POWER/VAC®
Metalclad Switchgear
Application Guide

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Medium Voltage Switchgear
General Electric Company

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 new POWER/VAC® vacuum metalclad switchgear. This guide is organized to present the 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 protection 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 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 serve 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 a useful starting point to begin the application procedure.

POWER/VAC METALCLAD SWITCHGEAR

POWER/VAC metalclad switchgear is designed for applications on 5-kV, 7.2kV, and 15-kV power systems with available short-circuit capacities from 250 through 1000 MVA nominal. A typical lineup of indoor POWER/VAC switchgear is shown in Figure 1-1.

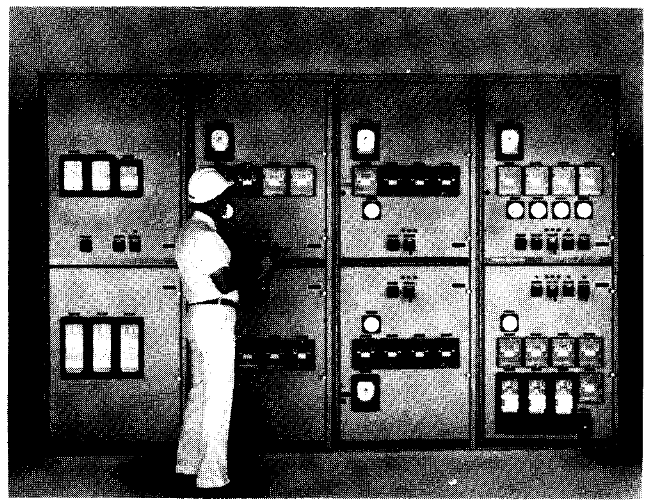


Figure 1-1. Typical lineup of indoor POWER/VAC switchgear.

POWER/VAC circuit breakers are rated per ANSI C37.06-1979, Table 2. 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 four basic types: indoor, minimum outdoor (no aisle), protected-aisle outdoor, and common-aisle outdoor (aisle shared by two facing lineups). Figure 1-2 shows typical section outlines for each of the basic equipment types. Dimensions and weights are shown in Section 8, page 8-7.

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		

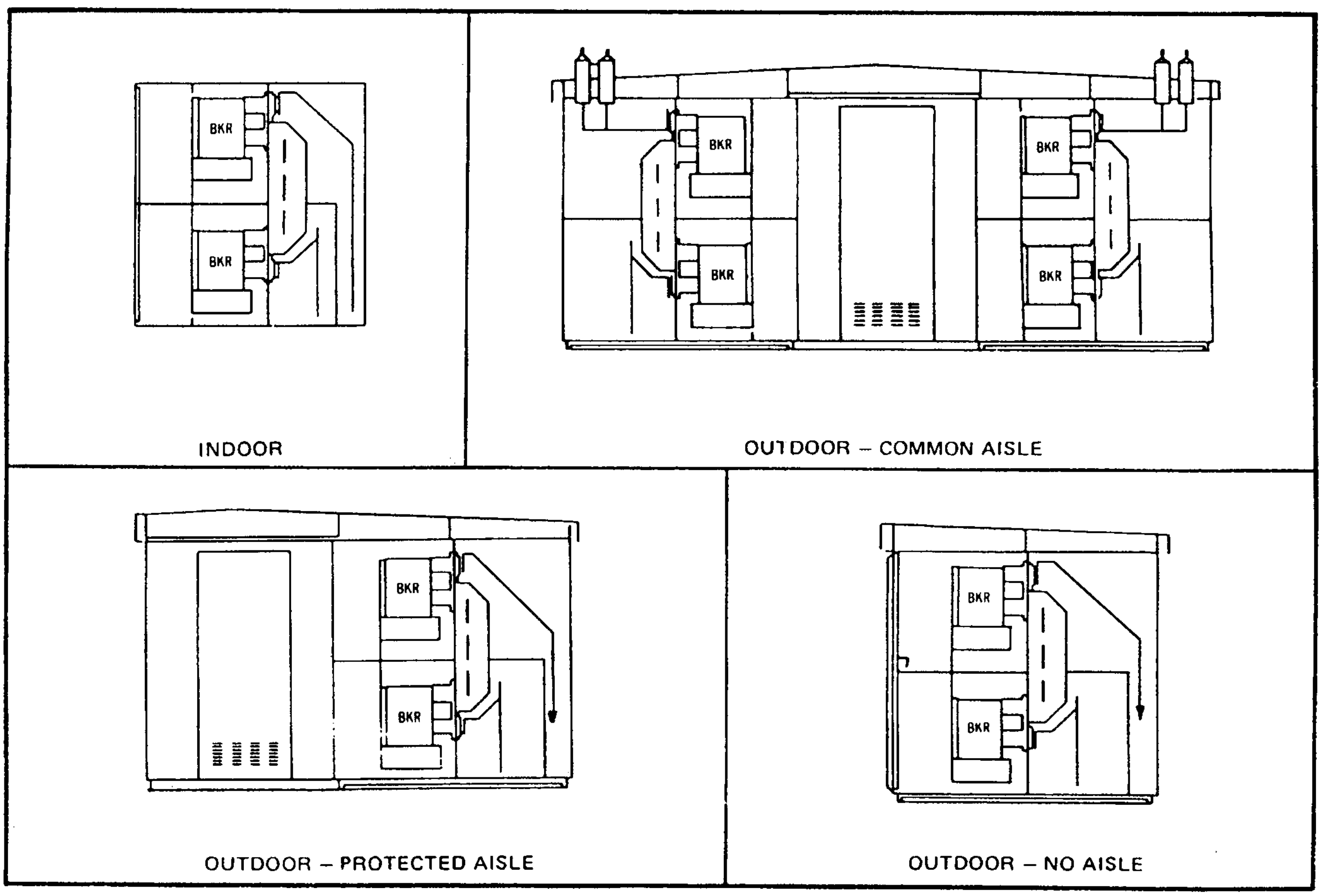


Figure 1-2. Typical section outlines.

POWER/VAC Switchgear Concepts

General Electric's POWER/VAC metalclad switchgear combines the advantages of metalclad construction —flexibility and economy — with the benefits of vacuum interrupters — reliability, low maintenance, and reduced breaker size and weight.

Specifically, POWER/VAC switchgear incorporates the following new basic design elements, compared to air-magnetic and early designs of vacuum metalclad switchgear.

- POWER/VAC offers two-tier breaker stacking for application flexibility and floorspace savings.
- POWER/VAC utilizes modular construction resulting in one basic vertical section size, thus simplifying system planning and providing installation savings.
- POWER/VAC features structured protection, instrumentation, and control (PIC) packages for most switchgear applications, minimizing planning and engineering time.

These fundamental design improvements affect certain elements in the switchgear application procedure, principally the one-line diagram and the arrangement of switchgear units in a lineup. Since these application considerations are a result of the equipment design, a brief illustration of POWER/VAC switchgear design concepts is provided.

TWO-TIER BREAKER STACKING

Mixing and matching of a variety of 92" deep unit types and breaker ratings is possible using two-tier unit stacking. The nine standard combinations of upper and lower units are shown in Figure 1-3. Indoor 82" deep, one-tier stacks are available.

MODULAR CONSTRUCTION

Breakers and auxiliary devices can be accommodated in the upper and lower breaker compartments as shown in Figure 1-4. Typical equipment section views in Figure 1-5 illustrate how upper and lower units can be combined.

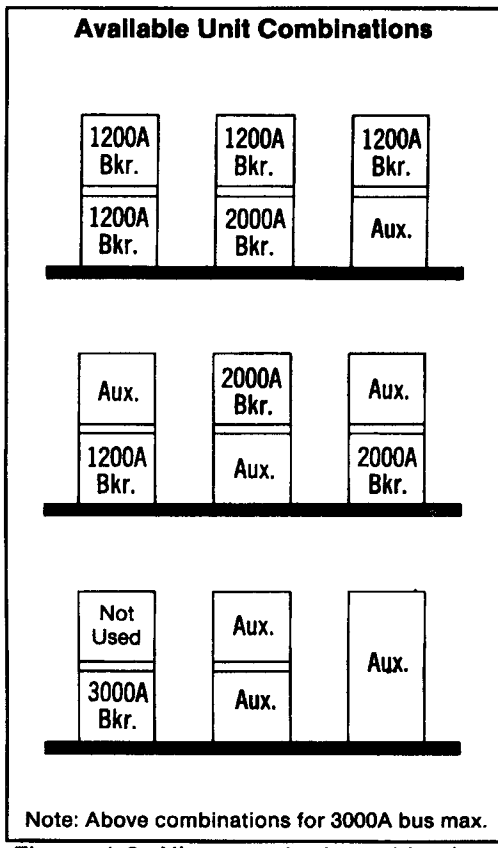


Figure 1-3. Nine standard combinations of upper and lower units.

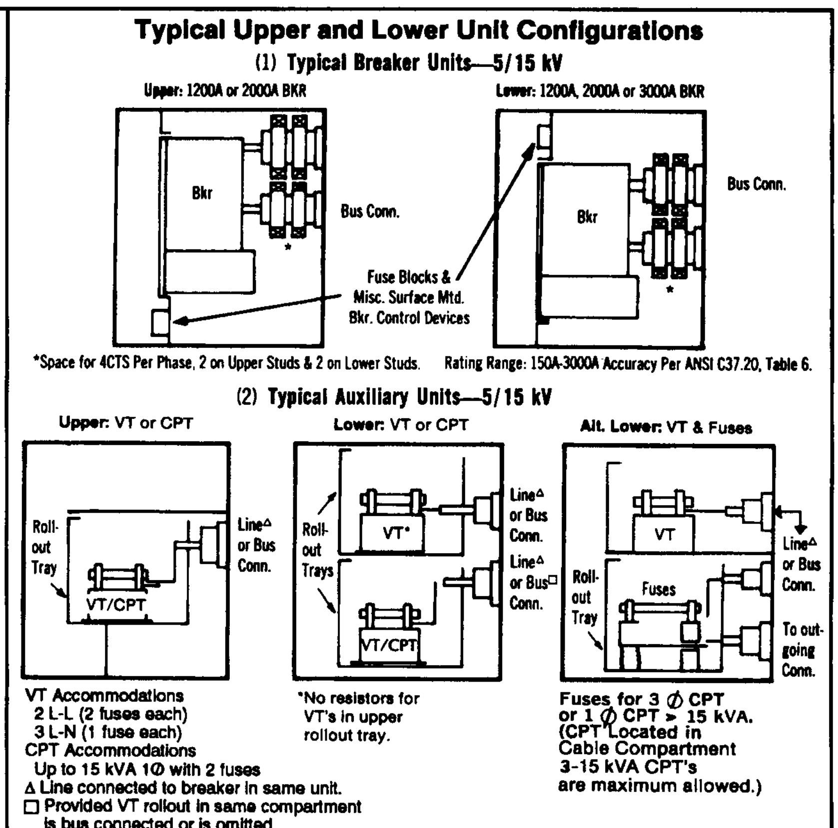
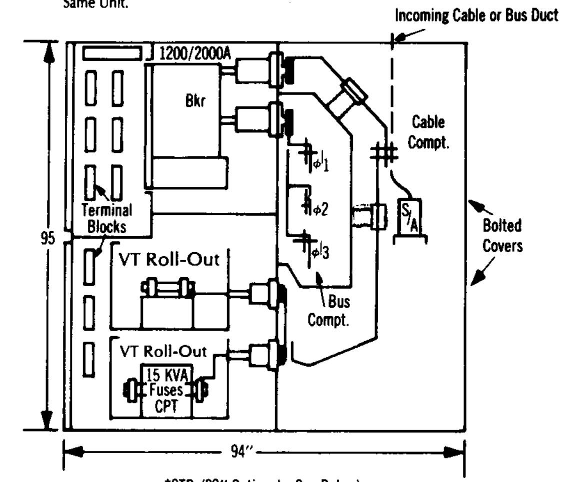


Figure 1-4. Typical upper and lower unit configurations.

Typical Equipment Section Views

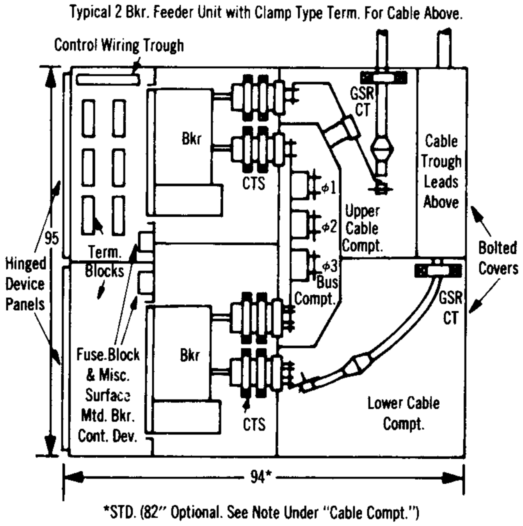
Typical Incoming Line Unit With Main Breaker & CPT & VT Roll-outs in Same Unit.



*STD. (82" Optional—See Below)

CABLE COMPARTMENT
- Designed for up to 2-750 MCM/ϕ 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 (TM), 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.

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



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

BUS COMPARTMENT
- 1200A and 2000A: Aluminum standard; copper optional.
- 3000A 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 standard, porcelain inserts optionsl for 5 or 15 kV.

Figure 1-5. 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 1-6. 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.

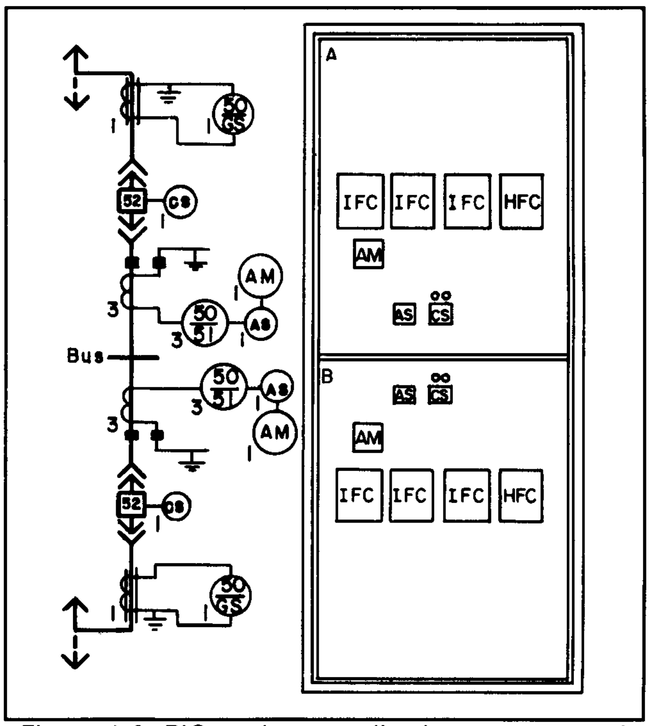


Figure 1-6. PIC package application on a general purpose feeder.

Contents

Section 2

System One-Line Diagram

System One-Line Diagram

INTRODUCTION

The first step in preparing a specification for metal-clad 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.

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 Reference 4 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 of this section.)

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

Table 2-1. Abbreviations

Abbr.	Description	Abbr.	Description
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	VARM	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 meter
VT	Voltage transformer	WM	Wattmeter

Table 2-2. ANSI Standard Device Function Numbers

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

System One-Line Diagram

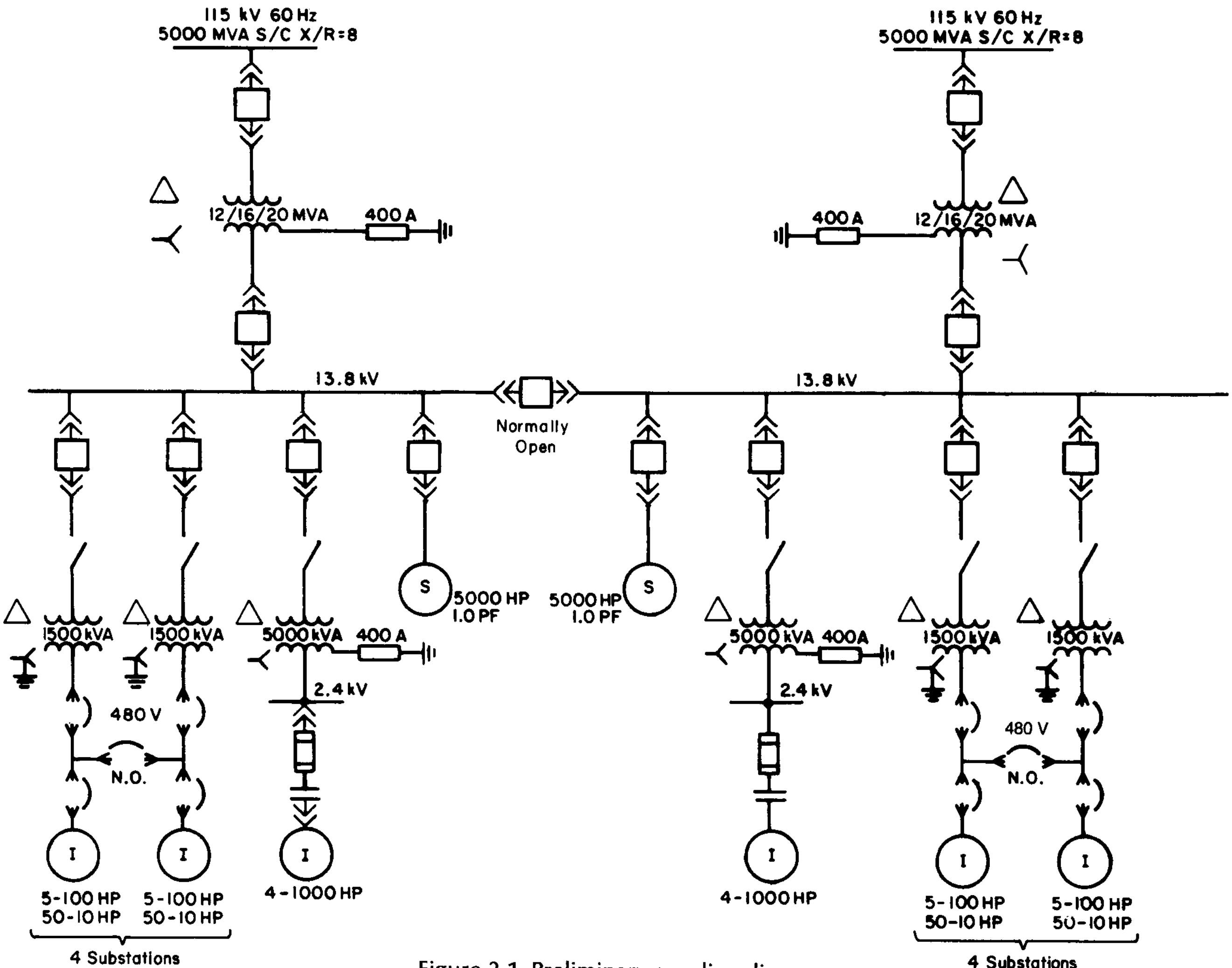


Figure 2-1. Preliminary one-line diagram.

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. (See Ref. 5 of this section.) From these 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 of Section 3.)

— Determine the applicable circuit breaker ratings.

— Compare the feeder cable short-circuit heating limit with the maximum available short-circuit current times K_t times K_o. (See Ref. 10 and 12 of this section.)

Note that the calculations performed in accordance with Reference 5 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. For other than power circuit breakers, refer to the appropriate ANSI standard for short-circuit calculation procedure.

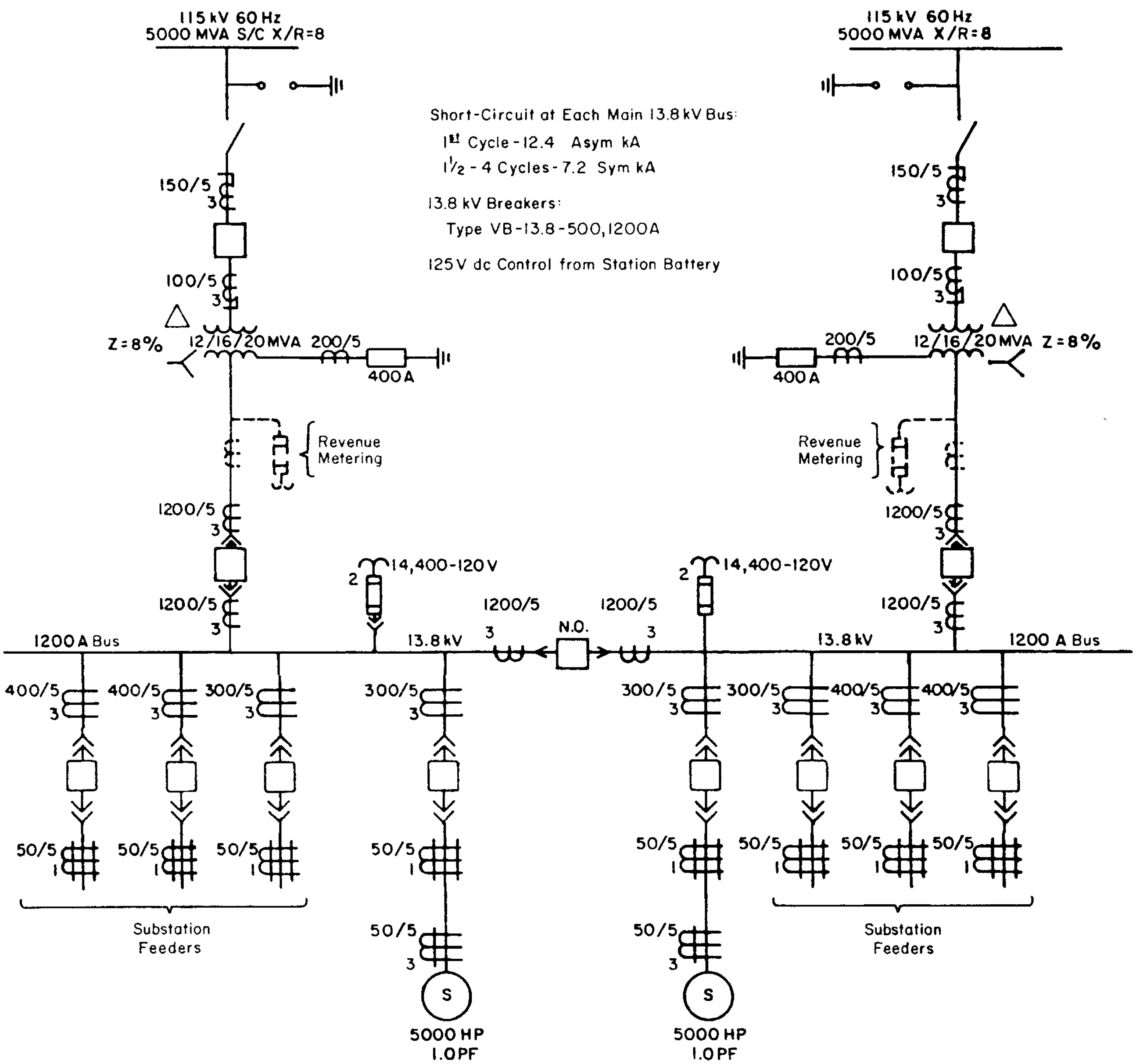


Figure 2-2. Partially developed one-line diagram.

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:

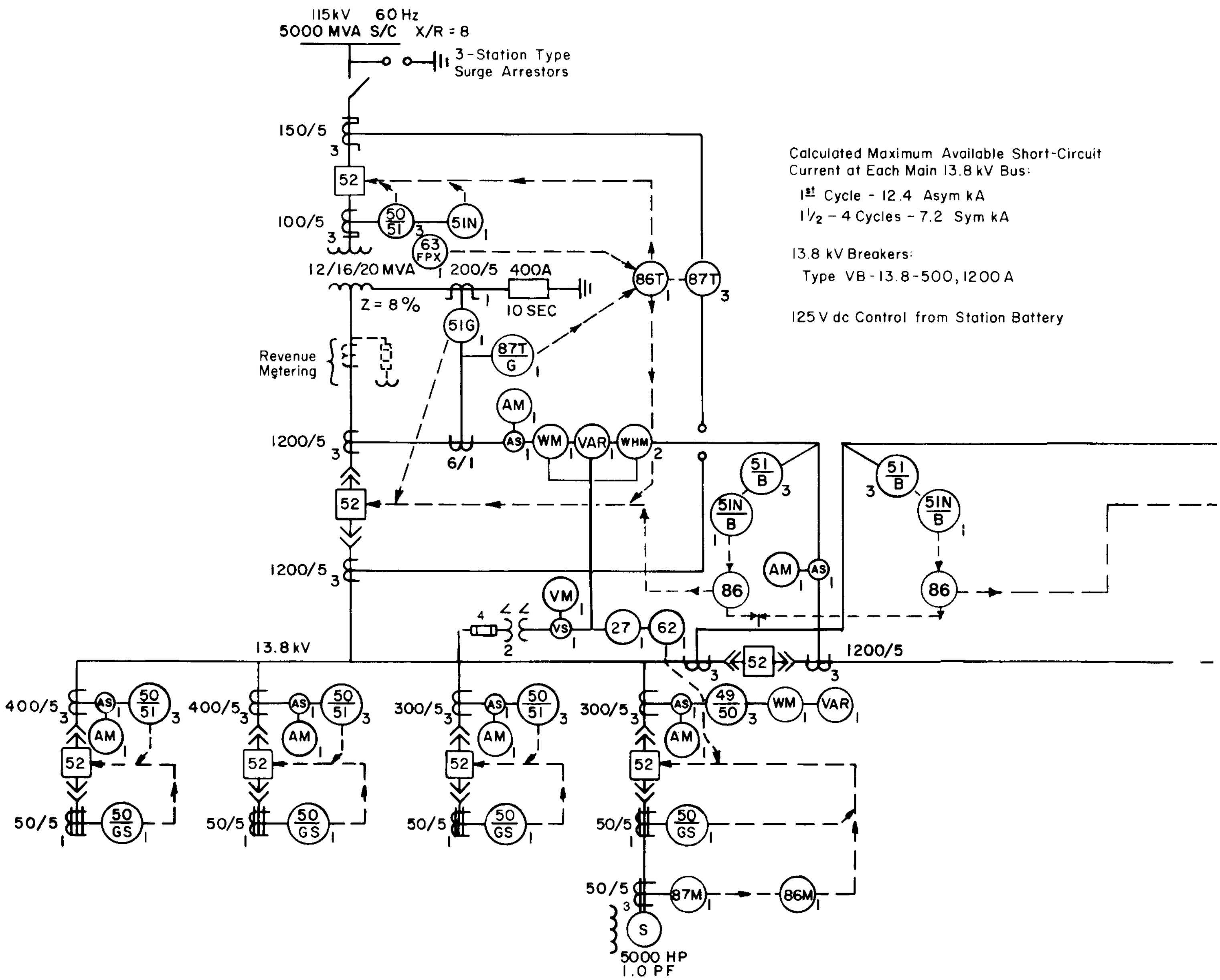
— Show the results of the short-circuit calculations performed, using the preliminary one-line diagram and selected circuit breaker ratings.

— 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 ratings, 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



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 of this section.)

— Include in the study an examination of all circuits for compliance with applicable local and national codes. (See Ref. 11 of this section.)

— Verify that all circuit conductors are applied within the conductor short-circuit heating limit. (See Ref. 10 and 12 of this section.)

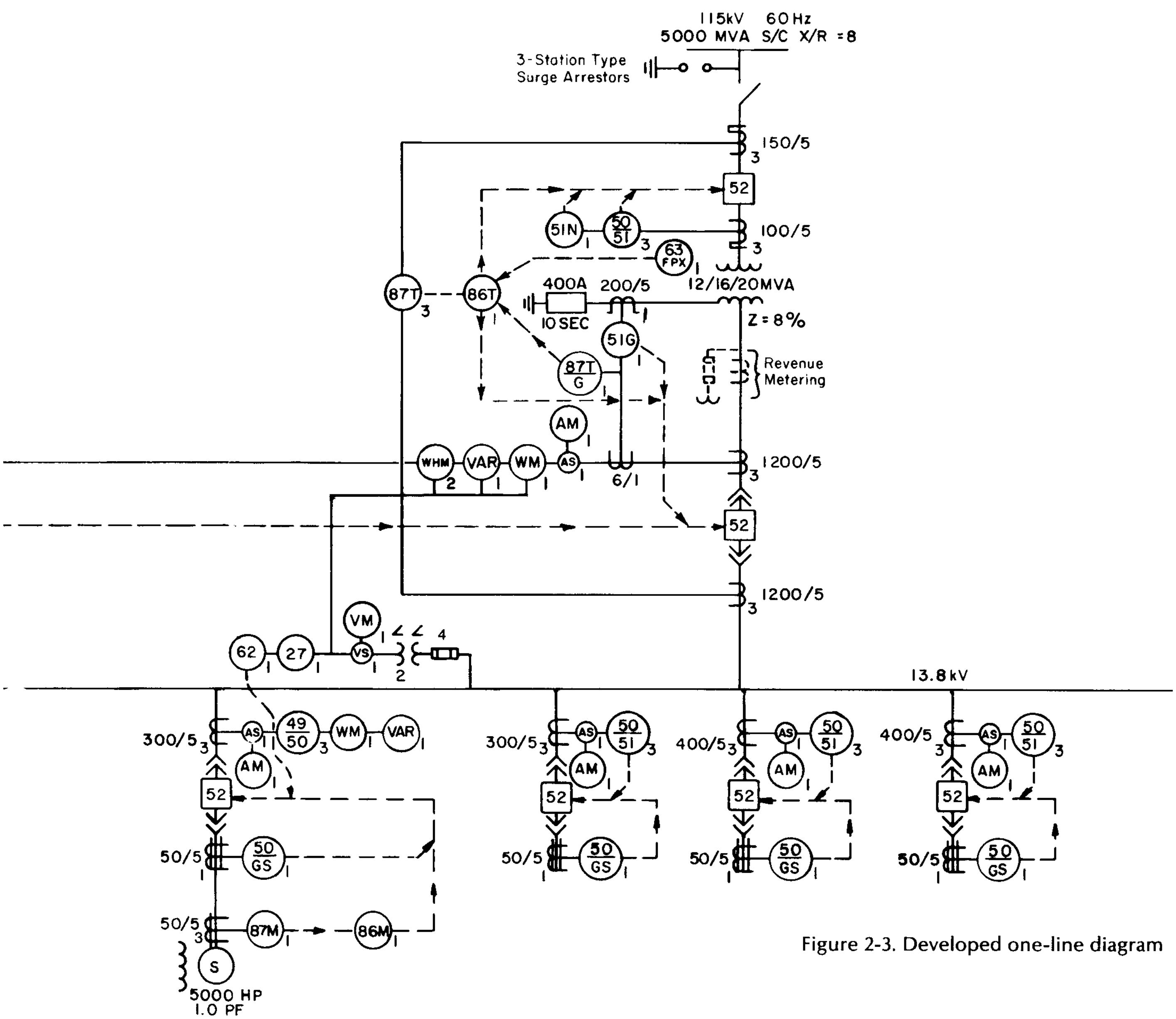


Figure 2-3. Developed one-line diagram

Protective Relays

Device	Description	Type	Device	Description	Type
50/51	Phase Time & Instantaneous Overcurrent Relay	12IFC	87T/G	Transformer Ground Differential Relay	1FC
51N	Residually Connected Time Overcurrent Relay	12IFC	86T	Transformer Lockout Relay	12HEA
51G	Ground Time Overcurrent Relay	12IFC	87M	Motor Differential Relay	12HFC
50/GS	Ground Sensor Instantaneous Overcurrent Relay	12HFC	86M	Motor Lockout Relay	12HEA
51/B	Phase Time Overcurrent Relay	12IFC	49/50	Motor Thermal & Instantaneous Relay	12THC
51N/B	Residually Connected Time Overcurrent Relay	12IFC	27	Undervoltage Relay	12NGV
87T	High Speed Transformer Differential Relay	12STD	62	Timer	(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 2-3. 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 11 for a Bill of Material, Front View Arrangement, and Floor Plan for "Arrangement 2" of Figure 2-4. The information in Section 11 is typical of proposal information supplied for POWER/VAC switchgear.

