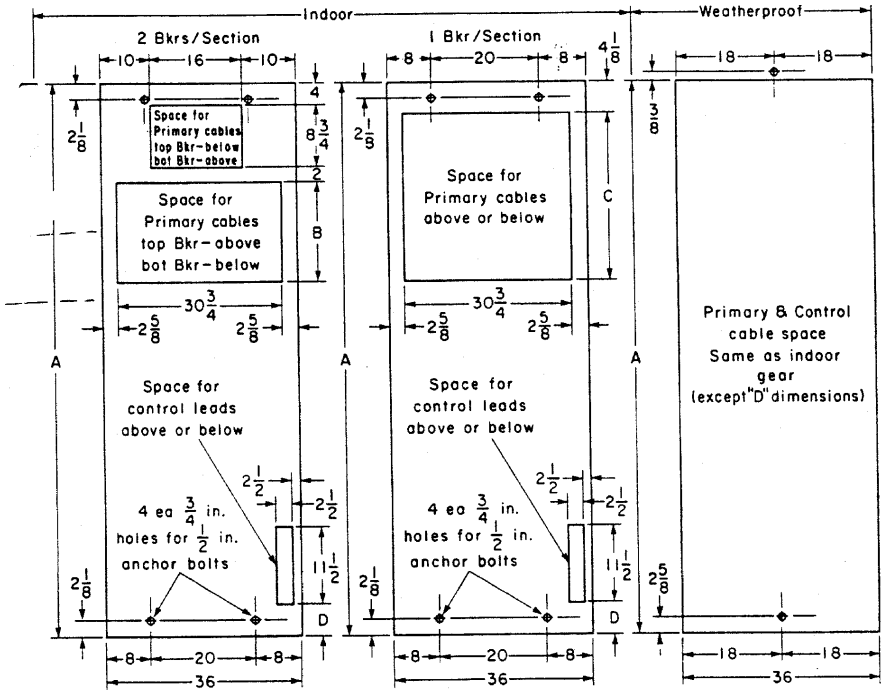


Figure 8-12
Outdoor No-Aisle Switchgear

- Two-high breakers
- Top Cable Entrance
- Cable Isolation to cover compartment
- Multi-cable connection

Recommended Minimum Rear-Aisle: 26 inches



All dimensions in inches

Figure 8-11. Floor Plan Details

Note: Allow 36 in. clearance at left end of lineup to provide space for door swing, with 18 in. right side space.
Recommended minimum front aisle space: 66 inches.

1200-2000 Amp Breaker
"Space Above" (Thru Top Cover)

Depth "A"	Dim "B"	Dim "C"	Dim "D"
Indoor 82		17.00	
Indoor 94	20.00	29.00	6.5
Weatherproof 97	20.00	29.00	9.5

3000-3500 Amp Breaker

		DIM "C"
Indoor 94 and Weatherproof 97		18.00

NOTE: These are minimum values for conditions as stated.

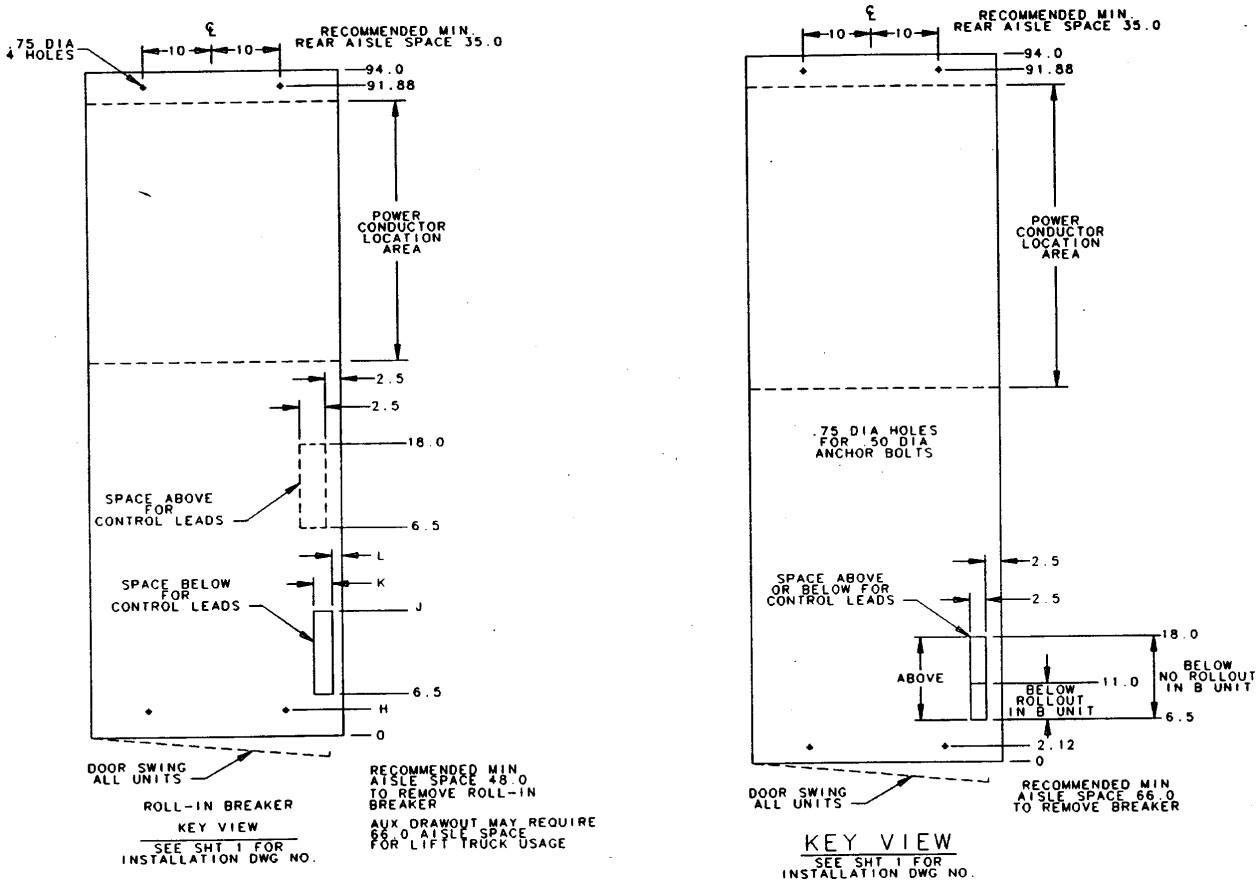
1200-2000-3000-3500-4000 Amp Breaker (2 Heaters in Cable Compartment) For (1) Heater Add 2" to ALL Dim.
"Space Below" (Thru Bottom of Gear)

Depth "A"	Dim "B"	Dim "C"	Dim "D"
Indoor 82		20.00	6.5
Indoor 94	20.00	32.00	6.5
Weatherproof 97	20.00	32.00	9.5

When Fuse Roll-out is in Lower Compartment *
(With 2 Heaters) For (1) Heater Add 2" to ALL Dim.

Depth "A"	Dim "B"	Dim "C"	Dim "D"
Indoor 82		15.00	
Indoor 94		27.00	6.5
Weatherproof 97		27.00	9.5

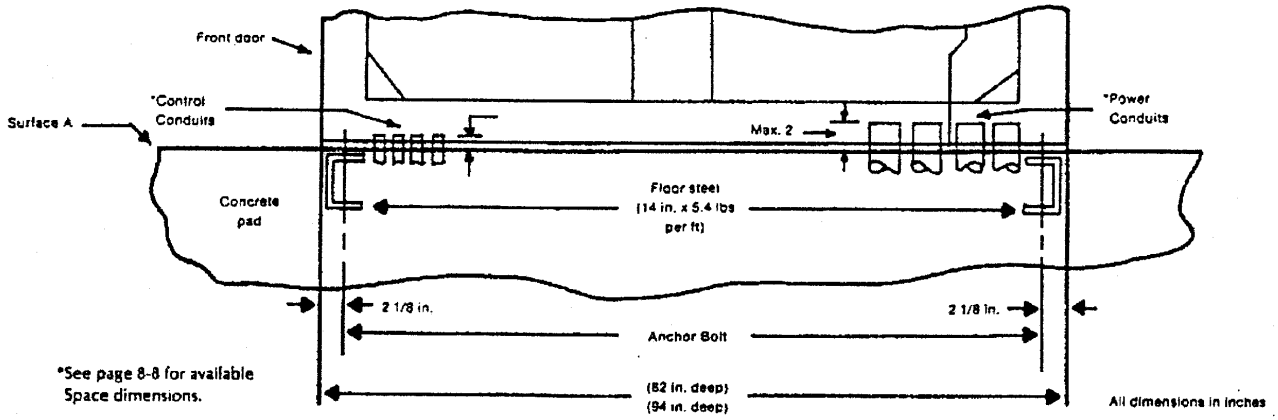
* Used with stationary CPT's mounted in rear.
No cables allowed to enter from below CPT.



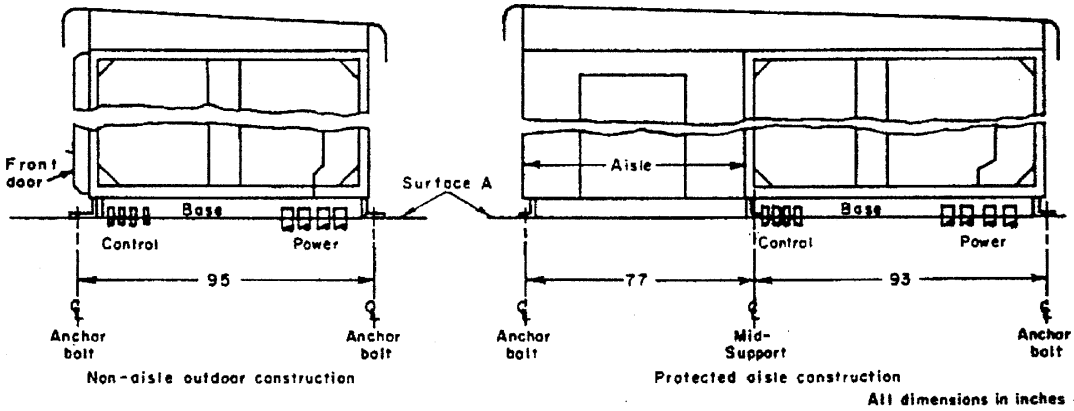
Type "B" Unit	H	J	K	L
Roll-In Breaker	5.00	18.0	1.69	1.5
Transformer Drawout	2.12	11.0	2.50	2.50
Blank Unit	2.12	18.0	2.50	2.50

Figure 8-14. Floor Details for Switchgear with Roll-in Breaker

RECOMMENDED METHOD



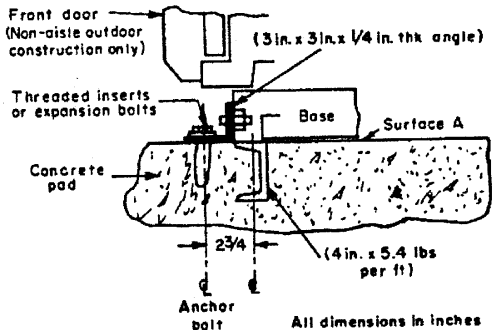
NOTE: All floor steel to be furnished by Purchaser. Floor steel members must be set level with each other, must be level over their entire length, and must be even with the level finish floor. The switchgear can be anchored to the floor steel by plug welds or ½ -inch bolts furnished by Purchaser.



Switchgear support should be concrete or reinforced concrete with depth, fill, drainage, etc., according to recommended foundation design for the loading, type of construction, and local conditions involved. The base furnished with the switchgear should be supported level between "ends" and level over the full length. Reference page 8-14 and 8-17.

Steel floor members to be furnished by Purchaser if required for leveling foundation and supporting switchgear .

Anchor bolts and clips should be used for anchoring the switchgear. The anchored clips are furnished with the switchgear. The Purchaser is to furnish the 5/8-inch threaded inserts or the 5/8-inch expansion bolts .



NOTE: Surface A should be level with switchgear support and reasonably level and smooth for easy handling of power circuit breaker removable elements.

Figure 8-15. Equipment anchoring details for POWER/VAC metalclad switchgear.

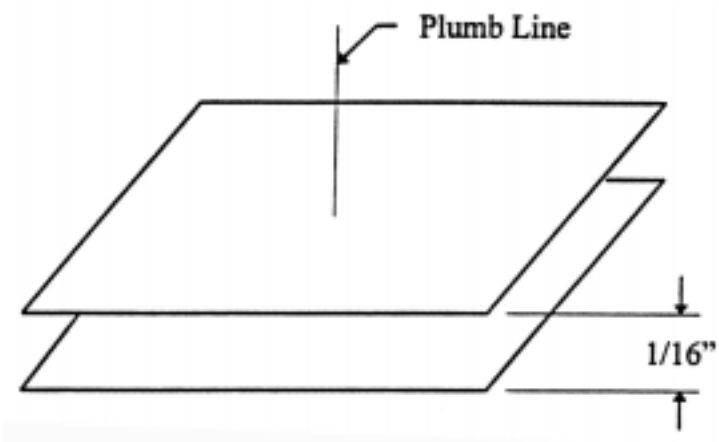
Power/Vac Switchgear Indoor Foundation Preparation

For optimum performance of Power/Vac switchgear equipment, the foundation requirements expressed in the Installation and Maintenance Manual, GEK 39672, and in the installation drawing furnished with the equipment should be strictly followed.

Although the switchgear can be mounted directly on a flat level floor, it is recommended that recessed steel channels be installed for supporting the equipment. These channel sills should be installed in accordance with the instruction materials referenced above.

The foundation must be strong enough to prevent sagging due to the weight of the switchgear structure and to withstand the shock stress caused by the opening of the breakers under fault conditions. The shock loading is approximately 1-1/2 times the static load.

The foundation must be flat and level in all planes. We must be concerned with how much the pad is out of level and to what degree this varies over the installation. Refer to Figure 8-8 for definition of flat and level.



FLAT-Surface of pad must lie between two parallel, level planes spaced 1/16 in. apart.

LEVEL-Planes must be perpendicular to plumb line within ¼ in. in 10 ft. span.

Figure 8-16

Extreme difference can result in problems with breaker alignment and the racking mechanism operation as well as placing unusual stresses on insulators and supporting structures. Minor adjustments can be corrected with shims. When used, shims should be placed beneath all vertical frame posts (located 33 or 36 inches from the front of the equipment, and runback support posts. The acceptance of the pad and the use of shims is the customer's responsibility.

Contents

Section 9
Custom Designed Equipment

Custom Designed Equipment

INTRODUCTION

As described in Sections 6,7, and 8 of this Application Guide, a wide variety of equipment configurations have been designed and pre-engineered for application to the most frequently required power switching functions. Specification, selection and application of these pre-engineered equipments will provide the advantages of high quality, from repetitive manufacture, readily available error-free documentation, and faster shipping cycles at reasonable cost.

CUSTOM APPLICATIONS

Every effort has been made to pre-engineer equipments to serve most applications; however, some applications are not covered due to variations in power distribution system characteristics and user operating procedure. For these applications, some of the units in a metalclad switchgear lineup may require custom design engineering and manufacturing effort.

Some examples of custom options are:

- Revenue metering compartments.
- Device other than those listed in Section 7.
- Arrangement of door-mounted devices other than as shown in Section 6.
- Key interlocks.
- Special control power throwover schemes.
- Special one-line arrangements (i.e., breaker and one-half scheme)
- Special wiring, materials, construction features, paint color and/or processes, etc. other than those described in Section 8, “Standard Equipment Specification”.
- Special drawings and drawing formats.

CUSTOM FEATURES

Specification of custom features will result in higher price and longer delivery so they should be avoided whenever possible. If an application demands such features, requirements should be referred to Medium Voltage Switchgear Marketing in West Burlington for evaluation.

Contents

Section 10
Power/Vac Arc Resistant Switchgear

POWER/VAC Arc Resistant Switchgear

APPLICATION

Although medium voltage switchgear provides significant protection against the probability of arcing faults, it can not completely prevent them. The use of Arc Resistant medium voltage switchgear minimizes the spread of an arcing fault in the switchgear, and provides added protection to persons in the vicinity of the switchgear. Arc Resistant Switchgear requires significant design modifications to the standard medium voltage switchgear.

The intent and goal of the Arc Resistant Switchgear is to provide the highest possible degree of safety and protection to operating personnel by containing the arc by-products and venting the gases in a safe manner. Protection should include against flying objects, flash burn, escaped hot gases and glowing particles whether the person is outside the enclosure or inside the adjacent live compartment during maintenance.

Other hazards associated with the internal arcing such as emission of toxic gas, loud noise, instant flash are not covered by the standards and hence operating personnel should wear protective clothing, protective equipment for the eyes, ears, including a face mask and hard hat. Although Arc Resistant Switchgear provides the highest possible degree of protection, the normal safety precautions should not be compromised.

The EEMAC Standard G14.1 describes three classes of Arc Resistant Switchgear: Type A, Type B, and Type C.

Type A protection - provides front protection only.

Type B protection - provides front, back and side protection.

Type C protection - provides front, back and side as well as protection against the spread of faults between compartments.

The GE Arc Resistant Switchgear Type B and Type C in the 5 kV to 15 kV ratings are listed in Table 1 and has been designed and tested to EEMAC Standard G14.1. Energy from an arc will cause a rapid build-up of pressure within the cubicle due to the extremely high temperatures created and the vaporization of metals. To maintain the Arc Resistant protection during operation requires that all doors/covers must be closed and latched/bolted, while energized. Unlatching or unbolting removes this protection. The lower front door has been designed to withstand pressure without opening and coming off. A window is provided to view the breaker trip and close flags with the door closed.

The breaker can and should be racked in and out of the connect and test position with the door closed.

When required, breaker and cable compartment doors, front and rear, have been provided with ventilation louvers. In the event of a sudden pressure increase due to an explosion, the spring loaded covers over the louvers are designed to close against the gaskets sealing off the openings at an immediate pressure increase. Before closing the door of each compartment the louver covers must be set in the open position.

Wire seals are used for maintaining arc resistant between the lower breaker or auxiliary transformer compartment and the upper device compartment.

The standard Arc Resistant Switchgear section is a one-high construction and must contain only one breaker due to the venting of the compartments. This provides for the GE standard withdrawal to the connected/disconnect position with the doors closed. The tape indicator visible from the outside with the door closed indicates the Disc/Test position in conjunction with the movement of the racking mechanism and the respective stops.

In addition, explosion vents located on top of the individual cells for the breaker, bus and cable compartment of the switchgear are designed to direct the gases upward from the breaker, bus and cable compartments resulting from a fault within any of the chambers in the switchgear. These vents are designed to open under minimal pressure. The switchgear is shipped with heavy cover plates. These plates must be removed and the thin explosion vents bolted in prior to energization. For maintenance, theses shipping plates can be reinstalled to allow a maintenance person to stand on them.

BREAKER COMPARTMENT

In Arc Resistant Switchgear the front door of the breaker compartment is designed to withstand the pressures caused by the fault. The door must be closed to allow access to the breaker racking mechanism. The latch system is positive, and interlocks with the breaker racking mechanism to ensure that the breaker door denies access to the compartment except when the breaker is in the test position. This protects the operator if a fault should occur while he is in the vicinity of the switchgear.

