# CenturyLink™
# Technical Publication

## Power Equipment and Engineering Standards



77385
Issue K
July 2015

# NOTICE

All requirements in this document are effective from the publication date of the document forward.

This document should be used in conjunction with CenturyLink™ Technical Publications 77350, 77351, 77355, and 77354; Telcordia® Recommendations; Alliance for Telecommunications Industry (ATIS) documents; American National Standards Institute (ANSI) documents; Institute of Electrical and Electronics Engineering (IEEE) standards; Federal Communications Commission (FCC) rules; the National Electrical Code (NFPA® 70); Underwriters Laboratories Requirements; Department of Labor - Occupational Safety and Health Standards (OSHA 29 CFR, Part 1910); and Federal, State, and local requirements including, but not limited to, statutes, rules, regulations, and orders of ordinances imposed by law. Detail engineering for CenturyLink™ sites shall meet all of the above references, as well as CenturyLink™ Standard Configuration Documents.

The origin of this Technical Publication 77385 was in 1996. Prior to that point, power requirements for USWEST were contained in Module C of Technical Publication 77351.

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Ordering information for CenturyLink™ Technical Publications can be obtained from the Reference Section of this document.

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**Tables**

# 1. General Requirements

## 1.1 General

This section is intended to provide general requirements that apply to all of the units of the document, which follow.

All power equipment shall be Manufactured, Engineered, and Installed in accordance with the following:

- CenturyLink™ Technical Publications
  - Detail engineering for CenturyLink™ sites shall meet all the standards stated herein;
  - CenturyLink™ standard configuration documents; and
  - CenturyLink™ fire and life safety practices.
- Telcordia® Recommendations
- Alliance for Telecommunications Industry (ATIS) documents
- American National Standards Institute (ANSI) standards
- Institute of Electrical and Electronics Engineers (IEEE) standards
- Federal Communications Commission (FCC) documents
- National Electrical Code (NFPA® 70)
- Underwriters Laboratories (UL®) Requirements
- RUS standards, except as modified by this document
- Department of Labor - Occupational Safety and Health (OSHA) Standards
- Federal, State, and local requirements including, but not limited to, statutes, rules, regulations, and orders of ordinances imposed by law.

All power equipment used by CenturyLink™ shall have passed through the CenturyLink™ Product Selection procedure.

Any changes made to requirements in this Technical Publication 77385 become effective as of the publication date of the revision, going forward.

CenturyLink™ prefers that all end equipment carrying Network traffic be powered by nominal -48 VDC power (the equipment shall be capable of accepting voltages at least from -42.65 to -56 VDC). The primary power plant is typically a -48 VDC plant, although in some microwave radio sites, the primary plant may be -24 VDC.

While some modern equipment does use the -48 VDC directly, much of the equipment needs to convert it to other nominal DC voltage levels, such as 3.3, 5, 9, 12, 24, 130, or 190 V. This is usually done on a power supply card in the shelf with on-board "brick" chip DC-DC converters. However, there are sometimes needs for bulk feeds to equipment at nominal +24 V, -24 V, -130 V, ±130, or ±190 VDC. In these cases, a large battery plant at the appropriate voltage can be used, or a bulk DC-DC converter plant (see Chapter 4 for converter plant requirements) can be placed and powered from the primary -48 or -24 VDC plant.

If there is equipment carrying Network traffic that needs an uninterruptible AC source, it most preferably would use a feed from an inverter plant (see Chapter 5 for requirements for inverter plants). In the case of very large uninterruptible AC needs, or Customer Premises installations (see Technical Publication 77368), a commercial UPS may be used (see Chapter 6 for requirements for UPS systems). (For further information on AC requirements, see Section 1.3.)

The use of a blowtorch, acetylene torch, fiber fusion splicing equipment, or any open flames and/or sparks are not permitted in any CenturyLink™ battery room, per CenturyLink's safety standards and the Fire Codes.

## 1.2 Reason For Reissue

This document is primarily being reissued to clarify power plant sizing rules, clarify minor wiring language, and merge combined company (Qwest, CenturyTel, Embarq, LightCore, etc.) power standards.

## 1.3 Requirement Applicability

The following applies:

| | |
|---|---|
| SHALL | When this designation is used in a requirement, it denotes a binding requirement (not optional) due to fire, life, or safety reasons. |
| MUST | When this designation is used in a requirement, it denotes a binding requirement, but does not involve fire, life, or safety. |
| WILL or SHOULD | When this designation is used in a requirement, it denotes a condition that is a CenturyLink™ preference. |

Note that regardless of the collocation rules listed in this document, if an individual CLEC ICA has differing language, the ICA is the governing document.

### 1.4 AC Requirements

There are three types of AC loads that may be required within a CenturyLink™ telecommunication site.

- Protected Loads — protected loads will use either an inverter (Chapters 5) or UPS (Chapter 6). If the inverter is operated in DC-preferred mode, or the UPS is "on-line" (aka double-conversion), there is no switching time (the power supplied is truly uninterruptible). If the inverter is operated in AC-preferred mode, or the UPS is line-interactive, the static transfer switch in the inverter/UPS will switch to backup power during a power "event" in less than 4 milliseconds.
- Essential Loads — those telecommunications and building AC loads that must operate during prolonged loss of commercial AC power. These loads are normally run off an on-site, auto-start, auto-transfer standby engine-alternator (Chapter 7). An example of an essential load is air-conditioning in a larger building in a hotter climate
- Nonessential Loads — those that can experience long periods of commercial power interruption without needing some form of backup. Generally, these loads are not switch-able to the standby source. Most building lighting qualifies as non-essential loads, for example. In smaller buildings, it may not be economical to provide two separate essential and non-essential buses. In those, buildings, if they are equipped with an on-site engine, generally all the loads are on the essential bus.

All installed AC equipment will be provided with adequate working space as defined in the National Electrical Code (NFPA® 70), Article 110.26.

AC equipment shall be capable of operating without damage from any input source with the following characteristics:

- The equipment shall be operational from a 60-Hertz (Hz) source ±10%.
- Voltage Limits — The limits shown in Table 1-1 are consistent with range B utilization limits of American National Standard Institute (ANSI) Voltage Rating for Electrical Power Systems and Equipment, and apply to sustained voltage levels:

**Table 1-1** Operating Voltage Ranges for AC-Powered Equipment

| Phases | Nominal Voltage | Voltage Limits | |
|---|---|---|---|
| | | minimum | maximum |
| 1 | 120 | 106 | 127 |
| 1 | 220/240 | 184 | 254 |
| 1/3 | 208/240 | 184 | 254 |
| 3 | 277/480 | 424 | 508 |

AC circuits shall use THHN or THWN type wire, color-coded in red, blue, black, white, yellow, brown, orange, and green per Table 1-2. THHN and THWN should not be used for DC applications except where they are run in conduit or within a bay where they are protected from abrasion or coldflow at impingement points (CLECs are exempt from this requirement for their runs after the point where CenturyLink™ has dropped DC power to them). The use of colored tape on both ends of the wire is acceptable for AC wire color coding, except that 6 AWG or smaller neutral conductors require a continuous white or natural gray outer finish along their entire length. All AC wire approved for CenturyLink-owned building applications shall be run in conduit, raceway, or metallic enclosure. Wire applications are defined in Chapter 9.

All AC neutrals shall be sized at the same size as the phase conductors, at a minimum.

AC wires used in RT/Prem applications do not have to be run in raceway or conduit if they are cords terminated in a NEMA® Twist-Lock plug. These wires must be fire retardant Hypalon coated or polyethylene (XLP-USE-2, or EPR-USE-2, or RHH/RHW-2).

AC power wire shall be copper conductor only within buildings owned by CenturyLink. The AC feeds from the house service panel (HSP) to the Power Distributing Service Cabinets (PDSCs) serving the rectifiers shall be dual feed for DC plants rated 2400 Amps and larger and/or where the AC service entrance size is 500 A or larger. One dual feed PDSC or two separately fed PDSCs will meet this requirement (if the separately fed PDSCs are served through step-up or step-down transformers, there should be one transformer for each PDSC). Attempt to evenly split the rectifier loads among the PDSCs when there are multiple PDSCs. PDSCs can be either stand-alone, wall mounted, or at the top of a rectifier bay. The PDSC feeds from the house service board shall be sized to the capacity of that PDSC, (i.e., a 600-Ampere PDSC shall be sized and fed at 600 Amperes). A PDSC shall be dedicated to that rectifier line-up which it is serving.

Rectifier circuit breakers shall be sized to the rectifier manufacturers' recommendation. PDSCs only need to be equipped with breakers for existing rectifiers. Future circuit breakers may be added when rectifiers are added to the power plant. The cabinet and the breakers will be rated for the available fault current (kAIC). (The fault current available at that point may need to be calculated by a Professional [P.E.] Electrical Engineer.) PDSCs for plants with an ultimate capacity of at least 2400 Amps DC should be rated at 600 Amps AC (and the feed to them should generally be at 600 Amps unless the entire site service entrance is not rated that high). In smaller sites the PDSC can be rated as small as 100 Amperes, or some smaller sites may not even have a PDSC, but will have the rectifiers fed from the primary AC distribution panel directly. Rectifiers fed from secondary AC distribution panels can only be fed from PDSCs dedicated to rectifiers. RT Sites that use a power pedestal for AC should be sized per Chapter 11.

All AC cabling in telecommunications equipment areas, (including power rooms), will be enclosed in conduit, or approved cable raceway. Armored power cable (type AC, aka BX) or Liquid-Tite™ will only be used in special applications where rigid conduit is not practical and as specified by the NEC® (see Chapter 9 of Technical Publication 77350 for rules governing the use of AC conduit types). Flexible metal conduit shall not be used ever in power rooms per NEC® Article 348.12(3), unless it is type MC.

All rigid, EMT and metallic liquid tight flexible conduit runs shall be made with steel compression or steel threaded type fittings, steel couplings, and junction boxes, unless they are larger than 1¼" diameter; in which case, set screw fittings are allowed, but not preferred.

No PVC conduit or tubing shall be used of any kind indoors or exposed outdoors. It may be used for underground or concrete pour applications for AC service. Horizontal runs of conduit across concrete pads outdoors must be EMT or rigid metal. AC feeds from the raceway or junction box to the rectifier/charger must be run in either thin wall or Liquid-Tite™ conduit. Flexible conduit shall not be installed on cable racks.

Collocators in CenturyLink-owned space may have CenturyLink-provided convenience outlets in their space or bay (depending on the ICA, there will usually be three in a cage, for example). These outlets are only for temporary power to test equipment and the like, and not for permanent powering.

If a collocator desires a permanent AC power feed, they may order standard non-essential AC, essential AC (backed by an engine, but interruptible during transfer events), or uninterruptible AC feeds (typically provided by a CenturyLink™ inverter fed from a CenturyLink™ Local Network DC plant); or, with CenturyLink™ permission, the customer may install an inverter in their space fed from CenturyLink™ DC feeds.

A customer-provided inverter must meet NEBS™ Level 1 (see Section 1.6) for NEBS™ spaces, and have its neutral and ground wired in accordance with Tech Pub 77355. For non-NEBS™ spaces, the inverter must be Listed, and if not caged must be separated from CenturyLink equipment by at least 6 feet if it is not NEBS™ Level 1. If the customer desires a maintenance bypass circuit for their inverter(s), they must order a permanent non-essential or essential AC feed from CenturyLink™.

A collocator is not allowed to install any rechargeable batteries (or UPS containing them) in their space inside a CenturyLink™ facility. A collocator is also not allowed to place flywheels in their space. They may install these items in an adjacent collocation.

For adjacent collocation (CLEC leasing property from CenturyLink in a separate CLEC-owned structure), the CLEC may procure their own AC feed from the electric utility, or get CenturyLink™-provided AC via one of the circuit types previously listed. While the CLEC can avail themselves of a generator-backed essential AC feed, they aren't allowed to install a permanent engine on CenturyLink™ property. When an adjacent collocation receives AC power from a CenturyLink™ structure, the AC must have an SPD where it leaves the structure, and the CLEC would be wise to use a TVSS on their end as well.

**Table 1-2** Color Codes for AC Wire

| Nominal Voltage | Phase/Line/Leg | Color |
|---|---|---|
| 240/120 | 1 | Black |
| 208/120 Y | A | |
| 240/120 Δ | | |
| 240/120 | 2 | Red |
| 208/120 Y | B | |
| 240 Δ | | |
| 208/120 Y | C | Blue |
| 240/120 Δ | | |
| 240/208 Δ | B | Orange |
| 480/277 Y | | |
| 480/277 Y | A | Brown |
| 480/277 Y | C | Yellow |
| Grounding | | Green or |
| | | Green w/yellow stripe |
| | | or bare Copper |
| 120/208/240 | Neutral | White |
| 277/480 | | or Gray |

### 1.4.1 AC Surge Suppression

Transient Voltage Surge Suppressors (TVSS) [aka Surge Protection Devices (SPDs)] must meet and be Listed to the latest edition of UL® 1449, the ANSI/IEEE C62 series document, and NEC® Articles 280 for surge arrestors over 1000 V, or 285 for SPDs. It is also preferable that TVSS/SPDs and surge arrestors be tested to NEMA® LS 1.

The SPD shall be as close as possible to the AC source (18 cable inches or less with no bends in the wire is preferred, with a maximum of 4 feet except when not physically possible). Install the SPD on the load side of the AC entrance unless also Listed and rated as a "Surge Arrestor". (If installed on the line-side, it is replaced "hot", so that placement is discouraged, especially when CenturyLink™ doesn't own the transformer serving the building). Install SPDs per the manufacturer.

If the SPD is connected directly to the hot buses, it must have a minimum surge rating of 69 kAIC. If connected through breakers (disconnects are preferred because it allows replacement without de-energizing the site), the breakers should be a minimum of 30 Amps (preferably 60 Amps or larger).

Downstream TVSSs are generally discouraged as unnecessarily costly unless they come as an integral part of the equipment (such as in a power strip or PDU), or are used to solve a specific proven problem.

For SPDs in COs, radio sites, or large Data Centers, the minimum kA suppression rating is 200 (400 or more preferred), with a minimum rating of 5000 J. These larger site TVSSs should provide common and transverse mode suppression. For TVSS in RT locations or fiber regen huts, minimum suppression is 100 kA (200+ preferred), with a minimum rating of 2000 J (3000+ preferred). SPDs used on 208 or 240 VAC sites should not have a breakdown rating > 600 V ( preferably 400-500 V), while those for nominal 480 VAC should have a breakdown typically from 800-1000 V.

## 1.5 Generic Technical Requirements

All power equipment must conform to American National Standards Institute (ANSI) requirements, and shall be Listed to the appropriate UL® (Underwriters Laboratory) standard (if no other standard applies, UL® 1950/60950-1 probably does). Power components (rectifiers/chargers, controllers/monitors, inverters, UPS, converters, engine-alternators, transfer systems, generator set plugs, AC power cabinets, and power pedestals) shall meet the requirements of the National Electrical Code.

Powering equipment with non-metallic components must be fire-retardant rated as UL® 94-V0 and have a minimum Limiting Oxygen Index (LOI) of 28% or greater.

Grounding cable (that is not manufacturer internal shelf and intra-bay wiring) in all larger sites (including all COs) shall be green in color, green with yellow stripe, or bare; and be in accordance with CenturyLink™ Technical Publication 77355.

All active electronic devices shall be solid-state.

All relays will be solid-state or provided with dust covers.

Protection devices can be either fuses or circuit breakers. All protection devices shall be sized at a minimum of 125% of the peak load and rated for the available fault current (kAIC) which meets or exceeds the maximum available fault current at that point in the system. All fuses or circuit breakers must be AC rated for AC circuits, and DC rated for DC circuits. One spare fuse shall be provided for every 5 fuses ordered.

Fuses and breakers feeding CenturyLink™ equipment must be coordinated from a size and time-current curve perspective to increase the chances that the downstream protector is the first to blow/trip. This does not apply if the relationship is 1-to-1 (in other words, the upstream fuse or breaker only feeds 1 downstream fuse or breaker).

Fuse blocks and circuit breakers shall be front accessible, and labeled to indicate their Ampere rating and circuit assignment (frame/shelf). Circuit breakers shall be labeled according to the NEC. When circuit breakers are mounted horizontally, the "UP" position shall be "ON". All circuit breakers should be equipped with shields to prevent accidental tripping.

Renewable link and H type fuses are not acceptable for use. All internal circuits shall be protected with fuses mounted in a "dead front" fuse holder. Internal fuses must be easily accessible. Each fuse shall be provided with a blown fuse indicator connected to an alarm-indicating lamp on the control panel. All power semiconductor circuits shall be fused using KAA type fuses to prevent cascading or sequential semiconductor failures. All electrolytic capacitors shall be fused. A maximum of two capacitors shall be protected by one fuse.

Parallel fusing (even with circuit breakers) is not allowed, per NEC® Article 240.8.

If circuit breakers are used, they shall be thermal-magnetic and trip free. Contacts shall not be capable of being manually held closed during an overcurrent condition.

All power semiconductor circuits shall be fused to prevent cascading or semiconductor failures.

Insulating materials in arcing paths of contacts, fuses, etc. shall be non-tracking type. Insulating material that independently supports combustion, or ignites from a spark, flame, or heating shall not be used. The combustion products of insulating materials shall not combine with normal air to form acid, toxic, or other deleterious products.

All DC runs under a raised floor or in a ceiling that is also used as an air plenum must be in a plenum rated raceway, metal conduit, or metallic liquid tight flexible conduit; or must be plenum-rated or MI or MC type cable.

If forced air-cooling is used to keep power components cool the blower motors shall be equipped with sealed ball bearings, (this does not pertain to the HVAC system). Blowers shall be redundant. A failure of a blower unit shall generate an alarm. All air inlet and exhaust openings shall be protected with expanded metal guards.
The structural members of power equipment shall not carry or conduct load currents. Ferrous materials shall not be used for current carrying parts.

Metal parts, unless corrosion resistant shall have a corrosion protection finish. Ferrous parts not required to meet an appearance criteria shall have zinc plate, cadmium plate, or an approved equivalent finish applied. The minimum thickness of the finish shall be 0.0002 inches, plus a chromate treatment. When dissimilar metals are used in intimate contact with each other, protection against electrolysis and corrosion shall be provided. This protection may be metal plating, or use of a suitable insulating material (including a thin film of anti-oxidant if electrical conductivity needs to be maintained).

Nut, bolts, and screws for connection and mounting should be grade 5 or equivalent.

Wire used for carrying load current shall be copper conductor only. Wire subject to hinged action shall be of the stranded type.

Copper crimp connectors (Listed for the application and applied with tools they were cross-Listed to), wire wraps or latching plugs shall be used for all DC wire connections to CenturyLink™ CO equipment shelves that would carry lifeline traffic (it is also encouraged for RT cabinets and Prems, but may not always be possible in small DC plants that take up 1 or 2 RUs). Use anti-corrosion compound on power connections.

Bus bar shall be of 95% hard-drawn copper (UNS-C11000 or ETP-110).

All individual components of power equipment should be designated. Each Test Point must be accessible and assigned a designation starting with TP1. Designations shall be shown on the schematic drawing, on or adjacent to the point being designated.

Equipment that provides power (i.e. power plants, converters, inverters, BDFB, miscellaneous fuse panels, etc.) shall be designated as follows:

- Fuse or circuit breaker panels as panels;
- Rectifiers with a G and a numeric designation (G-01, etc.), and;
- Rectifier shelves as a shelf.

## 1.6 NEBS™ Requirements

The requirements of this section only apply to CenturyLink™ equipment in NEBS-compliant equipment spaces. NEBS™ certification and compliance of CLEC equipment placed in CenturyLink facilities is the responsibility solely of the CLEC.

The supplier of power equipment going into NEBS-compliant CenturyLink™ telecommunications areas shall meet the requirements of Telcordia® GR-1089-CORE, and GR-63-CORE, as the GRs pertain to its equipment. Pertinent requirements and NEBS™ compliance are determined by the third party test lab for equipment supplied to CenturyLink. Depending on the technology, CenturyLink™ Product Selection may also require compliance to other Telcordia® GRs (many of them in the NEBS™ family) relevant to the technology and the environment into which the equipment may be placed.

The supplier must test to the GRs as required by CenturyLink. CenturyLink™ requires that all NEBS™ tests be performed at an independent third party test facility. These test facility must be accredited as part of a laboratory accreditation program sponsored by one of the following, American Association for Laboratory Accreditation (A2LA), National Voluntary Laboratory Accreditation Program (NVLAP), National Recognized Testing Laboratory (NRTL), and Underwriters Laboratories. Test facilities must be certified for those fields of accreditation that encompass NEBS™ requirement. CenturyLink™ cannot and does not certify testing facilities. CenturyLink™ will however accept test data from a supplier's testing facilities provided it is accredited to perform the test and observed by a member of another accredited laboratory as defined herein. CenturyLink™ will not accept test reports written by the supplier or a supplier's interpretation of a test lab report. CenturyLink™ will only accept test reports written by the independent test lab performing the work or by the representative of the observing third party lab. All test reports must be written on the letterhead of the lab.

All components shall be tested as a system. However, if individual components or subsystems have been tested a letter from the testing lab stating that the assembly of the unit or subsystems into the system will not change the NEBS™ data will be acceptable.

Note that wire and connectors are not tested to NEBS, but do have to be Listed. Equipment placed in non-Network areas (such as AC equipment or an engine in their own room) also do not have to be NEBS-tested, but must be Listed. Note also, that only equipment to be used in NEBS™ Earthquake Zones 3 and 4 must be tested to Zone 4 (equipment for use in COs in Zones 0-2 need only be tested to Earthquake Zone 2 criteria). Not all CenturyLink™ network equipment spaces/sites are NEBS-compliant. As a general rule of thumb, if the Network equipment area has an automatic fire suppression system, the equipment in it is not required to be NEBS-compliant.

Note that the lab testing requirements listed in Table 1-3 apply to only a sample of the equipment (not every piece leaving the factory must be tested). Note also, that these are the minimum requirements. It would be desirable, for example, if Customer Premises and CEV DC power equipment that are to be placed in Earthquake Zone 3 or 4 were tested to those criteria, but it is not absolutely required.

**Table 1-3** Summary of Minimum Lab Testing Requirements for DC Power Equipment

| Requirement | Site Type | | | |
|---|---|---|---|---|
| | **NEBS™ CO** | **CEV/C, UE, hut** | **RT Cab** | **Prem** |
| Listed | X | X | X | X |
| NEBS™ 1 | X | X | X | |
| Hardened | | X | X | |
| NEBS™ 2 | X | | | |
| EMI NEBS™ 3 | X | X | | |
| ESD NEBS™ 3 | X | X | | |
| Earthquake | X | | | |
| NEBS™ 3 | X | | | |
| NEBS™ Other | X | | | |

While Listing to a UL® standard denotes that the product is safe from a fire-safety perspective, it does not necessarily mean that the product will continue to work after being subjected to certain types of abuse. While some NEBS™ Level 1 requirements are similar to UL® safety tests, and can be done by the same lab, NEBS™ typically stresses equipment far beyond what UL® specifications require.

A detailed summary of NEBS™ Levels 1, 2, 3, and "Other" requirements is given in Telcordia® SR-3580; however the Levels generally mean:

- Equipment complying with NEBS™ Level 1 is not harmful to other nearby equipment. It will not emit EMI harmful to other equipment when its doors/shields are in place, will not sustain flame, will safely conduct internal short circuits out through the safety ground system, is Listed to the appropriate UL® standard, will withstand low-level lightning and AC power transients, and has its higher voltages shielded from accidental contact, and properly labeled.
- Equipment complying with NEBS™ Level 2 (in addition to not being harmful to nearby equipment, including with its EMI shields/doors open), will withstand some mild abuse; such as Zone 2 earthquakes and vibration, some temperature and humidity variation, some airborne contamination (including mild corrosive exposure), mild ESD while in-service, radiated and conductive/inducted EMI when its shields/doors are closed / in place, higher level lightning and other AC power transients, incoming conducted emissions on power and signaling leads, and mild DC overvoltage.
- Equipment complying with NEBS™ Level 3 meets the highest level of robustness to abuse (in addition to meeting all the Level 1 and 2 criteria). Additional testing includes: short-term wider-range temperature and humidity fluctuations; high terrestrial altitude operation; reliability after transportation, storage, and handling abuse; Zone 4 earthquake immunity; ESD immunity during poor-ESD maintenance handling; immunity to electrical fast transients; minimal radiated or conducted EMI with the shields removed or doors open; incoming conducted emissions on data leads; and protector coordination.
- "Other" NEBS™ requirements include: space and weight, equipment air filtration (if needed), heat dissipation, acoustic noise, etc.

## 1.7 Generic Alarming Requirements

All provided alarms will have a set of dry contacts so that the alarm can be remoted. The connecting point for these contacts will be easily-accessible. All analog monitoring points within the equipment will be equipped with terminal strip access for attaching remote monitoring devices. The connecting point for analog monitoring points will be located near the alarm connecting points and be easily accessible.

All DC circuit breakers shall generate an alarm signal when in the tripped state (electrical or midtrip type breakers). Battery disconnect breakers shall also generate an alarm when turned off (mechanical trip). For other breakers, whether to use breakers that generate an alarm in the off state (mechanical and electrical trip) is a decision left up to the Engineer.

The status indicators and alarm outputs shall be in the form of visual indicators in the plant (preferably lighted); and electrical signals for alarm sending circuits, and for connection to the office alarm system. The visual alarm and status indication system shall have its own dedicated power supply circuit, operating from the plant voltage. This supply shall have an overcurrent protection device that will send a visual alarm when it has operated, or power has been removed from the "control and status" system. Color-Codes for visual equipment indicators will be as follows:

**Table 1-4** Color Codes for Equipment Visual Indicating Lights

| Color | Description |
|---|---|
| Green | Indicates proper operation of the system or equipment. |
| Amber, Orange, or Yellow | MINOR/PRELIMINARY — indicates an abnormal operating condition within the power system or equipment that requires attention, but power service to the load is not currently affected. |
| Red | MAJOR/CRITICAL indicates a failure that currently affects power service to the load, or a failure, which may mask an alarm, associated with a service-affecting problem. |
| White | Signify conditions that have none of the above connotations of red, yellow, or green. |

The alarm output for the office alarm system may have multiple outputs for each alarm (e.g., one for an existing local audible alarm system, one for existing local visual alarm indications, and one for a remote alarm system). If only one set of contacts exists for each alarm, they can be wired to all 3 systems (audible, visual, remote) if necessary (local audible and visual systems are much less common now than they once were). In some cases, the power equipment may have its own audible and visual alarm system. The contacts for the alarms shall be capable of supporting 60 VDC and 0.5 Amperes, and shall be electrically isolated from each other and the frame ground.

It is desirable that an Alarm Cut-Off key or button (ACO) be provided to inhibit the office audible alarm function, without interfering with the visual or remote alarm systems.

A method shall be available to actively test all status indicators to verify they are in working condition.

Distribution fuse fail alarms for BDFBs (classified as Major in criticality) in the IOF areas must be run to the local e-telemetry device. Alarming miscellaneous fuse panels remotely may be optional depending on the legacy CenturyLink™ company, since the served equipment may signal the loss of power. The criticality of the equipment served may also play into the decision as to whether or not to alarm a miscellaneous fuse panel remotely. These alarm leads must be run in the switchboard cable rack.

Power alarm and monitoring leads that are within the power area only may be run on the side of the cable rack, on the horns, or on the hangers. Waxed 9-cord shall be used for securing these leads. Clips or wire ties are not acceptable for securing the alarm wires in this application in a Central Office.

Engine alarm leads (or other power alarm leads from non-traditional equipment areas without cable racking) may be run in conduit (inside the engine room, those leads must be run in conduit).

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**Figures**

# 2. DC Power Plants, and Rectifiers

## 2.1 Overview

This unit covers requirements for DC power plants and rectifiers used within telecommunications facilities.

## 2.2 General DC Power Plant Requirements

One powering scheme for a Central Office is shown in Figure 2-1. There are many other possible configurations. A characteristic powering scheme for an Outside Plant equipment enclosure (e.g., CEV, cabinet, Customer Premises site, etc.) is shown in Figure 2-2. Figure 2-3 shows a characteristic-powering scheme for a radio site.

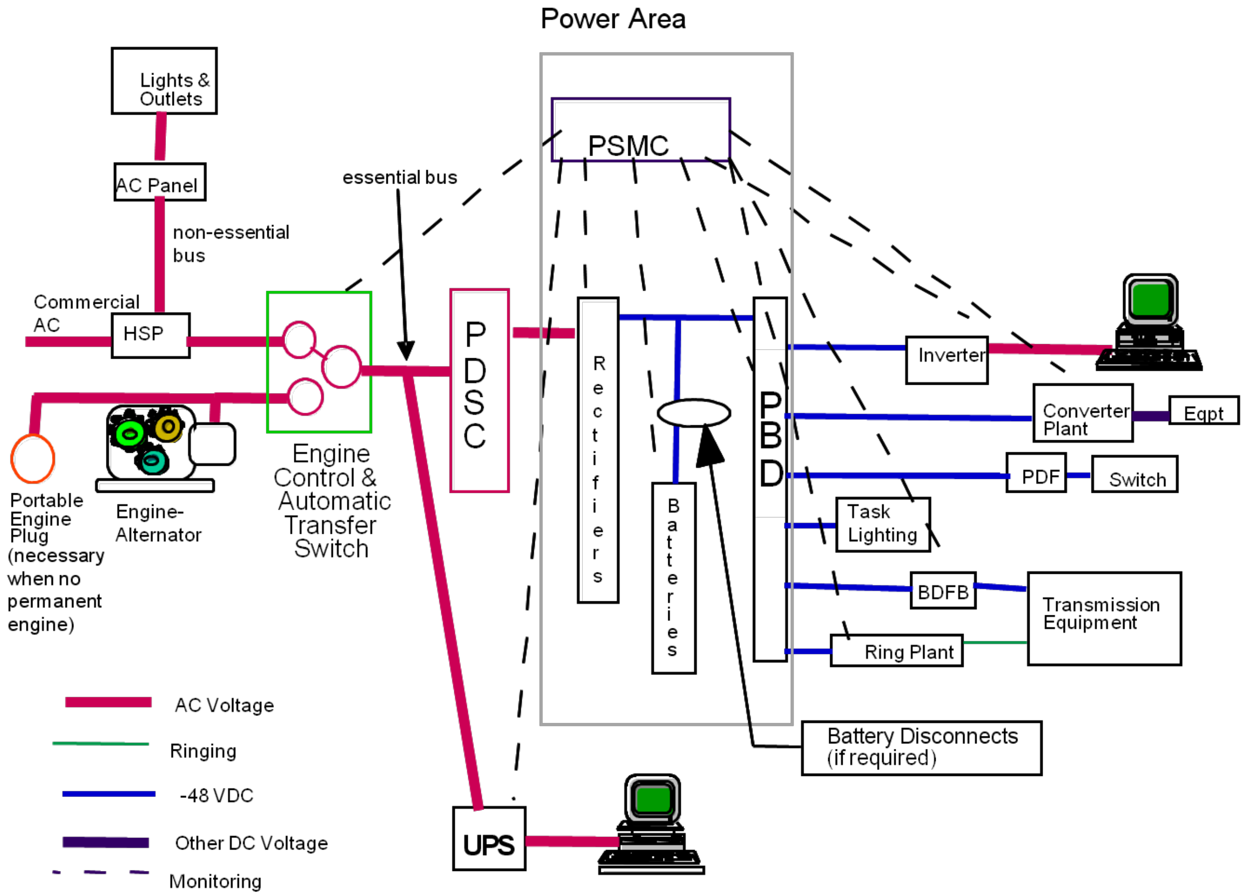


**Figure 2-1** A Powering Scheme for a Central Office

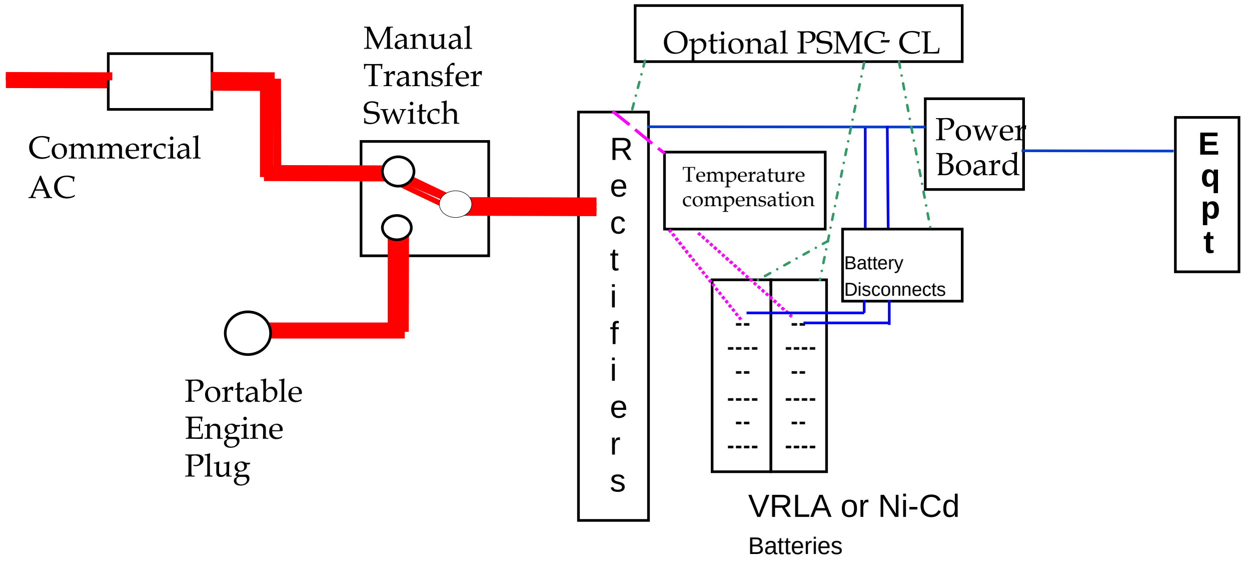


**Figure 2-2** Typical Outside Plant Equipment Enclosure Power Scheme

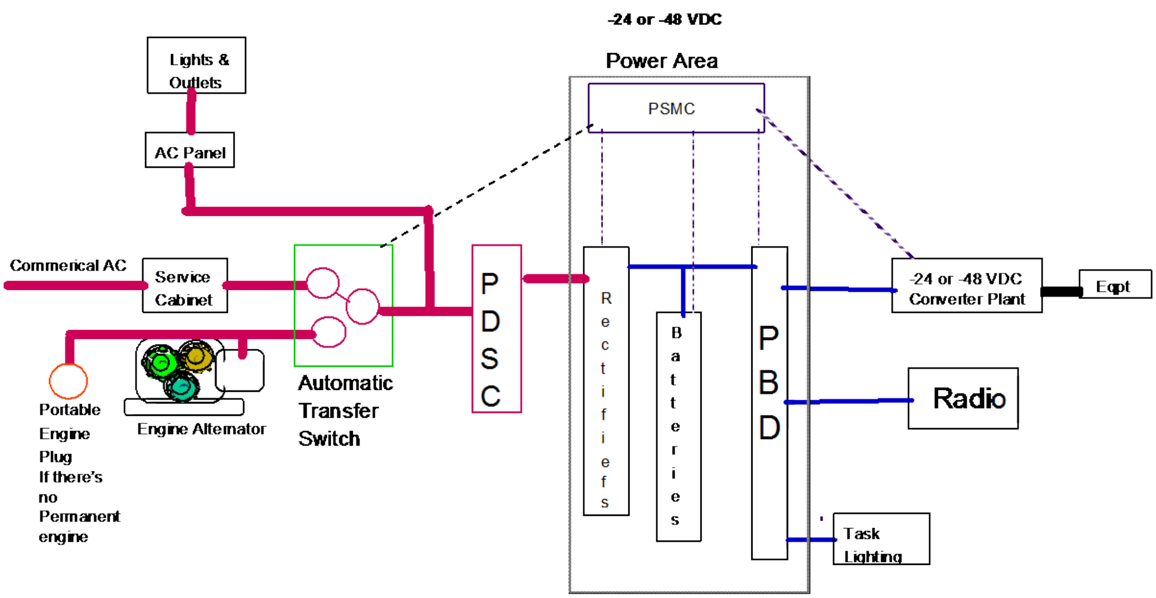


**Figure 2-3** Typical Radio Site Power Scheme

The principle components of the power distribution plant are:

- LOCAL AC POWER DISTRIBUTION —, which includes conduit, cabling, fasteners and protective equipment. The PDSC is an Essential AC panel that feeds the rectifiers.
- CHARGING/RECTIFIER EQUIPMENT — consists of rectifiers and associated equipment to convert AC power to DC power at voltages suitable for CenturyLink™ applications.
- TEMPERATURE COMPENSATION — and/or charge current limiting may be separate or an integral part of the charging equipment for use with VRLA batteries. Temperature compensation measures battery temperature(s), and adjusts the plant voltage accordingly to limit recharge current to the batteries thereby helping to reduce the risk of thermal runaway. The temperature sensing is preferably done once per string on the most negative cell post of that string; and the control of the power plant float voltage is adjusted based on the highest battery temperature measured. Charge Current Limiting simply limits the available charge current to the batteries (either to prevent thermal runaway or prevent overload of the rectifier current limiting circuitry in the case of super™/ultra™ capacitors).
- STORAGE BATTERIES — provide a source of DC power to the equipment when AC is not present, until the AC can be restored. They may also provide filtering of the rectifier output for some older types of rectifiers where the filtering wasn't integral to the rectifier output.
- DISCHARGE BAYS — contain the control and output circuits; including fuses and/or circuit breakers, shunts, meters, bus bar, alarm circuits and other equipment necessary for plant operation. May be the same as the PBDs described below.
- BATTERY DISTRIBUTION BOARD (BDB), or POWER BOARDS (PBDs) — is the primary power distribution within the DC plant (the originating PBD includes the controller). It is powered directly from the batteries and rectifiers. In addition, it contains the primary cable protection equipment, and shunts. The BDB may also contain meters and alarms. In some plants, these bays may contain any combination of one or more of the following: multiple rectifiers (ferroresonant rectifiers 200 A and larger are often a bay unto themselves), the PDSC, the controller, the power monitor (if separate from the plant controller), primary distribution fuses and/or breakers, converter plants, and residual ring plants.

