GE Consumer & Industrial
Electrical Distribution

PCR®
Application Guide

imagination at work

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Note: All NEC table references are to the NFPA 70 NEC 2002 Edition

Design Overview

Powell Electrical Manufacturing Company began the Power Control Room (PCR®) enclosure concept more than 30 years ago as a superior alternative to the site constructed brick or block concrete structure. The enclosure is designed for bottom lift and utilizes a welded structural base with a welded plate steel floor. The wall and ceiling systems are formed sheet steel panels with an interlocking design. This approach allows for complete assembly and testing prior to shipment of the entire electrical system including; switchgear, motor control centers, bus duct, battery systems, cable tray, DCS, SCADA, UPS, PLC, Analyzers, relay panels, and interconnecting wires. A PCR is designed as a complete package system to facilitate the customers' exact needs. It may include such auxiliary equipment as heating, air conditioning, pressurization, communication, restrooms, personnel offices, fire and gas detection systems, battery systems, and other miscellaneous customer furnished or customer requested items.

Design Concept

Powell Power Control Rooms are designed and built to withstand the most challenging environments (125 MPH - Seismic Zone 4). The wall, roof and ceiling panels are interlocked with Powell's unique POW-R-LOK® design to maximize structural strength and to minimize weight. Exterior panels are constructed of galvanized steel and finished with an electrostatic polyester powdercoat finish to provide the most corrosion resistant product on the market.

Standard Design Materials					
Exterior Wall	Interior Liner	Roof	Ceiling	Floor Plate	Roof and Wall Insulation
18 gauge galvanized steel	16 gauge galvanized steel	18 gauge galvanized steel	16 gauge galvanized steel	1/4 inch steel plate	3 inch fiberglass (R11)

Live Loads			
Floor (lbs/ft^2)	Roof (lbs/ft^2)	Equipment (lbs/ft^2)	Wall (lbs/linear ft)
250	40	100	400

Industry Standards

The Powell PCR is designed to comply with the following:

- National Electrical Manufacturers Association (NEMA)
- Institute of Electrical and Electronic Engineers (IEEE)
- National Electric Code (NEC)
- American National Standards Institute, Inc. (ANSI)
- Occupational Safety and Health Administration (OSHA)
- International Building Code (IBC 2000)
- Underwriters Laboratories (UL)

Normal Service Conditions

Normal service temperature falls between -30ºC (-22ºF) and +40ºC (104ºF). Normal environmental conditions include winds less than 125 miles per hour and free from highly corrosive elements or explosive gas and dust. Optional or special construction can be provided as part of the PCR system design for specific environmental or site conditions including extreme temperatures, winds, and corrosive or explosive atmospheres.

Dimensions

The exterior dimensions of a PCR are determined by a combination of specific customer needs and shipping considerations. The minimum length and width is six feet. All dimensions are affected by the equipment installed within the enclosure and the mandated code clearances that are required. Interior height is typically between 9' and 14'. Powell recommends that you first determine the equipment to be installed within the PCR including the required enclosure services and auxiliary equipment, then add the requirements for planned future expansion of any installed equipment. The orientation of the installed equipment will be the ultimate determination of the required equipment enclosure dimensions. PCR enclosures too large to ship as one piece may be designed to split for shipment and reassembly at the jobsite. All single-story PCR enclosures are completely factory assembled for functional testing prior to shipping preparation. Similarly two-story designs are constructed with each story shipping independently.

Power Control Room vs. Jobsite Erected Structure

Engineering and Design	
Powell Power Control Room (PCR®)	Jobsite Erected Structure
Powell performs the majority of engineering and design.	Customer must engineer and design complete electrical system and then engineer and design the total packaged system.
Powell coordinates the interfaces and interconnection of all systems. Completed package functions properly before leaving the factory.	Customer must engineer and manage the coordination issues, resolving conflicts in the field.
PCR is purchased from one source, tested and complete with all electrical, electronic, instrumentation, and control systems including all interfaces and interconnection.	Jobsite erected structures require numerous specifications and numerous vendors or contractors. The result is split responsibility, increased cost, and longer project time.
PCR can be designed for ease of expansion, both in width and length.	Jobsite erected structures must be coordinated by architectural and mechanical personnel resulting in time consuming approvals and longer construction time.
PCR is constructed utilizing patented Pow-R-LOK® panels with hinged rear access doors for switchgear and motor control.	Jobsite erected structures have, on the average, 20% larger footprint due to the additional space required for rear aisle space in the rear of switchgear and motor control.
PCR is factory fabricated and tested. Last minute changes can be incorporated prior to shipment under factory conditions allowing for testing and inclusion of changes in job record drawings. A single drawing package documents the assembly in a common format.	The end user or a third party engineering firm is required to develop interconnection drawings to include various equipment from a variety of manufacturers. Last minute changes may involve multiple vendors and add complexity to coordination. Record drawings must be edited and maintained by the customer.
PCR is completely tested prior to shipment by inspection personnel that are completely familiar with construction techniques. Customer functional inspection and witness testing is readily available.	Jobsite erected structures must be tested by personnel that are unfamiliar with at least some of the equipment included in the system. Diagnostic efforts are more complicated due to multiple vendors.
PCR is portable and may be relocated at minimal cost.	Jobsite erected structures are permanently located and cannot be moved.

Construction	
Powell Power Control Room (PCR)	Jobsite Erected Structure
PCR requires a minimum foundation typically piers or curbs.	Jobsite erected structures require costly concrete slabs usually with large bell-bottoms and footings.
PCR uses either metal base as a ground or a separate copper ground system depending on customer requirements. All equipment is grounded prior to shipment and the base is designed with an external connection for attachment to the ground grid.	Grounding systems in jobsite erected structures must be pre-planned and built into the concrete foundation, necessitating future expansion be made with initial construction.
PCR is easily adapted to overhead or underground conduit systems. Cable tray arrangements are available for side or bottom entry and bulkheads can be installed for present and future needs.	Jobsite erected structures with a concrete slab foundation require careful planning with regard to conduit location and entry. Future changes are costly.
PCR is supplied from a single source under highly efficient factory conditions.	Jobsite erected structures may require many different crafts including carpenters, iron workers, cement laborers, brick layers, electricians, crane operators, and millwrights. Each trade necessitates a foreman and various helpers.
PCR design minimizes jobsite activity in and around the substation which reduces total project schedule.	Jobsite erected structures require multiple contractors working in and around the substation, which requires project coordination and longer installation schedules.

Electrical Interconnection	
Powell Power Control Room (PCR)	Jobsite Erected Structure
PCR arrives with all equipment interconnected and tested. Even interconnect wiring across shipping splits is easily re-connected.	Jobsite erected structures require the customers to coordinate all internal interconnection. Extended testing time must be included in the schedule and often requires a third party to complete.
PCR includes detail electrical engineering interface, full wiring and schematic drawings, and detailed inspection reports.	Jobsite erected structures require customer preparation and maintain accurate interface, wiring, and schematic drawings.

Receiving, Handling, and Storage	
Powell Power Control Room (PCR)	Jobsite Erected Structure
PCR arrives at the jobsite on a predetermined schedule. Each PCR shipping section is designed for single point lift.	Jobsite erected structures receive numerous shipments made at different times and from different suppliers. This involves costly lifting charges, double handling costs, expensive warehousing charges, added insurance costs, special protection during long storage periods, damaged or lost equipment, and lost time due to inclement weather.

Scheduling	
Powell Power Control Room (PCR)	Jobsite Erected Structure
PCR construction schedule drives the equipment construction schedule.	Jobsite erected structure is independent of various manufacturer schedules.
PCR and equipment arrive together and fully functional.	Jobsite erected structures must be finalized after equipment arrival at the jobsite to facilitate the moving of equipment into place. This often results in delays of start-up and commissioning.
PCR includes project coordination of all related equipment, which may include customer furnished equipment.	Jobsite erected structures require customer to coordinate all equipment from suppliers and interpret multiple drawing package formats.
PCR arrives on schedule, with one set of related drawings, completely tested and with a single point warranty.	Jobsite erected structures require many additional hours during start-up resolving last minute details. Different warranties from different manufacturers may be in conflict.

Financial	
Powell Power Control Room (PCR)	Jobsite Erected Structure
PCR carries the same tax designation as weatherproof or shelter-form equipment.	Jobsite erected structures carry the same tax designation as any other real estate improvement. Regulatory permits and required progress inspections add to total cost.
PCR electrical equipment enclosure is typically depreciated over 9 to 16 years.	Jobsite erected structures are typically depreciated over 30 to 45 years.

Base and Floor Standard Construction

Powell uses a base design with channels which allows either permanent or portable installations. All structural members are sized by design structural calculations and reinforced to meet or exceed specified static and dynamic loads. Structural members are located to coordinate with the enclosed equipment to allow both proper support and maximum access for cable penetrations from below. Each base has at a minimum, four lifting lugs. A ¼" steel plate floor is stitch welded to the structural base assembly. Cutouts with surface-mounted aluminum covers for bottom access can be provided. Maximum allowed designed defection under lift will not exceed L/240 (base length divided by 240). Floor live loading is 250 pounds per square foot. Floor surface is finished with a non-skid enamel.

Base and Floor Optional Construction

- Bottom Mounted Cutout Covers – Floor cutout covers mounted from below to facilitate access from beneath the PCR.
- Flush Mounted Cutout Covers - Floor cutouts covered with aluminum covers flush-mounted in the floor.
- Increased Floor Live Loading - Floor loadings greater than 250 pounds per square foot can be accommodated.

- Certified Structural Calculations - Calculations of all structural members certified by a registered professional engineer and performed on your individual geometry.
- Bottom Entry Bus Duct - Bus duct flange mounted in the base.
- Belly Pan Cover - Provides a metal covering to protect the bottom of the base assembly.
- Computer Floor - Raised floor in all or part of a PCR® to facilitate data cabling below.
- Glastic Cutout Covers - Floor cutout covers constructed of fiberglass reinforced polyester instead of aluminum.
- Galvanized Steel Cutout Covers - Floor cutout covers constructed of galvanized steel instead of aluminum.
- Stainless Steel Cutout Covers - Floor cutout covers constructed of stainless steel instead of aluminum.

Base Coating Standards

PCR Bases are prepared and coated with the following process in order to maximize the protection against potential corrosion.

- The welded base assembly is grit blasted using GS80 steel grit to a profile pattern of 2 to 2.5 mils. This complies with Commercial Blast Standard SSPC-6 as published by AISC.
- After blast, an undercoat is applied to the entire base using an industrial grade, high solid, and high-build epoxy. The undercoat is applied to a minimum thickness of 4 mils.
- The structural elements of the base including all channels and angles are caulked to seal gaps and spaces that might allow moisture to collect.
- A second application of industrial grade, high solid, and high-build epoxy is applied to the bottom of the base assembly. This application is black in color and is applied to a minimum thickness of 4 mils.
- The sides of the base are finished using a black polyurethane paint with a minimum thickness of 2 mils.

Total dry film thickness after coating:
- For the floor is 4 mils minimum.
- For the sides of the base are 6 mils minimum.
- For the bottom of the base is 8 mils minimum.

Base Coating Options

- Foam Insulation - For added thermal insulation a polyurethane foam may be applied following the standard base coating procedure. Foam is applied using a spray process with the base assembly upside-down. The thickness of the applied foam is dependent on the thermal rating requirement. After the foam application all exposed areas on the bottom of the base are coated using PowlCoat® to provide physical protection to the foam material.

PCR Base Insulation R Values	
Insulation Thickness (inches)	R Value
1	6.75
2	11
3	20
6	30

- Galvanized - The entire base assembly may be galvanized for increased corrosion resistance.
- Carboline Paint System - Special three part finish system for increased corrosion resistance.

PowlCoat Base Undercoating

PowlCoat is a single component, water based, 100% acrylic latex coating with outstanding fire resistance. It is intended for applications over various flexible and rigid surfaces to reduce heat transfer and fire hazard. PowlCoat provides a protective membrane that will last for years and remains flexible even under adverse conditions. This coating works as a breather to prevent moisture build up.

- Features
  - o Provides long-term fire resistance
  - o Utilizes Rohm and Hass acrylic technology
  - o Material flexibility from the polymer for long-term crack and impact resistance
  - o Excellent adhesion characteristics
  - o Superior mold and mildew resistance
  - o Excellent ultra violet resistance and color stability
  - o Easily applied single component
  - o Can be applied in thick coats without cracking
  - o Environmentally friendly; water based, asbestos, lead, and mercury free

- Coating Thickness
  PowlCoat is extremely fire resistant. Its ability to protect various substrates is proportional to the coating thickness. The required thickness for each application will be determined during engineering.

- Typical Properties: at 75°F
  - o Color - Gray
  - o Tensile Strength (ASTM D412 after 50hrs W.O.M.) 188 lbs/in^2
  - o Elongation (ASTM D412 after 50hrs W.O.M.) 169%
  - o Solids by Weight - 73 +/- 2%
  - o Solids by Volume - 60 +/- 2%
  - o Flame Spread (ASTM E84) - 5
  - o Smoke Developed (ASTM E84) - 0
  - o Density - 12.1 lb/gal
  - o Temperature Limits - -30°F to +200°F

- Limitations and Precautions
  - o PowlCoat is not intended for use as a vapor barrier.

