

SCOPE

- I 1.1 This practice covers low and medium voltage switchgear, control centers and bus duct, including relaying for motor branch circuits.
- I 1.2 **An asterisk (*)** indicates that a decision by the purchaser is required or that additional information is furnished by the purchaser.
- I * 1.3 The following are **not** established in this practice and must always be specified separately:
 - a. Type of switching device for medium voltage control center.
 - b. Type of circuit breaker for medium voltage switchgear.
 - c. Relaying for other than motor branch circuits.

SUMMARY OF ADDITIONAL STANDARDS AND PRACTICES

- I ↗ * 2.1 **Purchase and use of equipment covered by this practice** shall conform to nationally recognized codes and standards which are approved by Owner's Engineer and which are acceptable within the country where the equipment will be used. **Table 1** lists specifications and standards which shall be applied for equipment purchased to U.S.A. standards.

TABLE 1

STANDARDS	
IEEE Standards C37.20.1 Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear C37.20.2 Metal-Clad and Station-Type Cubicle Switchgear C37.23 Metal-Enclosed Bus and Calculating Losses in Isolated-Phase Bus ANSI / NEMA Standards ICS 1 Industrial Control and Systems General Requirements ICS 2 Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated Not More Than 2000 VAC or 750 VDC ICS 3 Industrial Control and Systems Factory Built Assemblies	
ANSI / NEMA Standards ICS 4 Industrial Control and Systems Terminal Blocks ICS 6 Industrial Control and Systems Enclosures NEMA Standards SG 2 High Voltage Fuses SG 4 AC High-Voltage Circuit Breakers SG 5 Power Switchgear Assemblies UL Standards UL 489 Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	

DOCUMENTATION

- M 3.1 **Manufacturer's equipment diagrams** shall be furnished. The diagrams shall include:
 - a. Plan and section drawings
 - b. Front and rear elevation drawings
 - c. Device internals and switch development drawings
 - d. Wiring diagrams, showing physical location of all equipment, terminal blocks in cubicles, and all remote wiring
 - e. Schematic diagrams (covering both a-c and d-c control and metering circuits) showing individual wire numbers, terminal blocks and all device terminal numbers
 - f. Three-line diagrams, showing all current transformers, potential transformers, metering and protective relaying connections, main bus and breaker configurations
 - g. Instruction books, including assembly instruction and details, parts lists, and all individual components
- M 3.2 **Vendor shall provide documentation showing equipment meets the approval requirements of the local authority.** Approval requirements may include labeling, listing, or other certification by a nationally-recognized testing organization acceptable to the local authority.

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DEFINITIONS

- I 4.1 **Low voltage (LV) switchgear or control center:** 0 to 1000 volts.
- I 4.2 **Medium voltage (MV) switchgear:** 1001 to 34,500 volts
- I 4.3 **MV control center:** 1001 to 7200 volts
- I 4.4 **Drawout** means to be removable and arranged with a mechanism for moving the switching and interrupting device physically between connected and disconnected positions and equipped with self-aligning and self-coupling power and control disconnecting devices. Removal of the device may be accomplished without the necessity of unbolting connections or mounting supports.
- I 4.5 **Plug-in** means to be arranged for moving the switching and interrupting device physically between connected and disconnected positions and equipped with self-aligning and self-coupling power supply side disconnecting devices. Removal of the device may be accomplished without the necessity of unbolting power supply connections or mounting supports.
- I 4.6 **Switching device** as referred to in this practice is defined as the device in a motor controller (or starter) which makes and breaks motor current such as a magnetic contactor or vacuum switch. Such device may also break fault current when so rated and applied for this purpose.
- I 4.7 **"Healthy trip" pilot light** is defined as a pilot light which supervises the condition of a circuit which trips a circuit breaker or other switching device either directly or through an auxiliary relay. When energized, the light shows that the circuit, including series connected trip coils of the switching device or auxiliary relay, is continuous and ready to function if its associated protective device operates.
- I 4.8 **Undervoltage protection**, as applied to motor control, causes the motor controller to trip either instantaneously or after a predetermined time interval upon a dip or loss of motor supply voltage. Upon restoration of normal supply voltage, **the controller does not reclose or only recloses if supply voltage is restored within a predetermined time interval.**
- I 4.9 **Fully insulated bus bars** means bars fully coated or covered with solid insulating material, or individual bars fully surrounded by solid insulating material, so as to safely isolate personnel from live bars, and to prevent the propagation of arcs between phases or between phase and ground. The use of solid insulation coatings, coverings, or barriers shall not result in reducing the air-insulation clearances between the bars, or between the bars and ground.