- SECONDARY DISTRIBUTION EQUIPMENT — is fed from the PBDs. Secondary distribution includes Power Distribution Fuse Boards (PDFBs) for switches (they are known by many other switch-specific manufacturer names, such as LPDU, PD, PDF, PFD, GPDF, etc.), Battery Distribution Fuse and Circuit Breaker Boards (BDFBs and BDCBBs), Area Bus Centers (ABC), and protective equipment. The PBDs and secondary distribution equipment may be combined in smaller power plants.
- CONTROL VOLTAGE — is the voltage used to operate alarm relays and control circuits in the power plant. The primary voltage of the plant should be the control voltage. This power is often provided off a small fuse panel called the Alarm Battery Supply (ABS).
- CONVENTIONAL CONTROL and/or POWER SYSTEM MONITOR CONTROLLER (PSMC) — there are two types of DC battery plant controllers used in CenturyLink: a conventional rectifier controller, and a combined rectifier controller / power monitor. When the power monitor is part of the controller, it makes reading power information via the monitor much simpler (there may also be stand-alone power monitors coupled with conventional controllers in some sites/plants). The Conventional Controller provides the interface between the rectifiers and the plant for "on and off" control under normal and adverse conditions. Both the Conventional Controller and a PSMC may provide for rectifier and plant alarms, and contain the visual readout devices for operation of the plant. They provide the means to assess the status of the elements of the power plant (with indications provided locally and remotely) that will permit determination of the impact of the alarm. All DC plants should only have a single main controller for all the rectifiers connected to that plant (sub-controllers that talk to the main controller are permissible), and no rectifier should be hooked up to DC plant busses without being connected to a controller, except in a temporary emergency. Monitors for use in larger sites shall be capable of monitoring plant alarms and any other alarms connected to them. Power monitors also measure analog values, such as voltages, currents, and temperatures. All power monitors shall have local port (serial or IP) access, and preferably be capable of dialup and emulation of a dumb terminal (i.e. VT100).

DC Grounding (and grounded) connections for electronic equipment locations shall be of the two-hole crimp (preferred), exothermic weld, or amphenol type (single-hole lugs are allowed for chassis grounds and for grounds where manufacturer specifications call for wire smaller than 14 AWG). Mechanical connectors or connectors that depend solely on solder are not acceptable.

All DC power connections for both supply and return shall use crimp type copper connections and grade 5 steel nuts and bolts. Connectors for direct battery connections are defined herein. Aluminum connectors shall not be used. Power connectors will be configured as follows:

- Within the supplier's equipment, power connections will be configured to meet the supplier's requirements.
- Between the supplier's equipment in the bay and the top of the bay, connections can be one-hole or two-hole crimp, depending on equipment design.
- All connections to a battery return bus bar must be a two-hole crimp only. Exceptions to the “two-hole” requirement are allowed for battery return bus bar rated at 50 Amperes or less.

Details for ground conductors can be found in CenturyLink™ Technical Publication 77355, "Grounding - Central Office and Remote Equipment Environment".

RHW, RHH or XHHW Class I stranding are the preferred DC power and grounding cable types (for wire sizes smaller than 14 AWG, TFFN is allowed as long as it is protected at all tie points and points of impingement). This requirement does not apply to equipment in the CLEC area nor power runs to the CLECs, and is for new builds, and not augments or changes.

All power equipment (including rectifiers, batteries, ring plants, fuse panels, etc.) to be used in remote equipment enclosures (e.g., CEVs, huts, Customer Premises sites, RT cabinets) shall be fully front accessible where rear access will be needed and the equipment does not have a rear aisle or rear access.

It is preferred that the shunt for power plants rated at 800 Amperes or larger be in the battery return (grounded) side of the charge/discharge bus bar. For bus bar type and distributed type power plants (those without a remote chandelier), the shunt can be in the hot distribution and/or battery bus bar(s) located in the power board(s).

Low voltage disconnect devices are normally only permitted in series with the battery strings, not in series with the load (see figures 2-1 and 2-2) except for DSL load-shedding (when it is only allowed in series with the DSL loads). It is preferred that LVDs not be used at all for DSL (unless DSL load shedding cannot be accomplished by the DSL equipment itself). LVDs are required (usually built into the battery charge controller) for solar stand-alone sites.

Broadband load shedding times typically vary from 5-30 minutes for FTTP and for POTS/DSL combo cards not carrying video, and can be up to 90-120 minutes for video services from DSL cabinets not at the customer’s premises.

## 2.3 Charging Equipment (Rectifiers) and Their Controller

For proper plant operation, charging/rectification equipment shall have the following features or capabilities, whether they are required at the time of installation or not:

- HIGH VOLTAGE SHUTDOWN — for ferroresonant rectifiers will occur when high voltage on the DC output trips the high voltage alarm and causes rectifier shutdown. The high voltage shutdown setting shall be adjustable. Switch mode rectifiers' HVSD is controlled by the plant controller.
- REMOTE RESTART — allows a rectifier to be turned on from a remote location after high voltage shutdown (usually be a ground signal on the R lead of the TR pair).
- REMOTE STOP — permits rectifier shutdown. Remote stop may be used during transfer from commercial to standby AC power or vice-versa or for energy management. This is usually accomplished by a ground signal to the T (terminate) lead of the TR pair.
- CURRENT LIMITING — protects the rectifiers/charging equipment when operating in an overload condition. The current limiting circuit is normally designed so maximum output current will not exceed 120 percent of rating. The current limiting shall generally be set between 100 and 110% (alarm threshold levels for rectifier overcurrent are provided in Table 13-18).
- CURRENT WALK IN — controls the charging current from a gradual increase to full output. This feature limits the surge of AC power required after AC power restoration and allows the control circuits to stabilize. It typically takes at least 8 seconds for a rectifier to go from 0 to full load Amperes.
- LOCAL OR REMOTE SENSING — refers to the point where the output voltage is sensed for the feedback circuits. Local sensing (sometimes called "internal sense") causes the rectifier to regulate the voltage at its output terminals. Remote sensing (sometimes called "external sense") carries the regulation point to the battery terminals or some other selected point. Remote sensing is the only type that is allowed in plants with MTBs. Under no circumstances will local and remote sensing be mixed in the same power plant.
- AUTOTRANSFORMER — provides voltage matching of the AC supply, maintaining the nominal design voltage to the main transformers.

- SEQUENCE CONTROL — provides the ability to turn rectifiers on sequentially, so that when AC is restored the load imposed upon the Standby engine or AC transformers by the rectifiers is sequential rather than block. Sequence control may be provided in rare cases from the power plant controller where it is necessary due to building engine load issues or rectifier component failure issues (see Chapter 8, Paragraph 8.5.)
- PARALLEL CONTROL — is when all rectifiers are connected to the output DC bus at all load levels. The capability of each rectifier to monitor battery voltage individually and supply current on demand is called parallel control of charging units.
- TEMPERATURE COMPENSATION — Rectifiers to be used with Valve-Regulated Lead-Acid (VRLA) batteries shall have slope temperature compensation charging features utilizing temperature sensors located at the batteries. The compensation shall be capable of lowering the voltage of the rectifiers to within one Volt or less of open-circuit voltage at 55° C (131° F).
- VOLTAGE ADJUSTMENT — Rectifiers to be used with VRLA batteries shall be voltage adjustable, both locally and remotely (e.g., sense leads).
- ALARMS and ALARM SETTINGS — shall be in accordance with Chapter 13 of this publication.

For proper plant operation, rectifiers/charging equipment may have the following additional features depending on the system size and equipment served:

- PROPORTIONAL LOAD SHARING — can be connected with other rectifiers and set to carry the load in proportion to the rating.
- ENERGY MANAGEMENT — automatically places rectifiers above and beyond those needed to meet the load into hot standby. This allows the remaining rectifiers to save overall plant kW-hrs by having those rectifiers operate closer to full load (where they are more efficient at converting AC to DC).
- PHASE SHIFTING — provides the ability for the AC input to be shifted to minimize the power factor in the AC input line (also known as power factor correction or PFC).

For single-phase switchmode rectifiers (including those that masquerade as 3-phase rectifiers by having 3 single-phase rectifiers in a common chassis), the AC current total harmonic distortion (THD) reflected back toward the source must be limited to 15 percent at full load. The third, fifth, and seventh harmonics must be 12 percent or less.

For true 3-phase SMRs, the AC current THD reflected back toward the source must be limited to 35% at full load. The 3rd , 5th and 7th harmonics must be 20% or less.

On power plants that use the controller to regulate float voltage, if the controller fails, the rectifiers shall default to 2.17 to 2.23 Volts per cell for long-duration flooded batteries and low-gravity VRLA batteries, and 2.25 to 2.27 Volts per cell for typical VRLA batteries.

At startup, the total peak inrush current must not exceed ten times the steady state current requirement.

The power factor must be no less than 0.8 lagging or leading at loads of 10% or greater.

The acoustic noise shall be a maximum of 65 decibels audible (65 dBa), measured from a distance of two feet in any direction.

The DC ripple noise coming from the rectifiers shall be less than 35-decibel reference noise C-Message (35 dBrnC) and less than 300 mV peak-peak and 100 mV rms.

Power equipment for use in hardened equipment locations shall be capable of reliable operation at operating temperatures between -40 degrees and +65° C (149° F).

Any new rectifier should be capable of providing 60 V (for a nominal -48 V plant) or 30 V (for a nominal 24 V plant)

Each rectifier larger than 65 Amps should have its own dedicated AC connection (and it is recommended for even smaller rectifier sizes in COs, radio sites, and fiber regen huts). Where this is not the case in COs, radio sites and fiber regen huts, the "spare" rectifier becomes the sum of the rectifier output currents that would be lost if a single AC branch circuit were lost (typically due to a tripped breaker). In customer premises and outdoor cabinet installations the shelf is often configured for two feeds, one for the even numbered rectifiers and the other feed for odd numbered rectifiers. One AC circuit cannot be used to power an entire RT or Prem rectifier shelf (unless the total shelf output capacity is less than 21 Amps nominal).

AC connections must be run in conduit or other raceway. Prems, where AC is provided by the customer, are exempted. Hard wiring is preferred, but locking-type plugs are allowed. If a standard three-prong plug is used, a plug with a ground screw (or similar to prevent the plug from being pulled out), should be used whenever possible. If this is not possible, the Customer must sign a waiver absolving CenturyLink™ of liability in case of power plant outages (except for wall-mounted power supplies and equipment or equipment plugged into a rack-mount PDU in the same bay).

Green wire grounding (ACEG or "safety ground") must be run with each AC rectifier feed for individually fed rectifiers. For multiple rectifiers fed from one source, each AC feed shall have its own ACEG to the shelf or AC feed at the top of the power board. All ACEG must be run in accordance with the NEC®.

Bus bar type power plants powering a switch in a traditional isolated-integrated ground plane office must use a remote ground window (even if it's only a few feet away), per Tech Pub 77355.

Collocators may install rectifiers in their space (fed from CenturyLink-provided essential, non-essential, or uninterruptible AC feeds) with the permission of CenturyLink. However, these rectifiers may not have batteries, flywheels, or fuel cells connected to their output bus as a backup DC source (unless it is an adjacent collocation). Customer-provided rectifiers must meet NEBS™ Level 1 (see Section 1.6) for NEBS™ spaces. For non-NEBS™ spaces, the rectifiers must be Listed. The rectifiers used must meet the maximum reflected THD specifications cited previously in this section.

## 2.4 Engineering Guidelines

When sizing power plants, the following criteria shall be used:

- List 1 drain is used to size rectifiers and batteries, and cable voltage drop (see Section 9.2 for the details on voltage drop sizing rules) in some cases (size batteries at the List 1 drain + 10% to account for the average increase in current of constant power loads during a discharge, and cable voltage drop in some cases is done at 125% of the List 1 drain to account for the peak current at the lowest possible voltage of a constant power load). List 1 is the average busy-hour current at normal operating voltage. While manufacturers may provide NEBS™ List 1 drains, CenturyLink™ refines them via lab/field evaluation and experience, because List 1 drains can vary widely based on take rates, percent fill, loop lengths, usage, etc. POTS List 1 drains are at 6 ccs at 52 V for nominal -48 V equipment. For non-POTS equipment, the equipment usage and fill rates used to determine a L-1 drain are specified by CenturyLink™ consultation with the manufacturer. For example, an ONU with 16 broadband ports might be considered average with a 50% take rate (8 ports connected), 30% time usage of the connected ports, and 25% average broadband capacity use of the connected ports. If no other information is available, the initial size of a new DC plant may be calculated based on the sum of the individual List 1 drains for each equipment element, plus anticipated loads to cover forecasted growth. For installed operational networks, the annual busy-hour, busy-day current can be used as a proxy for the total installed equipment List 1 drain (since for sites with thousands of pieces of equipment, it is too burdensome to compile the total true List 1 drain of all of the existing equipment). Future expected List 1 loads should be added to this proxy in order to size batteries and rectifiers for growth.

- List 2 drain (or a proxy for it when unknown) is used for sizing circuit breakers and fuses; and is the peak current drawn at full capacity and bandwidth usage under worst operating conditions (typically lowest operating voltage, with startup currents for capacitor charging and locked rotor fans), as provided by the manufacturer. Telephony List 2 drains are measured at 36 ccs (or 100% usage at worst-case loop lengths). The minimum operating voltage is determined by the highest of the following values: the minimum operating voltage of the equipment given by the equipment manufacturer, or -42.64 V (for nominal -48 V equipment) or 21.32 V (for nominal 24 VDC equipment).
- List 3 drain is used for sizing converter plants. The peak current that is required by equipment at a regulated operating voltage should be used. For loads with no variability, the average busy-hour current at normal operating voltage should be used.

When a battery plant is initially installed, the meter and bus bar should be provided based on the projected power requirements for the life of the plant. Base rectifiers and batteries should be provided based on the projected end of engineering interval connected average busy-hour current drains (List 1).

One more rectifier should be provided than the number required for the "average busy-season busy hour drain" needed at the end of the engineering interval (n+1) for base rectifier requirements. The spare rectifier must be the largest rectifier in the plant. (In COs, radio sites, or fiber regen sites, for non-individually fed rectifiers, the rectifier capacity of all the rectifiers that could be lost when a single AC breaker trips shall be used as the “largest rectifier”.) In remote locations carrying aggregate traffic of more than 500 Mbps, a minimum of 3 rectifiers and n+2 redundancy should be considered.

Size the rectifier plant such that it will carry the office busy-hour load with a minimum excess float voltage current capacity of 20 percent to recharge the batteries (1.20 recharge factor). For sites with float voltages of 53.8 or higher (or 26.9 for 24 V plants) this factor should be 25% due to the higher float voltage of most VRLA batteries. For NSD sites, the factor is 35% due to the high capacity traffic nature of these sites, the need to recover from an overdishcarge, and potentially long travel distances to get to the site to replace a rectifier. The capacity of the working spare rectifier is included as part of the recharge capacity. NSD sites shall have a minimum of 3 rectifiers (except at Customer Premises end-user sites where a minimum of two is OK) regardless of the preceding calculations.

The minimum recharge factors will charge 4 hours of battery backup that has been nearly fully discharged back up to better than 90 percent of full capacity in less than 24 hours. For small power plants in remote terminal applications serving 96 or fewer POTS-only customers, rectifier redundancy is not required.

Follow these general engineering guidelines:

- Main conductors and feeders in the plant should usually be sized for the ultimate capacity of the plant. They should also be sized for a maximum temperature of 46° C (115° F). (See Chapter 9 for more information on distribution cable sizing.)
- Rectifier and battery capacity should be added as the load grows.
- Charge/discharge or supplementary bays should be added only as needed. The input cabling for these bays should be sized for the projected ultimate capacity (typically the bus bar ampacity rating of the bay).
- Distribution equipment (fuses, or breakers) should be added only as needed.
- For power plants with rectifier sizes exceeding 65 A and VRLA batteries, the largest rectifier should be equal to or less than the total power plant load and recharge requirements. If not, turn off excess rectifiers (leaving 1 spare on). This will help to avoid extreme thermal runaway.
- For energy saving purposes, if total rectifier capacity exceeds the load plus the spare and recharge capacity, then all excess rectifiers should be turned off (either manually, with semiannual rotation into service; or by an automatic energy management algorithm from the plant controller). These rectifiers should be turned back on when the load and recharge capacity requires it. If the rectifiers are old, and/or at risk of capacitor dry out if turned off, don't turn those off.

Power cable racking in the power room shall be located in accordance with CenturyLink™ Tech Pub 77351.

All rectifier cables and any battery cables not protected by a breaker shall be considered as unprotected (un-fused) leads. The charge leads shall be sized as follows for the rectifiers' sizes listed:

- The voltage loop drop for the charge leads shall never exceed two Volts for the full loop.
- Leads to the charge bus for stand-alone 200-Ampere rectifiers shall be one 350 kcmil per battery and return.
- Leads to the charge bus for stand-alone 400-Ampere rectifiers shall be two 350 kcmil per battery and return.
- For smaller rectifier sizes (or the rare 800 A rectifier), follow manufacturer recommendations for the leads to the charge bus.

- For rectification bays/shelves, follow the manufacturer recommendation for the leads to the charge bus, ensuring that the ampacity of the cables used exceeds 120% of the rectifier shelf/bay capacity (this may be reduced to the maximum current limit possible for rectifiers whose maximum current limit at any voltage is less than 120% of the rating), and that the voltage drop does not exceed two Volts for the loop. Note that cable ampacity is determined from NEC® Table 310.15B16 as modified by Articles 110.14C and 240.4D. Derating of ampacity due to cable rack pileup in larger sites (which is ultimately related to temperature) below these values is not necessary due to maximum cable rack temperature limitations found in Technical Publication 77350, and due to the oversizing of most cable because of voltage drop calculations.
- Rectifier output leads over 125 feet one-way shall be sized using the manufacturers' recommendations (where available), ensuring that the voltage drop does not exceed two Volts for the loop.

### 2.4.1 Example of Proper Calculation and Usage of List 1 and List 2 Drains

Equipment manufacturers often give power drain information in many formats, including, Watts, Amps, recommended fuse size; etc. It is often necessary to speak with the equipment manufacturer to clarify true List 1 and List 2 drains. To help understand List 1 and List 2 calculations for sizing batteries, rectifiers, fusing, and wires, an example might be helpful. The following assumptions apply for this example:

- the relay rack / bay to be added will be equipped with 3 shelves of EoCu (ethernet over copper) equipment
    - the shelves are A/B fed, each with 14 slots
        - of those 14 slots, 7 are normally fed from the A side, and 7 from the B, but during a failure of one fuse, the shelf is diode ORed in the backplane so that all 14 slots can be fed from either the A bus or the B bus
    - the cards that can be placed in the shelf are either short-reach, mid-range, or long-loop cards
        - the typical draw of a short-reach card is 24 W, and its capacitor charging current is limited to 143 mA
        - the typical draw of a mid-range card is 31 W, and its capacitor charging current peaks at 184 mA
        - the typical draw of a long-loop card is 45 W, and its maximum capacitor charging current is 265 mA

        - the distances of the EoCu spans vary by site, so mid-range cards are assumed to be average in this example for calculation of the List 1 drain, and long-loop cards are used to calculate List 2 drain
- for both List 1 and List 2 cases, it is decided for this particular example that the shelves will be fully-populated for planning purposes
- the relay rack / bay also has a variable speed fan shelf, fed only from the A side of the miscellaneous fuse panel at the top of the bay
    - the draw of the fan shelf at full speed is 144 W
        - full speed will be used for the List 2 calculation in this example
    - the draw of the fan shelf at mid-speed is 98 W
        - mid-speed will be used for the List 1 calculation in this example
    - the locked rotor current of the fans is 2.5 times the full-speed fan current
    - the momentary draw of the starter capacitors in the fan shelf is current-limited (by resistors in the fan shelf) to no greater than 500 mA.
- the nearest BDFB is 45 feet away via cable rack, and will take fuse sizes up to 100 Amps
- the PBD is 130 feet away via cable rack path routing
- All wire, lugs, and termination pads on the PBD, BDFB, and miscellaneous fuse panel are rated for at least 75° C
- 8 strings of flooded 1680 Ah batteries in the DC plant, floating at -52.80 V
    - the site is backed up by a permanent engine-alternator
        - the 4-hr rate of each string of batteries to 1.86 V/cell (see Table 3-1) is 280 A
            - per Section 3.8, this value is de-rated by 10% to account for aging:

$$280\ A\ \times 90\% = 252\ A$$

- existing -48 VDC plant busy-hour load during the last year (as recorded by the power monitor) was 1,713 A
- The plant presently has twelve 200 A rectifiers

The List 1 drain of the A side of the bay is:

$$\left(21\ slots\ of\ A\ side\ EoCu\ \times \frac{31\ W\ per\ slot}{52\ V}\right) + \frac{98\ W\ of\ fan\ power}{52\ V} = 14.4\ A$$

The List 1 drain of the B side of the bay is:

$$21\ slots\ of\ B\ side\ EoCu\ \times \frac{31\ W\ per\ slot}{52\ V} = 12.5\ A$$

The total List 1 drain of the bay is:

$$14.4\ A + 12.5\ A = 26.9\ A$$

Before calculating the List 2 drain of the bay, it is necessary to calculate the locked-rotor fan shelf current:

$$\frac{144\ W\ of\ full - speed\ fan\ power}{42.64\ V} \times 2.5 = 8.4\ A$$

The List 2 drain of the bay is:

$$\left(42\ slots\ \times \left(\frac{45\ W\ per\ slot}{42.64\ V} +\ 0.265\ A\right)\right) +\ (8.4\ A + 0.500\ A) = 64.4\ A$$

Now that List 1 and List 2 drains have been determined, the impact on rectifier and battery sizing can be determined.

As noted earlier in Section 2.4, the existing busy-hour load can be used as a proxy for the existing List 1 drain of the equipment in the office. To that can be added the List 1 for the new equipment:

$$1{,}713\ A + 26.9\ A\ \approx 1{,}743\ A$$

This number must then be compared to the n-1 rectifier capacity, and the recharge capacity. The n-1 rectifier capacity is:

$$(12\ rectifiers\ \times 200\ A) - (1\ rectifier\ \times 200\ A) =\ 2{,}200\ A$$

Per Section 2.4, because the float voltage of the plant is less than 53.8 V, the recharge factor is 120%:

$$1{,}743\ A\ \times 120\% \approx 2{,}092\ A$$

This number must be less than total rectifier capacity (and it is):

$$12\ rectifiers\ \times 200\ A = 2{,}400\ A$$

What these calculations mean is that the existing plant has enough capacity to handle the new bay. However, typically, for growth purposes, because it sometimes takes a little bit of time to engineer additional rectifier capacity, the Engineer wants to be informed when the load has reached 80-95% of the rectifier n-1 or recharge capacity.

Running these calculations yields, respectively:

$$\frac{1{,}743\ A}{2{,}200\ A} = 79.2\%$$

$$\frac{2{,}092\ A}{2{,}400\ A} = 87.2\%$$

Based on the second of these calculations, the ease of adding rectifiers to the existing plant, and what the Engineer knows about future growth, the Power Planning Engineer may or may not want to start a plan to add more rectifiers?

As noted in Section 2.4, 110% of the projected List 1 load is used for battery sizing to account for the increase in current during battery discharge:

$$1{,}743\ A \times 110\% = 1{,}917\ A$$

The total age-derated battery plant capacity is:

$$8\ strings \times 252\ A\ per\ string = 2{,}016\ A$$

Running a capacity calculation for what battery plant capacity will be yields:

$$\frac{1{,}917\ A}{2{,}016\ A} = 95\%$$

While there is enough battery capacity to add the new bay without embargoing the site for equipment additions, the Power Planning Engineer will probably want to start a job to add batteries soon.

The miscellaneous fuse panel at the top of the new bay needs to be fed with fuses that are at least 125% of the List 2 drain (see Section 9.5).

$$64.4\ A \times 125\% = 80.5\ A$$

Rounding up to the next common fuse size means that a minimum 90 A fuse is needed at the PBD or BDFB to protect both the A and the B feeds to the miscellaneous fuse panel at the top of the bay, and the miscellaneous fuse panel needs to be rated to carry that current as well (common ampacities for miscellaneous fuse panels near this number are 60 and 100 Amps, so a fuse panel capable of carrying 100 A with its buswork would be needed).

Voltage drop sizing from the PBD or BDFB, done per the rules of Section 9.2 would be based on 125% of the List 1 drain.

For the A feed, that value is:

$$14.4\,A \times 125\% = 18\,A$$

For the B feed, that value is:

$$12.5 \times 125\% = 15.6\,A$$

Because both the BDFB and the PBD are capable of accepting a 90 A fuse, it may be useful to run voltage drop calculations for both scenarios:

Using the rules of Section 9.2 yields the following voltage drop wire-sizing calculation from the BDFB for the A side:

$$\frac{11.1 \times 18\,A \times (2 \times 45\,ft)}{0.5\,V} = 35{,}964\ circular\ mils$$

And for the B side:

$$\frac{11.1 \times 15.6\,A \times (2 \times 45\,ft)}{0.5\,V} = 31{,}169\ circular\ mils$$

Per Table 9-4, either calculation would require the use of a minimum of 4 AWG; however, per that same table, at the 75 °C rating, that cable size only has an ampacity of 85 A, which does not equal or exceed the 90 A fuse so; therefore, 4 runs (A feed, A return, B feed, and B return) of #2 AWG (ampacity of 115 Amps) must be used in order to feed the miscellaneous fuse panel from the BDFB.

Running the same calculations for a feeder set from the PBD yields:

$$\frac{11.1 \times 18\,A \times (2 \times 130\,ft)}{1.5\,V} = 34{,}362\ circular\ mils$$

$$\frac{11.1 \times 15.6\,A \times (2 \times 130\,ft)}{1.5\,V} = 30{,}014\ circular\ mils$$

As previously, voltage drop calculations require a minimum of #4; however, the cable must be upsized to #2. Because four 45 ft runs of #2 from the BDFB are going to be much less expensive than four 130 foot runs of #2 from the PBD, the Engineer should choose to feed this bay's miscellaneous fuse panel from the BDFB.

## 2.5 Power Board Panel and Fuse Numbering for New Power Plants

This requirement is for new power plant panels and fuse numbering to accommodate newer system requirements. Existing power plants will continue with the existing numbering system, and are not affected by this requirement.

New power plant distribution bays will have panel labeling starting with Panel 01 (PNL-01) from the bottom in each bay to Panel XX (PNL-XX) at the top of the bay. Each panel's fuse positions will start with Fuse 01 (FS-01) to Fuse XX (FS-XX), which would be the last fuse number of that panel. This will allow fuse panels to be removed or added and not affect the fuse numbering in the bay. If multiple panels exist on a given level numbering will start in the lower left corner of the bay with PNL-01 proceed left to right on that level with PNL-02 then proceed up and left to right for additional panels in the bay. Fuses will be labeled left to right or top to bottom depending on the panel's orientation. Fuse positions will be assigned in the power boards from the bottom up.

To satisfy NMA® requirements in some power monitors, a unique 7-digit number will be created as follows:

- 1st digit "**P**" for power plant bay
- 2nd and 3rd digits will be the last 2 digits of the bay number (P0101.**03**)
- 4th and 5th digit will be the panel number (PNL-**04**)
- 6th and 7th digit will be the fuse number on that panel (FS-**08**)
- For the example shown above, the NMA® identifier would be P030408.
    - When the installer is ready to test fuse/breaker capacity alarms for the new NMA® numbering of the Power Board panel and fuse, mention to the technicians in the NMA® database group that these distribution numbers are not template generated and need to be manually databased.

In distributed power bays where rectifiers and distribution exist in the same bay, rectifiers are labeled as G-01 to G-XX in that bay from the bottom to top, left to right, as required, and continue with the next consecutive rectifier number in additional bays. The distribution panels will start with Panel 01 (PNL-01) wherever the first distribution panel starts in that bay and is then labeled from bottom to top. In additional bays, the distribution panels will always start with Panel 01 (PNL-01) where the rectifiers will continue with the next consecutive rectifier number.

Specific examples are shown in the CenturyLink™ configuration (Q&A) help files for a particular power plant. This aid is to help and assist planners, engineers, installers, and suppliers.

## 2.6 Conventional Controller

The traditional power plant controller shall be capable of basic alarm and control functions as described below. In some COs, the alarms will be connected to an "intelligent" power monitor/controller (PSMC) as described in Chapter 8.

All provided alarms must be capable of being monitored remotely. The connecting point for these contacts will be easily accessible. All analog monitoring points (current shunts or Volt meters) within DC plants larger than 100 A of capacity will be equipped with terminal strip access for attaching remote monitoring devices. The connecting point for analog monitoring points will be located near the alarm connecting points and be easily accessible. Binary alarm thresholds from analog points shall be settable. The following alarm indications shall be provided:

- Power Minor Alarms (generic summation power minor shall also be available)
  - Rectifier failure - single rectifier failure
- Power Major Alarms (generic summation power major shall also be available)
  - Discharge fuse
  - High Voltage
  - Low Voltage and/or Battery on Discharge (BOD)
  - Voltmeter and voltage regulator fuse
  - Charge fuse
  - Rectifier failure - multiple rectifier failure
- Power Critical Alarms
  - Very low Voltage (may not be remoted depending on legacy company)
  - High Voltage ShutDown (HVSD)

When the power plant controller (each DC plant should only have 1 master rectifier controller – there may be sub-controllers for differing rectifier types) and the power monitor are separate entities, the power plant controller major and minor alarms should be paralleled with the PSMC major and minor on the e-telemetry device or switch in case the PSMC fails.

Control functions of a traditional controller will be limited to high-voltage shutdown and restart capabilities, as defined herein; and rectifier sequencing.

Plant controllers for 50 Ampere plants and larger must have digital voltage and current meters (this may be a combined meter). Power plants with a capacity of less than 50 Amperes are not required to have a meter, but shall have test jacks so that the plant voltage and current can be measured with a meter.

Rectifiers whose outputs are controlled by the power plant's controller must default to the rectifier's settings if the controller fails.

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# 3. Batteries and Battery Stands

## 3.1 Overview

This unit covers requirements for batteries and battery stands used within telecommunications facilities.

## 3.2 General Description

During short term commercial alternating current (AC) disturbances, telecommunications equipment is operated on the direct current (DC) reserve power typically supplied by batteries. The reserve battery power required for telecommunications sites with lifeline service are 4, 8, or more hours (the 4 and 8 hour backup requirements are based on history, FCC Best Practices, and various state regulatory rules), as described herein (non-lifeline services, such as DSL, have no minimum battery backup standards unless they are on a combo card with POTS services). During normal AC power operation, batteries are maintained in a fully charged or float condition.

Some computer systems, such as Operational Support Systems and data processing centers, require an Uninterruptible Power System (UPS) to furnish continuous AC power to their loads. The UPS consists of chargers and inverters with an associated battery reserve. Reserve time for UPS systems is typically 15-45 minutes, although it can be more or less. This allows uninterrupted operation through brief power disturbances or, if necessary, provides the time for a smooth shutdown or transfer to a standby AC source. A UPS system with less than 4 hours of battery backup shall NEVER be used as backup for telecommunications Network loads critical to ensuring Network lifeline operations.

All materials used in battery cases shall have a minimum limiting oxygen index (LOI) of 28% (per ASTM standard D2863), and meet the UL® 94 V0 burn requirement. Battery cases shall have sufficient strength to withstand normal handling and internal pressure generated by positive plate growth (within their design lifetime) and/or discharging and recharging.