Lifting Lugs

A minimum of four (4), removable lifting lugs per shipping section are supplied as part of every PCR®. The size and number of lifting lugs is dependent on the base beam size and total weight of each liftable section. Lifting lug locations, center of gravity, and lifting capacity are supplied with each PCR section.

Wall System Standard Construction

The wall system consists of an interlocking exterior wall panel and an interior wall liner. The combined system provides the required mechanical strength. Exterior wall panels are generally 16 inches wide and attached to one another by the interlocking construction and thread forming screws. The wall system is anchored in a channel on the base assembly. The outside dimension of the wall is 3" and interior dimension is approximately 2 7/8". The interior space is used for wall insulation (see Wall and Ceiling Insulation Standards on page 8). The wind loading for the completely installed wall system is 125 miles per hour (mph). Cutouts in the wall system are made to facilitate entry of cable, bus duct, bulkhead fittings, or HVAC systems as required. Additional interior support may be added to specific wall sections to assure the integrity of heavy interior wall mounted equipment. Wall material is at a minimum 18 gauge galvanized steel for the exterior wall panels and at a minimum 16 gauge galvanized steel for the interior liners. Wall material gauge may be increased to accommodate the 125 mph wind loading on an extra height PCR or upon customer request.

Wall System Optional Construction

- Increased Material Gauge - (11, 12, 14, and 16 gauge available)
- Aluminum Wall System
- Stainless Steel Wall System
- Increased Wind Loading
- Increased Wall Thickness
- Fire Rated Walls

Roof and Ceiling Standard Construction

The roof and ceiling system consist of separate interlocking panels that run across the width of the PCR. The interlocking ridges of the roof system help prevent collection of water and aid in runoff. A trim assembly is installed along the entire perimeter. Roof panels are generally 16" wide and constructed using 18 gauge galvanized steel at a minimum. Material gauge may increase with an increased width PCR. Roof is sloped 3" across the width. Roof and ceiling system is one piece across any shipping section to avoid potential water leakage problems. Standard ceiling load is 100lbs/linear ft supported at 3 foot intervals which is adequate to support conduit runs and interior lighting.

Roof and Ceiling Optional Construction

- Aluminum Roof
- Aluminum Ceiling System
- Stainless Steel Roof
- Stainless Steel Ceiling System
- Increased Live Load
- Peaked Roof - May be utilized on any PCR that contains a shipping split. Not available on single section designs.
- Roof Bushings - May be utilized for incoming overhead high voltage conductors.

Wall and Ceiling Insulation Standards

Powell's standard PCR wall insulation is fiberglass with no backing and a rating of R11 and meets the ASTM E84 standard.

Wall and Ceiling Insulation Options

- Thermax - Powell offers Thermax insulation as an option when specified by the customer. Typical value is R19.

Enclosure Service Standards

Each PCR shall have a power panel for utility services. If the utility service is not provided from an external source, a transformer shall be provided capable of providing needed power for lighting and environmental equipment. The interconnection of all installed equipment as defined in drawings shall be the responsibility of Powell Electrical Manufacturing Company unless otherwise specified or agreed upon. All of the equipment shall be functionally tested after installation in accordance with specifications. Panelboards are typically surface-mounted directly to the interior PCR wall. Installation is designed to comply with NEC Article 404.8 "Accessibility and Grouping", NEC Article 110.26 "Spaces About Electrical Equipment", and NEC Articles 408.13 through 408.36.

Enclosure Service Options

PCR Enclosure Service panelboards may be specified as:

For 120/240vAC (1 phase, 3 wire) service:

- Panelboards may be 18, 24, 30, 36, or 42 circuit
- NEMA 1 enclosure
- Surface-mounted
- UL® Label
- Bolt-on branch circuit breakers 15A - 100A
- Fully rated to 10kAIC or 22kAIC
- Main circuit breakers available 60A to 800A
- Main Lugs available 125A to 800A
- Sub-feed circuit breakers 225A maximum (up to 6 poles)
- Bottom feed (preferred for applications including a building service transformer) or top feed

Main Circuit Breaker Sizing When Utilizing Transformer (1 Phase)	
Transformer Size (120/240VAC) (kVA)	Main Circuit Breaker Size (Amperes)
10	60
15	80
25	150
37.5	200
50	300

For 120/208vAC (3 phase, 4 wire) service:

- Panelboards may be 18, 24, 30, 36, or 42 circuit
- NEMA 1 enclosure
- Surface-mounted
- UL® Label
- Bolt-on branch circuit breakers 15A - 100A
- Fully rated to 10kAIC or 22kAIC
- Main circuit breakers available 60A to 800A
- Main Lugs available 125A to 800A
- Sub-feed circuit breakers 225A maximum (up to 6 poles)
- Bottom feed (preferred for applications including a building service transformer) or top feed

Main Circuit Breaker Sizing When Utilizing Transformer (3 Phase)	
Transformer Size (120/208VAC) (kVA)	Main Circuit Breaker Size (Amperes)
15	60
30	100
45	150
75	225

For 480vAC (3 phase, 3 wire) service:

- Panelboards may be 18, 24, 30, 36, or 42 circuit
- NEMA 1 enclosure
- UL Label
- Bolt-on branch circuit breakers 15A - 1200A
- Fully rated to 65kAIC
- Main circuit breakers available 150A to 1200A
- Main Lugs available 150A to 1200A
- Fusible switch available 200A to 1200A
- Sub-feed circuit breakers 225A maximum (up to 3 poles)
- Transient Voltage Surge Suppressor available
- Bottom feed (preferred for applications including a building service transformer) or top feed

For 277/480vAC (3 phase, 4 wire) service:

- Panelboards may be 18, 24, 30, 36, or 42 circuit
- NEMA 1 enclosure
- UL Label
- Bolt-on branch circuit breakers 15A - 1200A
- Fully rated to 65kAIC
- Main circuit breakers available 150A to 1200A
- Main Lugs available 150A to 1200A
- Fusible switch available 200A to 1200A
- Sub-feed circuit breakers 225A maximum (up to 3 poles)
- Transient Voltage Surge Suppressor available
- Bottom feed (preferred for applications including a building service transformer) or top feed

For 250vDC (2 wire) service:

- Panelboards may be 18, 24, 30, 36, or 42 circuit
- NEMA 1 enclosure
- UL Label
- Bolt-on branch circuit breakers 15A - 100A
- Fully rated to 10kAIC
- Main circuit breakers available 100A to 800A
- Main Lugs available 125A to 800A
- Sub-feed circuit breakers 150A maximum (up to 18 poles)

Lighting System Standards

- Internal - Dual tube fluorescent lights are ceiling mounted with an on/off switch provided at each door. Fixture height is determined based upon the number and size of cable tray installations within the PCR®. Fluorescent tubes are anchored in place for shipment using nylon wire ties.
- External - Weatherproof high pressure sodium 70 Watt lights are externally mounted at each door.

Lighting System Options

- Wire Guard - Internal fluorescent lighting fixtures provided with a wire guard for tube protection.
- Plastic Guard - Internal fluorescent lighting fixtures provided with a plastic guard and diffuser for tube protection.
- Plastic Tube Sleeve - Fluorescent tubes provided with a plastic sleeve that prevents glass falling in the event of broken tubes.
- Emergency Lights - Battery powered emergency lights to provide internal lighting in the event of power failure. Standard is lead calcium battery, but may also be supplied with nickel cadmium battery.
- Hazardous Area Emergency Light - Fixture for use in Class 1, Division 2, Group A through D areas. Powered by 120vAC only.
- Exit Sign - Used to mark door for egress. Available as non electric visual only or battery power lighted sign with nickel cadmium battery.
- Emergency Light/Exit Sign Combination Unit - Single fixture with emergency light and exit sign. Battery powered using either lead calcium or nickel cadmium batteries.
- Photocell for Exterior Light - Provides automatic operation of external lights.
- 100 Watt Exterior Light - Brighter light for greater visibility.
- Hazardous Area Exterior Lights - Fixture for use in Class 1, Division 2, Group A through D areas.
- Weatherproof Receptacle - Exterior mounted weatherproof receptacle for maintenance use.

Personnel and Equipment Door Standards

- Hollow core construction
- Insulation rating of R11
- Exterior stainless steel thumb-actuated entry handle
- Rim cylinder lock
- Aluminum interior panic exit device
- Stainless steel 4" ball bearing hinges
- Magnetic gasketed assembly for weather resistance and A/C
- Door sweep and threshold
- (1) Personnel door 3' x 7'
- (1) Equipment door 4' x 8'
- Double panel wire mesh safety glass window (12" x 12" x 1/4")
- Door closers with stop

Personnel and Equipment Door Options

- Hollow core construction using stainless steel
- Exterior lever entry handle
- Stainless steel interior panic device
- Double panel wire mesh safety glass window (24" x 30" x 1/4")
- Double equipment door
  - 6' x 7' with one 3' door inactive (non panic)
  - 6' x 8' with one 3' door inactive (non panic)
- Removable transom
- Rain Canopy

Equipment Rear Access Doors

- Equipment rear access doors may be provided when a piece of equipment is mounted flush against a PCR® wall and there is a need for rear access. Rear access may be required for installation or maintenance reasons.
- It is preferred that the PCR roof slope away from the rear access door. This will keep water drainage from personnel working on the equipment through the rear access doors.
- The maximum width for a rear access door on a special piece of equipment is 48". If the equipment is between 48 and 96 inches wide, a double door will be provided. A double door is comprised of two equal width doors. Equipment wider than 96" will be provided with a series of evenly sized doors.
- Split rear access doors may be provided as an option, but should only be used when the rear cell of the equipment is divided by a metal barrier (e.g., metal-clad switchgear with a two-high feeder breaker).
- Rear access doors use a three-point latching system and include gaskets to make the door weather-resistant. The door handle is a polyester material that is both corrosion and ultraviolet resistant. Rear door handles have provisions for a padlock as standard.
- Louvers are used when equipment requires rear ventilation. The louvers provided are rainproof. Several things must be considered when determining the application of rear access doors with rear louvers.
  - For PowlVac® switchgear no louvers are provided on rear access doors for 1200A or 2000A breaker cubicles. Louvers are to be provided for 3000A and 4000A cubicles only if the switchgear is to be UL® labeled or special applications.
  - For PowlVac-AR® arc resistant switchgear no rear louvers are required.
  - For low voltage switchgear louvers are provided for all breakers sizes on the rear access doors located at the top and bottom of the door.
  - An optional design for low voltage switchgear that will eliminate the need for louvers in the rear access doors is available.
  - For medium voltage MCC equipment no louvers are required for rear access doors.
  - For load interrupter switchgear (switch and fuse) no louvers are required for rear access doors.
  - Environmental concerns should take priority over other considerations when determining ventilation louvers in rear access doors. In high snow areas louvers are not recommended. Should the snow stack up above the louver, it will melt and water will leak into the PCR. In high dust areas louvers are not recommended. Dust and sand can get inside the switchgear through these openings and create potential tracking problems.
  - In no case should louvers be used on PCR designs that include pressurizing systems. Pressurizing requires a minimizing of air leakage.
- Filters may be provided along with louvers on all rear access doors as an option. Filters may be provided with aluminum or stainless steel frames.

Ground System

Every lighting panel, HVAC unit, panelboard, switchgear and MCC and their associated loads will be supplied with an equipment grounding conductor. The conductor is sized by the allowable current-carrying capability by a series of rules in the NEC.

The most common equipment grounding conductors are:

- Copper conductors (see NEC Table 250.122 for ampacity on page 11)
- Cable Tray (if listed for grounding) (see NEC Table 392.7(B) for ampacity on page 13)
- Rigid galvanized steel conduit
- Electrical metallic tubing
- Liquid-tight flex
- Greenfield flex under certain conditions
- Cable armor of armor clad and metal-clad cables
- Metallic sheaths of shielded cables

In accordance with the NEC Section 250.68(B), the metal frame of a PCR can serve as an equal potential plane, and thus a part of the grounding electrode system. To insure that it is effectively grounded, Powell supplies a minimum of two ground pads bolted to the steel base for connection to the customer's ground grid. These ground pads are located at the opposite corners of the PCR. A drawing note is included with instruction for these two points to be attached to the ground grid to form a single grounding electrode system consistent with NEC Section 250.52.

The ground bus of all the equipment (switchgear and motor control) in the PCR® will be bonded to the enclosure steel by an equipment grounding conductor. This is accomplished through a 1/4" x 2" copper bus for switchgear and motor control centers.

The ground bus for all other equipment installed in the PCR shall be grounded with an equipment grounding conductor, sized per NEC Table 250.122 (page 11).

The neutrals of any separately derived systems such as 480-208/120V or 480-120/240V transformer secondaries will be grounded to the PCR steel as near as possible to its transformer.

Grounding Design Options

A copper bus can be installed around the entire interior perimeter of the Power Control Room. This internal ground will connect all individual equipment ground bus and tie to the exterior PCR ground pads for connection to the ground grid.

- Cable Tray (if listed for grounding) (see NEC Table 392.7(B) for ampacity on page 13)
- Rigid galvanized steel conduit
- Electrical metallic tubing
- Liquid-tight flex
- Greenfield flex under certain conditions
- Cable armor of armor clad and metal-clad cables
- Metallic sheaths of shielded cables

NEC Table 250.122

Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment		
Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum*
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	800
5000	700	1200
6000	800	1200

Notes:

Where necessary to comply with NEC Section 250.4(A)(5) or 250.4(B)(4), the equipment grounding conductor shall be sized larger than given in this table.