The chimney above the breaker is configured to allow the gases and pressure from the fault to escape through the explosion vent on the roof. The breaker compartment front door contains venting for cooling the breaker. These vents are equipped with a mechanical mechanism that will close and latch over the opening to prevent the escape of hot gases and arcs for protection of personnel within the area of the switchgear.

BREAKER

The standard POWER/VAC circuit breaker is used in the Arc Resistant switchgear. Notes: A special cover support must be added to the standard breaker allowing for interchangeability with the Arc Resistant breaker. POWER/VAC circuit breaker ratings are shown in Table 10-1. Interrupting ratings are for 60-hz applications. For more complete information concerning service conditions definitions, and interpretation or ratings, tests, and qualifying terms, refer to Section 3 or to the applicable ANSI and NEMA standards listed in Table 1-1, Page 1-3.

BUS COMPARTMENT

The bus compartment of Arc Resistant Switchgear is increased in size to reduce the pressure on the barriers making up the bus compartment. The compartment must contain the fault and vent the pressure through an explosion vent on the roof while protecting from transferring the fault to other compartments either by pressure or burn through.

VENTS

The Arc Resistant explosion vent system must open quickly to reduce the amount of pressure built up in the individual compartment where the fault occurs. The quicker the explosion vent opens, the quicker the pressure is reduced. The design of the explosion vent provides a defined operating pressure for opening the vent and is toleranced so as to provide the same protection from one compartment to the next.

Table 10-1 — Standard Power/Vac Breakers in Arc Resistant

Symmetrical Rating Basis ANSI C37.06 (1987*)

Identification (6) & (7)*		Rated Values								Related Required Capabilities				
		Voltage		Insulation Level		Current						Current Values		
				Rated Withstand Test Voltage								Maximum Symmetrical Interrupting Capability (5)	3 Sec Short time Current Carrying Capability	
Normal rms Voltage Class (kV)	Normal 3-phase Class (MVA)	Rated Maximum rms Voltage (kV) (1)	Rated Voltage Range Factor, K (2)	Low Frequency rms Voltage (kV)	Crest Impulse Voltage (kV)	Continuous rms Current Rating at 60 Hz (amperes)	Short circuit rms Current Rating (at Rated Max kV) (kA) (3) (4)	Rated Interrupting Time (Cycles)	Rated Permissible Tripping Delay, Y (Seconds)	Rated Maximum rms Voltage Divided by K (kV)	Arc Resistant 1 Sec. maximum sym current rms (kA)	K times Related Short-circuit rms Current (kA)	K times Related Short-circuit rms Current (kA)	Closing and Latching Capability rms Current (kA)
4.16	250	4.76	1.24	19	60	1200	29	5	2	3.85	40	36	36	58
4.16	250	4.76	1.24	19	60	2000	29	5	2	3.85	40	36	36	58
4.16	250	4.76	1.24	19	60	3000	29	5	2	3.85	40	36	36	58
4.16	350	4.76	1.19	19	60	1200	41	5	2	4.0	40	49	49	78
4.16	350	4.76	1.19	19	60	2000	41	5	2	4.0	40	49	49	78
4.16	350	4.76	1.19	19	60	3000	41	5	2	4.0	40	49	49	78
7.2	500	8.25	1.25	36	95	1200	33	5	2	6.6	40	41	41	66
7.2	500	8.25	1.25	36	95	2000	33	5	2	6.6	40	41	41	66
7.2	500	8.25	1.25	36	95	3000	33	5	2	6.6	40	41	41	66
13.8	500	15	1.30	36	95	1200	18	5	2	11.5	40	23	23	37
13.8	500	15	1.30	36	95	2000	18	5	2	11.5	40	23	23	37
13.8	500	15	1.30	36	95	3000	18	5	2	11.5	40	23	23	37
13.8	750	15	1.30	36	95	1200	28	5	2	11.5	40	36	36	58
13.8	750	15	1.30	36	95	2000	28	5	2	11.5	40	36	36	58
13.8	750	15	1.30	36	95	3000	28	5	2	11.5	40	36	36	58
13.8	1000	15	1.30	36	95	1200	37	5	2	11.5	40	48	48	77
13.8	1000	15	1.30	36	95	2000	37	5	2	11.5	40	48	48	77
13.8	1000	15	1.30	36	95	3000	37	5	2	11.5	40	48	48	77

Notes Applying to Table 10-1

(1) Maximum voltage for which the breaker is designed and the upper limit for operation.

(2) K is the ratio of rated maximum voltage to the lower limit of the range of operating voltage in which the required symmetrical and asymmetrical interrupting capabilities vary in inverse proportion to the operating voltage.

(3) To obtain the required symmetrical interrupting capability of a circuit breaker at an operating voltage between 1/K times rated maximum voltage and rated maximum voltage, the following formula shall be used:

Required Symmetrical Interrupting Capability =

Rated Short-circuit Current x $\frac{\text{(Rated Max. Voltage)}}{\text{(Operating Voltage)}}$

For operating voltages below 1/K times rated maximum voltage, the required symmetrical interrupting capability of the circuit breaker shall be equal to K times rated short-circuit current.

(4) With the limitation stated in 5.10 of ANSI-C37.04-1991, all values apply for polyphase and line-to-line faults. For single phase-to-ground faults, the specific conditions stated in 5.10.2.3 of ANSI-C37.04-1991 apply.

(5) Current values in this column are not to be exceeded even for operating voltages below 1/K times rated maximum voltage. For voltages between rated maximum voltage and 1/K times rated maximum voltage, follow (3) above.

(6) NOTE: GE reserves the right to improve the design and/or modify the specifications in this publication without notice.

INSTRUMENT CONTROLS

A low voltage control compartment is provided in the upper front portion of the vertical section of Arc Resistant Switchgear. This provides a location for relays, switches, terminal blocks, and other control devices. The barriers that make up this compartment are reinforced to prevent the entry of the fault from the surrounding breaker or auxiliary compartments located below or behind the instrument compartment. All control wiring entering this compartment from the breaker or auxiliary transformers compartment must pass through seals to prevent entry of the fault.

The instrument control compartment in the upper compartment is sealed from the lower breaker compartment and the vent from that compartment. This requires that all wiring brought into the instrument compartment must be brought through seals on the bottom horizontal barrier of this compartment.

AUXILIARY TRANSFORMERS

In units where the auxiliary transformer trays are located in the front of the vertical section, the vertical section must be limited to one auxiliary transformer tray. The auxiliary transformer tray must move from the disconnect to the connect position with the front door closed and latched to prevent the possibility of a fault while inserting the auxiliary tray. For PT and CPT requirements refer to Section 7 and ANSI/NEMA Standards.

As an option some units can be designed as rear mounted PT or CPT trunions. For safety all power to trunion units must be removed before unbolting the door. The basis of Arc Resistant Switchgear is provided by the latched doors and bolted doors.

CABLE COMPARTMENT

The primary cable termination compartment located at the back of the gear requires that the primary cables or bus duct entering the switchgear enters from below to avoid interference with the operation of the explosion vents. For cable entry above a rear extension must be added to the cable compartment. The primary cable or bus duct should be isolated from the switchgear to avoid transferring the fault from the switchgear to another area. This assures that the explosion vents will operate quickly by eliminating an additional path for the pressure to follow. The rear covers of the primary cable termination compartment contain venting for cooling the bus. These vents are equipped with a mechanical mechanism that will close and latch over the opening and prevent the escape of hot gases and arcs, so as to protect the personnel in the area. The barriers that make up the primary termination compartment are reinforced to withstand the pressure .

INSTALLATION

The present switchgear design is for indoor use only. If outdoor switchgear is required, the Arc Resistant Switchgear must be installed in a contained outdoor building. Due to the large volume of expelled air, gas and vapor, the area directly above the Arc Resistant Switchgear should be free of any non-replaceable or flammable materials up to a distance of 3 meters (9.84 feet). Design of the building or room that contains the Arc Resistant Switchgear is normally the responsibility of the owner or his designated consultant.

Once installed, there should be absolutely no access to the top of the Switchgear, nor should any cables be run over the top of the switchgear as the hot gases released under the fault may melt the insulation and cause secondary failures.

All primary and secondary cables to Arc Resistant Switchgear must be feed from bottom entrance only, unless a special rear extension is provided.

Shipping splits must be bolted together in the field. Many of the barriers and bolted pieces have been provided with a seal of silicone to assist in the prevention of any gases between compartments (type C only). The integrity of these seals must be maintained.

MAINTENANCE

A recommended preventive maintenance plan based on extensive tests and proven reliability is available for all switchgear users. While the user is totally responsible for determining their own maintenance program and inspection routine, this recommendation may be applied to switchgear operating under service conditions with mild environments as defined in ANSI Std C37.04.

Circuit breakers utilizing vacuum technology have less moving parts than air, oil or SF6 breakers. And fewer operating parts means less can go wrong. The uncluttered configuration of the vacuum designed breaker allows for easier maintenance and significantly reduced spare/renewal parts inventory requirements.

Also, there is no contact maintenance. With vacuum, one set of contacts performs the function of both the main and arcing contacts that are required in other designs. These contacts are sealed in a high vacuum environment isolated from exposure to dirt, moisture and other pollutants.

The GE Arc Resistant switchgear and vacuum circuit breaker is designed for 18 full fault operation, 10,000 no-load operations and 5,000 normal-load operations prior to maintenance. After 5 full fault interruptions, it is recommended that the contact erosion indicator be checked to estimate the remaining interrupter life. Standard maintenance is eliminated because the high vacuum environment isolates contacts from exposure to dirt, moisture and other pollutants.

A means is provided for slow-closing the breaker mechanism during maintenance operations.

An optional motor operator is available for racking the breaker in and out of the cubicle.

In addition, a test cabinet can be provided as an option to allow testing of the circuit breakers from a location remote from the switchgear.

For specific information regarding the maintenance of devices such as circuit breakers, relays, meters, etc., refer to the separate instruction books furnished for each device or to NFPA 70B.

Table 10-2 Arc Resistant Weights and Dimensions

Arc Resistant Switchgear				Rollout	Breaker
Height	Depth	Width	Weight	Weight	Weight
104	94	36	4100	500	(1)

(1) Standard breakers are used. Weights are listed in Table 8-1.

Note:
Standard compartment width is 36 inches.

Figure 10-1 Arc Proof Side View of Standard Breaker Compartment

Figure 10-2 Arc Proof Side View of Standard Auxiliary Compartment

Figure 10-3 Arc Proof Stack Side View with expanded compartment

Note:
Standard compartment width is 36 inches.

Figure 10-4 Arc Proof Side View of expanded Auxiliary Compartment

Contents

Section 11
Ground And Test Device

Ground And Test Device

APPLICATION

The GE Ground and Test Device is an auxiliary removable device for use in Power/Vac metal-clad switchgear and Arc Resistant switchgear equipment during initial installation and at normal maintenance periods. The function of this device is to solidly ground the equipment manually as well as permit various types of tests. A convenient means of grounding a system is provided to safeguard personnel who may be working on the equipment. Exposed terminals can also be used for applying high-potential tests, measuring insulation resistance to ground, and phasing out cables.

DESCRIPTION

Ground and Test Devices can be provided in two types: A Manual operating device and an Electrical operating device. A different Ground and Test Device is required for each current rating of: 1200, 2000, 3000, 3500 and 4000 amperes. In applying a Ground and Test Device to a metalclad unit, only the current rating needs to be considered. Electrical insulation of the device has been designed to include voltage rating from 5 kV to 15 kV maximum system voltage. The Manual and Electrical Devices are designed to meet applicable ANSI/IEEE/NEMA standards.

MANUAL GROUND & TEST DEVICE

The Manual Ground and Test Device is an auxiliary removable device for use in Power/Vac metal-clad switchgear and Arc Resistant switchgear equipment during initial installation and at normal maintenance periods.

The Device does not have interrupters or a mechanism; therefore, it has no interrupting or closing capability. It is designed to meet the applicable ANSI Standards for Ground and Test Devices.

The function of this device is to solidly ground the equipment manually as well as permit various types of tests. A convenient means of grounding a system is provided to safeguard personnel who may be working on the equipment. Exposed terminals can also be used for applying a high-potential test, measuring insulation resistance to ground and phasing cables.

In applying a Manual Ground and Test Device to a metal-clad unit, only the current rating needs to be considered. A different Manual Ground and Test Device is required for each current rating: 1200, 2000, 3000, 3500, 4000 amperes. Electrical insulation of the device has been designed to include the voltage rating from 5 kV to 15 kV. An optional Manual Ground and Test Device is available utilizing one unit for either current rating of 1200 amperes or 2000 amperes.

ELECTRICAL GROUND AND TEST DEVICE

The Power/Vac Electrical Ground and Test Device uses a sealed vacuum ground switch (vacuum bottles) to make or break contact between the primary stud and the equipment ground. The ML-17 mechanism provides the vertical motion to move the lower contact of the ground switch to the open or closed position.

The Electrical Ground and Test Device has no interrupting rating, but is designed to close and latch against short circuit currents equivalent to the maximum momentary rating of 80 KA for the switchgear equipment.

It is composed of three major elements; the grounding switch, the selector switch and test receptacles, and the operating mechanism. The grounding switch, selector switch and test receptacles are composed of three similar pole units mounted on top of the unit frame that contains the operating mechanism.

The nameplate of the grounding device describes the control power requirements for the Electrical Ground and Test Device. Verify this is in agreement with the control voltage in the metal-clad switchgear via the secondary disconnect. On some units the control power may be supplied by an external power source via a cable connected to the front panel of the Grounding Device.

Various interlock arrangements are included within the Device, where possible, to insure proper operation. Since the Electrical Device has been designed to serve many purposes and cover many ratings, it is not practical to interlock every element. Therefore, it is the responsibility of the user to properly set up the components for the particular requirements of the application.

A single Electrical Ground and Test Device with interchangeable primary contact fingers for 1200/2000 amperes, and 3000 amperes will cover all the metal-clad equipment ratings and can be installed in the upper or lower compartments.

Proper installation and maintenance are necessary to insure continued satisfactory operation of the Electrical Ground and Test Device. Since a clear conception of the function of all parts and the application of placing the device in test service and maintenance is helpful in understanding the safe operation during the periods of installation and maintenance periods. Refer to the Ground and Test Device instruction book GEK 39672 for a detailed description of the design and operating principles before using.

SAFETY

The Ground and Test Device is often used during initial installation and for trouble shooting when the possibility of making an error is greatest. Unfortunately, it is not possible to eliminate every hazard with interlocks; therefore, is the responsibility of the person using this device to recognize the potential hazards while working on potential energized equipment and take adequate precautions.

The Ground and Test Devices and the metalclad switchgear have interlocks to prevent unsafe operation.

Interlocks are provided for the safety of the operator and correct operation of the device. If an interlock does not function as described, do not make any adjustment or force the device into position without reviewing the instruction book.

Ground and test cables and connectors are available and can be ordered as an option.

DUMMY ELEMENT

The Dummy Element is an auxiliary removable device for use with Power/Vac metal-clad switchgear equipment. It is designed to provide an economical means for making a connection between the bus and line or load terminations.

The Dummy Element does not have interrupters nor does it have a mechanism; therefore, it has no interrupting or closing capability. The Dummy element and the related metal-clad switchgear have mechanical and electrical interlocks to prevent unsafe operation.

Safety is critical in the use of this device. Any potential hazards can be eliminated if the customer takes adequate safety precautions and follows the GEK instruction manual and the applicable local safety procedures.

A separate device is required for each current rating of 1200, 2000, 3000, 3500 amperes. In applying the Dummy Element to a switchgear unit, only the current rating needs to be considered. Electrical insulation for 5 kV to 15 kV and mechanical strength for 250 MVA to 1000 MVA have been designed into the Dummy Element for each current rating. The Dummy element is designed to meet applicable ANSI Standards.

GROUND OR EARTH SWITCH

GE also has available several different offering of an earth/ground switch in metalclad switchgear. Earth switches are offered in the Power/Vac metalclad switchgear that manually ground the load side or the bus side of the breaker compartment. The current making capability of the earth switch is:

Options available are:

1. In single-high Power/Vac switchgear, an earth switch is available in the cable compartment and can be operated from the rear of the switchgear.

2. The earth switch design is also available in two-high stacks of Power/Vac switchgear. The two individual earth switches are located in the cable compartments and are operated independently from the rear of the switchgear.

3. The availability of a front operated earth switch, is restricted to only a one-high stack. Switchgear Marketing in West Burlington, Iowa should be consulted before consideration of a front-operated earth switch.

Ground And Test Device

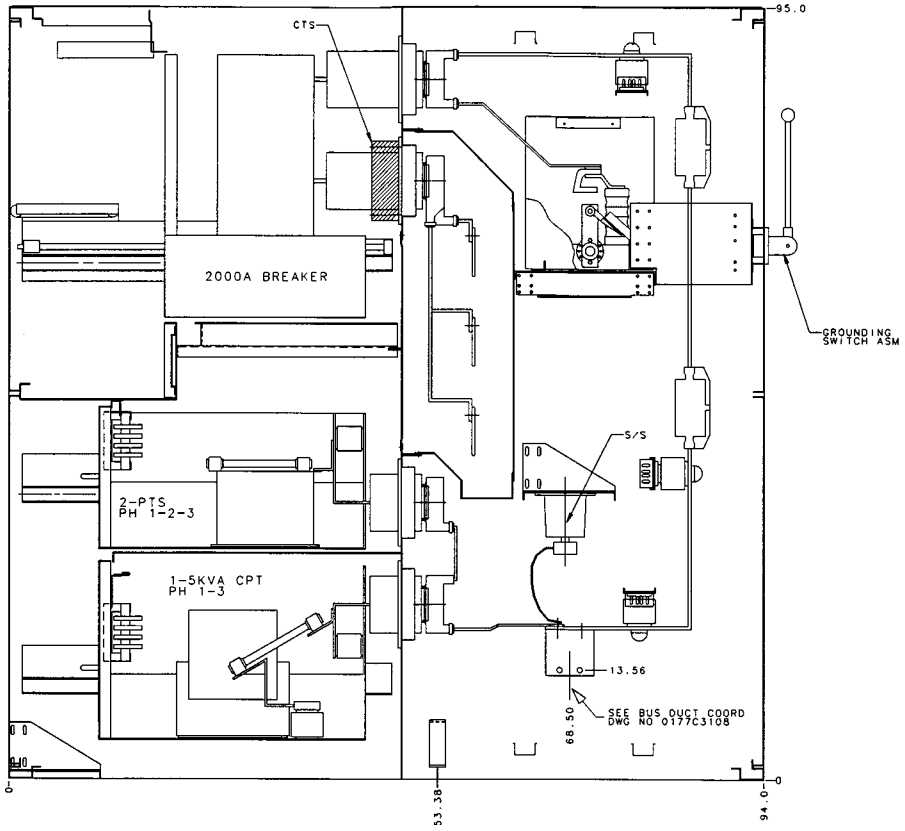


Figure 11-1
Two high breaker with single Earth Switch in Rear.