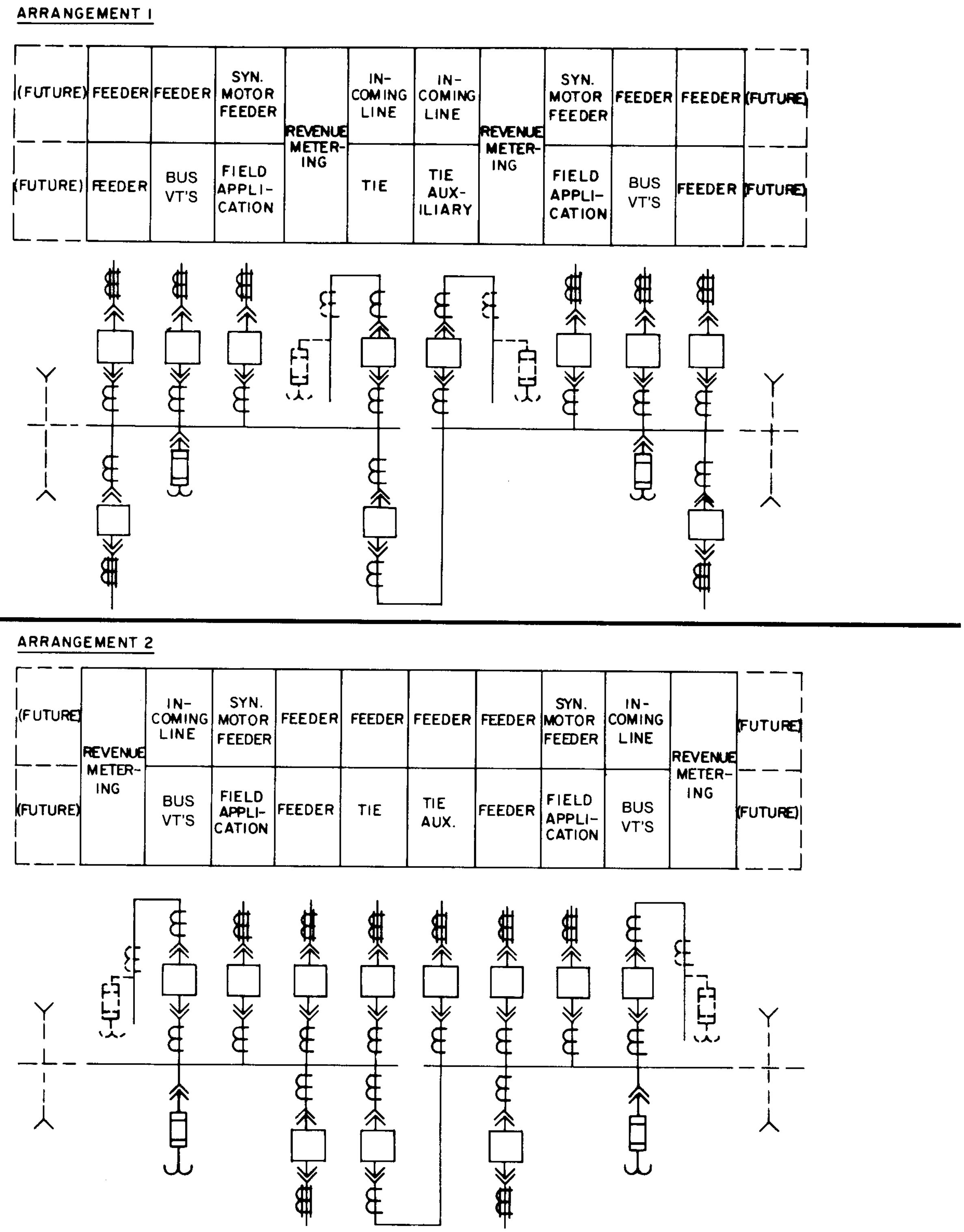


Figure 2-4. Two possible arrangements of POWER/VAC metalclad switchgear.

REFERENCES

Standards

	ANSI Standard	IEEE Standard	Title
1.	C42.100-1977	100-1977	IEEE Standard Dictionary of Electrical and Electronic Terms.
2.	Y32.2-1975	315-1975	Graphic Symbols for Electrical and Electronic Diagrams.
3.	Y14.15-1966 (R1973)	—	Electrical and Electronics Diagrams.
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 Electric Power Systems in Commercial Buildings.
10.	—	242-1975	IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

Codes

11. 1984 National Electrical Code — NFPA Publication 1984.

Books

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

Publications

13. GEA-10049 — POWER/VAC Metalclad Switchgear.

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

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 Table 3-1) 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 furnace)
- 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 preceding paragraph are addressed.

CIRCUIT BREAKER RATINGS

POWER/VAC circuit breaker ratings are shown in Table 3-1. Interrupting ratings are for 60-Hz applications. 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. 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 are 4.16 kV, 7.2 kV and 13.8 kV. POWER/VAC switchgear may be applied at operating voltages from 2400 volts through 13,800 volts, provided the maximum circuit operating voltage does not exceed the POWER/VAC rated maximum voltage, see Table 3-1 page 3-3.

TABLE 3-1—POWER/VAC Power Circuit Breaker Characteristcs (Symmetrical Rating Basis ANSI C37.06)

SYMMETRICAL RATING BASIS ANSI C37.06

Identification (6&7)*		Rated Values								Related Required Capabilities			
		Voltage		Insulation Level: Rated Withstand Test Voltage		Current					Current Values		
Nominal rms Voltage Class (kV)	Nominal 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)	Con-tinuous rms Current Rating at 60 Hz (amperes)	Short-circuit rms Current Rating (at Rated Max kV) (kA) (3) (4)	Rated Inter-rupting Time (Cycles)	Rated Per-missible Tripping Delay, Y (Seconds)	Rated Maximum rms Voltage Divided by K (kV)	Maximum Symmet-rical Inter-rupting Capability (5) — K Times Related Short-circuit rms Current (kA)	3 Sec Short-time Current Carrying Capability — 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	36	36	58
† 4.16	250	4.76	1.24	19	60	2000	29	5	2	3.85	36	36	58
4.16	250	4.75	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
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
† 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	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

† Breaker is Type VBI

High Close and Latch Capability Circuit Breakers (these ratings exceed ANSI-C37.06)

4.16	250	4.76	1.24	19	60	1200 2000 3000	29	5	2	3.85	36	36	78
7.2	500	8.25	1.25	36	95	1200 2000 3000	33	5	2	6.6	41	41	78
13.8	500	15	1.30	36	95	1200 2000 3000	18	5	2	11.5	23	23	58
13.8	750	15	1.30	36	95	1200 2000 3000	28	5	2	11.5	36	36	77

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 1979, 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-C37.04-1979 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.

In accordance with ANSI-C37.06, users should confer with the manufacturer on the status of various circuit breaker ratings.

6. General Electric POWER/VAC circuit breakers are designated as type VB-"KV"-"MVA" or type VB1—"KV"—"MVA".

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

Circuit Breaker Selection

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 and 50-Hz ratings, 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 $41 \text{ kA} \times \frac{4.76 \text{ kV}}{4.16 \text{ kV}} = 47$ 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).

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. 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. 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 energizing cold loads.

RATED INTERRUPTING TIME

POWER/VAC circuit breaker interrupting time is 5-cycles, as stated in Table 3-1. Three-cycle POWER/-VAC breakers are available. For additional information contact your General Electric Company Sales Engineer or Medium Voltage Switchgear, P.O. Box 488, Burlington, Iowa 52601.

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 evaluated 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.

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.

Calculation of Reclosing Capabilities

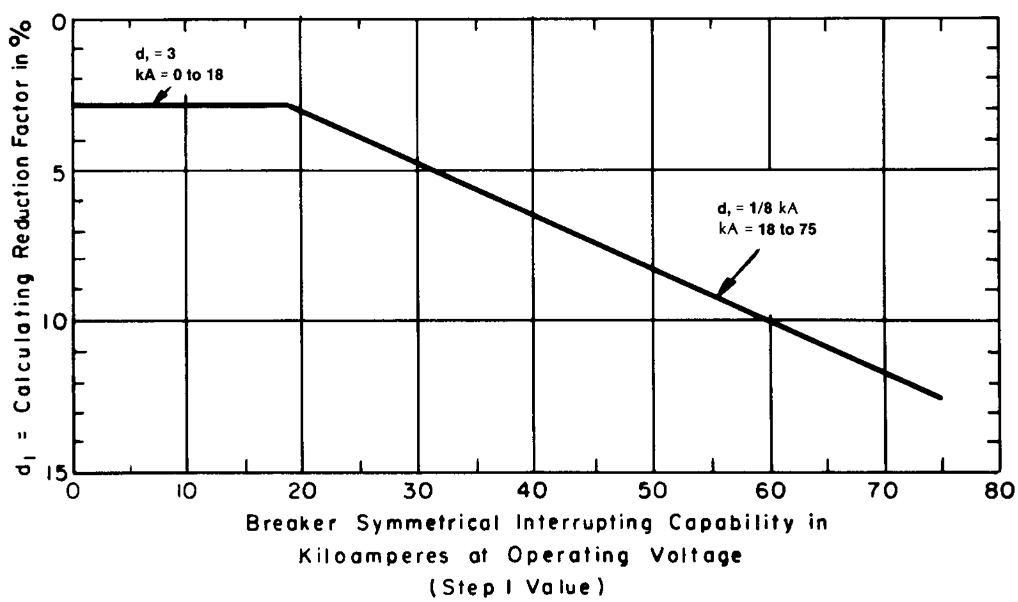
- A duty cycle shall not contain more than five opening operations.
- All operations within a 15-minute period are considered part of the same duty cycle.
- The circuit breaker may be applied, at the determined operating voltage and duty cycle, to a circuit for which the calculated short-circuit current 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 (Note 3).

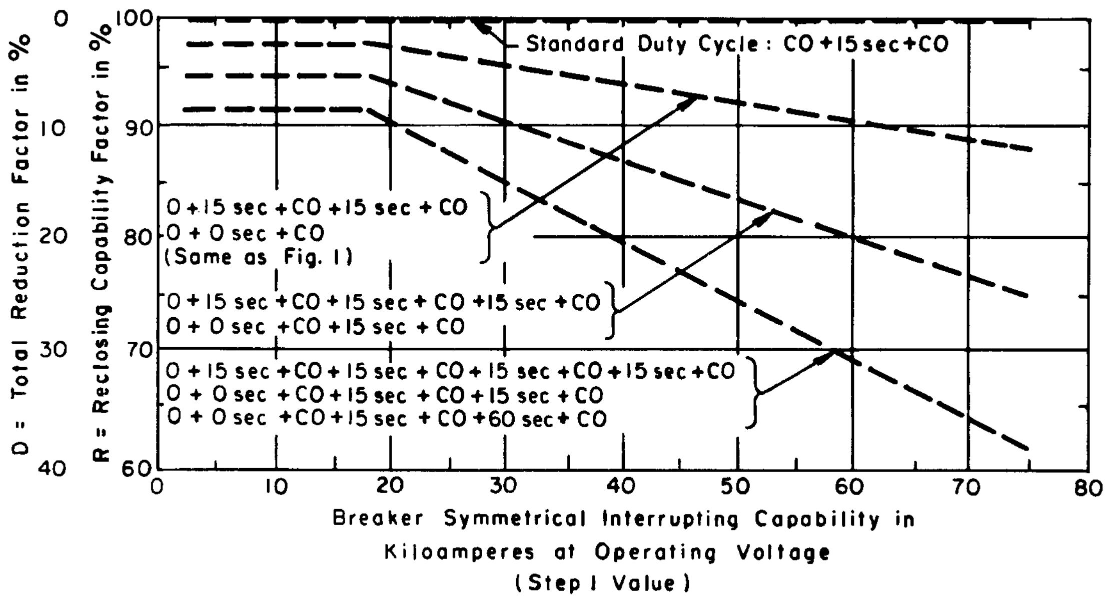
TABLE 3-2—REPETITIVE DUTY AND NORMAL MAINTENANCE FOR POWER/VAC BREAKERS USED IN MILD ENVIRONMENTS OTHER THAN FOR ARC FURNACE SWITCHING

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, lubricating, 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.	C. Close and trip within rated current, rated maximum voltage and 80% PF or greater.	D. Closing 600% of rated current or less at no less than 30% PF. Otherwise, same as C.
			E. Rated control voltage.	E. Applies	E. Applies.
			F. Frequency of operation not more than 20 in 10 minutes or not more than 30 in 1 hour.	F. Applies.	F. Applies
			G. Servicing at intervals given in Column 2.	G. Applies	G. Applies
			H. No parts replacement.	H. Applies	H. Applies
			I. Breaker meets all current, voltage, interrupting current ratings.	I. 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.	J. Applies
				K. After 15 full short circuit faults check the contact erosion.	K. Applies
All	All	10,000 or 10 years	10,000 minimum	10,000	10,000



REF. (ANSI C37.06-1979, PAGE 32)

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



REF. (ANSI C37.010-1979 PAGE 26)

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

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

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

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

$$+\, d_1\,\frac{(15-t_2)}{15} + \ldots + d_1\,\frac{(15-t_n)}{15}$$

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.

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.

TABLE 3-3—REPETITIVE DUTY AND MAINTENANCE REQUIREMENTS FOR POWER/VAC CIRCUIT BREAKERS APPLIED TO ARC FURNACE SWITCHING

BREAKER				NUMBER OF OPERATIONS	
TYPE	CONTINUOUS RATING (AMPERES)	ARC FURNACE FULL-LOAD RATING (AMPERES)	MAXIMUM NUMBER OF OPERATIONS BETWEEN SERVICING	NO-LOAD MECHANICAL	SWITCHING AND INTERRUPTING
COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6
			A. Servicing consists of adjusting, cleaning, lubricating, tightening, changing parts, as recommended by the Company. The operations listed are on the basis of service in a mild environment.	B. When closing and opening no-load.	
				C. Within 90 to 100% of rated control voltage.	C. Applies.
				D. Frequency of operation not more than 20 in 10 minutes or not more than 30 in 1 hour.	D. Applies.
				E. Servicing at no greater interval than shown in Column 4.	E. Applies.
				F. No parts replacement.	F. Applies.
				G. Breaker meets all current, voltage, interrupting current ratings.	G. Applies.
			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.		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	10,000

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 to the full continuous current rating of the breaker.

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

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 3-4B will not apply. These situations require evaluation of such factors as local high-frequency equalizing currents flowing between the separated, switched capacitor banks.

FAST BUS TRANSFER

Fast bus transfer is normally used for transferring a generating station auxiliary bus to an emergency power source upon failure of the normal source of power. During this transfer it is essential that bus "dead time" be as short as possible to prevent loss of critical auxiliary functions. "Fast" transfer means there is no intentional time delay in the transfer of a bus or load from one source of power to another. POWER/VAC circuit breakers with stored-energy closing meet the critical requirements for fast transfer.

The preferred circuit breaker operation sequence used to achieve fast transfer consists of giving a trip signal to the opening breaker. Then a "b" contact (open when the breaker contacts are closed) on the opening breaker initiates closing of the second breaker. The amount of dead time depends upon whether the POWER/VAC breaker is standard or is provided with a special early "b" (faster) contact and special closing coil.

Typical dead times for fast transfer, using standard and special POWER/VAC breakers, are shown in Table 3-5.

TABLE 3-4A—VB POWER/VAC CIRCUIT BREAKER (ML-17 MECHANISM) CAPACITOR BANK SWITCHING CAPABILITY FOR SINGLE BANKS AND BACK-TO-BACK SWITCHING

CAPACITOR VOLTAGE	BREAKER CONT. I	MAXIMUM NAMEPLATE CAPACITOR BANK RATING - MVAR UNGROUNDED BANK	GROUNDED BANK
2,400	1,200 2,000 3,000	4 7 10	3 6 9
4,160	1,200 2,000 3,000	7 11 17	6 10 16
7,200	1,200 2,000	12 20	11 18
12,470	1,200 2,000 3,000	20 34 45	19 32 36
13,800	1,200 2,000 3,000	23 30 30	21 23 23

NOTES:
1. 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.
2. Bank inrush currents are to be limited to 15kA at 2000 Hz or to 30kA-kHz if the inrush current is less than 15kA.
3. Surge suppressors are not required for switching transient voltages.
4. Interrupting time is in accordance with the rated interrupting time of the circuit breaker.

TABLE 3-4B—VB1 POWER/VAC CIRCUIT BREAKER (ML-18 MECHANISM) GENERAL PURPOSE CAPACITOR BANK SWITCHING CAPABILITY FOR 1200 AND 2000 CONTINUOUS CURRENT RATED POWER/VAC CIRCUIT BREAKERS

RATING	SYSTEM VOLTAGE -KV	RATED CAPACITOR SWITCHING RATING -AMPERES	MAXIMUM NAMEPLATE CAPACITOR BANK RATING—KVAR UNGROUNDED BANK	GROUNDED BANK
4.16KV-250MVA	2.4 4.16	400 400	1,300 2,300	1,200 2,100
13.8KV-500MVA	12.47 13.8	250 250	4,300 4,700	4,000 4,400

Footnotes: The capacitor-bank rating is subject to the following conditions:
1. The transient voltage from line to ground shall not exceed 3 times maximum design line-to-ground crest voltage measured at the breaker terminals.
2. 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.
3. The capacitor bank rating applies only to single bank switching as noted herein.
4. Interrupting time is in accordance with the rated interrupting time of the circuit breaker.
5. 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 3-4A.

TABLE 3-5—Typical Dead-Times for Fast Transfer Using POWER/VAC Circuit Breakers With ML-17 Mechanism

Power/Vac Breakers	Control Voltage (volts) (1)	Nominal Dead Bus Times (Milliseconds) Trip then close using: a) early "b" contact & special closing coil (2)		b) Standard "b" contact (3)	
		No Arcing (3)	With Arcing (4)	No Arcing (3)	With Arcing (4)
All Rating	125 DC or 250 DC	62	50	80	68

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.

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 3300 feet (1000 meters).

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 of this section.) 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 -30C) shall be considered as special. Such applications should be referred to the nearest General Electric Sales Office for evaluation.

High Altitude

POWER/VAC circuit breakers and switchgear assemblies utilize air for an insulating and cooling medium. Operation at altitudes above 1000 meters will result in a higher temperature rise and lower dielectric strength because the air is thinner. Thus, certain circuit breaker and switchgear capabilities must be corrected to adjust for high-altitude operation.

For operation of POWER/VAC circuit breakers and switchgear at altitudes above 1000 meters, the rated continuous current shall be multiplied by the appropriate correction factors shown in Table 3-6. For proper application, the derated values should equal or exceed the duty requirements of the application. Short circuit current ratings and rated operating voltage are not affected.

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

Altitude (feet)	Rating Correction Factor*	
	Rated Continuous Current	Insulation Level**
3,300 (and below)	1.00	1.00
5,000	0.99	1.00
10,000	0.96	1.00

Footnote:
*Values for intermediate altitudes may be determined by linear interpolation.
**Standard Power/Vac with Surge Suppressors.

Other Unusual Conditions

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.

BREAKER MOUNTED ACCESSORIES

POWER/VAC circuit breakers can be furnished with a redundant tripping circuit, including the additional shunt trip coil. It is designed specifically for use 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 voltage is lost. (See page 4-4.)

A four-stage auxiliary switch is furnished on every POWER/VAC circuit breaker. Three contacts are used for the close-and-trip circuits, leaving two "a" and three "b" contacts for Purchaser use. Additional switch stages are not available on the breaker. They must be provided using an auxiliary switch stationary-mounted on the equipment.

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" or "Connect" positions only.

Ground and Test Device

The POWER/VAC* Ground and Test Device is an auxiliary device for use with POWER/VAC* horizontal drawout metalclad switchgear equipment, and is designed for use during both the initial installation and at normal maintenance periods. The primary function of the device is to solidly ground the equipment as well as permit various types of tests. There are two types of ground and test devices available, the manual Ground and Test Device[7], Type: PVV-1200, PVV-2000, and PVV-3000 and the electrically operated type GMV-1000[8]. Detents permit the device to be inserted in the proper cubicle of a stack.

A different "manual" Ground and Test Device is required for each current rating of: 1200, 2000 and 3000 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 ratings from 4.16 kV to 13.8 kV.

A single "Electrical" Ground and Test Device with interchangeable primary contact fingers for 1200A/2000A, and 3000A will cover all the metalclad equipment ratings and can be installed in the upper or lower compartment. The 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 the equipment.

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 Metal-clad 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

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, are given in Table 4-1.

Operating currents for POWER/VAC circuit breakers are given in Table 4-2.

Table 4-1
Standard Control Voltage and Operating Ranges For POWER/VAC Circuit Breakers

Nominal Control Voltage		Operating Range (Volts)	
		Stored-energy Mechanism	
Volts		Spring Motor and Closing Spring Release Coil	Tripping Coil
DC	48	38-56	28-56
DC	125	100-140	70-140
DC	250	200-280	140-280
AC	120	104-127	not available
AC	240	208-254	See page 4-4

Motor is universally rated for AC or DC:
115 VAC/125 VDC
230 VAC/250 VDC

Table 4-2
Operating Currents of POWER/VAC® Circuit Breakers

Mechanism Type	Type of Breaker	Closing Current (Amperes)										Tripping Current* (Amperes)		
		At 48 Volts DC		At 125 Volts DC		At 250 Volts DC		At 120 Volts AC		At 240 Volts AC		At 48 Volts DC	At 125 Volts DC	At 250 Volts DC
		Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor	Closing Spring Release Coil	Spring Motor			
ML-17	VB-4.16-250 VB04.16-350 VB-7.2-500 VB-13.8-500 VB-13.8-750 VB-13.8-1000	8.0	12.3	6	3.7	2.2	2.3	8	8	4	5	19.0	10.0	4.5
ML-18	VB1-4.16-250 VB1-13.8-500	6.9	12.0	3.4	4.5	1.6	2.5	12.0	4.5	10.0	2.5	17.0	7.3	4.7

*Fuses for the tripping circuit should have an ampere rating of at least 2 times the tripping current and not less than 35 amperes.

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 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 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 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 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 to a 48-volt rating.

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

ST-230-3 POWER/VAC AUTO-CHARGE CAPACITOR TRIP DEVICE — The "auto-charge" trip device consists of the "simple" device, plus a 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 several days. The output tripping range is 295-360 V dc. The breaker trip coil is 325 V dc.

The "auto-charge" capacitor trip device is provided on POWER/VAC switchgear whenever ac trip or capacitor trip is specified.

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 is normally considered to be the most reliable auxiliary power source. Nevertheless, in many instances, the storage battery 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 lineups, 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.

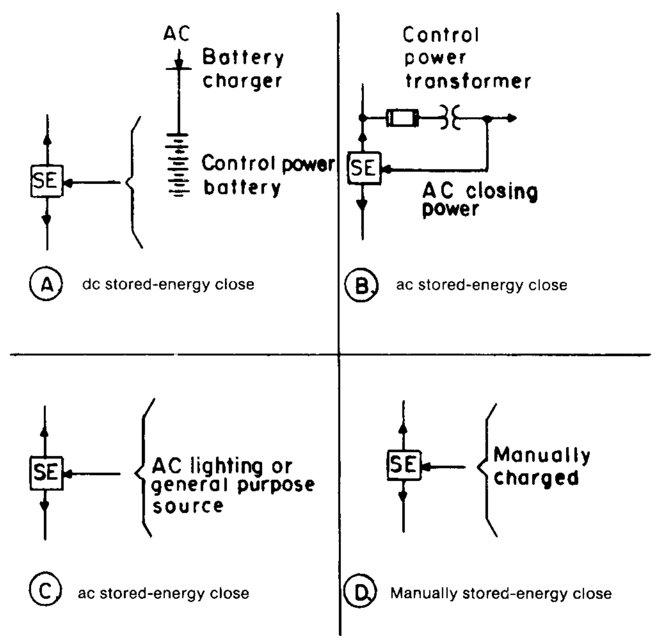


Figure 4-1. Closing mechanism arrangements.

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 4-2 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, motor-starting 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 trippings 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 A	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 from 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 from 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 in 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 motor, the load on the control power source is the same as for the breaker spring-charging motor; see Table 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 at 115 volts, and supplying a 125-volt battery, 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 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 4-2, 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, with the charger "off," is not a "continuous" source.

DC CONTROL POWER EQUIPMENT

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

Two types of batteries are used with switchgear: 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.

Planté 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, or the product of amperes output multiplied by hours of discharge, with the basic rate being for 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-acid, 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, published data is for cells at 25 C (77 F), and battery rating values must be reduced when the battery is at a lower temperature. The one-minute rating at -10C (15 F), for instance, is half the 25 C rating.

The *common rate base* mentioned earlier, refers to the conversion of one-minute-rate loads, etc. to equivalent ampere-hours at the eight-hour rate, and also includes any compensation for operating temperature. This conversion can be done in one of the following ways, after collection of the detailed load data.

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

For direct calculation, the battery is assumed to have carried its steady loads for eight hours, and then — as the worst case — subjected 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:

Control voltage, dc	48 V	125 V
Trip coil current	19 A	10 A
Spring motor current	12.3 A	3.7 A

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 4-5

Battery Type:	Lead-acid		Nickel-cadmium	
Control voltage (volts)	48	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. 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.

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 POWER 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.

Control Power Equipment

Selection

If breaker tripping power, with ac control, is being obtained from capacitor-trip devices, its demand need not be included in the 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 totalled and evaluated to determine their demand on the 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 4-6, the load is approximately 8 kVA, so the next larger available transformer (10 or 15 kVA) is selected.

Table 4-6

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.

Breakers 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
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.

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

5

System and Equipment Protection

INTRODUCTION

This section covers some of the basic considerations used when selecting equipment for protection, control instrumentation, metering, and control power protection.

Protection considerations include phase and ground directional and non-directional, overcurrent relaying, differential relaying, directional power relaying, underfrequency relaying, and under-voltage relaying.

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

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-overcurrent protection consists of one phase-overcurrent relay Type IFC 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.

Overcurrent relays are available with inverse, very inverse, or extremely inverse characteristics. In the absence of additional system information, the very inverse characteristic is most likely to provide optimum circuit protection and selectivity with other system protective devices. If selectivity with fuses and reclosers is a requirement, the extremely inverse characteristic is well suited for application. 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 time.

INCOMING LINES — Incoming line phase-overcurrent relays (51) are usually furnished without instantaneous attachments (50) 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 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 1984 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 Type IJCV voltage-restrained overcurrent relays (51 V). They operate faster and are more sensitive for faults close to the generator than for faults remote from the generator.

Ground-overcurrent Protection

Ground-overcurrent protection is provided by either Type IFC time-overcurrent relays or Type HFC 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.

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.

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.

INCOMING LINES — Incoming line ground-overcurrent 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-overcurrent relays (without instantaneous attachments) 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 protection 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 the Type IBC or JBC relay, polarized to operate on current flowing toward the source. The IBC relay, without instantaneous attachment, 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 Type JBC directional-overcurrent relay (67) with directional instantaneous unit is applied to incoming lines fed by long "dedicated" service incoming lines or large local transformer incoming lines. For 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 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.

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, the Type IBCG 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-wye connected voltage transformers (or wye-wye VT's with wye-broken delta auxiliary transformers) may be used for polarization. On occasion, dual polarization may be desirable.

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.

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.

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. High-speed relays, Type STD, 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, either a differentially connected Type IFC ground-overcurrent relay with a very inverse characteristic, or an IFD differential relay 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), Type HFC 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, Type IJD or CFD 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) Type CFD are 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, 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 unbalance relay Type NBV (60). To avoid tripping on system transient disturbances, this relay should operate through a timer usually set from 2 to 4 seconds. For systems subject to harmonics, apply a harmonic filter to the input to this relay.

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 or four attempts to close a breaker at variable times may either be programmed with an immediate initial reclosure or an initial time-delay reclosure. The Type SLR relay (79) is appropriate 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.