* See installation restrictions in NEC Section 250.120

Environmental System Standards

- Heating - Powell offers a variety of heating methods: electric wall-type, space heaters, or combination heating/cooling units. Thermostats are a standard. For HVAC (Heating, Ventilation and Air Conditioning) units, the heater size is usually specified as 8kw or 9kw.
- Cooling - Wall mounted cooling units are standard. Air conditioning is sized based upon a variety of factors, including: installed environment; heat gain from mounted equipment; insulation level of floor, wall and roof; as well as the desired operating temperature. Exterior clear space is required around wall mounted units. The exact requirements depend on the air conditioning equipment selected. Standard operating voltage is three phase 480vAC, although other voltages can be accomodated.
- Ventilation - Powell provides fixed or variable airflow, wall mounted electrical motor-driven ventilation equipment. On request, filtered ventilation units or optional automatic, thermostatically-controlled ventilation fans can be supplied.

Environmental System Options

- Central Cooling - Separate condenser and air handling systems.
- Chilled Water Cooling - For applications that have chilled water available a cooling system can be designed to utilize that resource.
- Roof Mounted Heating/Cooling Units - Larger systems or for applications where mounting space is not available.
- Pad Mounted Heating/Cooling Units - For very large systems a separate unit designed and constructed on its own metal base assembly for mounting adjacent to the PCR®.
- Explosion Proof Units - For installation and operation in Class I, Group D, Division 2 areas.
- Pressurization Systems - Electrically motor-driven and filtered units with single or double blowers. Capable of 1/2" of water static pressure and typically supplied with manometers and alarm contacts. Pressurizing units may be combined with existing filtered, fresh-air supply ducts. They require a separate power source which may come from the main power line ahead of any service disconnect to the PCR. The stacks may have bird screen and are free standing from grade. May be designed to meet NFPA 496.
- Filtering Systems - Designed to remove air contaminants that may be harmful to equipment installed within the PCR enclosure such as SO_2 and H_2S. System may be combined with other environmental systems. Details on concentration levels are required for proper sizing and cost determination.

HVAC Selection Guidelines

Wall Mounted Units	
Pros	Cons
Allows for multiple units, which may aid in redundancy.	Exterior clearance required for proper operation.
Loss of any one unit results only in a partial loss of cooling capacity.	Units must be removed from length-side walls and shipped separately from the PCR.
Easy access for maintenance	Multiple units increases the likelihood of individual unit failure or repair.
No duct work required, but may be added if required.	
Typically the lowest cost solution.	
Less air leakage than air duct penetrations.	
Can include filtration/purge units for classified locations.	
May be pre-wired to power source, control systems, and shutdown systems which expedites field re-assembly. No additional field contractor work necessary.	
HVAC units may be replaced by site personnel should a unit fail. HVAC vendor service personnel are not required.	
HVAC units are standard construction and readily available with very short lead-time.	
Individual units are inexpensive which may facilitate keeping a spare unit in the field.	
May be installed on walls across from mounted equipment and utilize space not allowable for other equipment mounting per the NEC.	

Pad Mounted Units	
Pros	Cons
Allows a single system for complex PCR or multi-story installations.	Requires separate foundation for mounting.
Easy access for maintenance.	Duct work system required to connect HVAC system to the PCR. Interior duct must be considered when running cable tray, wire way and bus duct.
Best suited if utilizing a complex filtration or purge system.	Requires customer to field install unit, install ductwork to PCR, field install power wiring from unit to power source, and field install any control wiring. Exterior conduits and cable tray may be required.
	Custom design requires vendor drawings prior to proceeding with other design aspects of the PCR including duct layout, wall cutouts, power connections, and cable tray layout.
	HVAC vendor must install duct inside PCR.
	Typically the most costly solution.

Roof Mounted Units	
Pros	Cons
Does not take up wall space or additional footprint outside PCR footprint.	Air flow from above may be restricted by cables and cable tray.
	Roof penetration may be a potential source of moisture leakage into the PCR.
	Roof must include additional supports requiring structural calculations.
	Access to unit is limited. OSHA requirements for access means, ladder, and handrails may be required.
	Unit is removed for shipment in all cases.
	Overhead crane necessary for re-assembly.

Cable Tray and Interconnect Wiring

Interconnection of the installed equipment is necessary to provide a fully functional Power Control Room. These connections include those between Powell supplied equipment and those between Powell and customer supplied equipment. For customer furnished material it is necessary that we receive connection requirements prior to the engineering design phase of the project.

The interconnect wiring is typically terminated at each end and routed overhead in cable tray suspended from the ceiling. Cable tray is sized per NEC fill requirements. When the cable tray is installed, the ceiling must be at least 12 gauge to allow for increased ceiling load requirements. Cable tray may be coordinated and sized per customer specifications so as to isolate low and high voltage circuits. This can be accomplished with separate trays or a common tray with an insulated divider. As a standard cable tray and associated supports are designed to carry a load of 100 lbs/linear foot.

NEC Table 392.7(B)

Metal Area Requirements for Cable Trays Used as Equipment Grounding Conductor				
Maximum Fuse Ampere Rating, Circuit Breaker Ampere Trip Setting, or Circuit Breaker Protective Relay Ampere Trip Setting for Ground-Fault Protection of Any Cable Circuit in the Cable Tray System	Minimum Cross-Sectional Area of Metal (a)			
	Steel Cable Trays		Aluminum Cable Trays	
	mm²	in²	mm²	in²
60	129	0.20	129	0.20
100	258	0.40	129	0.20
200	451.5	0.70	129	0.20
400	645	1.00	258	0.40
600	967.5	1.50 (b)	258	0.40
1000	---	---	387	0.60
1200	---	---	645	1.00
1600	---	---	967.5	1.50
2000	---	---	1290	2.00 (b)

Notes:

a) Total cross-sectional area of both side rails for ladder or trough cable trays; or the minimum cross-sectional area of metal in channel cable trays or cable trays of one-piece construction.

b) Steel cable trays shall not be used as equipment grounding conductors for circuits with ground-fault protection above 600 amperes. Aluminum cable trays shall not be used as equipment grounding conductors for circuits with ground-fault protection above 2000 amperes.

NEC Table 392.10(A)

Maximum Allowable Fill Area for Single-Conductor Cables in Ladder or Ventilated Trough Cable Trays					
Inside Width of Cable Tray		Column 1 Applicable for 392.10 (A) (2) Only		Column 2 Applicable for 392.10 (A) (3) Only	
mm	in	mm²	in²	mm²	in²
150	6	4200	6.5	4200-(1.1 Sd) (b)	6.5-(1.1 Sd) (b)
225	9	6100	9.5	6100-(1.1 Sd)	9.5-(1.1 Sd)
300	12	8400	13.0	8400-(1.1 Sd)	13.0-(1.1 Sd)
450	18	12600	19.5	12600-(1.1 Sd)	19.5-(1.1 Sd)
600	24	16800	26.0	16800-(1.1 Sd)	26.0-(1.1 Sd)
750	30	21000	32.5	21000-(1.1 Sd)	32.5-(1.1 Sd)
900	36	25200	39.0	25200-(1.1 Sd)	39.0-(1.1 Sd)

Notes:

a) The maximum allowable fill areas in Column 2 shall be computed. For example, the maximum allowable fill, in mm² for 150 mm wide cable tray in Column 2 shall be 4192.5 minus (1.1 multiplied by Sd) [the maximum allowable fill, in square inches, for a 6-in. wide cable tray in Column 2 shall be 6.5 minus (1.1 multiplied by Sd)].

b) The term Sd in Column 2 is equal to the sum of the diameters, in mm, of all cables 507 mm² (in inches, of all 1000 kcmil) larger single conductor cables in the same ladder or ventilated trough cable tray with small cables.

Interconnect Wiring Options

Either wireways or conduit may be used to route interconnect control wiring within the PCR. Customer specific requests can be addressed.

Minimum Clearance for Installed Equipment

NEC Table 110.26(A)(1)

Working Spaces			
Nominal Voltage to Ground	Minimum Clearance Distance		
	Condition 1	Condition 2	Condition 3
0 - 150V	900mm (3ft)	900mm (3ft)	900mm(3ft)
151 - 600V	900mm (3ft)	1m (3.5ft)	1.2m (4ft)

Notes: Where the conditions are as follows:

Condition 1 - Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at not over 300 volts to ground shall not be considered live parts.

Condition 2 - Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls shall be considered as grounded.

Condition 3 - Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

NEC Table 110.34(A)

Minimum Depth of Clear Working Space at Electrical Equipment			
Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
601 - 2500V	900mm (3ft)	1.2m (4ft)	1.5m (5ft)
2501 - 9000V	1.2m (4ft)	1.5m (5ft)	1.8m (6ft)
9001 - 25000V	1.5m (5ft)	1.8m (6ft)	2.8m (9ft)
25001V - 75kV	1.8m (6ft)	2.5m (8ft)	3.0m (10ft)
Above 75kV	2.5m (8ft)	3.0m (10ft)	3.7m (12ft)

Notes: Where the conditions are as follows:

Condition 1 - Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated busbars operating at over 300 volts shall not be considered live parts.

Condition 2 - Exposed live parts on one side and grounded parts on the other side. Concrete, brick, or tile walls shall be considered as grounded surfaces.

Condition 3 - Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

Stairs, Platforms, and Ladders - Optional

Stairs, platforms, and fixed ladders are custom designed for each customer application. All are anchored to the PCR® base and meet OSHA Standard 1910.21, Subpart D - "Walking-Working Surfaces". Often details of actual jobsite conditions are not adequate to accurately design these items. Powell will provide base attachment and anchor details should the customer decide to field construct these items.

Bus Duct

Bus duct may be installed internal to the PCR and include wall, floor, or roof penetrations so that external field connections are easily accomplished.

DC Battery System

Load supplied from station batteries should be limited to the electrical system protection, control, and alarms. Emergency lighting and other non power system related loads should utilize a separate battery system. Battery room may include racks, drip pans, vent hoods, eye wash stations, alarm systems, chargers, and UPS systems as specified.

The standard selection for station battery systems is lead acid type, but nickel cadmium batteries may be supplied upon request. The choice of battery type should be based on available space, cost, and user preference.

Definitions:

- Available capacity - The capacity for a given discharge time and end-of-discharge voltage that can be withdrawn from a cell under the specific conditions of operation.
- Battery duty cycle - The loads a battery is expected to supply for specified time periods.
- Cell size - The rated capacity of a lead-acid cell or the number of positive plates in a cell.
- Equalizing charge - A prolonged charge, at a rate higher than the normal float voltage, to correct any inequalities of voltage and specific gravity that may have developed between the cells during service.
- Float operation - Operation of a dc system with the battery, battery charger, and load all connected in parallel and with the battery charger supplying the normal dc load plus any charging current required by the battery. The battery will deliver current only when the load exceeds the charger output.
- Period - An interval of time in the battery duty cycle during which the load is assumed to be constant for purposes of cell sizing calculations.
- Capacity (lead-acid) - The capacity assigned to a cell by its manufacturer for a given discharge rate, at a specified electrolyte temperature and specific gravity, to a given end-of-discharge voltage.
- Vented battery - A battery in which the products of electrolysis and evaporation are allowed to escape freely to the atmosphere. These batteries are commonly referred to as "flooded."
- Valve-regulated lead-acid (VRLA) cell - A lead-acid cell that is sealed with the exception of a valve that opens to the atmosphere when the internal gas pressure in the cell exceeds atmospheric pressure by a pre-selected amount. VRLA cells provide a means for recombination of internally generated oxygen and the suppression of hydrogen gas evolution to limit water consumption.
- Absorbed electrolyte - Electrolyte in a VRLA cell that has been immobilized in absorbent separators.
- Gelled electrolyte - Electrolyte in a VRLA cell that has been immobilized by the addition of a gelling agent.

Defining Loads:
General considerations - The duty cycle imposed on the battery by any of the conditions described herein will depend on the dc system design and the requirements of the installation. The battery must supply the dc power requirements when the following conditions occur:

- Load on the dc system exceeds the maximum output of the battery charger.
- Output of the battery charger is interrupted.
- AC power is lost.

The most severe of these conditions, in terms of battery load and duration, should be used to determine the battery size for the installation.

Load classification- The individual dc loads supplied by the battery during the duty cycle may be classified as continuous or noncontinuous.

Noncontinuous loads lasting 1 minute or less are designated "momentary loads" and should be given special consideration.

Momentary loads - Momentary loads can occur one or more times during the duty cycle but are of short duration, not exceeding 1 minute at any occurrence. Although momentary loads may exist for only a fraction of a second, it is common practice to consider each load will last for a full minute because the battery voltage drop after several seconds often determines the battery's 1 minute rating. When several momentary loads occur within the same 1 minute period and a discrete sequence cannot be established, the load for the 1 minute period should be assumed to be the sum of all momentary loads occurring within that minute. If a discrete sequence can be established, the load for the period should be assumed to be the maximum load at any instant. Sizing for a load lasting only a fraction of a second, based on the battery's 1 minute performance rating, results in a conservatively sized battery.