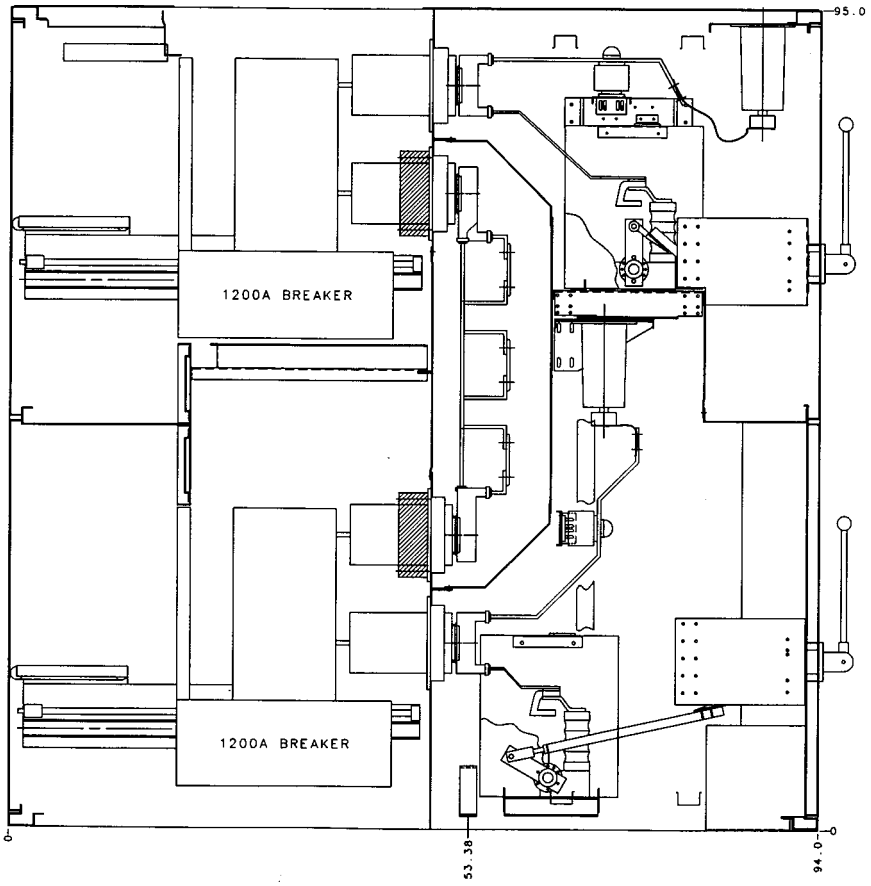


Figure 11-2
Two high breakers with individual Earth Switches mounted in Rear

Contents

Section 12
Distribution Breakers and Reclosers

DISTRIBUTION BREAKER

APPLICATION

First introduced in 1961, GE offers Power/Vac distribution circuit breakers in all the features required for outdoor switching, protection and control applications. The distribution breakers are rated at 15.5 kV and 28.0 kV with a symmetrical interrupting current capacity of 12.5 kA, 16 kA, 20 kA and 25 kA. See Table 2 for reference. Linear couplers are available for 1200 amp and 2000 amp breakers.

The distribution breaker is designed using air at atmosphere pressure to provide the primary insulation. The breakers are designed for application to 3300 feet altitude and where the temperature of the ambient is not above 40 C or below a minus 30 C. If the application exceeds these values, refer the application to GE marketing in West Burlington, Iowa.

DESCRIPTION

GE distribution breakers incorporate the same Power/Vac element used in GE Power/Vac metalclad switchgear. Thousands of these breakers elements are in service and have established a proven reliability record domestically and in over 30 countries. They are manufactured in the world's most sophisticated switchgear facility in West Burlington, Iowa.

Distribution breakers are simplified by a modular breaker design for convenient installation and to permit reasonable access to all parts for inspection, maintenance and adjustment. The design of the distribution breaker consists of three pole assemblies and the breaker mechanism within a weatherproof housing, the breaker is identical to the Power/Vac breaker design in metalclad switchgear. The entire module can be removed with a minimum of effort.

The housing design is outdoors, vented and designed to be proof against driving rain or snow, insects and vermin. The construction consists of a one-high voltage compartment. The one modular construction provides a continuous steel frame which simplifies grounding and provides greater rigidity for added strength. This design has lower reaction forces during operation, and therefore a lighter foundation can be used.

Features include a viewing window allowing convenient visual check of the operations counter, OPEN/CLOSE indication, spring charge indications, manual CLOSE and TRIP buttons, and pull-to trip lever mounted on the outside of the breaker, which trips the breaker and prevents reclosing from any source until manual reset by the operator.

Distribution Breakers rated 15.5 kV have standard porcelain bushing that are rated 110 kV BIL with a rated maximum withstand line-to-ground voltage of 8.9 kV. Bushing for the 28.0 kV breakers are rated 125 kV BIL or 150 kV BIL with a rated maximum line-to-ground voltage of 16.2 kV. Epoxy bushing can be supplied as an option.

The minimum clearance for the breaker from the lowest live part of the bushing to the breaker is 8' 6" minus zero plus 6 inches.

Current transformers and Linear Couplers are designed and built to meet exacting ANSI standards. CT's are readily accessible, refer to Table 1 on page 12-3 for ratings. The design of the distribution breaker features space for up to two double accuracy current transformers per bushing for a total of 12 per breaker.

The housing will have two copper boss ground pads, located diagonally at the bottom of the housing, each capable of carrying full short-circuit capability. Each boss pad can accommodate terminals sized from 1/0 to 300 MCM cables.

Heaters are provided to minimize condensation within the housing. Two heaters, operated at one-half voltage, giving a total of 300 watts output will be furnished in each breaker.

The standard distribution breaker has a seismic withstand capability of 0.2g static as defined in NEMA SG-4-3.18 for General Purpose Breakers and a Wind load of 100 MPH sustained.

Distribution breaker construction is offered in stainless steel as an option.

The "E COAT" paint system is applied with the cathodic electrodeposition method which bonds the paint to all surfaces to resist adverse effects of harsh environments. In addition, a final exterior finish coat, ANSI 61, provides extra protection as a standard. Other color options are available and special customer requests can be handled within the guidelines of the EPA regulations. For additional information on the E-COAT system see GEA11088.

Table 1
Current Transformer for 1200 and 2000 Amp Breakers

Multi-Ratio, Relaying Accuracy

Standard Accuracy		*Double Accuracy	
Full Turns Ratio	Class	Full Turns Ratio	Class
600:5	C100	600:5	C200
1200:5	C200	1200:5	C400
2000:5	C400	2000:5	C800
3000:5	C400	3000:5	C800

*Maximum of 1 CT per Bushing

Single-Ration, Metering Accuracy

1200 Amp Breaker Only		1200 and 2000 Amp Breaker	
Full Turns Ratio	Class	Full Turns Ratio	Class
300:5	0.6B0.9	1200:5	0.3B1.8
400:5	0.6B1.8	1500:5	0.3B1.8
600:5	0.3B1.8	2000:5	0.3B1.8
800:5	0.3B1.8	3000:5	0.3B1.8

For Linear Couplers, Consult Factory

INTERRUPTERS

At the heart of the distribution breaker is the Power/Vac metalclad vacuum interrupter. To date, this design has accumulated over 800,000 interrupter years of reliable field service experience.

The interrupting assembly and mechanism module will be fixed (bolted) in the housing assembly with easy access to perform standard maintenance, but arranged so as to be removable as a unit for major maintenance or replacement as required.

Arc interruption typical occurs at the first current zero after contact separation. The high dielectric strength of the vacuum gap results in an extremely short clearing time. From a normal closed position, the breaker can complete fault interruption in five cycles. One set of contacts performs both main and arcing contact functions.

The interruption module provides as standard features, a mechanically actuated counter, a close/open indicator, a charged/discharged indicator, a primary contact erosion indicator, and a means for measuring and adjusting the primary contact gap and wipe. The mechanism will also have provisions for mounting a keylock or padlock to lock the breaker trip-free.

Power/Vac interrupters experience no significant contact erosion during normal duty. They are designed and tested to meet or exceed performance requirements of applicable ANSI, IEEE and NEMA standards (Reference Table 2 on page 12-4). Their rated interruption time is 5 cycles. A 3 cycle breaker is optional and available upon request.

The interruption module provides as standard features, a mechanically actuated counter, a close/open indicator, a charged/discharged indicator, a primary contact erosion indicator, and a means for measuring and adjusting the primary contact gap and wipe. The mechanism will also have provisions for mounting a keylock or padlock to lock the breaker trip-free .

OPERATION

The outdoor distribution breakers uses the Power/Vac standard ML-18 operating mechanism. In addition, the circuit breaker offers a wide range of control voltages for the motor, close coil and trip coil of; 48, 125, and 250 VDC or 120, 240 VAC (60hz) with auto-charged, capacitor trip device and a 350 VDC trip coil. Operating control voltage ranges are per ANSI C37.06-1987 and listed on Table 3 of this section.

An undervoltage trip device in voltages of 48, 125, 250 VDC is available as an option.

All protection, indication, control devices and terminal blocks are mounted within the weather-proof low voltage compartment. A hinged door behind the weather-proof door is provided for mounting the protective relay package. This panel when swung open provides easy access to the wiring terminals of the relays and to other related terminal boards. Door stops are provided as standard to hold these panels in the open position.

In addition to the auxiliary switch contacts (2"a" and 2 "b") provided on the mechanism for customer use, an optional stationary mounted auxiliary switch is available with 6 stage/12 contacts (6 "a" and 6 "b"), or a 3 stage/6 contacts (3 "a" and 3 "b"), or 10 stage/20 contacts (10 "a" and 10 "b").

All control wiring in the low voltage compartment is 600 volt insulation; oil, water and flame resistant, #14 copper stranded wire. Current transformer lead wires are #10 copper stranded wire. Standard wire terminations are spring spade or locking spade compression type. Other types are available as an option.

Table 2
Distribution Breaker Ratings

Breaker Type	Symmetrical Basis of Rating												
	Rated Values								Related Required Capabilities				
	Voltage		Insulation Level		Current					Current Values			
			Withstand Test Voltage							Maximum Symmetrical Interrupting Capability	3-Sec. Short Time Current Carrying Capability	Closing and Latching Capability 1.6K Times	
	Max. kV, Rms	Range Factor K	Low Frequency kV, Rms	Impulse kV, Crest	Continuous Current at 60 Hz Amp, Rms	Short-curcuit Current (At Rated Max. kV) KA, Rms	Inter-rupting Time Cycles	Rated Permissible Tripping Delay Y-seconds	Max. kV Divided by K kV, Rms	K Times Rated Short-circuit Current		Rated Short-circuit Current kA, Rms	Shipping Wt. In Lbs.
										kA, Rms	kA, Rms		
PVDB1-15.5-12000	15.5	1.0	50	110	600	12	5	2	15.5	12	12	20	2000
PVDB1-15.5-16000	15.5	1.0	50	110	800	16	5	2	15.5	16	16	26	2000
PVDB1-15.5-16000	15.5	1.0	50	110	1200	16	5	2	15.5	16	16	26	2000
PVDB1-15.5-20000	15.5	1.0	50	110	1200	20	5	2	15.5	20	20	32	2000
PVDB1-15.5-20000	15.5	1.0	50	110	2000	20	5	2	15.5	20	20	32	2300
PVDB1-15.5-25000	15.5	1.0	50	110	1200	25	5	2	15.5	25	25	40	2000
PVDB1-15.5-25000	15.5	1.0	50	110	2000	25	5	2	15.5	25	25	40	2300
PVDB1-15.5-40000	15.5	1.0	50	110	1200	40*	5	2	15.5	40	40	64	2000
PVDB1-15.5-40000	15.5	1.0	50	110	2000	40*	5	2	15.5	40	40	64	2300
PVDB1-15.5-40000	15.5	1.0	50	110	3000	40*	5	2	15.5	40	40	64	2300
PVDB2-28.0-12000	28.0	1.0	60	125	1200	12	5	2	28.0	12	12	20	2200
PVDB-2-28.0-20000	28.0	1.0	60	125	1200	20	5	2	28.0	20	20	32	2200
PVDB-2-28.0-25000	28.0	1.0	60	125	1200	25	5	2	28.0	25	25	40	2200
PVDB-2-28.0-12000	28.0	1.0	60	125	2000	12	5	2	28.0	12	12	20	2500
PVDB-2-28.0-20000	28.0	1.0	60	125	2000	20	5	2	28.0	20	20	32	2500
PVDB-2-28.0-25000	28.0	1.0	60	125	2000	25	5	2	28.0	25	25	40	2500

Note: Rating apply for 20 cycle reclosing time. Breaker rated 28.0kV has optional bushings rated 150kV BIL

* Burlington marketing must be consulted before quoting.

Table 3
Rated Control Voltage and Currents for Distribution Breakers ML-18

Control Voltage Source	Closing Range	Tripping Range	Close Coil	Tripping Coil Current 5 CYC 3	Motor Inrush Current	Motor Running Current	52 Y Relay Current	Fuse Size Close	Fuse Size Trip
48 VDC ohms	36-56	28-56	6.9	22 22 3.5 2.14	34 2.14	12	1.2W 1800	30	35
125 VDC ohms	100-140	70-140	3.4 20.8	10.5 7.3 11.9 12.2	23	3.4	1.2W 1000	15	35
250 VDC ohms	180-280	140-280	1.6 88.3	4.7 10.8 50 23.1	18	1.6	1.2W 1800	10	35
120 VAC ohms	104-127	295-360 *	3.4 20.8	3.7 3.7 78.9 78.9	35	4.5	2.0VA 2250	15	35
240 VAC ohms	208-254	295-360 *	1.6 88.3	3.7 3.7 78.9 78.9	20	2.5	2.7VA 7200	10	35

* Capacitor Trip

- Approximate spring charge time is 2 seconds
- Tripping circuit - for 240 VAC with capacitor trip use 10A fuse.

CAPACITOR SWITCHING CAPABILITIES

The distribution breaker PVDB-1 has an ML-18 mechanism and has a capacitor switching rating of 250 amp for single bank switching. Capacitor switching capabilities of the Power/Vac distribution breaker and how it relates to other capacitor switching information is contained in Table 4.

The breaker continuous current rating in amperes is the same as the nameplate rating of the breaker - that is 1200, 2000, 3000* amps. The capacitor current rating of the various distribution breakers does not follow the continuous current breaker rating. The capacitor current rating is expressed in capacitor bank rating MVAR and whether the bank is grounded or ungrounded.

GE can, however, supply a PVDB-1 distribution breaker for special requirements with a PV-41 interrupter and an ML-18 mechanism. This is for single bank only, not back-to-back switching.

Table 4
Maximum Nameplate or Bank MVAR

System Voltage		Ungrounded		Grounded	
	(kV)	1200A Bkr	2000A Bkr	1200A Bkr	2000A Bkr
PVDB-1	12.47	4.3	4.3	4.0	4.0
with ML-18	13.8	4.7	4.7	4.4	4.4
& PV-40	14.4	4.9	4.9	4.6	4.6
PVDB-1	12.47	20.7	34.6	19.2	32.0
with ML-18	13.8	23.0	30.1	21.3	23.6
& PV-41	14.4	23.4	26.3	22.0	24.7

Footnotes: The capacitor bank rating is subject to the following:

1. The capacitor bank rating applies only to single bank switching.
2. The transient voltage from line to ground shall not exceed 3 times maximum design line-to-ground crest voltage measured at the breaker terminals.
3. The number of restrikes or reignitions shall not be limited as long as the transient voltage to ground does not exceed the value given in footnote 2.
4. Interrupting time is in accordance with the rated interrupting time of the circuit breaker.

* For 3000 ampere rating consult marketing in West Burlington, IA.

TESTING

A series of tests are conducted with the breaker element in the equipment to verify operation. Interlocks, auxiliary switches, wiring, relays and other components are tested for continuity and correctness. Every breaker element under-goes a 300 operation CLOSE/OPEN mechanical run-in test at the factory, experience indicates most component failures occur within this period. Thus, this stress test catches nearly all problems in the factory before they can have a impact on the system integrity.

MAINTENANCE

A recommended preventive maintenance plan based on extensive tests and proven reliability is available for all switchgear users. While the user is totally responsible for determining their own maintenance program and inspection routine, this recommendation may be applied to switchgear operating under service conditions with mild environments as defined in ANSI Std C37.04

Circuit breakers utilizing vacuum technology have less moving parts than air, oil or SF6 breakers. And fewer operating parts means less can go wrong. The uncluttered configuration of the vacuum designed breaker allows for easier maintenance and significantly reduced spare/renewal parts inventory requirements.

Also, there is no contact maintenance. With vacuum, one set of contacts performs the function of both the main and arcing contacts that are required in other designs. These contacts are sealed in a high vacuum environment isolated from exposure to dirt, moisture and other pollutants.

The GE distribution breaker element is designed for 10,000 no-load operations and 5000 full load operations prior to maintenance. After 18 full fault interruptions, it is recommended that the contact erosion indicator be checked to estimate the remaining interrupter life. Standard maintenance is eliminated because the high vacuum environment isolates contacts from exposure to dirt, moisture and other pollutants.

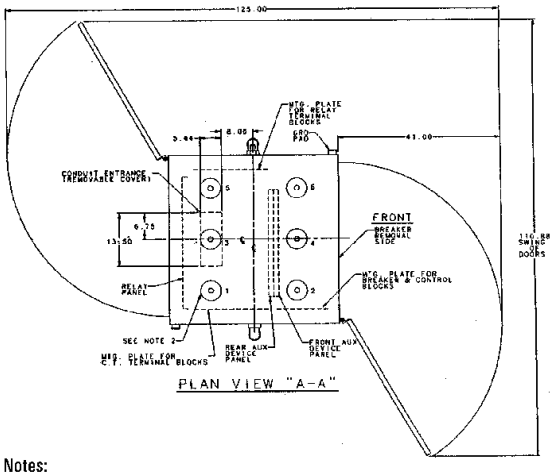
A means is provided for slow-closing the breaker mechanism during maintenance operations.

For specific information regarding the maintenance of devices such as circuit breakers, relays, meters, etc., refer to the separate GEK instruction books furnished for each device or to NFPA 70B.

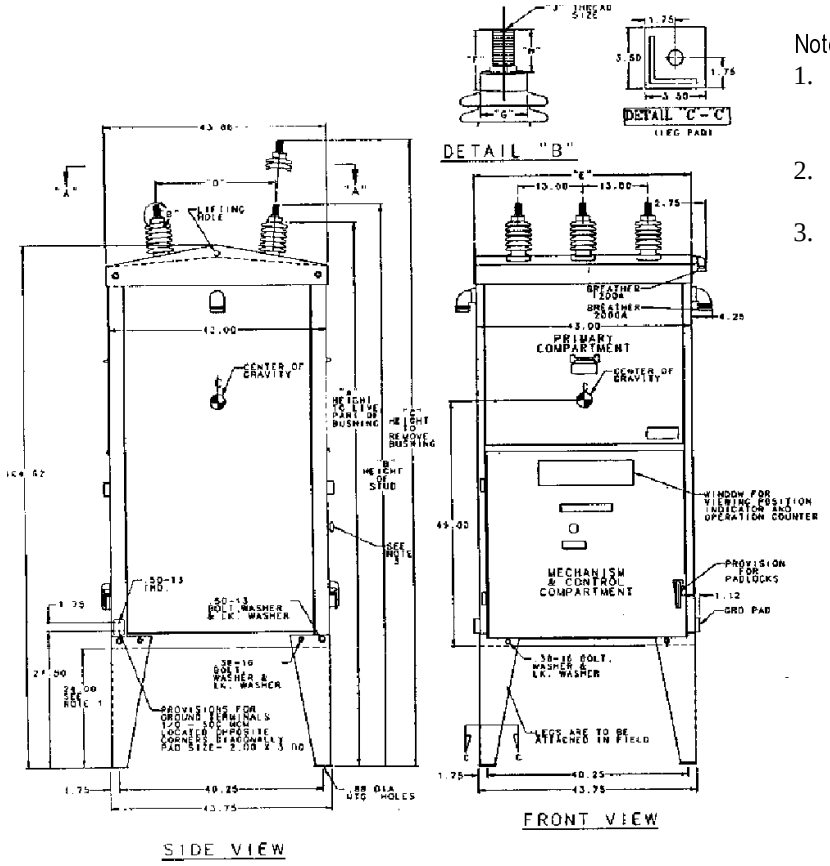
INSTALLATION

Distribution breakers are shipped completely assembled and ready for immediate installation, except for the legs, which are available in standard selected lengths of 12 and 18 inches and have provisions for anchoring to the foundation pad. Optional lengths available are 24, 30, and 36 inches.