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 an underfrequency relay (81), Type SFF; sensitive directional-power relay (32), Type CCP; and an undervoltage relay (27), Type NGV. For some applications, 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.

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-ampere 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.

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**				
Breaker Operation		**Close**		**Trip**		**Close**		**Trip**		
Breaker Position		**Conn**	**Test**	**Conn**	**Test**	**Conn**	**Test**	**Conn**	**Test**	**Devices Required (in addition to remote CS)**
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-band, 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 equipments.

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 light-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 7¼ 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, 7-35, and 7-35A.

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

Instrument transformer metering accuracies are of concern for billing metering applications. Current transformer relaying accuracies 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

Contents

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.

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 configuration necessary for each circuit and auxiliary compartment from the part of this section covering Power Conductor and Auxiliary Compartments (pages 6-43 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 equipments 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 from 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 entrance (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.

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

These metalclad feeder (IMFE) equipments are used for controlling and protecting full-voltage-start, essential-service motors and are designated as motor "branch circuit" protective equipment. ("Branch circuit" is defined in Article 100 of the National Electrical Code.) An essential service motor is defined by the NEC as a motor which would "introduce" additional or increased hazard to persons "if the motor were to be shut down automatically by its overload protective relay."

*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.

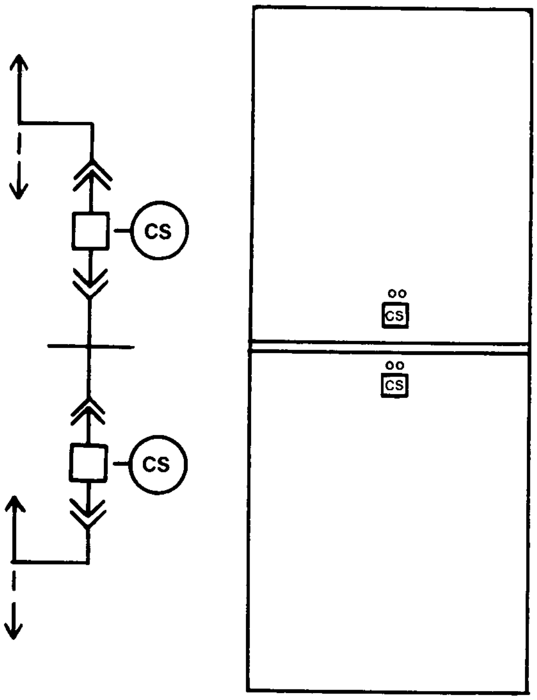
*SYNCHRONOUS MOTOR FEEDERS, FULL-VOLTAGE-START, 1500 HP AND LARGER

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.

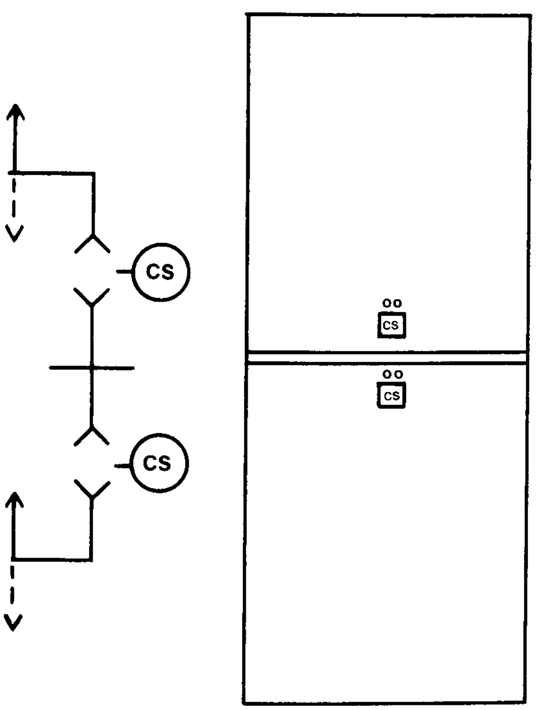
MATERIAL LIST—BASE



MATERIAL LIST—BASE
(Unit A or Unit B)

Quantity	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 dc 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)

Quantity	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 secondary 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).

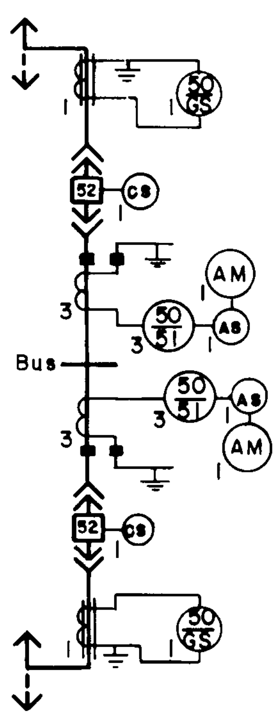
GPF-2 Use this type of feeder for systems which are impedance or solidly grounded and for which selectivity is required with downstream residually connected ground relays.

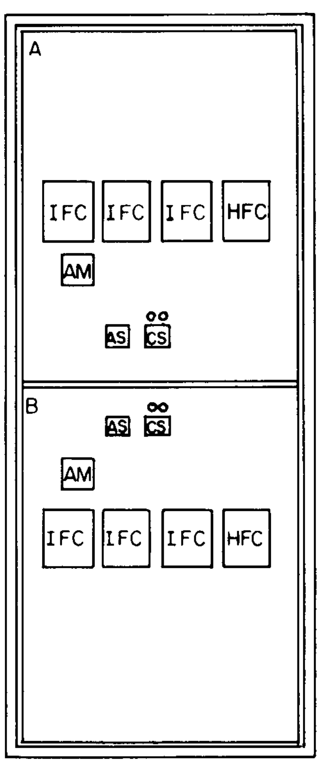
This type of feeder equipment includes three Type IFC phase-overcurrent relays (50/51) and one Type IFC residually connected time-overcurrent ground relay (51N).

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 three Type IFC phase-overcurrent relays (50/51) and no ground relays.

GENERAL PURPOSE FEEDER‡ (GPF-1)





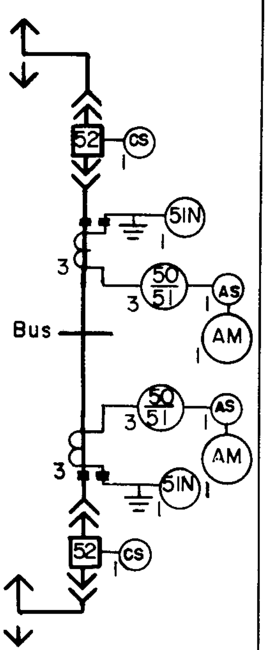
DEVICE LIST FOR GPF-1
(Unit A **or** Unit B)

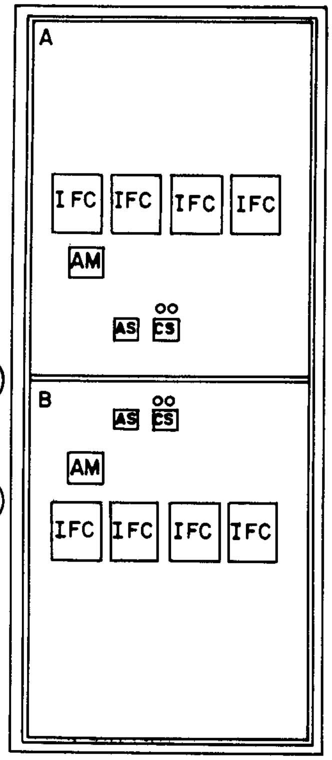
Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Phase Overcurrent Relays	‡50/51	3	121FC
Ground Sensor Relay	‡50GS	1	12HFC
Current Transformers	CT	3	BP (__/5A)
Current Transformer	GSCT	1	INSTR. TRANS. INC.
Breaker Control Switch	CS	1	16SB1 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

‡Ground CT connection

POWER/VAC Switchgear Equipment

GENERAL PURPOSE FEEDER‡ (GPF-2)



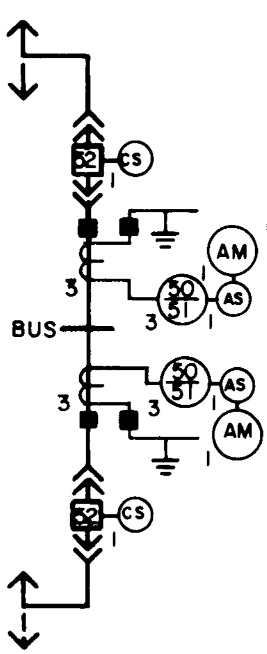


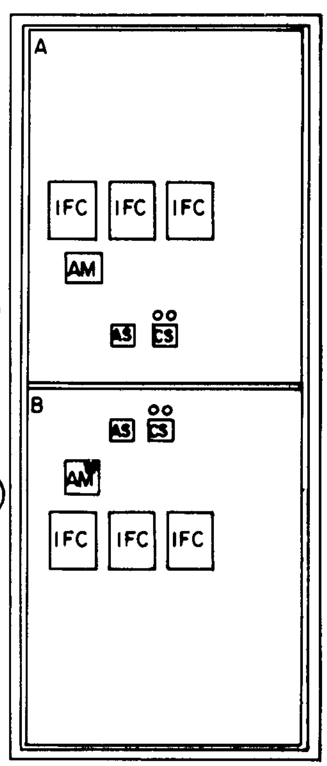
DEVICE LIST FOR GPF-2
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Type
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC
Residual Overcurrent Relay	‡51N	1	12IFC
Current Transformers	CT	3	BP (__/5A)
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 Relays	50/51	3	12IFC
Current Transformers	CT	3	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

‡No ground relays

OPTIONAL EQUIPMENT SELECTION

Protection

OVERCURRENT RELAY CHARACTERISTIC — For systems requiring other than very inverse Type IFC53 time-overcurrent relays for phase relays (50/51) and residually connected ground relays (51N), substitute relays with the desired characteristic from page 7-2. For systems requiring time-delay ground sensors (51G), substitute Type IFC53 relays for Type HFC relays.

OVERCURRENT RELAY QUANTITY — For feeders including ground-sensor, ground-overcurrent protection and for which the minimum protection is acceptable, omit one phase-overcurrent relay (50/51) from phase 2, and omit the associated current transformer. For feeders including residual ground overcurrent protection, omit one phase overcurrent relay (50/51) from phase 2.

AUTOMATIC RECLOSING — For open-wire overhead distribution circuits on which this feature is desired, add Type SLR 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 circuit breaker. For a 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, add indicating voltmeter plus transfer switch, watthour meter or watthour demand meter, as appropriate. For continuous indication of current, substitute three ammeters instead of 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 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 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 lineup, plus an auto-charged, capacitor-trip device for each circuit breaker in the lineup.

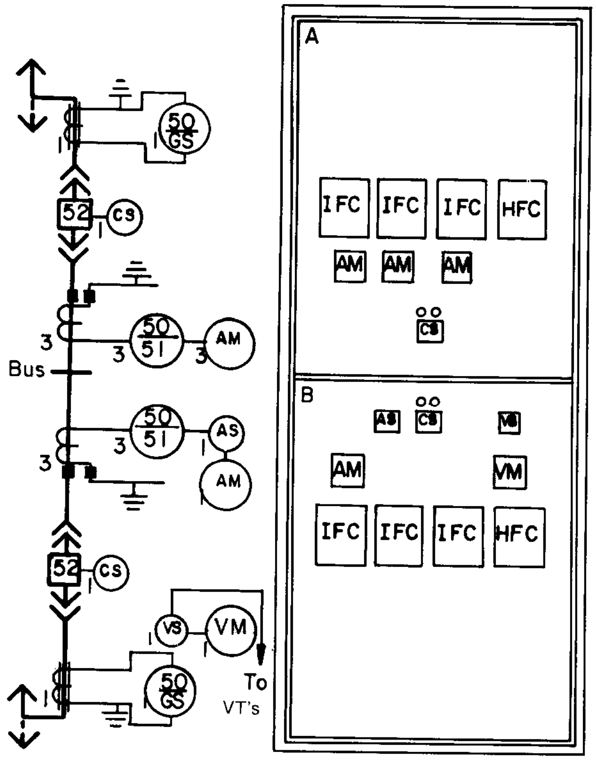
REMOTE CONTROL — For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-6 of this guide). From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch 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 CTs		1	BP
CT High accuracy 5kV		1	JKS-3
or 15kV		1	JKS-5
Ammeter		3	AB-40
Voltmeter Switch		1	SBI or SBM
Voltmeter		1	AB-40
Wattmeter		1	AB-40
Watthour Meter		1	DS
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
Lincoln Thermal Demand Ammeter		1	ADF7
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		1	ST-230

POWER/VAC Switchgear Equipment

TYPICAL MODIFICATIONS OF GPF-1



DEVICE LIST
(Unit A)

All GPF-1 Devices

OMIT:
One SB-1 Ammeter Switch

ADD:
Two AB-40 Ammeters

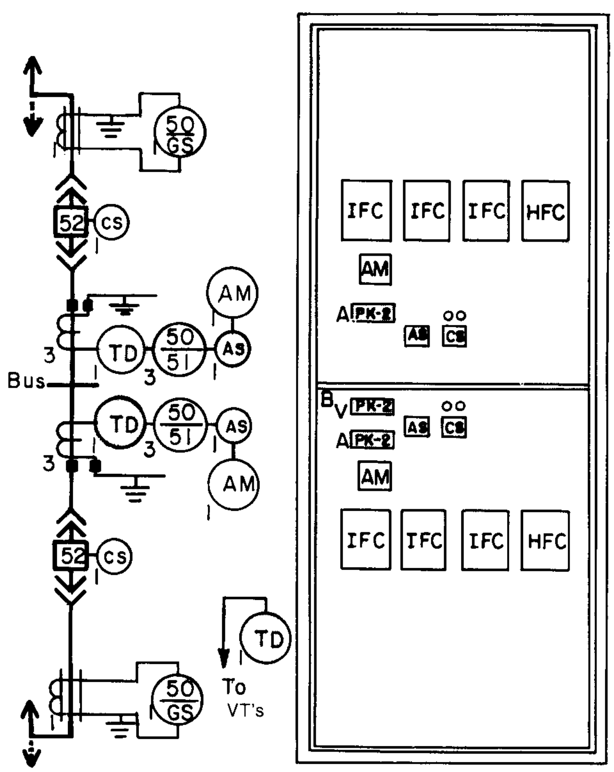
DEVICE LIST
(Unit B)

All GPF-1 Devices

OMIT: None

ADD:
One AB-40 Voltmeter
One SB-1 Voltmeter Switch

TYPICAL MODIFICATIONS OF GPF-1



DEVICE LIST
(Unit A)

All GPF-1 Devices

OMIT: None.

ADD:
One PK-2 Current Test Block

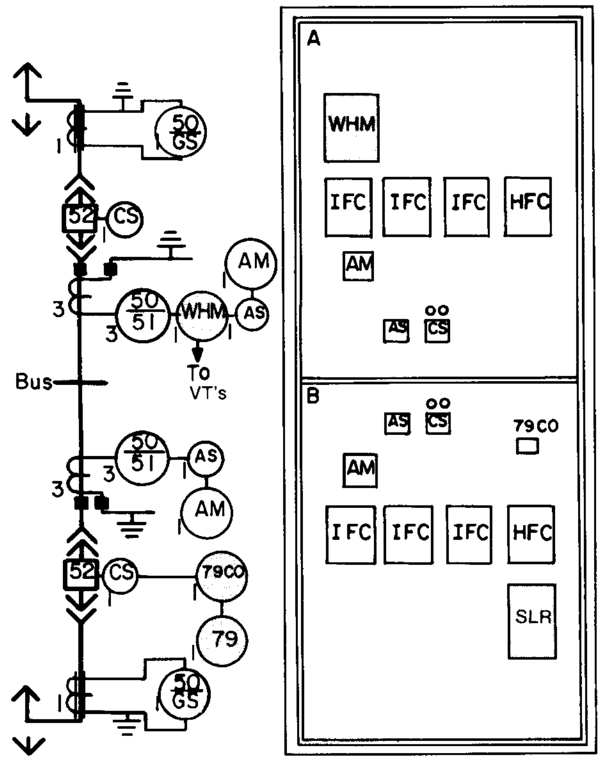
DEVICE LIST
(Unit B)

All GPF-1 Devices

OMIT: None

ADD:
One PK-2 Voltage Test Block
One PK-2 Current Test Block

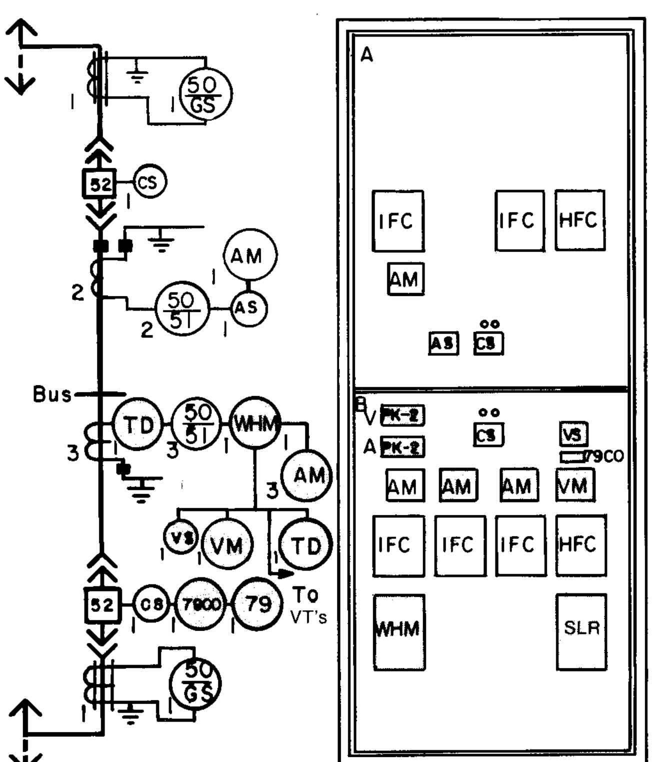
TYPICAL MODIFICATIONS OF GPF-1



DEVICE LIST
(Unit A)
All GPF-1 Devices
OMIT: None.
ADD:
One DS-63 Watthour Meter

DEVICE LIST
(Unit B)
All GPF-1 Devices
OMIT: None
ADD:
One SLR Reclosing Relay
One JBT Reclosing Cut-off Switch

TYPICAL MODIFICATIONS OF GPF-1



DEVICE LIST
(Unit A)
All GPF-1 Devices
OMIT:
One IFC Phase Overcurrent Relay
One Current Transformer
ADD: None

DEVICE LIST
(Unit B)
GPF-1 Devices
(Maximum optional devices)
OMIT:
One SB-1 Ammeter Switch
ADD:
Two AB-40 Ammeters
One AB-40 Voltmeter
One SB-1 Voltmeter Switch
One PK-2 Voltage Test Block
One PK-2 Current Test Block
One DS-63 Watthour Meter
One SLR Reclosing Relay
One JBT Reclosing Cut-off Switch

POWER/VAC Switchgear Equipment

BREAKER BYPASS FEEDERS

DEFINITION

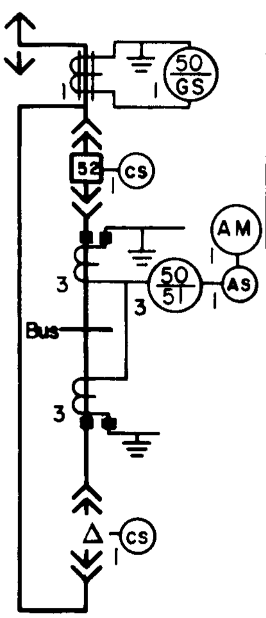
A breaker bypass feeder (BBF) equipment is a metalclad equipment similar to a general purpose feeder, except two breaker units are connected in parallel to feed a common load. A complete vertical section (Unit A and Unit B) is required for each breaker bypass feeder circuit. The purpose of this arrangement 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.

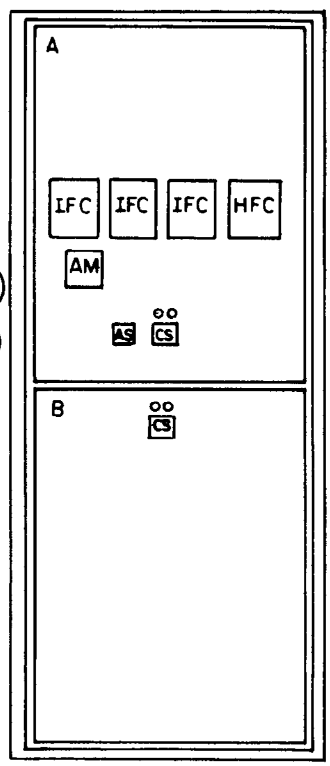
A lineup utilizing this arrangement of feeders may be specified with only one bypass position breaker element for the lineup since only one feeder circuit breaker is bypassed at a time.

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)



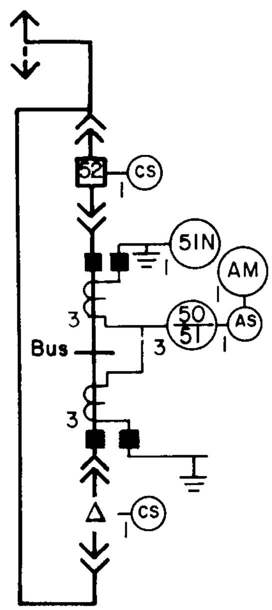


DEVICE LIST FOR BBF-1
(Unit A **AND** Unit B)

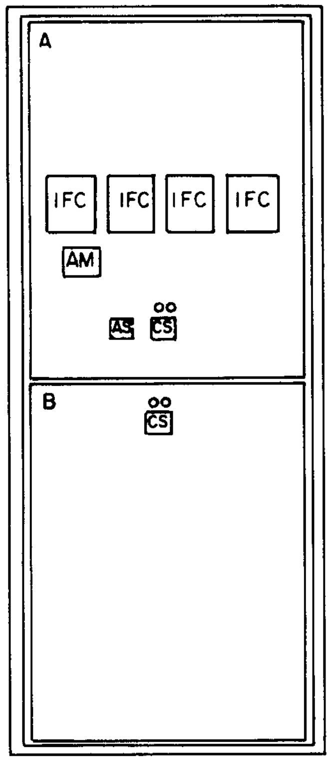
Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker†	52	1	VB-___-___-___ (kV) (MVA) (A)
Phase Overcurrent Relays	‡50/51	3	12IFC
Ground Sensor Relay	‡50GS	1	12HFC
Current Transformers	CT	6	BP (__/5A)
Current Transformer	GSCT	1	INSTR. TRANS. INC.
Breaker Control Switch	CS	2	16SB1 OR 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)
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

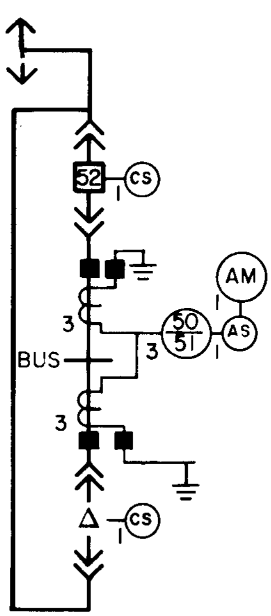
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker†	52	1	VB-____-_____-____ (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC
Residual Overcurrent Relay	‡51N	1	12OFC
Current Transformers	CT	6	BP (__/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

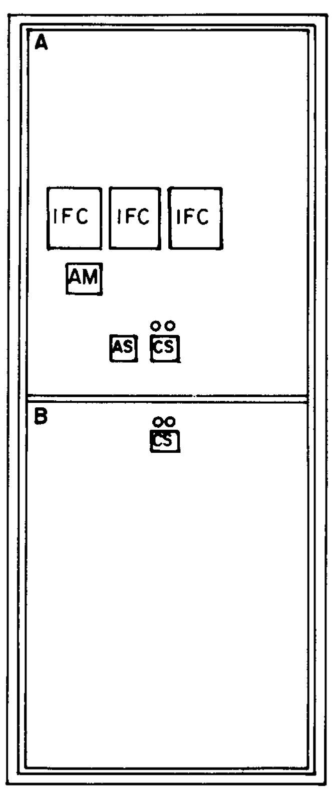
† For bypass operation, one additional breaker is required per lineup

‡ Residual ground CT connection

BREAKER BYPASS FEEDER‡(BBF-3)



△For spare breaker during maintenance



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	3	12IFC
Current Transformers	CT	6	BP (__/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

‡ No ground relays

POWER/VAC Switchgear Equipment

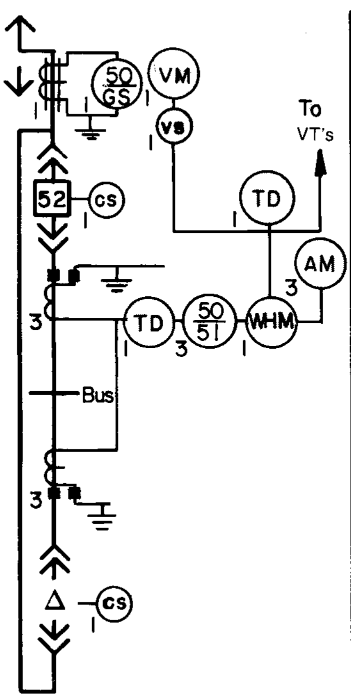
OPTIONAL EQUIPMENT SELECTION

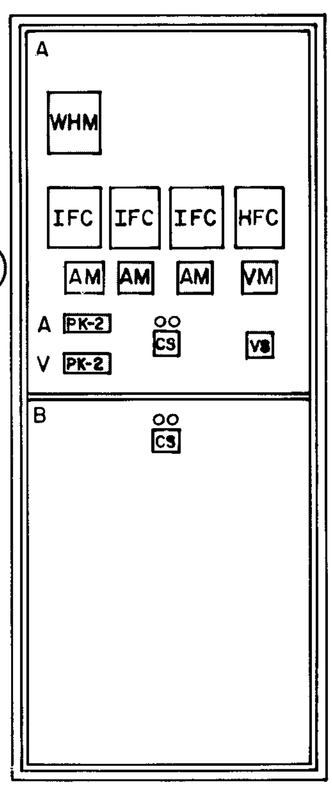
Options for a breaker bypass feeder are the same as for a general purpose feeder. Select options for BBF-1, BBF-2, or BBF-3 on the same basis as for GPF-1, GPF-2, or GPF-3.

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 CTs		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		1	DS
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
Lincoln Thermal Demand Ammeter		1	ADF7
Breaker Disagree Light		1	ET-16
Capacitor Trip Device		1	ST-230

TYPICAL MODIFICATIONS OF BBF-1





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

All BBF-1 Devices

OMIT:
- One SB-1 Ammeter Switch

ADD:
- Two AB-40 Ammeters
- One AB-40 Voltmeter
- One SB-1 Voltmeter Switch
- One PK-2 Voltage Test Block
- One PK-2 Current Test Block
- One DS-63 Watthour Meter

△For spare breaker during maintenance

TRANSFORMER PRIMARY FEEDERS

DEFINITION

A transformer primary feeder (TPF) equipment with differential relays Type STD (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 protection is not required, use a General Purpose Feeder.

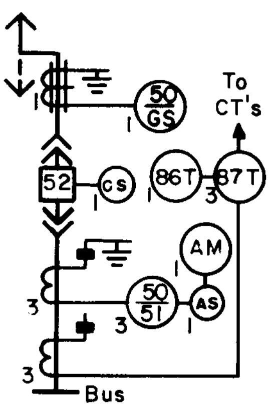
BASIC EQUIPMENT SELECTION

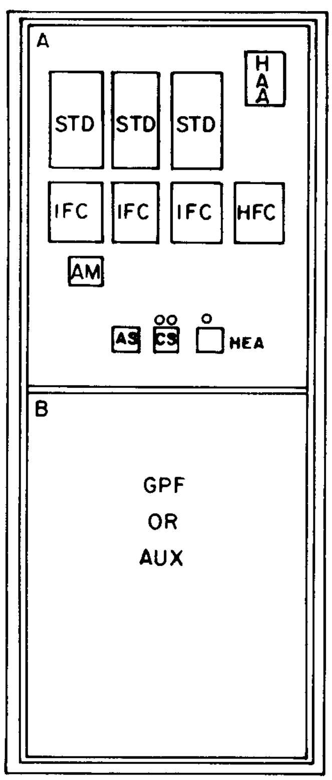
Basic devices included in a transformer primary feeder are the same as those included in a general purpose feeder plus three current transformers, three Type STD high-speed transformer-differential relays (87T), one Type HEA hand-reset lockout relay (86T), and one Type HAA transformer fault-pressure auxiliary relay (63FPX). Select TPF-1, TPF-2, or TPF-3 on the same basis as GPF-1, GPF-2, and GPF-3.