Typical momentary loads are as follows:

- Switchgear operations
- Motor-driven valve operations (stroke time 1 min)
- Isolating switch operations
- Field flashing of generators
- Motor starting currents
- Inrush currents

Continuous loads - Continuous loads are energized throughout the duty cycle. These loads are those normally carried by the battery charger and those initiated at the inception of the duty cycle. Typical continuous loads are as follows:

- Lighting
- Converters (e.g., inverters)
- Indicating lights
- Continuously energized coils
- Annunciator loads
- Communication systems
- Microprocessor based relays

Noncontinuous loads - Noncontinuous loads are energized only during a portion of the duty cycle. These loads may come on at any time within the duty cycle and may be on for a set length of time, be removed automatically or by operator action, or continue to the end of the duty cycle.

Typical noncontinuous loads are as follows:

- Emergency pump motors
- Critical ventilation system motors
- Fire protection systems actuations
- Motor-driven valve operations (stroke time > 1 min)
- Circuit breaker trip and close operations

Random loads - Loads that occur at random should be shown at the most critical time of the duty cycle in order to simulate the worst-case load on the battery. These may be noncontinuous or momentary loads. To determine the most critical time, it is necessary to size the battery without the random load(s) and to identify the section of the duty cycle that controls battery size. Then the random load(s) should be superimposed on the end of that controlling section.
Duty cycle diagram - A duty cycle diagram showing the total load at any time during the cycle is an aid in the analysis of the duty cycle. To prepare such a diagram, all loads (expressed in either current or power) expected during the cycle are tabulated along with their anticipated inception and shutdown times. The total time span of the duty cycle is determined by the requirements of the installation.

Determining Battery Size:
Selecting the most suitable type and size of battery cell for a stationary battery system can be complex. Several factors govern the size (number of cells and rated capacity) of the battery; the minimum system voltage, correction factors, and the duty cycle. Since a battery is usually composed of a number of identical cells connected in series, the voltage of the battery is the voltage of a cell multiplied by the number of cells in series. The ampere-hour capacity of a battery is the same as the ampere-hour capacity of a single cell.
If cells of sufficiently large capacity are not available, then two or more strings (equal numbers of series connected cells) may be connected in parallel to obtain the necessary capacity. The capacity of such a battery is the sum of the capacities of the strings.

Operating conditions can change the available capacity of the battery. For example:

- The available capacity of the battery decreases as its temperature decreases.
- The available capacity decreases as the discharge rate increases.
- The minimum specified cell voltage at any time during the battery discharge cycle limits the available capacity of the battery.

Number of cells - The maximum and minimum allowable system voltage determines the number of cells in the battery. It has been common practice with lead-acid batteries to use 12 cells, 24 cells, 60 cells, or 120 cells for nominal system voltages of 24v, 48v, 125v, or 250v, respectively. In some cases, it may be desirable to vary from this practice to more closely match the battery to system voltage limitations. It should be noted that the use of the widest possible voltage window, within the confines of individual load requirements, will result in the most economical battery. Furthermore, the use of the largest number of cells allows the lowest minimum cell voltage and, therefore, the smallest size cell for the duty cycle.

Temperature correction factor - The available capacity of a cell is affected by its operating temperature. The standard temperature for rating cell capacity is 25°C (77°F). If the lowest expected electrolyte temperature is below this standard temperature, select a cell large enough to have the required capacity available at the lowest expected temperature. If the lowest expected electrolyte temperature is above 25°C (77°F), it is a conservative practice to select a cell size to match the required capacity at the standard temperature and to recognize the resulting increase in available capacity as part of the overall design margin.

Design margin - It is prudent to provide a capacity margin to allow for unforeseen additions to the dc system and less-than optimum operating conditions of the battery due to improper maintenance, recent discharge, or ambient temperatures lower than anticipated, or a combination of these factors. A method of providing this design margin is to add 10–15% to the cell size determined by calculations. If the various loads are expected to grow at different rates, it may be more accurate to apply the expected growth rate to each load for a given time and to develop a duty cycle from the results.

Aging factor - As a rule, the performance of a lead-acid battery is relatively stable throughout most of its life, but begins to decline with increasing rapidity in its latter stages, with the "knee" of its life versus performance curve occurring at approximately 80% of its rated performance. IEEE Std 450-1995 recommends that a battery be replaced when its actual performance drops to 80% of its rated performance because there is little life to be gained by allowing operation beyond this point. Therefore, to ensure that the battery is capable of meeting its design loads throughout its service life, the battery's rated capacity should be at least 125% (1.25 aging factor) of the load expected at the end of its service life.

Initial capacity - Batteries may have less than rated capacity when delivered. Unless 100% capacity upon delivery is specified, initial capacity can be as low as 90% of rated capacity. This will rise to rated capacity in normal service after several charge-discharge cycles or after several years of float operation. If the designer has provided a 1.25 aging factor, there is no need for the battery to have full rated capacity upon delivery because the capacity normally available from a new battery will be above the duty cycle requirement. When a 1.00 aging factor is used, the designer should ensure that the initial capacity upon delivery is at least 100%, or that there is sufficient margin in the sizing calculation to accommodate a lower initial capacity.

Short Circuit Protection

Short circuits affecting stationary battery systems usually involve the total system voltage and occur mostly in the AC Switchgear or other electrical load circuits. Instantaneous high currents, as high as 9-12 times the 1-minute discharge rate to 1.75 volts per cell of the battery, can occur. Therefore, the battery system should be equipped with fault current protective interrupting devices strategically located throughout the power distribution system.

Ventilation of Battery Room

In the operation of a battery, hydrogen gas is formed, which may be explosive, if ignited. Significant amounts of hydrogen are evolved only as the battery approaches full charge. The battery room should be provided with ventilation, so as to prevent liberated hydrogen gas from exceeding a 1% concentration in the USA to comply with the OSHA. If the battery room is air conditioned as part of a PCR® air conditioning system, the exhaust air from the battery room should not be returned to the air distribution system. The room should have its own exhaust system direct to the outdoors.

Sizing the DC System

For Powell to size the DC system the following information will be needed from the customer/user:

- Continuous loads
- Noncontinuous loads
- Momentary loads
- Random loads
- Sequence of operation
- Duty Cycle Time

Powell Electrical Manufacturing Company has established a standard duty cycle guideline which shall be followed in each dc system sizing where information form our customer is unavailable or unknown.

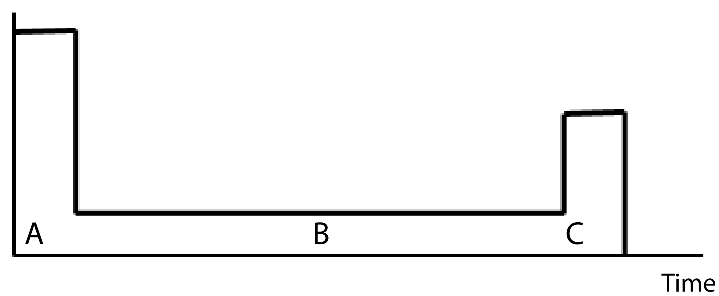
Standard Duty Cycle

Step 1 - Battery system shall be sized to trip all the breakers simultaneously.

Step 2 - Battery system shall provide continuous power to all steady load for 8-hours.

Step 3 - At the end of the discharge cycle, battery shall have enough capacity to close and charge all the breakers simultaneously.

Battery recharge time shall be 8-hours.



<u>Where:</u>

A-1st minute load

B-478-minutes load

C-Last minute load

Auxiliary Systems

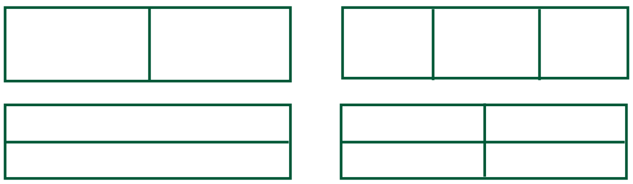
A wide variety of auxiliary systems may be incorporated into the PCR package. These systems include but are not limited to:

- Communications
- Fire and Gas Detection
- SCADA
- DCS
- Network connection for smart substations
- Annunciators
- Crew or work spaces
- Water closets
- Eye wash stations
- Showers
- Kitchens

Shipping Splits

For PCR® designs too large to ship as a single piece the design can incorporate splits which include facilities for split and re-connection of interconnect wires and cables. Individual shipping sections are sealed against weather for shipment and designed so that re-assembly is accomplished through attachment and alignment of structural members.

Splits can be designed so as to best allow for shipment and assembly. Designs can include these orientations:



Two-Story Construction

For two-story designs each floor is constructed as a complete PCR design. The bottom floor includes a welded structural framework upon which to mount and anchor the top floor. Interconnection between floors is accomplished just as between shipping splits. The two floors are built independently and meet all of the same certifications as a single story PCR. Floor assemblies are not attached for testing. Extensive structural calculations are required for proper design.

Arc-Resistant Switchgear Applications

Powell has tested arc-resistant switchgear when installed within a PCR application. To maximize the arc-resistant characteristics a plenum is designed and mounted above the PowlVac-AR® switchgear and vented to the outside using an external vent tunnel. Rear venting from the plenum requires a minimum of one vent for each 5 vertical sections of switchgear. On switchgear assemblies greater than 15 vertical sections, only 4 vents equally spaced across the switchgear lineup are required.

Arc-Resistant Switchgear		
Configuration	Where Typically Used	Minimum Height from Switchgear to Interior Ceiling (inches)
EEMAC Type A ANSI/IEEE Type 1 Protection from front of the equipment only	PCR applications where switchgear is against a rear wall	24
EEMAC Type B ANSI/IEEE Type 2 Protection front, sides, and rear of the equipment	PCR applications where switchgear is against a rear wall or has a rear aisle	24 - if against rear wall 36 - if free standing
EEMAC Type C ANSI/IEEE Type 3 Protection front, sides, and rear of the equipment and between compartments	PCR applications where switchgear is against a rear wall or has a rear aisle	24 - if against rear wall 36 - if free standing

This design has been third-party tested and UL® classified. Test reports are available upon request.

Foundation

A Powell PCR may be installed on any number of foundation types. Most typically used are concrete piers and concrete slabs. Powell will provide a drawing indicating minimum support locations, but foundation design is the responsibility of the customer. The following items should be considered when determining the foundation type:

- Pier or piling type foundations provide for an elevated structure making cable and conduit access from below an easier task.
- Pier or piling type foundations more easily facilitate the re-assembly of split designs.
- Pier or piling type foundations tend to be more stable over time and are less likely to create circuit breaker racking and alignment problems that result from equipment that is not level.
- Pier or piling type foundations tend to be less costly than slab type foundations.
- Slab type foundations provide greater thermal efficiency which may be important in particularly cold climates.

Power Control Room Layout Guide

Environmental Conditions

Outside Ambient Temperature Range: Low_____°F High_____°F

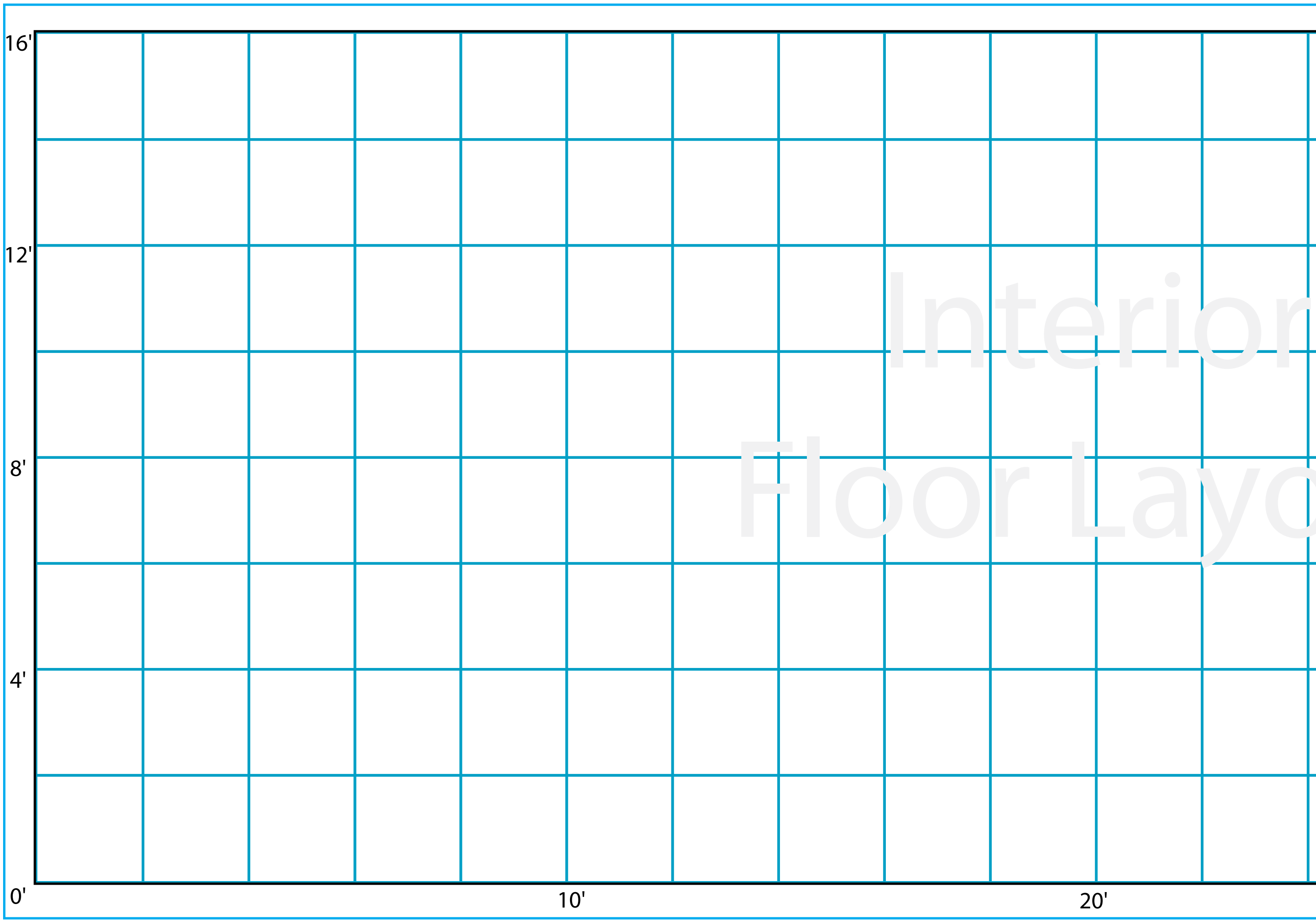
Inside Ambient Temperature Range: Low_____°F High_____°F