For weights and breaker housing dimensions see Table 2 and Figure 12-1 for the 15.5 kV breaker and Table 2 and Figure 12-2 for the 28.0 kV breaker.



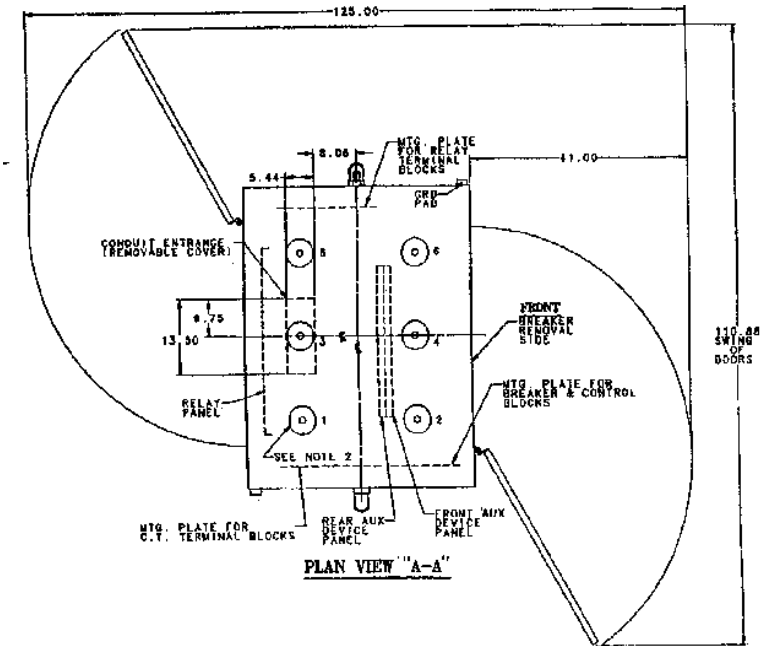
Notes:
1. 24.00 is standard leg height. For other leg heights (I.E. 12, 18, 30 & 36) adjust vertical dimensions accordingly.
2. Bushings 1, 3, 5, are connected to stationary side of vacuum interrupters.
3. "Emergency" pull to trip knob must be reset before breaker can be reclosed manually or electrically.



Notes:
1. 18.00 is standard leg height. For other heights (I.E. 12, 18, 30 & 36) adjust vertical dimensions accordingly.
2. Bushings 1, 3, 5, are connected to stationary side of vacuum interrupters.
3. "Emergency" pull to trip knob must be reset before breaker can be reclosed manually or electrically.

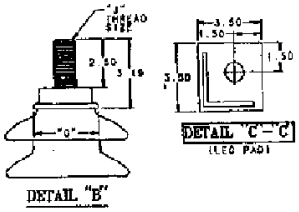
Rating	"A"	"B"	"C"	"D"	"E"	"F"	"G" DIA	"G"	"J"	Weight
Up to 1200 A	109.00	112.44	127.31	23.72	43.44	3.50	2.75	2.50	1.12-12	2000 lbs
Up to 2000 A	110.25	114.62	133.25	24.08	43.56	4.50	4.00	3.50	1.50-12	2300 lbs

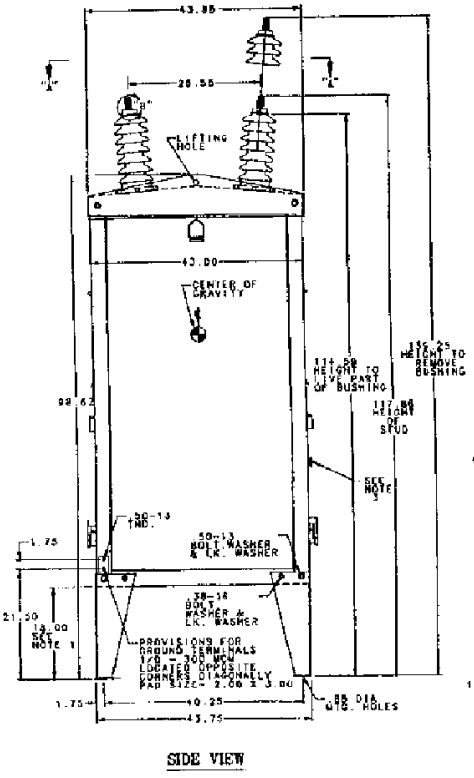
Figure 12-1 15.5 kV Distribution Breaker

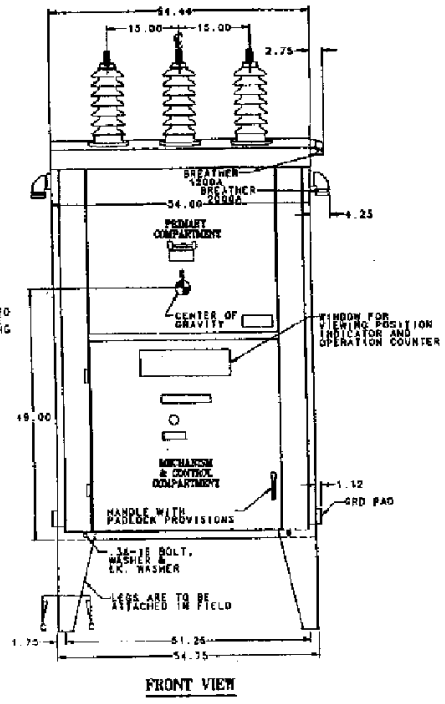


Notes:

1. 18.00 is standard leg height. For other heights (I.E. 12, 18, 30 & 36) adjust vertical dimensions accordingly.
2. Bushings 1, 3, 5, are connected to stationary side of vacuum interrupters.
3. "Emergency" pull to trip knob must be reset before breaker can be reclosed manually or electrically.







Rating	"G" DIA	"J"	Weight
Up to 1200 A	3.75	1.25-12	2200 lbs
Up to 2000 A	4.50	1.75	2500 lbs

Figure 12-2 28.0 kV Distribution Breaker

GE DISTRIBUTION RECLOSER

The Vacuum Distribution Recloser utilizes the same standard electrical design and physical construction as provided in the time proven Vacuum Distribution Breaker and detailed in the proceeding pages of this publication.

APPLICATION

The GE Recloser is a heavy-duty, power class type, four shot recloser, for use in applications on distribution circuits, within their voltage ratings and interrupting capability. The interrupting ampere rating of the reclosers must be as great as, or greater than, the maximum short-circuit current that they may be called on to interrupt. These new high-speed vacuum reclosers reduce the chance of line burn-down with approximately 5/3-cycle interruption of higher current faults on the initial operation.

The Type PVDR recloser is capable of interrupting at either 10,000, 12,000 or 16,000 amperes symmetrical fault current at rated voltage, depending on the particular unit specified. Recloser's have a continuous current rating of either 200, 400, 560, 800, or 1120 amperes. The duty cycle of each rating conforms to ANSI C37.60, Table 4, where applicable.

Reclosers are 100% rated for applications up to 3300 feet in altitude and where the temperature of the ambient is between -30°C and +40°C. For applications that exceed these requirements refer to additional information outlined in Section 3 of this publication or the nearest GE Sales Office.

DESCRIPTION

The Type PVDR, 15.5kV and 27.0kV, automatic vacuum distribution reclosers are designed to meet increased demands for uninterrupted power on distribution circuits requiring single or mult-shot reclosing.

The interrupter employed in the vacuum recloser is the standard vacuum interrupter used in the Power/Vac metalclad vacuum switchgear. To date, this design has accumulated over 800,000 interrupter years of reliable field service experience. GE introduced the world's first vacuum interrupter distribution breaker in the 1960's. Today, this same proven design is incorporated in the Vacuum Distribution Recloser.

Features include a viewing window allowing convenient visual check of the operations counter, open/close indication, spring charge indications, manual close and trip buttons, and manual pull-to trip lever mounted on the outside of the Recloser and prevents reclosing from any source until manual reset by the operator.

Each Distribution Recloser is manufactured, assembled and tested, including the vacuum bottles, at the West Burlington factory in Iowa. The housing design is outdoors, vented and designed to be proof against driving rain or snow, insects and vermin. The construction consists of a one-high, high voltage compartment and low voltage compartment. The one modular construction provides a continuous steel frame which simplifies grounding and provides greater rigidity for added strength. This design has lower reaction forces during operation and therefore a lighter foundation can be used. The complete Recloser is shipped in one piece with the adjustable legs to be mounted in the field which reduces the amount of installation time. For overall recloser construction details, weights, and dimensions refer to Figure 12-2.

The paint system is the GE standard "E COAT" system which is applies with the cathodic electrodepostion method which bonds the paint to all surfaces to resist adverse effects of harsh environments. In addition, a final exterior finish coat, ANSI 61, provides extra protection as a standard. Other color options are available and special customer requests can be handle within the guidelines of the EPA regulations. For additional information of the E-COAT system see GEA 11088.

Distribution Recloser construction is offered in stainless steal as an option.

HIGH VOLTAGE COMPARTMENT

There is but one high-voltage compartment containing three vacuum interrupters mounted between the individual phase porcelain entrance busing that are rated 110kV BIL with a rated maximum withstand line-to-ground voltage of 8.9kV.

The interrupter employed is quite a relative simple device, consisting of a pair of butt contacts, a vapor-condensing shield and a bellows through which one of the contacts is moved, all sealed in a vacuum tight enclosure. The interrupter requires no maintenance, has an exceptionally long interrupting life and its internal condition can be readily determined by field checks as described in the GEK instruction book. Polyester glass insulators connect the interrupter's moving contact to the linkage. Air at atmosphere pressure provides the primary insulation, eliminating the need for oil or other insulating media .

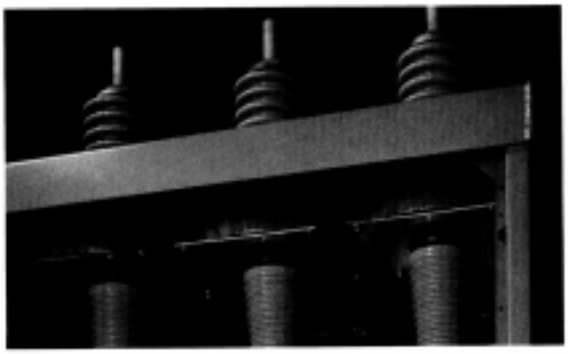
The Recloser operation features a ML-18 motor operated spring charged mechanism which is electrically trip-free. In addition, the recloser offers a wide range of control voltages for the motor, close coil and trip coil of; 48, 125, and 250 VDC or 120 VAC and 240 VAC (60hz) with an auto-charged, capacitor trip device and a 350 VDC trip coil. Operating control voltage and current ranges are per ANSI C37.06-1987 and listed on Table 5.

Table 5
ML-18 & ML-18H

Control Voltage Source	Closing Range	Tripping Range	Closing Coil Current		Tripping Coil Current		Motor Inrush Current	Motor Windup Current	Fuse Size Close CKT. Protection	
			W/O FBT	With FBT	5 Cycle	3 Cycle			W/O FBT	With FBT
48 VDC	38-56	28-56	13.7	-	22	22	34	17	30	-
125 VDC	100-140	70-140	6.0	35.7	7.3	10.5	23	8.0	20	30
250 VDC	200-280	140-280	2.8	12.0	4.7	10.8	18	3.8	15	20
240 VDC	208-254	295-360 •	2.8	-	3.7	14.7	20	6.0	20	30
120 VAC	104-127	295-360 •	6.0	-	3.7	14.7	35	15	20	-

• Capacitor Trip, 208-254 for ML18H
- Approximate Spring Charge Time: ML18=3 sec
- Tripping Circuit Fuse is 35A except for 240 VAC with Capacitor Trip - Use 10A

If the customer chooses to select AC control power with a capacitor trip device, the capacitor trip device can not be used to supply power to the recloser relay. An option with the recloser control relay for those systems that use AC power for control power is to install a UPS system to power the relay.



Space is available on all bushing for two current transformers per bushing of the multi-ratio relay type or single ration metering type.

Table 6
Current Transformer for 1200 Amp Recloser

Multi-Ratio, Relaying Accuracy

Standard Accuracy		*Double Accuracy	
Full Turns Ratio	Class	Full Turns Ratio	Class
600:5	C100	600:5	C200
1200:5	C200	1200:5	C400
2000:5	C400	2000:5	C800

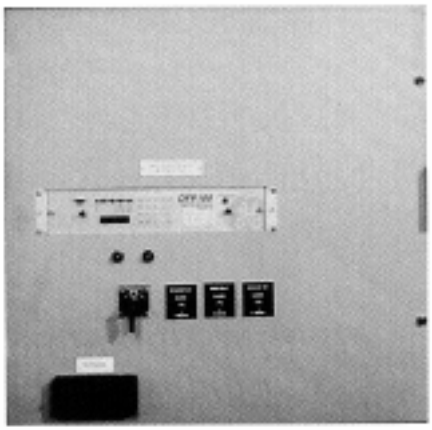
* Maximum of 1CT per Bushing

Single-Ration, Metering Accuracy

1200 Amp Breaker Only	
Full Turns Ratio	Class
300:5	0.6B0.9
400:5	0.6B1.8
600:5	0.3B1.8
800:5	0.3B1.8
1200:5	0.3B1.8

LOW VOLTAGE COMPARTMENT

The low voltage compartment contains all the relays, metering and terminal blocks which are completely insulated from the high voltage section and mounted within the weather-proof low voltage compartment. A hinged door within the weather-proof compartment is provided for mounting the recloser relay package. This panel when swung open provides easy access to the wiring terminals of the relays and to the other related terminal boards. Door stops are provided as standard to hold these panels in the open position.



AUTOMATIC RECLOSER CONTROL

The control unit used in the Type PVBR is by either a GE DFP100 or DFP200 integrated microprocessor based drawout relay, which provides protection, control and monitoring for substation reclosers. These extremely flexible digital relays are designed to provide, up to six multiple setting groups for, instantaneous, inverse, and extremely inverse time-current tripping for coordination with other reclosers, breakers, relaying and fuses. They provide a single to four shot recloser circuit that can operate with one instantaneous and three time delayed recloser shots. For each reclose attempt, the time between trip and reclose can be independently programmed between 1 and 600 seconds. This allows the user to program which functions are allowed to initiate reclosing for each of the recloser shots and which functions are allowed to trip after the shot.

Remote communications can be interfaced through an RS232 port front and back or an optonal RS485 port in the back. The serial ports provide full access to data, metering, and recloser status. Serial port communication security is maintained with three levels of password protection. Several communications protocols are available; GE Link, ASCII, ModBus and DNP 3.0. For additional DFP functions and information, refer to GEZ 8188.

The DFP100 and DFP200 digital relay, while controlling the recloser functions, also provide a digital protection, control, metering and monitoring system. The DFP's use waveform sampling of the current and voltage inputs, together with appropriate algorithms to provide distribution feeder protection. By incorporating the protection, control and metering with both local and remote human interfaces in one assemble, it eliminates the need for expensive discrete components. The relays store up to 200 events with the date and time stamped to the nearest millisecond and captures current and voltage waveforms at 16 samples per cycle. Up to six total oscillography records can be stored in memory. In additional, the DFP200 provides, as on option, High Impedance Fault Detection. The Hi-Z fault detection funtion is intended to detect high impedance arcing faults, and to differentiate between downed conductors and other arcing faults.

Table 7
Three Phase Vacuum Recloser Performance Characteristics

Nominal System Voltage, kV rms	Rated Maximum Voltage, kV rms	Rated Impulse Withstand Voltage, kV Crest	Low-Frequency Insulation Level Withstand Test kV rms		Current Ratings (Amps)	
			1 min Dry	10 s Wet	Continuous, 60 Hz	Symmetrical Interrupting at Rated Maximum Volts
14.4	15.5	110	50	45	200	2000
14.4	15.5	110	50	45	400	6000
14.4	15.5	110	50	45	560	12000
14.4	15.5	110	50	45	800	12000
14.4	15.5	110	50	45	560	16000
14.4	15.5	110	50	45	800	16000
14.4	15.5	110	50	45	1120	16000

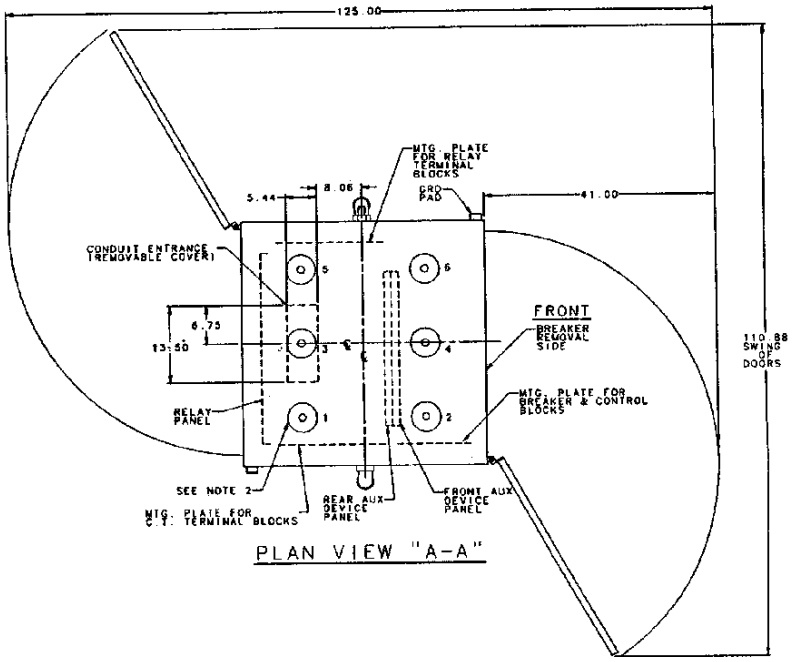
Existing bushing current transformers provided with the Recloser are used for ac current measurements.