## 3.3 Battery Discharge Characteristics

Battery strings designed for use with standard DC Central Office plants provide at least 4 hours of reserve time. On discharge, as a lead-acid battery initially supplies the load current, the voltage will rapidly drop, then levels out, (turnaround voltage) before rising to a slightly higher voltage (plateau voltage) before beginning to fall again. This phenomenon is referred to by the term “coup de fouet” (crack of the whip).

During the remaining discharge, the voltage falls slowly until the "knee" of the curve. At this point, further discharge results in rapid voltage drop caused by electrochemical depletion of the cell. Plots of "initial voltage" versus discharge Amperes are available from battery suppliers as either separate curves or part of the normal discharge curves.

A plant and its loads are designed to operate to minimum lead-acid discharge voltages of 1.94 - 1.63 Volts per cell (also known as end or cut-off voltages). Voltage below 1.75 on long duration discharges can indicate reversed (non-recoverable) cells. The MVPC (minimum Volts per cell) for chemistries besides lead-acid is determined from the end voltage of the equipment, (typically no higher than -42.64 for nominal 48 V equipment) plus the voltage drops defined in Chapter 9, divided by the number of cells per string.

The coup de fouet and the voltage at the knee of the discharge curve depend on the discharge current, cell type, float voltage, and amount of time since the last discharge; and they are generally lower at higher discharge currents relative to battery capacity.

A fully charged (1.215 specific gravity) lead-acid wet/flooded cell has an open circuit voltage of about 2.06 Volts after a day or two off of charge (this will decrease with time off charge). The "calculated" open circuit voltage of a lead-acid battery can be found by adding 0.85 to the specific gravity of the electrolyte of that battery. The minimum recommended float voltage could be found by adding 0.95 to the specific gravity (the bare minimum voltage needed to keep the cell charged is a little less than this).

The highest voltage reached during a discharge after the lowest coup de fouet voltage is sometimes referred to as the plateau voltage. The lowest coup de fouet voltage is sometimes called the turnaround voltage.

Batteries shall be floated and alarmed at the levels prescribed in Chapter 13. Exceptions to this include flooded batteries that are installed in some old WECO 100 or 300 series plants with their original controller. They should generally be floated at 2.17 Volts per cell due to the inability to change some alarm and HVSD thresholds in these plants.

The first and last cells of a flooded string should not be adjacent on the same shelf. They should be either on opposite ends of the shelf or on separate shelves. Cell 1, the positive end of the string, should be on the lower tier on two-tier stands where a string uses both tiers. Exceptions are allowed for small VRLA batteries rated at 250 Ah or less. Exceptions are also allowed for flooded batteries where placing the first and last cells next to each other is more convenient due to existing busbar and/or cable-racking arrangements. In those cases, the terminals and term plates shall be protected with insulation, and an effort should be made to separate them by at least 12 inches in order to avoid accidental shorting from dropped tools or other metal objects.

Follow the manufacturers' recommendations for installation of all batteries. Each cell in the battery string shall be numbered, unless it is a monobloc (multicell battery) with an opaque jar. The numbers should be placed on the battery stand under the corresponding cell where possible, or on the battery if that is not possible.

### 3.4 Battery Recharge Characteristics

A float voltage of 2.20 Volts per cell, for flooded type lead-calcium, nominal 1.215 s.g. batteries, available from rectifiers in typical DC plants, not only maintains the batteries at full charge, but also recharges them after discharge. Whenever the DC plant and the equipment being served will accept a power plant voltage by floating the batteries at 2.20 Volts/cell (as opposed to the older 2.17 Volts/cell typically used for lead-antimony batteries), the higher float voltage should be used. This higher float voltage will result in reduced maintenance and longer battery life.

If an office loses commercial power and is required to use battery power for several hours, the batteries must be recharged when commercial power returns. If the rectifiers can deliver much more current than the load requires, the batteries will recharge quickly. However, there is a danger in having too many rectifiers for certain battery types. If the batteries recharge very quickly, they are receiving a lot of current. Because of the internal resistance of the battery, heat is generated when current passes through the battery, on either discharge or recharge. If too much current passes through the batteries, some older VRLA batteries are not able to dissipate all of the heat, and may go into thermal runaway. Also, Li-based batteries have a charge current limiting circuit that may disconnect the batteries if too much charge current is flowing to them. Therefore, it is unwise to oversize the rectifiers to recharge the batteries quickly. Use the n+1 and 120 or 125% rules described in Chapter 2 for proper rectifier sizing to the load, and recharge. As a general rule do not leave more than 200% of the load in rectifier capacity turned on (lockout/tagout excess rectifiers) unless it is necessary to meet the n+1 and 120 or 125% recharge rules. Recharge time will be lengthened when current limiting or temperature compensation is used with VRLA batteries. Although this slightly compromises reliability, safety concerns necessitate the use of these devices.

New flooded cells are given an initial boost charge at a relatively high voltage to help finish "formation" of the plates. This charge usually lasts several days (follow manufacturer recommendations), and care must be taken to prevent a buildup of Hydrogen gas in the battery area. In addition, individual cells may sometimes become weak (with a depressed voltage and/or specific gravity) over time. Sometimes boost or equalize charging (equalize charging is very similar to boost charging) for the individual cells may bring these weak cells up to proper float voltage.

Boost charging is also sometimes used on flooded cells to recharge the batteries quickly if they have recently experienced multiple deep drains and there is a fear that there are more commercial AC outages pending in the near future. Boost charging is commonly used in solar/cycling/photoVoltaic applications.

Valve-Regulated (VRLA) batteries are much more susceptible to thermal runaway at high voltages than are flooded cells. For this reason, all plants equipped with VRLA batteries going forward must employ temperature-compensated charging. Preferably, there will be one cell/monoblock monitored per string (typically the most negative cell/monoblock in the highest row of the string), with the highest temperature determining the float voltage compensation.

VRLA batteries are also sometimes contained in a relatively confined space, enabling the possible buildup of volatile concentrations of Hydrogen during thermal runaway. For this reason, boost (including initial boost) and equalize charging of VRLA batteries is strongly discouraged (except in PV applications). These batteries can be placed in service and will finish plate formation and recharge over time (they also receive a better formation charge at the factory than a flooded cell). Safety takes precedence over having a fully-charged battery all of the time. If boost or equalize charging is done to VRLA batteries, ensure that manufacturer's recommendations are strictly followed, and the batteries are checked on frequently for abnormal heating or gassing.

Note that not all lead-acid batteries are designed with the same types of plates. UPS and engine start batteries typically have thinner plates (thus they can get current out quickly in a smaller footprint but won't last as long), and VRLAs used in UPS or engine-start applications are typically of the AGM type (see Section 3.6). Cycling/solar or engine-start batteries may have antimony in the plates, or other special manufacturing methods to ensure at least 800 cycles to an 80% depth-of-discharge.

### 3.4.1 Ventilation of Battery Areas

All aqueous batteries (such as lead-acid and Ni-Cd) gas potentially explosive Hydrogen; especially during thermal runaway, boost charging, or equalize charging. Under normal float operating conditions, flooded cells will gas much more Hydrogen than a VRLA battery (under normal operating conditions, the VRLA battery should be recombining much of the Hydrogen with Oxygen to replace the water). However, during the first year of service for VRLAs (especially for gel technology), the VRLA may gas the same amount as an equivalent flooded cell. In addition, under thermal runaway conditions VRLA batteries are capable of gassing incredible amounts of Hydrogen; and under extreme thermal runaway conditions; they may even gas potentially toxic Hydrogen Sulfide.

Because of these potentially toxic and explosive gasses, it is very important to ensure that battery rooms/compartments/areas are adequately ventilated. Hydrogen buildup in battery rooms/areas or compartments should be limited to approximately 1% (the LEL — Lower Explosive Limit — of Hydrogen is 4%). This applies to battery rooms as well as battery compartments in cabinets.

As a minimum, CenturyLink™ has adopted a minimum air change rate of 0.5 ach (air changes per hour), unless other calculations are done ensuring that Hydrogen concentrations do not exceed 1% under boost charge conditions (this is a Fire Code requirement). In the great majority of cases, 0.5 ach will ensure that Hydrogen concentrations do not exceed 1% (see IEEE 1635 / ASHRAE 21 for gassing and ventilation calculation methods to meet the Fire Codes). Note also that normal occupancy calculations require even greater than 0.5 ach for "occupied" rooms.

For Customer Premises cabinets, both the cabinet itself and the surrounding room should meet the air change and Hydrogen buildup guidelines.

Engineers typically do not prefer to design excessive air changes into the ventilation system, as this would compromise thermal efficiency of the HVAC, especially in hot or cold climates. In some cases, redundancy and/or DC-powering are designed into the ventilation system to ensure that there will always be minimal ventilation.

Some "confined space" applications (like CEVs) also require alarming or testing before entering for toxic and explosive gasses (as the Hydrogen vented by batteries). The alarm levels are set by OSHA and are outside the scope of this document (more information on gas monitoring can be found in Telcordia® GRs 26 and 27).

Note that Li-based batteries do not gas, and thus do not require ventilation (although if they are used in "people space" there must be ventilation for personnel).

### 3.5 Battery Configurations

General descriptions of a battery plant, its configuration, sizing, etc. are in Chapter 2.

Cells with different recommended float voltages cannot be mixed. For example, most VRLA and flooded cells can't be placed in the same plant (although low-gravity VRLA strings may be paralleled with flooded cells if a CenturyLink™ Power Maintenance Engineer has reviewed it and a Letter of Deviation is signed [see Tech Pub 77350 for Letters of Deviation]). Differing string sizes and battery manufacturers may be used in the same plant; however, this is discouraged for VRLA batteries. Cells of differing sizes and/or manufacturers shall not be used in the same battery string, unless the battery is no longer manufactured; in which case consult the manufacturer for replacement alternatives. If replacement alternatives do not exist, then replace the entire string.

Battery rooms (or exterior doors to small buildings containing rechargeable batteries) must be equipped with the appropriate signage as required by the Fire and local Codes.

## 3.6 Battery Types

CenturyLink™ uses several battery technologies in equipment locations. The characteristics and requirement of the battery types are not always interchangeable. The CenturyLink™ Engineers are responsible for the sizing of the battery reserve of a site. The battery technologies used in CenturyLink™ are:

- FLOODED LEAD ACID — flooded (also known as wet or vented) lead-acid batteries are the "traditional" batteries used in large telecommunications equipment locations. This group of batteries includes the pure lead, lead-antimony, and lead-calcium battery types. Lead-antimony batteries are not to be used by CenturyLink™ going forward except in engine-start and cycling (solar/photoVoltaic) applications. If it is feasible to use flooded batteries, they should be used. Lead-calcium is the preferred battery type for long duration float applications. The manufacturer is required on new flooded battery strings to ship us a voltage-matched set (all cells within 0.03 V of each other on formation charge) manufactured within a month of each other.

  In lead-antimony cells, antimony is added to the plates to add mechanical strength. As these batteries age, they develop higher and higher self-discharge rates, require higher trickle currents, and need greater maintenance because of higher water loss from gassing than other flooded cells. A 1680 Ampere-hour lead-antimony cell takes approximately 550-650 mA of float current when new, and 1100-1300 mA when approaching end-of-life. The Ampere-hour efficiency, calculated by dividing the Ampere-hours of discharge by the Ampere-hours required to restore the cell to full charge, is lower for these cells than for most other types. The average expected life on float at 77° F is 14-15 years, based on experience. (When these batteries start using an appreciable amount of water [over half a gallon per month], they must be replaced immediately!).

While new lead-antimony cells are no longer allowed in CenturyLink™ for long duration standby applications, European lead-selenium (low-antimony; i.e. less than 2%) designs are a good compromise between between pure-lead or lead-calcium and lead-antimony (5-8% antimony content in the positive plate grids), and may be used. While float current and watering needs increase towards the end-of-life of a lead-selenium cell (they should last 18-20 years), the effect is not as severe as in a standard lead-antimony design, and the need to water the cells frequently towards the end of their useful lives can be mitigated by using flame-arresting vents equipped with catalysts that recombine some of the electrolysis-evolved hydrogen and oxygen back into water. All designs with antimony in the plates (whether lead-antimony or lead-selenium) self-discharge faster than most other battery types, and thus their maximum storage interval without a freshening charge is typically no more than 3 months (shorter in higher temperature environments).

The lead-calcium cell design results in lower self-discharge, lower trickle charge current and less maintenance than the lead-antimony design. However, the condition of the cell is more difficult to determine using specific gravity (other than initial installation inspection, specific gravity readings are discouraged for pure-lead and lead-calcium cells) and voltage readings because of the lower gassing rate and; therefore, limited electrolyte gravity change.

In float operation, the cells take 60 to 300 milliamperes of float current for a 1680 Ampere-hour cell. Experience has shown an average life on float at 77° F of 18-20 years.

Lead-calcium and lead-selenium cells shall not be used in the same string due to differences in charge/discharge rates, and the possibility of electrolyte contamination from maintenance activities, etc.

The pure lead flooded cell is designed to minimize the physical deterioration associated with conventional designs. The float current range for these cells is similar to that for lead-calcium cells. The expected life on float of the second generation of these cells at 77° F is better than 40 years. The pure lead flooded cell most commonly found in the U.S. is also known as the "round" cell, or the "Bell" cell (there may also be expensive European pure lead thick-plate rectangular designs known as Planté). (There are also pure lead and pure lead-tin VRLA designs, and while they won't last 40 years, they will last longer than other VRLA alloys in float service, and like pure lead flooded designs, they store very well, lasting 12-18 months without a freshening charge, as opposed to the typical 6 months for lead-calcium designs.) While the round cells last a long time, they were extremely expensive, so the demand was low and the manufacturer eventually stopped making them.

- VALVE REGULATED — Valve-Regulated Lead-Acid (VRLA) batteries include both the starved electrolyte (absorbed glass mat or AGM), and immobilized electrolyte (gel) technologies. Starved electrolyte should be avoided whenever possible in CenturyLink™ Local Network (LNS) Central Offices (with the exception of engine-starting applications), and when used in such applications should almost always be in a "centralized" power plant. A "characteristic problem" of valve regulated batteries is the potential for thermal runaway. Suppliers of VRLA batteries will provide "safe operating environment" characteristics with VRLA batteries.

  Most VRLA batteries typically require a higher float voltage than flooded lead acid batteries. Rectifier plants supporting valve-regulated batteries should be able to sustain a float voltage of up to 2.31 Volts per cell. VRLAs shall not be boost or equalize charged unless they have not been charged for at least 6 months or are in service in a PV application. In those cases, follow the suppliers' recommendations for charge times and charge voltages.

  For -48 Volt plants, twenty-four battery cells should be used for each string wherever possible. This also applies to ±24 Volt plants, where twelve battery cells must be used for each string.

- NICKEL CADMIUM — Ni-Cd batteries used within CenturyLink™ are generally based on a flooded technology. Because of their relatively small capacity, low cell voltage, and high cost, Ni-cd battery use is generally limited to standby engine-alternator start/control batteries or RT cabinet batteries in higher temperature environments (although some models can have a slight space advantage over some VRLA batteries and so may be used in certain cabinets in all climates where the extra capacity in the available battery compartment space is needed), or cycling/solar batteries in low temperature environments. Ni-Cd batteries are also excellent for areas (such as hurricane-prone areas) that might experience a deep discharge followed by days or weeks without power (they recover much better from overdischarge abuse conditions than lead-acid). Ni-Cd batteries used by CenturyLink™ for long-duration backup typically ship with a very low state of charge, which enables them to be stored for periods of 12-24 months without a freshening charge, but will cause a large current draw when they are first connected to a dc bus without a pre-charge. The long-duration Ni-Cd batteries used in CenturyLink™ are packaged in multi-cell blocks, but it takes 38 cells to make a nominal 48 V string, so there are odd block sizes. Lead-acid cells are also used as start or control batteries for engine-alternators in CenturyLink™ Equipment, in traditional flooded, maintenance-free flooded, and VRLA designs.

- NICKEL-METAL HYDRIDE (NMH) — Like Ni-Cd, NMH (or NiMH) is an alkaline (potassium hydroxide electrolyte, which means it must be neutralized with an acid instead of the typical baking soda basic solution used for lead-acid batteries) chemistry. Alkaline chemistries generally have a nominal voltage of 1.2 V/cell (as compared to nominal 2 V/cell for lead-acid chemistries and 3-4 V/cell for Lithium chemistries). The actual charging and open-circuit voltages for NiMH cells are very similar to those of Ni-Cd cells. Often, the individual cells are pre-packaged into a nominal 12, 24, or 48 V monobloc. Nickel-metal hydride cells have been deployed as a longer life alternative to lead-acid cells in some distributed power constant current charging RT applications, and are under consideration (along with Li-based batteries) for constant voltage applications where they can save space and weight. Temperature compensation must be employed when these batteries are used with traditional telecom constant float voltage rectifiers (although this can be accomplished through a BMS integrated into the battery itself).
- LITHIUM — The sealed nature of Li-based batteries eliminates traditional concerns of out-gassing. Construction of battery modules in integral 48 or 24 V monoblocs eliminates the series connection of modules to achieve the required plant potential.

  Lithium-ion (Li-ion) has been popular for portable applications (cell telephones, camcorders, laptops, etc.), and is presently in the early stages of deployment for larger stationary applications incorporating both high rate and long duration discharge applications (note that like lead-acid cells there are internal differences between high-rate and long duration discharge cells). A Li-ion cell consists of lithium ions imbedded in a carbon-graphite substrate (positive plate) or a nickel-metal-oxide, or a polymer phosphate. The electrolyte is a liquid carbonate mixture, or a gelled polymer. The lithium ions are the charge carriers in the battery.

  There is no gassing, no free electrolyte, and no hazardous materials with Lithium batteries. Li-ion batteries are best-suited for indoor environments. Most Li-ion batteries can be used in remote applications, but with reduced life in high-temperature environments. The shelf life of most Li batteries is 2 years plus, provided the parasitic loads of the built-in charge-control circuitry are put to sleep.

  The drawback to Lithium is that it is an extremely reactive metal (it reacts in free air). This means that sealing the battery and controlling the charge current are very important. Controlling the charge current is done quite well with electronics imbedded in the battery.

Due to the electronic charge current controls, the newness of the technology, and the clean-room manufacturing environment, Lithium-based batteries are more expensive initially than their lead-acid counterparts. However, where gassing, high-temperature environments, space, or weight are an issue, lithium batteries can pay for themselves in 6 years or less.

Lithium-ion based cells used in CenturyLink™ up to this point have a charge voltage of between 3.4 and 4.1 V (depending on chemistry). However, charge voltages too close to the top end shorten battery life, while those closer to the bottom end reduce capacity. Open circuit voltage for these cells is 0.05 V below the charge voltage. Expected life for stationary Li-ion batteries is expected to be 15-20 years (regardless of environment), with a minimum of 10, and possibly a maximum of 25 or more years. The cells may be cylindrical (spiral-wound) or prismatic (rectangular), and typically packaged in series "blocks" to achieve higher individual module voltages. In some cases, these monoblocs may be packaged in rack-mountable metal-encased "shelves" that can mount in a relay rack.

- SUPER/ULTRA™ CAPACITORS — Electric double charge layer capacitors (commonly known as super- or ultra™-capacitors) using carbon-based electrodes have made capacitances of thousands of Farads possible in small, packages. For very short duration discharges (less than a few minutes), they provide an economic alternative to batteries. Generally, due to their extremely low internal resistance, they must be coupled with a DC-DC converter or a charge current limiter to be used with existing DC plant rectifiers.

## 3.7 Selection

The selection of battery type and size for an installation depends on:

- Initial busy hour load and estimated growth pattern with time
- Added Power failure loads (such as AC-preferred inverters and switched DC lighting)
- End voltage per cell
- Office reserve requirements
- Battery aging characteristics
- Ultimate Power Plant size
- Temperature
- Environmental constraints

For a new plant, the optimum battery stand and floor layout is achieved by using only one battery model. However, strings of different types and sizes may be mixed. The CenturyLink™ engineer will determine the type and manufacturer of the batteries to be used.

In RT cabinets, where the temperature of the battery compartment will regularly drop below 30 degrees F in the winter, battery heater pads should be installed where lead-acid batteries are used. They normally operate when the temperature is below 40 degrees F, and normally do not operate when the temperature is above 50-60 degrees.

### 3.8 Sizing

At least 4 hours of battery reserve shall be provided for sites serving lifeline POTS with a permanent on-site auto-start, auto-transfer engine (this reserve can be reduced to an hour for traditional CATV sites with an engine). Sites served by a portable genset that serve lifeline POTS loads shall have at least 8 hours of battery reserve, unless they have a host, tandem, standalone, or long distance switch, in which case they shall be equipped with a permanent auto-start, auto-transfer engine, or contain at least 24 hours of battery backup.

Note that per section 2.4, battery sizing is calculated at 110% of the List 1 drain. In addition, the standard accepted end-of-life figure for most batteries is 80% capacity (this represents the point in the capacity vs life curve of a lead-acid battery, where capacity begins to fall off rapidly as time goes on). Because of the general dropoff in capacity as a battery ages (some battery types actually increase in capacity for the first few years of life, but some of these begin their life at less than 100% of rated capacity), and because in larger sites, the parallel battery strings are often a mix of different ages, an average derating factor of 10% is applied to rated battery capacity (i.e., 90% of rated battery capacity is used) to account for the varying capacities of parallel strings (especially those of different ages).

Customers at Prem sites have the option of less or no battery backup (see Tech Pub 77368 for further information). Backhaul services for wireless can have battery backup reserve time that matches that provided by the wireless company for themselves (in fact, it’s best to get a DC feed from the wireless company so that the cell tower and the backhaul fail at approximately the same time).

DSL and video services may or may not be backed up. When the services are combined on the same circuit packs (such as DSL combo cards, or FTTH sites), the suggested backup time before load-shedding of the broadband loads is 30 minutes. When video services are served from DSL combo cards, that suggested time is increased to 90 minutes.

Radio sites that are inaccessible during part of the year should have more than 8 hours of battery reserve (determined by the Common Systems Power Planner in consultation with field personnel). Sites solely solar power should have multiple days of battery reserve, depending on the climate.

Lead-acid batteries shall be sized using an end voltage of 1.86 Volts per cell (or 1.17 for Ni-Cd 38-cell strings in buildings). (For the rare 23-cell VRLA strings or 37-cell Ni-Cd strings, 1.94 Volts per cell must be used for sizing.)

For applications using VRLAs, there shall be a minimum of two strings. This requirement is waived for small RTs and customer prem locations serving 672 or fewer POTS customers or SONET equivalent customers (unless the circuits are to a government installation, to a nuclear plant, are an FAA circuit, or serve a 911 PSAP site). It is also waived for ADSL and VDSL backup.

Lithium batteries have a current limit linked to an internal disconnect. When sizing a plant using Lithium batteries, it is essential to ensure that a loss of a single battery will not cause the other batteries to exceed their discharge or recharge current limits. In cases of plants where Lithium batteries are paralleled with lead-acid batteries, at points during the discharge and recharge cycles, the Lithium batteries will be supplying or receiving almost all of the current. As a result, sizing must take this into consideration so that the internal disconnect of the Lithium battery is not operated. Paralleling Li-ion strings with lead-acid strings requires the review and approval of a CenturyLink™ Power Maintenance Engineer, and a signed Letter of Deviation.

Lithium batteries in -48 V plants in COs should use an end voltage of -44.45. In outdoor RT cabinets, they (and Ni-Cd batteries) can use an end voltage of -44. Batteries are sized such that, given voltage drops, the minimum voltage delivered to CLEC equipment at the end of battery discharge is -42.64 V.

## 3.9 Battery Stands and Connections

### 3.9.1 Metal Stands, Trays, and Compartments/Boxes

Metal battery stands are available in a variety of configurations to suit power room applications. The stands are steel finished with acid-resistant paint. Shelves of battery stands for flooded cells should be protected by a non-conductive, acid-resistant, plastic sheet under the batteries. The engineer should follow all the specifications pertaining to battery equipment installation to avoid hazardous conditions resulting from abnormal stress, chemical corrosion, or electrical faults.

Large VRLA batteries are generally mounted with the terminals facing forward in large metal powder-coated battery stands. The stand used must be designed for the battery used, installed according to manufacturer instructions, and rated for the Earthquake Zone in which it is used (an existing stand that is not earthquake rated may be re-used in place if the earthquake zone of the site is 0, 1, or 2).

Battery trays that mount in heavy-duty relay racks are also made of metal. They must be rated for the weight they will support, and specify the number of screws needed for the weight supported. The shelves should be powder-coated, and may optionally be protected with a non-conductive, acid-resistant plastic sheet.

Very small batteries may mount in a powder-coated metal box that may be wall or relay rack mounted.

In outdoor RT cabinets, batteries are housed in metal trays and/or battery compartments. If housed in sliding drawers, the drawer slides shall be rated for the weight they will carry, and the top clearance between the battery posts and the compartment above shall be at least ½" (the battery posts should be protected with insulating covers if the clearance is less than 2"). The trays and/or compartments may be powder-coated, and should have a heater pad for climates where the temperatures will regularly drop below 30 degrees F in the winter, and lead-acid batteries will be used. The heater pad should keep the batteries to a temperature of at least 40 degrees F, but not be active at battery or ambient temperatures above 60 degrees F.

All battery stands and relay racks equipped with battery trays that don't have battery disconnect breakers should be grounded with a #6 AWG ground wire. For battery disconnect breakers (for the purposes of this section, if a breaker does not have overcurrent protection, it is considered a simple disconnect and not a breaker) rated 15 A and smaller, a #14 AWG ground wire to the metal box may be used. For 20 A battery disconnect breakers, a #12 AWG may be used. For 25-60 A disconnect breakers, a #10 AWG may be used. For 70-100 A disconnect breakers, a #8 AWG must be used. For 110-200 A disconnect breakers, a #6 AWG is required as a minimum. For 225-300 A disconnect breakers, a #4 AWG is required for stand grounding. For 350-500 A disconnect breakers, a #2 AWG minimum is required. For 600-800 A disconnect breakers, a 1/0 AWG grounding conductor is necessary. For 1000 A disconnect breakers, a 2/0 AWG ground is needed. For 1200 A and larger disconnect breakers, ground the stand with a 4/0.

### 3.9.2 Round Cell Stands

A modular polyester-fiberglass battery stand is available for use with pure-lead flooded round cells. These types of stand are acid-resistant, fire retardant, and eliminate the possibility of a ground fault or an electrolyte path between cells of widely different voltages. These stands are no longer available (and round cells are no longer manufactured either). Although the stands are not metallic, a #6 AWG ground wire should be run to them to allow a place for a technician to discharge static electricity before working on cells.

### 3.9.3 Battery and Stand Installation and Intercell Connections

Battery stands must be placed in accordance with CenturyLink™ Technical Publication 77351. Single sided battery stands must not be placed closer than 6 inches to any wall, post, or pillar. All other battery stands shall follow aisle requirements stated in CenturyLink™ Technical Publication 77351. The battery side of two-tier two-row battery stands must not be placed next to a wall; however the end can be placed near the wall using the spacing requirements found in Pub 77351.

Spacing requirements for battery bays (heavy duty relay racks) equipped with VRLA or Li-based batteries are not covered by Tech Pub 77351 however. These bays do not need rear or side clearance (unless there are side handles or other items on the batteries that require such clearance), although rear access is desirable if the batteries are top terminal batteries installed in a stationary tray. Front clearance for battery bays where the installed batteries will not exceed 85 lbs. each is only required to be a minimum of 2 feet. However, for batteries weighing more than that, 3 feet is the desired minimum front clearance, and 30" is the required minimum.

The majority of battery installation requirements are found in Chapter 10 of Tech Pub 77350, with some related requirements in other chapters of that installation Tech Pub.

A minimum of two intercell connectors should be used in all applications where battery posts are designed to accept multiple intercell connectors. The thickness of the connectors should be designed so that the connector(s) will have sufficient strength and flexibility for earthquake zone 4.

All nut and bolt connections made to battery posts, terminal plates, and intercell connectors shall be made with stainless steel (preferred), lead, lead coated copper, or nickel-plated copper.

Intercell connector and all connector lugs connected directly to flooded lead-acid posts shall be lead or lead coated copper. Lead plated connector lugs do not have to have an inspection window. All other lugs should have an inspection skive. Tin-plated copper compression type lugs can be used when connecting to the terminal plates and to VRLA, Li-ion and NiMH batteries; however they cannot be used to connect directly to flooded battery posts (lead-plated copper for flooded lead-acid batteries, and nickel-plated copper for flooded Ni-Cd batteries. There will be no connectors varnished, Karo™-syruped or painted, during or after installation.

During activities that could result in an acid spill, including the installation, removal, or rearrangement of batteries, sufficient acid neutralization material shall be on hand to neutralize and contain a minimum of eight gallons of acid for large flooded batteries, or one gallon for flooded engine-start batteries.

All battery stands shall provide means for anchoring to the floor in order to meet CenturyLink™ earthquake Zone standards as required. The CenturyLink™ approved battery stand anchor shall be used except when shimming is required, or the washer or bolt-head of the battery stand anchor won't fit the "foot" of the battery stand. The approved CenturyLink™ toll anchor shall be used when shims are necessary due to uneven floors.

Battery strings should use alpha designations (A, B, C, etc.) going forward (the next battery job is a good opportunity to relabel mislabeled plants). The letters:"O" and "I" should not be used. If more than 24 strings exist in a plant, label the 25th string as "AA", the 26th as "BB", etc..

Battery strings are connected in parallel, and individual batteries within a string are connected in series. Individual cells will not be connected in parallel externally; however multiple cell batteries can be connected in parallel within the battery case.

Lead-calcium batteries shall not be reused in another site if the cells are older than 5 years from the manufacturing date on the battery.

New and significantly remodeled battery rooms must conform to the provisions of the Fire Code); be compartmentalized (for lead-acid batteries), and have acid spill containment with sealed flooring (typically epoxy or a linoleum-like acid-resistant material that is epoxied or thermally welded at the seams) if the total free-flowing liquid electrolyte exceeds 1000 gallons (or if so ordered by the Fire Marshal or Building Inspector). Where containment is necessary, whole room containment is preferred within CenturyLink™ for multi-string DC plants with flooded batteries in larger offices, however if this is not practical or cost-effective, area containment or individual stand containment are available options. Unless specifically ordered otherwise by the Fire Marshal, neutralization and/or absorptive pillows are not required under the battery stands (they are in the spill kits in the battery area for reactive response). Permanently-placed spill containment pillows shall be Listed for flame-retardancy in NEBS-compliant offices.

The bus bar, auxiliary framing, or cable rack, shall be a minimum of 6 inches directly above the highest point of the battery. No framework, cable racking, bus bars or any other obstruction shall not interfere or impede with the maintenance of the batteries.

Battery bus bars over flooded battery stands (except the chandelier) may be stacked as long as the following requirements are met. The battery feed bus bar shall be located a minimum of one foot above the cable rack. The battery return bus must be located a minimum of six inches below the cable rack. Battery bus bar shall not be stacked on the same side of the cable rack when above battery stands (however, when not above battery stands, they may be on the same side of the cable rack as long as the vertical separation between buses of opposite polarities is at least 6 inches). When the bus bar is not stacked, the bus bar shall be a minimum of six inches below the cable rack. If there is insufficient room to place the bus bars below the cable rack the battery termination bars may be installed a minimum of four inches above the cable rack.

There must also be a separation of eighteen (18) inches minimum (center line to center line) between the battery and return buses (see Figure 9-5) when they are installed in the horizontal plane by each other.

Sizing of the cables from the bus bar above the battery stand to the main bus bar (chandelier) shall be in accordance with Chapter 9.

Battery suppliers shall provide a label or stamping on each battery containing the following information:

- voltage
- the rating of the battery at a specific discharge rate, the temperature for that rating, and the end-voltage to which the rating applies
- the minimum and maximum Float voltage
- the operating temperature at which the battery lifetime is guaranteed (e.g., 25 degrees C or 77 degrees F)
- the date of manufacture (may be part of the serial number), preferably in an easily intelligible format

Pilot cells (aka, the Temperature Reference cell) should be in the top tier of the battery stand and have the lowest voltage reading after initial charge of all the batteries on that tier for that string. Cells 1 and 24 cannot be used as the pilot cell.

All VRLA batteries shall have a minimum of ½” spacing between batteries to allow for natural circulation of air, and adequate top clearance (preferably at least 4”) to allow for maintenance. The requirement for top clearance may be reduced to ½” for batteries whose posts/terminals are front-accessible, or when the batteries are in a slide-out tray so that the tops are accessible.

**Figure 3-1**: Typical Arrangement of Cables for a Flooded Battery Stand

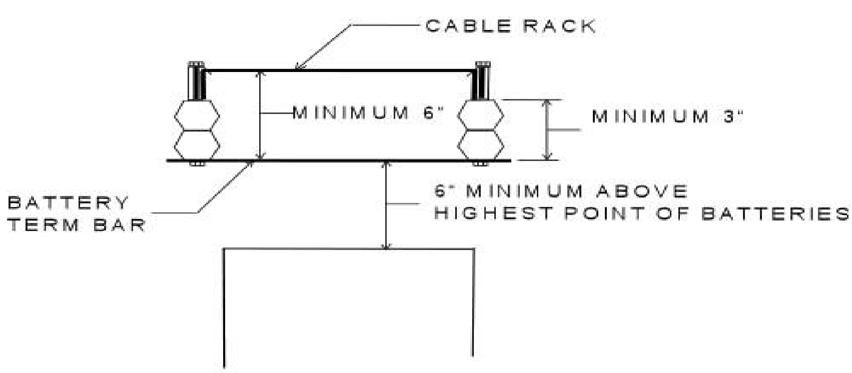


**Figure 3-2**: Minimum Dimensions for Bus Bar above Flooded Battery Stands

### 3.10 Battery Disconnects

A disconnect breaker or other means to disconnect the battery (e.g., quick-disconnect plug, or a switch) shall be connected in series with each VRLA string (and is required as part of the built-in protection for Li-ion batteries – size designed by the Li-ion pack manufacturer) that is not in a CO or microwave radio site. Battery disconnects may also be required by a Fire Marshal, or when battery cables are not separated from fused cables on an unfused rack (in that case a fuse or breaker is required). The breaker or disconnect shall be large enough to handle recharge capacity. When the Fire Marshall requires the installation of Battery Disconnects for each string of and/or an Emergency Power Off (EPO) switch, the EPO switch will disconnect the batteries, Engine, and AC Service. This requires the installation of a battery disconnect with shunt-trip capability.

Battery cabling voltage drop standards are in Chapter 9. The disconnect is sized at the 125% of the 2 hour battery discharge rate (for an end point cell voltage of 1.86 for lead-acid cells). The 2-hour rate rule only applies to long duration (3 hour or more designed discharge times) applications.

Note that after the voltage drop calculation is completed, the cable size suggested by that calculation should be compared to the ampacity of an overcurrent protection device (where one exists), and it is suggested (although not absolutely required in CenturyLink-owned buildings) that the ampacity of the cables meet or exceed the protector size (when the disconnect is a breaker or fuse). In space that is not owned by CenturyLink, if the battery disconnect also happens to be a breaker or fuse, by Code, the ampacity of the cables must equal or exceed the protector (fuse or breaker) size.