Maximum Wind Velocity: ☐ Less than 125 mph ☐_____ mph

Roof Live Load (snow and ice): ☐ Less than 40 lbs/ft^2 ☐_____ lbs/ft^2

Classified Area: ☐ No ☐ Yes - Class _____ Division _____ Group_____

Corrosive Atmosphere: ☐ No ☐ Yes - Describe:_____________________



Project ____

Customer ______________________________________

Name ____

Date ____

Equipment to be Installed_________________________

____

____

____

____

____

____

____

Environment Control

☐ Ventilation Only ☐ Air Conditioning - _____ BTU ☐ Heating - _____kW

☐ Pressurization - _____" of water ☐ free standing with stack ☐ without stack

☐ For installation in a NFPA 496 Classified area.

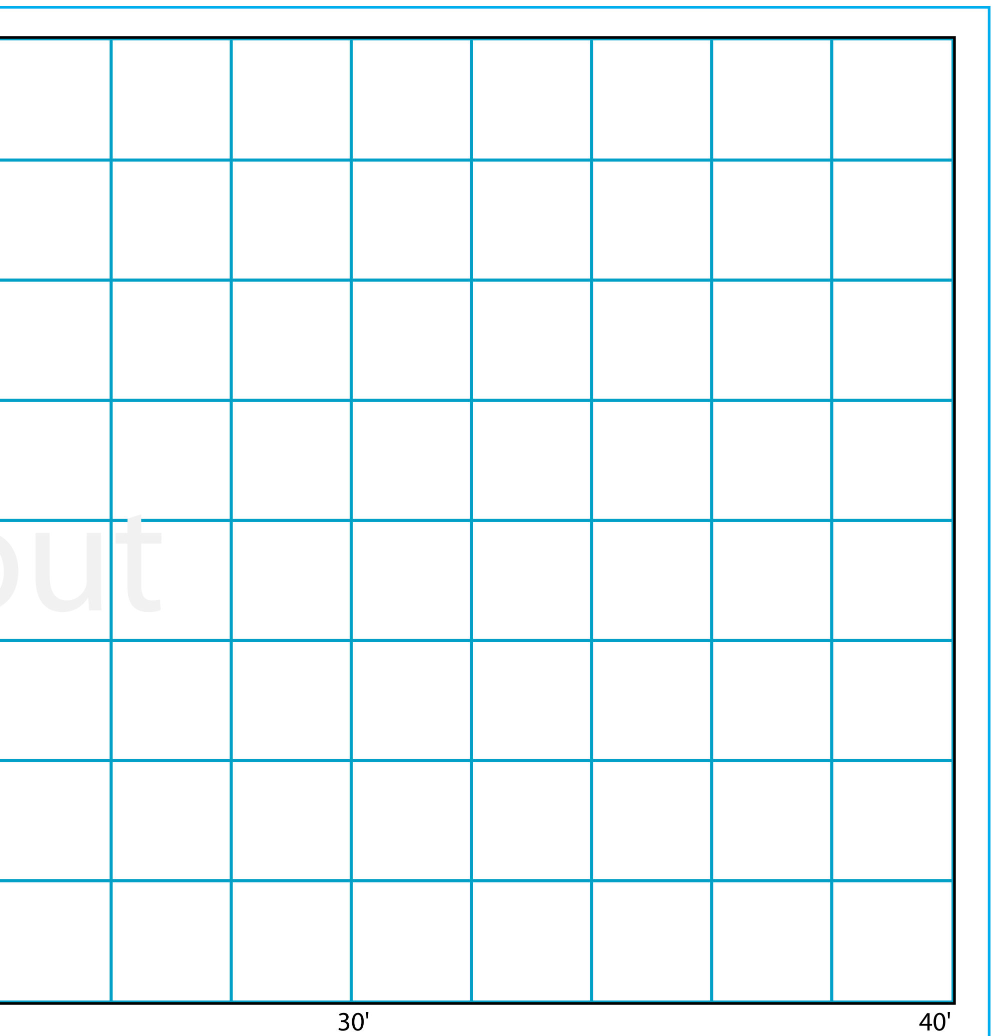
Insulation Requirements

Walls: ☐ R11 ☐ R19 Ceiling: ☐ R11 ☐ R19

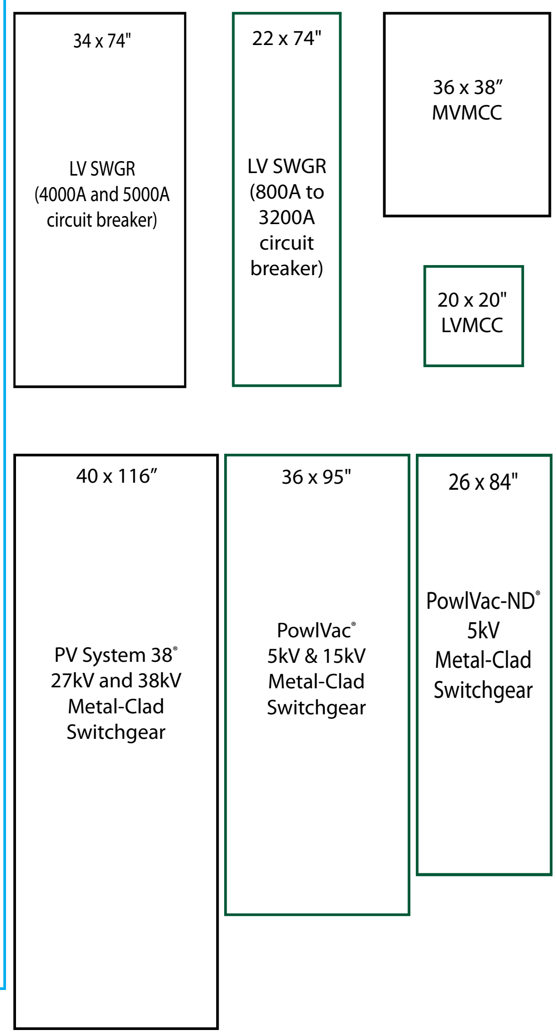
Base: ☐ R6.75 ☐ R11 ☐ R20 ☐ R30 Doors: R11 ☒

Interior Dimensions _____ wide _____ long _____ high

Exterior Dimensions _____ wide _____ long _____ high



Typical Footprint Dimensions



Wall thickness is 3". Roof overhang is 4 1/2".

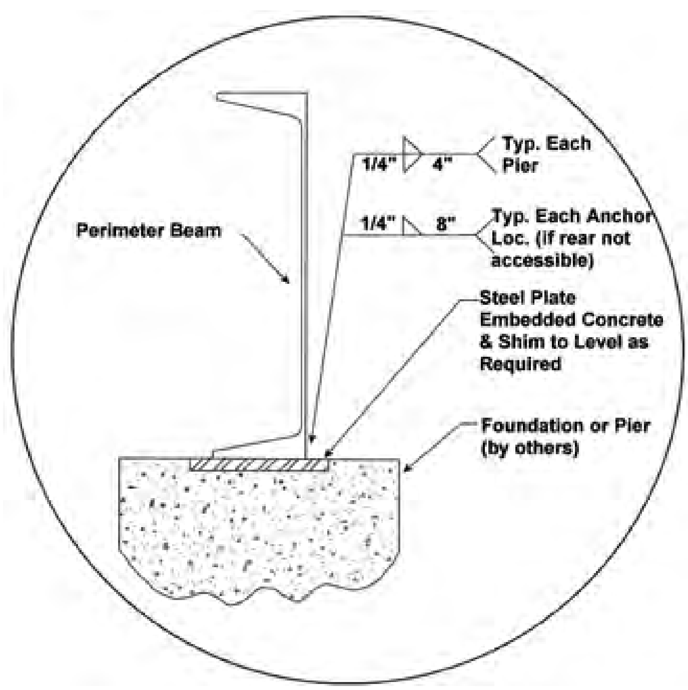
Base your aisle space on N.E.C. Table 110.34(A) and 110.26(A)
Minimum length of 6' (see page 13)

Maximum PCR size may be limited by federal, state or local shipping regulations

Recommended Anchoring

The method of anchoring as well as the design and construction of the piers or slab are the customer's responsibility. These recommendations are suggestions to assist in the decision process.

- A steel plate should be embedded in the concrete pier or slab to provide an anchor location for the PCR® perimeter base.
- After installation it is critical that the PCR be level. Improper leveling will result in personnel door, equipment door, and rear access door closure problems. Doors that close improperly will not seal and may leak.
- PCR perimeter base should be welded to the embedded steel plate.
- When pier mounting a PCR that was split for shipment care must be taken on the piers located at the shipping split. A minimum of 12" must be allowed between perimeter beamsof the PCR to allow for the removal of the PCR lifting lugs prior to the split sections being joined.



Wall and Ceiling Finish Specifications

The Powell standard panel finish procedure consists of a Metal Pretreatment Process, an Electrostatic Polyester Powdercoat Process, and a Curing Process. All parts are moved using a continuous conveyor traveling at 8 feet per minute. Final finish is 2.0 to 4.0 mils Dry Film Thickness (DFT) and has a minimum pencil hardness of 2H as tested per ASTM D3363. Finish will successfully pass ASTM B117 salt spray test for a minimum of 1000 hours. It will also pass the impact testing per ASTM D2794 with minimum values of 160 in-lbs for direct impact and 120 in-lbs for reverse impact. Design test reports are available upon request.

Metal Pretreatment Process

- Precleaned utilizing an alkaline caustic cleaner with a concentration of 3% - 12% by volume with water at a temperature of 110 ºF – 130 ºF.
- Overflowing clean water rinse at ambient temperature.
- Iron phosphate conversion coating with a concentration of 1.5% - 2.2% by volume with water at a temperature of 90 ºF – 120 ºF.
- Dead rinse in water at ambient temperature.
- Overflowing clean water rinse at ambient temperature.
- Convection oven drying at 325 ºF – 400 ºF for dry and preheat.

Electrostatic Polyester Powdercoat Process

- Powder is given a negative electrostatic charge.
- All metal parts are grounded which takes on a positive charge.
- The resulting electrostatic field causes the powder to adhere to the metal parts.
- Powder is applied by eight automatic spray guns (four per side) positioned to allow for powder projection onto the part as it enters the spray booth.
- Two manual touch-up hand guns assure complete powder coverage.

Curing Process

- All parts are cured in an oven at 370 ºF - 420 ºF for twelve minutes.

Underwriters Laboratory Label (UL®)

The Powell PCR is UL Classified in accordance with The National Electric Code and ANSI/IEEE C37.20.2 Section 5.2 for electrical equipment enclosures constructed at the Powell Electrical Manufacturing Company facility on Mosley Drive in Houston, Texas. The PCR may bear a UL Classified Label and contain any of the following equipment:

- UL Listed Equipment when used for its intended purpose and not exceeding marked ratings.
- UL Recognized Component Equipment when meeting all specified conditions for use.
- Unevaluated Electrical Equipment when noted on the UL data plate installed on the PCR exterior.
- Unevaluated Equipment which is nonelectrical and involving only inert substances.

A Classification Mark and a Data Plate will be permanently affixed to the exterior of the PCR in a visible and prominent location. The Classification Mark will reference the National Electric Code and the ANSI/IEE C37.20.2, Section 5.2 and shall include the serial number/job number for the PCR building. The Data Plate will be coated to prevent field alteration and contain the following information:

- Powell name and address
- Type of concealed wiring, if any.
- Maximum voltage rating of equipment located in the PCR.
- Drawing reference which lists all factory installed equipment.

- List of field-completed electrical constructions subject to inspection by the local authorities.
- List of unevaluated equipment subject to approval by the local authorities.

Compliance with specific construction and assembly requirements is necessary for UL® Classification. Powell can review project specifications and detail any issues which may present a conflict. Contact your Powell representative with your individual needs.