Table 8
Recloser Settings

Recloser Settings	
Description	**Range**
Number of Reclosers	1 to 4
Number of Repetitive Trips	1 to 50
Reset Time Available	1.00 to 600.00 seconds
Hold Time	0.00 to 100.00 seconds
Reclose Delay	0.10 to 600.00 seconds

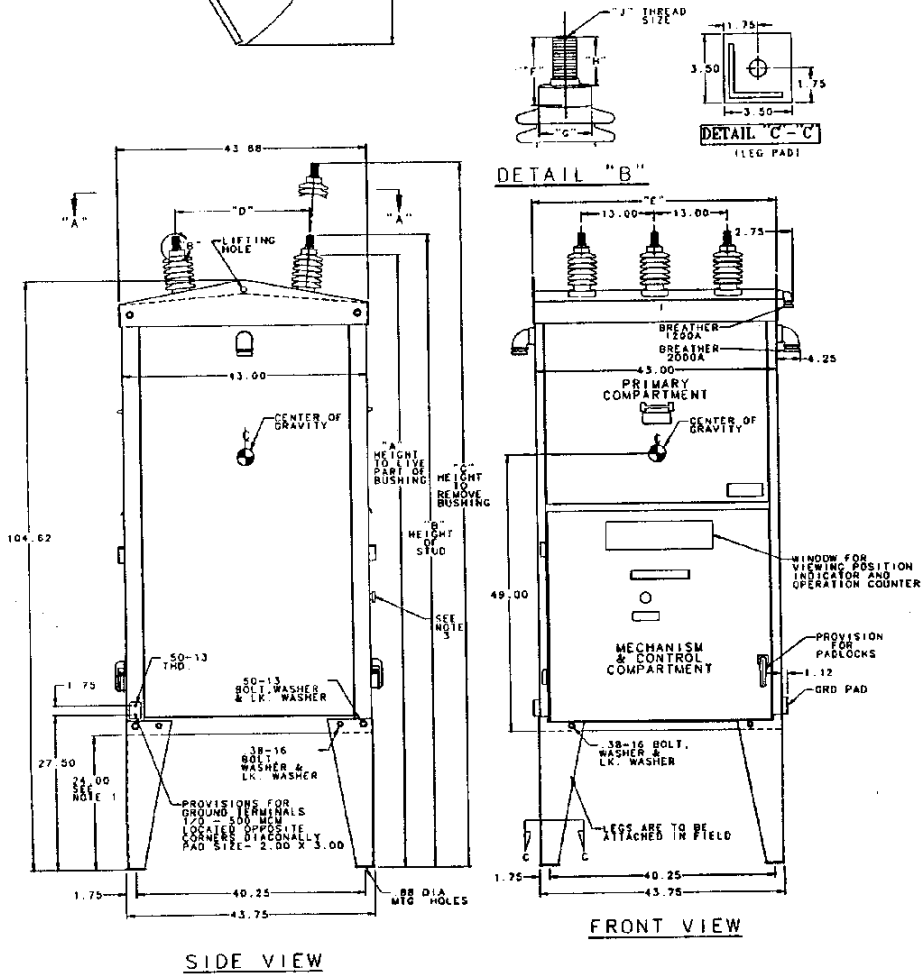
When instrumentation voltage transformers are available from the customer, these will be used for ac voltage measurements. Input control power shall be 120/240 vac from an external power transformer. Output from this same control power transformer shall be used for single-phase voltage and frequency information when instrumentation voltage transformers are not available at a substation.

If required, backup power can be supplied from a UPS or battery system.



Notes:

1. 18.00 is standard leg height. For other heights (I.E. 12, 18, 30 & 36) adjust vertical dimensions accordingly.
2. Bushings 1, 3, 5, are connected to stationary side of vacuum interrupters.
3. "Emergency" pull to trip knob must be reset before breaker can be reclosed manually or electrically.



Rating	"A"	"B"	"C"	"D"	"E"	"F"	"G" DIA	"G"	"J"	Weight
Up to 1200 A	109.00	112.44	127.31	23.72	43.44	3.50	2.75	2.50	1.12-12	2000 lbs
Up to 2000 A	110.25	114.62	133.25	24.08	43.56	4.50	4.00	3.50	1.50-12	2300 lbs

Figure 12-3 15.5 kV Distribution Recloser

TESTING

A series of tests are conducted with the recloser element before installing in the Distribution Recloser and after installation to verify operation. Interlocks, auxiliary switches, wiring, relays and other components are tested for continuity and correctness. Every recloser element under-goes a 300 operation CLOSE/OPEN mechanical run-in test at the factory, experience indicates most component failures occur within this period. Thus, this stress test catches nearly all problems in the factory before they can have an impact on the system integrity.

MAINTENANCE

A recommended preventive maintenance plan based on extensive tests and proven reliability is available for all recloser users. While the user is totally responsible for determining their own maintenance program and inspection routine, this recommendation may be applied to recloser operating under service conditions with mild environments as defined in ANSI Std C37.61.

Distribution Reclosers utilizing vacuum technology have less moving parts than air, oil or SF6 breakers. And fewer operating parts means less can go wrong. The uncluttered configuration of the vacuum designed recloser allows for easier maintenance and significantly reduced spare/renewal parts inventory requirements.

Also, there is no contact maintenance. With vacuum, one set of contacts performs the function of both the main and arcing contacts that are required in other designs. These contacts are sealed in a high vacuum environment isolated from exposure to dirt, moisture and other pollutants.

For specific information regarding the maintenance of devices such as distribution reclosers, relays, meters, etc., refer to the separate GEK instruction books furnished for each device or to NFPA 70B.

INSTALLATION

Distribution reclosers are shipped completely assembled and ready for immediate installation, except for the legs, which are available in standard selected lengths of 12 and 18 inches and have provisions for anchoring to the foundation pad. Optional lengths available are 24, 30, and 36 inches. For weights and recloser housing dimensions see Figure 12-3 for the 15.5kV recloser .

Contents

Section 13
Vertical Lift Vacuum Power Circuit Breaker

13

Vertical Lift Vacuum Power Circuit Breaker

APPLICATION

GE Power/Vac® Vertical Lift "VL" circuit breakers in 5 kV and 15 kV ratings have the tried and proven components of the GE Power/Vac® breaker which have been engineered and designed into a completely **new** medium voltage vertical lift breaker to replace the Type "AM" air magna-blast vertical lift circuit breaker. Reference Table 1.

To maintain GE quality and reliability the VL circuit breaker has been engineered and designed tested to ANSI C37.06 and C37.59 from the ground up to be directly interchangeable with the existing direct roll-in GE magna-blast breakers and contains all new, unused parts. Existing GE drawings and product engineering summary sheets are used to make replacements simpler, safer and faster. These engineering documents have been maintained and updated on the vertical lift AM breakers by GE since the early 1950's. The tools. dies, jigs and fixtures emanate from the original equipment and do not rely on previously used frame and top plate assemblies for questionable alignments. The breaker retro-fit requires no cable re-routing and no cable modifications to the switchgear.

The 5 kV GE Vertical Lift breaker is 28" wide and uses the standard Power/Vac® interrupters with a new designated ML-19 mechanism. The ML-19 mechanism retains the original design of the Power/Vac® and 65% of the original parts of a ML-18 mechanism. This product is currently in final design. GE Marketing in West Burlington, Iowa must be consulted before specifying.

The 8.25 kV and the 15 kV GE Vertical Lift breakers are used in the standard 36" width compartment and they retain the time proven ML-18 mechanism.

Experience has shown that normal wear and aging of contacts, mechanisms, insulation and arc chutes of the AM breaker can lead to failure. Also, electrical distribution systems have grown over the years, leaving equipment underprotected. Equipment, production and personnel may be at risk, and down-time is costly. Power/Vac® VL will extend the useful life of Type AM, magna-blast metalclad breakers and reduce breaker maintenance costs by as much as 50%.

The Power/Vac® VL is not a vacuum conversion breaker that uses old frames, bushing or other parts, nor does it rely on the proper installation of an "interlock kit" to ensure safe operation. In providing a new VL breaker downtime is saved. It is not required that the magna-blast breakers be taken out of service for lengthy periods while the unit is converted to vacuum. As some competitors modify the existing breakers versus building new.

The VL breakers use all new parts, including frames, bushing, interlocks, mechanisms, secondary disconnects and position switches. Original design documents are referenced before manufacturing to ensure exact mechanical and electrical replacement of existing Magna-Blast Type AM breakers. An inspection should be of the breaker compartment to verify that interlocks, wiring, insulation and the racking mechanism are in acceptable working condition.

To ensure the original design requirements are meet, it is required that the customer review and/or submit the on-site drawing of the switchgear to GE. This will identify any additions or deletions to the wiring by the customer and allow for the inclusion of these wiring changes into the design for the new VL breaker. See DET-198.

TESTING

From a safety and quality standpoint, Power/Vac® VL breakers exceed all applicable ANSI/IEEE requirements for new general purpose breakers. Rigorous testing to ANSI C37.59 includes active/passive interlocks, dielectric, momentary, temperature rise, and mechanical life. Bushing have been corona tested inside a magna-blast compartment to ensure dielectric integrity during insertion and removal from the connect position. Every VL breaker undergoes production tests which includes 300 mechanical operations, high potential testing, min/max control voltage operational tests and min/max timing tests with travel curves produced.

The GE Power/Vac® "VL" breaker is not merely a "retrofitted adaptation" of a horizontal drawout breaker, but a true direct roll-in vertical lift circuit breaker. Where safety concern is first and internal live part clearances are more than the original breakers. The assurance of performance, conformance, reliability, maintainability and durability with this new design is second to none.

Power/Vac® "VL" breaker is engineered to be a direct roll-in "replacement", requiring no cable re-routing and no cubicle modifications.

Replacing an air magnetic (Type AM) medium voltage circuit breaker to vacuum operation provides substantial opportunity to extend the life of the existing breaker and consideration of switchgear upgrade, while significantly increasing reliability.

Table 1
POWER/VAC VL Vacuum Replacement Breakers are Available in the Ratings shown below for Insertion into 5 kV, 28" Wide and 15 kV, 36" Wide Mane-Blast Type AM Breaker Compartments

Symmetrical Rating Basis ANSI C37.06 (1979)

		Rated Values								Related Required Capabilities			
		Voltage		Insulation Level		Current					Current Values		
				Rated Withstand Test Voltage							Maximum Symmetrical Interrupting Capability	3-Sec. Short Time Current Carrying Capability	
Nominal RMS Voltage Class (kV)	Nominal 3-Phase Class (MVA)	Rated Max. RMS Voltage (kV)	Rated Voltage Range Factor K	Low Frequency RMS Voltage (kV)	Crest Impulse Voltage (kV)	Continuous RMS Current Rating at 60 Hz (A)	Short-circuit RMS Current Rating (at Rated Max. KV) (KA)	Rated Inter-rupting Time (Cycles)	Rated Permissible Tripping Delay Y (Seconds)	Rated Max. RMS Voltage Divided by K (kV)	K Times Rated Short-circuit RMS Current		Closing and Latching Capability RMS Current (kA)
											kA	kA	
4.16	250	5	1.24	19	60	1200	29	5	2	3.85	36	36	58
4.16	250	5	1.24	19	60	2000	29	5	2	3.85	36	36	58
4.16	350	5	1.19	19	60	1200	41	5	2	4.0	49	49	78
4.16	350	5	1.19	19	60	2000	41	5	2	4.0	49	49	78
7.2	250	8.25	1.25	36	95	1200	33	5	2	6.6	41	41	66
7.2	250	8.25	1.25	36	95	2000	33	5	2	6.6	41	41	66
7.2	500	8.25	1.25	36	95	1200	33	5	2	6.6	41	41	66
7.2	500	8.25	1.25	36	95	2000	33	5	2	6.6	41	41	66
7.2	500	8.25	1.25	36	95	2500	33	5	2	6.6	41	41	66
13.8	150	15	1.30	36	95	1200	18	5	2	11.5	23	23	37
13.8	150	15	1.30	36	95	2000	18	5	2	11.5	23	23	37
13.8	250	15	1.30	36	95	1200	18	5	2	11.5	23	23	37
13.8	250	15	1.30	36	95	2000	18	5	2	11.5	23	23	37
13.8	500	15	1.30	36	95	1200	18	5	2	11.5	36	36	58
13.8	500	15	1.30	36	95	2000	18	5	2	11.5	36	36	58
13.8	500	15	1.30	36	95	2500	18	5	2	11.5	36	36	58
13.8	750	15	1.30	36	95	1200	28	5	2	11.5	36	36	58
13.8	750	15	1.30	36	95	2000	28	5	2	11.5	36	36	58
13.8	750	15	1.30	36	95	2500	28	5	2	11.5	36	36	58
13.8	1000	15	1.30	36	95	1200	37	5	2	11.5	48	48	77
13.8	1000	15	1.30	36	95	2000	37	5	2	11.5	48	48	77
13.8	1000	15	1.30	36	95	3000	37	5	2	11.5	48	48	77

NOTE: Optional 4000A and 5000A breakers are available. Burlington must be consulted before ordering.
*Consult GE Marketing in West Burlington before specifying.

Vertical Lift Vacuum Power Circuit Breaker

LONGER LIFE

Longevity and reliability are two factors that should be considered in reviewing the requirements of upgrading your medium voltage breakers and power system. With the GE Power/Vac interrupter element and the ML's mechanism, you get proven quality demonstrated in over 800,000 interrupter years of vacuum service.

Can Magna-blast type switchgear also be upgraded? Some GE magna-blast switchgear may be reviewed for upgrading to a higher MVA, example: 500 MVA to 750 MVA or 750 MVA to 1000 MVA, depending on the original design. To evaluate a Switchgear upgrade the following information must be obtained and forwarded to GE Switchgear Operations in West Burlington, Iowa; shop order and requisition number of the switchgear, including the breaker serial number and nameplate data. See DET-198.

MAINTENANCE

A recommended preventive maintenance plan based on extensive tests and proven reliability is available for all switchgear users. While the user is totally responsible for determining their own maintenance program and inspection routine, this recommendation may be applied to switchgear operating under service conditions with mild environments as defined in ANSI Std C37.04.

Circuit breakers utilizing vacuum technology have less moving parts than air, oil or SF6 breakers. And fewer operating parts means less can go wrong. The uncluttered configuration of the vacuum designed breaker allows for easier maintenance and significantly reduced spare/renewal parts inventory requirements.

Also, there is no contact maintenance. With vacuum, one set of contacts performs the function of both the main and arcing contacts that are required in other designs. These contacts are sealed in a high vacuum environment isolated from exposure to dirt, moisture and other pollutants.

The GE Vertical Lift (VL)Vacuum circuit breaker element is designed for 18 full fault operations, 10,000 no-load operations or 5,000 load operations prior to maintenance. After 5 full fault interruptions, it is recommended that the contact erosion indicator be checked to estimate the remaining interrupter life. Standard maintenance is eliminated because the high vacuum environment isolates contacts from exposure to dirt, moisture and other pollutants.

Caution: Addition of a new VL Breaker does not substitute the original requirements for the Magna-blast switchgear in regards to interrupting capabilities and maintenance requirements.

A means is provided for slow-closing the breaker mechanism during maintenance operations.

In addition, a test cabinet can be provided as an option to allow testing of the circuit breakers from a location remote from the switchgear.

For specific information regarding the maintenance of devices such as circuit breakers, relays, meters, etc., refer to the separate GEK instruction books furnished for each device or to NFPA 70B.

QUALITY

A Power/Vac® VL circuit breaker is more rugged and lighter. Vulnerable parts such as asbestos arc chutes, box barriers and air booster cylinders have been eliminated. In their place is a compact vacuum bottle which fully contains the arc and literally draws it apart in less than 5 cycles. When the AC circuit is opened by contact separation in vacuum, interruption occurs at the first current zero. Dielectric strength across the contacts rises at a rate thousands of times higher than is possible with conventual circuit breakers. Because vacuum is nearly a perfect dielectric for arc extinction, no oil, gas or high pressure air is needed to aid interruption. The result is a more simplified design of operation that is both quiet and reliable.

INSTALLATION

Installation is as easy as rolling out your old Magna-blast breakers and rolling in your new Power/Vac® VL replacements. VL breakers minimize downtime by arriving on site ready for immediate insertion into the existing magna-blast compartment.

Section 14
Guide Form Specifications

Guide Form Specifications

FOR POWER/VAC SWITCHGEAR
INTRODUCTION

Upon completion of the one-line diagram and the layout of the equipment lineup, the specifier may use the following guide to prepare his purchase specifications for Power/Vac Switchgear. The form is completed by circling the appropriate ratings and filling in the blanks.

For the specifier's convenience, the following pages illustrate the content of the specification guide applicable to the available pre-engineered, medium-voltage switchgear assemblies. Refer to GET 6600E for additional information.

SWITCHGEAR SPECIFICATIONS

GENERAL

The (indoor), (outdoor), (protected aisle), (common aisle) metalclad switchgear described in this specification is intended for use on a (2400-volt) (4160-volt) (4800-volt) (6900-volt) (13,800-volt), three phase, (three-wire) (four-wire) (grounded) (ungrounded) 60-Hz system. The switchgear shall be rated (5000-volts) (8250-volts) (15,000-volts) and shall have removable-element vacuum circuit breakers. The enclosure and circuit breaker, either individually or as a unit, shall have a basic impulse rating of (60 kV) (95 kV). The switchgear, including circuit breakers, meters, relays, etc. shall be factory tested.

APPLICABLE STANDARDS

The switchgear equipment covered by these specifications shall be designed, tested, and assembled in accordance with the latest applicable standards of ANSI, IEEE, and NEMA.

ARRANGEMENT

The switchgear shall include the units as shown on the attached one-line diagram.

STATIONARY STRUCTURE

The switchgear shall consist of ( ) breaker units and ( ) auxiliary units assembled to form a rigid, self-supporting, completely metal-enclosed structure. Outdoor metalclad switchgear shall be enclosed in a weatherproof enclosure and shall include: suitable weatherproof access doors or doors with provision for padlocking; protected openings for ventilation as required; interior lighting and utility outlets with protective devices; and equipment heaters with protective devices. In each unit, the major parts of the primary circuit, such as the circuit breaker, buses, voltage transformers, and control power transformers shall be completely enclosed by grounded metal barriers. This shall include an inner barrier in front of, or part of, the circuit breaker.

CIRCUIT BREAKER COMPARTMENT

Each circuit breaker compartment shall be designed to house (4160-volt) (7200-volt) (13,800-volt), removable-element circuit breakers. The stationary primary-disconnecting contacts shall be constructed of silver-plated copper. Grounded-metal safety shutters shall be provided which isolate all primary connections in the circuit breaker compartment when the breaker is withdrawn from the connected position.

GROUND BUS

The standard ground bus matches the rating of the main bus and is ¼-inch by 2-inch copper up to a rating of 1000 MVA, which equates to 50 kA symmetrical 2 second rating. For the special 1500 MVA applications, the ground is 0.40-inch by 2-inch to achieve a 63 kA symmetrical 2 second rating.

The ground bus extends throughout the lineup with connections to each breaker grounding contact and each cable compartment ground terminal. All joints are made with at least two 3/8-inch zinc-plated, bronze iridescent chromate conversion coated steel bolts per joint. Station ground connection points are located in each end section.

BUS COMPARTMENT

The main bus shall be rated (1200 amperes) (2000 amperes) (3000 amperes) (3500 amperes) (4000 amperes). Bus bars shall have a continuous current rating, in accordance with ANSI standards of temperature rise and documented by design tests. Bus and bus joints will be tin plated with at least two bolts per joint. Bus bars will be braced to withstand the magnetic stresses developed by currents equal to the main power circuit breaker close, carry, and interrupt ratings. The bus shall be provided with front access through removable panels.

FINISH

All steel surfaces shall be chemically cleaned and treated to provide a bond between the primer paint and metal surfaces. The switchgear exterior will be finished with air-dried acrylic enamel of gray color (ANSI 61) for outdoor equipment or cathodic electrodeposition of light gray epoxy paint (ANSI 61) for indoor equipment.