The following calculation examples apply to Table 3-1:

- 4000 Amp-hr Mini Tanks are rated at 927 Ampere-hours at the 2-hour rate, therefore 927A × 125% = 1158.75 Amperes. That indicates the need for a 1200 Ampere battery disconnect. Three 750 kcmil cables are the minimum suggested number of cables (the ampacity of each 750 kcmil cable is 475 Amps). This exceeds the minimum of four 350 kcmil cables required by Chapter 9. Voltage Drop calculations (per Chapter 9) may require more cables.
- 1680 Amp-hr type batteries are rated at 415 Amperes at the 2-hour rate, therefore 415 × 125% = 519 Amperes, which indicates the need for a 600 Amp battery disconnect. Two 350 kcmil cables are the minimum number of cables suggested (cable ampacity of 350 kcmil cable is 310 Amps) based on this calculation, but Chapter 9 requires four 4/0 AWG cables or equivalent as a minimum. Voltage Drop calculations (per Chapter 9) may require more cables.

Note that for all 3 long duration battery disconnect sizing tables, most of the values are approximate, and will vary by manufacturer and model.

**Table 3-1** Typical Battery Disconnect Sizes for Long-Duration Flooded Lead-Acid

| Amp-hr Rating to 1.75 V/cell | Amps @ 2 hour rate to 1.86 V/cell | Amps @ 4 hour rate to 1.86 V/cell | Amps @ 8 hour rate to 1.86 V/cell | 125 % of the 2 hour rate | Minimum Disconnect in Amperes |
|---|---|---|---|---|---|
| 110 | 30 | 19 | 12 | 38 | 40 |
| 155 | 43 | 28 | 17 | 54 | 60 |
| 200 | 54 | 35 | 22 | 67 | 70 |
| 270 | 66 | 45 | 29 | 83 | 90 |
| 360 | 88 | 60 | 39 | 110 | 110 |
| 420 | 102 | 70 | 45 | 128 | 150 |
| 450 | 110 | 75 | 48 | 138 | 150 |
| 540 | 132 | 91 | 58 | 165 | 175 |
| 660 | 157 | 110 | 71 | 196 | 200 |
| 720 | 175 | 121 | 77 | 219 | 225 |
| 840 | 208 | 140 | 91 | 260 | 300 |
| 1008 | 246 | 170 | 108 | 308 | 350 |
| 1176 | 287 | 199 | 126 | 359 | 400 |
| 1344 | 328 | 227 | 144 | 410 | 450 |
| 1680 | 415 | 280 | 181 | 519 | 600 |
| 1810 | 441 | 306 | 194 | 551 | 600 |
| 2016 | 491 | 341 | 216 | 614 | 700 |
| 2110 | 544 | 366 | 223 | 680 | 700 |
| 2320 | 619 | 409 | 243 | 774 | 800 |
| 3344 | 795 | 554 | 354 | 994 | 1000 |
| 3623 | 852 | 600 | 384 | 1065 | 1200 |
| 3900 | 907 | 639 | 409 | 1134 | 1200 |
| 4000 | 927 | 653 | 418 | 1160 | 1200 |

**Table 3-2** Typical Battery Disconnect Sizes for Ni-Cd Batteries

| Amp-hr Rating to 1.0 V/cell | Amps @ 2 hour rate to 1.17 V/cell | Amps @ 8 hour rate to 1.17 V/cell | 125 % of the 2 hour rate | Minimum Disconnect in Amperes |
|---|---|---|---|---|
| 75 | 25 | 9 | 32 | 35 |
| 100 | 32 | 12 | 40 | 40 |
| 140 | 45 | 17 | 56 | 60 |
| 175 | 55 | 21 | 69 | 70 |

**Table 3-3** Typical Battery Disconnect Sizes for Long-Duration VRLAs

| Ah Rating @ 1.75 V/cell | Amps @ 2 hr rate to 1.86 V/cell | Amps @ 4 hr rate to 1.86 V/cell | Amps @ 8 hr rate to 1.86 V/cell | 125 % of 2 hr rate | Minimum Disconnect in Amps |
|---|---|---|---|---|---|
| 5 | 1.9 | 1.1 | 0.6 | 2.4 | 3 |
| 7 | 2.7 | 1.5 | 0.8 | 3.4 | 5 |
| 9 | 3.1 | 1.7 | 0.9 | 3.9 | 5 |
| 12 | 4.9 | 2.5 | 1.3 | 5.9 | 6 |
| 18 | 6.5 | 3.5 | 1.9 | 7.9 | 10 |
| 25 | 11 | 5.8 | 3.0 | 14 | 15 |
| 30 | 12 | 6.5 | 3.5 | 15 | 15 |
| 45 | 17 | 10 | 5.4 | 24 | 25 |
| 60 | 24 | 14 | 7.5 | 30 | 30 |
| 70 | 26 | 15 | 8.0 | 33 | 35 |
| 80 | 29 | 16 | 9.1 | 36 | 40 |
| 90 | 35 | 19 | 10 | 44 | 45 |
| 100 | 39 | 21 | 11 | 48 | 50 |
| 110 | 43 | 23 | 13 | 54 | 60 |
| 125 | 45 | 26 | 15 | 56 | 60 |
| 145 | 53 | 29 | 17 | 66 | 70 |
| 150 | 54 | 30 | 18 | 68 | 70 |
| 155 | 56 | 31 | 19 | 70 | 70 |
| 170 | 62 | 35 | 20 | 78 | 80 |
| 180 | 65 | 37 | 22 | 81 | 90 |
| 190 | 70 | 40 | 23 | 88 | 90 |
| 570 | 183 | 110 | 60 | 229 | 250 |
| 760 | 237 | 146 | 86 | 296 | 300 |
| 950 | 299 | 189 | 113 | 374 | 400 |
| 1045 | 336 | 201 | 119 | 420 | 450 |
| 1425 | 449 | 283 | 169 | 561 | 600 |
| 1520 | 488 | 293 | 173 | 610 | 700 |
| 2000 | 627 | 371 | 227 | 784 | 800 |
| 3000 | 940 | 556 | 340 | 1175 | 1200 |

There are a few scenarios that differ from the standard design already covered.

- Excess Rectifiers. This scenario has the possibility of providing more current to the batteries than even the two-hour charge rate. Obviously, this may operate the breakers, but excess rectifiers are the main cause of thermal runaway, and this is one of the reasons to place the breakers in series with the batteries. The recommendation in these cases is not to upsize the breakers, but to shut off excess charging capacity.
- Excess Battery Capacity with Large Cells (cells with large Amp-hour ratings require fewer strings). Excess rectifiers coupled with this scenario could be a problem, because the large cells mean that fewer strings are necessary. Another scenario is that the breaker sizing, based on the large Amp-hr rating of the cells, would exceed the total charging capacity of the plant. For example, a 540 Amp-hour VRLA cell used in a 100 Ampere plant with three 50 Ampere rectifiers would call for a breaker rated at 200 Ampere. However, the total charging capacity of the plant is only 150 Amp-hours. Although a disconnect breaker (if a thermal-magnetic breaker is used as the disconnect) will never trip on charging, it can still be useful as a maintenance tool for manually disconnecting the string (and magnetic breaker will still also protect against short circuit currents).

For UPS type applications, the battery disconnect must be sized at a minimum of 125% of the expected maximum discharge current. This current can be calculated from the following formula:

$$I_{max} = \frac{R_{VA}}{mvpc \times n_{c/s} \times \eta}$$

Where,

$I_{max}$ is the maximum DC current that would be drawn from the battery of a fully-loaded UPS at the inverter minimum operating voltage

$R_{VA}$ is the rating of the UPS in Volt-Amps (if the unit is rated in kVA, multiply that kVA value by 1000 to get the Volt-Amp rating)

$mvpc$ is the minimum volts per cell design of the battery, based on the inverter minimimum operating voltage, and the number of cells in series per UPS battery string

$n_{c/s}$ is the number of cells (nominal 4, 6, 8 and 12 V monobloc lead-acid batteries have 2, 3, 4, and 6 cells per jar, respectively, and all cells must be counted) per string (note that many UPS have multiple strings in parallel for reliability reasons, but that for this calculation, only the number of cells in a single string is used)

$\eta$ is the conversion efficiency of the inverter when the UPS is fully loaded

The typical design *mvpc* for most North American UPS lead-acid battery systems is 1.67 V. Most modern UPS have maximum inverter conversion efficiencies of at least 95% ($\eta \geq 0.95$). Substituting these two values yields the following simplified equation for UPS lead-acid battery maximum current:

$$I_{max} = \frac{0.63 \times R_{VA}}{n_{c/s}}$$

The simplified equation can be used to perform a sample calculation, as follows:

- For an 80 kVA UPS, there are forty 12 V VRLA monoblocs per string. This means that for purposes of the equation, $R_{VA}$ is 80,000 (1000 x 80), and $n_{c/s}$ is 240 (6 x 40). Plugging the numbers into the formula yields a maximum current of 210 Amps. Multiplying this number by 125% gives a value of about 263 Amps. Upsizing to the next standard size breaker means a battery disconnect size of 300 Amps. Even when there are parallel strings on the UPS, the user would want to protect each string with a DC-rated breaker of at least 300 Amps in case of open circuits in parallel strings during operation or testing.

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# 4. Converters (DC/DC)

## 4.1 General

This unit covers DC/DC converters that transform the output of a rectifier/battery plant. The converter output voltage may be higher, lower, or at a different polarity than the input voltage. In some special cases, where ground, noise, or transient isolation is required, the output voltage and polarity may be the same as the input.

Converters can be applied in two ways: as bulk converter plants or as imbedded (dedicated) converters. Imbedded plants are generally provided as a component of the served equipment. The requirements of this unit apply to bulk converter plants.

If the capacity of the converter plant is exceeded for any reason, the output voltage of the converters must be lowered rather than allowing the plant to fail.

PLANT SIZING — Converter plant size is based on the peak loads of the connected equipment. In other words, sufficient converter capacity must be provided for possible short-term peaks.

WORKING SPARE — The number of converters in a plant should be at least one more than is required for the total anticipated current drains defined above, so that the failure of any one converter does not overload the remaining converters.

Collocators may install DC-DC converters in their space (fed from CenturyLink-provided DC feeds) with the permission of CenturyLink. However, these converters may not have batteries or fuel cells connected to their output bus as a backup DC source. Customer-provided converters must meet NEBS™ Level 1 (see Section 1.6) for NEBS™ spaces. For non-NEBS™ spaces, the converters must be Listed.

## 4.2 Alarm Features

The following converter plant alarm indications are minimum alarming considerations (the alarms noted in the combined major and minor alarms may be broken out individually). Alarms provided should include the ability to be wired to local audible and visual alarm systems as well as the remote alarm system.

- MINOR — One converter failed: A single converter failure (as opposed to being turned off) will initiate a minor alarm.
- MAJOR — Converter majors include plant distribution, or control fuse/breaker operation, low bus voltage, high bus voltage, and two or more converters failed.

## 4.3 Technical Requirements

Protection (fuses or circuit breakers) for feeds from a converter plant shall NOT exceed the capacity of the plant minus the spare converter.

Individual Converters should have individual power feeds, rather than a single power feed to the Converter Plant. If there are feeds common to more than one converter, the combined total size of the converters served by the common feed becomes the "spare converter" size.

Converter output voltage static regulation shall be ±1% over a load range of 10% to full load.

Converter input voltage range shall be at least -42 to -59 VDC for nominal -48 Volt input, and ±21 to ±29.5 VDC for nominal ±24 Volt input.

The converter case and/or shelf shall contain an adjustable high voltage shutdown circuit that automatically shuts itself down when the output voltage exceeds a preset value. When this occurs, a low voltage alarm indication shall be given as a minimum.

The converter output current shall be limited to no more than 110% of its rated capacity. The converter output voltage shall be adjustable to ±10% of its normal output voltage.

The converters plant shall have meters displaying the output voltage and current. Analog current meters shall have a scale with a range of 150% of the rated capacity. The converters should have either a meter or LED bar graph to display the load current. They should also have test jacks to measure converter voltage.

All components of the plant and converters shall be removable through front access. The converter equipment shall be modular. During growth and additions, the delivery of power to the using systems shall be maintained.

All converter equipment shall have a nameplate with a minimum of the supplier's name, model and serial numbers, input and output voltages, and manufacturing date.

For loads with a different voltage and/or polarity than the primary battery plant, two choices exist to serve them:

- Converter plant
- A separate Battery plant

For loads less than 100 Amperes, typically a converter plant is the preferred option. For loads exceeding 100 Amperes, typically it is less costly over time to serve those loads with a new battery plant at their voltage and polarity. The engineer should evaluate the economics before making a decision.

Step-up converters are considered separately derived DC power sources by Code. This means that in addition to the frame grounding, the output return bus of the converter plant must be directly referenced to a COGB, PANI MGB, or OPGP (see CenturyLink™ Technical Publication 77355, Section 5.5). Step-down converters may or may not be separately derived. If they are separately derived, they are typically described as "isolated".

## 4.4 Line-Powering

### 4.4.1 Introduction to Line-Powering

Line powering (including express/span powering) is the use of twisted pair copper (AWG 19-26) to pass DC power from a source in a building/cabinet to an RT or housing (the powering may be from headend to a remote end, or "back-powering"). Telecommunications networks have a long history of using line powering for various tasks, such as the coin return mechanism of payphones, T-1 repeater powering, HDSL remote unit powering, FTTC powering, etc. Line powering remains popular for existing and emerging technologies because it doesn't require placement of power company meters, rectifiers, and batteries at remote locations. Even though power is wasted ($I^2R$ losses) in the transmission of line power, it is still often more cost effective for relatively small wattage needs compared to placing AC power and associated power-conditioning equipment at the remote end.

Line-powering voltages commonly found in the industry and addressed by Telcordia® NEBS™ document GR-1089, ITU-T recommendation K.50, and UL® Standards 60950-1 and 60950-21 are less than 200 V with respect to ground (e.g., nominal -48 VDC, -130, -190, ±130, ±190, etc.).

Line-powering voltages are either positively ground-referenced (e.g. – 190 VDC), or bipolar center-tap grounded (e.g., ±130, ±190 VDC). Negative voltage on the energized conductor(s), such as a nominal -130 V system, limits corrosion of the copper pairs when water intrusion occurs in Outside Plant cables.

In addition to the information on line-powering in the above-referenced documents, there are maximum power and current limits in the NEC® and NESC; maximum voltage, power, and current limits in ANSI/ATIS-0600337; and additional electrical protection information for line-powering schemes in ANSI/ATIS-0600332.

### 4.4.2 Nominal Line-Powering Voltages

There are many historical systems that have used line-powering (both voltage and current-based), such as T-1, HDSL, payphone coin return, etc. Their voltage windows, current levels, and power usage vary based on the system and manufacturer. The purpose of this section is to define line-powering circuit characteristics (e.g., voltage windows, power maximums) for non-MDed existing and going-forward systems, rather than cover all of the legacy systems. This does not preclude the use of other voltages and systems, but allows for interoperability of systems meeting these guidelines.

The recommended voltage windows for line-powering are summarized in Table 4-1. Whenever possible, negative uni-polar voltages (e.g., -48, -130, -190 should be used to minimize the corrosion of copper pairs.

**Table 4-1** Recommended Voltage Operating Windows for Line-Powered Equipment

| Nominal Line-Powering Source-End Voltage | Minimum Voltage Operating Window for the End-Use Equipment | Extended Maximum Operating Voltage | Extended Minimum Operating Voltage |
|---|---|---|---|
| -48 VDC[2] | -30 to -56 | -60 | -27 |
| -130 VDC | -70 to -140 | -150 | -65 |
| ±130 VDC | ±70 to ±140<br>(140 to 280 across pairs) | ±150<br>(300 across pairs) | ±65<br>(130 across pairs) |
| -190 VDC[1] | -100 to -200 | N/A (-200) | -95 |
| ±190 VDC[1] | ±100 to ±200<br>(200 to 400 across pairs) | N/A (±200) | ±95<br>(190 across pairs) |

Notes:

1. Any voltage on a copper pair exceeding 140 V (positive or negative) to ground must have fast-acting source current-limiting (to 10 mA or less) when a ground fault is detected
2. The -48 VDC line-powering source referenced here excludes legacy POTS circuits, and PoE within a building.

### 4.4.3 Pairs and Wire Gauges Used in Line-Powering

Line powering can be done over the data transmission pairs, spare pairs (often referred to as "express powering"), or both. While 24 AWG and 26 AWG are the most common wire sizes in typical OSP distribution, some 22 AWG has been deployed specifically to enhance broadband bandwidths. If 19 AWG exists in the OSP, it is usually deployed primarily for line-powering applications to extend the reach (19 AWG has approximately half the resistance of 22 AWG).

Line-powering over distance often requires more than 1 pair (bonded at both ends), depending on the wire gauge used for the transmission, the end power requirements, and the equipment operating voltage window.

In a line-power system, an equipment manufacturer-supplied calculator is typically used to determine the number of pairs needed so that the minimum end voltage of the equipment is met. However, to calculate it manually, the following information must be known: the max expected operating temperature (higher temperatures increase the cable resistance – note that aerial cable will typically operate hotter than buried cable), the cable gauge(s) and their resistance (typically given per kft) at the expected maximum operating temperature, the number of available parallel pairs, the maximum power usage (in watts or constant current amps) expected at the end-use equipment, and the minimum operating voltage of the end-use equipment.

The resistivity of copper (IACS) is an SI-derived unit, and is approximately 1.721 x $10^{-8}$ $\Omega \cdot$ m at 20°C (68°F). Over normal operating temperature ranges, the coefficient of resistivity for copper is approximately 0.393%/°C (≈ 0.218%/°F). The following Table (4-2) gives some baseline values of twisted pair resistivity at various temperatures, which can be adjusted for the expected maximum temperature based on the coefficient values given in the preceding sentence.

**Table 4-2** Resistance and Ampacity of Common Sizes of OSP Copper Pairs

| **Wire Size** (AWG) | **circular mils** | **diameter** (inches) | **Ampacity** | **Ω/kft/pair at various temperatures** | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | **68°F** | **77°F** | **122°F** | **149°F** | **167°F** |
| 26 | 254 | 0.0159 | 0.8 | 84.6 | 86.3 | 94.7 | 99.6 | 103.0 |
| 24 | 404 | 0.0201 | 1.3 | 53.2 | 54.3 | 59.5 | 62.6 | 64.7 |
| 23 | 509 | 0.0226 | 1.5 | 42.2 | 43.4 | 47.3 | 49.7 | 51.5 |
| 22 | 642 | 0.0253 | 2.1 | 33.5 | 34.2 | 37.4 | 39.4 | 40.8 |
| 20 | 1020 | 0.0320 | 3.0 | 21.0 | 21.6 | 23.5 | 24.7 | 25.6 |
| 19 | 1290 | 0.0359 | 4.2 | 16.7 | 17.0 | 18.7 | 19.7 | 20.3 |

Note: the resistances are approximate and are those of the complete circuit created by a pair of solid un-tinned soft annealed copper wires (e.g., the resistance of 1 kft of a 26 AWG copper pair is actually the resistance of 2000 ft of 26 AWG copper conductor)

If the far-end equipment is constant current, use the cable resistances at maximum expected operating temperature and Ohm's Law to calculate the voltage drop.

If the far-end equipment is constant power (much more common than constant current for modern line-powered equipment) use the minimum operating voltage of the equipment, divided into its maximum watt draw, to determine the maximum operating current. This current can then be plugged into Ohm's law to determine the voltage drop. If the voltage drop from the source normal operating voltage (which will typically be the nominal voltage or slightly above it, but typically not quite as high as the maximum from Table 4-1) drops the far-end equipment operating voltage below its window (see Table 4-1), then more pairs must be used. Add pairs until the resistance decreases enough (2 parallel pairs of the same gauge are half the resistance of a single pair, 3 parallel pairs is a third of the resistance, etc.) that the voltage window is met at the far end. Note that the equipment (both source and far-end) may be limited in the number of pairs it can accept.

The following equation condenses the text of the paragraph above in order to determine the number of pairs needed for end-use equipment that is relatively constant power:

$$N_p > \frac{R_{p/k} \times d_k \times P_{max}}{{V_{min}}^2}$$

where;

| | |
|---|---|
| $N_p$ | is the minimum number of pairs needed |
| $R_{p/k}$ | is the loop resistance per kft for the wire size to be used at the expected maximum temperature |
| $d_k$ | is the one-way distance (in kft) from the source to the use end of the line-powering circuit |
| $P_{max}$ | is the maximum power usage of the end equipment |
| $V_{min}$ | is the minimum voltage at the end equipment |

### 4.4.4 Line-Powering Current and Power Limits

The NEC, the NESC, UL® 60950-21, and GR-1089 limit the amount of power that can be transmitted per each twisted pair circuit (i.e., the bonded multi-pair circuit, not just per pair) to 100 VA (which is 100 W in DC terms). In practical terms this means that the user does not have to worry about exceeding the ampacity of the twisted pair since for all of the nominal line-powering voltages listed above (except for nominal -48 VDC), the current will be less than the 1.3 Amp maximum specified by some standards. The NEC® also limits current to $100/V_{max}$ for continuous current and $150/V_{max}$ for short durations. This will not cause an issue with nominal line-powering voltages of 130 and higher; however, it may cause an issue with nominal 48 V line-powering. For nominal -48 VDC circuits drawing between 1.3 and 2.4 A, multiple pairs may need to be used (except for 19 AWG) to ensure the ampacity of the smaller gauge twisted pair wire is not exceeded; and the connectors must be rated for the higher current.

The 100 W source limit also imposes a practical limitation of about 50 W (although this can be exceeded with enough pairs, shorter distances, etc.) on the served equipment circuit (since it is expected that up to half of the source end power, or up to 50 W, will be lost through $I^2R$ cable losses – see section 4.4.5). For line-powered equipment that needs more than 50-75 W, the common method has been to use multiple 100 W maximum line-powering twisted pair circuits feeding individual DC-DC converters at the equipment end. Those converters usually step down the voltage to nominal -48 VDC and parallel the converter outputs, since there is no 100 W limitation on the power circuit at the user end (the limitation is on the power that can be transmitted on twisted pair telephony wires).

While 100 W is the max source limit per twisted pair circuit, if the end equipment needs much less power, it may be more economically efficient to source a power supply with capabilities matched more closely to twice the load power requirement.

Many central office 5-pin protectors have a heat coil or PTC resistor that effectively limits the current on a single pair to 150 mA (older versions) or 350 mA (newer versions). Applying the nominal 125% protector sizing rule (see NEC® Article 210.20A, for example), this means that each pair out of a CO should probably carry no more than 120 or 280 mA, depending on the type of protector for that pair at the frame. When more current is needed, pairs must be multipled or the line-powering voltage must be stepped up (to a max of nominal ±190 VDC) to lower the current on the individual pairs. Overvoltage protectors in RTs do not commonly have heat coils or PTCs, so there is usually no 120 mA limitation to pairs leaving an RT site for line-powering purposes.

When the manufacturer of the near end line-powering equipment differs from the manufacturer of the power supply(ies) at the far end, extensive lab testing may be necessary to ensure compatibility, especially at "turn on" due to capacitor charging, slew rates, etc.

### 4.4.5 Transmission Power Loss

While a wider voltage operating window suggests more $I^2R$ losses in the transmission, it also suggests that more power was transmitted over the fewest number of possible pairs.

In a typical scenario for line-powering (as defined by the voltage windows of Table 4-1), up to half the power is lost in the transmission (the voltage at the end is also half of what it was at the source). This also works well with DC-DC converters that are found at the end of a line-powering loop, since many "brick" DC-DC converters have a bottom of the voltage window that is exactly half their maximum input voltage.

Because the design of the line-powering circuit is with worst-case draw of the end-use equipment, most equipment will lose less than half the power in the transmission, since the actual normal draw of the equipment is often much less than the maximum due to fill rates and usage patterns.

There are many applications where more than half the source end maximum power is used in the end equipment being powered (e.g., an end-use ONU on a nominal -130 VDC circuit drawing a peak of 74 W, which leaves only 26 W to be lost in the transmission pairs). What this means is that more pairs will have to be used than in a circuit that shares the power equally between transmission and end-use in a maximum draw scenario.

### 4.4.6 Human Susceptibility Thresholds for Voltage and Current

Through testing, various voltage and current thresholds (in conjunction with contact time) have been established as "cross-over" points for human shock and safety. While standards and other documentation on the subject disagree slightly on exact current and voltage levels, due to test methods, differences in subjects, etc., generalizations can be made.

Current through the body determines the severity of a shock. For DC, the following generally applies:

- 2-30 mA may possibly be felt as a slight shock or tingle, but no harmful effects occur
- 30-100 mA can produce mild shock and muscle paralysis
- 100-300 mA can cause severe pain and trouble breathing
- Currents through the body greater than 300 mA can stop breathing and cause cardiac arrest

Current levels are typically determined by the voltage, the current path through the body, and the resistance of the body. Depending on the path through the body and the individual person, the typical resistance of the human body ranges from 20,000 to 1,000,000 ohms. However the resistance of a wet or sweaty human body (or the resistance through an open wound since the skin is the most resistive element of the body) can be as low as 500-2,000 ohms.

The following DC voltage levels represent thresholds relevant to this document for differing physiological effects with human body resistance as described by the currents and resistances in the preceding paragraphs (they do not cover the increased danger to humans as voltage increases from arc flash and arc blast events associated with inadvertent metal contact):

- Below 60 V is generally classified as "safety - extra low voltage", and will have little effect on a body (unless it is wet or has open wounds)
- 60-150 V can produce a mild shock and muscle paralysis
- 150-300 V can cause severe burns and ventricular fibrillation
- Voltages above 300 V can stop breathing and cause cardiac arrest

The voltage levels in the bullet points above can be to ground when one hot conductor is contacted and the current path is from the contact point through the feet or other grounded body point, or they can be across the body when two hot conductors are contacted at separate points (such as inadvertently holding a +190 V tip conductor in one hand and a -190 V ring conductor in the other).

Very short duration (in the microsecond, nanosecond, or shorter range) pulses (such as those used by police in non-lethal weapons) or transient events of extremely high voltage or currents above the top levels given here may not be lethal (even though they are quite painful) because they are not long enough to cause fibrillation or excessive internal body heating. Line-powering schemes exist (although not in wide use) using relatively higher pulsed voltages in order to avoid the greater personnel dangers, but take advantage of the power transfer efficiencies of higher voltages.

### 4.4.7 Safety Precautions for Line-Powering Voltages Above 60

All of the line-powering voltages discussed here are classified as A2 or A3 by Telcordia® GR-1089, and must be appropriately marked for the hazard, and protected against accidental contact where possible at all appearance points along the circuit (especially at the source and use ends).

Accessibility requirements should be based on the voltage level and on the training level of personnel who are expected to contact, or who might accidentally contact, these voltages. Two levels of training are identified in standards: *trained* and *untrained*. *Trained persons* are individuals who are knowledgeable and experienced in working on energized telecommunications circuits. Such persons are typically technicians employed by telecommunications companies to install, repair, and maintain telecommunications equipment. *Untrained persons* are those who are unfamiliar with the principles of electricity and have little or no knowledge of electrical circuits. Such persons may be customers utilizing telecommunications services.

Class A3 voltage sources shall be inaccessible for contact by untrained persons. Class A3 voltage sources shall have restricted access for contact by trained personnel. If it is exposed for contact by trained personnel, it shall comply with the following precautions.

- *Baffling and Segregation*: When an enclosure or baffle is removed, or energized electrical circuits are otherwise exposed for contact by trained personnel, Class A3 sources shall be segregated from lower voltage A2 sources by appropriate insulation, baffling, or location to prevent inadvertent contact
- *Labeling*: Designed appearances of Class A3 voltage sources on equipment that is powered by or that generates such voltages shall be labeled where trained personnel are normally intended to contact them for service or repair

Determination of accessibility should be done by the equipment manufacturer based on the intended application.

The following minimum safety precautions should be taken when working on line-powering circuits covered in this document:

- *Storm conditions* – Do not work on exposed plant during a thunderstorm
- *Temporary bonds* – When work operations require such activity as opening a cable shield, place temporary bonds as appropriate to minimize potential differences caused by a temporarily discontinuous path to ground
- *Insulated tools* – Use only hand tools with insulated handles
- *One conductor at a time* – Whenever possible, work on only one conductor of a pair at a time; which prevents contact with the higher voltage between two conductors in ± line-powering system
- *Small, dry contact area* – Keep the area of the skin in contact with a conductor as small and as dry as possible (resistance of the skin is directly proportional to the area of skin contact and inversely proportional to the moisture content of the skin)
- *Contact with ground* – Avoid simultaneously contacting a grounded object with part of your body while handling bare conductors (dry footwear will provide some insulation from ground)
- *Training* – Service personnel working on line-powered systems shall be properly trained to work on such systems

UL® 60950-21 and ATIS-0600337.2010 do not permit communications circuits in excess of TNV limits (60 VDC) past the service provider's point of demarcation.

### 4.4.8 Current-Limiting of Higher Voltage Ground Faults

For safety purposes, -145, ±145, -190 and ±190 VDC line-powering sources must be current-limited to 10 mA if a ground fault is detected from a "hot wire (either tip or ring). That said, there is generally no such protection if a technician gets across the positive and the negative of a ±145 or ±190 circuit. This means that the current through a technician on such a 100 W current-limited circuit could be as high as 500 mA (but more usually maxing out at 250 mA), depending on their body resistance at the moment of contact, and how far from the twisted pair circuit source end they are located (voltage drop across the pairs to that point). For this reason, technicians should always be careful when dealing with any line-powered circuit, but especially careful with ±190.

Note also that the ground fault detection circuit required for circuits over 140 V to ground can cause nuisance tripping and resets if not properly tuned.

### 4.4.9 Additional Concerns Above 300 VDC Across the Pairs

In addition to the aforementioned safety precautions for nominal ±190 VDC circuits, existing older cable pairs must be tested with a meg-ohmmeter to ensure that there is no insulation breakdown (some older OSP cable may not be capable of more than 300 V due to age-induced insulation breakdown), nor operation of TLPU protectors when ±190 VDC is applied (some protectors are designed to “fire” around 300 V).

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# 5. Inverters (DC/AC)

## 5.1 General

Inverters change DC to AC at a voltage suited to the load, and although they are often truly uninterruptible, they are not classified as a commercial UPS. Inverters are more reliable than a standard UPS and may be of the solid state or rotary type.

Two basic configurations are provided:

- Standby — in the standby configuration, the AC input powers the load directly and the inverter is a source of backup power. This operating mode conserves the life of the inverter and conserves energy. However, the incoming power is untreated so the load must be able to tolerate any power line disturbances that may be present. This mode is also known as AC-preferred.
- ON LINE — in the on line configuration, the inverter usually operates off the DC source to power the load, and the AC source, (if available) is the backup power. The on line option is preferable. This mode is also known as DC-preferred.

Online is the preferred configuration. An automatic static transfer switch is often provided to switch to commercial AC in case of an inverter failure. A maintenance bypass switch must be provided. The maintenance bypass and AC feed with its static transfer switch are not required in LNS when the inverter has redundant power modules that can carry 100% of the load (eliminating the need for maintenance bypass) during the service or replacement of a failed inverter module.

Components of the inverter shall be front-removable.

Inverters shall be modular to facilitate growth. Maintainability shall be stressed in the design. The design shall allow repair by module replacement.

Inverter nameplates shall contain the following information as a minimum: Supplier's name, inverter model number, inverter serial number, and manufacturing date.

The following equipment should generally be connected to an inverter if it is found in a larger Network site and uses AC power:

- Switches or other Network equipment that should have uninterrupted service and that require AC power.
- Computers essential to switch operation. Typically, no more than 2 maintenance terminals need to be powered from inverter protected AC. No printers or personal computers are permitted on the inverters.
- 911 equipment that is not DC powered.
- Fire Alarm panels.
- Card Entry Systems.

- Task lighting (as an alternative to DC-powered lighting for these applications).
- Switch room telephone systems (key systems, wireless systems, etc).
- Outlets serving modems essential to network elements.
- Outlets serving devices installed in frames that control or are essential to the operation of equipment serving over 1400 DSO's and/or any DS1's or DS3's (DISC controllers, TLS controllers, etc).
- The circuit shall be identified that it is inverter powered by a permanent label at the point of termination.

As implied in Chapter 1, unless specified in the individual contract, CenturyLink™ National Network inverters may not power CLEC equipment (in the CenturyLink™ local Network they are allowed to do this under state rules, tariff or contract).

Uninterruptible AC power provided by an inverter is expensive (due to the high cost of the inverter, and the battery backup and rectifiers required to support it). Non-critical and non-network loads should not usually be placed on the inverter. The Common Systems Power Engineer and the Power Maintenance Engineer are the final arbiters if there is disagreement over whether to place certain types of equipment on the inverter.

## 5.2 Inverter Selection

Inverter plants must be selected to have proper characteristics and designed to be compatible with the equipment served.

For inverters operating in a Stored Program Control System (SPCS) environment, all loads must meet the grounding requirements described in Chapters 4, 8, and 9 of Technical Publication 77355.

Any CenturyLink™ load requiring backup that can be DC-powered generally should be (especially in sites that already have a DC power plant), even if the power supplies cost a little more. In sites with a DC plant (or more than one DC plant) with equipment that does not have a DC-powered option, an inverter plant powered off a DC plant is the first choice when the total AC loads in the site/area that require uninterruptible power are less than 60 kW. For larger total uninterruptible AC loads, or for a site that does not have a DC plant, a commercial UPS (see Chapter 6) may be the choice.

## 5.3 Load Classification

Inverter plants are always classified as an "essential load" for sizing standby AC. Inverters are also included as part of the "power fail load" for sizing the feeding DC plant batteries when the inverter is operated in the continuous "on line" mode. Inverters must be included as part of the "busy hour" load for sizing the DC plant.

### 5.4 Alarm Features

The following alarm indications shall be provided for local and/or remote surveillance:

- Inverter "fail" — an inverter has failed.
- Inverter "supplying load" — a status indication used as an AC power failure indication for inverters normally operated in AC-preferred mode.

All points, loads, and alarms shall be accessible for connection to a Power System Monitor Controller (PSMC). The inverter shall produce alarms as described herein and in Chapter 8.

Each fuse shall be provided with a blown fuse indicator connected to an alarm-indicating lamp on the control panel.

### 5.5 Technical Requirements

The inverter shall be capable of tolerating power factors as low as 0.8 (80%) leading or lagging without damage to the inverter.

Multi-phase inverters shall be able to operate with a line-to-line load imbalance of 20 percent or greater without damage to the inverter

All external metal parts shall be grounded, and the grounding requirements of CenturyLink™ Technical Publication 77355 shall be met.

The inverter shall have built-in protection against under voltage, overcurrent, and over voltage.

Inverters shall be capable of being mounted in 19" or 23" racks, or in a floor-mounted cabinet.