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)



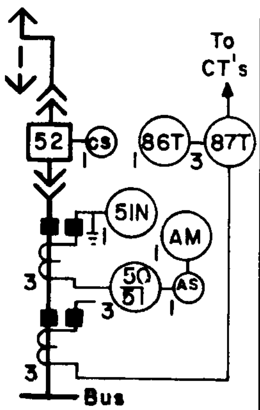


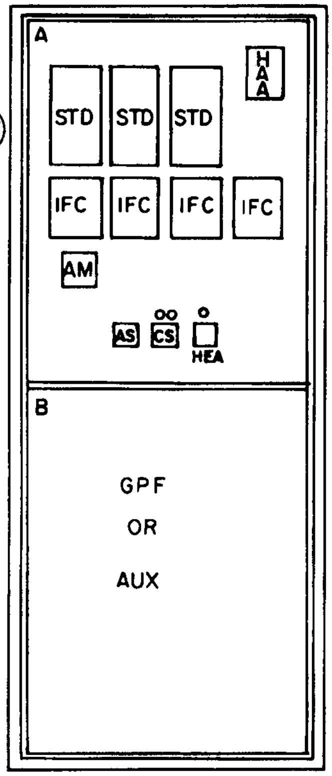
DEVICE LIST FOR TPF-1
(Unit A only)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Phase Overcurrent Relays	‡50/51	3	12IFC
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)



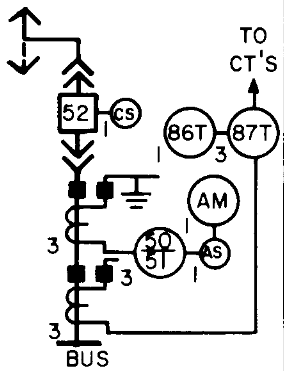


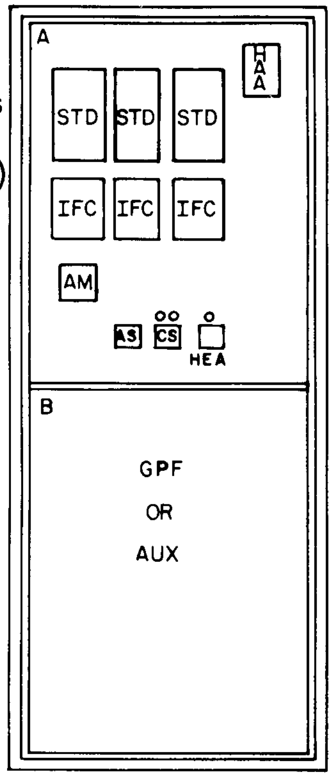
DEVICE LIST FOR TPF-2
(Unit A only)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Phase Overcurrent Relays	50/51	3	12IFC
Residual Overcurrent Relay	‡51N	1	12IFC
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)
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 Relays	50/51	3	12IFC
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 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)
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

‡No ground relays

TPF OPTIONS

Device	Device No.	Qty	Description or Type
Interposing Relay		2	12HGA
Multi-ratio CTs		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

POWER/VAC Switchgear Equipment

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-overcurrent relay (51G) to be connected to the neutral current transformer of a local power transformer feeding the incoming line.

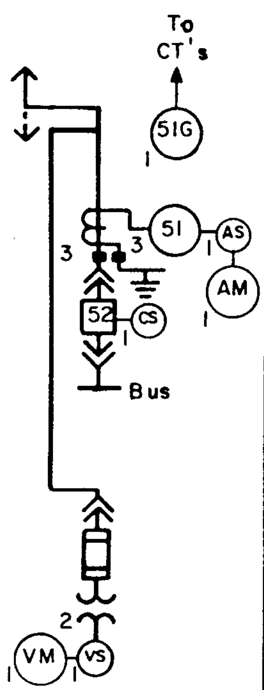
SSIL-2 Use this type of incoming line for an impedance or solidly grounded system fed from a remote wye-connected transformer, or a local wye-connected transformer with no current transformer in the transformer neutral connection.

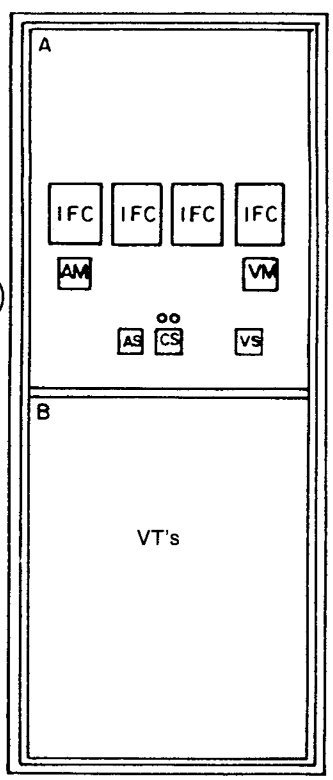
This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and Type IFC residually connected ground-overcurrent relay (51N).

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 IFC phase-overcurrent relays (51) and no ground relays.

SINGLE SOURCE INCOMING LINES‡ (SSIL-1)



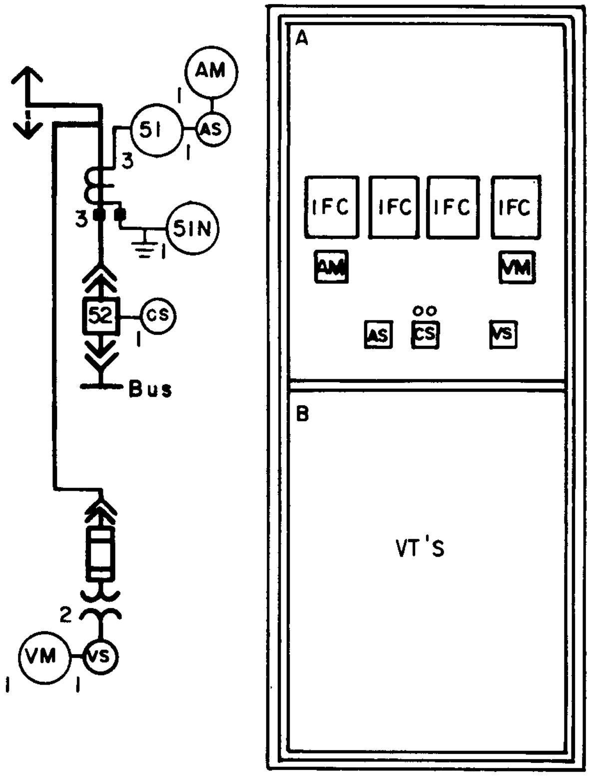


DEVICE LIST FOR SSIL-1
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Phase Overcurrent Relays	51	3	121FC
Ground Overcurrent Relay	‡51G	1	12IFC
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	1	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

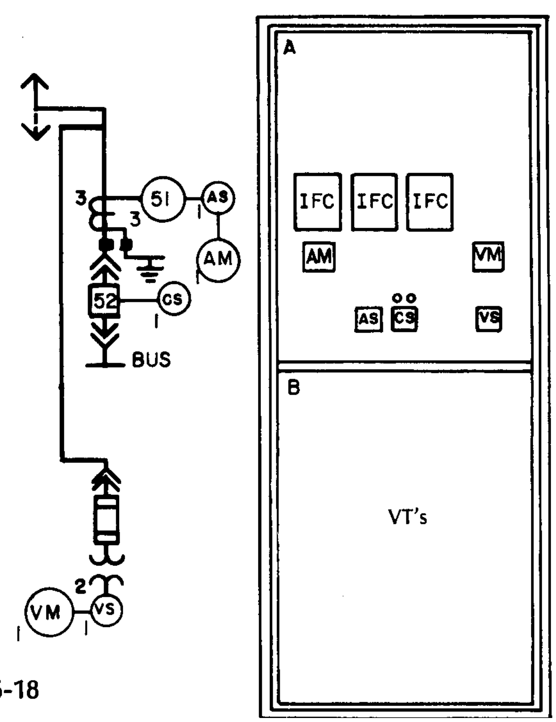
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description or Type
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Phase Overcurrent Relays	51	3	121FC
Residual Overcurrent Relay	‡51N	1	12IFC
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	1	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 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 Relays	51	3	12IFC
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	1	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

‡No ground relays

OPTIONAL EQUIPMENT SELECTION

Protection

OVERCURRENT RELAY CHARACTERISTIC — 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 the minimum protection is acceptable, omit one 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 a negative-sequence voltage relay Type NBV (60) and a 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 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 transformer 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).

CURRENT TRANSFORMERS FOR REMOTELY 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), undervoltage 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.

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 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

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 lineup; 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 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 "connected" position; local close with the breaker in the "test" position; and local trip with the breaker in the "connected" or "test" position.

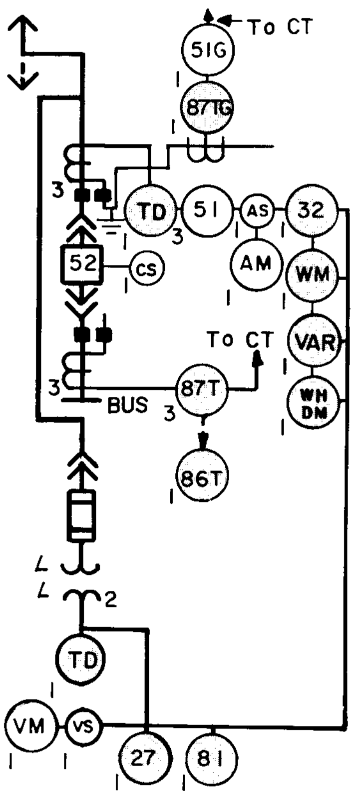
Location of Optional Devices

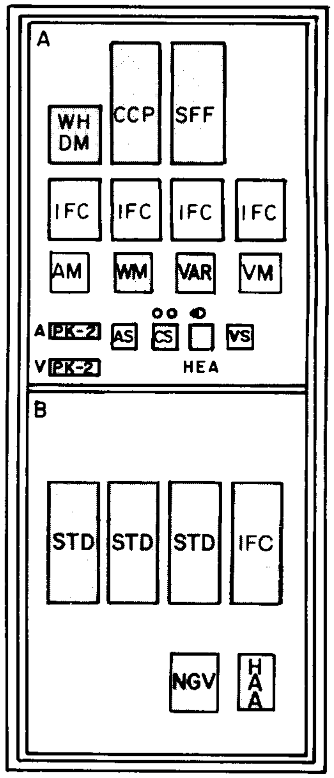
If several optional devices are added to an incoming line equipment, there may not be sufficient space to mount them all. In this case, specify excess relays to be mounted on the tie breaker vertical sections or an adjacent auxiliary compartment. This makes the vertical section a custom section.

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

TYPICAL MODIFICATIONS OF SSIL-1





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

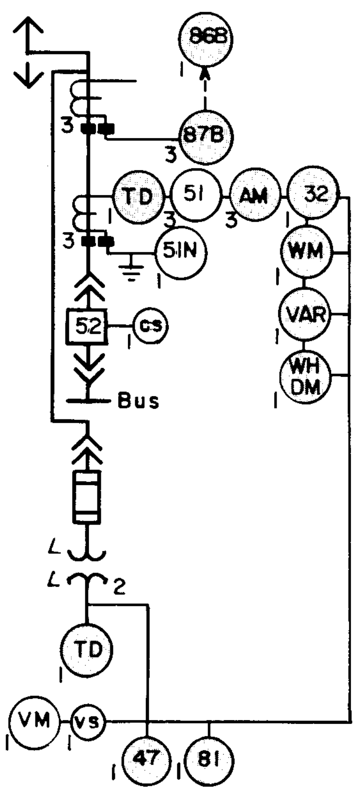
All SSIL-1 Devices

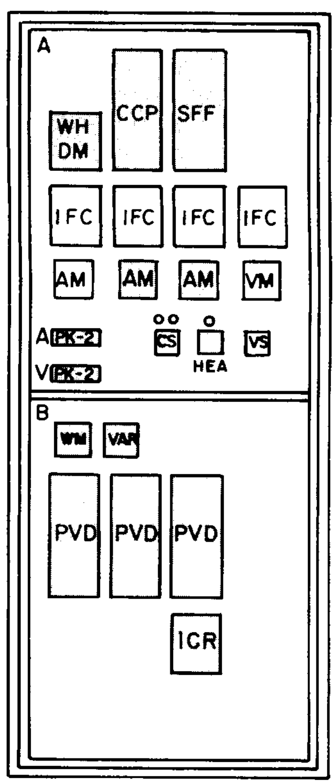
OMIT: None

ADD:

- Three STD Transformer Differential Relays
- One IFC Transformer Ground Differential Relay
- One HEA Lockout Relay
- One HAA Transformer Fault Pressure Auxiliary Relay
- One CCP Directional Power Relay
- One SFF Frequency Relay
- One NGV Undervoltage Relay
- One DSM Watthour Demand Meter
- One AB Wattmeter
- One PK-2 Voltage Test Block
- One PK-2 Current Test Block
- One AB Varmeter

TYPICAL MODIFICATIONS OF SSIL-2





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

All SSIL-2 Devices

OMIT:
- One Ammeter Switch

ADD:
- Two AB Ammeters
- Three PVD Bus Differential Relays
- One HEA Lockout Relay
- One CCP Directional Power Relay
- One SFF Frequency Relay
- One ICR Undervoltage and Phase Sequence Relay
- One DSM Watthour Demand Meter
- One AB Wattmeter
- One PK-2 Voltage Test Block
- One PK-2 Current Test Block
- One AB Varmeter

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.

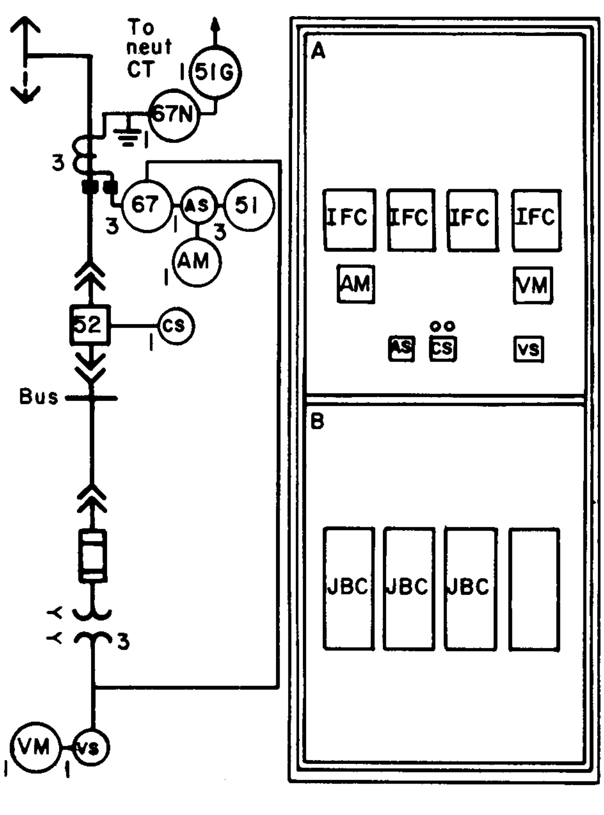
This type of incoming line equipment includes three Type IFC phase-overcurrent relays (51) and three Type IBC directional phase-overcurrent relays (67). It includes one Type IFC residual connected ground-overcurrent relay (51G) and one residually connected directional ground-overcurrent relay (67N) polarized 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 three Type IFC phase-overcurrent relays (51) and three Type IBC directional phase-overcurrent relays (67). There are no ground relays included.

DUAL SOURCE INCOMING LINES‡ (DSIL-1)

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



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

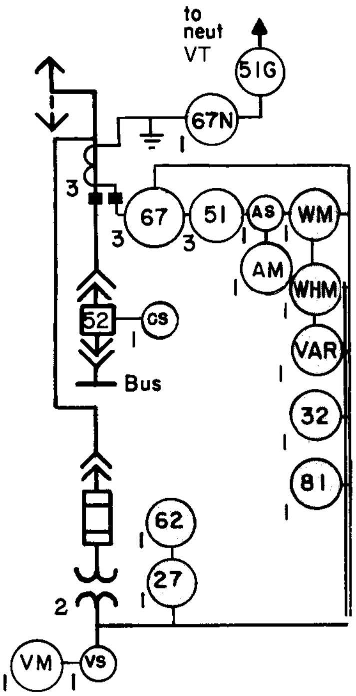
Local transformers — No tie or normally closed tie.

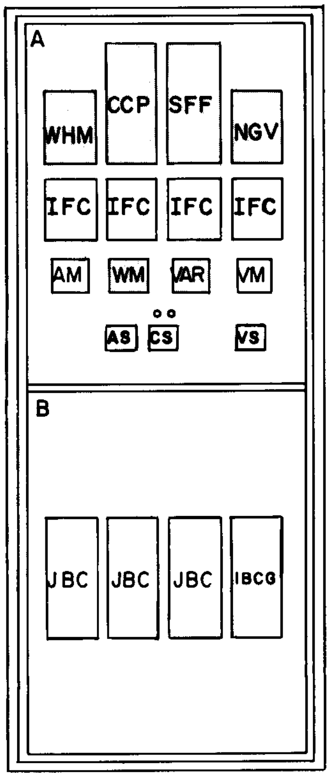
Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB-__(KV)-__(MVA)-__(A)
Directional Phase Overcurrent Relays	67	3	12JBC
Directional Ground Overcurrent Relay	67N	1	12IBCG
Phase Overcurrent Relay	51	3	12IFC
Ground Overcurrent Relay	51G	1	12IFC
Current Transformers	CT	3	BP (__/5A)
Voltage Transformers	VT	3	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	1	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	AS	1	16 SBM or SB1
Voltmeter Switch	VS	1	16 SMB or SB7
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

‡Grounded CT connection

DUAL SOURCE INCOMING LINES‡ (DSIL-2)

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





DEVICE LIST FOR DSIL-2

(Unit A **AND** Unit B)

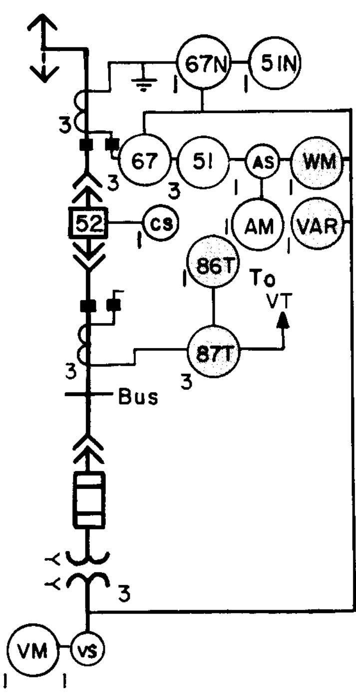
Local transformers — No tie or normally closed tie.

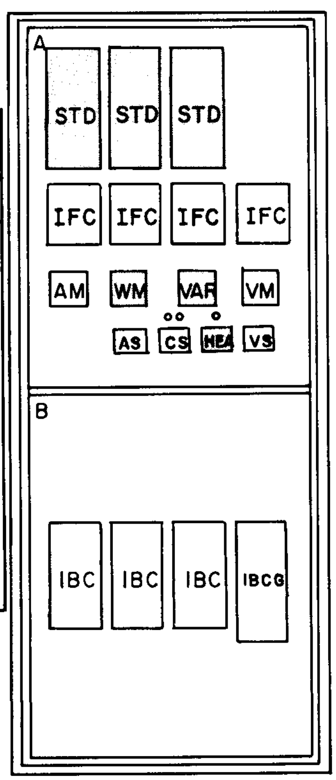
Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Directional Phase Overcurrent Relays	67	3	12IBC
Directional Ground Overcurrent Relay	67N	1	12IBCG
Phase Overcurrent Relay	51	3	12IFC
Residual Overcurrent Relay	‡51N	1	12IFC
Current Transformers	CT	3	BP (___/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	1	2P-60A (Fuses)
VT Fuses	FU-VT	3	2E
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale to Match VT)	VM	1	AB-40
Ammeter Switch	AS	1	16SB1
Voltmeter Switch	VS	1	16SM1
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

‡Residual ground CT connection

DUAL SOURCE INCOMING LINES‡ (DSIL-3)

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





DEVICE LIST FOR DSIL-3

(Unit A **AND** Unit B)

Local transformers — No tie or normally closed tie.

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Directional Phase Overcurrent Relays	67	3	12IBC
Phase Overcurrent Relay	51	3	12IFC
Current Transformers	CT	3	BP (___/5A)
Voltage Transformers	VT	3	JVM (___/120V)
Breaker Control Switch	CS	1	16SBM or SBI
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)
VT Fuses	FU-VT	3	2E
Ammeter (Scale to Match CT)	AM	1	AB-40
Voltmeter (Scale to Match VT)	VM	1	AB-40
Ammeter Switch	AS	1	16SBM or SBI
Voltmeter Switch	VS	1	16SBM or SBI
Provision for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

‡No ground relays

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, 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

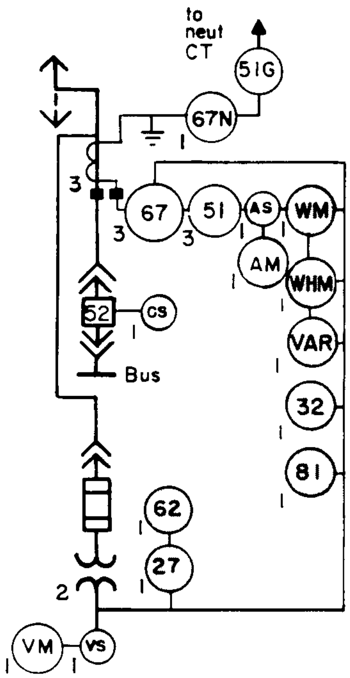
Optional feature involving control voltage and permissive control switch are the same as for single-source incoming line equipments.

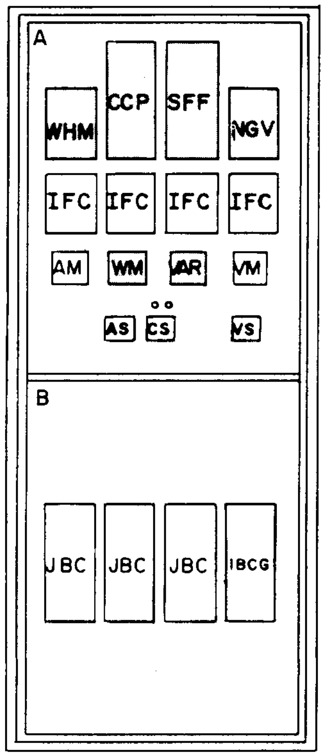
Location of Optional Devices

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.

POWER/VAC Switchgear Equipment

TYPICAL MODIFICATIONS OF DSIL-1





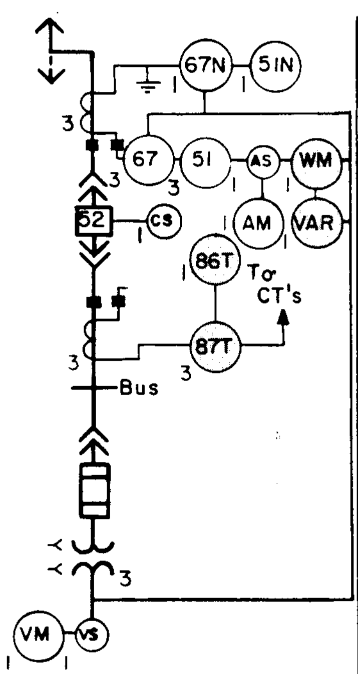
DEVICE LIST
(Unit A **AND** Unit B)

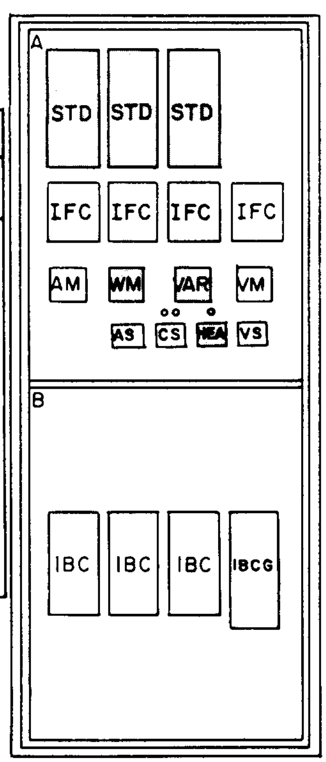
All DSIL-1 Devices

OMIT: None

ADD:
- One CCP Directional Ground Relay
- One SFF Frequency Relay
- One NGV Undervoltage Relay
- One DS Watthour Meter
- One AB Wattmeter
- One AB Varmeter
- One Agastat Timer

TYPICAL MODIFICATIONS OF DSIL-2





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

All DSIL-2 Devices

OMIT: None

ADD:
- Three STD Transformer Differential Relays
- One HEA Lockout Relay
- One HAA Transformer Fault Pressure Auxiliary Relay
- One AB Wattmeter
- One AB Varmeter
- Three Current Transformers

DSIL OPTIONS

Device	Device No.	Qty	Description or Model No.
Bus Differential Relay	87B	3	12PVD
Transf Differential Relay	87T	3	12STD
and 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
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 distribution 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 overcurrent 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 IFC overcurrent relays (51) to be wired for a summation current connection. If Type IFC residually connected ground-overcurrent relays (51N) are included 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.

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 an ammeter and switch.

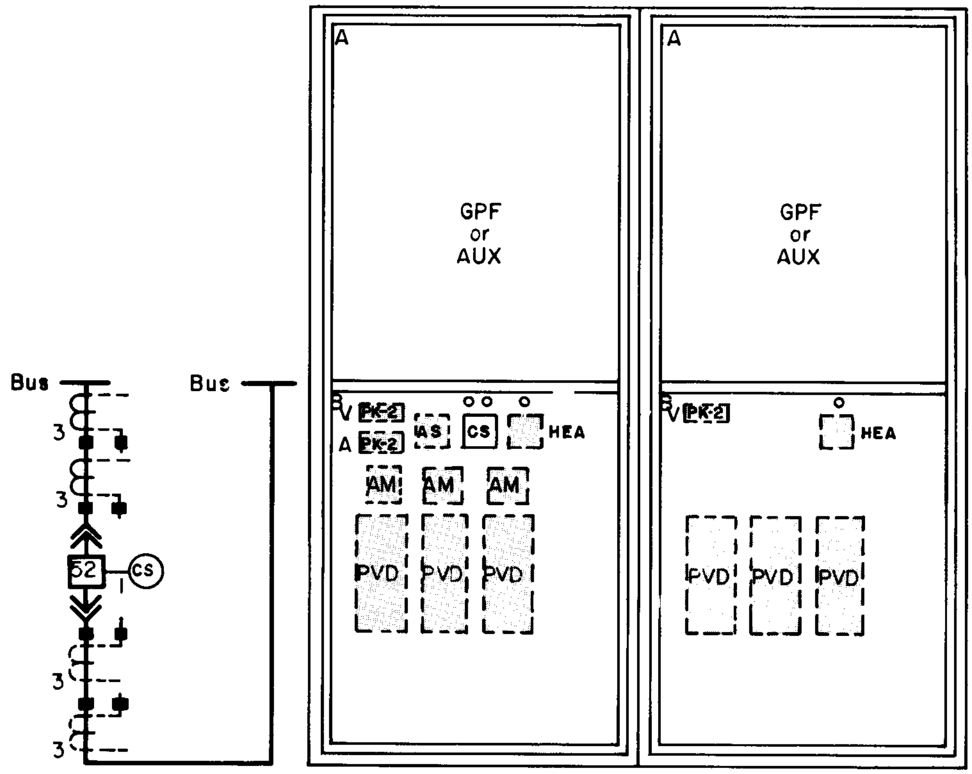
TEST BLOCKS — For circuits which require the provision for insertion of portable recording meters or other similar devices, add current and voltage test blocks. Basic current test block is wired to maintain the circuit when the test plug is removed.

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 B **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description **or** Model No.
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 Pullouts	FU	1	2P-60A (Fuses)

BT OPTIONS

Device	Device No.	Qty	Description or Model No.
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)

POWER/VAC Switchgear Equipment

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 amperes.

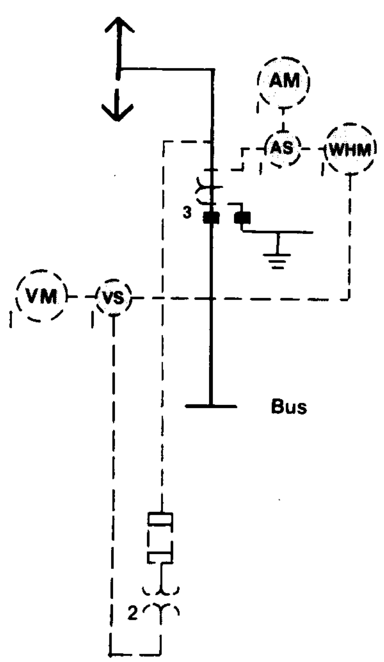
OPTIONAL EQUIPMENT SELECTION

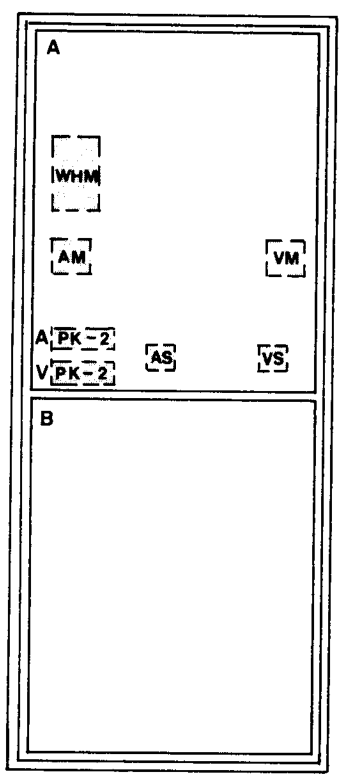
Indication

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 6-43 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** Model No.
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

OPTIONS

OMIT: None

ADD:
- Three Current Transformers, BP (__/5A)
- One Ammeter, Type AB
- One Ammeter Switch, 16SB1
- Two Voltage Transformers, Type JVM, (__/120V)
- Four VT Fuses
- One Watthour Meter, Type DS, 2-element, Secondary Reading, 701X90G1
  or
- One Watthour Demand Meter, Type DSM
- One Voltmeter, Type AB
- One Voltmeter Switch, 16SB1
- One PK-2 Current Test Block
- One PK-2 Voltage Test Block

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

DEFINITION

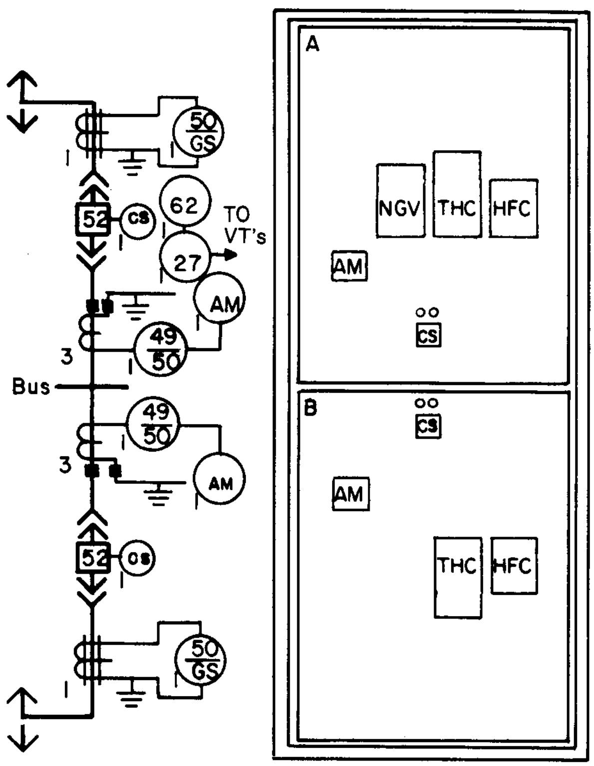
These metalclad feeder equipments (IMF1) are used for controlling and protecting full-voltage-start motors of less than 1500 hp and are designated as "branch circuit" protective equipment. Economics usually preclude protecting a motor smaller than 1500 hp with a device package as complete as that used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

BASIC EQUIPMENT SELECTION

Basic equipment for an 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 6-30) 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** Model No.
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
Provisions 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

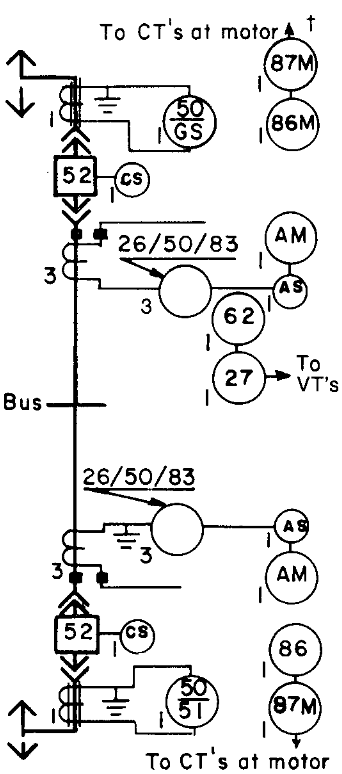
Basic equipment for an IMF2 includes three single-phase Type IFC relays (26/50/83) for locked rotor and short-circuit protection; one Type IRT temperature relay (49); one Type NGV undervoltage and timing relay (27, 62); one Type HFC 3-element self-balancing differential relay (87M); one Type HFC ground-sensor relay (50GS); and an ammeter in phase 2.