CIRCUIT BREAKERS

The circuit breakers shall be rated (4160) (7200) (13,800)-volts, 60-Hz, with a continuous current rating of (1200) (2000) (3000) (3500) (4000)-amperes and a nominal interrupting rating of (250) (350) (500) (750) (1000)(1500) MVA. All circuit breakers of equal rating shall be interchangeable.

The circuit breaker shall be operated by an electrically charged, mechanically and electrically trip-free, stored-energy operating mechanism. Provision shall be included for manual charging of the mechanism and for slow closing of the contacts for inspection or adjustment.

The circuit breaker shall be equipped with secondary disconnecting contacts, which shall automatically engage in the connected positions.

The breaker compartment shall be furnished with a mechanism which will move the breaker between the operating and disconnect positions. The mechanism shall be designed so that the breaker will be self-aligning and will be held rigidly in the operating position without the necessity of locking bars or bolts. In the disconnect position, the breaker shall be easily removable from the compartment.

Interlocks shall prevent moving the breaker to or from the operating position unless its contacts are in the open position. As a further safety precaution, the operating springs shall be discharged automatically when the breaker is rolled fully into the compartment or is moved into the disconnect position. Means shall be provided for padlocking the racking mechanism in either the connected (operating) position or the disconnected position. When locked in the disconnected position, the breaker shall be removable from the compartment. Padlocking shall not interfere with operation of the breaker or its mechanism.

The circuit breaker control voltage shall be (48 volts dc) (125 volts dc) (250 volts dc) (120 volts ac 60-Hz) (240 volts ac 60-Hz) with capacitor trip device.

INSTRUMENT TRANSFORMERS

Current Transformers

Current transformers shall have ratios and relay and metering accuracy as indicated in the details of each switchgear unit. The transformers shall have mechanical rating equal to the momentary rating of the circuit breakers, and shall be insulated for full voltage rating of the switchgear.

Voltage Transformers

Voltage transformers shall be drawout type, equipped with current-limiting fuses, and shall have an accuracy as required by the details of each switchgear unit. The ratio shall be as indicated in each switchgear unit specification.

CONTROL WIRING

Secondary control wiring shall be No. 14, extraflexible, stranded, tinned-copper control wire; Type SIS (Vulkene®), rated 600 volts, except for specific circuits for which a larger wire size is required. Crimp-type, un-insulated spade terminals shall be furnished on all wire ends, except where non-insulated ring terminals are used to connect to fuse blocks, instrument studs, or terminal block points which have two or more wire connections. Secondary control wires shall be armored or enclosed in grounded metal troughs where they pass through primary compartments.

DRAWINGS

Upon award of the contract, the manufacturer shall furnish drawings for (record) (approval and record). Drawings for approval shall include a front view, plan view, elementary diagram, and device summary. Drawings for record shall include the above information, plus wiring diagrams.

DEVICES

All protection, instrumentation, and control devices shall be General Electric type, as indicated, or equal.

GENERAL PURPOSE FEEDER (GPF)

BASIC UNIT

The metalclad switchgear for control of a feeder circuit shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) (3500) (4000*) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) (3500) (4000*) amperes.
1 Digital relay, Type MDP three-phase overcurrent.
1 Current transformers, single secondary, :5 ratio, Type ITI.
1 Switch, breaker control, Type SBM.
2 Indicating lamps, breaker open-close, red and green, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
1 Ammeter, indicating, Type AB-40.
1 Switch, ammeter transfer, Type SBM.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cable per phase, maximum.)

*4000A is fan cooled.

DEVICE OPTIONS

1 Multifunction digital relay type DFP100, DFP200, SR750

or

3 Relays, phase overcurrent, Type IFC or DIFC.

or

1 Relay, ground sensor overcurrent, instantaneous, Type HFC

or

Relay, ground sensor overcurrent, time-delay, Type IFC

or

Relay, overcurrent residual, Type IFC.

1 Watthour meter Type DS-63

or

Watthour demand meter, Type DSM-63.

1 Voltmeter, Type AB-40
1 Switch, voltmeter transfer, Type SB-1.
3 Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
1 Relay, circuit breaker reclosing, Type SLR.
1 Switch, reclosing relay cut-off, Type JBT.
1 Test block current, Type PK-2.
1 Test block, voltage, Type PK-2.
1 Switch, permissive, Type SB-1 (in lieu of breaker control switch).
1 Indicating lamp, breaker disagreement, Type ET-16.
1 Switch, breaker position, Type SB-12. (For remote control.)
3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
3 Current transformers, single secondary, :5, ratio, Type ITI (for transformer differential).
1 Current transformer, ground-sensor, 50:5 ratio, ITI.
3 Surge arresters.

BREAKER BYPASS FEEDER (BBF)

BASIC UNIT

The metalclad switchgear for control of a breaker by-pass feeder circuit shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) (3500) (4000*) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) (3500) (4000*) amperes.
1 Space for power circuit breaker of same rating. Output terminals paralleled with output terminals of above breakers.
1 Digital relay, three-phase overcurrent, Type MDP
6 Current transformers, single secondary :5 ratio, Type ITI. (Three located on output terminals on each breaker position.)
2 Switches, breaker control, Type SBM.
4 Indicating lamps, breaker open-close, two red and two green, Type ET-16.
2 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
2 Breaker tripping fuse block, pull-out type, two-pole, 30 amperes.
1 Ammeter, indicating, Type AB-40. (Scale to match CT).
1 Switch, ammeter transfer, Type SBM.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

*4000A is fan cooled

DEVICE OPERATIONS

1 Multifunction digital relay, Type DFP100, DFP200, SR750.

or

3 Relays, phase overcurrent, Type IFC or DIFC.

or

1 Relay, ground-sensor overcurrent, instantaneous, Type HFC.

or

Relay, ground-sensor overcurrent, time-delay, Type IFC.

or

Relay, residual overcurrent Type IFC.

1 Watthour meter, Type DS-63

or

Watthour demand meter, Type DSM-63.

1 Voltmeter, Type AB-40.
1 Switch, voltmeter transfer, Type SB-1.
3 Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
1 Relay, circuit breaker reclosing, Type SLR.
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2.
2 Switch, permissive Type SB-1 (in lieu of breaker control switch).
2 Indicating lamp, breaker disagreement, Type ET-16.
2 Switch, breaker position, Type SB-12. (For remote control.)
3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
3 Current transformers, single secondary, :5 ratio, Type ITI (for transformer differential).
1 Current transformer, ground-sensor, 50:5 ratio, ITI.

TRANSFORMER PRIMARY FEEDER (TPF)

BASIC UNIT

The metalclad switchgear for control of a transformer primary feeder circuit shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) (3500) (4000*) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.

1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) (3500) (4000*) amperes.

1 Multifunction digital transformer relay, Type SR745

1 Relay, lockout, Type HEA.

3 Current transformers, single secondary :5 ratio, Type ITI.

3 Current transformers, single secondary, :5 ratio, Type ITI (for transformer differential).

1 Switches, breaker control, Type SBM.

3 Indicating lamps, breaker open-close, two red and two green, Type ET-16.

1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.

2 Breaker tripping and lockout fuse block, pull-out type, two-pole, 60 amperes.

1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

*4000A is fan cooled.

DEVICE OPTIONS

3 Relays, phase overcurrent, Type IFC.

3 Relays, transformer differential, Type STD.

1 Relay, auxiliary, transformer sudden pressure, Type HAA.

1 Ammeter, indicating, Type AB-40.

1 Switch, ammeter transfer, Type SBM.

or

1 Relay, ground-sensor overcurrent, instantaneous, Type HFC.

or

Relay, ground-sensor overcurrent, time-delay, Type IFC.

or

Time overcurrent residual relay, Type IFC.

1 Watthour meter, Type DS-63

or

Watthour demand meter, Type DSM-63.

1 Voltmeter, Type AB-40.

1 Switch, voltmeter transfer, Type SB-1.

3 Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).

1 Test block, current, Type PK-2.

1 Test block, voltage, Type PK-2.

1 Switch, permissive Type SB-1 (in lieu of breaker control switch).

1 Indicating lamp, breaker disagreement, Type ET-16.

1 Switch, breaker position, Type SB-12. (For remote control.)

3 Current transformers, single secondary, :5 ratio, Type BP (for bus differential).

1 Current transformer, ground-sensor, 50:5 ratio, ITI.

3 Surge arresters.

SINGLE SOURCE INCOMING LINE (SSIL)

BASIC UNIT

The metalclad switchgear for control of an incoming line shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) (3500) (4000*) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200), (2000) (3000) (3500) (4000*) amperes.
1 Multifunction digital feeder relay, Type DFP100.
3 Current transformers, single secondary, :5 ratio, Type ITI.
2 Voltage transformers, Type JVM.
4 Fuses, Type EJ-1.
1 Switch, breaker control, Type SBM.
2 Indicating lamps, breaker close-open, red and green, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum).

*4000A is fan cooled.

DEVICE OPTIONS

3 Relays, phase overcurrent, Type IFC.
1 Ammeter, indicating, Type AB-40.
1 Switch, ammeter transfer, Type SBM.
1 Voltmeter, Type AB-40.
1 Switch, voltmeter transfer, Type AB-40.

or

1 Relay, time overcurrent residual, Type IFC

or

Relay, ground overcurrent Type IFC (transformer neutral).

1 Watthour meter, Type DS-63

or

Watthour demand meter, Type DSM-63.
3 Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
1 Wattmeter, indicating, Type AB-40.
1 Varmeter, indicating, Type AB-40.
1 Relay, underfrequency, Type SFF.
1 Relay, power directional, Type CCP.
1 Relay, undervoltage, Type NGV

or

Relay, phase sequence, Type ICR.
3 Relays, transformer differential, Type STD.

or

Relays, bus differential, Type PVD.
1 Relay, lockout, Type HEA.
1 Relay, lockout, Type HEA.
3 Current transformers, single secondary, :5 ratio, Type ITI (for transformer differential).
3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
1 Auxiliary relay, transformer sudden pressure, Type HAA.
2 Relay, time delay, Agastat.
1 Relay, negative sequence (blown fuse), Type NBV.
1 Relay, transformer ground differential, Type IFD and auxiliary CT.
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2.
1 Switch, permissive, Type SB-1 (in lieu of breaker control switch).
3 Indicating lamp, breaker disagreement, lockout, Type ET-16.
1 Switch, breaker position, Type SB-12. (For remote control.)
2 Lockout fuse blocks, pull-out type, two-pole, 60 amperes.
3 Surge arresters.

DUAL SOURCE INCOMING LINE (DSIL)

BASIC UNIT

The metalclad switchgear for control of an incoming line shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) (3500) (4000*) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire (1200) (2000) (3000) (3500) (4000*) amperes.
1 Multifunction digital, Type DFP200
3 Current transformers, single secondary, :5 ratio, Type ITI.
1 Switch, breaker control, Type SBM.
2 Indicating lamps, breaker close-open, red and green, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum).

*4000A is fan cooled.

DEVICE OPERATIONS

3 Relays, phase overcurrent, Type IFC.
3 Relays, directional phase overcurrent, Type JBC.
1 Ammeter, indicating, Type AB-40.
1 Voltmeter, Type AB-40.
1 Switch, voltmeter transfer, Type SBM.
Watthour demand meter, Type DSM-63.
3 Ammeters, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
1 Wattmeter, indicating, Type AB-40.
1 Varmeter, indicating, Type AB-40.
1 Relay, underfrequency, Type SFF.
1 Relay, power directional, Type CCP.
1 Relay, undervoltage, Type NGV
or
2(3) Voltage transformers, Type JVM.
4(3) Fuses, Type EJ-1.
1 Relay, time overcurrent residual, Type IFC
or
Relay, ground overcurrent Type IFC (transformer neutral).
3 Relays, directional phase overcurrent, Type IBC (in lieu of 3-JBC's).
1 Relay, directional ground overcurrent, Type IBCG.
1 Watthour meter, Type DS-63
or
Relay, phase sequence, Type ICR.
3 Relays, transformer differential, Type STD.
or
Relays, bus differential, Type PVD.
1 Relay, lockout, Type HEA. (For STD or PVD.)
1 Relay, lockout, Type HEA. (For CCP and SFF.)
3 Current transformers, single secondary, :5 ratio, Type ITI (For use with CFD's)
3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
1 Auxiliary relay, transformer sudden pressure, Type HAA.
2 Relay, time delay, Agastat.
1 Relay, negative sequence (blown fuse), Type NBV.
1 Relay, current balance, Type IJC.
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2.
1 Switch, permissive, Type SB-1 (in lieu of breaker control switch).
3 Indicating lamp, breaker disagreement, lockout, Type ET-16.
1 Switch, breaker position, Type SB-12. (For remote control.)
2 Lockout fuse blocks, pull-out type, two-pole, 60 amperes.
3 Surge arresters.

BUS ENTRANCE UNIT (BE)

BASIC UNIT

The metalclad switchgear for a bus entrance shall contain:

1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) (3500) (4000*) amperes.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

*4000A is fan cooled.

DEVICE OPTIONS

3 Current transformers, single secondary, :5 ratio, Type ITI.
1 Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
1 Voltmeter, Type AB-40.
1 Switch, voltmeter transfer, Type SB-1.
1 Ammeter, indicating Type AB-40
and
1 Switch, ammeter transfer, Type SB-1.
or
3 Ammeters, Type AB-40.
1 Test block current, Type PK-2.
1 Test block voltage, Type PK-2.
2 or 3 Voltage transformers, Type JVM.
4 or 3 Fuses, Type EJ-1 (VT primary).
3 Surge arresters.
or
1 Digital meter, Type EPM.

BUS TIE UNIT (BT)

BASIC UNIT

The metalclad switchgear for control of a bus-tie circuit shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) (3500) (4000*) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) (3500) (4000*) amperes. (Includes necessary bus-tie conductors.)
1 Switch, breaker control, Type SBM.
2 Indicating lamps, breaker close-open, red and green, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
3 Current transformers, single secondary, :5 ratio, Type ITI.
1 Ammeter, indicating, Type AB-40.
1 Switch, ammeter transfer, Type SBM.

*4000A is fan cooled

DEVICE OPTIONS

2 Lockout fuse blocks, pull-out type, two-pole, 60 amperes.
3 Ammeters, indicating, Type AB-40 (in lieu of one ammeter and ammeter transfer switch).
1 Test block, current, Type PK-2
and
1 Test block, voltage, Type PK-2.
or
2 Test blocks, voltage, Type PK-2.
1 Switch, permissive, Type SB-1 (in lieu of breaker control switch).
1 Indicating lamp, breaker disagreement, Type ET-16.
1 Switch, breaker position, Type SB-12. (For remote control.)
6 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
6 Relays, bus differential, Type PVD.
2 Relays, lockout, Type HEA.
2 Indicating lamps, lockout, bus differential, Type ET-16.
3 Current transformers, single secondary, :5 ratio, Type ITI (For machine differential.)

INDUCTION MOTOR FEEDER (IMFE)

BASIC UNIT

The metalclad switchgear for local control and full-voltage-start of an induction motor for essential service shall contain;

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
3 Current transformers, single secondary, :5 ratio, Type ITI.
1 Switch, breaker control, Type SBM.
2 Indicating lamps, breaker close-open, red and green, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
1 Ammeter, indicating, Type AB-40.
1 Current transformer, 50:5 ratio, round-sensor, ITI.
1 Relay, motor protection, Type 269.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

1 Switch, permissive, Type SB-1 (in lieu of breaker control switch) (for remote control.)
1 Relay, lockout, Type HEA (for remote control).
1 Indicating lamp, lockout, Type ET-16 (for remote control).
1 Switch, breaker position, Type SB-12. (For remote control.)
1 Lockout fuse block, pull-out type, two-pole, 60 amperes (for remote control).
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2.
1 Switch, ammeter transfer, Type SB-1.
1 Wattmeter, indicating, Type AB-40.
1 Varmeter, indicating, Type AB-40.
3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
1 Indicating lamp, breaker disagreement, Type ET-16.
1 Watthour meter, Type DS-63.

or

Watthour demand meter, Type DSM-63.

or

1 Relay, ground-sensor overcurrent, instantaneous, Type HFC.
3 Relays, phase overcurrent, Type IFC66.

INDUCTION MOTOR FEEDER (IMF1)

BASIC UNIT

The multiclad switchgear for local control and full-voltage-start of an induction motor shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
3 Current transformers, single secondary, :5 ratio, Type ITI.
1 Switch, breaker control, Type SBM.
2 Indicating lamps, breaker close-open, red and green, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
1 Ammeter, indicating, Type AB-40.
1 Current transformer, 50:5 ratio, ground-sensor, ITI.
1 Relay, motor protection, Type 269+
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

1 Switch, permissive, Type SB-1 (in lieu of breaker control switch). (For remote control.)
1 Relay, lockout, Type HEA. (For remote control).
1 Indicating lamp, lockout, white, Type ET-16. (For remote control).
1 Switch, breaker position, Type SB-12. (For remote control.)
1 Lockout fuse block, pull-out type, two-pole, 60 amperes (for remote control).
1 Type HFC. (Requires three ring CT's located at the machine. These CT's are *not* included in IMF-1 device package.)
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2.
1 Relay, temperature, Type IRT.
1 Switch, ammeter transfer, Type SB-1.
1 Relay, instantaneous overcurrent, 3-element, Type HFC.
1 Wattmeter, indicating, Type AB-40.
1 Varmeter, indicating, Type AB-40.
3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
1 Indicating lamp, breaker disagreement, Type ET-16.
1 Watthour meter, Type DS-63.
1 Relay, ground-sensor overcurrent, instantaneous, Type HFC.
1 Relay, thermal, 3-element, Type THC.
or
Watthour demand meter, Type DSM-63.
1 Relay, undervoltage auxiliary, Type HFA (one per lineup).
1 Relay, negative sequence (blown fuse), Type NBV (one per lineup).
1 Relay, undervoltage, Type NGV (one per lineup).
1 Relay, time-delay, Agastat (one per lineup).

INDUCTION MOTOR FEEDER (IMF2)

BASIC UNIT

The metalclad switchgear for local control and full-voltage-start of an induction motor with RTD'S and self-balancing differential shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
3 Current transformers, single secondary, :5 ratio, Type ITI.
1 Switch, breaker control, Type SBM.
3 Indicating lamps, breaker close-open, (red and green) and lockout relay (white), Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Fuse blocks, breaker tripping and lockout, pull-out type, two-pole, 60 amperes.
1 Ammeter, indicating, Type AB-40.
1 Current transformer, ground-sensor, 50:5 ratio, ITI.
1 Relay, ground-sensor overcurrent, instantaneous, Type HFC.
1 Relay, lockout, Type HEA.
3 Relays, phase overcurrent, Type IFC66.
1 Relay, machine differential, self-balance, Type HFC. (Requires three ring CT's are not included in the 1MF-2 device package.)
1 Relay, temperature, Type IRT.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

1 Switch, permissive, Type SB-1 (in lieu of breaker control switch). (For remote control.)
1 Switch, breaker position, Type SB-12. (For remote control.)
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2.
1 Switch, ammeter transfer, Type SB-1.
1 Wattmeter, indicating, Type AB-40.
1 Varmeter, indicating, Type AB-40.
1 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
1 Indicating lamp, breaker disagreement, Type ET-16.
1 Relay, undervoltage auxiliary, Type HFA (one per lineup.)
1 Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
1 Relay, negative sequence (blown fuse), Type NBV (one per lineup.)
1 Relay, undervoltage, Type NGV (one per lineup).
1 Relay, time delay, Agastat (one per lineup).
3 Relays, machine differential, self-balance, Type CFD. (In lieu of HFC.)
3 Current transformers, single secondary, :5 ratio, Type ITI. (For use with CFD's)

SYNCHRONOUS MOTOR FEEDER (SMF1)

BASIC UNIT

The metalclad switchgear for control and full voltage-start of a synchronous motor (smaller than 1500 hp) with direct connected or brushless exciter shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
1 Relay motor protection, Type 469.
3 Current transformers, single secondary, :5 ratio, Type ITI.
1 Current transformer, ground-sensor, 50:5 ratio, ITI.
1 Switch, breaker control, Type SBM.
2 Indicating lamps, breaker close0open, red and green, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker, tripping fuse block, pull-out type, two-pole, 60 amperes.
1 Drilling and wiring for exciter field rheostat. (Rheostat shipped with motor and installed by Purchaser.)
1 Ammeter, field, Type DB-40.
1 Field shunt. (For field ammeter.)
1 Varmeter, Type AB-40.