An n+1 inverter configuration should be considered for critical loads and in high profile offices. N+1 inverter bays or shelves shall be designed so that the parallel inverters remain synchronized in their AC waveform in case of a bay/shelf controller failure.

Inverters may be separately derived power sources and shall be equipped with a grounding bus, and a neutral bus on the output. These buses should be grounded and bonded in accordance with CenturyLink™ Technical Publication 77355, Sections 5.5 and 4.2 (which follows NEC® Code requirements for separately derived sources). A simple way to tell if an inverter is separately-derived is if it has a hard-wired AC neutral that passes through and/or around the inverter (single line drawings of the inverter may be needed to determine if the internal AC neutral is hard-wired – not switched in the static transfer switch). If an inverter is only fed by DC, it is guaranteed to be separately derived.

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# 6 Uninterruptible Power Supplies (UPS)

## 6.1 General

This unit outlines general engineering considerations for Uninterruptible Power Supplies (UPS).

UPS require cooling of the ambient air to allow for full output and longevity of components. UPS equipment areas should be designed with the same environmental considerations as other equipment locations containing batteries.

The air in the room containing the UPS batteries must be exchanged a minimum of one complete change per hour to relieve the accumulation of battery fumes. If the batteries are located in an enclosed cabinet, that cabinet must be ventilated to the outside room at a minimum of one complete air change per hour. Local codes may require a higher rate of air exchange.

Larger UPS may induce extreme floor loading due to the combined weight of the system components. The loading factor may require the engineering of special floors. Some systems may require reinforced raised floors so that cool air can be introduced under the floor.

A UPS system must be engineered to be as reliable as the system it serves. As such, the manufacturers' recommendations for installation must be followed. This unit is an engineering guide for UPS systems that are not so defined by the manufacturer and provide minimum requirements for all UPS systems. Batteries for the UPS shall be flooded types wherever possible. Isolation transformers shall be used on all UPS systems above 10 kVA.

All components of the UPS shall be removable via front access.

UPS shall be modular to help design growth. Maintainability shall be stressed in the design. The design shall allow modular replacement for repair as much as possible. The design should be such that failure of any one module will not cause a complete UPS malfunction.

UPS nameplates shall contain the following information as a minimum: Supplier's name, UPS model number and serial number, kVA rating, nominal input and output voltages, and manufacturing date.

## 6.2 Definition of Terms

UPS Definitions:

- AC LOAD PROTECTION — Devices to allow one of several loads to be isolated for fault clearance or maintenance.

- BATTERY BANK — a group of cells/monoblocs used to provide the required reserve power to the inverters while there is no AC input to the rectifiers. The battery bank should be sized to provide the reserve for a minimum of 5 minutes (typical design is a minimum of 15 minutes) at full load, but may be designed for much longer reserve times, at an admittedly higher cost (for critical Network circuits in COs [and possibly in some RT/Prem sites], the desired reserve time is at least 4 hours, but a minimum of 2 hours is required). For sites where the UPS serves high heat-density loads, long battery reserve times are untenable since the served equipment will fail without the air-conditioning provided by engine-alternator or commercial AC). (Note that at least in Tier III and Tier IV Data Center designs, there are multiple strings of batteries, and because the equipment is typically at least dual fed from more than one UPS, any one UPS is typically not loaded to greater than 40%, so the actual reserve time is often at least 3 times the designed reserve time.)
- BATTERY DISCONNECTS — a means to open leads between the UPS and the battery bank. This device should safely open both the + and - leads, as most systems are not grounded on either battery lead. The device must be rated for the voltage and current of the battery bank. For DC battery strings having a voltage greater than 250, disconnects are also usually placed mid-string to minimize technician risk during maintenance.
- BYPASS — a source of AC power (commercial AC or engine-alternator backup) that will replace the inverter output. This source can be internal or external.
- HARD/MAINTENANCE BYPASS — an external source of AC that will allow shutdown of the UPS for maintenance and provide AC for distribution while the UPS power electronics components are not energized.
- DOUBLE-CONVERSION — This type of unit always converts AC power to DC, and then inverts it back to AC, providing truly uninterruptible and protected AC power to the load.
- FLYWHEEL — Some UPS systems (commonly known as rotary UPS systems) are equipped with a heavy flywheel (instead of battery backup) that provides 10-15 seconds of backup by storing rotational energy.
- INVERTER — Unit that converts DC to the necessary AC voltage required by the distribution system, normally 120/240 V single-phase, or 120/208 or 277/480 V three-phase.
- LINE-INTERACTIVE — This UPS unit normally passes a surge-protected commercial AC source through to the load, but switches to battery backup (through the inverter) in less than 4 milliseconds when the source is lost, or the quality of the AC waveform is poor.

- OFF-LINE — This UPS unit normally passes a surge-protected commercial AC source through to the load, but switches to battery backup (through the inverter) in less than 4 milliseconds when the source is lost.
- ON-LINE — (see the definition for double-conversion.)
- RECTIFIERS — change AC to DC to power inverters and float the battery banks.
- ROTARY UPS — a UPS consisting of an electric motor coupled through a clutch to an alternator (sometimes incorrectly called a generator), and including a heavy flywheel to keep the alternator spinning for a short time period when commercial AC power is lost to the motor.
- STATIC TRANSFER SWITCH — a very-fast acting (typically less than 4 ms) automatic transfer switch that transfers a UPS (or -48 VDC powered inverter) from AC source to the DC backup or vice-versa.
- STATIC UPS — a traditional UPS consisting of power electronic components (in rectifiers and inverters), and DC backup (usually batteries).
- SUPER™/ULTRA™ CAPACITORS — may be used in a static UPS to provide very short duration (almost always 2 minutes or less, and typically 10-30 seconds) DC backup to feed the inverters.
- TRANSFER SWITCH — A means of transferring the distribution system from the inverter's output to an alternate source, usually commercial power, or a source that can be transferred to a standby generator.

## 6.3 Technical Requirements

Outlets served from UPS shall be labeled as to source.

**CAUTION**

High voltage may be present on both the AC and DC sides of an UPS. AC or DC voltages may be as high as approximately 545VDC and 480VAC.

AC wiring must be sized to meet manufacturers' specifications. Rigid conduit must be used in areas where activity could jeopardize the integrity of the system.

Four hundred Hz systems may require the use of line regulators to provide a match of impedance between the load and the UPS.

Breakers feeding CenturyLink™ equipment must be coordinated to ensure proper isolation of feeders due to faults/overloads. The input and output main circuit breakers shall be equipped with a factory-installed shunt-trip capability for UPS larger than 10 kVA that will be installed in sites/rooms/areas requiring EPO shutoff of these UPS per the requirements of NEC® Article 645 (EPO should be avoided wherever possible).

DC wiring must be sized to meet manufacturers' specifications for loop loss between the battery and the rectifier or inverter. The voltage drop must meet National Electric Code (NEC®) requirements. When the batteries are separate from the power electronics components of the UPS, the DC leads are usually run on cable racks or trays and should have RHW, RHH or XHHW type insulation. Conduit may be used if both positive and negative leads are run in the same conduit. Conduit may be used only if other means are not available due to space requirements.

The operating temperature of all AC and DC wiring in UPS equipment will not exceed 20 degrees F higher than the ambient room temperature or 46 degrees C (115 degrees F) whichever is higher.

Electrically operated disconnect devices (aka EPO switches) are required in some computer room installations by Code. EPO switches/buttons should be guarded and preferably be pull-type rather than push-type.

The neutral lead of UPS systems must be grounded at one point only because it is a separately derived source when equipped with any transformer. A dedicated transformer and switchgear are normally used to provide bypass power. The neutral must be grounded at the secondary side of this transformer. The ground lead must not be switched. Grounding of computer areas served by UPS must be in accordance with the UPS manufacturers' specifications and the requirements defined in Technical Publication 77355, Chapter 11 (the neutral and ACEG grounding of the output of the UPS in covered in Sections 4.2 and 5.5 of that same Pub). Ground bonds between the UPS plant and the metallic structures shall consist of electrical conductors specifically provided for grounding purposes. Incidental paths through framework, cable rack, building steel, etc., shall not be used for grounding purposes. Daisy chaining between frames is not permitted. The doors of the UPS enclosures shall be equipped with grounding strap connections for static electricity control.

The major power electronics components (and monobloc VRLA batteries) of UPS larger than 40 kVA shall be housed in freestanding, "dead front" vertical enclosures with a maximum height of 7 feet. The enclosures may be mounted on heavy-duty casters with leveling screw jacks. The enclosures shall be equipped with "piano-hinged" doors or equivalent. These doors shall be equipped with locking mechanisms to prevent the doors from opening. All sheet metal used in the enclosures shall be 16 gauge or better. All joints and seams shall be welded. Cable entry shall be through either the top or the bottom of the cabinet.

Forced air-cooling and/or ventilation are normally required. Blower motors shall be equipped with sealed roller (ball) bearings. Each enclosure with a blower for UPS larger than 40 kVA shall have a redundant blower. A failure of a blower unit shall generate an alarm. All air inlet and exhaust openings shall be protected with expanded metal guards.

UPS designed to serve non-linear (non-sinusoidal, or high harmonic) loads shall have an output voltage THD of less than 20%. No single harmonic shall have an output distortion of less than 10% under any or all of the following conditions: up to 100% non-linear load; up to 100% load current THD; and/or a load current crest factor up to 3.0.

The UPS shall have built-in protection against under voltage, overcurrent, and over voltage on both the input and output.

The UPS shall conform to NTA, Telcordia® (Bellcore) TR-TSY-000757, Issue 1, *Generic Requirements for Uninterruptible Power Systems*. The UPS shall also be Listed.

Wherever possible and feasible, flooded batteries specifically designed for high discharge rate applications will be used with UPS, rather than VRLA batteries. When VRLA batteries are used, those designed specifically for high discharge rates (or general purpose batteries designed for many types of discharge rates) shall be used.

## 6.4 Alarming and Control

The UPS shall produce alarms as described herein and in Chapter 8.

Internal alarms and monitoring devices shall be built into the UPS to identify failed modules. Monitoring of VRLA batteries with a permanent monitor (based on the items discussed in sections 8.2.3 and 8.6.3) is desirable, especially if the UPS serves critical loads and only has a single string. Some UPS have the battery monitoring built into them, but for those that don't have this, external monitors are available. Wireless communication by UPS battery monitoring devices is not allowed in Central Offices and major long-haul transport sites (wired connections are always encouraged).

If the UPS utilizes a microprocessor and software for control, detection of a UPS unit failure shall be built into the software. It is desirable that microprocessor-based units be equipped with an IP port for html and/or SNMP communication, or at least serial data communication through an RS-232 port. Microprocessor driven UPS alarm/control will be either fully redundant, or capable of self-diagnostic and isolation in case of a microprocessor failure. This isolation will remove the microprocessor control from the system, provide a dry contact alarm, and revert to conventional operation.

All UPS shall be equipped with dry contacts for connection to an alarm system; these contacts will provide indication of UPS unit failure and operating status.

Battery backup (separate from the batteries used for the primary backup of the loads fed from the inverter) may be provided within the UPS to maintain power to the internal clock or save microprocessor settings, in case of failure of the power source. If such memory battery backup is provided, a low battery voltage alarm shall be provided allowing sufficient time to permit battery replacement on a non-emergency basis.

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# 7. Standby Engine-Alternators

## 7.1 General

This unit contains requirements for all standby AC systems and equipment including engine-alternators with automatic transfer equipment to be deployed in all CenturyLink™ facilities. Standby AC power plants provide long term backup for essential AC loads, as defined in Chapter 1 of this publication.

Terminology commonly used for AC power plants includes emergency, reserve, auxiliary, and standby. Standby (as opposed to "Emergency") is used in this document in conformance with the definitions of Article 701 "Legally Required Standby Systems" and Article 702 "Optional Standby Systems" of the National Electric Code (NEC®); as well as the definitions given in NFPA® 37 and NFPA® 110. The use of the term emergency should be avoided because true emergency engines and their associated AC systems have many additional maintenance and wiring requirements in the NEC.

The grounding system of a separately derived source (the minority of engine-alternators) shall be per Tech Pub 77355 Chapter 4, and NEC® Articles 250.30 and NEC® 250.20B. Grounding for most engines (those that aren't separately derived sources) shall conform to Sections 4.8-4.10 of Tech Pub 77355, and Article 250 of the NEC.

All engine-alternators must conform to local code and should be coordinated with the local, state, or federal agency having jurisdiction.

Air dryers and/or compressors must not be installed in the engine rooms due to the static electricity and heat generated. In fact, engines should be in their own room or outdoor enclosure (per NFPA® 76) for fire safety reasons, and in a separate room from the AC switchgear for reliability reasons.

CenturyLink™ doesn't require n+1 for engines or transfer gear, although paralleled engines in an n+1 configuration should be considered for the most important facilities.

In some cases of load growth, if engine horsepower is sufficient to support a larger alternator, it may be less expensive to replace just the alternator rather than the entire engine-alternator set. This might also be the case if the alternator fails.

Operating documentation (including control programming and prints/drawings) must be provided with each engine-alternator and transfer system. The documentation should include how to start or shut down the engine; how to back out of a transfer operation; how to manually transfer the system, and how to transfer the load when load shedding. If these can be shortened to a sheet or two for each operation, these sheets should be laminated and posted on the transfer and engine control cabinets.

Single-line diagrams for a site must be updated (and preferably laminated) by the electrical contractor whenever an engine or transfer system is added or replaced.

All systems and equipment to be deployed in telecommunication sites shall satisfy the relevant space and environment requirements of Telcordia® (Bellcore) GR-63-CORE. Major spatial (building space) requirements for standby AC plants are shown as follows:

- The clear ceiling height required for installation of an engine in a room shall not be less than 12 feet 6 inches. This means the minimum height from the floor surface to the bottom of the lowest building structural. Coordination may be necessary to ensure that the standby AC plant installation will not interfere with cabling, air ducts, or other building systems.
- The equipment weight, averaged over any 20 by 20 foot floor area, should not exceed an absolute limit of 140 pounds per square foot (140 $lb/ft^2$) for equipment, supporting structures, cabling and lights, unless the floor has been certified by a building engineer to be able to support more weight. Special building structural considerations may exist due to the load concentration and dynamic loads associated with the engine/alternators. Professional Engineers contracted by the CenturyLink™ Real Estate Department can determine this, plus any earthquake bracing that must be done for the engine installation at the specific site location. Outdoor engine enclosures should be placed on a pad designed to the engine-alternator manufacturer's specifications to withstand exposure, meet the local Codes, and support the weight and vibration. Unless otherwise specified, the minimum generator pad will be constructed of at least 6" thick reinforced (typically reinforced with 10 AWG wire mesh on a 6x6" grid and #8 rebar) concrete. The concrete strength shall be at least 4000 psi (a 6 sack mixture). The engine enclosure should be centered on the level pad (with a minimum of 3′ on each side and 2′ on each end) and anchored at all 4 corners.
- All connections from the engine/alternator (e.g. exhaust, fuel lines, coolant lines, electrical, etc.) shall be made with a flexible section for control of vibration. For outdoor engine enclosures, lines should enter through the pad on the bottom, or through another method that limits their exposure to the outdoors and to vibration damage.
- The environmental requirements in Telcordia® GR-63 and GR-1089 address temperature, humidity, heat dissipation, fire resistance, earthquake, office vibration, air borne contaminants, grounding, acoustical noise, illumination, electromagnetic compatibility, and electrostatic discharge. Environmental test methods are included in these NEBS™ documents, and they may be used for evaluating equipment compliance with these requirements.

CenturyLink™ requires a factory representative to go to the job site for the initial start up of an engine-alternator.

The design engineering and installation of power systems for all sites served by an engine-alternator should conform to the requirements of Occupational Safety and Health Administration (OSHA) and all applicable local health and safety codes. All power systems and equipment shall be designed and constructed to comply with applicable requirements of the NEC® and with applicable local electrical and building codes. When special requirements are necessary, they will be furnished by the CenturyLink™ Engineer. The standby AC plant, as installed, shall also conform to the requirements of NFPA® 37 (Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines); NFPA® 110 (Standard for Emergency and Standby Power Systems); and the "Flammable and Combustible Liquids Code" (NFPA® 30) or the "Liquified Petroleum Gas Code" (NFPA® 58); including the placement of bollards as required by NFPA® 30 or NFPA® 58 and local Codes and AHJs, depending on the location of above-ground tanks and outdoor engine enclosures.

The documentation for standby AC plants shall be provided in a clear, concise, and organized manner per CenturyLink™ requirements. The information shall include all the equipment building environmental requirements.

Engine-alternators should not be re-used in another site if they are over 30 years old. Before they are re-used they should be looked at by a qualified diesel mechanic, either a CenturyLink™ employee, or an outside engine-alternator vendor.

## 7.2 Site AC Power Systems

A typical AC power system for a site equipped with a standby engine-alternator consists of the following:

- Commercial AC Service Entrance
- Standby AC System
  - Engine-alternator
  - Transfer System
- Building AC Distribution System
  - Essential AC
  - Non-Essential (may not exist in smaller buildings)

The main building AC disconnect should preferably be outside the engine room but relatively nearby.

For CenturyLink™ sites other than buildings, AC requirements are defined in Chapter 11.

Commercial AC is the normal energy source for most CenturyLink™ sites. A prolonged commercial power fail requires backup in the form of standby AC for telecom services and essential building services. The standby AC system consists of one or more engine driven alternator(s), transfer system(s), electrical and mechanical controls, fuel storage and supply system(s), combustion air intake and exhaust systems, engine starting system(s), and cooling systems appropriate to the type of equipment employed.

The size and type of standby AC system is determined by the combined building and equipment loads that require essential AC service. Telecommunications equipment may represent only a portion of the total load. The alternator kW should generally be sized between 125-333% of the essential load (see the next section for further detail).

### 7.3 Sizing and Ratings

Standby engine-alternator power plants are power-limited sources that can be overloaded by simultaneous starting of connected loads.

In order to avoid transient overloads or oversizing of the engine, large motors (such as those found in chillers and other HVAC) should be on lead-lag control, and any VFDs should have soft-start. In addition, it might be necessary to add sequenced starting of rectification, although this need is rare because modern rectifiers have current walk-in.

Standby engines shall be designed and configured for reliable starting and continuous operation at full load within a range of operating conditions specified for CenturyLink™ sites. Generally, the engines should be sized (based on the criteria below) between 125 and 333 % of the existing peak load on the site (peak load will occur on battery recharge in the summer). The more growth in load expected at the site over the next 10 years, the more the sizing would be towards the 333 percent. When an engine is sized at greater than 333 percent of the existing peak (which normally shouldn't be done except in cases of extreme expected load growth), diesel engines will need to be permanently or periodically load-banked to prevent wet-stacking (if the site can be served by a portable load bank, that load banking for these oversized engines as compared to the existing load should be done at least annually for a minimum of 4 hours; but if the site is inaccessible to a portable load bank, a permanent load bank may need to be installed). The system capacity specified shall be while operating under the following conditions:

- Alternator output at the kW rating specified in the paragraph below.
- Operating at the site specified altitude
- Operating at the specified engine room ambient temperature
- Maximum back pressure from the exhaust piping system
- Maximum drop of radiator air handling system

- Maximum pressure of fuel supply system imposed on the engine fuel pump.
- De-rating for sites with high total harmonic content (voltage THD > 15%).

The kW (kiloWatt) rating of all engines shall be based on the Continuous Duty Rating at an 80% power factor. For small applications (under 30 kW where the power factor of the engine-alternator is 1.0), the engine-alternator must be capable of providing a peak load of 125% of the kW rating of the unit.

AC standby power systems shall provide outputs within Range A limits specified by ANSI document C84.1, "Voltage Ratings (60 Hz) for Electrical Power Systems and Equipment", and provide one of the preferred systems voltages per Table 1 of C84.1.

## 7.4 Alternator Technical Requirements

The alternator's design and performance shall comply with National Electrical Manufacturers Association (NEMA®) MG 1, Part 22. The windings shall be "tropicalized" (i.e. designed to minimize effects of fungi and moisture). Alternators shall also meet the following requirements:

- Insulation for the rotor and stator shall be Class H per NEMA® MG 1, Section 1.65, and shall be designed to last at least 20 yrs or 10,000 operational hours. Design full load temperature rise shall not exceed the continuous duty values in NEMA® MG 1, Section 22.40
- The engine-alternator shall be capable of continuously delivering the output kW specified by the CenturyLink™ Engineer for environmental ambient temperatures from –34 degrees C to 52 degrees C (-30 to 125 °F) and at the altitude where the engine-alternator is installed. The manufacturer shall supply de-rating charts in 1000 foot increments (de-rating may be estimated in the absence of a chart as 3.5% per 1000 feet for liquid-cooled engines and 5% for air-cooled engines). This requirement shall be met at any power factor from 80% leading or lagging to unity, at any voltage within the limits of ±10% of rated voltage, and at a frequency of 60 Hz ±3 Hz.
- The alternator shall conform to the provisions of NEMA® MG 1, Sections 22.41 and 22.45, "Maximum Momentary Overloads," and "Short Circuit Requirements", respectively. Ground fault protection is required for sets with output voltages ≥ 480 VAC and/or output currents of 1000 Amperes or greater.
- The rotors (alternator and exciter) shall be in both mechanical and electrical balance at all speeds up to 125% of rated speed.
- The alternator bearings shall be the antifriction type. The bearings, shaft, and housings shall be so designed as to prevent leaks onto the machine parts or windings. Each bearing shall be sealed for life.

- The deviation factor of the alternator open circuit terminal voltage shall not exceed 6%. The deviation factor is determined in accordance IEEE Standard 115, "Test Procedures for Synchronous Machines".
- The balanced line-to-line open circuit voltage TIF (telephone influence factor) shall not exceed 50. The line-to-line open circuit low frequency modulation is not to exceed 0.5 Volts peak-to-peak, in the frequency range of 5 to 30 Hz. The total open circuit harmonic content of any line-to-line or line-to-neutral voltage shall not exceed 3% rms, with no single harmonic exceeding 1.5%.
- Alternator leads shall terminate on the line side of the breaker. A means will be provided to prevent connectors from turning when mounted on breaker studs.
- Each engine-alternator set will be mounted on vibration isolators, either internal or external to the sets' skid base, as determined by the CenturyLink™ Engineer.
- Exciters (if used) shall be brushless, using a rotating rectifier bridge circuit.
  - Exciter field current shall be automatically controlled by the voltage regulator. This regulator shall also provide under frequency protection.
- The output circuit breaker shall be equipped with adjustable instantaneous trips, long time trip elements (thermal trips), and a shunt trip circuit.
  - When an on-set breaker is required, the breaker assembly shall provide contact closure for OVERCURRENT audible, visual, and remote alarms. Lockout contacts should be provided and interfaced with the control circuit to prevent starting of the engine before the breaker is reset.
  - The engine-alternator breaker trip settings shall protect the alternator from damage due to AC system faults, and avoid nuisance tripping.
- AC grounding will be in accordance with CenturyLink™ Technical Publication 77355 and the NEC®. The only acceptable method of grounding the neutral of a set producing 480 VAC power or less is to solidly connect it to the neutral of the commercial power at the house service entrance.

## 7.5 Control Cabinet and Transfer System Requirements

To minimize potential loose connections or trouble spots in the control circuitry, all interconnections of control circuitry wiring shall be stranded wire with crimp connectors and ring terminals securely fastened to terminating points with a machine screw (preferred). Only one termination shall be provided per screw.

The only gauges that aren't part of the controller that may be on a stationary engine are oil pressure, temperature, tachometer (if applicable), and fuel pressure non-electronic gauges. These gauges must be capable of remote connection to the control cabinet.

A stationary engine-alternator must have a control cabinet. The control cabinet shall be NEMA® 1 (as a minimum for indoor applications; and may need to be NEMA® 3 or higher and weatherproof for outdoor applications), with a hinged door. Contents of the controller shall be solid state. The solid state controller shall not be physically mounted on the engine-alternator unless there is vibration isolation (in which case it's metallic enclosure shall be bonded to the set's chassis with a braided strap or stranded wire).

The engine-alternator set and/or control cabinet shall include the following:

- Gauges and Meters (may be part of a digital display instead of analog):
  1. Oil Pressure
  2. Coolant Temperature
  3. Output Ammeter and Voltmeter (with selection for each phase)
  4. Running Time Meter
  5. Frequency Meter
- Manual Selector Switch/Button(s) with positions for:
  1. RUN or MANUAL operation
  2. STOP or OFF
  3. REMOTE or AUTOMATIC operation
- Others:
  1. Remote, 2-Wire control start-stop terminals
  2. Manual reset Field Circuit Breaker
  3. Indicator lamp(s) for the alarm conditions causing an automatic engine shut down.
  4. A manual alarm-reset switch shall be provided (either on the engine or remotely) to clear the indicators and reset the system to allow engine restart after shutdown.
  5. Manual reset Exciter Field Circuit Breaker (where applicable).
  6. Emergency STOP switch.
  7. Dry alarm contacts for each failure condition.
  8. If not adjustable via digital display, potentiometers shall be provided to adjust:
     — Voltage (5%)
     — Frequency (2%)

The remote control cabinet shall meet the requirements of this document. All connections between the remote control cabinet and the set cabinet will be run in conduit. These leads may be run along with the alarm leads.

The cabinet shall be front access via a hinged door that will latch (outdoor cabinets must be lockable unless they are behind a locked gate). All switches, lamps, gauges, and meters shall be mounted on the door. All electrical wiring shall be routed and secured to prevent connection deterioration due to movement and to allow access to the cabinet interior.

For floor mounted cabinets, leveling screws, wedges, or shims shall be part of the usable cabinet to level and plumb the cabinet and to compensate for variations in floor flatness. In addition, there shall be four holes provided in the corners at the bottom of the cabinet that will allow $^5/_8$-inch anchor bolts to secure the cabinet to the floor. The cabinet shall have a kick plate extending a minimum of 4-½ inches from the floor.

All Automatic Transfer Systems shall be **LISTED** to Underwriters Laboratory (UL®) 1008 or 1066 (restricted and certified are not acceptable), and meet the requirements of NEMA® ICS 10, Part 1 Standard, and ANSI C37.16. The transfer system should be sized to the main entrance facility whenever possible.

The transfer system itself shall be able to withstand 100% of its closing ratings.

Each automatic transfer system can be either an electrical or solenoid-operated mechanism. The transfer system should be either circuit breakers or a switch. If breakers are used, these breakers may be used as the ground fault current protection device (when that is required for larger systems and/or higher voltages). Where permitted by local Code, the commercial breaker may also serve as the main service breaker. External shunt trips with engine start inhibit may be provided if required by local fire codes.

Circuit breakers shall be of the thermal-magnetic type, rated for the fault current, and must be Listed. Contacts shall not be able to be held closed during an overcurrent condition by holding the lever in the closed position. They shall be trip-free type. The AC circuit breakers shall be clearly marked as AC breakers (not DC). AC breakers shall generate an alarm signal when they either are in the tripped state or turned off.

The transfer system and its devices shall meet all requirements of the applicable UL® and ANSI standards and be rated for fault current. Ferrous materials shall not be used for current-carrying parts.

All transfer systems shall be equipped with plug-in elements, or a maintenance bypass isolation switch to facilitate maintenance and replacement (such as the inspection and replacement of main arcing contacts) without creating an extensive power outage.

Automatic transfer systems can be either equipped with a load disconnect delay option (preferred) or closed transition switching (not recommended for Network sites). The disconnect delay option shall be set for a 3-7 second delay.

The manufacturer shall supply interconnection information for connecting the engine-alternator with an Automatic Transfer System. A manufacturer's representative shall review all installed new transfer systems to ensure they are properly installed and working.

There shall be a single standby engine-alternator test switch mounted on the AC switch gear. This test switch will simulate a Commercial AC failure to the standby engine-alternator and all transfer systems. Operating this Test switch will cause all of the standby engine-alternators to start, and all transfer systems that operate when there is an actual AC failure to transfer. Restoring this test switch will cause the standby engines and transfer systems to proceed with their normal timing to return to Commercial AC and engine shut down.

For all automatic transfer, the system shall be capable of the following:

1. Recognize the occurrence of a power failure.
2. Open the commercial power source.
3. Start the engine-alternator set.
4. Close the alternator circuit breaker and/or transfer to the alternator (availability indicated by a light).
5. Automatically control loading of the emergency bus.
6. Recognize the return of commercial power (indicated by a light).
7. Transfer all loads from the standby power source to the commercial power source (only if the commercial AC load has been restored for 30 minutes).
8. Shut down the engine-alternator.

There shall be a time delay for engine start (at least 5 seconds), a time delay on retransfer to permit polyphase motor stop, a time delay on shutdown to permit engine cool down (minimum 5 minutes unloaded), and a time delay before transfer to engine to permit warm-up, polyphase motor stop or sequential loading. There shall be a minimum run time (at least 30 minutes loaded for engines smaller than 300 kW, and at least 45 minutes loaded for engines larger than that). All of the above times will be per engine manufacturer's specification.

For automatic paralleling of multiple engines, the system shall be capable of performing the following operations:

1. Recognize the occurrence of a power failure.
2. Open the commercial power source.
3. Initiate the Start signal to all engines simultaneously.

4. The first engine to reach proper voltage and frequency closes its on-set breaker initiating closure of the engine transfer breaker powering the static loads;
5. As additional engine-alternators are paralleled to the essential bus, the Load Management Controller connects these loads on a priority basis.
6. Recognize the return of commercial power.
7. Transfer all loads from the standby power source to the commercial power source after the Holdover Timer has operated (the holdover timer should ensure that commercial AC is back and stable for at least 15 minutes).
8. Shut down the engine-alternator.

There shall be engine-starting contacts that will allow each unit to be started independently.

For automatic paralleling of the engines to the commercial grid system, the ATS shall be capable of performing the following operations:

1. Initiate the Start signal to engine;
2. Bring the engine up to speed;
3. Synchronize and parallel it with the utility;
4. Gradually transfer all loads from the commercial source to the standby source;
5. Open the commercial power source;
6. Upon completion the controls shall synchronize and parallel it with the utility;
7. Then it shall gradually reduce the load on the standby source to zero;
8. Then it shall open the standby source connection;
9. Shut down the engine-alternator.

Note: Utility company permission must be obtained to allow paralleling to the commercial grid with the CenturyLink™ engine/alternator. Special protection mechanisms may be required by the utility to ensure that the engine-alternator will not export power onto their grid when they want it de-energized for maintenance. The paralleling of the two power sources increases the short circuit current magnitude on the building distribution system. The engineer must consider this when specifying the short circuit interrupting rate of the distribution system protective devices.

The standby AC plant shall be equipped with load management features. Both manual and automatic control capabilities shall be provided for sequential operation of the served load. The system shall provide suitable time delays to prevent failure of the standby plant, too quick of a disconnect from commercial AC, and/or too quick of a standby engine-alternator start in response to transient conditions.

The system shall be equipped with a test switch to facilitate simulation of a power fail. It shall also be equipped with a manually controlled retransfer override. The system shall have indicating lights to indicate the source feeding the load (all transfer switches and engine control panels with indicating lights should have a lamp test feature).

Each automatic transfer system shall include a control panel. The transfer system should preferably be outside the engine room (but relatively nearby). An isolation plug in the wiring harness shall be provided to disconnect all circuits between the control panel and the main transfer panel.

Full-phase voltage sensing must be provided. Full phase protection shall also be provided. Three-phase relays may be field adjustable, close-differential type, with 92-95% pickup, and 82-85% dropout. Relays are to be connected across the commercial AC voltage input line side of the transfer system.

Independent voltage and frequency sensing of the commercial source must be factory preset to initiate transition to standby at 90% voltage and 58 Hz.

Overvoltage and over-frequency sensing of the commercial source (to initiate disconnect from commercial, and startup and transfer to engine) is highly desirable, and should typically be adjustable from 110-120% of nominal voltage and 62-64 Hz.

Exercise timers may be provided. If provided, they must be adjustable for monthly (or 1 or 2 weeks in special circumstances, when requested) operation.

Synchronization for paralleling (whether to the bus or the grid) must occur within 20°.

The neutral shall not switch except on sets where the output voltage exceeds 600 VAC. The neutral and ground shall not be bonded at the transfer system, although they may be bonded at a very close panel in small sites.

Meters may be either analog or digital.

The overcurrent protection device can be either a fuse or a circuit breaker placed in the ungrounded supply lead.

All components must be marked on both the schematic drawings and in the cabinets.

New transfer systems must be microprocessor or PLC-controlled. Microprocessor-controlled is preferred with a non-proprietary interface.

Transfer systems should be installed indoors whenever possible.

For nominal 208 V systems of greater than 2000 A, or nominal 480 V systems of greater than 800 A; upon loss of a single-phase (for more than 10 sec) from either commercial or engine source, the transfer system should lock out the respective source and issue an alarm. The transfer system may be set up to automatically allow reconnection if the lost phase returns for 10 sec or more; or it may be set up to require manual intervention. This single-phase lockout prevention is allowable for smaller systems too. The system may be powered from the engine start-control batteries or from an AC inverter source. Single-phase lockout is not required for sites with single-phase protection built into the chiller motors' input circuitry.

## 7.6 Additional Engine Requirements

Engines must be "In-Line" or "V", water cooled, and mounted on a common steel sub-base. The engine must ship with required accessories (except items subject to shipment damage). All parts shall be new. Engines should have replaceable cylinder liners.

All engine-moving parts must be maintainable. Any "lifetime" - permanently lubricated parts must be easily replaceable and 100% warranteed for material and labor for a minimum of 7 years from the date of installation.

## 7.7 Voltage and Frequency Regulation

The voltage regulator shall be of the solid state design and shall not be frequency-sensitive between frequencies of 55 to 67 Hz. The regulator shall sense all phases.

On engine-alternator sets equipped for parallel operation, the regulator circuit shall have adjustable cross current compensation. The voltage droops due to the cross current compensation circuitry shall be adjustable from 0 to 5% of the set's rated voltage and shall be factory set at 3.5 to 4%.

The voltage regulator shall be furnished with an adjusting rheostat (or be adjustable via a digital controller) that allows the alternator terminal voltage to be adjusted ±10% of its normal value. Means for voltage adjustment shall be furnished at the control cabinet.

With the voltage regulator operating, the cross current compensation shorted out, and the thermal effect constant, the regulator shall control the terminal voltage at any load from 0-100%, and from 0.8 leading or lagging to 1.0 power factor. This terminal voltage shall be within 2% of nominal when the no load speed is as much as 3 Hz above 60 Hz.

With the voltage regulator operating, the regulator shall hold the alternator output terminal voltage constant within 2% over an environmental ambient temperature range from --30 degrees F to 125 degrees F, with a speed change of ±5%, based on the following conditions:

- The cross current compensation is shorted out.
- The load power factor is between 80% leading or lagging and unity.

- The engine has stabilized at its operating speed.
- The governor is adjusted for any droop between 0 and 5%.
- The ambient temperature remains within a 30° F band after 5 min of operation.

Each alternator, exciter, and voltage regulator should have under frequency and over voltage protection, including for shutdown and/or coast down conditions.