Factory Testing and Inspection Process

- In-Process Inspections - The in-process inspections are performed on the equipment by production personnel during fabrication and assembly. In-Process inspection records are verified by the inspection department personnel.
- Final Inspection - The following inspections will be performed on the equipment, As-Built drawings, and listed document by inspection.
  - o Bussing Check - The bussing of the equipment will be checked to confirm that it matches the drawings and is built to the company standards.
  - o Engineering Approval - The inspector coordinates with Engineering for approval of any changes made during the inspection process.
  - o Specification Review - The inspector reviews the engineering documents and compares them to the equipment and the As-Built drawings.
- Final Testing
  - o Mechanical Tests
    1. Mechanical Tests are performed to ensure proper function of the mechanical aspects of the PCR® and associated equipment.
    2. Mechanical Operations Tests - All doors, locks, door stops, mechanical interlocks, overhead lift devices, and louvers are checked for proper operation.
    3. Interchangeability Tests - The interchangeability of drawout or removable units designed to be interchangeable is verified.
  - o Electrical Tests
    1. All electrical circuits are verified by comparison to the engineering documents.
    2. Control Wiring Insulation Test - Control wiring insulation test is performed with 1500VAC at 60 Hz for one minute. The test set will be monitored for voltage breakdown.
    3. Grounding of Instrument Transformer Case - Instrument transformer case grounding is verified with an ohmmeter or bell set if the transformer case is of metal design.
    4. Polarity Verification Tests - Polarity verification tests are made to ensure that connections between instrument transformers and meters have the correct polarities and that instrument pointers deflect in the proper direction. All relays, meters, and devices in the circuits are verified to operate as required by the control schemes.
       - a Current - Current levels are checked during functional test with clamp on ammeter to see if they are within desired limits.
       - b Voltage - Primary voltage is applied to the equipment to test all potential and control power transformer circuits.
  - o Control Wiring Continuity Tests - Control wiring continuity is verified by the functional electrical check of the equipment with all applicable control schemes. Dry contacts will be checked with an ohmmeter or bell set. Circuits that cannot be energized or have their operation simulated are verified with an ohmmeter or bell set.
  - o Sequence Tests - Sequential operation of devices are tested to ensure that the devices in the sequence function properly and in the order intended.
- Final Documentation Check
  - o Equipment Discrepancy Record - Any discrepancies identified are checked for completion.
  - o Customer Inspection Discrepancy Record - All discrepancies or changes will be checked for completion and that the documentation has been signed off.
  - o As-Built Drawings - The drawings are checked to confirm that all circuits have been verified and that any corrections have been identified. The drawings will be dated and initialled by the inspector prior to releasing to engineering.
  - o Engineering Approval - The Inspector coordinates with the Engineer for approval of changes made during the inspection process.
  - o Equipment Cosmetic Condition Checklist - The inspector reviews the checklist against the equipment for compliance.
- Certification
  - o Verification that all areas of the Final Inspection/ Test Record have been completed. This certification is signed by the inspector and will be made available to the customer upon request.
  - o Short circuit and system coordination studies are available as options from the PowlTech advanced engineering group.
  - o Programming of intelligent meters and relays is available as an option from the PowlTech advanced engineering group.

Shipping Procedures

Prior to shipment some external items along the long walls are removed from the PCR® including: HVAC, door canopies, lights, stairs, walkways, and landings. Switchgear may be shipped with the circuit breakers installed and blocked to prevent movement and damage during transport. Ship loose items may be shipped inside the PCR and are blocked or tied to prevent shipping damage. Doors are shut, locked, and secured with nylon wire ties and may be anchored for shipment. Removable lifting lugs are installed depending on the width of the PCR. Openings in the PCR wall, floor, or roof are temporarily sealed to prevent water and/or dust from entering during transit. In the case of shipping splits, temporary supports are installed and wall openings are crated with plywood and sealed for weather resistance. Powell service personnel are available as an option to supervise the installation and re-assembly of the PCR.

Storage Procedures

Storage of all electrical distribution equipment requires special handling and storage measures to prevent deterioration. Of most importance is the mechanical and dielectric integrity which must be protected during the storage period. Electrical equipment may be designed for use in a variety of environments. When the equipment is placed in storage, the equipment may be subjected to environments for which the design is inappropriate. The warranty of the equipment is void if proper storage practices are not used. It is recommended that you contact the Powell Apparatus Service Division at 713-944-6900 prior to placing equipment into storage.

In general the Power Control Room (PCR) will protect the equipment mounted within from environmental elements. For periods longer than 3 days or in environmental conditions that include temperatures not exceeding 60ºF – 80ºF (16ºC – 26ºC) daily inspections should be performed to verify that all temporary shipment coverings are in good condition and not allowing the entrance of wind, dust, water, or rodents into the interior of the PCR.

For periods longer than 3 days, or for environmental conditions beyond the previously mentioned limits, the PCR environmental system should be energized and functional. This may be accomplished by energizing the enclosure services transformer or by connecting power to the HVAC/Heater system directly. Equipment anti-condensation heaters should be energized to prevent condensation.

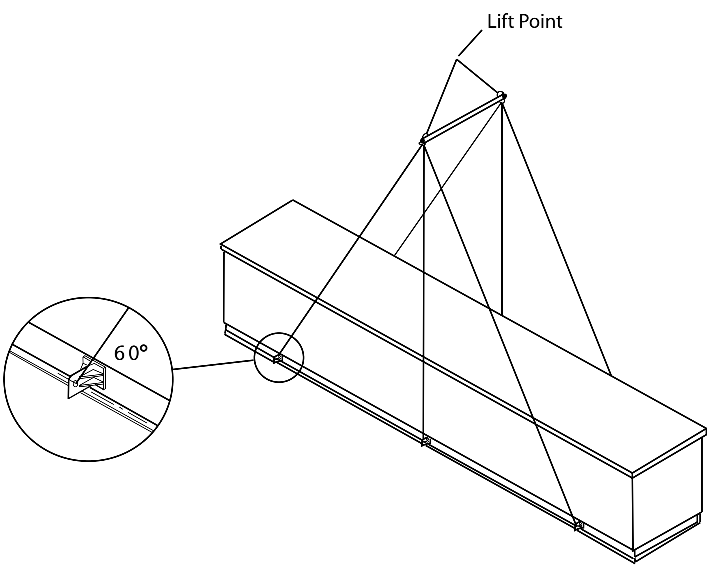
In all cases of corrosive environments where an air filtration system is used, that system should be functional if the PCR is to be un-energized for more than 24 hours. For storage periods greater than 14 days it is highly recommended that Powell Apparatus Service Division performs an inspection prior to installation and commissioning. For storage periods longer than 90 days this inspection is required to maintain the equipment warranty.

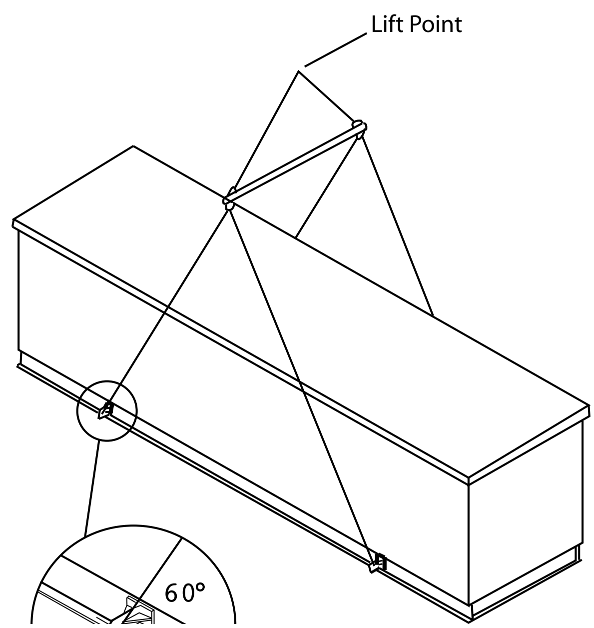
Auxiliary control devices, protective relays, battery chargers, UPS systems, lighting, installation hardware, air conditioners, and ship loose material must be stored indoors or inside of the PCR. If storage for longer than 30 days is anticipated, humidity controlling desiccant materials should be utilized. Packets should be installed in all compartments and packing containers.

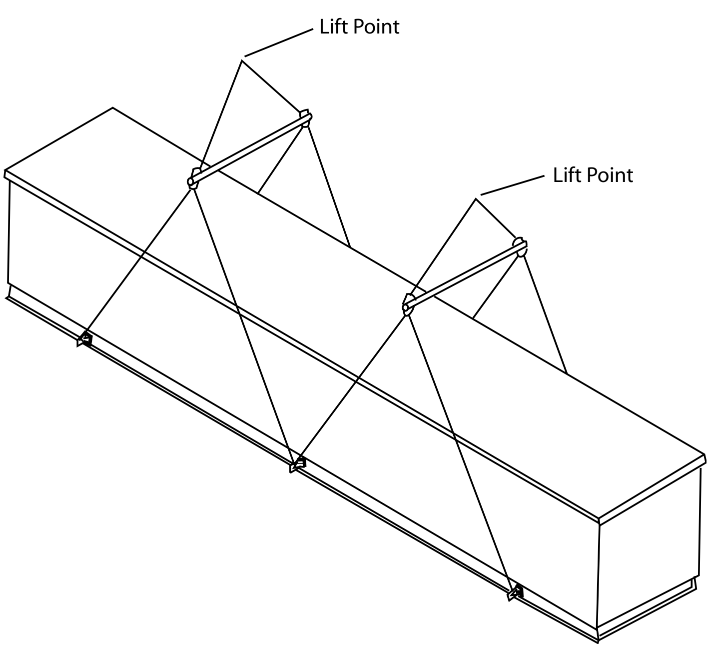
Please contact Powell Apparatus Service Division for site specific needs with regard to short or long-term storage of Power Control Rooms and associated equipment.

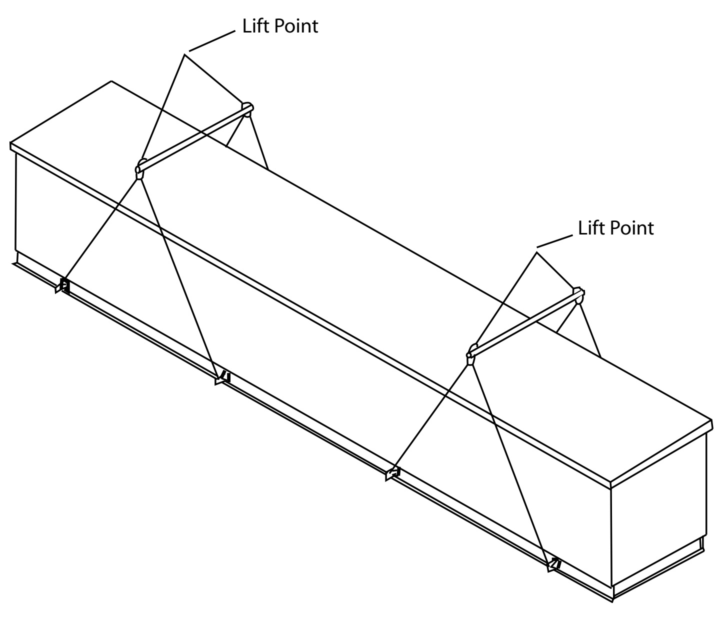
Lifting Recommendations

1) Attach cables to all lifting points. Cables at each lift point need to be sized to the total PCR® weight, divided by the number of lifting points. A safety factor of 4 times is recommended.
2) Spreader bar lift points need to be 2 feet wider (1 foot on each side) than the PCR. A safety factor of 4 times is recommended for spreader bar lifting.
3) Cable lengths should be sized to allow the PCR to be lifted level.
4) Shackles at each lifting point should be sized for that lift point.
5) Do not lay spreader bar on roof.
6) No nylon or polyester slings should be used to lift a PCR.
7) No turn buckles should be used to lift a PCR.
8) A lift plan should be devised to determined the size of the lift cables and lengths required to maintain a minimum 60 degree angle at the lifting lugs.
9) Lifting lug holes are 2" diameter and extend 9" past the PCR wall.
10) Slings and shackles can be provided upon customers' request.









Smart Substations - PCRi™

A smart substation is an integration of both traditional and modern components with local/remote terminals, personal computers, pagers, and cellular telephones. This integration shifts the function of the electrical technician from time consuming tasks performed at the substation, to time saving tasks remote from the substation location. When fully implemented, it automates substation activities and refines the control system actions for both process and power systems. A successful implementation will be cost effective, include an intuitive interface, and improve operator safety.

Smart substations may be provided for new installations or as an upgrade to existing equipment by taking advantage of existing communications capable components. A smart substation enables real-time monitoring of switchgear, motor control, and other systems; and annunciation of traditional and new alarms. Greater notification and more timely information on critical systems translates to quick problem identification and faster response to changing conditions. Cost justification is easy and project payback is quick when considering the cost of downtime and daily rounds for a typical power substation.