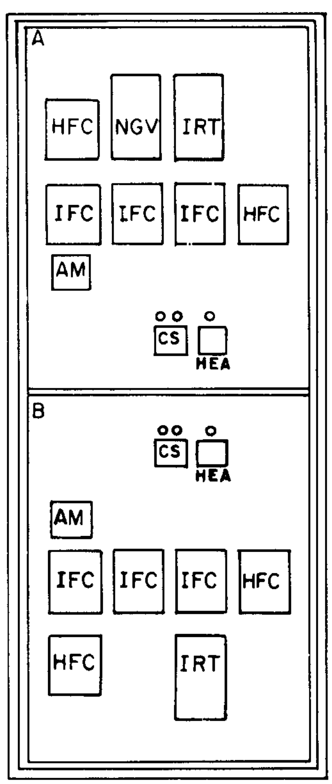
The equipment is specified for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-30) for modifications of this equipment for use on systems with other types of grounding.

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 Model No.
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
Phase Overcurrent Relay	26/50/83	3	12IFC
Ground Sensor Relay	50GS	1	12HFC
Differential Relay	87M	1	12HFC
Lockout Relay	86M	1	12HEA
Temperature Relay	49	1	12IRT
Undervoltage Relay*	27	1	12NGV
Timer, Agastat*	62	1	0.5-5 sec
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)
Ammeter (Scale to Match CT)	AM	1	AB
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

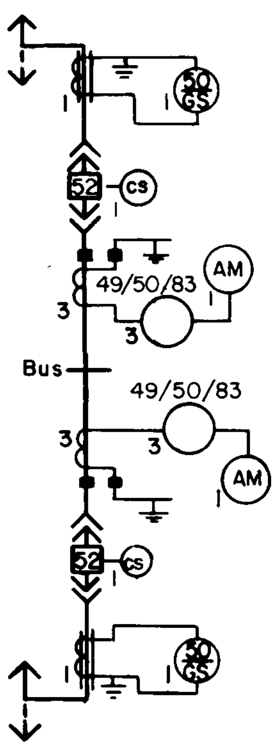
IMFE basic equipment includes three single-phase Type IFC relays for overload indication, locked-rotor tripping, and short-circuit tripping (49/50/83), a Type HFC relay (50GS) for ground-fault protection and an ammeter for phase 2. No undervoltage protection is included. These relays operate from three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

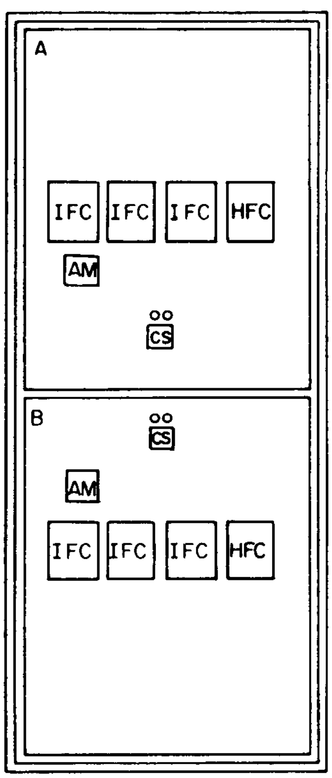
The equipment specified is for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (page 6-30) for modifications of this equipment for use in systems with other types of grounding.

OPTIONAL EQUIPMENT SELECTION

Options for IMFE are discussed on page 6-30.

INDUCTION MOTOR FEEDER (IMFE)





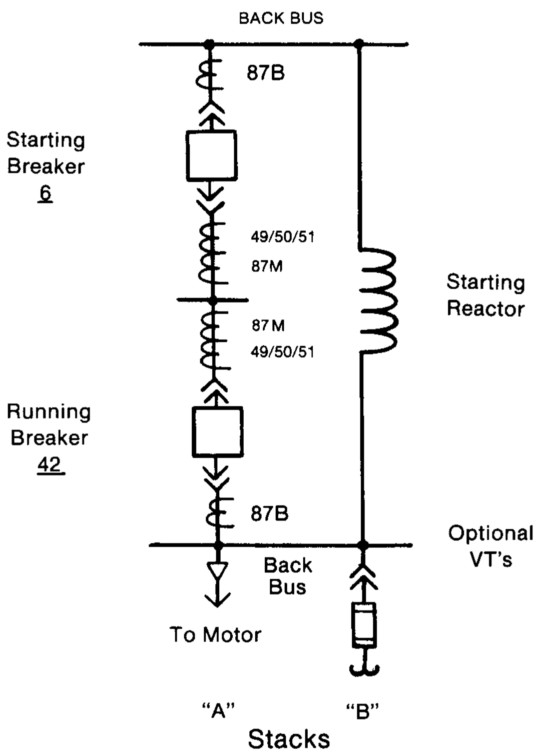
DEVICE LIST FOR IMFE
(Unit A **or** Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB- - - (kV) (MVA) (A)
Phase Overcurrent Relay	49/50/83	3	12IFC
Ground Sensor Relay	50GS	1	12HFC
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	1	2P-60A (Fuses)
Ammeter	AM	1	AB
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

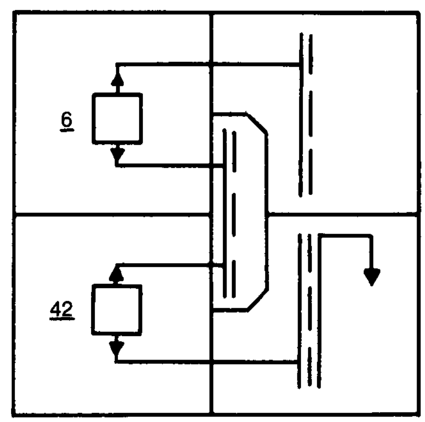
INDUCTION MOTOR FEEDERS, REDUCED-VOLTAGE-START

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.

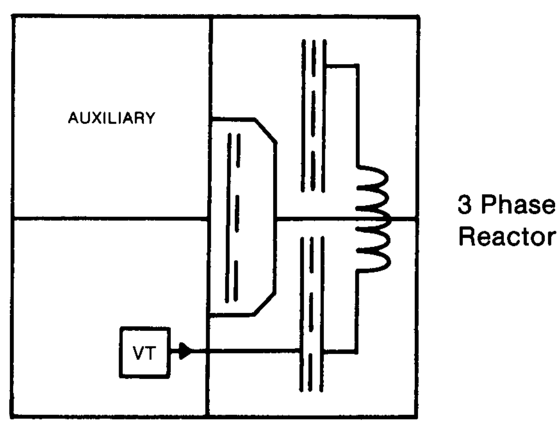


Notes:
1. Add metering, instrumentation control, and additional relaying as required. (See pages 79 & 80)
2. Starting reactor must fit in available space. The main bus must penetrate reactor cubicle. If these conditions are not met the reactor must be housed separately.



Stack "A"—Side Elevation

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.)

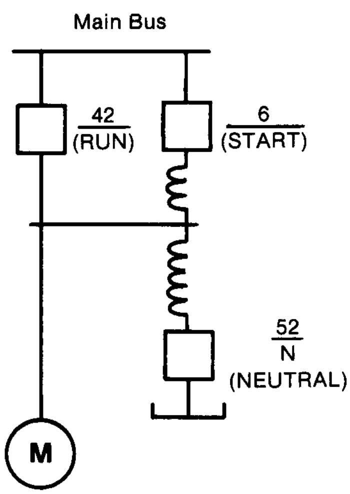
POWER/VAC Switchgear Equipment

INDUCTION MOTOR FEEDERS, 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.

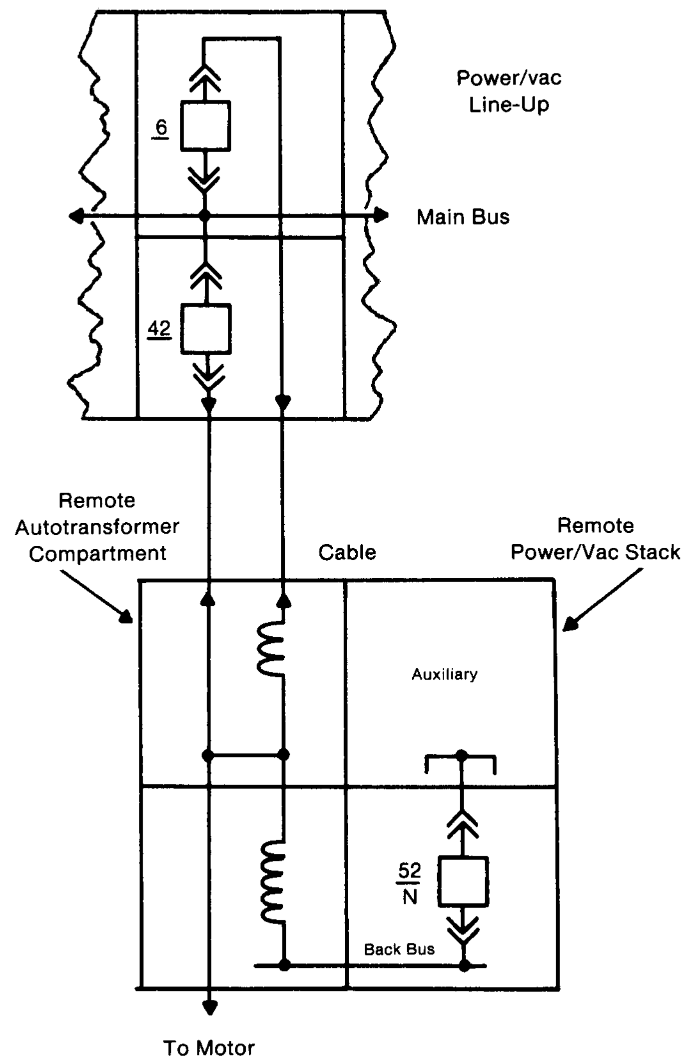
ONE-LINE DIAGRAM



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.

POWER/VAC CONFIGURATION

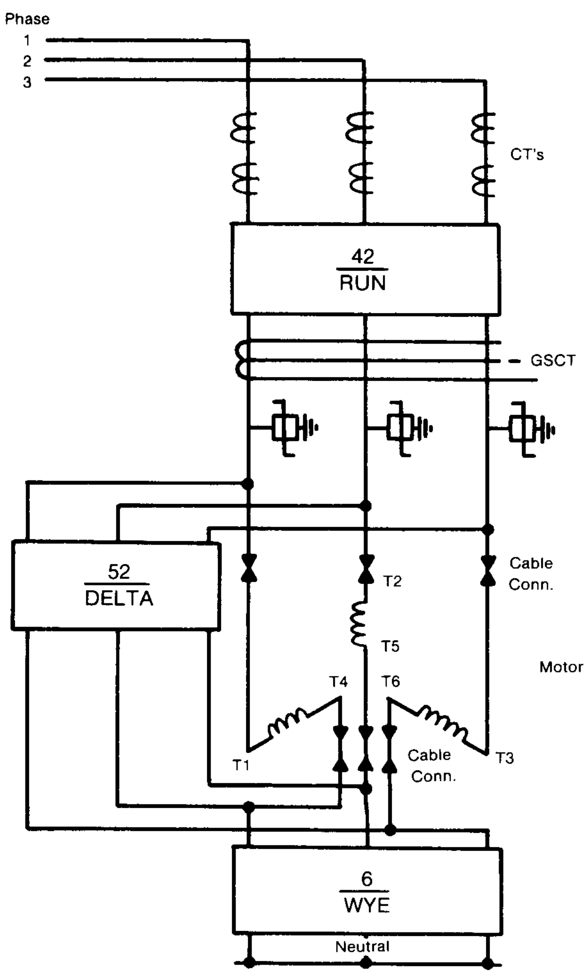


INDUCTION MOTOR FEEDERS, REDUCED-VOLTAGE-START

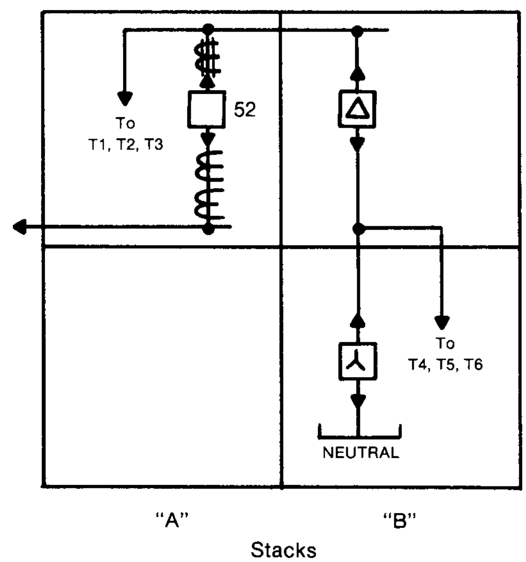
WYE-DELTA MOTOR STARTING

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 indicating varmeter, wattmeter, watthour meter, or watthour demand meter as appropriate. For indication of all three phases of current, add an ammeter 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 — For circuits requiring a circuit breaker disagreement or spring-charged indication function, add a white indicating lamp.

Control

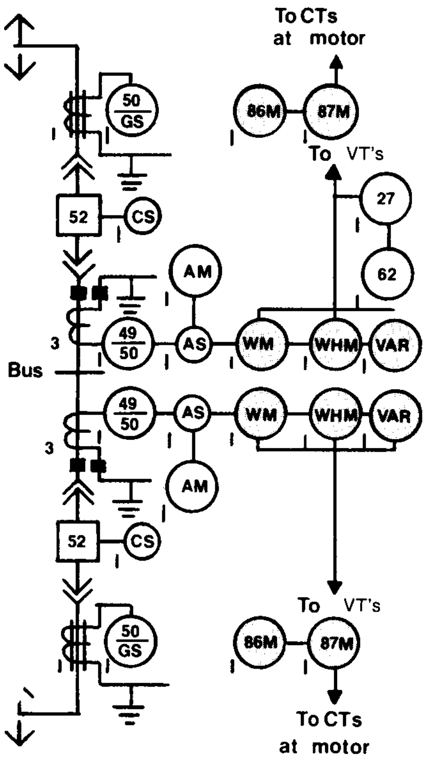
REMOTE CONTROL — For circuit breakers controlled from a remote location, choose the remote control scheme from those listed in Table 5-1 (page 5-7 of this guide). From this table, Scheme C is recommended, since it provides maximum operating flexibility. It requires the use of a breaker position switch 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.

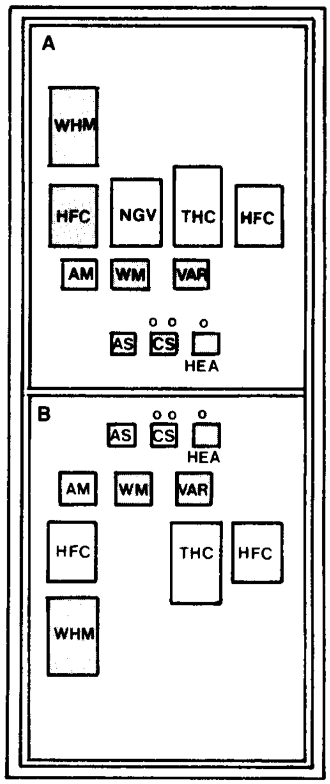
In addition, remote control for motors requires a lockout relay (86), which prevents breaker closing (after a relay-initiated trip) until the lockout device is manually reset. (The 86 device furnished standard on IMF2 may be used for both 87M and remote control.)

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.	Qty	Description or Model No.
Phase Overcurrent Relay (motor)	49/50/83	3	12IFC
Phase Overcurrent Relay (motor)	26/50/83	3	12IFC
Differential Relay (motor)	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	0.0-5 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
Wattmeter		1	AB
Varmeter		1	AB
Watthour Meter		1	DS
or Watthour Demand Meter		1	DSM
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

*One required per lineup

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

All IMF Devices

OMIT: None

ADD:
- One DS Watthour Meter
- One HFC Differential Relay
- One AB Wattmeter
- 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 includes 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; an 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.

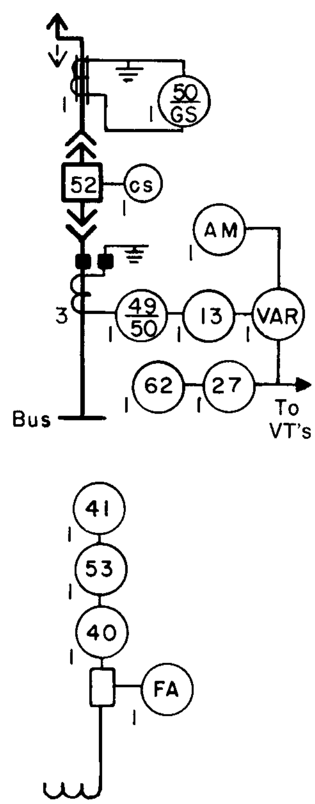
The equipment is specified for use on an impedance grounded or solidly grounded system. See "Optional Equipment Selection" (Page 6-34) for modifications of this equipment for use on systems with other types of grounding or having motors with other types of excitation.

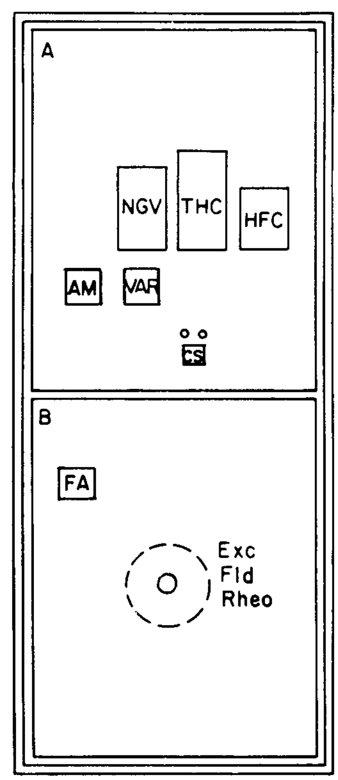
SYNCHRONOUS MOTOR FEEDER (SMF1)

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

Device	Device No. or Abbr.	Qty	Description **or** Model No.
Power Circuit Breaker	52	1	VB-____-____-____ (kV) (MVA) (A)
3-Phase Thermal Over-current 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	
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase
FIELD APPLICATION 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.

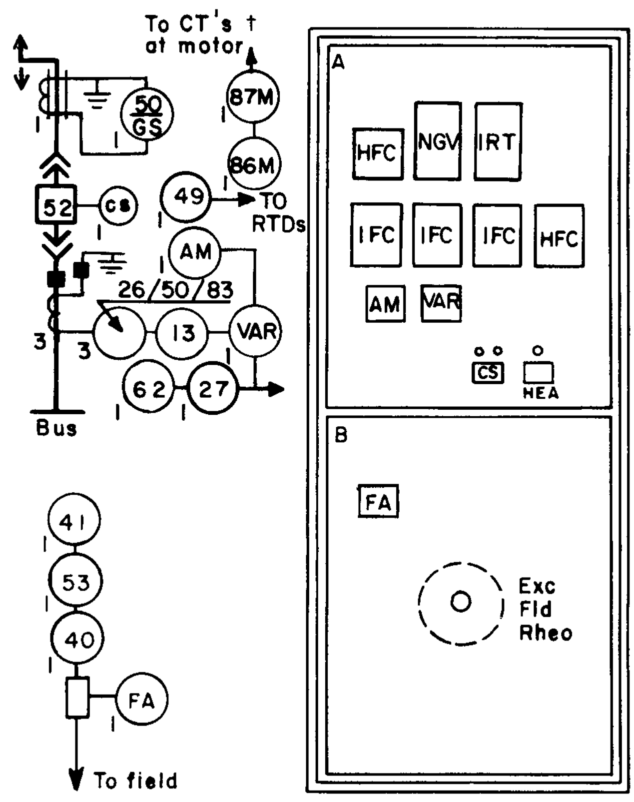
SYNCHRONOUS MOTOR FEEDER (SMF2)

DEVICE LIST FOR SMF2

(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
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 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)
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	
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase
FIELD APPLICATION DEVICES			
Exciter Relay	53	1	IC2820
Field Contactor	41	1	IC2812
Field Discharge Res.		1	
Field Forcing Res.		1	
Rotor Thermal Dev.	26	1	IC2820
Auxiliary Relay	41X	1	12HFA
Slip Guard Relay	55	1	IC3655
Field Application Pnl.	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, omit the field application equipment included in the basic equipment and add appropriate field application panel.

If 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 of additional electrical quantities, add an indicating varmeter, a wattmeter, a watthour meter, or a watthour demand meter as appropriate. For indication of all three phases of current, add 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 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 5-6 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 "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 CTs		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	
Stabilizing Transformer		1	

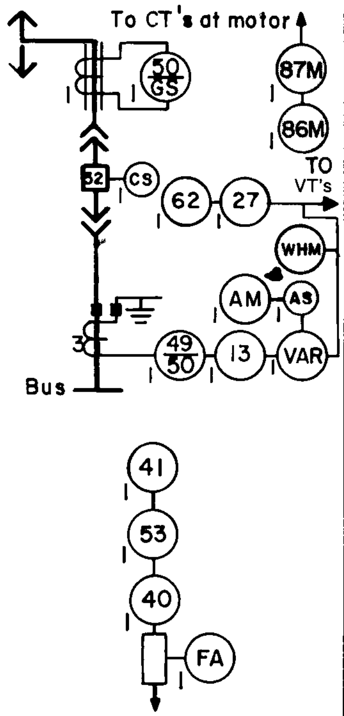
Power Utilization or M-G Set or Condenser Brush-type Direct Connected Exciter

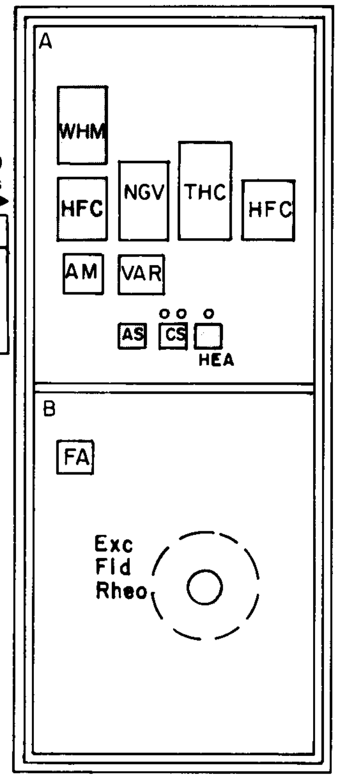
Device	Device No.	Qty	Description or Model No.
Synchronous Speed Device	13	1	12PJC
Synchronous Speed Device Aux	13X	1	12HGA
Exciter Relay	53	1	IC2820
Field Failure Relay	40	1	IC2820
Field Contactor	41	1	IC2812
Field Ammeter		1	DB
Shunt for Field Ammeter		1	501400
Motor Field Discharge Resistor		1	
Field 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.
Synch Speed Device	13	1	12PJC
Synch 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 field 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 anti-motoring protection, add one Type ICW directional power relay (32).

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

FOR GENERATORS OPERATING IN PARALLEL WITH OTHER POWER SOURCES ON GROUNDED SYSTEMS — Add one Type IFC53 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).

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 cutoff relay (25A).

Isolated Systems

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

Current Transformers

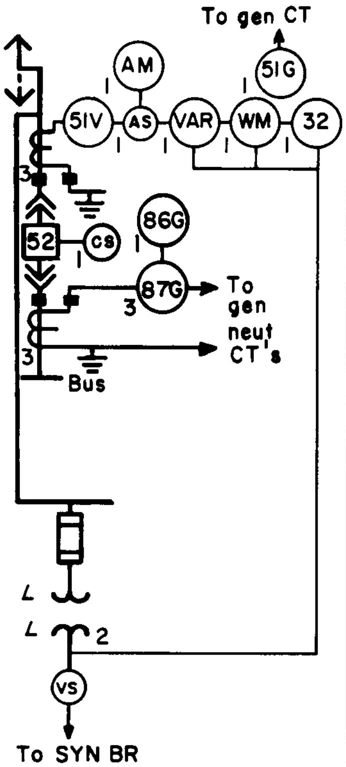
Add three current transformers for lineups that include bus differential protection.

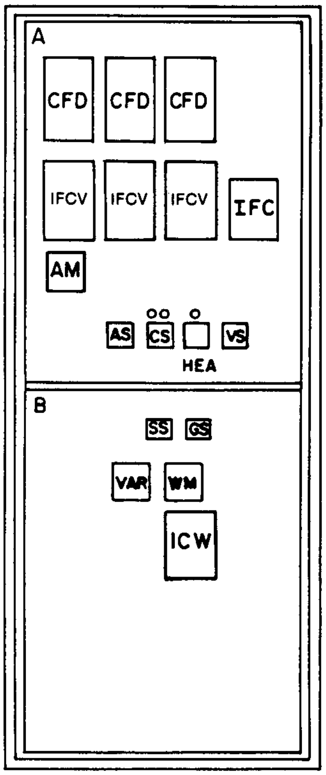
Indication and Metering

For generators requiring supplementary indication and metering, add one Type DB-40 temperature meter and a transfer switch for monitoring three RTD's, one Type KT time meter, one Type DS-63 watthour meter, one Type DSM-63 watthour demand 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.