SWITCHGEAR AND CONTROL CENTER CONSTRUCTION PRACTICES

- O,R 5.1 **Switchgear** construction shall be used for LV drawout **air** circuit breakers, and for MV drawout circuit breakers (all types).
- O,R 5.2 **LV control center** construction shall be used for the following plug-in equipment:
 - a. Fused contactors
 - b. Fused switches
 - c. Fused switch combination starters
 - d. Molded case breakers
 - e. Molded case breaker combination starters
- O,R 5.3 **MV control center construction** shall be used for drawout controllers consisting of latched or magnetically held switching devices with or without fuses or fused isolating switches.
- R 5.4 **Aluminum shall not be used** for current carrying parts of switchgear and control centers without the specific approval of Owner's Engineer.
- O,M 5.5 **A wiring identification** system shall be provided for all secondary circuits to facilitate trouble-shooting and maintenance. System may consist of color coding, printed identification on the wires, securely mounted wire markers at each end of a circuit wire, or a combination of these methods. All wires shall be tagged at both ends per the destination method. If the manufacturer's standard method is individual wire name, then he shall add destination in parenthesis after wire name at both ends. All wire tags shall be clearly readable after installation.

SWITCHGEAR

- S * 6.1 **All low-voltage switchgear shall be metal-enclosed low-voltage power circuit-breaker switchgear type** as defined in ANSI C37.20.1. **All medium-voltage switchgear shall be metal-clad switchgear type** as defined in ANSI C37.20.2. If arc-resistant switchgear is not specified, but is an available option, manufacturer shall submit a proposal to supply arc-resistant switchgear. Arc-resistant designs shall be submitted for approval by Owner's Engineer. All switchgear shall have drawout power circuit breakers contained in individual grounded metal compartments. Mechanical interlocks shall be provided on all switchgear to prevent connecting the circuit breaker while closed, and to prevent the closing of the circuit breaker unless the power drawout disconnecting devices are fully coupled (connected) or separated by a safe distance.
- S * 6.2 **All switchgear shall have a ground bus** which shall extend throughout the length of the switchgear assembly. Bus shall be capable of carrying the maximum ground fault current without damage (to the bus or its supports) for the time allowed by the slowest responsive relay. Purchaser will specify available current and relay time.
- S 6.3 **All switchgear shall have fully insulated main and vertical bus bars and bus connections.** Other bus insulation, isolation, or segregation methods may be proposed for approval by Owner's Engineer. **Arc propagation barriers** shall be provided to prevent the following:
- Arcs occurring in incoming bus duct from flashing through or around the main incoming breaker to the main bus or bus taps off the main bus.
 - Arcs occurring on the load side of feeder breakers from flashing through or around the feeder breaker to the main bus or bus taps off the main bus.
 - Arcs occurring in one main bus from flashing through or around the bus tie to the other main bus in secondary-selective and spot networks.
 - Arcs occurring in one vertical section from flashing into adjacent vertical sections.
- O,M 6.4 **Each protective device** shall have **provisions** for testing and calibrating the device using an external power supply without disconnecting the permanent wiring. Each protective device shall also have provisions for test tripping its associated circuit breaker(s) by applying a test current or voltage, manually operating a test trip button or by manually operating the device.
- O,M 6.5 **The protective-device test provision** shall consist of built-in test plugs or switches, or separately mounted test terminal blocks. The test provisions shall permit the shorting of any current transformer circuit and for the selective disconnection of the protective device from current transformers, potential transformers, auxiliary power, and circuits controlled by the device.
- O,M 6.6 **All protective devices and devices initiating reacceleration, load shedding and transfer schemes,** such as overcurrent, undervoltage, underfrequency, and thermal overload relays, **shall have targets** or other devices to indicate when relay operates regardless of relay's mounting location. Targets or indicating devices shall be visible from the front of lineup without the need to open relay covers or compartment doors.
- R,S 6.7 **Current transformers** shall be mounted in the switchgear stationary part, not on the circuit breakers, and shall be located such that:
- Their current ratio and polarity markings can be readily identified after their primary connections have been made.
 - For transformers having secondary terminals, the terminals and shorting bars (if any) are accessible and the shorting bar position is visible after the primary connections have been made.
 - The current transformers can be isolated and removed safely while the main bus is energized.
- O,M 6.8 **Engraved nameplates** shall be provided per the following:
- *
- On the front of the enclosure of each circuit breaker, identifying its service by name or equipment number.
 - On the outside of drawers or doors of drawout potential transformers supplying motor undervoltage relays. Nameplates shall be engraved white on red background and shall read:

WARNING

OPENING DRAWER (OR DOOR) TRIPS MOTOR

- On the front of panels, identifying each relay, showing the device function number such as 51-1, 27M-2, 86T.
- On the front of panels, giving reset instruction for transformer protection lockout relays, 86T (when provided).



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SWITCHGEAR (Cont)

- e. On the front of panel, identifying remote trip pushbutton for source breaker (when provided).
- f. Adjacent to each protective and auxiliary relay which trips more than one circuit breaker. Nameplates shall be provided for both front-panel mounted relays and relays that are mounted inside compartments. Nameplates shall be engraved white on red background and shall read:

WARNING	
OPERATION OF THIS RELAY TRIPS MORE THAN ONE CIRCUIT	
BREAKER AS LISTED:	BREAKER _____
	BREAKER _____

- g. On the front of the enclosure of each circuit breaker located in the same vertical section as the bus tie breaker. Nameplate shall identify which bus the circuit breaker is connected to.

S **6.9 Battery ventilation.** Provisions shall be made to prevent accumulation of an explosive mixture inside outdoor switchgear of standard or protected aisle construction, when batteries are housed within the switchgear. Provisions shall be:

- a. **For standard outdoor construction**, ventilating louvers shall be provided in the battery enclosures.
- b. **For protected aisle outdoor construction**, an adequate rate of air changes shall be provided for the protected aisle enclosure, and battery enclosures, if used, shall have ventilating louvers.

Note: Determination of air changes required shall be based on the charge method and battery vendor's estimate of H₂ evolved. Credit may be taken for air changes resulting from enclosure leakage.

O **6.10 All circuit breaker trip coils and all lockout relay coils** shall be **supervised** by normally energized "healthy trip" pilot lights, using long-life lamps. It is preferred that the breaker trip coil light be the red "breaker closed" pilot light.

LOW VOLTAGE SWITCHGEAR

R **6.11 Electrically operated breakers** shall be used for transformer secondary and bus tie breakers in secondary selective and spot network systems. All other breakers shall be manually operated except where electrical operation is required to:

- a. Permit remote operation such as for motor control.
- b. Meet applicable codes, standards, or the breaker manufacturer's requirements for safe operation without instantaneous protective trip devices.
- c. Conform to manufacturer's standard design.

R **6.12 Relays are preferred** as the protective devices for incoming circuit breakers in spot network substations. Relays plus circuit breakers with direct acting trip devices (with shunt trip capability) may be used with the approval of Owner's Engineer.

R *** 6.13 If main bus neutral** is specified without specifying its current rating, the rating shall be 50% of the phase bus current rating.

R *** 6.14 Main bus neutrals**, when specified, shall extend the length of the switchgear, and shall be insulated from ground.

R **6.15 A means for isolating neutral busses** from the supply system source neutral, such as a bolted link, shall be provided.

S **6.16 Potential transformer fuses, control fuses, and control power switches** shall be accessible for replacement or operation. These devices shall be isolated from or located a safe distance away from uninsulated normally energized parts of the switchgear. Potential transformer fuses and the connection circuit between these fuses and the main bus shall be located and physically protected in such a way as to prevent accidental contact with energized parts during routine maintenance and inspection.

MEDIUM VOLTAGE SWITCHGEAR

R **6.17 All breakers** shall be electrically controlled, with either a stored energy (preferred) or a solenoid operating mechanism.

S **6.18 Potential transformers** and their fuses shall be mounted in a separate compartment of drawout construction or equivalent. The primary connection shall be disconnected before the transformer or its primary fuses become accessible. A similar arrangement shall be provided for the primary fuses of **control power transformers**.