When considering the possible installation of a smart substation these enhancements to existing operations may apply:

1) Notification of alarms, trips, or other critical substation actions through email, pagers, and telephones can greatly reduce response time, while making sure the proper people are included based upon pre-determined criteria.
2) Real-time monitoring and instant access to data from local and remote locations.
3) User-friendly intuitive graphical interface to provide an operator with a more thorough understanding of both the substation configuration and the current state of health.
4) Control of substation functions from remote locations, such as closing or tripping circuit breakers while outside of the arc flash zone.
5) Trending data and online testing to provide predictive maintenance, failure detection, and reduce unplanned equipment shutdowns.
6) Instant online availability of equipment documentation for operator use including the latest revisions of drawings, manuals, and instructions.
7) Instant online procedural documentation in the form of text, audio, or video for operator review prior to performing an equipment related task.

Although each smart substation will have unique requirements, Powell has identified three levels of complexity to describe the application. Each level increases the initial cost, but provides greater capability. The user must decide which level might be appropriate for the specific installation. Additionally, this breakdown may provide a framework for incremental substation improvements.

Level One

Level One installations are easily added to existing substations, often by simply utilizing the existing communications capable relays and devices which are being applied in stand alone instances. This is the least costly and likely has the greatest rate of return on investment.

- All equipment is located within the Power Control Room and no remote interfaces are provided.
- Relay communications are linked and data acquired.
- Standard pre-built screens.
- An interface in the form of terminal or computer is provided with system mimic one-line so that interface is not directly in front of energized equipment.
- Annunciators are tied into the communications and notification system.
- Online testing capability.
- Online trending of data to provide predictive maintenance.
- Online documentation.

Justification for Level One applications can be identified as follows:

- Overall substation safety is improved.
    - o Less work performed by operators within the arc flash zone.
    - o Available online documentation improves the performance of operators while conducting at risk tasks.
    - o Visualization of substation configuration including mimic one-line diagrams, existing relay settings, and annunciator alarms provides increased understanding and optimizatiion of equipment performance.
- Appropriate personnel can respond to alarms faster when more information is available and notification rules can be more complex.
- Reduced process downtime due to reliability based proactive maintenance.
- Fewer introduced problems due to longer maintenance intervals.
- Process outage is controlled and predictive, not unplanned on an emergency basis.

Level Two

Level Two provides all the features and advantages of Level One plus:

- Data and information is available outside of the

substation through a variety of possible remote access.
- Customization of screens and operator views.
- Greater detail of documentation packages.
- Diagnostic tools are available both locally and remotely.

Additional justifications for Level Two applications:

- Quickly identify potential fault locations for quick and timely response.
- Real-time monitoring of substation primary systems, protection systems, and control systems means greater system reliability and up-time.
- Operators make fewer rounds to check equipment status.
- Response time to developing problems is greatly increased.
- Maintenance may be scheduled based on equipment condition.
- Data acquisition increases visibility of voltage, load, and VARs so that systems can be optimized to reduce ongoing losses.

Level Three

Level Three applications link the substation communications and the process DCS systems together. Hardware with increased capability is utilized.

Level Three provides all the features and advantages of Levels One and Two plus:

- Smart Motor Control Center is integrated directly with the Process Distributed Control System which provides direct communication between control system and motor control eliminating hard wired controls.
- Changes to the process operation are easily facilitated.
- This improved communications link is less costly than marshalling panels and discrete input/output wiring.

Additional justifications for Level Three applications:

- Maximum use of current technology to provide true lean operating system.
- System changes are accomplished without long down time and hard wiring changes.
- Best application for the user striving to maximize efficiency with a new installation.
- Installed cost of the electrical system is greatly reduced.

Typical Electrical Energy Losses in Power Systems

The following data has been calculated or gathered from various product engineering groups. It is based on rated load flowing through the equipment and must be reduced to actual load for a particular case. It is representative data to give the user an estimate of equipment energy losses. Specific units may vary considerably depending upon their particular application.

Medium Voltage PowlVac® Switchgear (5kV & 15kV)		
	Watt Loss	BTU Loss
1200A Breaker Unit	705	2406
2000A Breaker Unit	1320	4505
3000A Breaker Unit	2200	7509
4000A Breaker Unit with Forced Air Cooling Fan	2600	8874
Auxiliary Compartment	300	1024

Bus Duct (480V, 5kV, & 15kV)		
Bus Rating (Amperes)	Watt Loss/ft	BTU Loss/ft
1200	60	205
1600	85	290
2000	89	304
2500	116	396
3000	133	454
3200	152	519
4000	176	601
5000	193	659

Low Voltage Metal-Enclosed Switchgear		
Breaker Frame Size	Watt Loss	BTU Loss
800AF	400	1365
1600AF	1000	3413
2000AF	1500	5120
3200AF	2400	8191
4000AF	3000	10239
5000AF	4700	16041
800AF fused	600	2048
1600AF fused	1500	5120
2000AF fused	2250	7679
3200AF fused	3600	12287
4000AF fused	4500	15359

Load Interrupter Switchgear 600A Switch - 5kV			
	Watt/BTU Loss		
Load Current (Amperes)	Unfused Switch	Fuse	Total
50	5/17	109/372	114/389

100	14/48	171/584	185/631
200	55/188	300/1024	355/1212
300	125/427	405/1382	530/1809
400	222/758	528/1802	750/2560
500	347/1184	---	---
600	500/1707	---	---

Load Interrupter Switchgear 1200A Switch - 5kV			
	Watt/BTU Loss		
Load Current (Amperes)	Unfused Switch	Fuse	Total
50	2/7	109/372	111/379
100	5/17	171/584	176/601
200	20/68	300/1024	320/1092
300	46/157	405/1382	451/1539
400	83/283	528/1802	611/2085
500	130/444	---	---
600	187/638	---	---
800	333/1137	---	---
1000	521/1778	---	---
1200	750/2560	---	---

Load Interrupter Switchgear 600A Switch - 15kV			
	Watt/BTU Loss		
Load Current (Amperes)	Unfused Switch	Fuse	Total
50	5/17	468/1597	473/1614
100	14/48	840/2867	854/2915
200	55/188	---	---
300	125/427	---	---
400	222/758	---	---
500	347/1184	---	---
600	500/1707	---	---

Load Interrupter Switchgear 1200A Switch - 15kV			
	Watt/BTU Loss		
Load Current (Amperes)	Unfused Switch	Fuse	Total
50	2/7	468/1597	473/1614
100	5/17	840/2867	854/2915
200	20/68	---	---
300	46/157	---	---
400	83/283	---	---
500	130/444	---	---
600	187/638	---	---
800	333/1137	---	---
1000	521/1778	---	---
1200	750/2560	---	---

Low Voltage Motor Control (480V)		
NEMA Size Starter	Watt Loss	BTU Loss
1	27	92
2	57	195
3	99	338
4	165	563
5	280	956

Medium Voltage Motor Control 400A Contactor		
Load Current (Amperes)	Fuse Rating	Watt/BTU Loss
40	3R	253/863
40	6R	233/795

40	9R	225/768
40	12R	220/751
40	18R	216/737
40	24R	213/727
60	4R	280/956
60	9R	247/843
60	12R	236/805
60	18R	227/775
60	24R	220/751
80	6R	204/696
80	9R	266/907
80	18R	243/829
80	24R	231/788
120	9R	375/1280
120	18R	324/1106
120	24R	296/1010
160	12R	495/1689
160	24R	415/1416
240	18R	677/2311
240	24R	644/2198
360	24R	1057/3608

Note:

Watt losses include 1 kVA Control Power Transformer (54 watts), Contactor coils (178 watts), and overload heaters (36 watts).

Medium Voltage Motor Control 720A Contactor		
Load Current (Amperes)	Fuse Rating	Watt/BTU Loss
240	18R	513/1751

240	24R	480/1638
240	600A	381/1300
240	700A	378/1290
360	24R	746/2546
360	600A	523/1785
360	700A	515/1758
500	600A	481/1642
600	700A	952/3249

Method #1 - For PCR®'s larger than 200 square feet

PCR Load:

Total Roof Area (PCR width x PCR Length)
=_____ ft^2 x 5 BTU = _____BTU

Total Wall Area (PCR perimeter x PCR Length)
= _____ ft^2 x 3 BTU = _____BTU

Total PCR Load (Sum of Above Calculations)
= (A) _____ BTU

Internal Load:

Installed Equipment Heat Loss
= _____ watts x 3.413 = _____ BTU

Lighting Loss (Floor Area)
= _____ ft^2 x 10 BTU/ft^2 = _____ BTU

Total Internal Load (Sum of Above Calculations)
= (B) _____ BTU

Outside Air Load:

Non-pressurized (H x L x W)
= _____ ft^3 x 2.8 BTU/hr/ft^3 = _____ BTU

Pressurized (H x L x W)
= _____ ft^3 x 0.1 x 75 BTU/cfm = _____ BTU

Total Outside Air Load (Sum of Above Calculations)
= (C) _____ BTU

Total Air Conditioning Requirement:
= (A + B + C) = _____ BTU
or _____ BTU/12000 = _____ tons

Method #2 - For PCR's smaller than 200 square feet

PCR Load (non pressurized)

Total Roof Area (PCR width x PCR Length)
=_____ ft^2 x 75 BTU = _____BTU

Total Wall Area (PCR perimeter x PCR Length)
= _____ ft^2 x 75 BTU = _____BTU

Total PCR Load (Sum of Above Calculations)
= (A) _____ BTU

PCR Load (pressurized)

Total Roof Area (PCR width x PCR Length)
=_____ ft^2 x 105 BTU = _____BTU

Total Wall Area (PCR perimeter x PCR Length)
= _____ ft^2 x 105 BTU = _____BTU

Total PCR Load (Sum of Above Calculations)
= (A) _____ BTU

Internal Load:

Installed Equipment Heat Loss
= _____ watts x 3.413 = _____ BTU

Total Internal Load (Sum of Above Calculations)
= (B) _____ BTU

Total Air Conditioning Requirement:
= (A + B) = _____ BTU
or _____ BTU/12000 = _____ tons

Notes:

- For every 1° above 95°F outside air, add 1% to the PCR load only.
- The PCR calculations are based upon wall insulation of R11, ceiling insulation of R11, and floor insulation of R11.
- Do NOT figure higher than 85°F space temperature when determining inside room temperature, as A/C unit cannot function at any higher inlet temperature for long periods of time.
- The calculation methods are ESTIMATES ONLY and are NOT CERTIFIED.
- Certified calculations are available on customers' request.

Field Assembly Instructions

No Split

1) Install the lifting lugs and connect the shackles and lifting cables to the PCR® so that it will be level.
2) Square the PCR on the foundation.
3) To level, shim the base of the PCR on the foundation.
4) Anchor the base to the foundation at the pier locations, shown on the PCR drawings for your particular project.
5) Remove the lifting lugs and reinstall the bolts in the holes.
6) Weld PCR to piers or slab. Connect PCR ground pads to ground grid.

With Split Across the Width

1) Install the lifting lugs and connect the shackles and lifting cables to the first section of the PCR so that it will be level when lifted. Set the PCR on the foundation.
2) Square the PCR on the foundation.
3) To level, shim the base of the PCR on the foundation.
4) Anchor the base to the foundation at the pier locations, so the first section of the PCR will not move when attaching the next section.
5) Remove the lifting lugs.
6) Install the lifting lugs and connect the shackles and lifting cables to the second section of the PCR so that the PCR will be level.
7) Remove all crating materials from the ends of both shipping sections.
8) Place pulling soap on the bottom of the base.
9) Also soap the foundation where the base will come in contact with it.
10) Set the next section of the PCR on the foundation as close as possible to the previous section.
11) Remove the lifting lugs. Reinstall bolts on all sections.
12) Grease all bolting locations.
13) Install a continuous strip of mobile seal (Powell #S1001).
14) Reinstall the bolts from the lifting lugs in the holes in the base. (both sections)
15) Attach two industrial type lever chain pullers to each side of the two sections and pull the bases together.
16) Shim the PCR as required.
17) Install the bolts in the holes at the shipping split and tighten.
18) Apply sealant (Powell #S123) at any external cracks.
19) Go inside of the PCR with no lights on and look for any light coming through holes or cracks. If light can be seen, repeat step #18 as necessary.
20) Install the shipping split channel and splice plates on roof and wall cap.
21) Weld PCR to piers or slab. Connect PCR ground pads to the ground grid. Remove any shipping bracing as required

Contact the factory for lengthwise or four-way splits.

Bus Duct Mounting Instructions

1) Remove any packing from bus duct connection.
2) Read re-assembly instructions from drawing packet attached to the PCR, marked re-assembly instructions.
3) Lift bus duct to proper height to align with connection point on PCR wall.
4) Install hardware to bus duct flange and flange attached to PCR wall.
5) Slide 2" collar over flange of bus duct and flange of PCR wall then install hardware and keep bus duct supported to the next section.
6) Connect the remaining section as shown on bus duct drawings layout.
7) Connect space heater circuits.

HVAC Mounting Instructions

1) Remove packing from unit.
2) Read re-assembly instructions from drawing packet attached to the PCR, marked re-assembly instructions.
3) Set the unit at the wall connection location.
4) Install 1/4" x 20" hardware in flange of air conditioning unit and flange attached to the PCR wall.
5) Slide 2" rain collar over flange of air conditioning unit and flange attached to PCR wall, then install hardware.
6) Connect the electrical wiring to control point of the air conditioning unit.