With a direct-connected exciter, the field control shall consist of:

1 Field control panel (for direct-connected exciter) consisting of:
    1 Exciter relay, Type 1C2820.
    1 Field contactor, Type 1C2812.
    1 Field discharge resistor.
    1 Field forcing resistor.
    1 Rotor thermal device, Type 1C2820.
    1 Auxiliary relay, Type HFA.
    1 Slip-guard relay, Type IC3655.
    1 Field application panel.

With a brushless exciter, the field control shall consist of:

1 Field control panel (for brushless exciter with either shutdown or resynchronization on pull-out) consisting of:
    1 Rectifier, Syntron, Type Y2080.
    1 Voltpac, Type 9T92.
    1 Discharge resistor.
    2 Relays, time delay, Agastat.
    1 Relay, starting protection, Type IFC. (This relay mounted on compartment door.)
    1 Relay, field application, Type HGA.
    1 Relay, slip-guard, Type IC3655.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

1 Switch, permissive, Type SB-1 (in lieu of breaker control switch).
1 Switch, breaker position, Type SB-12. (For remote control.)
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2.
1 Wattmeter, indicating, Type AB-40.
1 Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.
1 Relay, negative sequence (blown fuse), Type NBV.
3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
1 Switch, ammeter transfer, Type SB-1.
1 Relay, undervoltage, Type NGV. (one per lineup.)
1 Relay, time delay, Agastat (for undervoltage).
1 Relay, undervoltage auxiliary, Type HFA.
1 Relay, lockout, Type HEA. (For remote control.)
1 Indicating lamp, breaker disagreement, Type ET-16.
1 Relay, machine differential, self-balance, Type HFC. (Requires three ring CT's located at machine. These CT's are *not* included in SMF-1 device package.)
or
1 Relay, phase overcurrent, three-element, Type THC.
1 Relay, ground-sensor, Type HFC
1 Relay, time delay, Agastat (incomplete sequence).
1 Ammeter, indicating, Type AB-40. (scale to match CT's.)

SYNCHRONOUS MOTOR FEEDER (SMF2)

BASIC UNIT

The metalclad switchgear for control and full-voltage-start of synchronous motor (1500 hp or larger) with direct connected or brushless exciter shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) (amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
1 Relay, phase overcurrent, three-element, Type THC.
1 Relay, ground sensor, Type HFC.
1 Relay, machine differential, self-balance, Type HFC. (Requires three ring CT's located at machine. These CT's are *not* included in SMF-2 device package.)
1 Relay, lockout, Type HEA. (For machine differential.)
1 Relay, time delay, Agastat (incomplete sequence).
3 Current transformers, single secondary, :5 ratio, Type ITI.
1 Current transformer, ground-sensor, 50:5 ratio, ITI.
1 Switch, breaker control, Type SBM.
2 Indicating lamps, breaker close-open, red and green, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker, tripping fuse block, pull-out type, pull-out type, two-pole, 60 amperes.
1 Drilling and wiring for exciter field rheostat. (Rheostat shipped with motor and installed by Purchaser.)
1 Ammeter, indicating, Type AB-40. (Scale to match CT's.)
1 Ammeter, field, Type DB-40.
1 Field shunt, (for field ammeter).
1 Varmeter, Type AB-40.

With a direct-connected exciter, the field control shall consist of:

1 Field control panel (for direct-connected exciter) consisting of:
  - 1 Exciter relay, Type IC2820.
  - 1 Field contactor, Type IC2812.
  - 1 Field discharge resistor.
  - 1 Field forcing resistor.
  - 1 Rotor thermal device, Type C2820.
  - 1 Auxiliary relay, Type HFA.
  - 1 Slip-guard relay, Type IC3655.
  - 1 Field application panel.

With a brushless exciter, the field control shall consist of:

1 Field control panel (for brushless exciter with either shutdown or resynchronization on pull-out) consisting of:
  - 1 Rectifier, Syntron, Type Y2080.
  - 1 Voltpac, Type 9T92.
  - 1 Discharge resistor.
  - 2 Relays, time delay, Agastat.
  - 1 Relay, starting protection, Type IFC. (Mounted on compartment door.)
  - 1 Relay, field application, Type HGA.
  - 1 Relay, slip-guard, Type IC3655.

1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

1 Switch, permissive, Type SB-1 (in lieu of breaker control switch).
1 Switch, breaker position, Type SB-12. (For remote control).
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2
1 Wattmeter, indicating, Type AB-40.
1 Watthour meter, Type DS-63

or

Watthour demand meter, Type DSM-63.

1 Relay, negative sequence (blown fuse), Type NBV.
3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
1 Switch, ammeter transfer, Type SB-1.
1 Relay, undervoltage, Type NGV (one per lineup).
1 Relay, time delay, Agastat (for undervoltage).
3 Relays, machine differential, Type CFD (in lieu of HFC).
1 Indicating lamp, breaker disagreement, Type ET-16.
3 Current transformers, single secondary, Type ITI. For machine differential for use with Type CFD relays. (Requires three ring CT's located at machine. These CT's are *not* included in SMF2 device package.)

GAS TURBINE OR DIESEL-GENERATOR

BASIC UNIT

The metalclad switchgear for generator control shall contain:

1 (4160-volt) (7200-volt) (13,800-volt) vacuum power circuit breaker, (1200) (2000) (3000) (3500) (4000*) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) (3500) (4000*) amperes.
1 Relays generator protection, Type DGP
1 Relay, lockout, Type HEA. (For machine differential)
1 Relay, power directional, Type ICW.
3 Current transformers, single secondary, :5 ratio, Type ITI.
3 Current transformers, single secondary, :5 ratio, Type ITI. (For machine differential.)
1 Switch, breaker control, Type SBM.
1 Switch, synchronizing (removable handle), Type SBM.
1 Switch, generator, Type SBM..
2 Indicating lamps, breaker open-close, red and green, Type ET-16.
1 Indicating lamp, lockout relay, white, Type ET-16.
1 Breaker closing fuse block, pull-out type, two-pole, 30 amperes.
1 Breaker tripping fuse block, pull-out type, two-pole, 60 amperes.
1 Generator governor fuse block, pull-out type, two-pole, 30 amperes.
2 Voltage transformers, Type JVM.
4 Fuses, Type EJ-1. (VT primary.)
1 Lockout fuse block, pull-out type, two-pole, 60 amperes.
1 Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

*4000A is fan cooled.

DEVICE OPTIONS

3 Relays, machine differential, Type CFD.
1 Relay, time overcurrent, Type IFC (ground overcurrent protection).
3 Relays, time overcurrent, voltage restraint, Type IFCV.
1 Ammeter, indicating, Type AB-40.
1 Wattmeter, indicating, Type AB-40
1 Varmeter, Type AB-40.
1 Switch, ammeter transfer, Type SBM.
1 Switch, voltmeter (removable handle), Type SB-1.

or

3 Current transformers, single secondary, :5 ratio, Type ITI (for bus differential).
1 Indicating lamp, lockout relay, white, Type ET-16.
1 Relay, voltage balance, Type CFVB.
1 Relay, ground directional, Type IBCG.
1 Temperature meter, Type DB-40.
1 Voltmeter, Type AB-40.
1 Time meter, Type KT.
1 Watthour meter, Type DS-63

or

Watthour demand meter, Type DSM-63.

1 Frequency meter, Type AB-40.
1 Synchronizing panel consisting of:
  2 Voltmeters, Type AB-40.
  1 Frequency meter, Type AB-40.
  1 Synchroscope, Type AB-16.
  2 Indicating lamps, for synchronizing, white, Type ET-16.
  (Only one synchronizing panel required per lineup.)
1 Switch, temperature meter, Type SB-1.
1 Relay, negative sequence, Type 1NC.
1 Test block, current, Type PK-2.
1 Test block, voltage, Type PK-2.
1 Relay, loss-of-field, Type CEH.
1 or 2 Voltage transformers, Type JVM. (For generator regulator.)
2 or 4 Fuses, Type EJ-1 (VT primary.)
1 Current transformers, single secondary, :5 ratio, Type BP (for generator regulator).
3 Surge arresters.

Guide Form Specifications

AUXILIARY COMPARTMENT

AUXILIARY COMPARTMENT

Auxiliary compartments shall be furnished (as required) to house the following devices:

( )Drawout voltage transformers, Type JVM, with current-limiting fuses.

( )Drawout-mounted single-phase control power transformer, rated 120/240V, with current limiting fuses .

( )Stationary-mounted control power transformers with drawout current-limiting primary fuses (2400-volts) (4160-volts (7200-volts) (13,800-volts). kVA, (three-phase) (208Y/120V) (480Y/277V), (single-phase 120/240V) secondary.

( )Tripping battery and battery charger.

( )Power company metering (specify).

( )Instruments, meters and relays.

Contents

Section 15

Sample Proposal Documentation

Sample Proposal Documentation

INTRODUCTION

It is the objective of the General Electric Company to provide its customers quality documentation of the POWER/VAC Metalclad Switchgear product offering. Selection of pre-engineered equipment configurations enables early availability of drawings and bills of material for use in building layout or construction planning. Early detailed definition also means minimum delivery cycles and maximum assurance of quality equipment.

Typical example of POWER/VAC documentation are exhibited in the following pages.

Sample Specification

INDEX TO PROPOSAL DRAWING

Customer Unit	GE Unit	Description
1,15	001A,B and 010A,B	Power Company Metering Units
2,14	002A,B and 009A,B	Incoming Line Units
3, 4, 12, 13	003A,B and 008A,B	Synchronous Motor Feeders
5, 6, 7, 8,	004A,B and 005A	General Purpose Feeders
10, 11	006A and 007A,B	
9	005B and 006B	Bus Tie Unit

GENERAL ELECTRIC

SUMMARY OF SWITCHGEAR EQUIPMENT

Sample Specification

DEVICE SUMMARY OF METALCLAD EQUIPMENT - VAC

LINE-UP NO. 01 UNIT NO. 002A

MK-QTY-DEV	LOC-	DESCRIPTION	DEV NO OR ABBR	ORDERING NO.
100 001		CIRCUIT BREAKER	52	VB-13.8-500-1200A
110 003 ZA		BP CURR TRAN CT		GE
130 003 ZD		BP DIFF TRAN CT		GE
130 003 AA	AB	PHASE OC RELAY	51/B	GE 121FC53A1A
AC				
140 001 AD		RESIDUAL OC RLY	51N/B	GE 121FC53A2A
373 001 CA		BKR CONTROL SW 3 STAGE	CS	16SB1B9X2
37F 001 HA		AMMETER SWITCH	AS	16SB1CA15X2
37K 001 HD		VOLTMETER SW	VS	16SB1CF11X2
380 002	FB	INDICATING LTS	IL	GE 0116B6708G043
38A 001		ET16 RED CAP		0208A3768P009
38B 001		ET16 GREEN CAP		0208A3768P008
400 001 GA		AMMETER AB-40	AM	GE 50103131LSSV2
410 001 GD		VOLTMETER AB-40	VM	GE 50103021PZXE2
7G2 001 TA		FUSE BLK 2P 30A	FU	0673D0515421G01
7G3 002 TB	TC	FUSE BLK 2P 60A	FU	0673D0515422G01
003		PHASE OC RLY	50/51	GE 12IFC53B1A
001		RESID OC RLY	51N	GE 12IFC53B2A

REQ NO 123-45678 SO NO 912345
ENGR JOHN DOE SUMMARY NO 1234A1234 CONT ON SH DO4 SH DO3
DATE 06/29/76 REV NO 00

Figure 15-1. Sample bill of material of the POWER/VAC metalclad switchgear equipment .

Sample Proposal Documentation

Section 16345000
5 and 15 KV Medium Voltage Metal-Clad Switchgear

$$$BEGIN SPECIFIER NOTE *This is Part 1 of Extended Section 16345000, 5 and 15 KV medium voltage metal clad switchgear-POWER/VAC®.* **ESN$$$**

$$$BEGIN SPECIFIER NOTE *This document incorporates CSI Manual of Practice principles of cross-references to Division 1 sections for procedural requirements to avoid repetition and duplication. It cross-references other specification sections for Related Work. Edit cross-references to retain only those sections used for the specific project. Manual of Practice is copyrighted by Construction Specifications Institute.* **ESN$$$**

PART 1 GENERAL

A. The requirements of the Contract, Division 1, and Division 16 apply to work in this Section.

1.01 SECTION INCLUDES
$$$BEGIN SPECIFIER NOTE *List generic products, services, or work specified.* **ESN$$$**

A. Medium Voltage, 5 and 15 KV, Metal Clad Switchgear.

1.02 RELATED SECTIONS
$$$BEGIN SPECIFIER NOTE *List applicable Sections from CSI MASTERFORMAT Master List of Titles and Numbers for the Construction Industry.* **ESN$$$**

1.03 REFERENCES
$$$BEGIN SPECIFIER NOTE *Include all standards used in this specification. Edit list from "REFERENCES" document for each project.* **ESN$$$**
The medium voltage metal clad switchgear and protection devices in this specification are designed and manufactured according to latest revision of the following standards(unless otherwise noted).

A. ANSI C37.06, Switchgear - AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis - Preferred Ratings and Related Required Capabilities (includes supplement ANSI C37.06a)

B. ANSI C39.1, Electrical Analog Indicating Instruments, Requirements for

C. ANSI/IEEE C37.04, Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (includes supplements C37.04C, C37.04G, C37.04H, C37.04I)

D. ANSI/IEEE C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear

E. ANSI/IEEE C57.13, Instrument Transformers, Requirements for

F. IEEE C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus

G. NEMA SG 2, High Voltage Fuses

H. NEMA SG 4, Alternating - Current High Voltage Circuit Breaker

I. NEMA SG 5, Power Switchgear Assemblies

1.04 DEFINITIONS
$$$BEGIN SPECIFIER NOTE *Define unusual terms or terms used in unique ways not normally included in standard references.*
ESN$$$

1.05 SYSTEM DESCRIPTION

$$$BEGIN SPECIFIER NOTE *Use this article to list performance or design requirements as needed to link this product to other system components or to link this system to other systems.* **ESN$$$**

A. [{Indoor} {Outdoor}] [{protected aisle} {common aisle}] metalclad switchgear intended for use on [{2.4} {4.16} {4.8} {6.9} {7.2} {12.47} {13.8}] KV, 3-phase, [{3} {4}] wire [{grounded}{ungrounded}]

B. Metal-clad switchgear and breakers will be rated for a maximum three-phase fault level up (250,) (350,) (500,) (750,) (1000,) (1500) MVA

C. 60-Hz system. Switchgear shall be rated as indicated in drawings and have removable-element vacuum circuit breakers. Enclosures and circuit breaker(s), <{individually,}{as a unit,}> shall have a basic impulse rating of [{60}{95}]KV. Switchgear, including circuit breakers, meters, and relays, shall be factory tested.

D. Equipment shall be completely factory-built, assembled, wired, and tested. All equipment and components shall be of new construction.

1.06 SUBMITTALS

$$$BEGIN SPECIFIER NOTE *When using specific manufacturer's installation instructions, ensure they agree with PART 3 EXECTUTION statements.* **ESN$$$**

A. Manufacturer shall provide copies of following documents to owner for review and evaluation in accordance with general requirements of Division 1 and Division 16:

1. Product Data on a specified product;

2. Shop Drawings on a specified product;

3. Certified copies of all Type (Design) and Verification Test Reports ON A SPECIFIED PRODUCT.

1.07 PROJECT RECORD DOCUMENTS

A. Maintain an up-to-date set of Contract documents. Note any and all revisions and deviations that are made during the course of the project.

1.08 OPERATION AND MAINTENANCE DATA

A. Manufacturer shall provide copies of installation, operation and maintenance procedures to owner in accordance with general requirements of Division 1 and Division 16.

B. Submit operation and maintenance data based on factory and field testing, operation and maintenance of specified product.

1.09 QUALITY ASSURANCE (QUALIFICATIONS)

A. Manufacturer shall have specialized in the manufacture and assembly of medium voltage metal clad switchgear for a minimum of [25] years.

B. Manufacturer's Certificate of ISO 9002 Compliance.

1.10 REGULATORY REQUIREMENTS

1.11 MOCK-UPS (FIELD SAMPLES)

1.12 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products in accordance with recommended practices listed in manufacturer's Installation and Maintenance Manuals.

B. Deliver each medium voltage metal clad switchgear section in individual shipping splits for ease of handling. Each section shall be mounted on shipping skids and wrapped for protection.

C. Inspect and report concealed damage to carrier within specified time.

D. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. (Heat enclosures to prevent condensation.)

E. Handle in accordance with NEMA [____] and manufacturer's written instructions to avoid damaging equipment, installed devices, and finish. <Lift only by installing lifting eyes.>

1.13 PROTECT CONDITIONS (SITE ENVIRONMENTAL CONDITIONS)

$$$BEGIN SPECIFIER NOTE *List data on environment in which product can function. Include all required seismic qualifications for specified equipment and components.* **ESN$$$**

A. Follow (standards) service conditions before, during and after switchgear installation.

B. Switchgear shall be located in well-ventilated areas, free from excess humidity, dust and dirt and away from hazardous materials. Ambient temperature of area will be between minus [30] and plus [40] degrees C. Indoor locations shall be protected to prevent moisture from entering enclosure.

1.14 SEQUENCING AND SCHEDULING

1.15 WARRANTY

$$$BEGIN SPECIFIER NOTE *Use this article to specify a special or extended warranty or bond covering the work of the section.* **ESN$$$**

A. Manufacturer warrants equipment to be free from defects in materials and workmanship for 1 year from date of installation or 18 months from date of purchase, whichever occurs first.