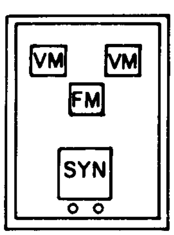




DEVICE LIST FOR GEN 1
(Unit A **AND** Unit B)

Device	Device No. or Abbr.	Qty	Description or Model No.
Power Circuit Breaker	52	1	VB- - - (kV) (MVA) (A)
Phase Overcurrent Relays 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
Provisions for Power Conductor Terminations (NEMA Drilling Only)	—	2	Per phase

SYN BR



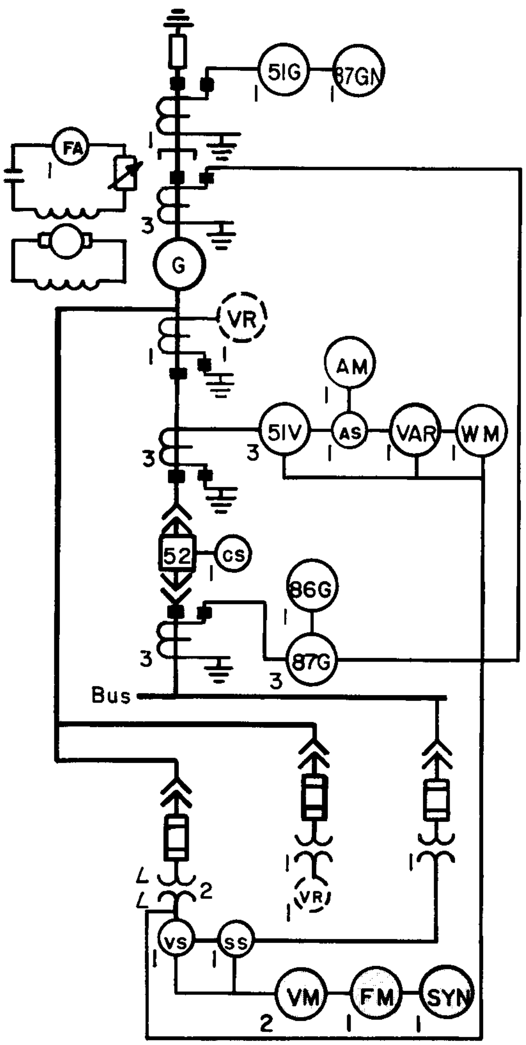
DEVICE LIST FOR SYNCHRONIZING BRACKET

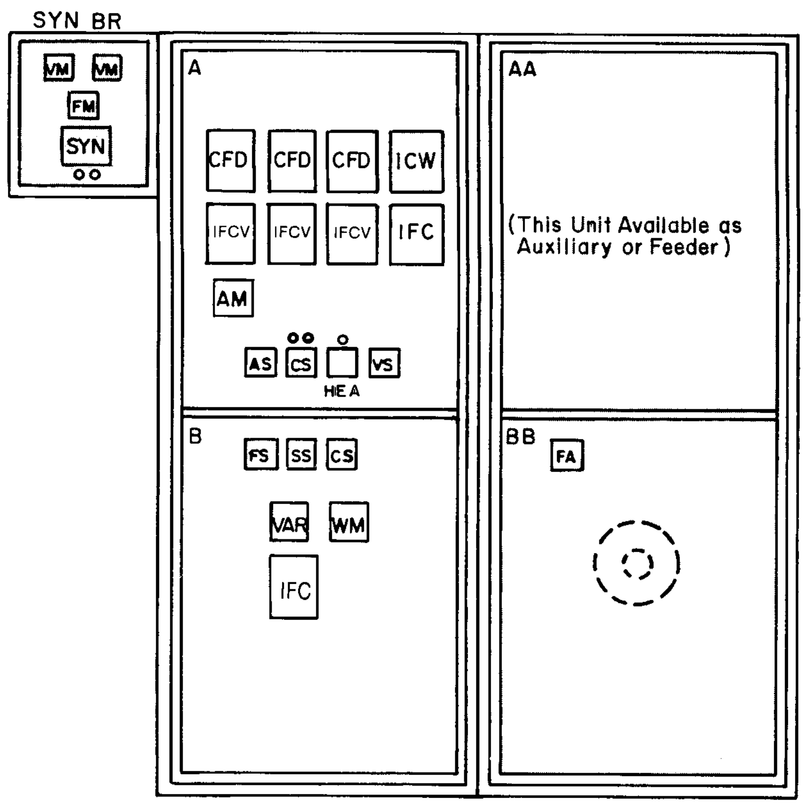
Device	Device No. or Abbr.	Qty	Description or Model No.
Voltmeter (Scale to Match VT)	VM	2	AB
Frequency Meter	FM	1	AB
Synchroscope	SY	1	AB

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
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	12SB1
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)

TYPICAL MODIFICATIONS OF GEN





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)

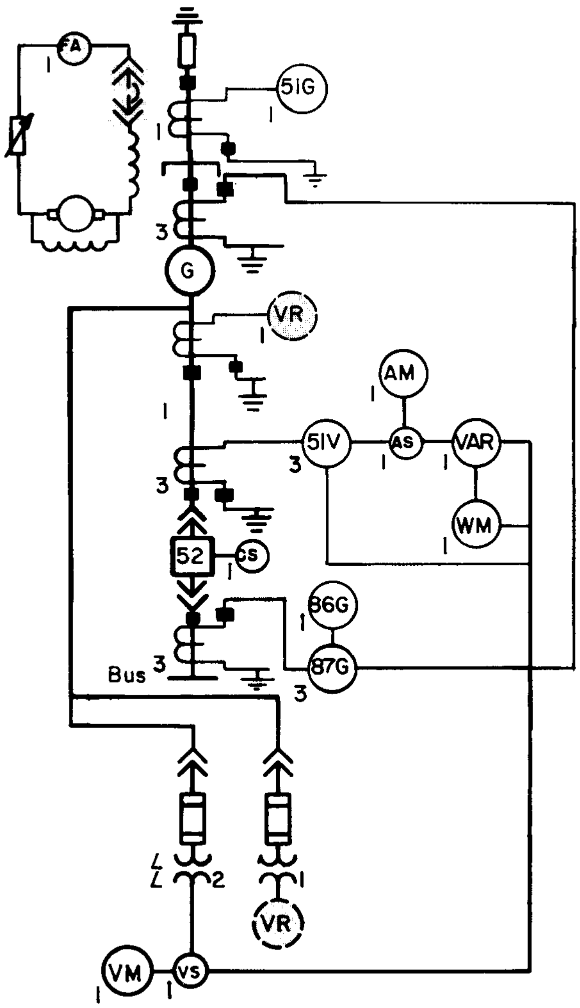
All GEN Devices
Parallel Operation
(Larger Diesel Brushless Generator)

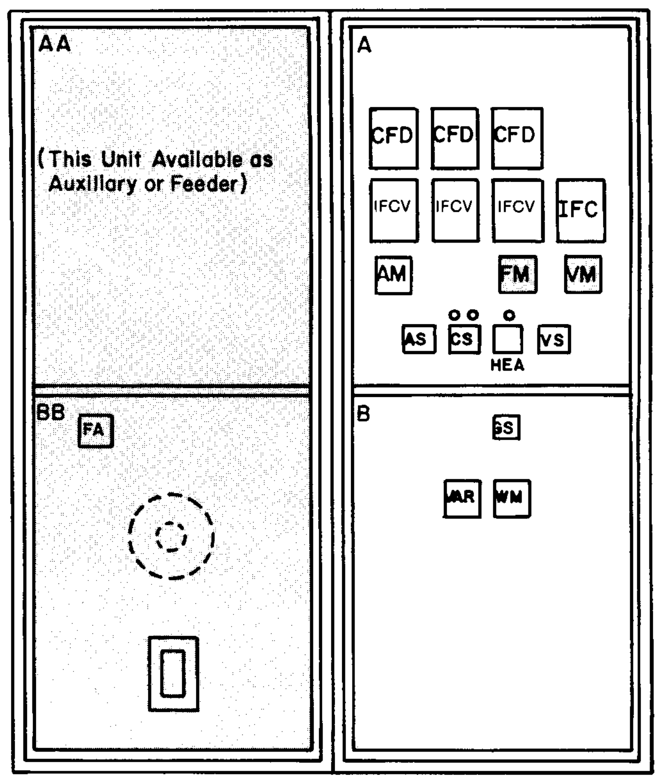
OMIT: None

ADD:

One Voltage Transformer
One Field Ammeter
Provision for Mounting Exciter Field Control
Synchronizing Bracket Per Basic Specification

TYPICAL MODIFICATIONS OF GEN





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

All GEN Devices
Isolated Operation
(Smaller Generator with Slip Ring Exciter)

OMIT: None

ADD:
- Provision for Mounting Voltage Regulator
- Provision for Mounting Field Rheostat
- One DB Field Ammeter and Shunt
- One Field Breaker

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

All GEN Devices
Isolated Operation
(Smaller Generator with Slip Ring Exciter)

OMIT:
One Synchronizing Switch

ADD:
- One Voltmeter
- One Voltage Transformer

POWER/VAC Switchgear Equipment

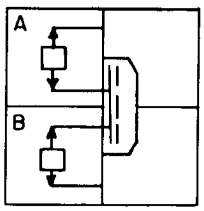
POWER CONDUCTOR COMPARTMENTS AND AUXILIARY UNITS

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.

Breaker in A
Breaker in B



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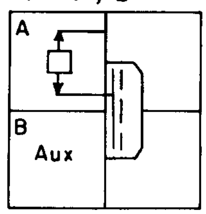
Breaker in A
Auxiliary B



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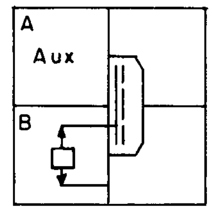
Auxiliary A
Breaker B



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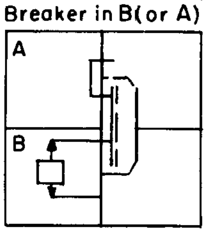
Bus entrance in A (or B)
Breaker in B(or A)



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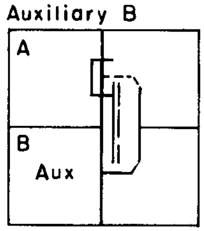
Bus entrance in A
Auxiliary B



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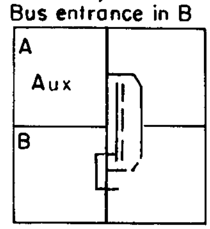
Auxiliary in A
Bus entrance in B



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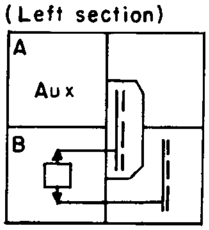
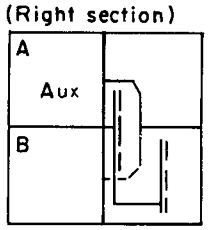
Bus tie

Auxiliary in A
Tie breaker in B
(Left section)



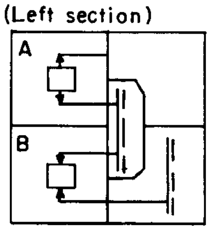
← page 6-55 →

Auxiliary in A
Tie aux in B
(Right section)



Bus tie

Breaker in A
Tie breaker in B
(Left section)



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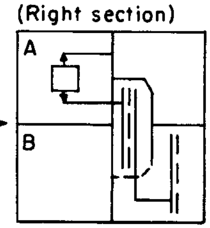
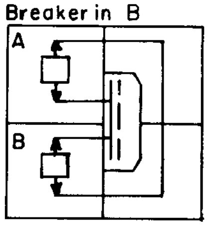
Breaker in A
Tie aux in B
(Right section)



Feeder by-pass
Breaker in A
Breaker in B



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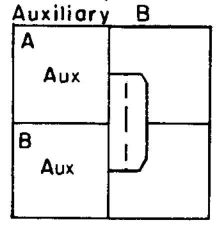
Auxiliary
Auxiliary A
Auxiliary B



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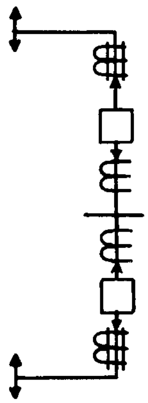
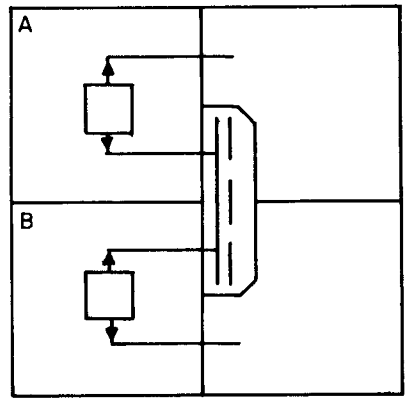


Breaker in A
Breaker in B

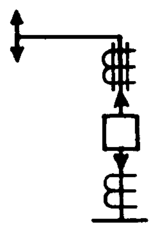


<table>
<tr><th></th><th></th><th>94 IN. DEEP VERTICAL SECTIONS</th><th>82 IN. DEEP VERTICAL SECTIONS</th></tr>
<tr><td rowspan="2">RATINGS</td><td>BUS</td><td colspan="2">1200, 2000, or 3000 A</td></tr>
<tr><td>BREAKERS</td><td colspan="2">Both 1200 A or top 1200 A/bottom 2000 A</td></tr>
<tr><td rowspan="4">ENTERING POWER CONDUCTORS</td><td>TYPE</td><td colspan="2">Shielded, non-leaded cable</td></tr>
<tr><td>DIRECTION</td><td colspan="2">Top circuit from above and bottom circuit from below</td></tr>
<tr><td></td><td>Both circuits from below
Both circuits from above</td><td></td></tr>
<tr><td>TERMI-
NATION</td><td colspan="2">Provision for 2 terminals per phase (NEMA drilling less terminals)up to and including 750 MCM for each circuit (21″ allowed for stress cones)</td></tr>
</table>

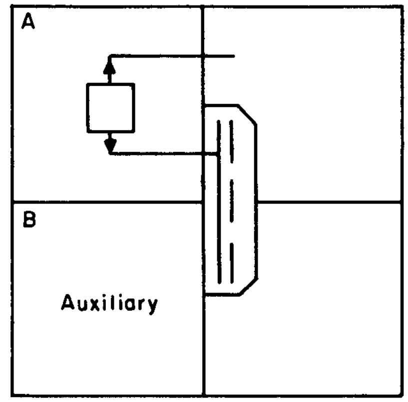
OPTIONS

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

POWER/VAC Switchgear Equipment



Breaker in A
Auxiliary in B

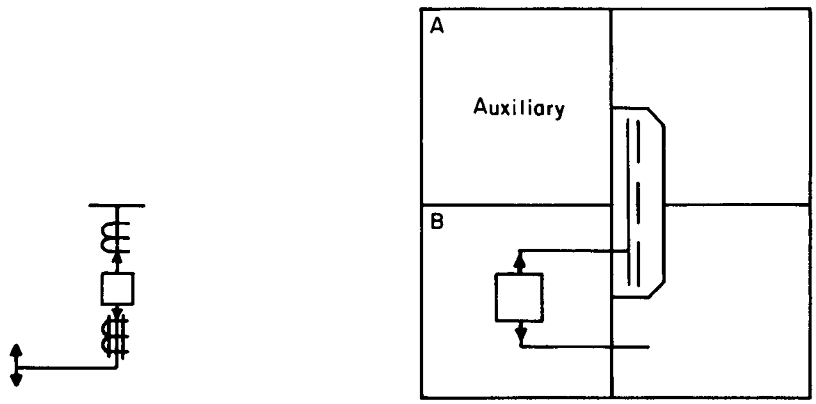


		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000 or 3000 A	
	BREAKERS	1200 or 2000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below except above only when CPT mounted in bottom rear of Unit B	
	TERMI-NATION	Provision for 2 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 3-1/C or 1-3/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 near Unit B)	

Auxiliary in A
Breaker in B

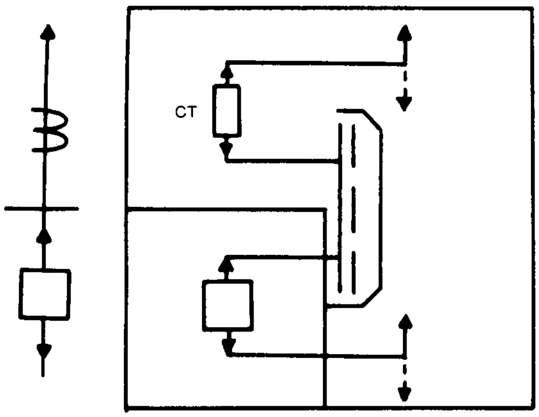


		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	3000 A	
	BREAKERS	3000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below	
	TERMI-NATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to 750 MCM (21" allowed for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

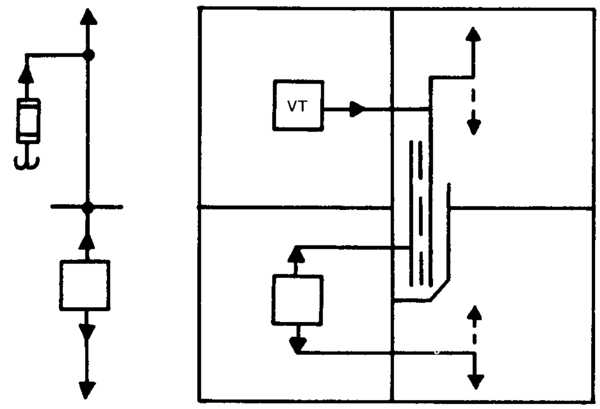
OPTIONS

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 3-1/C or 1-3/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	

POWER/VAC Switchgear Equipment

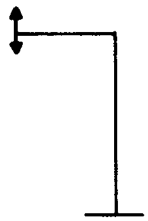


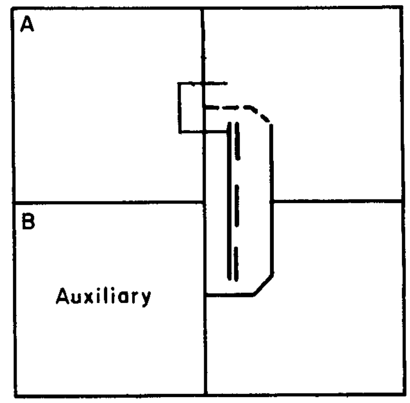
CT or VT in A
Breaker in B



		94 IN. DEEP VERTICAL SECTIONS	
RATINGS	BUS	1200, 2000	
	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	
	TERMI-NATION	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 breaker circuits	
		Add large ground sensor CT (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 to either or both circuits	
		Add clamp type terminals per Tables 7-45, 7-46 to either or both circuits	
		Add provision for 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



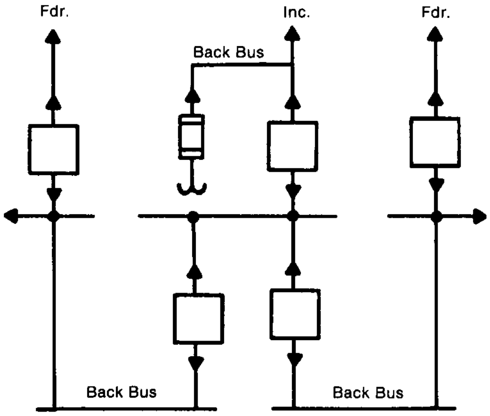


		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000 or 3000 A	
	BREAKERS	1200 or 2000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below except above only when CPT mounted in bottom power conductor compartment	
	TERMI-NATION	Provision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

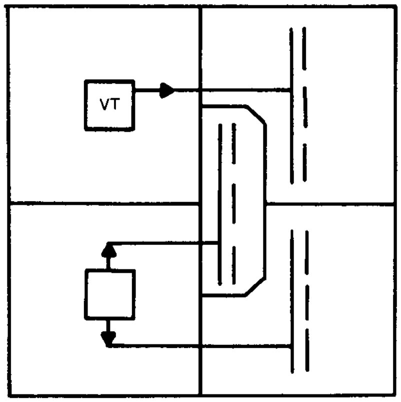
OPTIONS

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 3-1/C or 1-3/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	

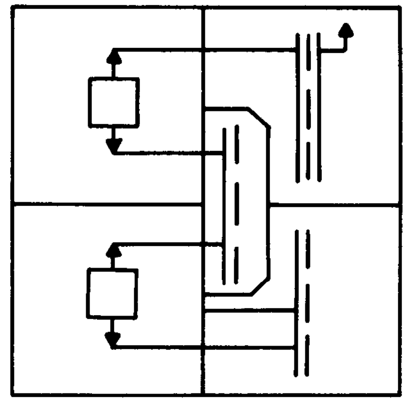
SSIL With Bus Tie Breakers To Seperate Buses



Stacks



Stack "B"—Side Elevation

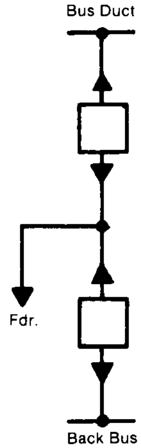

Stack "C"—Side Elevation

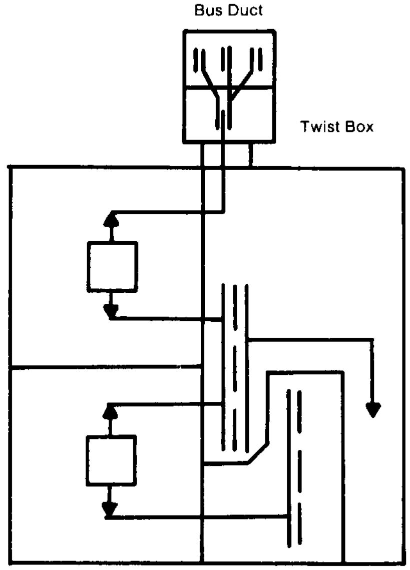
		94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200 or 2000
	BREAKERS	1200 or 2000 A
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable
	DIRECTION	Incoming from above. Feeders from above or below if not larger than 2-500 MCM per phase.
	TERMI-NATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to 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	

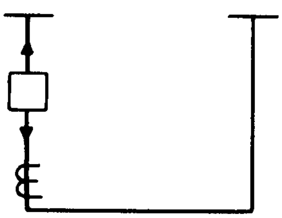
DOUBLE BUS - DOUBLE BREAKER



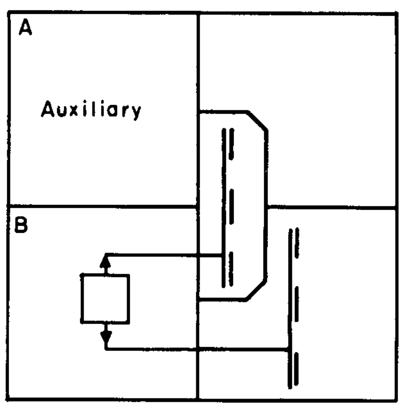


		94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000 or 3000 A
	BREAKERS	1200 or 2000 A (See Fig. 1-3)
FEEDER CABLE		Shielded, non-leaded cable

BUS-TIE

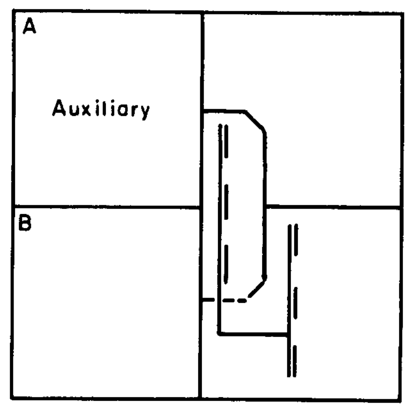


Auxiliary in A
Tie Breaker in B



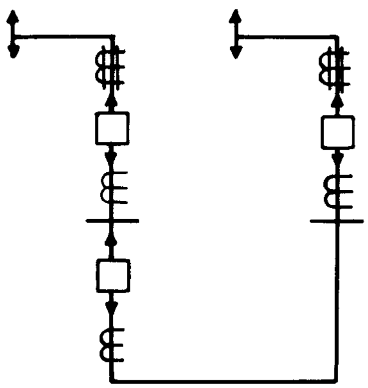
Left hand section

Auxiliary in A
Tie Auxiliary in B

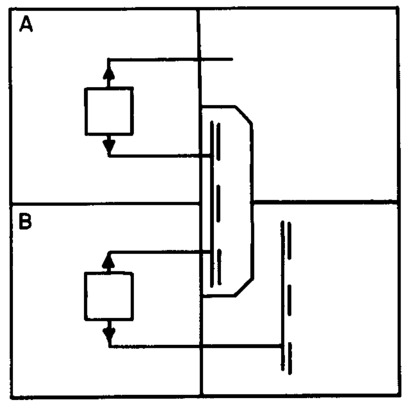


Right hand section

POWER/VAC Switchgear Equipment

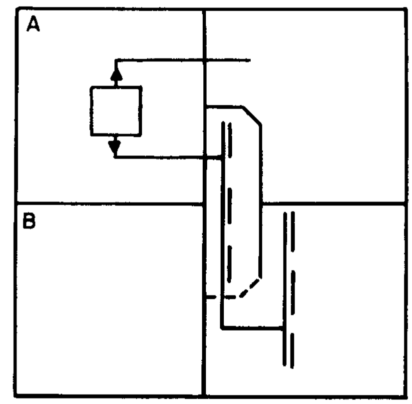


Breaker in A
Tie Breaker in B



Left hand section

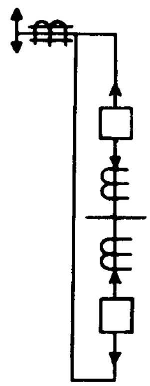
Breaker in A
Tie Auxiliary in B

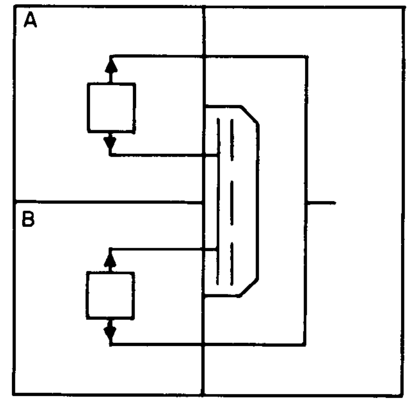


Right hand section

		94 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 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
	DIRECTION	From above or below
	TERMI-NATION	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 Table 7-45, 7-46
		Add clamp type terminals per Tables 7-45, 7-46
POTHEADS		Add 3-1/C or 1-3/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

Feeder Breaker in A
By-pass Breaker in B



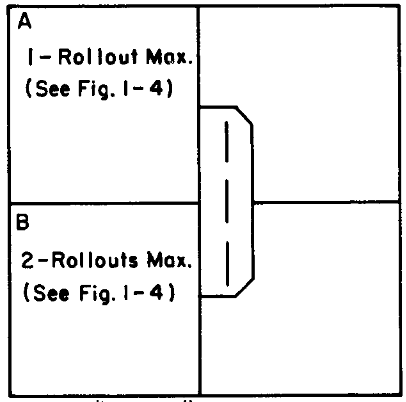


		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
RATINGS	BUS	1200, 2000, or 3000 A	
	BREAKERS	1200 or 2000 A	
ENTERING POWER CONDUCTORS	TYPE	Shielded, non-leaded cable	
	DIRECTION	From above or below	
	TERMI-NATION	Provision for 2 terminals per phase (NEMA drilling less terminals) up to and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

OPTIONS

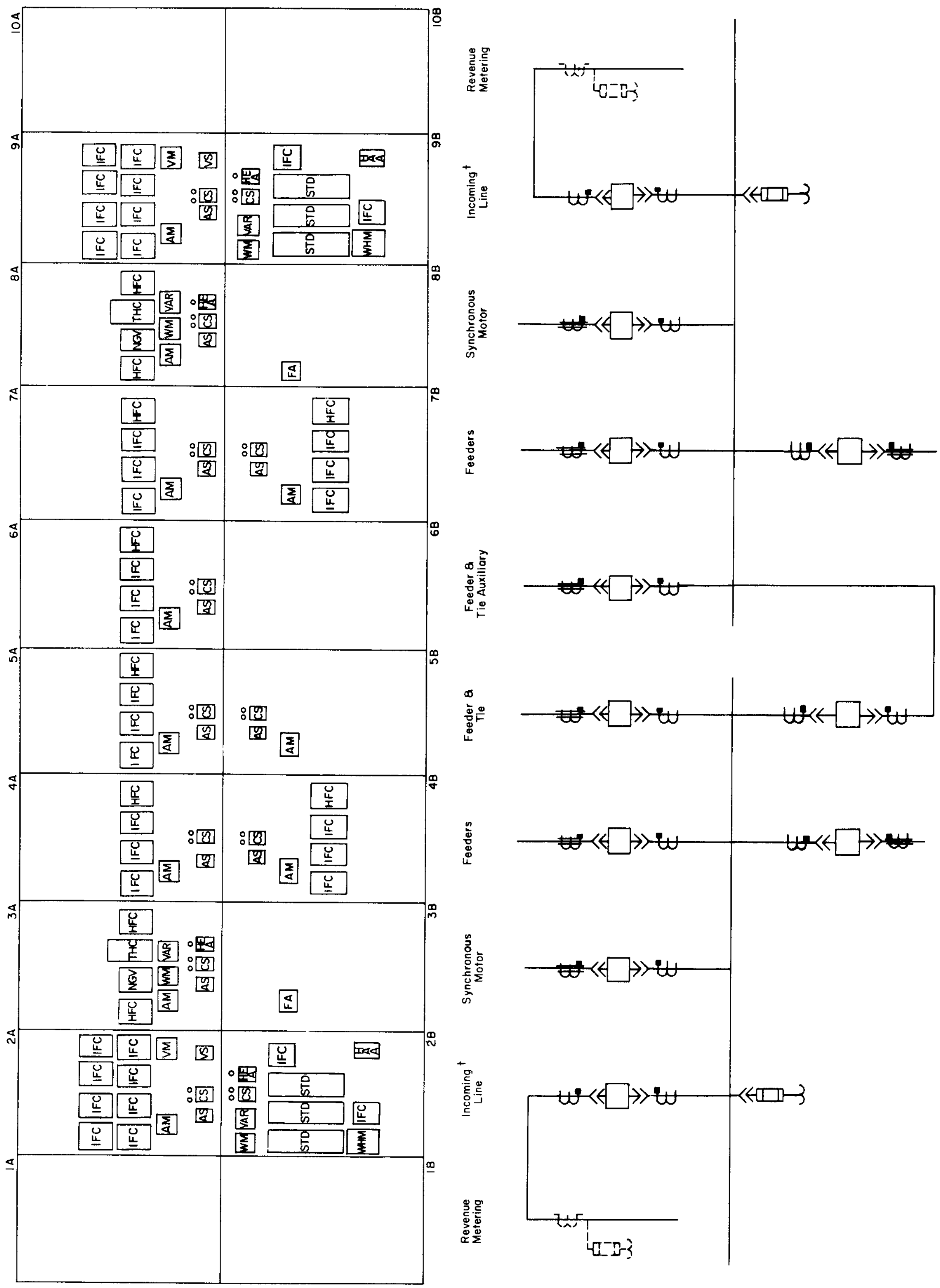
		94 IN. DEEP VERTICAL SECTIONS	82 IN. DEEP VERTICAL SECTIONS
CT's		Add small ground sensor CT (7" window)	
		Add large ground sensor CT (12" window)	
		Add 2 or 3 wound type phase CT's	
TERMINALS		Add provision for total of 4 terminals per phase (NEMA drilling less terminals) up to and including 750 MCM (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. No ground sensor, no wound type CT's	
		Add 2-3/C or 6-1/C potheads. No ground sensor or wound type CT's	
ROOF BUSHINGS (OUTDOOR ONLY)		Add 3 roof bushings, no ground sensor	
METAL-ENCLOSED BUS		Add metal-enclosed bus — no ground sensor	

Auxiliary in A
Auxiliary in B



82" OR 94" DEEP

MAXIMUM VT's PER ROLLOUT	3 — Fused VT's with 1 fuse each, rated 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 14,400 V or less, connected in open delta
MAXIMUM CPT PER ROLLOUT	1 — Single-phase, 2-fuse CPT rated 15 kVA or less, with a non-automatic secondary breaker
MAXIMUM CPT IN REAR COMPARTMENT	1 — 37.5 kVA dry-type, 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, 37½ kVA (only 25 kVA at 2400 V) } cable entry from above only Three-phase, dry: 30, 45 kVA (only 30 kVA at 2400 V) }
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



†This is a custom vertical section, because controls for the 115 kV primary breaker are located on this panel. (See Figure 2-3.)

Figure 6-1. Illustration of sample lineup discussed in Section 2 and documented in Section 11.