When load on an engine-alternator is increased in 25% steps from 0-25%, 25-50%, 50-75%, and 75-100%, the output voltage should recover to within 0.5% rms of the previous voltage within one (1) second after reaching the new load.

When the full-rated kVA load is rejected in one step, the transient surge voltage shall not exceed 20% of the rated voltage and shall recover to within 1% of the new steady-state voltage within two (2) seconds.

Either a hydraulic or an electronic governor that meets the following requirements can be used. Isochronous type governors are preferred, with the engine-alternator set manufacturer to specify the type used.

- The governing system shall be capable of providing frequency vs. load regulation characteristics from isochronous to 5% droop.
- There shall be no sustained periodic variations in alternator output frequency under any conditions, including abrupt load changes.

At any constant load from no load to full load, the maximum frequency ripple for the AC output shall be 0.15 Hz (¼%) at any frequency between 57 and 63 Hz and at any load from no load to full load. This requirement is intended to apply at steady state conditions including stable temperature within the governing system. Frequency variations within the 0.15 Hz range shall be random (aperiodic).

Frequency drift due to changes in governing system temperature shall not exceed ±0.15 Hz for steady state operation at any load from no load to full load.

Note: "Steady State", for the purposes of this requirement is defined as operating at constant real (kW) load for a minimum of 5 minutes after full speed is attained at start up, or, for a minimum of 2 minutes after the disappearance of transients in output voltage and frequency due to a load change.

After stabilizing at steady full load conditions, the engine-alternator set shall return to the same output frequency ±0.15 Hz when load is repeatedly added or removed. This requirement shall be met for isochronous and droop operation, where applicable.

The output frequency shall be adjustable over the range of 57 to 63 Hz from the system control cabinet. External droop adjustment shall be provided at the governor or, where droop adjustment is via electrical means, by means of a potentiometer located within the engine control cabinets.

For both increasing and decreasing loads, the change of alternator output frequency with load shall be within ¼% of true linear response with the governor set for any droop between 0 to 4%.

The response of the engine-alternator set to sudden changes in load shall meet the following criteria:

- For any sudden quarter-load change from no load to full load (increasing or decreasing the load) the frequency shall recover to and stay within the 0.15 Hz band within one second.
- For any sudden full load change (full load to no load), the frequency shall recover to and stay within 0.15 Hz band within 2.5 seconds.
- For any sudden quarter-load change from no load to full load (increasing or decreasing the load) the frequency shall depart from the steady state value by no more than 2% of the steady state value.
- For any sudden full load to no load change, the frequency shall depart from the steady state value by no more than 5% of the steady state value.
- For all of the above, the frequency shall stabilize at the steady state value after no more than one overshoot and no more than one undershoot.

Hydraulic governor mechanisms, where used, shall be designed to employ the same oil used in the engine.

### 7.8 Additional Paralleling Requirements

For engine-alternator sets equipped for parallel operation, the voltage regulator and governor circuitry shall be designed to allow droop compensation type paralleling. Standby engine-alternator sets equipped for automatic paralleling shall also be provided with means for manual synchronization (e.g., phase lamps, sync scopes, etc.). For paralleling applications, the engine-alternator breaker will be of the size and type to ensure protection of the engine-alternator in case of out-of-phase paralleling.

Each alternator set equipped for parallel operation shall have suitable characteristics to permit it to be paralleled with another unit or units specified by the CenturyLink™ Engineer. Each set shall be capable of operating in parallel with the set(s) so specified at any load from no load to full load, at any power factor from 1.0 to 0.8 lagging, while meeting the following requirements:

- Circulating current shall not exceed 10% of the combined full load current of all sets in parallel.
- The transfer of power between sets shall not exceed 2% of the rating of one set, and such transfer shall not be cyclic.

- The division of real load between sets shall be proportional to the set capacity.

For automatic paralleling, the system shall also be capable of paralleling the alternators and sending signals to automatically close successive load group circuit breakers as each associated alternator is brought on-line (or the load can be transferred all at once, if not too large, when all sets are paralleled);

Recognize the non-operation of any alternator(s) and open the designated load circuit breakers to shed/disconnect those loads to maintain system operation if there is not sufficient capacity to support all of the loads. If an existing site without n+1 redundancy in a paralleled engine-alternator system serves a 911 PSAP, or hosts a 911 selective router, and it does not have an automatic load-shedding control system, the site must have a posted manual load shedding plan.

### 7.9 Alarms and Shutdowns

Standby AC plants must be capable of extended operation without human intervention, since there should be remote surveillance of alarms. The standby AC plants covered by these requirements shall provide alarm interfaces with maintenance and operation systems in accordance with requirements in this publication.

An alarm termination strip shall be provided for all the engine alarms. The engine installer shall run the alarms from the engine to the terminal strip. The terminal strip(s) should normally be in an EAT (Engine Alarm Termination) box located in the power room or engine room. The installer will be required to label the engine alarms and analog monitoring points on the terminal strip(s). Engine alarms and analog monitoring points are covered in this chapter and in Chapter 8. The alarms and analog points are run from the EAT box to the PSMC by a CenturyLink-hired subcontractor familiar with PSMC installation and programming.

Normal shutdown of standby AC plants operating under manual control shall be accomplished by depressing a "STOP" or "OFF" switch located on the plant control panel. It shall be placed in a convenient location, readily accessible and clearly marked.

A momentary contact push button type switch designated "EMERGENCY STOP" shall be provided on each control panel or cabinet. When this switch is actuated, the set shall shut down and an alarm indication shall be given. The "EMERGENCY STOP" switch function shall also be capable of being duplicated by a switch located as required by local code (generally outside the engine room or enclosure door). The button/switch shall be in a housing, or otherwise protected, to prevent accidental operation.

There must be a manual shutdown device mounted on the engine. Operating it will:

- Shut down the engine;

- Close a solenoid-operated valve in the fuel line (unless there is an anti-siphon valve as an alternative to the solenoid valve in non day tank sites, or if the fuel tank is below the engine);
- Activate alarm circuits; and
- Disable the set's starting circuits

Operating conditions to be monitored for standby AC plants include those listed below. Where an engine-alternator set employs additional features or support systems essential to proper operation of the plant, additional monitoring and/or alarms may be required. Visual alarm and status indication shall be provided by colored lamps mounted directly on the local and, where present, remote control cabinet. Provisions shall also be made for transmitting alarm signals per the alarm requirements in this publication.

- The local control cabinet will be equipped with meters or gauges (or these values shall be displayable on the digital controller), with minimum accuracy as indicated below in parentheses, providing the following outputs:
  1. Alternator Output (alternator output meter shall be duplicated on the remote control cabinet, where equipped);
     — Amperes (3.0%)
     — Volts (3.0%) (Engine and Commercial)
     — Frequency (1.0%)
     — Kilowatts (2.0%)
     — Lubricating Oil Pressure (5%)
     — Fuel Pressure (5%)
     — Lubricating Oil Temperature (5%) (over 900 kW)
     — Engine Temperature (3%)
     — Hours of Operation (0.1 hour)
     — Tachometer
  2. Engine Start Battery voltage (always operational, not just during run)
- The control cabinet and/or transfer system should be equipped with step-down current and voltage transformers to meet the monitoring needs of the Power System Monitor Controller at the site (these are most often only in the transfer system on the load side, or in a subsequent load side cabinet).

An alarm indication shall be given and the plant controls shall shut down affected standby engine-alternator sets if one or more of the conditions listed below exist. For each of the conditions listed in this section, the engine-alternator set shall shut down and require a manual reset after the problem has been cleared in order to restart the set.

- Low Engine Oil Pressure— operates if the oil pressure falls below the safe value recommended by the manufacturer
- Engine Over Crank — operates if the engine does not come up to a threshold speed within 10 seconds after three cranking attempts
- Engine Over Speed — operates when engine rpm exceeds 108-125% (most engines are capable of at least 125% overspeed without damage) of normal operating speed (the overspeed sensor is often factory present between 116-125% of rated speed, but when allowed, and user-adjustable, it may be set lower – between 108 and 110% – as a safety margin). (Turbines operate at higher speeds than internal combustion engines, and where used, must have tighter overspeed controls: a maximum overspeed setting of 115% is all that is allowed.)
- Over/Under Voltage or Under Frequency — operates if the alternator voltage exceeds normal range by ±15-18% and/or the frequency deviation is greater than 3 cycles for 5 cycles (the engine should shut down on an inverse time delay basis)
- Over Current — operates if the alternator circuit breaker trips open
- Reverse Power — (required only for engine-alternator sets equipped for parallel operation, which may include paralleling with the commercial power) operates if the engine-alternator receives reverse power in excess of the threshold value specified by the manufacturer
- Differential Fault — (required only for engine-alternator sets rated 800 kW or larger and when the engine output breaker is less than 50% of the transfer system breaker) on sets so equipped, operates if the differential fault relays are energized due to differential fault current
- Ground Fault — (required only for engines with output voltages ≥ 480 VAC and/or sets with rated output current of 1000 Amperes or greater) on sets so equipped, operates if the ground fault protection device is activated. (Ground fault detection devices may be set to cause tripping of the alternator output breaker up to 1200 Amps, but it is more typical to set them between 100 and 400 A. They should not be set too low, or nuisance tripping will occur. A study by a licensed electrical P.E. may be needed to determine the proper setting for the particular building and AC motors it contains that will cause the least amount of equipment damage while still avoiding nuisance tripping.)

- Control Breaker or Fuse — operates if a circuit breaker or fuse providing power to essential engine-alternator set control functions operates
- High Coolant Temperature — operates if the temperature of the coolant, measured on the engine side of the set mounted thermostat, exceeds recommended coolant temperature by 15% (sensing arrangements shall be such that a shutdown signal will be issued if loss of coolant occurs)

An alarm indication shall also be given if one or more of the following conditions exist. These conditions indicate impending problems, which may result in plant shutdown or other impairment if corrective action is not taken.

- Charger Failure — an Alarm shall be issued if the charger(s) floating the start/control batteries fail (or have high or low voltage)
- Fuel System Trouble — for plants equipped with auxiliary fuel pumping systems and/or day tanks, an alarm shall be issued if the fuel level in the day tank is above or below the normal range
- Preliminary High Coolant Temperature — an alarm may be issued if coolant temperature in a liquid cooled diesel engine rises to within 10 degrees F of the "High Coolant Temperature" shutdown point (although this alarm may be available, it might not be wired past the EAT box, depending on the spare points available on the PSMC)
- Low Coolant Temperature and/or Heater Failure — an alarm shall be issued if the heating element fails or if coolant temperature drops to a level that may impair starting reliability
- Visual Alarm Codes — Visual alarm and status indications are defined in Chapter 1 except as noted.

  **Note:** A red indicator on a circuit breaker indicates closed and is not an alarmed condition — per the NEC.

### 7.10 Fuel and Lubrication Systems

The rate of fuel supply to the engine's injection system shall be as required to prevent stalling, overspeed, or over temperature under any steady state or transient loading conditions within the engine-alternator's rating, and when operating within the environmental limits (temperature, altitude, and humidity) of Telcordia® GR-63.

Manufacturers shall provide fuel consumption charts for their systems operating at full, ¾, and ½ loads.

Acceptable fuels that may be considered are diesel, natural gas, LP gas (a mixture of propane and butane, where propane should predominate, especially at lower temperature sites), and gasoline (gasoline should be avoided for permanent engines due to long-term storage difficulties, shorter life, and increased maintenance of gasoline engines). Natural gas engines should be backed up by a propane source.

**Note:** In special environments governed by special governmental rules (National Forest, National Parks, wilderness, etc.) the fuel used will be based on regulatory requirements.

Diesel engines shall be capable of using No. 2-D, or winter blend (#1 and #2 diesel combination) fuel per ASTM Specification D-975. Where regulatory bodies require or seek to require the use of biodiesel blends, CenturyLink™ should seek exemptions for its permanently-installed engine-alternator sets. Biodiesel blends do not store well, even with biocide and pour-point depressant additives. Where the local regulatory rules/laws require the use of biodiesel blends in telecommunications backup engine-alternators in spite of the best efforts of CenturyLink, periodic fuel filtering/cleansing will be required. This can be done by a contractor or CenturyLink employee on a routine (every 1-4 months for biodiesel blends that contain more than 5% biodiesel, and every 4-12 months for biodiesel blends that contain 5% or less biodiesel); or especially with higher quantity biodiesel blends (above 5%), a permanent on-site pumping filtering system (possibly equipped with a periodic timer) may be considered.
Install the fuel tank as near as possible to the engine without violating Code (for example, fuel tanks generally cannot be placed within 500 feet of a public water supply; sensitive/protected ground water transition/recharge receptor zone; or registered/known underground drinking, irrigation, or other beneficial water well). Because the fuel pump influences tank location, the manufacturer shall provide fuel pump lift data. The use of double wall tanks with a cavity leak detection system is preferred (double-walled tanks are required for all direct-buried tanks). All single-walled tanks must have a containment structure — vault, curb, etc. All double-wall tanks, and vaults must be able to contain an overfill of at least 10%.

Above-ground storage tanks (ASTs), which include vaulted tanks (even if the vault is below grade), are generally preferred over direct-buried tanks (USTs), and fiberglass tanks are preferred when direct-buried due to regulatory paperwork. Depending on soil conditions and local regulations, direct-buried steel tanks may require cathodic protection (active or passive). CenturyLink™ has a corrosion engineer who may be consulted, in addition to or as an alternative to outsourcing the work to a qualified P.E. More information on cathodic protection of tanks can be found in IEC BS EN 13636.

Fuel tanks should be sized going forward at a minimum of 48 hours of reserve based on full engine load (sites hosting 911 selective routers are required to have 72 hours of combined battery and engine reserve at the actual peak fuel run rate with a 90% full tank). Depending on how hard the site is to access in the winter, or if the site is in a hurricane-prone area, tanks with much greater reserve may be decided upon by the Power Engineer. The fuel consumption is given by the engine manufacturer. However, if it can't be found, it can be estimated as 0.07 gal/kW/hr at full load for diesel fuel and 0.1 gal/kW/hr for gasoline, natural gas, and LPG (propane) engines at sizes 50 kW and larger. For smaller sizes, estimate use at 0.1 gal/kW/hr for diesel and 0.14 gal/kW/hr for gasoline, natural gas and LPG. Generally, diesel and gasoline tanks shouldn't be filled above 90% (95% being an absolute maximum); and LPG tanks shouldn't usually be filled above 80% (85% being an absolute maximum).

A day tank is a fuel transfer tank used when the engine's fuel pump doesn't have the lift to draw fuel from the supply tank. Day tank pumps (and all other electric fuel tank pumps) may be DC-driven from the engine start/control batteries, or driven from the essential AC bus (pumps driven from essential AC may be necessary when the "lift" is extreme).
DAY TANKS SHALL BE AVOIDED WHENEVER POSSIBLE by use of a high-lift fuel pump when the required fuel lift is between 6-18 feet or the tank is more than 50' away. Note that if the lift is less than that, no day tank or high-lift pump is required: the standard on-set engine pump can do the job. Day tanks are generally required when the lift is greater than 18' (or the equivalent due to piping length, bends and other things that add to backpressure, thus increasing the effective lift). They are also generally required when the tank is above the engine by more than a few feet. Use of a day tank in these instances reduces the pressure (thus lengthening life) on the input seal of the on-set fuel pump.

If the use of a day tank is unavoidable, it shall incorporate both a containment device and a leak detection alarm. In addition, it should be equipped with a high fuel level and a low fuel level alarm. It should be equipped with a vent that is routed outside of the building. It should be sized to provide a minimum of 1 hour engine run at full load.

Base fuel tanks under the engine are allowed, but when used, if they elevate common engine service points (such as oil and coolant drain and add points, filters, etc.) to more than 6' off the floor or ground, a catwalk must be provided in CenturyLink™ Local Network sites.

When a day tank or high lift fuel pump is not used, and the tank is not above the engine, the return line should extend at least halfway down into the main tank (so that it is normally submersed) to prevent air getting into the fuel system due to backflow. The return point in the tank should be spatially far away from the feed line pickup.

Fuel tanks and exhaust emissions shall be monitored in accordance with EPA, State, Local, and CenturyLink™ requirements. Contact the local CenturyLink™ Environmental Consultant and/or CSPEC Engineer and/or Real Estate Engineer for approved fuel tank monitoring systems and locally required inspection schedules. At a minimum, fuel tanks must have a low fuel alarm.

All direct-buried tanks and any above-ground or vaulted underground tanks where the total site fuel storage equals or exceeds 1320 gallons must also have an overfill alarm, and a monitoring system capable of at least monthly leak detection tests, including the interstitial space between the two tank walls. Fuel tank monitors shall be equipped with a dialup modem and a working phone line (some sites where phone service is inaccessible may be exempt from this requirement).

Fuel delivery/return systems shall meet all national and local codes, including Listing of appropriate components. When rigid piping is used for diesel, it must be double-walled (double-walled is always required for buried pipe) or black iron (per ASTM spec A53), and a minimum of 6 inches of flexible piping, or Aeroquip™ or Stratoflex™ hose in sealed containment shall be placed between the engine and the supply and return lines. Natural gas or LPG piping may also be galvanized steel or a Listed and NFPA® 30 or NFPA® 58 compliant synthetic material (fuel piping should meet ASME B31, and non-metallic fuel pipe must be Listed to UL® 971). Natural gas pipe must be coated/wrapped, of the minimum size required by the local gas company, be able to carry at least 150% of the full-rated fuel flow of the engine, and buried a minimum of 24" when underground. It is recommended that outdoor fuel lines be buried or protected when in locations susceptible to vandalism/damage, or when they are a tripping hazard (including on rooftops). A sight window/glass shall be provided in the feed fuel line.

In some jurisdictions, fire marshals or insurance requirements may require a valve (in the feed line – this is also true for return lines that are under pressure, such as when the fuel tank is above the engine) that closes if there is a fire in the engine room/enclosure. This valve contains a meltable link that closes the valve when the temperature reaches approximately 195 degrees in the room/enclosure. CenturyLink™ requires installation of these valves going forward for all diesel fuel supply lines in buildings except when there is a belly tank. Natural gas feeds require a manual shut-off valve at the engine.

All new standby diesel engine-alternators shall be equipped with an engine oil cooler.

Grounding of fuel tanks shall conform to CenturyLink™ Technical Publication 77355, Chapter 4. In addition, copper and galvanized piping shall not be used in fuel systems because of the impurities they may introduce into the fuel injectors.

A solenoid-operated valve (powered from the engine start/control batteries; although it may be powered from the essential AC bus on sites with day tanks) in the fuel line feed shall be provided and connected to the emergency stop switch (closes when the switch/ button is pressed or the wiring is open). This solenoid-operated valve may be supplanted by an anti-siphon valve if there is no day tank; and it is not required in sites with the tank below the engine. It is preferable that this solenoid-operated valve be at the highest point in the line between the main tank (it may even be located on top of the tank) and the engine, or at least at a point above the engine fuel pump if possible. If the placement is outdoors, the solenoid valve should be enclosed in a rain-resistant opaque enclosure. For sites where the main tank is located above the engine pump, the solenoid valve must be located between the main tank and the first point of entrance into the engine room/enclosure (it may be placed right after it enters the room/enclosure). For sites without a day tank, the solenoid valve is not needed if an anti-siphon valve is installed as close as possible to the point where the fuel line leaves the main tank (note however that the anti-siphon valve does cause a bit of an addition of back pressure). When main fuel tanks are located above the engine or day tank they serve they shall have an anti-siphon valve in the feed line at the point they enter the engine room. It is desirable to have a bypass with a normally closed manual ball valve around anti-siphon and solenoid valves for diesel engines to allow for quick temporary function of the engine if the anti-siphon and/or solenoid valve(s) fail.

The primary and secondary fuel filters and strainers shall be of the replaceable element type and of sufficient capacity to permit a minimum of 200 hours of continuous operation without requiring service.

Note: This requirement must be met when operating with fuels containing total organic and inorganic particulate matter (i.e., 1 micron or larger) of up to 5 milligrams per 100 $cm^3$ of fuel. For example, if the engine filtration system(s) removes 100% of the particles 1 micron or larger, the filter or combination of filters shall be sized to trap and hold approximately one pound of particulate matter for every 2000 gallons of fuel circulated through the filters.

Diesel fuel systems may be equipped with water separators.

The fuel control system shall not require lubrication, adjustment, or other maintenance more often than every 500 operating hours.

A manually-operated, DC electrical or mechanical, permanently-mounted priming pump shall be incorporated in the on-set fuel system. The priming system shall be capable of priming the complete on-set fuel system, starting with drained fuel lines to the supply tank and a drained on set fuel system, in 1 minute or less.

When a high lift fuel pump is used, it shall be capable of delivering at least 120% of the set's fuel consumption rate when the set is operating at full-rated load and the suction lift (including flow losses in pipe and fittings) is 15 vertical feet of diesel fuel.

The fuel system may consist of two supply and return loops (day tanks are required to have two supply lines [each with its own pump] from the main tank for reliability):

- Fuel from the main or day tank flows through a fuel strainer, a gear or belt-driven fuel pump, and possibly into a fuel cup (the fuel cup is on engines with a high lift pump). A return line provides a path for fuel not consumed to return to the tank. This return line shall normally be free from traps and/or valves (a check valve may be used where the tank and/or a significant portion of the return line is above the engine), and shall be at least as large as the supply line. A return pump may be required in rare instances for long distance runs or vertical lift (for tanks above engines by more than a few feet) in order to overcome backpressure.
- The second loop runs from the fuel cup (on those engines with a fuel cup) to the engine's fuel metering/injection system (usually filtered and boosted by a high-pressure fuel transfer pump) with unburned fuel returning to the fuel cup (or to the day or main tank in the absence of a high lift pump).

Filter elements in the engine lubrication system shall be adequately sized to permit a minimum of 168 hours of continuous operation without replacement of the elements. The lubricating oil capacity of the set shall also be adequately sized to enable unattended operation for a minimum of 168 hours.

Positive lubrication shall be provided for all moving parts in the engine and accessory drive. The lubricating oil pump shall be gear-driven from the engine.

Lubricating oil filtration shall be of the full-flow type. The lubricating oil filter shall have a built-in bypass arranged to permit oil to bypass the filter if the filter element becomes clogged. Lubricating oil filters shall be of the replaceable element type.

If the lubricating system is designed to require priming after the system is drained for any reason, a manually operated pump shall be provided. This pump shall be permanently mounted on the engine-alternator set.

Lubricating oil vapors shall not be vented within the building unless the engine room only ventilates to the outside. All lubricating oil vapors from the engine should be recycled or consumed within the engine. The crank case breather tube shall be routed to a discharge damper duct of the radiator, or in some other manner that avoids oil residue buildup on an on-set radiator fan.

A lube oil pressure switch/gauge equipped with pressure sensors shall be provided to operate appropriate electrical contacts to shut down the engine if lubricating oil pressure falls below a safe level.

When engine oil sumps (pans) are not easily accessible, they shall be equipped with a drainpipe, valve, etc., to facilitate changing of the oil.

### 7.11 Exhaust System Requirements

The engine exhaust manifold channels exhaust gases from each cylinder to an exhaust outlet. The manifold shall afford a minimum of backpressure and turbulence to the engine cylinders and valves. The two primary types of manifolds are the dry air-cooled and the water jacket water-cooled. Air-cooled with a standard steel flange is preferred.

Exhaust pipes must comply with applicable codes. Minimum requirements follow:

- Pipes shall be wrought iron or steel and strong enough to withstand the service.
- Pipes must not be supported by the engine or silencer.
- Pipes must use vibration proof flexible connectors.
- Pipes must have a clearance of at least 9 inches from combustible materials and terminate outside the building.
- Pipes in an engine room or walk-in enclosure (not applicable to external engine enclosures that aren't walk-in) must be guarded and/or insulated to prevent burn injuries to personnel (and possibly excessive heat) in an engine room. The guards or insulation is not required to extend above 7 feet high. Insulation used solely to prevent heat buildup is at the discretion of the designer of the system.
- All connections shall be bolted flanges with gaskets, or welded. No automotive type exhaust pipe clamps are permitted.
- The outlet of the exhaust pipe should be a 90 degree horizontal bend, designed for minimum back pressure, with the end of the pipe cut at a 45 degree angle, scarfed, with expanded metal over the open end. For cases where the outlet must be vertical (to meet air quality rules, or prevent backflow of the exhaust into the intake, etc.), caps and or bird screens should be used to prevent intrusion of water or debris, but hinged rain caps are not permitted due to their propensity to rust shut (unless they are made of aluminum or stainless steel).
- Exhaust pipes shall not terminate within 10′ of a fuel tank vent or fill cap.

A piece of flexible, bellows-type exhaust pipe must be used between the engine exhaust connection and the exhaust piping system.

Provide Exhaust silencer(s) for engines, sized per manufacturer recommendation and/or as a result of an engineering acoustical noise analysis to meet local requirements, and be engineered for a site-specific sound level. Place the silencer close as practical to the engine to avoid unwanted carbon deposits. If the exhaust stack rises more than 20 feet, and/or ends vertically, a water drain plug may be considered at the muffler/silencer.

Exhaust must extend above the building whenever possible, and not be placed near building fresh air intakes. Exhaust must meet local/state/federal laws/requirements.

### 7.12 Starting Systems

The battery shall be sized to permit a minimum of five (5) cranking attempts of 30 seconds at the design low engine room temperature specified by CenturyLink™ (40 degrees F). After the third cranking attempt, no more attempts to start the engine should be made, and the control cabinet should issue an alarm labeled "overcrank".

The start and control batteries shall be Ni-Cd or Lead Acid type. The batteries shall be covered with protection while working on the engine-alternator set (if they are right next to the set). The start and control batteries shall be marked with the installation date. Where applicable, the battery stand is to be a heavy earthquake zone installation. Engine driven alternators/generators shall not be used on a going forward basis for start and control battery charging.

Engines rated 600 kW and larger should have redundant starter motors and batteries.

The engine start batteries shall be floated with a regulated (filtered) charger. A start battery charger may be mounted either in the control cabinet or mounted on a wall near the start battery stand. The charger shall have the following:

- output capacity of 2 Amperes minimum
- output Voltage and Ampere meters/display
- adjustable output voltage
- internally protected output leads
- high and low voltage alarms
- charger fail alarm

It is desirable that the charger have temperature compensation to avoid overcharging.

### 7.13 Cold Starting Aids

All water-cooled diesel engine-alternator sets shall be provided with thermostatically-controlled heaters or a heat exchange system, designed to maintain jacket water temperatures not lower than 90 degrees F (per NFPA® 110) and not higher than 120 degrees F. Because traditional electric heating elements wear out, it is desirable to equip the cooling system with manual valves (preferably ball valves, but never valves or hoses with quick disconnects) on either side of the heater (as close to the engine block as possible) so that the entire cooling system doesn't have to be drained to effect an element replacement or heater hose replacement.

For warmer climates, or externally heated engine rooms, it is permissible on dual element heating systems to only connect for half the Wattage output in order to lengthen the life of the block heater system. For engine-alternator sizes in excess of 750 kW, it is desirable that the heating system have some sort of circulation pump, since natural thermo-siphoning may not provide heat to all areas of the water jacket on these large engines.

Engine rooms (and their ventilation systems for use during engine run) should be designed for a max temperature (while the engine is running) approximately 15 °F above the ASHRAE maximum summer outside ambient temperature for that location.

For all engine-alternator sets to be installed where outdoor ambient temperatures will fall below 40 degrees F, provisions shall be made to keep the indoor engine room temperature at a minimum of 40 degrees F, or have a battery heater pad that maintains the batteries at that temperature. It is preferred to have the engine start and/or control batteries at an indoor temperature (when the engine is not running) between 50 degrees and 90 degrees F (see NFPA® 110). The temperature shall be allowed to go up to 120 degrees F if the engine start/control batteries are Ni-Cd.

### 7.14 Acoustic Noise

Sound levels within the building housing the standby plant and outdoor sound levels resulting from operation of this equipment shall meet the requirements specified by OSHA, Telcordia® GR-63, and local codes as specified.

Where the engine-alternator set is equipped with a sound attenuating enclosure, the enclosure shall be designed to allow adequate cooling of the engine-alternator set.

Sound-attenuating enclosures, where employed, shall provide hinged doors or latched panels to allow access for normal maintenance and repair operations, including:

- removal and replacement of fuel and lubricating filters
- replacement or cleaning of air filters
- performance of all other manufacturer-specified normal maintenance operations

Where the engine-alternator set is equipped with a sound- attenuating enclosure; it is desirable that the enclosure cooling requirements be met without booster fans or other accessory devices.

Note: The supplier must consider widely different climates in CenturyLink™. Some locations will require booster fans or other accessory devices.

Acoustical materials, such as acoustically absorbent liners, shall be non-capillary, non-hygroscopic, free from perceptible odors, and must maintain their acoustic attenuating properties under the conditions of temperature, mechanical vibration, and exposure to petroleum products to which they may be subjected under normal operation. Elastomeric material used in sealing the acoustic enclosure must remain flexible and resist cracking in the environment they are exposed to in normal use.

## 7.15 Cooling System

The cooling system for the engine-alternator (water-cooled is preferred to air-cooled for all engine-alternators 10 kW and larger, with the only exception being for documented space reasons) shall have sufficient cooling capacity to ensure continuous operation at full load at ambient temperatures up to 50 degrees C (122 degrees F) at the site altitude.

Engines may have a switch that shuts down the engine when the radiator fan fails.

Some installations require the radiator and fan mounted separately from the engine-alternator. This is known as a remote radiator, and the following requirements apply:

- When water flow is produced by the engine driven water pump, total piping pressure drop shall not exceed the engine manufacturer's recommendation. If water flow is assisted by an auxiliary pump, piping pressure drop must be matched to pump capacity at desired water flow, per manufacturer specs.
- Remote radiators are designed for installations where no external airflow restrictions occur. If the remote radiator ventilates a room, has any ducting, or its airflow is opposed by prevailing winds, the cooling capacity is reduced.
- Areas with below freezing temperatures' will require consideration to protect against ice formation that can block air flow or damage fan blades.
- A remote radiator fan requires an electric motor compatible with the standby power source. The voltage, frequency, and horsepower of the required motor must be specified. The fan can be direct-drive or belt drive. If belts are used, multiple belts must be employed to ensure reliability. An indicator lamp must be on the Engine Control Panel, indicating proper operation of the fan. The fan motor shall be powered from the engine-alternator it serves.
- Remote radiators shall be grounded to the existing driven ground system if it can be located. If the existing driven ground system is not available a lead from the remote radiator shall be run outdoors to a point close to the OPGP. At that point, it may enter the building and tie to the OPGP. In addition, the external radiator lines will be bonded to the site's internal ground system where they enter the building.

- Heat exchangers shall be utilized when the engine manufacturer's specified maximum head pressures are exceeded. If a heat exchanger is required, an auxiliary pump shall be used in the system. The pump shall be powered from the engine-alternator it serves.
- The remote radiator fan shall be rated as "Quiet" with a maximum noise level of 81 dBa measured at twenty-five (25) feet.

When the radiator is mounted on the same sub-base as the engine-alternator, the cooling fan shall be mechanically driven from the engine. The fan shall be of the pusher type (that is, the cooling air shall be blown through the radiator). Where the fan is a belt-driven, a redundant belt shall be provided, so that if one belt breaks, the remaining belt(s) shall be capable of driving the fan continuously. These set-mounted radiator fans shall also be equipped with a shroud / duct flange for safety reasons.

The set-mounted cooling systems as described above shall be capable of operating with total fan head pressure equal to or greater than 0.5 inch of water.

If air intake has ductwork, a flexible radiator section, (rubber or flame retardant canvas type is preferred), shall be utilized to connect the radiator with the ductwork.

Silicone type radiator hoses are required for use in all 3D-condo buildings. Elsewhere silicone, or teflon, or high-pressure thick rubber hose is most desirable on the hoses that connect to the block heater, but is recommended elsewhere in the cooling system too.

Outdoor enclosures shall provide access to service the coolant level. A sight glass and low coolant level alarm shall be provided for all outdoor engines 300 kW and larger. Radiator sight glasses shall also be provided for indoor engines larger than 800 kW.

Louvers on the combustion / radiator cooling / exhaust air openings to engine rooms or enclosures are not absolutely required, nor are filters on the air inlets (filters are a site-by-site decision based on the amount of dust, dirt, and other pollutants that might be drawn in). However, when louvers are used, they must be powered closed so that they spring open (using a mechanical spring) upon loss of power to the louver motors. Louver motors should be powered off the engine start-control batteries or off an Essential AC bus, and are activated by the engine start-stop control signals. The design of the louver system shall satisfy the engine air requirements of the particular engine with a maximum design back pressure of ½ inch of water column.

## 7.16 Safety

The engine-alternator set shall be designed and constructed so that personnel hazards are minimized. Component parts shall be suitably arranged and labeled and/or guards shall be employed to minimize the possibility of accidental contact with hazardous voltages, rotating parts, excessively sharp edges, and/or high temperature surfaces per OSHA CFR29 Part 1910 and NEC Article 445.14.

Materials and components employed in the standby AC system shall meet the requirements for fire resistance as stated in Telcordia® GR-63.

Exposed equipment surfaces below the 7 foot level where temperatures will rise to greater than 46 degrees C (115 degrees F) shall be marked with warning labels (the warning label does not have to attach to the surface, but can be nearby in a highly visible location – for engine rooms, a warning on the door may be sufficient). Insulation and/or ventilated guards shall be provided to protect the operator from coming into accidental contact with the high-temperature external surfaces of diesel engine exhaust system parts and piping; plus any other components with surface temperatures higher than 54 degrees C (130 degrees F) when the engine is not running (a general high temperature warning label on an engine room door is sufficient warning for when the engine is running). Temperature guarding requirements do not apply to outdoor engine enclosures that are not walk-in type (the enclosure provides the personnel protection); nor do they apply more than 7 feet above the ground.

The appropriate NFPA® 704 hazard diamond sign shall be provided for fuel tanks, and any room door behind which a fuel tank may be located. In addition, the house service panel (HSP, also known as the service entrance) must have a sign near it (per NEC® Article 702.7) noting the location of the on-site engine-alternator.

Engine room / fuel tank areas shall be labeled to prohibit smoking (within 50′ for propane, in addition to "flammable" and "propane" labels for LPG tanks) nearby per national and local Codes. Eye and ear protection requirements (as well as an auto-start warning) shall be labeled at engine room doors (see OSHA CFR29, Part 1910).
Suitable guards shall be provided for all rotating parts to which the operator might be exposed to, including all fans, blowers, and any other rotating parts of alternators.

- Guards shall be of substantial construction; removable but securely fastened in place and of such design and arrangement that any part of the operators' body cannot project through, over, around or underneath the guard.
- All set screws, projecting bolts, keys, or keyways shall either be suitably guarded or of a safety type without hazardous projections or sharp edges.
- All running gears and sprockets exposed to personnel contact shall be enclosed or be provided with band guards around the face of the gear or sprocket. Side flanges on the band guard shall extend inward beyond the root of gear teeth.