1.16 EXTRA MATERIALS

$$$BEGIN SPECIFIER NOTE *Specifier, include options as indicated in contract documents.* **ESN$$$**

A. Provide [{parts} {spares}] as indicated in drawings.

B. Provide sizes and ratings of spare fuses as indicated in drawings.

<C. Provide fuse cabinet.>

1.17 FIELD MEASUREMENTS

A. Make all necessary field measurements to verify that equipment shall fit in allocated space in full compliance with minimum required clearances specified in local codes and standards.

$$$BEGIN SPECIFIER NOTE *This is Part 2 of Extended Section 16345000, 5 and 15 KV medium voltage metal clad switchgear - POWER/VAC®.* **ESN$$$**

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Manufacturer shall be GE or approved equal as listed below:

2.02 EQUIPMENT

$$$BEGIN SPECIFIER NOTE Specifier to verify if UL/CSA label is required by governing authority. ESN$$$

A. Furnish GE POWER/VAC® Medium Voltage Metal Clad Switchgear [{with UL label} {UL/CSA label}] as indicated in drawings

2.03 COMPONETS

Refer to Drawings for: actual layout and location of equipment and components; voltage ratings of devices, bus bars, and components; voltage ratings of devices, components and assemblies; and other required details.

A. Enclosure

1. Switchgear shall consist of breaker and auxiliary units, as indicated I drawings, assembled to form a rigid, self-supporting, metal-enclosed structure. Outdoor metalclad switchgear shall be enclosed in a weatherproof enclosure and shall include suitable weatherproof access doors, doors with provision for padlocking; protected ventilation openings as required; interior lighting, utility outlets with protective devices; and equipment heaters with protective devices. In each unit, major primary circuit parts (breaker, buses, transformers) shall be completely enclosed by grounded metal barriers, including a front barrier as part of the circuit breaker.

2. Switchgear units shall be arranged as shown on attached drawings.

3. For rigidity during fault conditions all connections to roll-out potential transformer trays and control power transformer trays shall be rigid bus bars insulated to full voltage rating of switchgear assembly.

4. Circuit breaker compartments shall be designed to house [{5.0}{8.25}{15.0}] KV removable-element circuit breakers. Stationary primary disconnect contacts shall be silver-plated copper. Grounded metal safety shutters shall isolate all primary connections in compartment when breaker is withdrawn from connected position.

5. Furnish nameplates for each device as indicated in drawings. Nameplates shall be [{black letters on white background}{white letters on black background}]. Nameplates shall be fastened by [{plastic rivets, standard}{screw, optional}]. <{There shall be a master nameplate} that indicates equipment ratings, manufacturer's name, shop order number and general information.>

B. Main Bus

1. The main bus shall be tin plated copper and rated as indicated in drawings. Bus bars shall have a continuous current rating based on temperature rise and documented by design tests. All joints will be tin plated with at least 2 bolts per joint. Bus bars will be braced to withstand magnetic stresses developed by currents equal to main power circuit breaker close, carry, and interrupt ratings. Access to bus bars shall be through removable front panels. Bus bars shall have fluidized bed epoxy flame retardant and nonhydroscopic insulation with a continuous current rating.

C. Ground Bus

1. A ground bus (1/4 by 2 inch copper) shall extend throughout assembly with connections to each breaker grounding contact and cable compartment ground terminal. Joints shall be made up as indicated in drawings. Station ground connection points shall be located in each end section .

D. Circuit Breakers

1. Circuit breakers shall be rated as indicated (1200A, 2000A, 3000A, 3500A, 4000A) in drawings. Circuit breakers of equal rating shall be interchangeable. Circuit breakers shall be operated by an electrically charged, mechanically and electrically trip-free, stored-energy spring. A [handle] shall be used to manually charge the spring for slow closing of contacts for inspection or adjustment.

2. Circuit breakers shall be equipped with secondary disconnecting contacts which shall automatically engage in the connected position.

3. Each breaker compartment shall have a breaker rackout device. Using rackout device, a breaker will be self-aligning and will be held rigidly in the operating position. In the disconnect position, breaker shall be easily removable from compartment. Breaker racking shall be accomplished with door closed and latched. Insert handle through a hole in front door to operate rackout device.

4. An indicating tape shall show breaker position when racking breakers in or out of their connected positions.

5. Interlocks shall prevent moving breaker to or from operating position unless main contacts are open. Operating springs shall be discharged automatically when breaker is rolled fully into connected or disconnected position. Rackout device shall have provisions to padlock in connected or disconnected position. When locked in disconnected position, breaker shall be removable from compartment using portable lifting device. Padlock shall not interfere with breaker operation.

6. Automatic shutters shall cover primary disconnect stabs when breaker is withdrawn to test/disconnect position. Shutters shall be positively driven by linkages connected to racking mechanism. A stationary barrier shall be located in front of the shutters for additional safety.

7. Breaker control voltage shall be [{48 VDC} {125VDC} {250VDC} {120VAC} {240VAC}].

E. Instrument Transformers

1. Current transformer ratios are listed in each switchgear units specification paragraphs. Transformer mechanical ratings shall equal the momentary rating of the circuit breakers. Transformers, when mounted in switchgear assemblies, shall be rated for the full voltage of the switchgear.

2. Voltage transformers shall be drawout type, with current-limiting fuses and with BIL rating equal to the switchgear. Transformer ratios are listed on drawings.

3. Secondary control wiring shall be No. 14, extra flexible, stranded, tinned-copper control wire, Type SIS cross-linked polyethylene, rated 600 volts, except for specific circuits requiring larger wire. Crimp-type, uninsulated spade terminals shall be furnished on all wire ends, except where non-insulated ring terminals are used to connect to fuse blocks, instrument studs, or terminal block points with two ore more wire connections. Secondary control wires shall be armored where they pass through primary compartments.

2.04 PROTECTIVE DEVICES AND METERING

$$$BEGIN DESIGN NOTE Specifier to refer to Relaying specification sections for specific relays including power monitoring communication if applicable for use in the switchgear equipment **ESN$$$**

A. Protective Devices - Protective relays shall be GE/MULTILIN relays or other approved relays as indicated below:

$$$BEGIN DESIGN NOTE Specifier to refer to Metering specification sections for specific meters including power monitoring communications if applicable for use in the switchgear equipment. **ESN$$$**

B. Metering - Meters/monitors shall be GE EPM - series or PQM meters or other approved equivalent devices as indicated below:

2.05 ACCESSORIES

A. Lift truck (1 furnished per lineup)

B. Manual racking handle (1 furnished per lineup)

{C. Test cabinet} to bench test, inspect and maintain the POWER/VAC® breaker (optional)

{D. A ground and test device shall e provided (optional)}

{E. A high potential test kit shall be provided (optional)}

{F. A remote racking device} shall be provided including push-button, motor operator, and 25 feet of cable (optional)}>

2.06 TESTING

A. The switchgear equipment and circuit breakers shall receive factory production test as listed below:

1. Equipment

a. Low frequency dielectric test

b. Grounding of instrument cases

c. Control wiring and device functional tests

d. Polarity verification

e. Sequence test

f. Low frequency withstand voltage test on major insulation components

g. Low frequency withstand test on secondary control wiring

2. Breakers

a. Coil check test

b. Clearance and mechanical adjustment

c. 300 Electrical and mechanical operation test

d. Timing test

e. Conductivity of current path test

f. Hi-potential testing of breaker

g. Vacuum bottle integrity test

<{B. Manufacturer shall provide the Engineer} documents verifying completion of factory production test.>

2.07 FINISH

A. All steel surfaces shall be chemically cleaned and given an iron phosphate corrosion resistant treatment providing a strong bond for paint adhesion. All parts shall be immersed in paint applying 0.7 - 0.8 mils of cathodic epoxy paint electrically bonded to all surfaces for maximum adhesion. The finish shall be cured in an oven at to insure maximum toughness and prolong service in severe environments.

B. All exterior surfaces of the switchgear assembly shall be given final finish coats of ANSI 61 light gray air dried acrylic enamel.

$$$BEGIN SPECIFIER NOTE *This is part 3 of extended Section 16345000, 5 and 15 KV medium voltage Metal clad switchgear - POWER/VAC®.* **ESN$$$**

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine installation area to assure there is enough clearance to install switchgear.

B. Check concrete pads for uniformity and level surface.

C. Verify that medium voltage metal clad switchgear are ready to install.

D. Verify field measurements are as [{shown on Drawings}{instructed by manufacturer}].

E. Verify that required utilities are available, in proper location and ready for use.

F. Beginning of installation means installer accepts conditions.

3.02 LOCATION

$$$BEGIN SPECIFIER NOTE *Specify location and access requirements to meet NEC 110-16.* **ESN$$$**

3.03 INSTALLATION

Additional provisions and editing may be required for this part.

A. Installer's Certificate of ISO 9000 Compliance.

B. Installer has specialized in installing medium voltage 5 and 15 KV metal clad switchgear with [minimum___years documented experience].

C. Install per manufacturer's instructions.

D. Install required safety labels.

E. Installer has specialized in installing medium voltage 5 and 15 KV metal clad switchgear with [minimum___years documented experience].

3.04 FIELD QUALITY CONTROL

$$$BEGIN SPECIFIER NOTE *List other controls as required.* **ESN$$$**

A. Inspect installed switchgear for anchoring, alignment, grounding and physical damage.

B. Check tightness of all accessible electrical connections<with A calibrated torque wrench>. Minimum acceptable values are specified in manufacturer's instructions.

C. Megger and record phase to phase and phase to ground insulation resistance of each bus section. Megger for [1] minute(s) for each measurement at minimum voltage of [1000] VDC. Measured Insulation resistance shall be at least [1] megohm(s).

D. Test each key interlock system for proper functioning.

3.05 ADJUSTING

A. Adjust all < {circuit breakers} {,} {switches} {,} {access doors} {,} {operating handles} > for free < {mechanical} {and/or} {electrical} > operation as described in manufacturer's instructions.

B Adjust relay trip and time delay settings to values [{specified} {determined}] by Customer's Engineer.

C. Return “odd” Kirk keys to Engineer before energizing equipment.

3.06 CLEANING

A. Clean interiors of <{switchgear} {,} {switchboards} {,} {panels} {,} {separate enclosures}> to remove construction debris, dirt, shipping materials.

B. Repaint scratched or marred exterior surfaces to match original finish.

END OF SECTION

Sample Proposal Documentation

GENERAL ELECTRIC

SUMMARY OF SWITCHGEAR EQUIPMENT

Sample Specification

DEVICE SUMMARY OF METALCLAD EQUIPMENT

LINE-UP NO. 01 UNIT NO. 002A

MK-QTY-DEV		LOC-	DESCRIPTION	DEV NO OR ABBR	ORDERING NO.
100 001			CIRCUIT BREAKER	52	VB-13.8-500-1200A
110 003	ZA		BP CURR TRAN CT		GE
171 001	ZE		GRD SENSOR TRAN	CT	
180 003	AA AC	AB	PHASE OC RELAY	49/50	GE 12THC30A_A
190 001	AD		GRD SENSOR RLY	50GS	GE 12HFC11B1A
200 001	AJ		MOTOR DIFF RLY	87M	GE 12HFC13B1A
210 001	AZ		HAND RESET L/O RELAY	86M	GE 12HEA61B235X2
220 001	AE		UNDERVOLT RLY	27	GE 12NGV13B29A
230 001	LA		AGASTAT TIMER	62	GE 7022PB
260 001	GF		WATTMETER AB-40	WM	GE 50103221ARAS1DWC
280 001	GH		VARMETER AB-40	VAR	GE50103742AHSE1DMC
373 001	CA		BKR CONTROL SW 3 STAGE	CS	16SB1BX2
37F 001	HA		AMMETER SWITCH	AS	16SB1CA15X2
380 003			INDICATING LTS	IL	GE 0116B6708G043
38A 001			ET16 RED CAP		0208A3768P009
38B 001			ET16 GREEN CAP		0208A3768P008
38D 001			ET16 WHITE CAP		0208A3768P005
400 001	GA		AMMETER AB-40	AM	GE 50103131LSRX2
7G2 002	TA	TD	FUSE BLK 2P 30A	FU	0673D0515421G01
7G2 002	TB	TC	FUSE BLK 2P 60A	FU	0673D0515422G01
899 001			PROVISION FOR CABLES		NEMA DRILLING FOR MAX. OF 2-750MCM CABLES PER PHASE

REQ NO 123-45678 SO NO 912345

ENGR JOHN DOE SUMMARY NO 1234A1234 CONT ON SH DO6 SH DO5
DATE 06/29/76 REV NO 00

Figure 15-2. Sample bill of material of the POWER/VAC metalclad switchgear equipment.

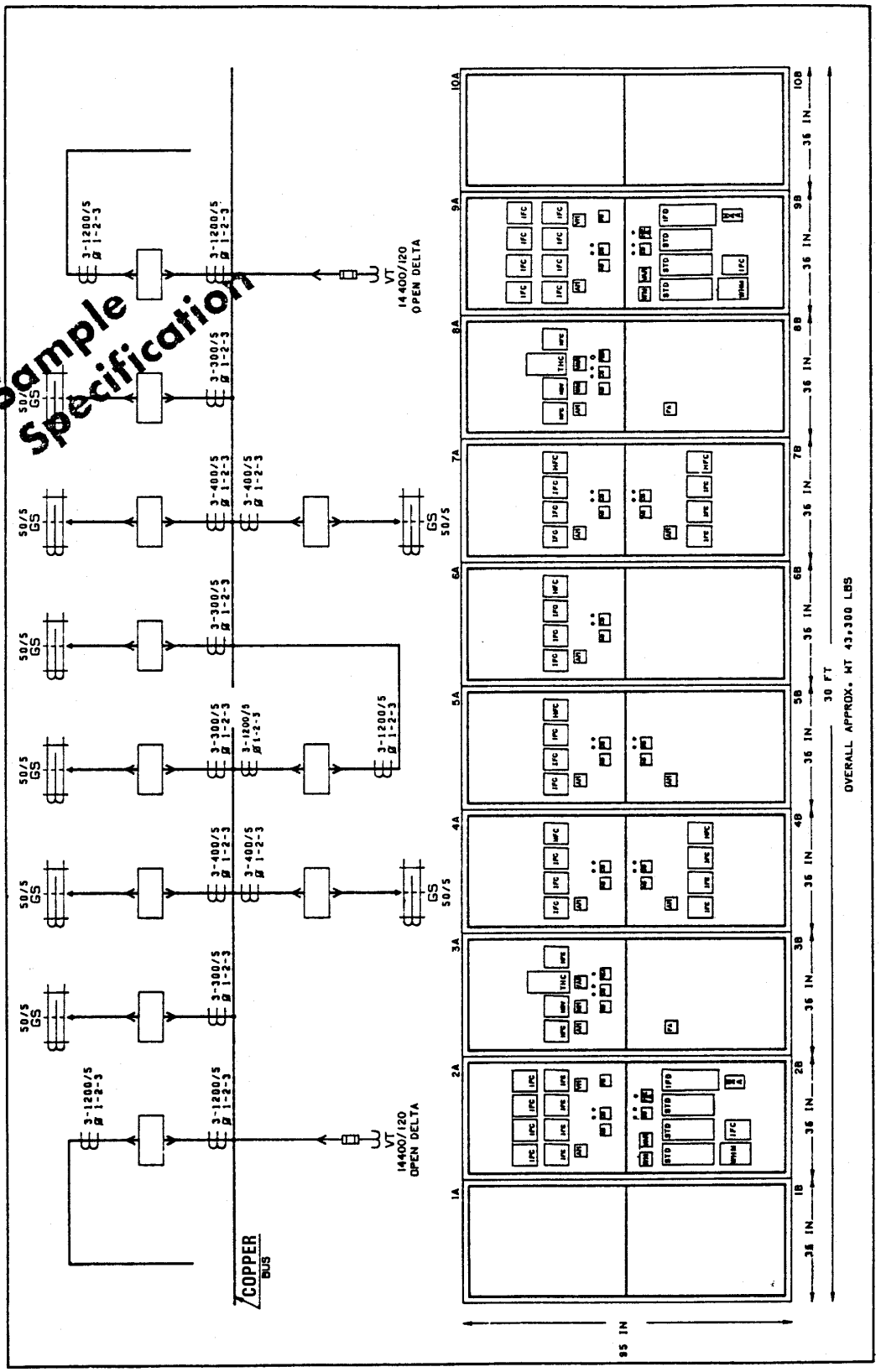


Figure 15-3. Sample front elevation and panel arrangement .

Sample Proposal Documentation

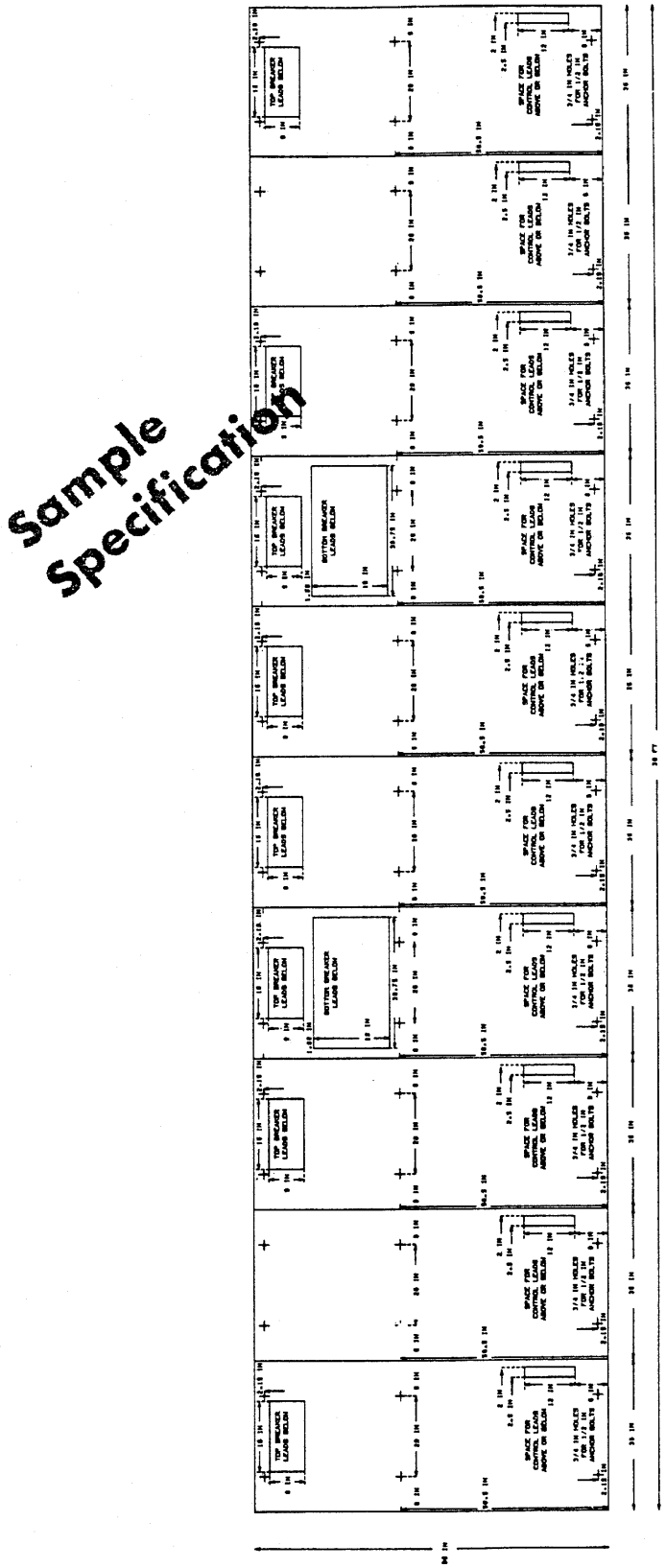


Figure 15-4. Sample floor plan.

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GENERAL ELECTRIC

GET-6600E
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