DEVICE LIST FOR VERTICAL SECTIONS

Vertical Section	Device	Dev. No.	Qty	Description
1A,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	52	1	VB-13.8-500, 1200A
	Phase Overcurrent Relays	51B	3	12IFC53A1A
	Residual Overcurrent Relay	51N/B	1	12IFC53A2A
	Phase Overcurrent Relays	50/51	3	12IFC53B1A
	Residual Overcurrent Relay	51N	1	12IFC53B2A
	Circuit Current Transformers	CT	3	BP 1200/5A
	Differential Current Transformers	CT	3	BP 1200/5A
	Circuit Breaker Control Switch	CS	1	16SB1B9X2
	Indicating Lights	IL	2	ET-16, 125V (1-R, 1-G)
	Ammeter	AM	1	AB-40, 1200A Scale
	Ammeter Switch	AS	1	16SB1CA15X2
	Voltmeter	VM	1	AB-40, 18-kV Scale
	Voltmeter Switch	VS	1	16SB1CF11X2
	Breaker Closing Fuse Pullout	FU	1	2P-30A (15A Fuses)
	Breaker Tripping Fuse Pullout	FU	1	2P-60A (35A Fuses)
2B 9B	Transformer Differential Relays	87T	3	12STD15C5A
	Transformer Ground Relay	87TG	1	12IFC53
	Transformer Fault Pressure Auxiliary Relay	63FPX	1	12HAA16B2
	Hand Reset Lockout Relay	86T	1	12HEA61B237X2
	Ground Overcurrent Relay	51G	1	12IFC53B2A
	Auxiliary Current Transformer	CT	1	BP 5/0.833A
	Voltage Transformers	VT	2	JVM 14,400/120V 2E Fuses)
	Circuit Breaker Control Switch	CS	1	16SM1B9X2
	Indicating Lights	IL	3	ET-16, 125V (1-R, 1-W, 1-G)
	Wattmeter	WM	1	AB-40, 30MW Scale
	Varmeter	VARM	1	AB-40, 15MVAR Scale
	Watthour Meter	WHM	1	DS-63
4A,B 5A,6A 7A,B	Power Circuit Breaker	52	1	VB-13.8-500, 1200A
	Phase Overcurrent Relays	50/51	3	12IFC53B1A
	Ground Sensor Relay	50GS	1	12HFC11B1A
	Circuit Current Transformers	CT	3	BP 300/5A (5A, 6A) BP 400/5A (4A, 4B, 7A, 7B)
	Ground Sensor Current Transformer	GSCT	1	ITI 50/5
	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, 300A Scale (5A, 6A) AB-40, 400A Scale (4A, 4B, 7A, 7B)
	Ammeter Switch	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, 1200A
	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 Transformer	GSCT	1	ITI 50/5A
	Wattmeter	WM	1	AB-40, 7000kW Scale
	Varmeter	VARM	1	AB-40, 3500kVAR Scale
	Ammeter	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

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

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	12IFC51A2A	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	12HFC23B1A	87M
3-Element	None	2-50	12HFC23B2A	50

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

Time-current Charac-teristics	Pickup Current Range (Amperes) Time	Instan-taneous	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.
Inverse	2-16	120	12IFCV51ADIA

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

Temperature-Range Rating-	Voltage Range (Volts)	Model No.
80-160C	120/240	12IRT51F1A

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 0.2/2A target and seal-in, 15/25/40% slope 0.5A minimum pick-up	2.9, 3.2, 3.5 3.8, 4.2, 4.6 5.0, 8.7,	12STD15C5A 12IFC53 (See GER-3071)	87T 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
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

Basic and Optional Device Lists

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

Contacts N.O.	Contacts N.C.	Voltage Rating (Volts)	Model No.
3	3	125V dc	12HEA61A223x2
5	5	125V dc	12HEA61B235x2
7	3	125V dc	12HEA61B237x2
13	3	125V dc	12HEA61C243x2
3	3	48V dc	12HEA61A233x2
5	5	48V dc	12HEA61B255x2
7	3	48V dc	12HEA61B257x2
13	3	48V dc	12HEA61C263x2
3	3	250V dc	12HEA61A213x2
5	5	250V dc	12HEA61B215x2
7	3	250V dc	12HEA61B217x2
13	3	250V dc	12HEA61C223x2
3	3	230 vac	12HEA61A303x2
5	5	230 vac	12HEA61B375x2
7	3	230 vac	12HEA61B377x2
13	3	230 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	12HGA11A51
125V dc	12HGA11A52
48V dc	12HGA11A54
115V dc	12HGA11A70
230V dc	12HGA11A71
250V dc	12HFA51A41
125V dc	12HFA51A42
48V dc	12HFA51A44

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) Target Coil	Minimum Pickup	Model No.
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 No.
To be set by user (One instantaneous and 3 time-delay reclosures maximum)	48/125 240V ac	12SLR11A1A 12SLR11B1A

Table 7-18
Reclosing Cut-Off (Cutler-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 delay	12SFF31C1A

INSTRUMENTS

Table 7-20
Type AB-40 Ammeters
(5-ampere movement, 40-70 Hz)

Scale (Amperes)	Model No.
100	50103131 LS PK2
150	50103131 LS PZ2
200	50103131 LS RL2
250	50103131 LS RS2
300	50103131 LS RX2
400	50103131 LS SC2
500	50103131 LS SF2
600	50103131 LS SJ2
800	50103131 LS SN2
1000	50103131 LS SS2
1200	50103131 LS SV2
1500	50103131 LS TC2
2000	50103131 LS TM2
2500	50103131 LS TV2
3000	50103131 LS UA2
4000	50103131 LS UE2

Table 7-21
Type AB-40 Voltmeters
(150-volt movement, 40-70 Hz)

Scale	Model No.
3000V	50103021 PZ UA2
5250V	50103021 PZ UL2
6000V	50103021 PZ UP2
9000V	50103021 PZ UY2
10.5kV	50103021 PZ WMJCU
15kV	50103021 PZ WZ2
18kV	50103021 PZ XE2

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.

3-PHASE, 3-WIRE
Root number for zero left scales = 50-103221A

TR	Scale kW	Suffix
100	100	RBU1CAC
120	120	RBU1CCC
160	150	XAG1CEC
175	175	RBU1GGC
200	200	RBU1CGC
210	200	XGJ1CGC
240	250	RDR1CJC
280	300	RET1CKC
300	300	RBU1CKC
320	320	RBU1CLC
350	350	RBU1CMC
360	350	RAS1CMC
400	400	RBU1CNC
480	500	RDR1CRC
500	500	RBU1CRC
525	500	XGJ1CRC
600	600	RBU1CTC
700	700	RBU1CWC
720	700	RAS1CWC
800	800	RBU1CYC
900	900	RBU1CZC
960	1000	RDR1DAC
1000	1000	RBU1DAC
1050	1000	XGJ1DAC
1200	1200	RBU1DCC
1400	1400	RBU1DDC
1500	1500	RBU1DEC
1600	1500	XAG1DEC
1750	1750	RBU1HGC
1800	1800	RBU1DFC
2000	2000	RBU1DGC
2100	2000	XGJ1DGC
2400	2500	RDR1DJC
2800	3000	RET1DKC
3000	3000	RBU1DKC
3200	3000	XAG1DKC
3500	3500	RBU1DMC
3600	3500	RAS1DMC
4000	4000	RBU1DNC
4200	4000	XGJ1DNC
4800	5000	RDR1DRC

TR	Scale kW	Suffix
5000	5000	RBU1DRC
5600	6000	RET1DTC
6000	6000	RBU1DTC
6400	6500	RCP1DUC
7000	7000	RBU1DWC
7200	7000	RAS1DWC
8000	8000	RBU1DYC
8400	8000	XGJ1DYC
	Scale MW	
9600	10MW	RDR1BAD
10000	10MW	RBU1BAD
10500	10MW	XGJ1BAD
11200	12	RET1BCD
12000	12	RBU1BCD
12800	12.5	RAU1FCD
14000	15	RET1BED
14400	15	RDR1BED
16000	16	RBU1FED
17500	17.5	RBU1FGD
18000	18	RBU1BFD
19200	20	RDR1BGD
20000	20	RBU1BGD
21000	20	XGJ1BGD
24000	25	RDR1BJD
28000	28	RBU1FKD
28800	30	RDR1BKD
30000	30	RBU1BKD
32000	32	RBU1BLD
36000	35	RAS1BMD
38400	40	RDR1BND
40000	40	RBU1BND
48000	50	RDR1BRD
50000	50	RBU1BRD
60000	60	RBU1BTD
72000	70	RAS1BWD
80000	80	RBU1BYD
96000	100	RDR1CAD

Table 7-22 (Cont'd)

TR	Scale kW	Suffix
3-PHASE, 4-WIRE Root number for zero left scales = 50-103251A		
100	200	RBU1CGC
120	240	RBU1CHC
160	300	XAG1CKC
200	400	RBU1CNC
240	450	XAG1CPC
300	600	RBU1CTC
320	600	XAG1CTC
350	700	RBU1CWC
360	700	RAS1CWC
400	800	RBU1CYC
420	800	XGJ1CYC
480	1000	RDR1DAC
560	1200	RET1DCC
600	1200	RBU1DCC
700	1400	RBU1DDC
800	1600	RBU1HEC
900	1800	RBU1DFC
1000	2000	RBU1DGC
1050	2000	XGJ1DGC
1200	2500	RDR1DJC
1400	3000	RET1DKC
1600	3000	XAG1DKC
1800	3500	RAS1DMC
2000	4000	RBU1DNC
2100	4000	XGJ1DNC
2400	4500	XAG1DPC
2800	5500	RAX1DSC
3000	6000	RBU1DTC
3200	6000	XAG1DTC
3500	7000	RBU1DWC
3600	7000	RAS1DWC
4000	8000	RBU1DYC
4200	8000	XGJ1DYC

TR	Scale MW	Suffix
4800	10	RDR1BAD
5600	12	RET1BCD
6000	12	RBU1BCD
6400	12.5	RAS1FCD
7000	14	RBU1BDD
7200	14	RAS1BDD
8000	16	RBU1FED
8400	17.5	RDR1FGD
9600	20	RDR1BGD
10000	20	RBU1BGD
11200	24	RET1BHD
12000	25	RDR1BJD
12800	25	RAU1BJD
14000	28	RBU1FKD
14400	30	RDR1BKD
16000	30	XAG1BKD
16800	35	RDR1BMD
18000	35	RAS1BMD
19200	40	RDR1BND
20000	40	RBU1BND
21000	40	XGJ1BND
22400	45	RBX1BPD
24000	50	RDR1BRD
28000	55	RAX1BSD
30000	60	RBU1BTD
32000	60	XAG1BTD
35000	70	RBU1BWD
36000	70	RAS1BWD
42000	80	XCJ1BYD
48000	90	XAG1BZD

Table 7-23
Type AB-40 Wattmeters
(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 open-delta voltage transformers.
Coil rating 5 ampere, 120 volt, 50/60 Hz, connections 2634K26.
Root number = 50-103742A.

TR	Scale kvar	Suffix	TR	Scale kvar	Suffix
100	50	JLE1BRC	4800	2500	JUK1DJC
120	60	JLE1BTC	5000	2500	JLE1DJC
160	80	JLE1BYC	5600	3000	KPD1DKC
175	90	JSG1BZC	6000	3000	JLE1DKC
200	100	JLE1CAC	6400	3000	GXB1DKC
210	100	HMJ1CAC	7000	3500	JLE1DMC
240	120	JLE1CCC	7200	3500	HSE1DMC
280	150	KPD1CEC	8000	4000	JLE1DNC
300	150	JLE1CEC	8400	4000	HMJ1DNC
320	160	JLE1GEC	9600	5000	JUK1DRC
350	175	JLE1GGC	10000	5000	JLE1DRC
360	175	HSE1GGC	10500	5000	HMJ1DRC
400	200	JLE1CGC	11200	5500	HUC1DSC
480	250	JUK1CJC	12000	6000	JLE1DTC
500	250	JLE1CJC	12800	6000	GXB1DTC
525	250	HMJ1CJC	14000	7000	JLE1DWC
600	300	JLE1CKC	14400	7000	HSE1DWC
700	350	JLE1CMC	16000	8000	JLE1DYC
720	350	HSE1CMC	17500	9000	JSG1DZC
800	400	JLE1CNC	18000	9000	JLE1DZC
900	450	JLE1CPC	**TR**	**Scale Mvar**	**Suffix**
960	500	JUK1CRC			
1000	500	JLE1CRC			
1050	500	HMJ1CRC	19200	10	JUK1BAD
1200	600	JLE1CTC	20000	10	JLE1BAD
1400	700	JLE1CWC	21000	10	HMJ1BAD
1500	750	JLE1CXC	24000	12	JLE1BCD
1600	800	JLE1CYC	28000	14	JLE1BDD
1750	900	JSG1CZC	28800	15	JUK1BED
1800	900	JLE1CZC	30000	15	JLE1BED
2000	1000	JLE1DAC	32000	16	JLE1FED
2100	1000	HMJ1DAC	36000	17.5	HSE1FGD
2400	1200	JLE1DCC	38400	18	GXB1BFD
2800	1400	JLE1DDC	40000	20	JLE1BGD
3000	1500	JLE1DEC	48000	25	JUK1BJD
3200	1600	JLE1HEC	50000	25	JLE1BJD
3500	1750	JLE1HGC	60000	30	JLE1BKD
3600	1750	HSE1HGC	72000	35	HSE1BMD
4000	2000	JLE1DGC	80000	40	JLE1BND
4200	2000	HMJ1DGC	96000	50	JUK1BRD

Three-phase, four-wire, cross-phased,
Wye-wye voltage transformers, 208-volt voltage coils
Root number = 50-103742B.

TR	Scale kvar	Suffix	TR	Scale kvar	Suffix
100	100	AWN1CAC	4800	5000	BTX1DRC
120	120	AWN1CCC	5600	5500	ARS1DSC
160	160	AWN1GEC	6000	6000	AWN1DTC
200	200	AWN1CGC	6400	6500	BMR1DUC
240	250	BTX1CJC	7000	7000	AWN1DWC
300	300	AWN1CKC	7200	7000	ANR1DWC
320	300	KSC1CKC	8000	8000	AWN1DYC
350	350	AWN1CMC	8400	8000	KWD1DYC
360	350	ANR1CMC	**TR**	**Scale Mvar**	**Suffix**
400	400	AWN1CNC			
420	400	KWD1CNC			
480	500	BTX1CRC	9600	10	BTX1BAD
560	600	CPL1CTC	10000	10	AWN1BAD
600	600	AWN1CTC	11200	12	CPL1BCD
700	700	AWN1CWC	12000	12	AWN1BCD
800	800	AWN1CYC	12800	12	KSC1BCD
900	900	AWN1CZC	14000	14	AWN1BDD
1000	1000	AWN1DAC	14400	14	ANR1BDD
1050	1000	KWD1DAC	16000	16	AWN1FED
1200	1200	AWN1DCC	16800	17.5	BTX1FGD
1400	1400	AWN1DDC	18000	18	AWN1BFD
1600	1600	AWN1HEC	19200	20	BTX1BGD
1800	1800	AWN1DFC	20000	20	AWN1BGD
2000	2000	AWN1DGC	21000	20	KWD1BGD
2100	2000	KWD1DGC	22400	24	CPL1BHD
2400	2500	BTX1DJC	24000	24	AWN1BHD
2800	3000	CPL1DKC	28000	30	CPL1BKD
3000	3000	AWN1DKC	30000	30	AWN1BKD
3200	3000	KSC1DKC	32000	30	KSC1BKD
3500	3500	AWN1DMC	35000	35	AWN1BMD
3600	3500	ANR1DMC	36000	35	ANR1BMD
4000	4000	AWN1DNC	42000	42	KWD1BND
4200	4000	KWD1DNC	48000	50	BTX1BRD

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)	50103502CAAB2

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-ANAN

Table 7-27
Type AB-16 Synchroscope

Description	Model No.
120V	50-120452-AAAA

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	—	700X63G1
3-phase, 3-wire, 2-element, watthour demand	DSM63	15 min.	700X64G1

Table 7-29
Type KT Time Meter

Description	Model No.
120V ac, Register (in hrs.)	50240711AAAD1

Table 7-30
Control Switches

Description	Stages	Positions	Model No.
Type SBM			
Circuit Breaker control or Permissive	3	(C) (NAC) (NAT) (T)	10AA106
Governor 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 7-31
Type SBM Transfer Switches

Description	Stages	Positions	Model No.
Ammeter Switch (Middle of Circuit)	5	(1) (2) (3) (OFF)	10AA093
Voltmeter Switch (3-phase, 3-wire)	2	(OFF) (1-2) (2-3) (3-1)	10AA004
Voltmeter Switch (3-phase 4-wire)		(OFF) (1-2) (2-3) (3-1) (OFF) (1) (2) (3)	10AA006
Voltmeter Switch (Removable Handle)	2	(OFF) (1-2) (2-3) (3-1)	10AA069
Synchronizing Switch (Removable Handle)	3	(OFF) (ON)	10AA070

CURRENT TRANSFORMERS

Table 7-32
Type BP Window-type Phase Current Transformers

Ratio	Model No.	Accuracy Class	Saturation Curve
100:5	0144D2654G001	C10	0209B4756SH.1
150:5	0144D2654G002	C20	0209B4756SH.2
200:5	0144D2654G003	C20	0209B4756SH.3
250:5	0144D2654G004	C20	0209B4756SH.4
300:5	0144D2654G005	C20	0209B4756SH.5
400:5	0144D2654G006	C50	0209B4756SH.6
500:5	0144D2654G007	C50	0209B4756SH.7
600:5	0144D2654G008	C50	0209B4756SH.8
800:5	0144D2654G009	C100	0209B4756SH.9
1000:5	0144D2654G010	C100	0209B4756SH.10
1200:5	0144D2654G011	C100	0209B4756SH.11
1500:5	0144D2654G012	C200	0209B4756SH.12
1600:5	0144D2654G017	C200	0209B4756SH.17
2000:5	0144D2654G013	C200	0209B4756SH.13
2500:5	0144D2654G014	C200	0209B4756SH.14
3000:5	0144D2654G015	C200	0209B4756SH.15
4000:5	0144D2654G016	C200	0209B4756SH.16

Table 7-33
Ground-sensor Current Transformers

Type	Ratio	Window Size	Model No.	Saturation Curve
Instr. Transf. Inc.	50:5	7-1/4 in.	143500	5121A00886
JCG-0	50:5	12 inches	848X67	H-96899241-468

Table 7-34A
Type JKS-3 Wound Primary Current Transformers (5kV Single Secondary)

Ratio	Catalog No.	Accuracy Class Metering			Relay-ing	Saturation Curve
		B=0.1	B=0.5	B=2.0		
50:5	671X22	0.6	1.2	—	T10	C145325
75:5	671X23	0.6	1.2	—	T20	C145325
100:5	671X24	0.3	0.6	—	T20	C145325
150:5	671X25	0.3	0.6	—	T50	C145325
200:5	671X26	0.3	0.3	1.2	T50	C145325
250:5	671X27	0.3	0.3	1.2	T50	C145325
300:5	671X28	0.3	0.3	1.2	T50	C145325
400:5	671X29	0.3	0.3	0.3	T100	C145325
500:5	871X30	0.3	0.3	0.3	T100	C145325
600:5	671X31	0.3	0.3	0.3	T100	C145325

Table 7-34B
Type JKS-5 Wound Primary Current Transformers (15kV Single Secondary)

Ratio	Catalog No.	Accuracy Class Metering			Relay-ing	Saturation Curve
		B=0.1	B=0.5	B=2.0		
50:5	639X86	0.6	2.4	—	T10	C-5453777
75:5	639X87	0.6	1.2	—	T20	C-5453777
100:5	639X88	0.3	0.6	2.4	T20	C-5453777
150:5	639X89	0.3	0.3	1.2	T50	C-5453777
200:5	639X90	0.3	0.3	1.2	T50	C-5453777
250:5	670X63	0.3	0.3	1.2	T50	C-5453777
300:5	639X91	0.3	0.3	1.2	T50	C-5453777
400:5	639X92	0.3	0.3	0.3	T100	C-5453777
500:5	827X28	0.3	0.3	0.3	T100	C-5453777
600:5	639X93	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 7-35
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 Lists

VOLTAGE TRANSFORMERS

Table 7-36
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	643X94
JVM-5	4800V-400VA	40:1	95	827X79
JVM-5	7200V-400VA	60:1	95	685X37
JVM-5	8400V-400VA	70:1	95	685X39
JVM-5	12000V-400VA	100:1	95	685X40
JVM-5	14400V-400VA	120:1	95	685X41

Table 7-37
Voltage Transformers (Line-to-Line)

	Rating		System			
Type	V	VA	kV	Ratio	BIL	Model No.
JVM-3	2400	50	2.4	20:1	60	763X21G43
	2400	50	2.4	20:1	60	643X88
	2400	200	4.16	20:1	60	643X88
	4200	200	4.2	35:1	60	643X88
JVM-5	4800	50	4.8	40:1	110	845X81
	7200	200	7.2	60:1	110	670X42
	8400	200	8.4	70:1	110	670X44
	12000	200	12.0	100:1	110	670X45
	14400	200	14.4	120:1	110	670X46
	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 7-38
Control Power Transformers

	Volts		Primary	BIL	Model No.
kVA	Primary	Secondary	Taps %	kV	9T28-
5	2400	120/240	1 ± 7½	60	Y5600
	4160	120/240	1 ± 7½	60	Y5601
	4800	120/240	1 ± 7½	95	Y1040G20
	7200	120/240	1 ± 7½	95	Y1040G21
	8400	120/240	1 ± 7½	95	Y1040G22
	12000	120/240	1 ± 7½	95	Y5604
	13300	120/240	1 ± 7½	95	Y5605
10	2400	120/240	1 ± 7½	60	Y5610
	4160	120/240	1 ± 7½	60	Y5611
	4800	120/240	1 ± 7½	95	Y1041G20
	7200	120/240	1 ± 7½	95	Y1041G21
	8400	120/240	1 ± 7½	95	Y1041G22
	12000	120/240	1 ± 7½	95	Y5614
	13300	120/240	1 ± 7½	95	Y5615
15	2400	120/240	1 ± 7½	60	Y5620
	4160	120/240	1 ± 7½	60	Y5621
	4800	120/240	1 ± 7½	95	Y1042G20
	7200	120/240	1 ± 7½	95	Y1042G21
	8400	120/240	1 ± 7½	95	Y1042G22
	12000	120/240	1 ± 7½	95	Y5624
	13300	120/240	1 ± 7½	95	Y5625
25	2400	120/240	1 ± 7½	60	Y5430
	4160	120/240	1 ± 7½	60	Y5431
	4800	120/240	1 ± 7½	95	Y1242G20
	7200	120/240	1 ± 7½	95	Y1242G21
	8400	120/240	1 ± 7½	95	Y1242G22
	12000	120/240	1 ± 7½	95	Y5434
	13300	120/240	1 ± 7½	95	Y5435
37.5	4160	120/240	1 ± 7½	60	Y1223G2
	7200	120/240	1 ± 7½	75	Y1233
	12470	120/240	1 ± 2½	95	Y1243G14
	13200	120/240	1 ± 2½	95	Y1243G3

FUSES, TEST BLOCKS AND INDICATING LAMPS

Table 7-39
Pull-out Control Fuse Blocks

Description (Two-pole)	Catalog No.
30A	0673D0515 421 G01
60A	0673D0515 422 G01

Table 7-40
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 7-41
Type ET-16 Indicating Lights

Rating		Color
Volts	Ohms	
48	200	Available in all colors listed below
125	2000	
250	5100	
120	1900	
240	4800	
Available in all ratings listed above		Red Green White Clear Blue

TERMINATIONS

Table 7-42
Terminals For Copper Cable

Optional Type
Clamp (Screw) Type-Burndy

Cable Size	Catalog No.
No. 4 Standard	QA1C-BSV
1/0-2/0 AWG	QA26-BSV
3/0-4/0 AWG	QA28-BSV2N
250-350 MCM	QA31-BSV2N
400-500 MCM	QA34-BSV2N
600-800 MCM	QA40-2NSV
850-1000 MCM	QA44-2NSV

Preferred Type
Crimp Type-Burndy

Cable Size	Catalog No.
1/0 AWG	YA25-2N
2/0 AWG	YA26-2N
3/0 AWG	YA27-2N
4/0 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

Table 7-43
Terminals For Aluminum Cable

Preferred Type
Crimp Type-Burndy Hylugs

Cable Size	Catalog No.
1/0 AWG	YA25A7
2/0 AWG	YA26A3
3/0 AWG	YA27A5
4/0 AWG	YA28A5
250 MCM	YA29A3
300 MCM	YA30A3
350 MCM	YA31A3
500 MCM	YA34A3
750 MCM	YA39A5
1000 MCM	YA44A3

Optional Type
Clamp (Screw) Type-Burndy

Cable Size	Catalog No.
No. 4-1/0 AWG	NAR25A-2N
1/0 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 7-44
Potheads For Single-conductor Aluminum Cable (15kV)

Type: PLM

Description	Catalog No.
250 MCM (with wiping sleeve)	X54271SUV-LH-M
500 MCM (with wiping sleeve)	X64571SUV-LH-M
750 MCM (with wiping sleeve)	X64771SU-LH-M
1000 MCM (with wiping sleeve)	X64871SU-LH-M
1500 MCM (with wiping sleeve)	X65971SU-LH-M
2000 MCM (with wiping sleeve)	X65X71SU-LH-M
250 MCM (with no entrance fitting)	54271SUV-LH-M
500 MCM (with no entrance fitting)	64571SUV-LH-M
750 MCM (with no entrance fitting)	64771SU-LH-M
1000 MCM (with no entrance fitting)	64871SU-LH-M
1500 MCM (with no entrance fitting)	65971SU-LH-M
2000 MCM (with no entrance fitting)	65X71SU-LH-M

For Single-Conductor Copper Cable (15kV)

Type: PLM

Description	Catalog No.
250 MCM (with wiping sleeve)	X54271SUV-LH
500 MCM (with wiping sleeve)	X64571SUV-LH
750 MCM (with wiping sleeve)	X64771SU-LH
1000 MCM (with wiping sleeve)	X64871SU-LH
1500 MCM (with wiping sleeve)	X65971SU-LH
2000 MCM (with wiping sleeve)	X65X71SU-LH
250 MCM (with no entrance fitting)	54271SUV-LH
500 MCM (with no entrance fitting)	64571SUV-LH
750 MCM (with no entrance fitting)	64771SU-LH
1000 MCM (with no entrance fitting)	64871SU-LH
1500 MCM (with no entrance fitting)	65971SU-LH
2000 MCM (with no entrance fitting)	65X71SU-LH

For Three-Conductor Aluminum Cable (15kV)

Type: PLM

Description	Catalog No.
250 MCM*	0152C5409G021
500 MCM*	0152C5409G022
750 MCM*	0152C4309G023
1000 MCM*	0152C5409G024

For Three-Conductor Copper Cable (15kV)

Type: PLM

Description	Catalog No.
250 MCM*	0152C5409G017
500 MCM*	0152C5409G018
750 MCM*	0152C4309G019
1000 MCM*	0152C5409G020

*-Without wiping sleeve or entrance fitting

Table 7-45
Stuffing Boxes For Potheads

Type: PLM

Outside Diameter (Inches)	Base Size	Catalog No.
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

Table 7-46
Wiping Sleeves For Potheads
Type: PLM

Description	Catalog No.
Base Size 4	WS-4
Base Size 5	WS-5

Table 7-47
Adapters For Potheads

Description	Base Size	Catalog No.
Three conductor	4	006273645P001
Three conductor	5	006216909P001
Single conductor	5	0722D0350P016

Table 7-48
PLM Fittings For Potheads

Pothead Description	Outside Diameter (Inches) Min.	Outside Diameter (Inches) 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)	2.90	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 7-49
Surge Arresters

Arrester Type and Rating	System Nominal kV and grounding: Solid Gnd	System Nominal kV and grounding: Ungrounded	Catalog No.
Intermediate Line			
3 kV L/G	4.16 kV	2.4 kV	9L12MGB003
6 kV L/G	6.9 kV	4.8 kV	9L12MGB006
9 kV L/G	12.47 kV	8.3 kV	9L12MGB009
12 kV L/G	13.8 kV	12.4 kV	9L12MGB012
15 kV L/G		13.2 kV	9L12MGB015
Station Type			
3 kV L/G	4.16 kV	2.4 kV	9L11RGB003
4.5 kV L/G	4.8 kV	4.16 kV	9L11RGB004
6 kV L/G	6.9 kV	4.8 kV	9L11RGB006
7.5 kV L/G		6.9 kV	9L11RGB007
9 kV L/G	12.47 kV		9L11RGB009
12 kV L/G	13.8 kV	11.5 kV	9L11RGB012
15 kV L/G		13.8 kV	9L11RGB015

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 and 15 kV, 250 MVA through 1000 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, and floor plan)

Standard documentation does **not** include side views, 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 which are mounted side-by-side and connected electrically and mechanically to form a complete switching equipment.

Each vertical section is a self-supporting structure consisting of a bolted steel frame with reinforcing gussets. Assembled to this frame are front doors and top, side and rear covers. The external covers and doors are 11-guage (or equivalent thickness) steel.

A vertical section will accommodate a maximum of two circuit breakers or three voltage transformer, control power transformer or fuse rollout trays or certain combinations of these as defined in Section 6 of this guide.

Two front doors are mounted on each vertical section. Each door is provided with a full-length hinge, door stop, and two hex-knob closing screws. Mounted on each breaker door are 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 designed for that purpose within the associated breaker compartment.

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.

Primary compartments of each circuit are isolated by grounded metal barriers which have no intentional openings. (The 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 are armored or enclosed in grounded metal troughs where they pass through primary compartments.

Power termination compartments are located at the rear of the equipment, and are 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.)

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 or control cable entry). Top exhaust vents are equipped with dust guards to keep dirt off the top breaker.

Outdoor Equipment

Weatherproof construction begins with basic indoor equipment and is partly provided by gasketing the end 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 of the equipment, 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 extended life, which provide 75 watts for each breaker and cable compartment, totaling 300 watts per vertical section. These heaters 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 doors (with padlocks) are provided on the front of the basic weatherproofed equipment to protect the device doors. Grounded 120-volt convenience outlets are provided on each device door.