## 7.17 Hazardous Voltages

Voltages at or above 150 Volts DC or 50 Volts AC rms shall be enclosed or guarded to prevent accidental personnel contact. Warning labels shall also be provided and conspicuously displayed so that they are visible with guards in place or removed.

## 7.18 Portable Engines and Trailers

The portable engine-alternator (the AC engine-alternator is sometimes incorrectly referred to as a portable generator or genset, since a generator has a DC output) shall meet all requirements of the previous sub-sections of this Chapter, except that grounding conductors need only be sized to meet the NEC® requirements).

Although the ratio of portable engines to sites is a local decision, new ones must be equipped as described in this document. Examples of items to be considered when determining the ratio of generator sets to sites are:

- Area covered (including typical area climate)
- Voltage and phase configurations of sites to be covered (single/three-phase combo gensets are available and recommended for areas that have sites with differing voltage and phase configurations)
- Number of high priority sites
- Power company restoration history
- Tolerable down time duration

For liquid-cooled engines, a coolant heater shall be provided that can be plugged into a typical 120 V outlet. The battery charger will also be connectable to a 120 VAC outlet.

Portables larger than 15 kW shall be mounted on a multiple axle-type trailer that meets all Department of Transportation and local requirements.

- The trailer shall have a locking tool box. Among the items in this toolbox, there will be four rubber wheel chocks, and any adapter cords that are necessary to connect to the sites that could be realistically served by this portable.
- The trailer will be equipped with surge brakes, towing lights (lights, wiring harness, and connector), and an adjustable towing hitch.
- The trailer and portable will have a minimum 100 gallon fuel tank and gauge (or equivalent for LPG tanks).
- Permanently mounted generators or alternators must be grounded to the vehicle chassis they are mounted on. However, the neutral and ground should not be bonded together at the engine since that connection already exists at the AC meter, and we do not switch the neutral at the transfer system.

All 15 and 20 A convenience outlets on the vehicle/trailers must be equipped with GFCI protection. These outlets are intended to provide power for test equipment and tools, instead of powering the telecommunications equipment. Single-phase 30 A receptacles (see Figure 7-2) on engines 15 kW and smaller, are required to have GFCI protection, per NEC® Article 590.6A3. Any other outlets or cordsets, including hard-wired 30 A cordsets (see Figure 7-1) and 30 A receptacles on engines larger than 15 kW, should not have GFCI protection in order to avoid nuisance tripping.

## 7.19 Portable Engine Connections

Standardization of portable engine connection hardware meets the need for a quick positive response during extended power failures. This section presents the standards for new equipment and enables retrofitting of existing equipment/sites.

Portable engine sets shall be grounded according to Tech Pub 77355 and the NEC.

Sites equipped with a permanent engine are generally not equipped with portable receptacles. However, for large/important locations, it may be wise to have a tap box to allow faster connection of a large rented portable. As an alternative to a tap box, for sites that need up to 400 A per pole, single-pole connectors are available. Sites served by portables where the manual transfer switch size exceeds 200 A shall either have a tap box, or single-pole connectors (when the transfer switch size does not exceed 400 A). When tap boxes are used, they should be connected such that two sources cannot be tied together simultaneously. This may be done with a manual transfer switch, interlocked breakers, etc.

There are many variations of portables in use by CenturyLink. Primarily, units capable of producing a rated power output from 3.5 to 75 kW will be addressed in this section.

Although almost all RT powering is 120/240 Volt single-phase, some of these sites may be served by engines capable of single or three-phase operation. These engines are sometimes also used with three-phase sites (typically 120/208 Volt three-phase wye, but could be 240 V three-phase delta). For conformity, some of the 100 ampere connectors and all of the 200 Ampere connectors have been designed to accommodate these types of engines. The 100 and 200 Ampere inlets have 4 pins, but only 3 of the pins are used on single-phase sites when a UL® 1686 C1 Style 1 compliant metallic-case is used where the ACEG "green-wire ground" is connected to the metallic case of the plugs and receptacles (all 4 pins are used on plastic-sleeve 100 Ampere IEC 60309 orange inlets designed for single-phase service).

The plugs, receptacles and cable sets illustrated in the Figures in this section have been standardized for use in CenturyLink. The local Power Maintenance Engineer should be consulted before gauge (AWG) changes are made to the power cables specified in this document.

The Ampere rating of the plug chosen (see the Figures) will depend on the ultimate load expected at a given site (this load is to be computed by the Design Engineer, who should then specify the Ampere rating of the AC service and portable genset plug).

All hardware, including power panels, cabling, and devices shall be Listed by a Nationally-Recognized Testing Laboratory (NRTL). Installations shall conform to the NEC® and local electrical codes.

Van or truck mounted engine-alternators presently in service capable of producing 120/240 Volt single-phase AC are generally 3.5-13 kW in rating. They shall be equipped with at least a two pole 30-Ampere breaker. (The 30-Ampere plug is only actually rated to carry about 6 kW of 240 V power. The breaker will protect the cabling, engine, and plugs from having their ratings exceeded.) As an option, a cable may either be permanently attached to the engine-alternator terminal block as, or the alternator terminal block may be wired to a NEMA® WD-6 L14-30R locking receptacle.

The DLC housing or power pedestal shall be equipped with an L14-30P inlet. The typical 25-30 foot cable run between the engine and the site inlet must use four #10 AWG conductors in a Type W cable.

Van, truck, or trailer mounted engines presently in service capable of producing 100 A of 120/240 V single-phase AC, 120/208 V 3-phase wye, or 240 V 3-phase delta power shall be equipped with at least a 2-pole 100 A breaker for single-phase sets, or a 3-phase 100 A breaker for 3-phase or three/single-phase sets. (The 100 Ampere plugs are actually rated to carry only about 20 kW of nominal 240 V single-phase power, 30 kW of nominal 208 V 3-phase wye power, or 35 kW of 240 V 3-phase delta power. The breaker will protect the cabling, engine, and plugs from having their ratings exceeded.)

As an option, there may be a cable permanently attached to the engine-alternator terminal block, or the alternator terminal block may be wired to a either an IEC 60309 plastic-sleeve receptacle or a Style 1 (ACEG attached to the metal housing of the receptacle) UL® 1686 C1 4-pin pin-and sleeve device with a metallic housing on the connector. The site housing or power pedestal shall be equipped with either an IEC 60309 inlet plug, or a Style 1 UL® 1686 C1 pin and sleeve reverse-service (the reverse-service connectors ensure that "hot" power is not on an exposed pin) inlet plug.. For single-phase sites, pin 3 may be pulled on the building/site side of a 100 or 200 Amp inlet, as shown in the drawings . The typical 25-30 foot cable is made up of four or five, number 2 gauge conductors in a Type W, UL® sheath. Engines that are capable of three-phase operation will have five (5) conductors in their cables.

In some cases, the power requirements of a site served by a portable engine will exceed 100 A. Trailer mounted engine-alternators capable of producing 200 A of 120/240 V single-phase AC shall be equipped with a 2-pole 200 A breaker for single-phase sets, or a three-phase 200 Ampere breaker for 3-phase or 3-phase/single-phase sets. (The 200 A plugs are actually rated to carry about 40 kW of 240 V single-phase power, 70 kW of 240 V delta 3-phase power, or 60 kW of 208 V 3-phase wye power. The breaker will protect the cabling, engine, and plugs from having their ratings exceeded.)

200 A connectors shall all be of the UL® 1686 C1 Style 1 pin-and-sleeve 4-pin type with metallic housings. The typical 25-30 foot cable is made up of four or five 3/0 AWG conductors in a Type W, UL® sheath (engines that are capable of three-phase operations will have 5-conductor cable).

Existing 50 and 60 A (and other sizes besides 30, 100 and 200 A) older connection devices may be retrofitted to conform to this document as money is available and by attrition to conform to this section. Until "migration" to the new standard is complete, it may be necessary to make adapter cords to match up old engines with new receptacles, and vice-versa.

Custom buildings should be provided with a commercial power cabinet or panel, a transfer system, and a distribution panel that receives its power from the transfer system. This arrangement allows nonessential loads to be eliminated from the standby power load.

Variations in sites require power load calculations based on each individual installation. Portable engine inlets at custom buildings should be sized for the ultimate power requirement of that installation. The -48/24 Volt bulk DC power plant load should be calculated based on all rectifiers being in operation at full rated output (recharge). During a power failure, the engine-alternator will have to provide power for the equipment and the recharging of the batteries, and usually the HVAC system too.

In some cases, the AC service size sold by the electric utility is much larger than what we need. For example, we may only need a 30 A plug on an RT cabinet, but the Power Company gives us a 100 A service. This is generally not a problem because the power pedestal is equipped with separate breakers for the incoming AC service and the portable engine plug. However, some local regulators insist that the portable engine plug be the same size as the service. These cases should be handled individually. Generally, size the receptacle for the expected future maximum site load, rounding up to the nearest of the 4 standard Ampere sizes noted in this section. It won't necessarily be the same size as the incoming commercial AC service from the Power Company. Portable engine receptacles and tap boxes on buildings shall be marked for voltage, phases, phase rotation (for 3-phase sites), and Ampere rating.

Sequenced instructions for implementing standby power operation should be posted in all buildings served by a portable genset.

Most 3-phase sites will have forward phase-rotation (A-B-C rotation). However, there are some sites where the commercial feed and all motors in the building will be wired with reverse rotation (C-B-A). As a general standard, all three-phase alternators, cords, and plugs should be wired for forward rotation. Sites with reverse rotation shall have the wiring between the portable engine plug and the transfer system configured so that the forward rotation from the generator becomes reverse rotation at the transfer system. It is useful to label 3-phase sites served by portable generators with the phase rotation scheme at the portable genset inlet plug/receptacle on the building.

UL® 2201 requires small portables less than 15 kW to have the engine frame and the neutral bonded at the set, making them "separately-derived". However, they usually serve sites having a "hard-wired" neutral (non-separately-derived). This situation can be made safer by limiting genset distance from the site receptacle to 15′, and by ensuring that the receptacle is less than 10′ from the HSP MGN-ACEG bond. This is mostly not an issue, because most smaller gensets are not presently Listed to UL® 2201. Another option on some small portable gensets is the ability to open up their electrical panel and remove the bond.

All new portable genset inlet plugs/receptacles mounted to a structure should be labeled with whether the transfer system neutral is hardwired (the overwhelming majority of our sites), or has a switched neutral (for connection to a separately-derived portable engine-alternator. Only in the latter case (where the manual transfer switch switches the neutral) should a ground rod be driven at the engine-alternator, and assurances made that the portable alternator neutral and frame are bonded together.

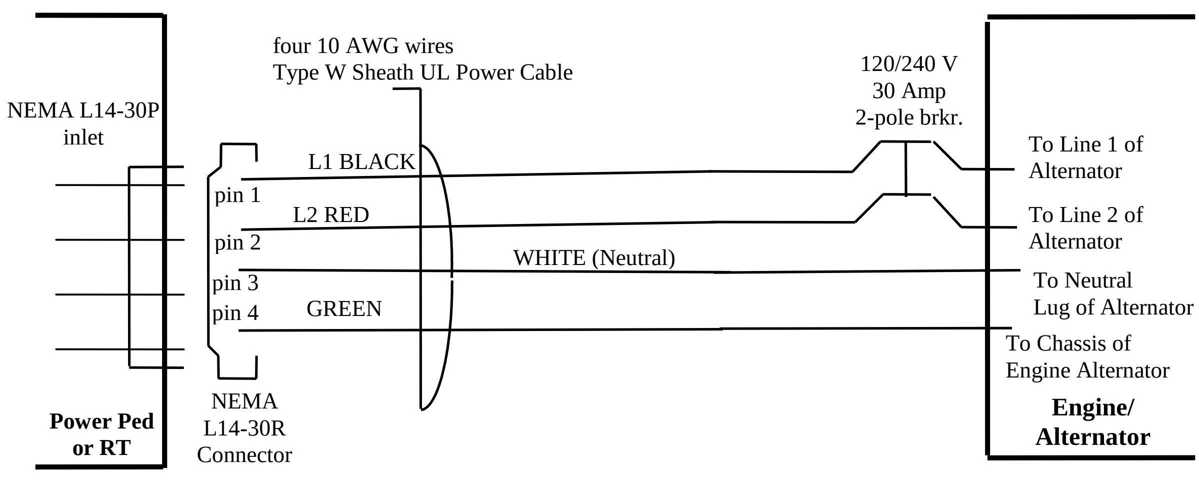



**Figure 7-1:** 30-Ampere Cable Hardwired to Single-Phase Engine-Alternator

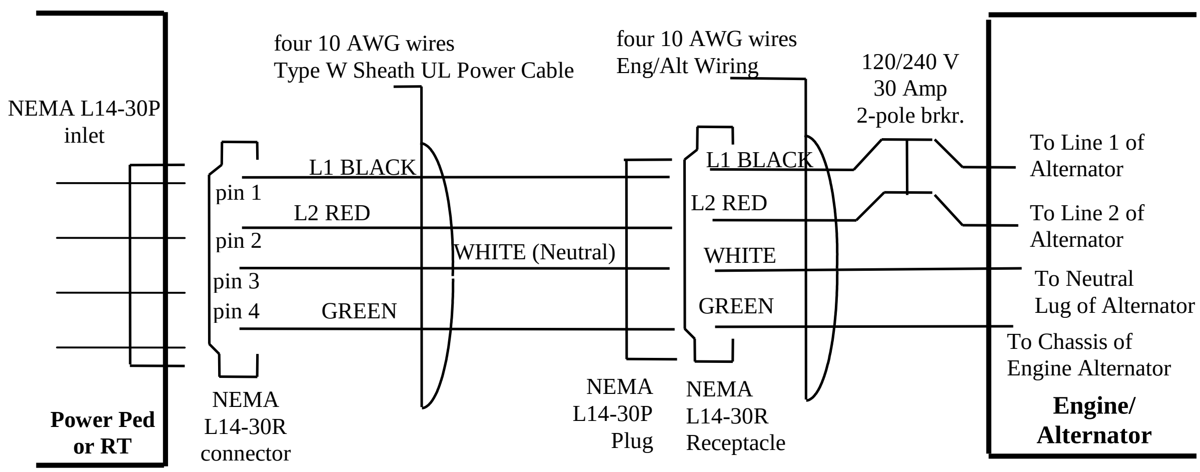



**Figure 7-2:** 30-Ampere Cable to Single-Phase Engine-Alternator Receptacle

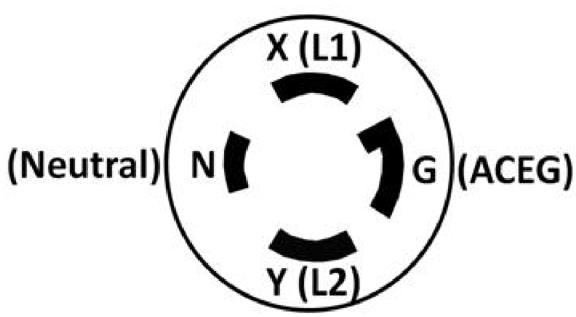



**Figure 7-3:** 30-Ampere NEMA® L14-30P Locking Connector Pin Configuration

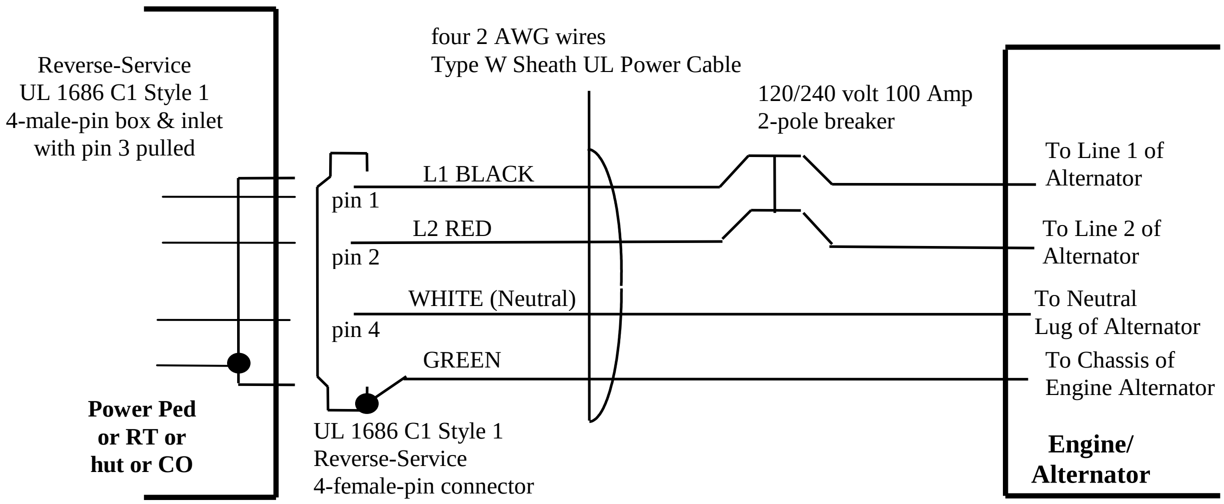



**Figure 7-4:** 100-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve 4-Pin Connector, Cable Hardwired to Single-Phase Engine-Alternator

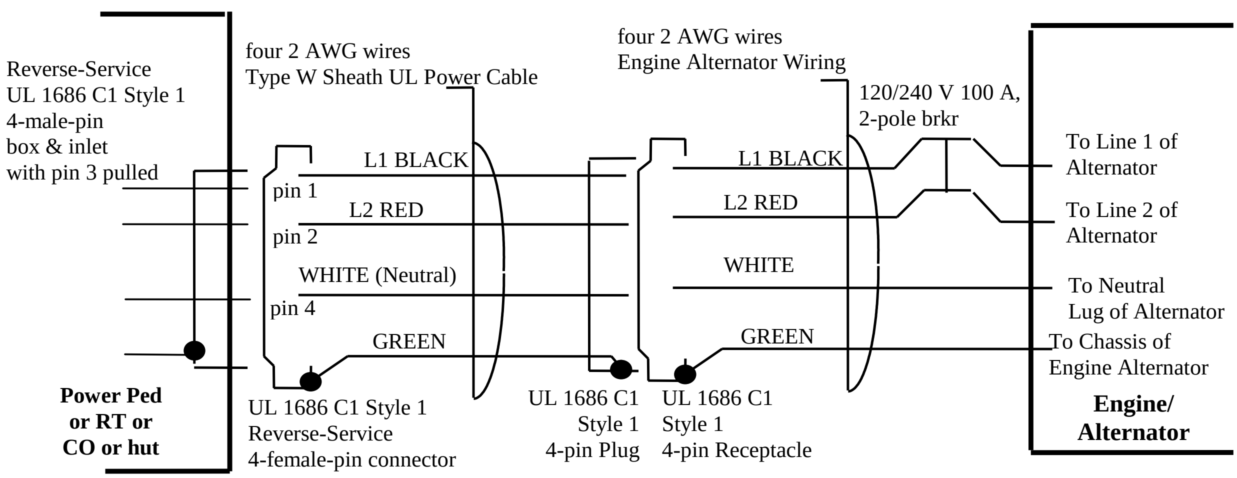



**Figure 7-5:** 100-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve 4-Pin Connectors, Cable to Single-Phase Engine-Alternator Receptacle

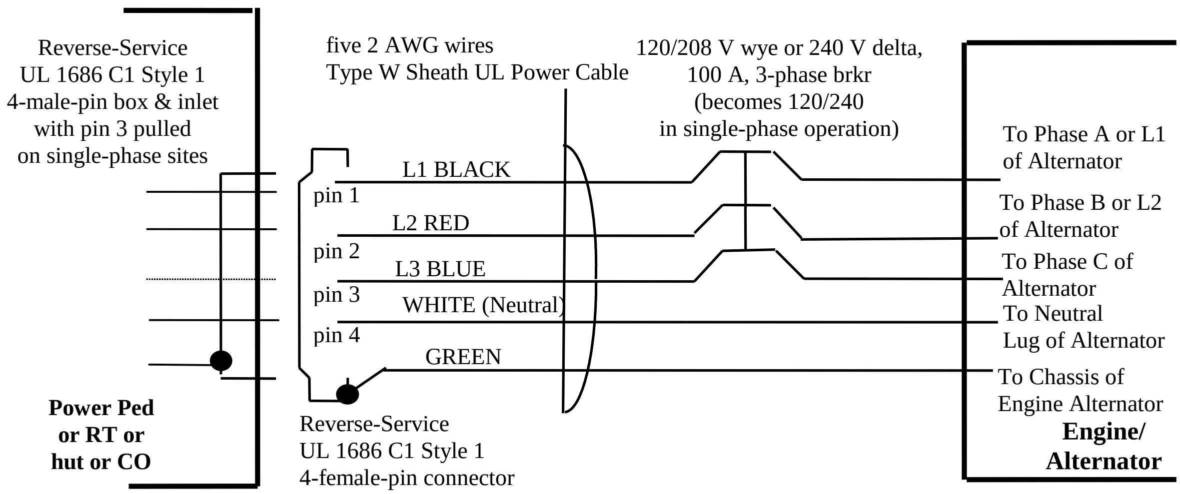



**Figure 7-6:** 100-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve 4-Pin Connector, Cable Hardwired to Three-Phase or Single/Three-Phase Engine-Alternator

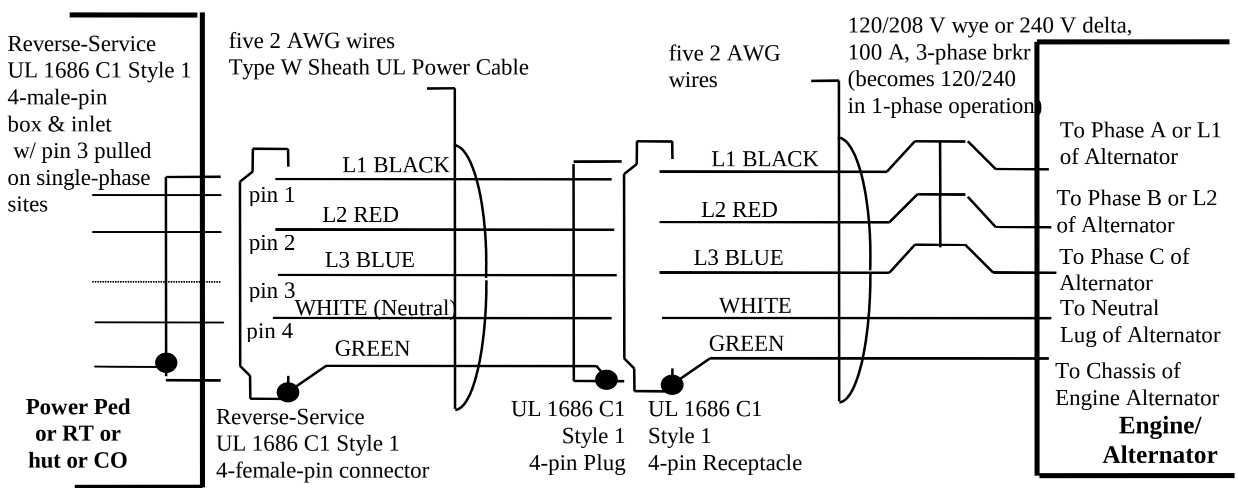



**Figure 7-7:** 100-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve 4-Pin Connectors, Cable to Three-Phase or Single/Three Phase Engine-Alternator Receptacle

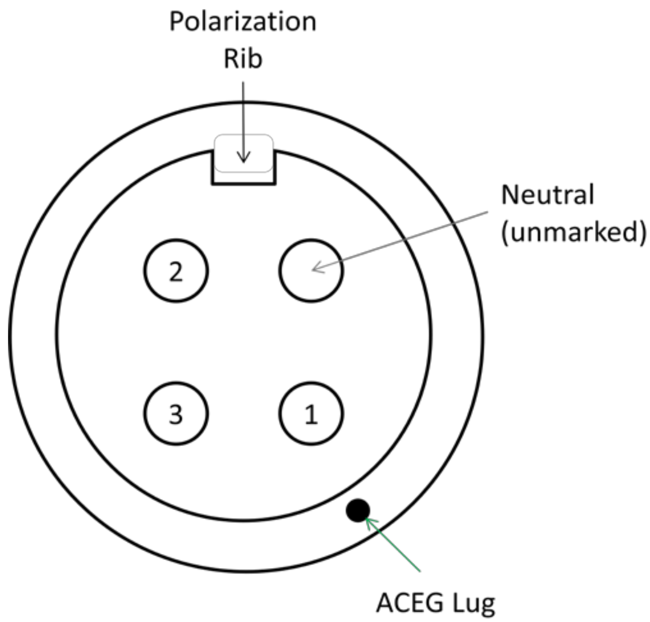



**Figure 7-8:** 100/200-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve Receptacle Front-View Pin Configuration

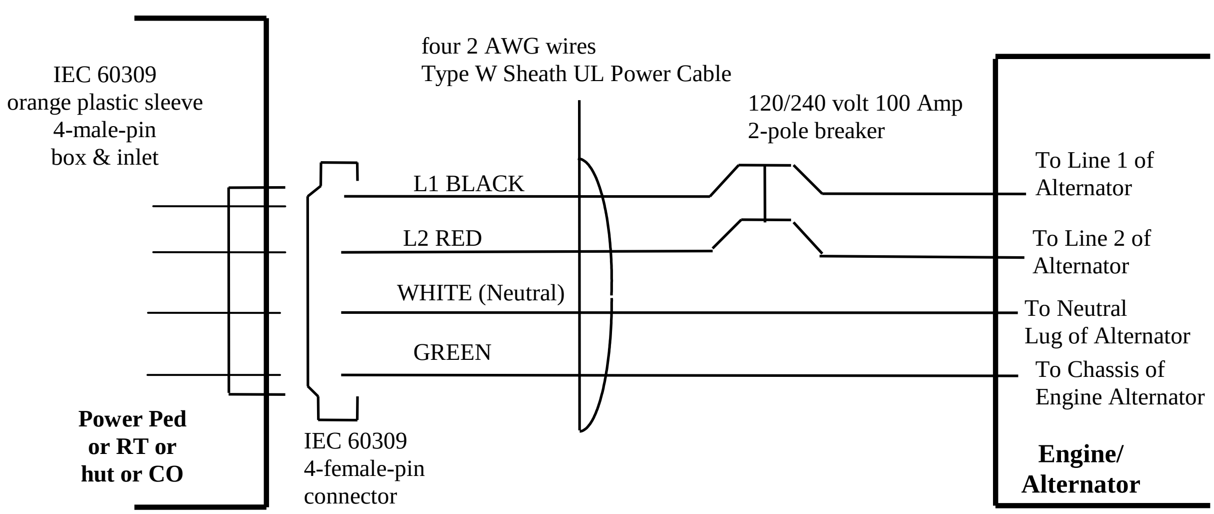



**Figure 7-9:** 100-Ampere IEC 60309 Orange Plastic-Sleeve 4-Pin Connector, Cable Hardwired to Single-Phase Engine-Alternator

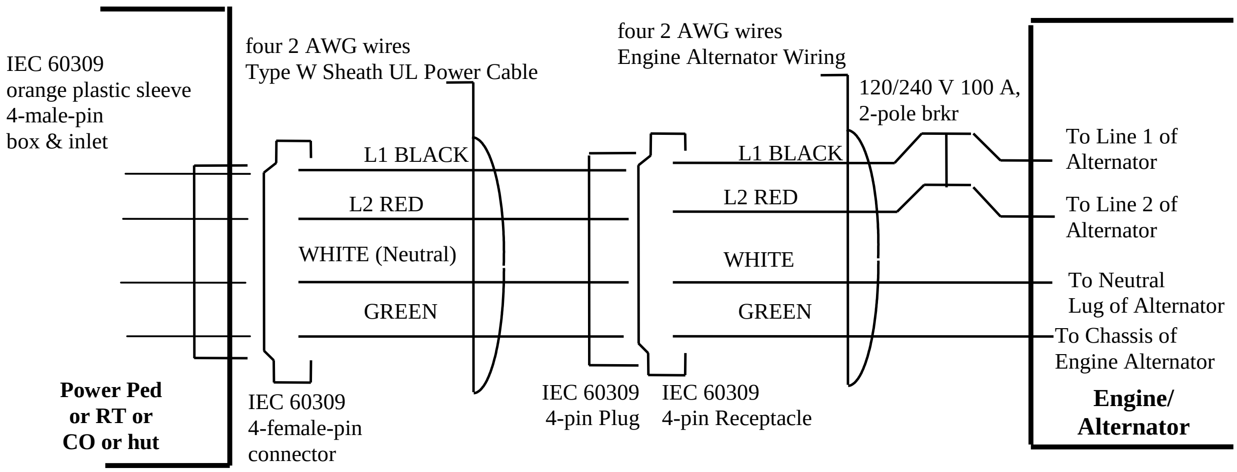



**Figure 7-10:** 100-Ampere IEC 60309 Orange Plastic-Sleeve 4-Pin Connectors, Cable to Single-Phase Engine-Alternator Receptacle

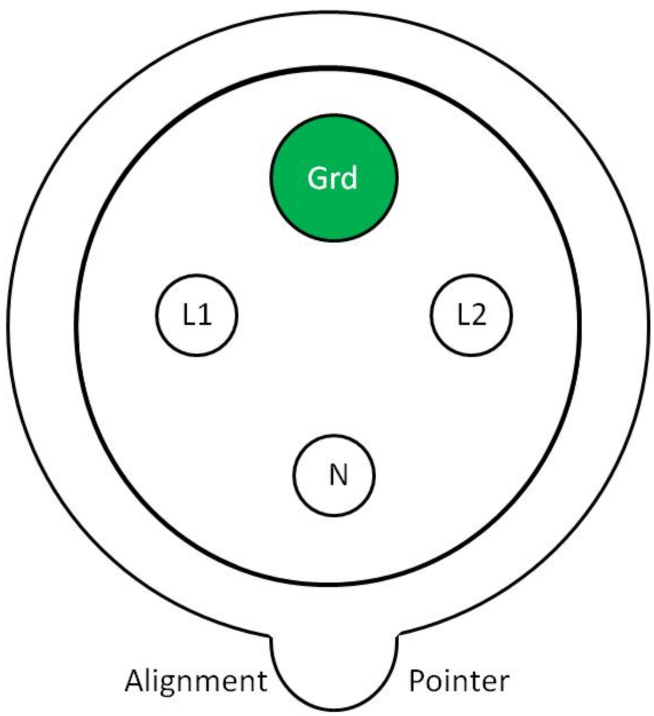



**Figure 7-11:** IEC 60309 Orange Plastic Sleeve 100 Amp Receptacle Pin Configuration

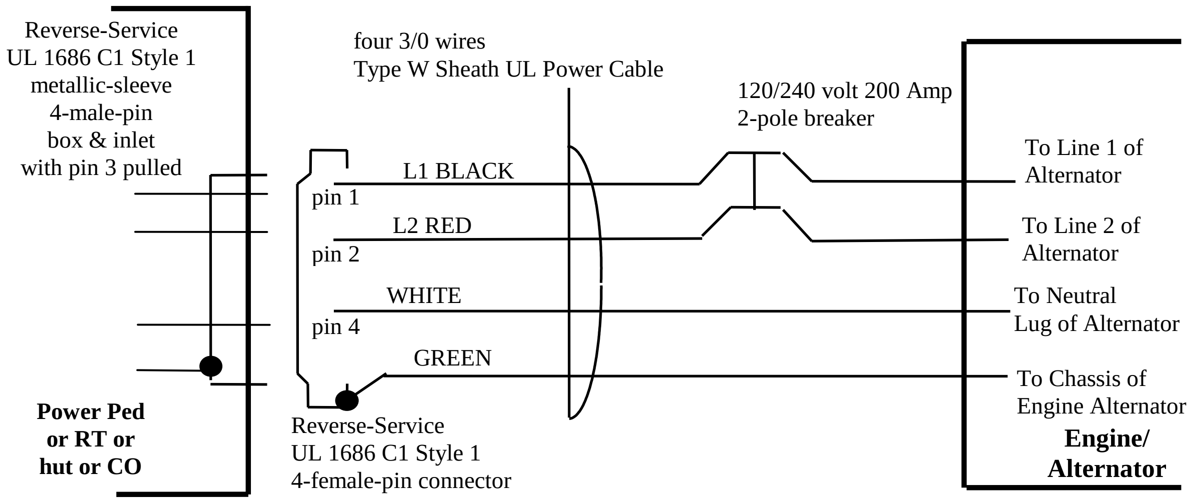



**Figure 7-12:** 200-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve 4-Pin Connector, Cable Hardwired to Single-Phase Engine-Alternator

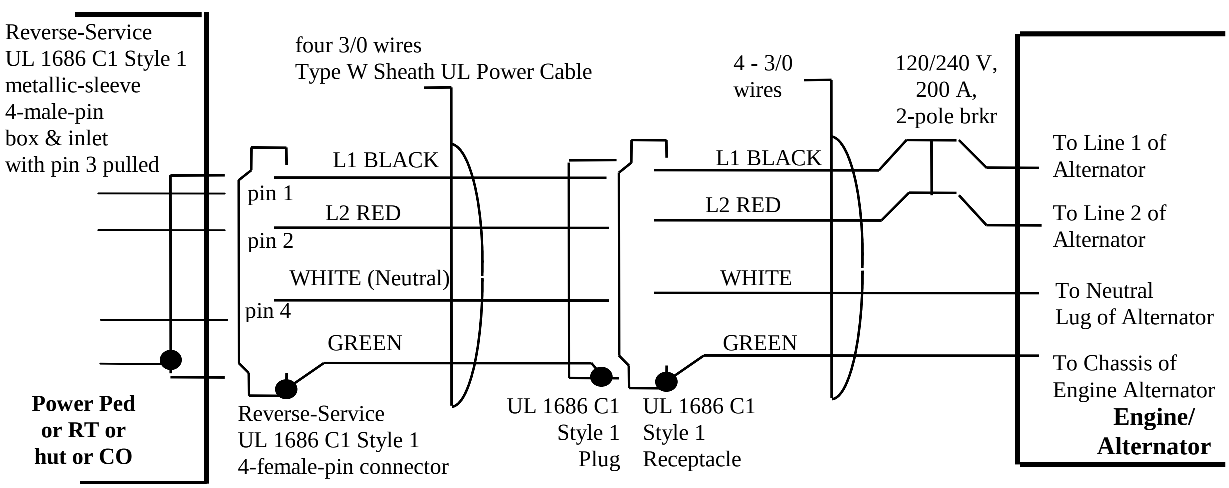



**Figure 7-13:** 200-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve 4-Pin Connectors, Cable to Single-Phase Engine-Alternator Receptacle

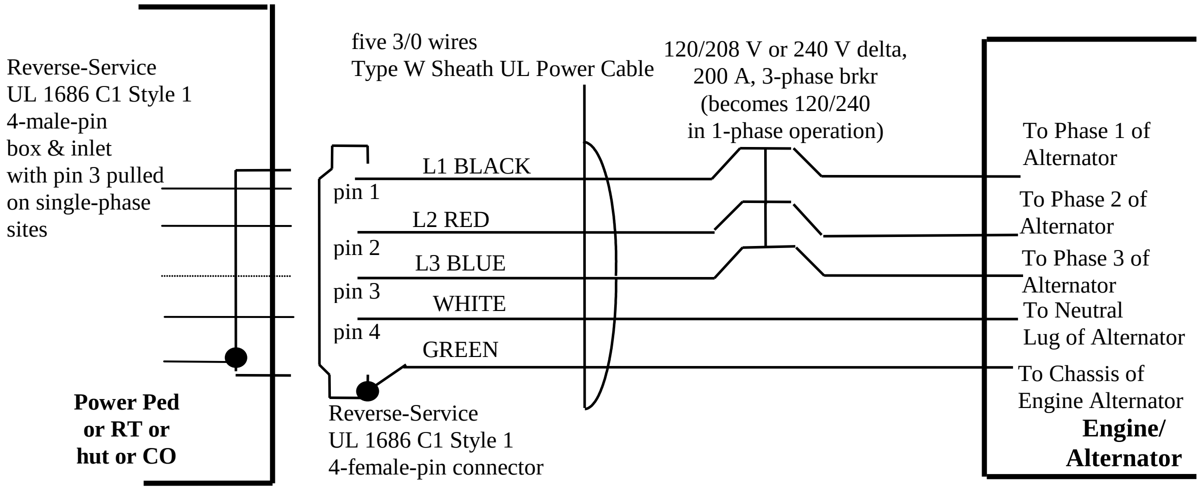



**Figure 7-14:** 200-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve 4-Pin Connector, Cable Hardwired to Three-Phase or Single/Three-Phase Engine-Alternator

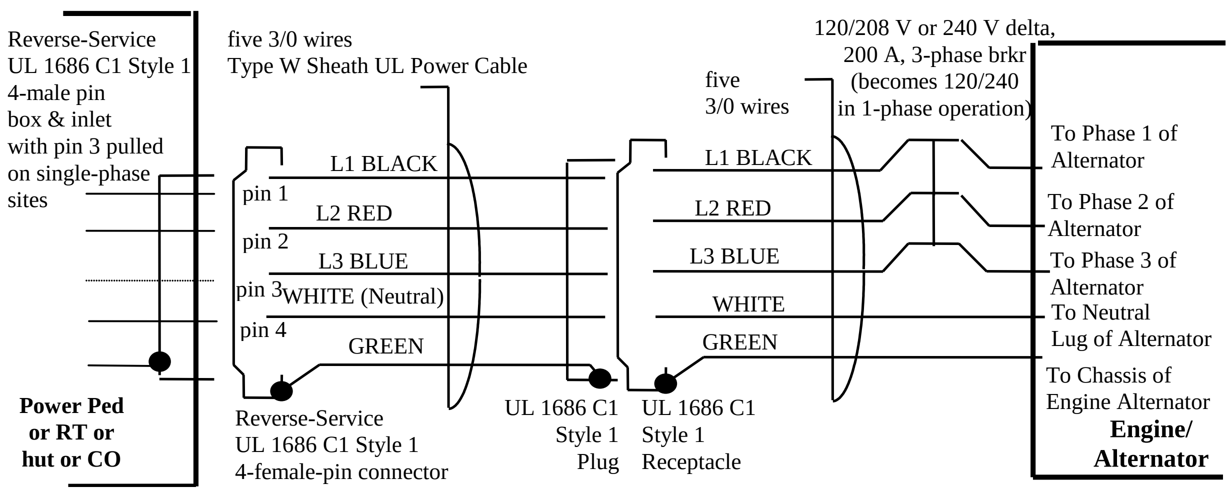



**Figure 7-15:** 200-Ampere UL® 1686 C1 Style 1 Metallic-Sleeve 4-Pin Connectors, Cable to Three-Phase or Single/Three-Phase Engine-Alternator Receptacle

## CONTENTS

**Chapter and Section** **Page**

# 8. Power System Monitor/Controller (PSMC) and Battery Monitors

## 8.1 General

The Power System Monitor/Controller (PSMC) provides front-end status for power plants in CenturyLink. Control functions (of the DC plant rectifiers) must be provided only when the power monitor is designed as an integral part of the DC power plant controller. It is recommended that each battery plant have its' own PSMC; however every office should have at least one PSMC for power alarming and monitoring.