Door Canopy

1) Door canopies are marked for specific doors.
2) Reattach canopy above the door with #14 TEK screws.

Rain Gutter Re-Assembly Instructions

1) Locate downspouts with the ship loose items.
2) Lineup downspouts with locations marked on the PCR.
3) Attach top of downspouts to the rain gutter with one ¾" long #14 TEK screw.
4) Locate tape on back side of the downspout.
5) Make sure that area on the PCR that the tape will contact is clean and dry. If necessary, wipe area with denatured alcohol.
6) Peel the clear cover on the tape off.
7) Lineup downspout vertically and press against the PCR. Apply pressure for about 15 seconds to insure a good seal between the tape and the PCR.

Site Planning

Each process unit typically requires a separate unit substation. Some process units with large loads may require several substations. The determining factors are maximum transformer capacity and the distance between the loads and the substation.

To keep installation costs to a minimum low voltage load cable runs should be 200 meters maximum, with 100 meters as a realistic target. Optimizing substation position is a function of cost, available space, cable runs, arc flash boundaries, and capacity requirements.

Long-term success will be a function of maintenance flexibility and this equipment must be de-energized for maintenance. If a given substation is designed to supply more than one process unit or group of coordinated loads, then scheduling a shutdown for expansion or maintenance will be difficult. Coordinating substations with the loads to be supplied can have benefits. Often two smaller substations in lieu of one large substation is the superior solution based on site conditions. A possible solution is to locate separate switchgear assemblies within the same PCR®.

Adequate space is required for outgoing cables. The greater the number of cables exiting the PCR, the more difficult it will be to route them to the loads efficiently. As more cables are grouped together, current de-rating issues may apply.

Guide Specifications

1.0 General

1.1 The intent of this specification is to have the manufacturer furnish the equipment and material specified herein complete and operable.
1.2 All standard accessories to the equipment specified shall be supplied even if not specifically mentioned in this specification.
1.3 Material used in the fabrication of the specified equipment shall be new, unused, and of the highest quality available.

2.0 Scope

2.1 Work Included

2.1.1 Furnish assembly as detailed in Sections 3.0 through 12.0 of these specifications. Any drawings or data sheets attached to the inquiry shall be considered part of this specification. The equipment shall be complete and operable.

2.1.2 Provide production tests and inspections as detailed in Section 13.0 of this specification.

2.1.3 To reasonably prevent the possibility of shipping damage, the manufacturer shall prepare the equipment for transportation to the jobsite and monitor the load out of this material.

2.1.4 It shall be the responsibility of the manufacturer to furnish all material, connections, splices, links, special tools, and information required to completely reassemble the PCR in the field or to facilitate the installation of the PCR when performed by an electrical contractor.

2.1.5 Guarantee the performance of the Power Control Room during a reasonable warranty period. This warranty shall, at a minimum, cover the equipment for eighteen (18) months from time of shipment or twelve (12) months from date of energization whichever occurs first.

2.1.6 Supply all drawings, documentation, and information detailed in Section 14.0.

2.2 Work Not Included

2.2.1 Field installation of equipment enclosure, unless otherwise specified.

2.2.2 Connection of incoming cables or bus.

2.2.3 Connection of outgoing cables or bus.

2.2.4 Connection of external control cables or wiring.

2.2.5 Reconnection of shipping split wiring.

2.2.6 Re-assembly of items removed for shipment.

3.0 Applicable Codes and Standards

3.1 The applicable codes and standards listed below should be considered as part of this specification. The latest revision in effect at time of inquiry shall apply for all standards referenced.

3.1.1 National Electrical Manufacturers Association (NEMA)

3.1.2 Institute of Electrical and Electronic Engineers (IEEE)

3.1.3 National Electric Code (NEC)

3.1.4 American National Standards Institute, Inc. (ANSI)

3.1.5 Occupational Safety and Health Administration (OSHA)

3.1.6 International Building Code (IBC 2000)

3.1.7 Underwriters Laboratories (UL®)

3.2 It shall be the manufacturer's responsibility to be knowledgeable of these standards and codes.

4.0 Service and Environmental Conditions

4.1 Unless otherwise specified this equipment is intended for use in ambient temperatures that do not exceed a maximum of 40°C (104°F) or a minimum of -30°C (-22°F).

5.0 Basic Construction

5.1 The equipment supplied shall be of metal construction and shall be self-supporting and free standing. All metal work shall be free from burrs and sharp edges. Elements may be connected by bolts, thread forming screws, or welds.

5.2 The equipment shall be suitable for industrial or utility service.

5.3 The PCR base shall be constructed of structural members sized by design structural calculations and reinforced to meet or exceed specified static and dynamic loads. Structural members shall be located to coordinate with the enclosed equipment so as to properly support it and allow maximum access to equipment floor openings for cable penetration.

5.4 The base shall be designed with base lifting lugs capable of lifting the fully equipped structure at the specified lifting points with deflection not to exceed L/240.

5.5 The steel floor plate shall be ¼" steel stitch welded to the structural base assembly.

5.6 The installed structure shall be capable of supporting a floor loading of 250 pounds per square foot.

5.7 Structure walls shall consist at a minimum of a formed, interlocked, self framing outer wall of 18 gauge galvanized steel and an inner wall of 16 gauge galvanized steel.

5.8 Structure walls shall be insulated between the inner and outer walls as specified on the data sheets:

5.8.1 Fiberglass insulation, 3 inches, (R11)

5.8.2 Foam insulation, 2-3/4 inches, (R19)

5.9 Structure walls shall be able to withstand a wind loading of 125 miles per hour.

5.10 The ceiling and roof structure shall consist of two layers of formed interlocked panels, 18 gauge galvanized steel roof and an inner ceiling panel of 16 gauge galvanized steel.

5.11 The ceiling and roof structure shall be insulated to match the walls per Section 5.8 or as specified in the data sheets.

5.12 The roof shall be able to withstand a minimum live load of 40 pounds per square foot.

5.13 It shall be the manufacturer's responsibility to coordinate all necessary alignment and interconnection between component sections. The entire assembly must be electrically and mechanically assembled into one single lineup prior to final inspection and shipment.

5.14 Two-story applications shall be constructed with each floor as a complete PCR design.

5.15 The PCR® must be shipped complete, without missing components or "ship shorts". Purchaser may waive this requirement upon request prior to shipment.

6.0 Doors

6.1 A minimum of two doors, located at opposite ends of the PCR, are required. Additional doors can be provided as specified on the drawings.

6.1.1 One equipment door measuring 4' by 8' shall be provided to allow for equipment entry and removal.

6.1.2 One personnel door measuring 3' by 7' shall be provided to allow for personnel entry and exit.

6.1.3 Personnel and equipment doors shall have a 12" by 12" safety glass window.

6.1.4 For small protected aisle applications only one door may be furnished.

6.2 Access doors will be provided for any installed equipment and future planned spaces to allow for rear access to the installed switchgear.

6.2.1 Equipment access doors shall be sized to match the installed equipment.

6.2.2 Equipment access doors shall be hinged and have the ability to be padlocked for restricted entry.

6.2.3 Equipment doors shall have a gasket to provide a weather seal.

7.0 Grounding

7.1 Two external ground pads shall be bolted to the structural base to serve as an equipment ground connection point to the ground grid.

7.2 The ground bus from each piece of installed equipment will be connected to the base assembly so as to provide a continuous ground path.

7.3 An additional continuous copper ground bus around the interior perimeter of the PCR shall be installed only if specified on the data sheets.

8.0 Environmental

8.1 The PCR shall be cooled and/or heated with air conditioning equipment sized to meet the conditions as specified in the data sheets. Customer shall be responsible for determining the required temperature limits and providing the ambient conditions for the jobsite.

8.2 Air conditioning units may be wall, roof, or pad mounted depending on size and physical limits.

8.3 Over-sizing, redundancy, or automatic cycling of air conditioning equipment can be provided if specified on the data sheets.

8.4 Air filtration from dust, or chemical filtration of other contaminates can be provided if specified on the data sheets.

8.5 Positive pressurizing of the PCR per NFPA 496 can be provided for classified areas if specified on the data sheets.

9.0 Mechanical

9.1 Cable tray shall be installed to facilitate external and internal connections per drawings.

9.2 Internal walls shall be installed as requested so as to provide separation of battery rooms, personnel, or other equipment.

9.3 Removable lifting lugs shall be shipped with the PCR for off loading purposes (see Section 5.4).

9.4 Switchgear and other electrical equipment shall be installed within the PCR as specified. The equipment shall be electrically and mechanically functional after installation. Sufficient aisle space shall be provided to withdraw removable elements and otherwise properly maintain and service the equipment.

10.0 Electrical

10.1 Each Power Control Room shall have a power panel for enclosure services.

10.2 If enclosure services power is not provided from an external source, a transformer shall be provided capable of providing needed power for lighting and environmental equipment.

10.3 The interconnection of all installed equipment as defined in drawings and documentation attached shall be the responsibility of the manufacturer unless otherwise specified or agreed.

10.4 All equipment shall be functionally tested after installation in accordance with specifications.

11.0 Finish of Walls, Ceiling, and Roof

11.1 All steel structure members shall be cleaned prior to finishing.

11.2 Coating process shall be an electrostatically applied polyester powder with a final baked on average thickness between 2.0 and 4.0 mils.

11.3 Standard exterior finish shall be white.

11.4 Finish shall have a minimum pencil hardness of 2H as tested per ASTM D3363.

11.5 Finish shall pass the ASTM B117 salt spray test for a minimum of 1000 hours.

11.6 Finish shall pass impact testing per ASTM D2794 with minimum values of 160 in-lb. for direct impact and 120 in-lb. for reverse impact.

11.7 Test reports for compliance with 11.4, 11.5, and 11.6, shall be available upon request.

12.0 Finish of Structural Base Assembly

12.1 Base assembly shall be grit blasted prior to finishing.

12.2 Grit blast process shall comply with Commercial Blast Standard SSPC-6 as published by AISC.

12.3 Solvent cleaning is unacceptable.

12.4 An undercoat shall be applied to the entire base using an industrial grade, high solid, and high build epoxy. This undercoat shall be a minimum of 4 mils.

12.5 All structural elements including channels and angles shall be caulked to seal gaps and spaces.

12.6 An additional 4 mil undercoat shall be applied to the bottom of the base assembly.

12.7 The sides of the base assembly shall be finished using polyurethane paint to a minimum thickness of 2 mils.

13.0 Inspection and Testing

13.1 Component bill of material shall be checked for proper quantity, description, and part number.

13.2 Physical dimensions shall be checked against approved drawings.

13.3 All installed equipment shall be functionally tested and in accordance with specifications.

13.4 Manufacturer shall have in place a system of recording, correcting, and verifying resolution of discrepancies discovered during the inspection and testing process. The manufacturer shall be ISO 9001-2000 certified.

13.5 Certified production test reports indicating satisfactory completion of all inspection and test procedures shall be available upon request.

13.6 Upon request the equipment shall be made available for customer inspection prior to shipment.

13.7 Each PCR shall bear an Underwriters Laboratories (UL®) certified label if specified in the drawings or data sheets.

14.0 Documentation

14.1 Drawings

14.1.1 Prior to fabrication the following drawings shall be submitted by the manufacturer for approval.

14.1.1.1 Internal equipment layout diagram.

14.1.1.2 Side elevation view.

14.1.1.3 Base plan including mounting details, cable entry area, and door swing requirements.

14.1.1.4 Enclosure services electrical diagram.

14.1.1.5 Component bill of material indicating quantity, description, and part number.

14.1.1.6 Detailed electrical interconnection diagram for all equipment installed within the PCR.

14.1.2 Diagrams shall be based upon data sheets, interconnection documents, and system design requirements attached to this specification.

14.1.3 After the return of approval drawings or after any change made to previously approved drawings, the manufacturer shall submit a record copy of any and all drawings that contained revisions.

14.1.4 After completion of the inspection and testing procedures the manufacturer shall submit a complete set of "as built" drawings. These drawings shall function as a record of the final construction of the equipment at the time it left the factory.

14.1.5 Drawings may be provided in any of the following forms as requested by the customer:

14.1.5.1 Full size plotted reproducible drawings size as required. "D size" measuring approximately 34" x 22", "C size" measuring approximately 22" x 17", "B size" measuring approximately 17" x 11", or "A size" measuring approximately 11" x 8½".

14.1.5.2 Three (3) reduced photocopies of original plotted drawings.

14.1.5.3 Digital files in AutoCAD 2002 (xxxxxxxx.dwg) format.

14.1.6 Each drawing prepared by manufacturer shall show, at a minimum, the name, jobsite location, purchase order or contract number, and equipment identification number in addition to any information required by manufacturer.

14.2 Operating and Maintenance Manuals

14.2.1 At time of shipment the manufacturer shall provide three (3) copies of the operating and maintenance instructions for all major components contained in the PCR assembly. This does not include equipment provided "free issue" by the customer for installation within the equipment enclosure.

14.2.2 Manuals shall contain a table of contents to allow for easy reference.

14.2.3 Instruction Bulletins and manuals may be provided in electronic form (Adobe pdf format) on CD in lieu of paper copies.

14.3 Spare Parts List

14.3.1 Upon completion of the engineering phase, a quotation for one (1) year's recommended spare parts shall be submitted.

Notes:

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