PROTECTED-AISLE CONSTRUCTION — A preassembled weatherproof aisle of 11-guage 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 CONSTRUCTION — To provide common-aisle construction, the aisle between facing lineups of weatherproofed gear is spanned by a weatherproof roof. Space is provided 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.

HARDWARE

All standard hardware will be high tensile-strength steel which is zinc plated and bronze irridescent chromate conversion coated to resist corrosion.

Equipment and Installation Information

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.

*Optional motor operator is available.

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 trays can be accommodated in the bottom primary auxiliary compartment and one 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 General Electric epoxy-cast, V-8, dry-type transformers. A rollout tray can accommodate 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.

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 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.

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 A STM B317 aluminum alloy No. 6101 for 1200-ampere rating (1/4-inch by 6-inch bar) and 2000-ampere rating (1/2-inch x 6-inch bar), and A STM B187 Type ETP copper for the 3000 ampere rating (2-3/8 inch x 6 inch bars). All main bus joints are silver plated and utilize at least two 1/2-inch zinc-plated, bronze iridescent chromate conversion coated steel bolts per joint. 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). All bus joints are insulated with pre-formed vinyl boots secured by nylon hardware.

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-guage 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 without the addition of a rear extension. 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

A ground bus of 1/4-inch by 2-inch copper 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 irridescent chromate conversion coated steel bolts per joint. Station ground-connection points are located in each end section.

Equipment and Installation Information

EQUIPMENT HEATERS

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 suppled 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 mounted in a holder. 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 3/16-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 and Figure 8-1, respectively. Shown in Figure 8-2 are floor plan details, including anchor bolt locations and power conductor and conduit entrance locations. Equipment anchoring information is provided in Figure 8-3.

SHIPPING SPLITS

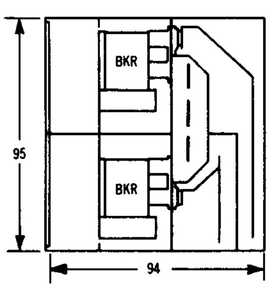
Most metalclad switchgear lineups require many vertical sections, or stacks. These lineups are broken down into shipping splits of four stacks or fewer after the lineup is assembled and tested at the factory. These shipping sections must be reassembled, in the correct order, when received at the job site.

Ratings, Dimensions and Weights

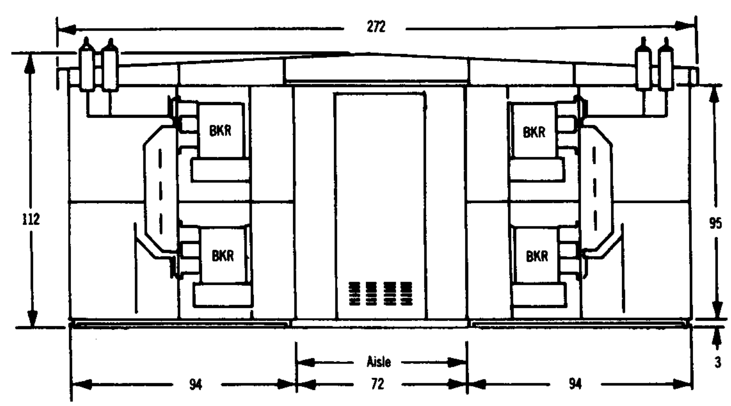
TABLE 8-1. Typical POWER/VAC Switchgear Weights (Pounds)

Breakers			Indoor Equipment		Outdoor Equipment			
Breaker Type	Current Rating (Amperes)	Breaker Weights	Breaker Vertical Section Weight (Less Brkrs)	Auxiliary Vertical Section Weight (No Trays)	Breaker Vertical Section Weight (Less Brkrs)	Auxiliary Vertical Section Weight (No Trays)	Add for Protected Aisle (Per Vert. Section)	Roll-out Tray Weight (VT or CPT)
VB-4.16-250	1200	550						
3000A-780#	2000	650						
VB-4.16-350	1200	550						
	2000	650						
	3000	780						
VB-7.2-500	1200	550						
3000A-780#	2000	650						
VB-13.8-500	1200	556	3100	3100	3600	3600	1100	500
3000A-780#	2000	650						
VB-13.8-750	1200	550						
3000A-780#	2000	650						
VB-13.8-1000	1200	550						
	2000	650						
	3000	780						

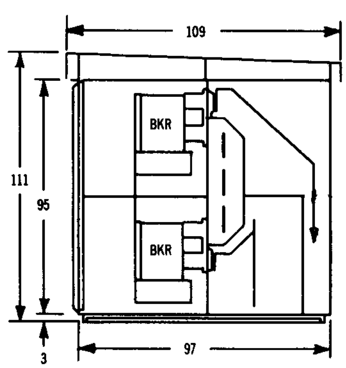
NOTE: For common aisle construction, add 1500 lbs. to the weight of two indoor vertical sections.



INDOOR

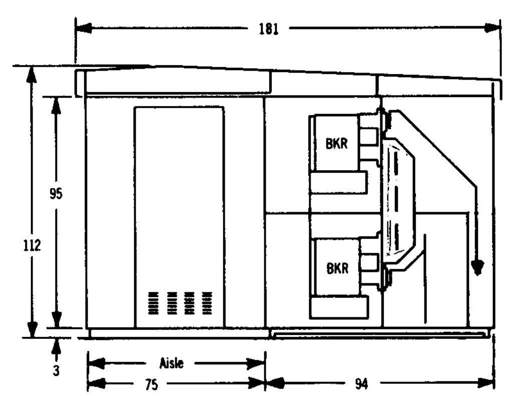


OUTDOOR – COMMON AISLE



OUTDOOR – NO AISLE

NOTE: All outdoor equipment should be mounted on concrete pad. Refer to page 8-9 for foundation and mounting details.



OUTDOOR – PROTECTED AISLE

Figure 8-1. Typical Section Dimensions—Indoor and Outdoor Equipment (All dimensions in inches)

Recommended Minimum Rear-Aisle: 26 inches

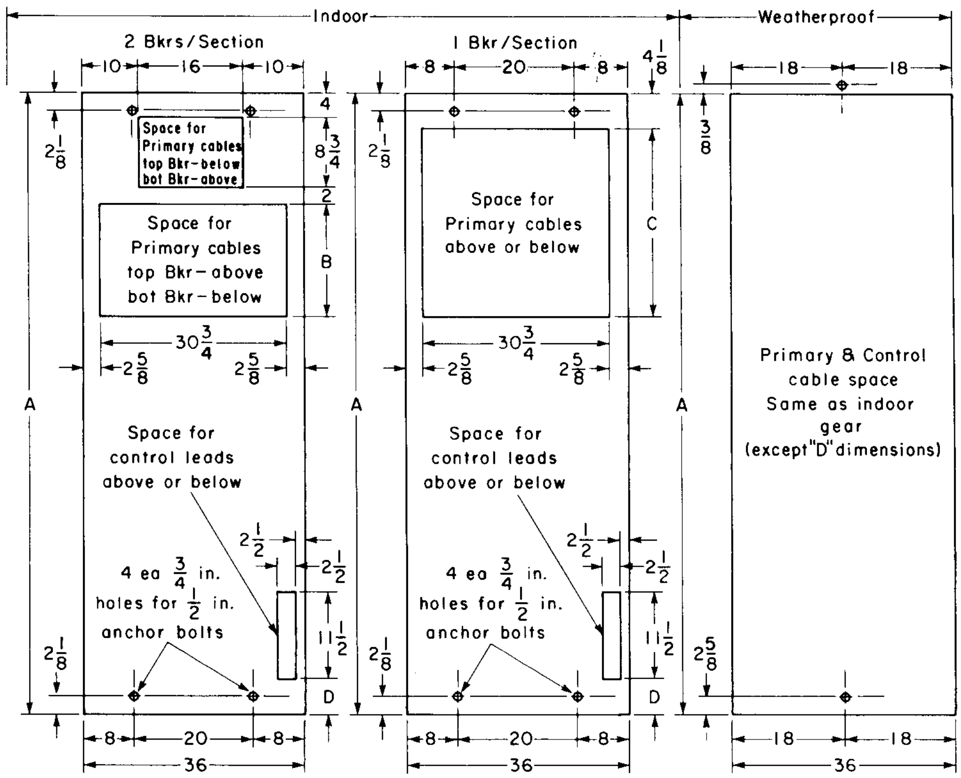


Figure 8-2. Floor Plan Details

All dimensions in inches.

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: 66 inches

Dim "D" – Indoor 6.50
– Outdoor 9.50

1200-2000 Amp Breaker
"Space Above" (Thru Top Cover)

Depth "A"	Dim "B"	Dim "C"
Indoor 82		17.00
Indoor 94	20.00	29.00
Weatherproof 97	20.00	29.00

3000 Amp Breaker

Indoor 94 and Weatherproof 97		18.00

NOTE: These are minimum values for conditions as stated.

1200-2000-3000 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"
Indoor 82		20.00
Indoor 94	20.00	32.00
Weatherproof 97	20.00	32.00

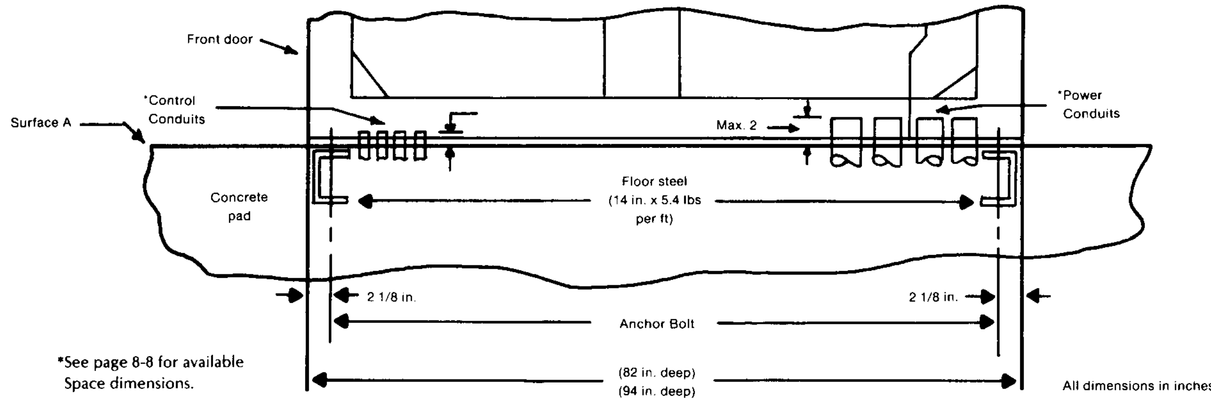
When Fuse Roll-out is in Lower Compartment (With 2 Heaters) For (1) Heater Add 2" to ALL Dim.

Depth "A"	Dim "B"	Dim "C"
Indoor 82		15.00
Indoor 94		27.00
Weatherproof 97		27.00

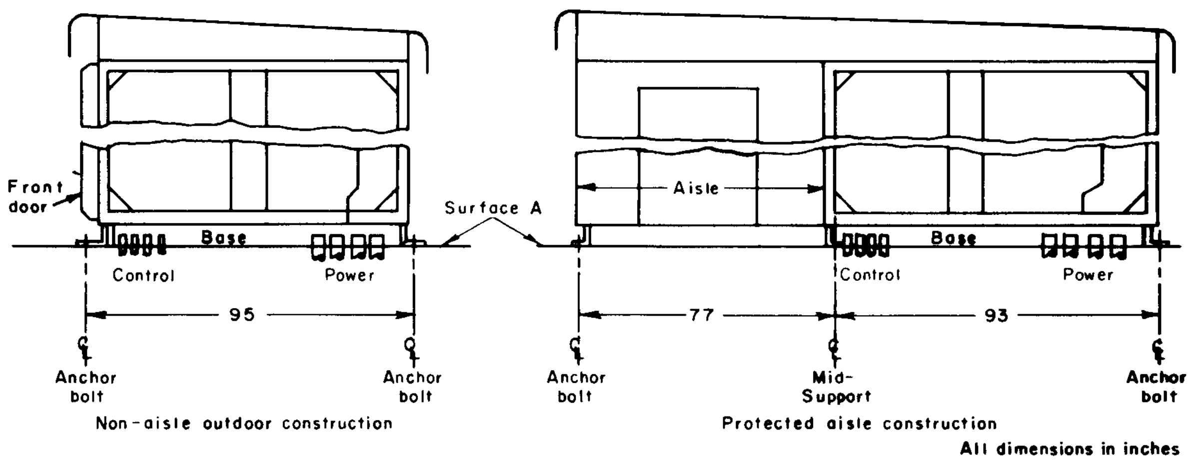
Figure 8-2. Floor Plan Details

Equipment and Installation Information

RECOMMENDED METHOD



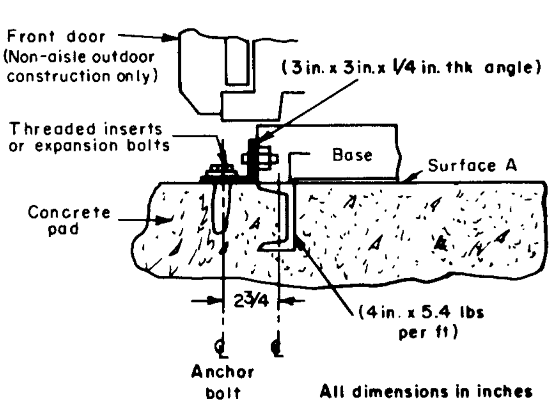
NOTE: All floor steel to be furnished by Purchaser. Floor steel members must be set level with each other, must be level over their entire length, and must be even with the level finish floor. The switchgear can be anchored to the floor steel by plug welds or ½-inch bolts furnished by Purchaser.



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.

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 ⅝-inch threaded inserts or the ⅝-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 8-3. Equipment anchoring details for POWER/VAC metalclad switchgear.

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.

EXAMPLES

Some examples of custom options are:

- Revenue metering compartments.
- Devices 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 for evaluation.

Section 10

Guide Form Specifications

Guide Form Specifications

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. 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.

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 (4160-volts) (7200-volts) (13,800-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.

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 a part of, the circuit breaker.

ARRANGEMENT

The switchgear shall include the units as shown on the attached one-line diagram.

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

A ground bus of 1/4-inch by 2-inch copper shall be extended throughout the lineup with connections to each breaker grounding contact and each cable compartment ground terminal. All joints shall be made with at least two 3/8-inch zinc-plated, bronze irridescent chromate conversion coated steel bolts per joint. Station ground-connection points shall be located in each end section.

BUS COMPARTMENT

The main bus shall be rated (1200 amperes) (2000 amperes) (3000 amperes). Bus bars shall have a continuous current rating, in accordance with ANSI standards of temperature rise and documented by design tests. All joints will be silver 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 provided 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) (31,800)-volts, 60-Hz, with a continuous current rating of (1200) (2000) (3000)-amperes and a nominal interrupting rating of (250) (350) (500) (750) (1000) 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).

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.

Guide Form Specifications

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) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
3 — Relays, phase overcurrent, Type IFC.
1 — Current transformers, single secondary, :5 ratio, Type BP.
1 — Switch, breaker control, Type SB-1.
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 SB-1.
1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cable per phase, maximum.)

DEVICE OPTIONS

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 NLR.
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 BP (for bus differential).
3 — Current transformers, single secondary, :5 ratio, Type BP (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) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
1 — Space for power circuit breaker of same rating. Output terminals paralleled with output terminals of above breakers.
3 — Relays, phase overcurrent, Type IFC.
6 — Current transformers, single secondary :5 ratio, Type BP. (Three located on output terminals on each breaker position.)
2 — Switches, breaker control, Type SB-1.
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, 60 amperes.
1 — Ammeter, indicating, Type AB-40. (Scale to match CT).
1 — Switch, ammeter transfer, Type SB-1.
1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

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 closing, 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 BP (for bus differential).
3 — Current transformers, single secondary, :5 ratio, Type BP (for transformer differential).
1 — Current transformer, ground-sensor, 50:5 ratio, ITI.

Guide Form Specifications

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) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 — Set of insulated bus, three-phase, three-wire (1200) (2000) (3000) amperes.
3 — Relays, phase overcurrent, Type IFC.
3 — Relays, transformer differential, Type STD.
1 — Relay, lockout, Type HEA.
1 — Relay, auxiliary, transformer sudden pressure, Type HAA.
3 — Current transformers, single secondary :5 ratio, Type BP
3 — Current transformers, single secondary, :5 ratio, Type BP (for transformer differential).
1 — Switch, breaker control, Type SB-1.
3 — Indicating lamps; breaker close-open, lockout; red, green, and white, 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 — Ammeter, indicating, Type AB-40.
1 — Switch, ammeter transfer, Type SB-1.
1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

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) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
3 — Relays, phase overcurrent, Type IFC.
3 — Current transformers, single secondary, :5 ratio, Type BP
2 — Voltage transformers, Type JVM.
4 — Fuses, Type EJ-1.
1 — Switch, breaker control, Type SB-1.
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 — Switch, ammeter transfer, Type SB-1.
1 — Voltmeter, Type AB-40.
1 — Switch, voltmeter transfer, Type AB-40.
1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

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 BP (for transformer differential).
3 — Current transformers, single secondary, :5 ratio, Type BP (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.

Guide Form Specifications

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) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
3 — Relays, phase overcurrent, Type IFC.
3 — Relays, directional phase overcurrent, Type JBC.
3 — Current transformers, single secondary, :5 ratio, Type BP
1 — Switch, breaker control, Type SB-1.
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 — Voltmeter, Type AB-40.
1 — Switch, voltmeter transfer, Type AB-40.
1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

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
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. (For STD or PVD.)
1 — Relay, lockout, Type HEA. (For CCP and SFF.)
3 — Current transformers, single secondary, :5 ratio, Type BP (For use with CFD's.)
3 — Current transformers, single secondary, :5 ratio, Type BP (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) amperes.
1 — Provisions for power conductor terminations. (NEMA drilling only. Lugs not included. For two 750 MCM cables per phase, maximum.)

DEVICE OPTIONS

3 — Current transformers, single secondary, :5 ratio, Type BP
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.

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) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes. (Includes necessary bus-tie conductors.)
1 — Switch, breaker control, Type SB-1.
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 BP
1 — Ammeter, indicating, Type AB-40.
1 — Switch, ammeter transfer, Type SB-1.

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 BP (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 BP (For machine differential.)

Guide Form Specifications

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) 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 BP
1 — Switch, breaker control, Type SB-1.
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, ground-sensor overcurrent, instantaneous, Type HFC.
3 — Relays, phase overcurrent, Type IFC66.
1 — Relay, overtemperature alarm, Type HGA.
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 BP (for bus differential).
1 — Indicating lamp, breaker disagreement, Type ET-16.
1 — Watthour meter, Type DS-63
or
Watthour demand meter, Type DSM-63.

INDUCTION MOTOR FEEDER (IMF1)

BASIC UNIT

The metalclad 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) 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 BP
1 — Switch, breaker control, Type SB-1.
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, ground-sensor overcurrent, instantaneous, Type HFC.
1 — Relay, thermal, 3-element, Type THC.
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 IME-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 BP (for bus differential).
1 — Indicating lamp, breaker disagreement, Type ET-16.
1 — Watthour meter, Type DS-63
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).

Guide Form Specifications

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) 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 BP
1 — Switch, breaker control, Type SB-1.
2 — 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 located at machine. These 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 BP (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 BP. (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) 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, time delay, Agastat (incomplete sequence).
3 — Current transformers, single secondary, :5 ratio, Type BP.
1 — Current transformer, ground-sensor, 50:5 ratio, ITI.
1 — Switch, breaker control, Type SB-1.
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 — 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 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 BP (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.)

SYNCHRONOUS MOTOR FEEDER (SMF2)

BASIC UNIT

The metalclad switchgear for control and full-voltage-start of a 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) 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 — Machine differential, self-balance, Type HFC. (Requires three right CT's located at machine. These CT's *not* included in SMF-2 device package.)
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 BP.
1 — Current transformer, ground-sensor, 50:5 ratio, ITI.
1 — Switch, breaker control, Type SB-1.
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 — 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 IC2820.
  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 BP (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 BP. 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) amperes continuous, three-pole, with electrically operated, stored-energy mechanism.
1 — Set of insulated bus, three-phase, three-wire, (1200) (2000) (3000) amperes.
3 — Relays, machine differential, Type CFD.
1 — Relay, lockout, Type HEA. (For machine differential.)
1 — Relay, time overcurrent, Type IFC (ground overcurrent protection).
1 — Relay, power directional, Type ICW.
3 — Current transformers, single secondary, :5 ratio, Type BP
3 — Current transformers, single secondary, :5 ratio, Type BP. (For machine differential.)
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, breaker control, Type SB-1.
1 — Switch, ammeter transfer, Type SB-1.
1 — Switch, voltmeter (removable handle), Type SB-1.
1 — Switch, synchronizing (removable handle), Type SB-1.
1 — Switch, generator, Type SB-1.
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.)

DEVICE OPTIONS

3 — Current transformers, single secondary, :5 ratio, Type BP (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.

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 11

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 examples of POWER/VAC documentation are exhibited in the following pages.

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, 10,11	004A,B and 005A 006A and 007A,B	General Purpose Feeders
9	005B and 006B	Bus Tie Unit

GENERAL ELECTRIC COMPANY
SWITCHGEAR BUSINESS DEPARTMENT

VACUUM METALCLAD SWITCHGEAR SPECIFICATION

SPECIFICATIONS: VMC-123-45678
REVISION: 00
DATE: 06/29/76
CUSTOMER: ABC ELECTRIC COMPANY
PLANT/STATION: SUBSTATION Z-10
ENGINEER: John Doe

GENERAL DESCRIPTION

These specifications describe indoor, drawout, vacuum, metalclad switchgear, rated 13.8 kV, as proposed for operation on a solidly grounded system, rated 13,800 volts, line-to-line, three-phase, four-wire, 60 hertz.

APPLICABLE STANDARDS

The vacuum metalclad switchgear equipment covered by these specifications will be designed, tested, and assembled in accordance with the applicable standards of ANSI, IEEE, and NEMA.

DRAWINGS AND INSTRUCTION BOOKS

The following drawings of the switchgear will be furnished:

- Arrangement and floor plan drawings
- Elementary and wiring connection diagrams

Suitable instruction books will be shipped with the switchgear.

BUS RATING

The three-phase, insulated aluminum buses will have a continuous current rating of 2000 amperes.

POWER CIRCUIT BREAKERS

The power circuit breakers will be vacuum interrupter Type VB-13.8-500, 1200A, 125V dc stored energy closing, and 125V dc tripping.

CONTROL POWER

A 125V dc source for operation of electrical devices is not included.

CONSTRUCTION

GET-6451 describes the general construction and installation features of the metalclad switchgear, and gives

ARRANGEMENT AND DETAIL SPECIFICATION INDEX

The units, when viewed from the control panel side of the structure, will be arranged in accordance with the front view drawing submitted with this specification.

GENERAL ELECTRIC

SUMMARY OF SWITCHGEAR EQUIPMENT

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 AC	AB	PHASE OC RELAY	51/B	GE 12IFC53A1A
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 D04 SH D03

DATE 06/29/76 REV NO 00

Figure 11-1. Sample bill of material of the POWER/VAC metalclad switchgear equipment.

GENERAL ELECTRIC
SUMMARY OF SWITCHGEAR EQUIPMENT

DEVICE SUMMARY OF METALCLAD EQUIPMENT-VAC

LINE-UP NO. 01 UNIT NO. 003A

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	GE 50103742AHSE1DMC
373	001 CA		BKR CONTROL SW 3 STAGE	CS	16SB1B9X2
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 D06 SH D05
DATE 06/29/76 REV NO 00

Figure 11-2. Sample bill of material of the POWER/VAC metalclad switchgear equipment.

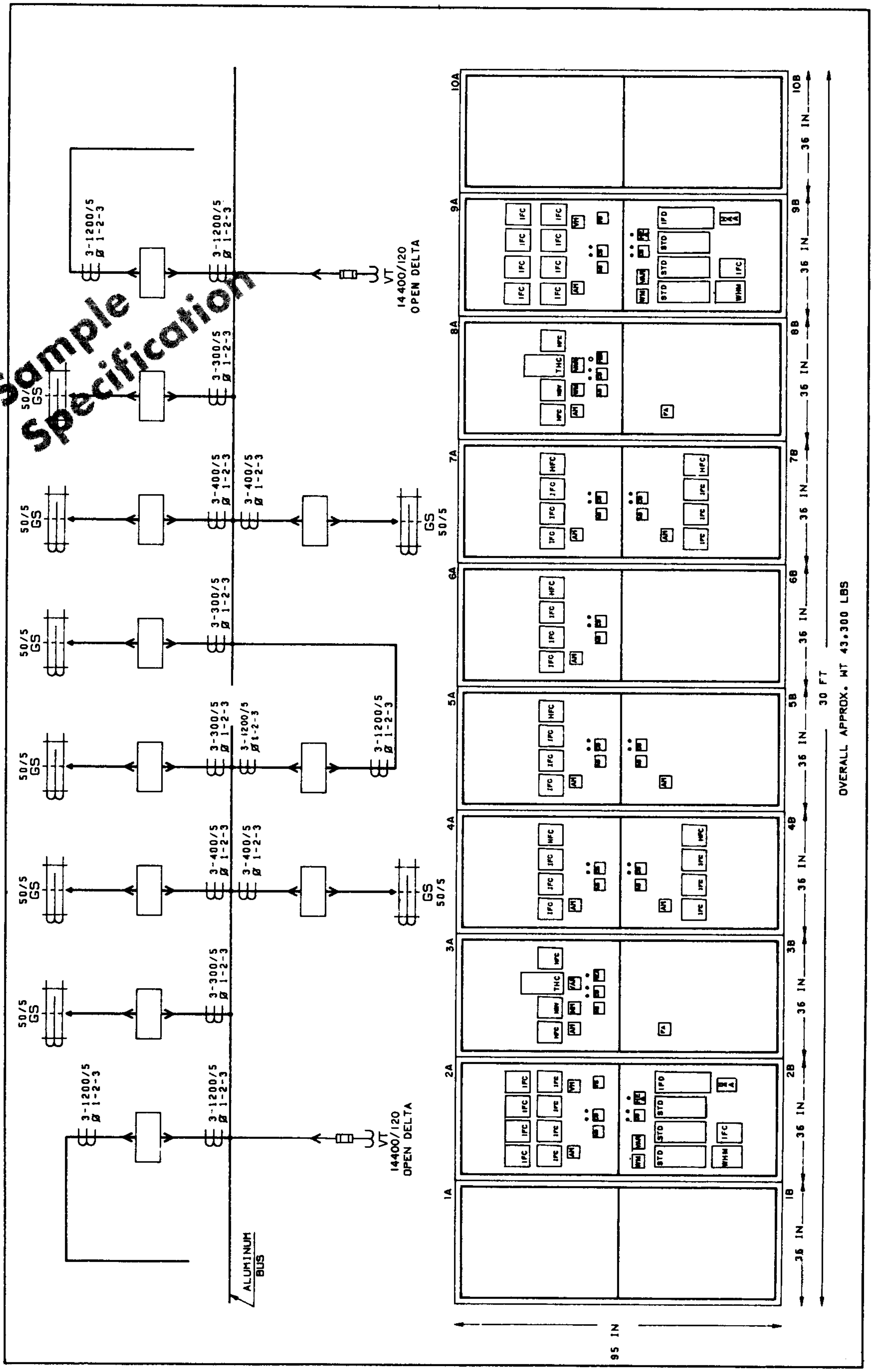


Figure 11-3. Sample front elevation and panel arrangement.

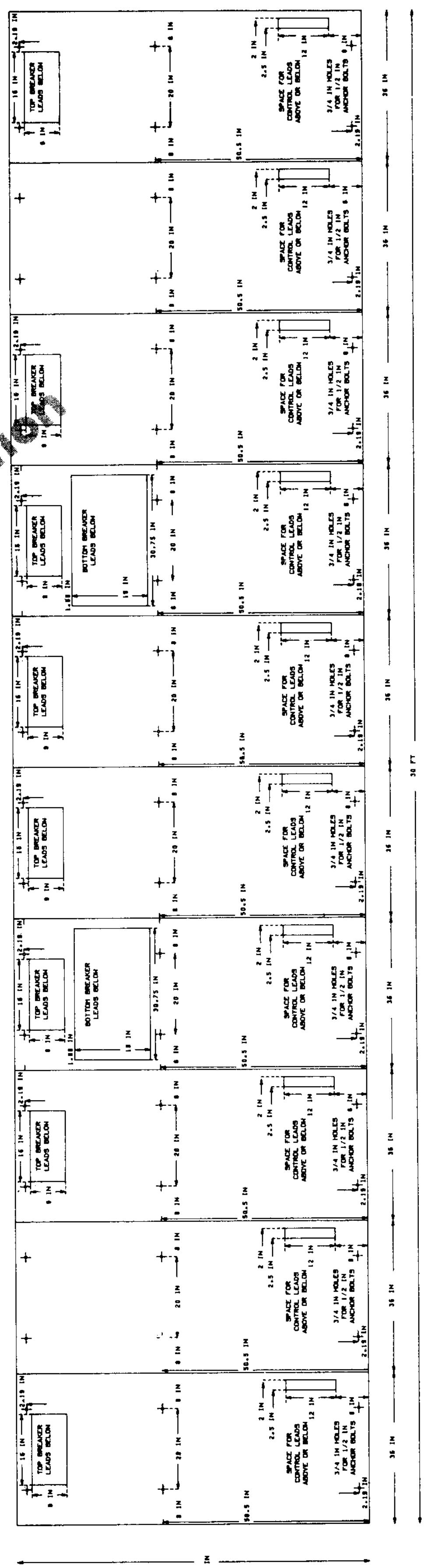


Figure 11-4. Sample floor plan.

Medium Voltage Switchgear • P.O. Box 488 • Burlington, IA 52601

GENERAL ELECTRIC

GET-6600D
5-84 (15M)