The PSMC shall be equipped for IP communication that can be simultaneously accessed even when alarm system channels are operating. Preferably, there will also be backup dialup access in case the IP connection is lost. Although there may be a proprietary interface, there must also be a dumb-terminal, menu-driven VT-100 interface for the dialup and/or IP telnet access (each of which must be password-protected). IP interfaces should be through standard html web browser pages rather than proprietary interfaces.

The monitor should have an RS-232, USB, or IP interface such that it can be accessed locally by connection of a cable to a laptop.

All modems/DSUs and PADs shall be DC only. AC modems/DSUs and PADs are not used within CenturyLink™ (an exception is allowed for UPS battery monitors backed up by the UPS) unless powered by a DC-plant backed inverter.

For PSMCs that will be used in locations where NMA® is the ultimate aggregating alarm system, the PSMC should be NMA®-compatible and support the CenturyLink™ TL1 recommended Power message set (see Chapter 13) via X.25 protocol standards (TL1 over IP is optional). IP-addressable PSMCs and Battery Monitors may optionally report SNMP traps and be tested through Telcordia's OSMINE™ Light process so that a template is available for loading into NMA® that translates between SNMP and TL1. Control functions must not be accessible via dialup access without a special password (typically known as a "super-user" password, which should be changed on initial installation from its default, with the new password reported to the CenturyLink™ Power Tech Support person responsible for the area). The installation provider is responsible for verifying that all the alarms are reporting to the proper alarm center, and note the center responses on the proper form from Chapter 15.

When a larger distribution fuse/breaker doesn't have a shunt, and monitoring is required, the use of a split core transducer is desirable. If the BDFB has a shunt then it is an option to monitor the BDFB load from that shunt. If the CenturyLink™ Engineer makes a decision that, a transducer cannot be used or the distance to the BDFB is too great then that CenturyLink™ Engineer can waive the requirement for monitoring the BDFB load current, and should note this in the job package.

Alarm and monitor leads (wireless communication for monitoring devices isn't allowed in COs and larger long-haul sites, and is discouraged in smaller sites) don't require fiber tags, but it is desirable to mark them on both near and far end for source/termination.

Where plant LVDs or EPOs exist in a plant, the PSMC shall be connected on the hot side of the disconnect point (unless the AHJ objects to this in a site with an EPO). Where power distribution from more than one nominal -48 VDC plant exists on the same floor, it is desirable for reliability to power standalone power monitors from a plant other than the one they are monitoring.

## 8.2 Standard Monitor and Control Points

The following sequence details the desired order of points for equipment to be monitored by the PSMC when a new monitor is placed. Note that battery monitors may only monitor the battery portions of the list below (including UPS batteries).

- -48 Volt battery plants
- 24 Volt battery plants
- 130 Volt battery plants
- 24 Volt converter plants
- 48 Volt converter plants
- 130 Volt converter plants
- Ringing plants
- Inverter plants
- Uninterruptible Power Supply (UPS) systems
- Standby engines
- Commercial AC

Many of the monitoring points for standby engines and commercial AC may be furnished as part of the transfer system. The requisition should list the exact equipment to be monitored and what is to be monitored on each unit of equipment.

The subsections below list required points to monitor (if possible). Monitor optional points when the PSMC has the capacity, or if directed by the CenturyLink™ Engineer.

### 8.2.1. Primary Power Plant

- Analog Points
    - Plant voltage
    - Plant current

  - Collocation feeder orders greater than (but not equal to) 60 Amperes (basically 80 A and larger fuses or breakers)
  - BDFB feeder current
  - Current of PDF feeders greater than 100 Amperes (optional)
  - Current feeding inverters (optional)
- Binary Points
  - Distribution fuse/breaker alarm (FA)
  - High DC Plant Voltage (HVA) – this may be derived from the analog voltage via a threshold
  - Low Voltage / Battery on Discharge (BOD) – this may be derived from the analog voltage via a threshold
    - Very Low Voltage (optional, except in some Legacy CenturyLink™ companies, where it is required)
  - Low Voltage Disconnect (LVD), if installed (preferably in series with batteries)
  - Plant major alarm (this is generally only an output from the PSMC to an alternate alarm system, and not an input into the PSMC)
  - Plant minor alarm (this is generally only an output from the PSMC to an alternate alarm system, and not an input into the PSMC)

NOTE: The power plant major and minor from the standard controller may be run to a power monitor, but it's better to parallel them with PSMC major and minor on the primary alarm device in case the PSMC fails.

### 8.2.2 Rectifiers

- Analog Points
  - Rectifier current, when spare monitor points are available
- Binary Points
  - Rectifier Fail (RFA) – Individual RFAs are required unless the controller or monitor has the ability to escalate from minor (single rectifier) to major (multiple rectifiers)
  - High Voltage ShutDown (HVSD) – this may be via the rectifiers and/or DC plant controller

For PSMCs that are also the power plant controller, the following control functions will be available from the controller to the rectifiers:

- Re-start (RS)
- Shutdown (TR)
- Sequencing (usually not used)
- Energy Management

### 8.2.3 Batteries

- Analog Points
  - String current – A shunt (minimally sized per Section 3.10) will be placed in each new flooded battery string in DC plants to monitor charge and discharge current (this may be pulled off the shunt on a battery disconnect breaker if it exists). String current is optional for VRLA and Lithium-based battery strings. A Hall Effect sensor may optionally be used in place of a shunt, especially for measuring float current. In UPS systems, AC ripple current is commonly measured by use of a split-core CT/transducer.
  - Room temperature – One temperature sensor will be placed to monitor room temperature, approximately five feet above the floor in the area of the batteries. It must be placed away from heating and cooling sources, such as rectifiers, and HVAC vents.
  - Single cell Voltage – The voltage of at least one flooded cell (typically known as the pilot cell) will be monitored per plant.
  - Cell Temperature – Flooded batteries require one temperature sensor to be placed, to monitor the temperature of one cell per plant (typically the same as the pilot cell used for single-cell voltage). VRLA batteries require multiple temperature sensors to monitor the temperature of a cell/block in each string. A function channel should be established for VRLA batteries to monitor the differential between cell/monobloc temperatures and ambient. If there is no cell temperature monitoring for VRLA batteries in controlled environments, and temperature compensation from the power plant controller has a deadband (see Table 13-16), then temperature compensation may be alarmed as a minor alarm; otherwise temp comp should not be alarmed.

- Internal Cell/Monobloc Impedance – The internal resistance, conductance, or impedance of VRLA batteries may optionally be measured (with an adjustable daily-monthly measurement period). It usually applies to VRLA UPS batteries, but can be used for other lead-acid batteries (especially VRLA) where the PSMC/monitor is capable.
- Mid-point Voltage – Measure the voltage at the midpoint of each battery string (optional).

• Binary Points
  - Battery String Disconnect (which may be internal, especially on Li-ion batteries) breaker tripped or turned off (if installed — this may be daisy-chained to one point from multiple disconnects, and should be wired in series from the normally closed contacts for Li batteries).
  - Battery (String) Major (for batteries with a BMS, or coming from a battery monitor)
  - Battery (String) Minor (if it exists for batteries with a BMS, or coming from a Battery monitor)

### 8.2.4 Converter Plants

• Analog Points
  - Voltage
  - Current (if shunts are already installed)

• Binary Points
  - Distribution Fuse fail (possibly both major and minor alarms)
  - Converter Plant Major (if available)
  - Converter Plant Minor (if available)
  - Individual Converter Fail Alarms (CFA) — only required if Plant Major/Minor are not available

### 8.2.5 Inverters

• Analog Points (Optional)
  - AC Voltage (per phase, line to neutral)
  - Current (per phase)

- Binary Points
  - Inverter Fail/Major alarm
  - Minor alarm
  - Inverter off normal (indicates when a DC-preferred inverter is in AC-preferred mode or bypass, or when an AC-preferred inverter is in maintenance bypass)
  - Bypass Not Available (when bypass is used – optional for less critical systems)

### 8.2.6 Residual Ringing Plants

- Binary Points
  - Minor (single ring generator or interruptor failure)
  - Major
  - Distribution Fuse Alarm (if available – if not, it must be part of the major or minor alarm)

### 8.2.7 Uninterruptible Power Supplies (UPS)

- Analog Points (Optional)
  - AC Voltage (per phase, line to neutral)
  - Current (per phase)
- Binary Points
  - UPS Fail/Major
  - UPS Battery on Discharge and/or Low Voltage
  - EPO Activated (for sites with an EPO)
  - Mode indicator (indicates when UPS an on-line UPS is in line-interactive mode or bypass, or when a line-interactive UPS is in maintenance bypass)

### 8.2.8 Standby Engines and Transfer Systems

These points should be installed on a going forward basis. Older engines and control equipment may not be capable of all of these points.

- Analog Points
  - Start Battery Voltage (optional if Start Battery Charger Fail alarm installed)

    - Engine Temperature (if available it is optional)
    - Engine Oil Pressure (if available it is optional)
    - Engine Room Temperature (measured inside the room, not on the outside wall – optional)

- Binary Points
    - Engine Run
    - Engine Switch Off Normal
    - Engine Breaker Open (optional)
    - Engine Emergency Stop
    - Fuel Heater Fail (when a fuel heater exists - optional)
    - Engine Supplying Load or Transfer Switch Proper Operation (optional or filtered in some CenturyLink™ entities)
    - Single-Phase Lockout (for transfer switches equipped with this feature)
    - Engine Fail/Major (generic – use if there are not individual alarms as described below – Engine Fail may be broken out separately)
        1. Low Oil Pressure (Optional)
        2. Overcrank (Optional)
        3. Overspeed (Optional)
        4. High Coolant Temperature (Optional)
        5. Start Battery Charger Fail (Optional if Start Battery Voltage installed)
    - Engine Minor (generic – use if there are not individual alarms as described above and below)
        1. Load Transfers (Optional)
        2. Transfer System and/or Engine Controls not set to Automatic (off Normal)
        3. Block Heater Alarm or Low Coolant Temperature
    - Engines Failed to Parallel (for paralleled systems)
    - Fuel System Trouble (or individual alarms below)
        1. Low Fuel (this may be combined into the Fuel System Trouble, and if there is a Day Tank, it too should be alarmed for this)

2. Fuel Leak (this may be combined into the Fuel System Trouble) or Tank Leak (including interstitial space for all direct-buried tanks and any aboveground or underground vaulted tank where the total site fuel storage capacity is ≥ 1320 gallons)
3. Overfill (can be combined with the Fuel System Trouble Alarm, but in any case, it is required on all direct-buried tanks and aboveground or underground vaulted tanks where total site fuel storage capacity is equal to or larger than 1320 gallons)

### 8.2.9 AC Power

- Analog Points (facilities with multiple transfer switches shall be equipped with voltage and current monitoring at the load side of each transfer switch serving critical power and/or HVAC systems)
  - AC Voltage per phase/leg – measured phase-neutral, and monitored on the transfer system load side (it is desirable for the PT voltage step-down transformers to be fused or breaker-protected for ease of replacement)
  - AC current per phase/leg – monitored on the transfer system load side
- Binary Points
  - AC fail (although there should be one alarm, individual sensors per phase are desired, if possible). This should be monitored on the line side of the transfer system (at the main disconnect if possible). The relay shall be served from a fuse or breaker to allow for servicing.
  - TVSS alarm (indicates when the TVSS has failed or is degraded – may not be available on older surge suppressors).
  - Ground Fault detection (larger systems may detect a large ground fault on the incoming commercial AC, the engine, or large branch circuits)

## 8.3 Alarms

If the PSMC fails, local visual and audible alarms will not be disabled when control is passed to the traditional power plant controller.

The PSMC will analyze incoming alarm information from the power plant components and provide settable downstream alarm levels (thresholds) as required (see Chapter 13).

If the PSMC is an alarm-transmitting device, it will also report at least major, minor, and monitor fail (watchdog) alarms to another alarming system, as a backup to the X.25/IP TL1 communications or to the SNMP over IP communications.

## 8.4 Statistical Channels

The PSMC will be capable of storing statistical data for engineering power plants. There will be a minimum of ten statistical channels supplied with the PSMC. Any analog channel can be assigned for statistical data. Each statistical channel will be capable of storing peak high, hourly average high, daily low and hourly average low for each day while the channel is active. This data will be retained daily for a minimum of 30 days.

## 8.5 Energy Management and Sequencing

The PSMC will not be wired for power plant or engine control, unless the PSMC is also the power plant controller (then it may control the rectifiers, including energy management and rectifier sequencing).

The power plant controller shall provide energy management for ferroresonant rectifiers as follows:

- The power plant controller will activate sufficient rectifier capacity per controlled plant to support the presented load.
- When energy management is active, the power plant controller will ensure that each rectifier in each controlled plant is active for a minimum of 4 hours during each 30-day period.
- Sequencing priority will be individually selectable by rectifier.

The power plant controller will be capable of providing rectifier restart sequencing upon restoral of AC power. The sequencing should be separately controllable for transitions to commercial AC versus the standby engine. If the transition scheme will not allow two configurations, then the transition scheme must be based on the capability of the standby engine. Sequencing is not normally employed except in cases of overloaded engines or closed transition transfer switches.

## 8.6 Requirements of a PSMC for Small Sites, or Battery Monitor for UPS

A PSMC or Battery Monitor for Confined Locations (PSMC-CL) may exist to perform monitoring for locations in CenturyLink™ smaller than COs or other large installations; or a permanent battery monitor is common for larger UPS applications. A PSMC-CL is optional. A PSMC-CL may be the same unit as that used for a PSMC in COs, but equipped with fewer points.

A PSMC-CL should (shall if it doesn't have an IP interface) be equipped for remote access dialup capabilities. Although it may have a proprietary interface on dialup and local RS-232 access, it must also present a dumb-terminal VT-100 menu-driven interface. The PSMC-CL's modem shall automatically adjust baud rate to match the baud rate of the originating modem with no parity, 8 bits, and 1 stop bit (N81). The PSMC-CL may be capable of TL1 over X.25 or IP, or SNMP via IP, but it is not required. An external battery monitor for UPS systems shall be IP-equipped (some UPS manufacturers build battery monitoring into their UPS – in those cases, it is also desirable that the battery monitoring and alarms be transmitted via IP, but at a bare minimum, alarms must be provided via dry Form C contacts), and is not necessarily required to have a dialup modem.

The PSMC-CL shall be password protected. Multiple access levels with "super user" capabilities must be provided in order to make database changes.

The PSMC-CL shall report Power Major, Minor, and watchdog alarms, via dry form C contacts, to the alarm telemetry of the site.

If a PSMC-CL or UPS battery monitor is installed, it should be able to monitor up to 6 battery strings, including the required monitor points specified in the sub-sections below (assume the point is required unless otherwise specified – note that only the battery points are required for battery-only monitors):

### 8.6.1 Primary Power Plant

- Analog Points
  - Plant Voltage
  - Plant Current
- Binary Points
  - Low Voltage (also known as "battery on discharge)
  - High Voltage
  - Power Distribution Fuse/Breaker Fail

### 8.6.2 Rectifiers

- Binary Points
  - Rectifier Fail (may be both minor for single rectifier fails, and major for multiple rectifier failures)

### 8.6.3 Batteries

- Analog Points (this can include engine start/control batteries in sites with permanent engines and battery monitors – especially UPS battery monitors)
    - Voltage – Voltage monitoring can be placed on pilot cells/monoblocks (optional)
    - Cell Temperature – One temperature sensor will be placed to monitor the temperature of a "reference" battery in each battery string; preferably the most negative cell on the highest row of the string. If the plant employs temperature compensation, additional probes run to the monitor are not necessary.
    - Room Temperature – Only one temperature sensor will be placed to monitor room (or cabinet) temperature. The sensor should not be placed next to a heating or cooling source. String bulk charge/discharge current – A shunt (which may be a part of a disconnect breaker) may be placed in each battery string to monitor charge and discharge current (optional).
    - String float current – A Hall effect sensor (shunts are not sensitive enough) may be placed to monitor string float current (optional). For UPS systems, a CT can monitor AC ripple current.
    - Internal Cell/Monobloc Impedance – The internal resistance, conductance, or impedance of VRLA batteries may optionally be measured (with an adjustable daily-monthly measurement period).
- Binary Points
    - Temperature differential / thermal runaway – the difference between ambient and cell temperature, set to alarm at a certain threshold (per Chapter 13). This may be a function channel programmed in the monitor.
    - Battery String Disconnect breaker tripped or turned off (if installed — the alarm may be daisy-chained to produce one alarm from multiple disconnects).

## 8.7 Power Alarms in Sites without a PSMC

When there is no PSMC for the site the following binary alarms should be connected to the alarm device on site as a minimum (some older power systems may not have all of these alarms available). When there are older overhead bitstream housekeeping miscellaneous environmental alarm systems that do not have enough points, alarms should be combined (minimum of two – major and minor) onto the available points.

- DC Plant alarms
  - Major
    - Includes multiple rectifier fail
    - Includes main distribution fuses (can be a separate alarm)
    - Includes High DC Plant Voltage (can be a separate alarm)
  - Minor (including a single rectifier failure, which can be separate)
  - Low Voltage (also known as "battery on discharge")
    - Very Low Voltage (optional in some CenturyLink™ entities)
  - Low Voltage Disconnect (in the rare cases where used)
  - Battery Disconnect (when used)
  - High Voltage Shutdown (HVSD)
  - Converter Plant Distribution Fuse / Major Alarm (also applies to multiple converter failures – only applicable for sites with converter plants)
  - Converter Plant Minor / Individual Converter Failure (only applicable to sites with converter plants
- Miscellaneous Power System alarms
  - Ring Plant Major
    - Includes multiple ringers failed
    - Includes ring plant distribution fuses (can be a separate alarm)
  - Ring Plant Minor / single Ring Generator / Interrupter Failure

- AC system alarms
  - Commercial Power Fail (at main disconnect if possible)
  - Surge Arrestor Fail (TVSS/SPD)
  - ATS SystemNot in Auto (when there's a permanent engine on site)
  - Single-Phase Lockout (when transfer switch is so-equipped)
  - AC system Ground Fault Detection (when equipped)
  - Inverter on Bypass (for systems with a bypass)
  - Inverter Bypass Not Available (for the most critical systems)
  - Inverter Fail/Major
  - UPS on Bypass (for sites with UPS)
  - UPS Battery on Discharge or Low Voltage (for sites with UPS)
  - UPS Fail/Major (for sites with UPS
- Engine alarms (when there's a permanent engine on site)
  - Engine Run
  - Engine Fail (can be a combination of many alarms)
  - Engine Emergency Stop (can be combined with the Engine Fail)
  - Low Fuel (can be part of Fuel System Trouble – both day and main tanks)
  - Fuel Leak / Fuel System Trouble – from fuel monitor if available
  - Engine Start Battery Charger Fail and/or Engine Battery Low Voltage
  - Engine Controls Not in Auto
  - Engines Failed to Parallel (for large paralleling systems)

## CONTENTS



**Tables**

**Figures**

# 9. DC Power Distribution

## 9.1 General

CenturyLink™ is responsible for the floor plan(s) layout of a site. Layouts of equipment shall be per CenturyLink™ Technical Publication 77351, CenturyLink™ Standard Configuration Documents, and Telcordia® GR-63, as required.

## 9.2 Telecommunications Equipment Loads

The total load fed by the DC distribution system is determined by the type, quantity, and mix of telecom equipment in a site. Once the load is determined, it is matched to a distribution system and a power source with adequate capacity to power the loads and the distribution losses. The power cable is sized per the voltage drop guidelines of this section (once DC power has been handed off to a CLEC [typically at their fuse panel], voltage drop rules are of their own choosing from that point downstream, although following the voltage drop rules of this section maximizes battery reserve time to their equipment). Ampacity of the cable shall equal or exceed the fuse or breaker size.

Nominal voltages for standard telecom equipment are 24, 48, and 130 VDC. Operating voltage limits permitted on individual equipment assemblies are more variable. For example, NEBS™ specifies that nominal -48 VDC equipment must work from -42.64 to -56 V. However, some old equipment won't work at -56 V (e.g., some might only work to -53.5), while more modern equipment might work above it (60 V, for example). Most equipment will work down to at least -42.64 V, and some will work even lower.

The formula for calculating voltage drop is:

$$CM = \frac{K \times I \times d}{V_D}$$

where,

*CM* is Circular Mils (see Tables 9-1 through 9-4 for bus bar and wire)

*I* is Amperes – 125% of the List 1 drain if known, or one of the following:

- half the protector size for feeds to a BDFB/BDCBB
- CLEC power feed order if the CLEC does not provide List 1 drain
- 4 or 8 hour battery discharge rate for runs from a battery stand to main term bars / chandelier, or plant buses where there is no MTB
- The PBD busbar rated ampacity for MTB to a PBD hot bus runs
- The shunt size for runs from the MTB to a PBD return bus
- 80% of the protector size in all other cases (split that load for true A/B-fed equipment)

*K* is 11.1 for copper and 17.4 for aluminum at approximately 40°C (typical cable rack temperature)

*d* is distance (for distribution, this is top-to-top distance and does not include the drop cabling into or out of equipment or distribution bays – distance may be loop or one-way – see the bullet items and Figures of this section for further guidance)

$V_D$ is the voltage drop maximum as described in the rest of this section

The requirements for distribution voltage drop, and which drains to use for sizing are specified below, and illustrated in Figures 9-1, through 9-7. These Figures and the bullets are designed around nominal -48 V battery/rectifier plants (nominal -48 V is the DC voltage that CenturyLink™ provides to all CLECs, and to most CenturyLink™ equipment). For nominal 24 V output battery plants, cut the voltage drops in half. For nominal 130 V output battery plants, double the allowable voltage drops. For converter plants without batteries attached to the output bus, the voltage drops can be much greater (follow the NEC® note of maximum 5% voltage drop from the converter plant to the using equipment overall, with no more than 3% in any one branch).

- The 0.10 one-way voltage drop from the "chandelier" (MTB) negative bus to the primary power distribution boards/bays/panels, shall be calculated to the bus bar ampacity of the distribution bay/panel (unless the shunt capacity of the plant is less, in which case it may be calculated at the plant's main shunt capacity). The 0.10 one-way voltage drop from the chandelier positive bus to the plant return bar(s) is calculated at the Amp rating of the shunt. The shunt(s) in the chandelier or PBDs also have a maximum voltage drop (typically 0.05 V — 50 mV).
- Battery cable from the battery strings to the main bus bar chandelier (MTB) shall be sized to either the 4 or the 8 hour 1.86 V/cell (for lead-acid cells) 100% discharge rate (4 hours for sites with permanent on-site auto-start, auto-transfer engines, and 8 hours for all other sites), using a 0.20 loop voltage drop. Where 2 strings exist on a stand (or the potential for two strings exists on a stand) that use common termination (term) bars for both strings (stand term bars are recommended for all battery stands to provide a convenient connect/disconnect point, especially for battery strings that don't have disconnects), the 4 or 8 hour rate of the batteries is doubled for the voltage drop sizing between the bars. Where even more strings exist or could exist in the stand (more typical with 12 V front-terminal battery stands/racks), size the cabling between the bars at the 4 or 8 hour rate of all the potential strings in the stand.
- For plants that do not have a "chandelier" MTB (all battery strings are cabled directly to the main buses above or internal to the PBDs), their cables are also sized at the 4, or 8 hour rates using a 0.2 V loop drop.

- The switch manufacturer's recommended total List 2 drain for the PDF, with a 1.0 V loop voltage drop shall determine the cable size from the power board to the PDF. The manufacturers' recommended drain shall also determine the fuse or circuit breaker size for the power board. It is Switch Engineering/ Installation’s responsibility to run and size the battery feed and return cables from the main power board.
- The voltage drop, cable sizing, and drain from the switch secondary distribution (PDF) to the switch bay shall be determined by the switch manufacturer.
- Any feeder from a power board to a BDFB/BDCBB should generally be protected based on a load of 225-400 Amperes for quadruple (4) loads or 6-load BDFBs, or 400-600 Amperes for dual (2) loads. Exceptions can be made based on the size of the panels and the loads at the BDFB/BDCBB. The cable sizing for this loop should be computed based on half the protector size used as the drain. However, cable ampacity shall always equal or exceed the protector size. BDFB/BDCBB loads are limited to one half of the protector size on any one side of the feed (A or B, C or D, etc.) so that one side can carry the whole load if the other side fails and there is true redundancy in the equipment. For example, if we were feeding A and B panels on a BDFB/BDCBB with a protector size of 500 Amperes, the voltage drop calculation would be done at 250 Amperes (since any one side should normally not carry more than that). Cable ampacity would still need to equal or exceed 500 Amperes in this example.
- Each distribution fuse panel in a BDFB/BDCBB shall be individually fed. All feeds to a given BDFB/BDCBB shall originate in the same power plant. The conductor(s) shall be, at a minimum, sized for the protection device and be increased in size as required to allow the total voltage drop (calculated at half the protector size) to not exceed 0.5 Volts one way, or 1 Volt loop.
- The maximum allowable loop voltage drop from the BDFB/BDCBB to any facilities (non-switch) equipment shall be 0.5 Volts, based on 125% of the List 1 drain of the equipment that CenturyLink™ expects to place in the bay.
    - Follow the recommendations of the manufacturers of the equipment expected in a bay for the protector sizing for a bay receiving a miscellaneous fuse or breaker panel. Lacking that information, add up the expected List 2 drains of the equipment expected to be fed from that panel. Calculate the voltage drop cable sizing for the miscellaneous fuse panel based on 125% of the List 1 drain for the bay, or 80% (the inverse of the 125% protector sizing rule) of the feeder fuse or breaker size if List 1 is unknown (for true A/B loads, this current is halved to run the voltage drop calculation – see Section 2.4.1 for an example).

– Note that most loads fed from miscellaneous fuse or breaker panels go to equipment that can switch from "A" to "B" if one supply fails. This will double the load on the remaining fuse panel supply fuse; so, the feeds to the panel must each have an ampacity to handle both loads. The voltage drop calculation need only be sized for one load.

– Feeds to miscellaneous fuse panels feeding only DSX bays are exempt from voltage drop standards, and can be fed with wire meeting the minimum ampacity of the feeding fuse. These fuses feed only LEDs (non-service-affecting) and a single feed miscellaneous fuse panel feeding many bays is the general method of providing power. Few LEDs in the lineup will be on at any one time. To qualify for this exemption, the miscellaneous panel must be marked as "DSX Only".

- Equipment fed directly from the power distribution board/bay (e.g., equipment in a smaller site, and/or equipment relatively close to a DC power plant) should have the cable sized based on 125% of the List 1 equipment drain provided by the manufacturer, and with a loop voltage drop of 1.5 V.
- In large sites, there may be remote PBDs. The voltage drops to these remote PBDs can be balanced with the overall allowable voltage drop from the main PBD to a BDFB or piece of equipment (in other words, part of the 1.0 V loop allowed from a main PBD to a BDFB can be "borrowed"), but in no case shall the overall voltage drop exceed the maximum allowed from the main PBD to the equipment. Along the same lines, for individual special cases, the power Engineer can rearrange the voltage drops for which they are responsible (battery to secondary distribution point typically) as long as overall voltage drop within that "loop" remains the same. However, when voltage drops for remote PBDs aren't engineered per Figures 9-4 or 9-5, the Engineer must mark the voltage drops used both in the CenturyLink-authorized CAD system, and ensure that Installation marks it at the remote PBD in the field.

Every equipment bay and/or shelf which includes any Designed Services Circuits (coin, ISDN, 56kb, FXS, FX0, DX , TO etc.), and/or DS-1/T1 (or higher data rate SONET) circuits must be fed independently from both the "A" and "B" power source (primary and/or secondary distribution). Equipment bays and/or shelves, which include only less than 1400 DS-0 and/or POTS circuits (or are carrying only non-regulated best-effort ethernet) are not required to have A and B feeds, although it is always desirable to have dual feeds for network traffic-carrying equipment.

Mounting of more than one wire/cable, terminal end on a single lug (commonly referred to as "double-lugging") is prohibited. A splice or tap should be used instead.

Input power connections to the using equipment should be of a crimped lug type. If plastic connectors are used they shall not protrude from the front or rear of the equipment where they may be inadvertently knocked off or loosen.

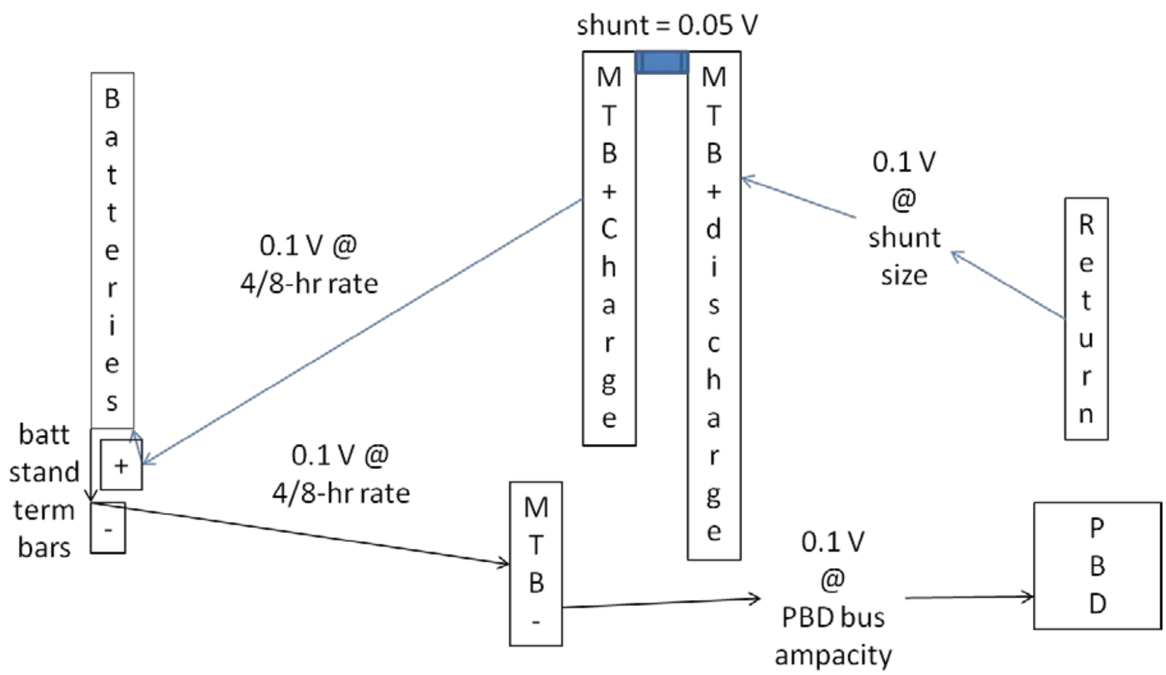



**Figure 9-1:** Batteries to Main Distribution Voltage Drops Via MTBs

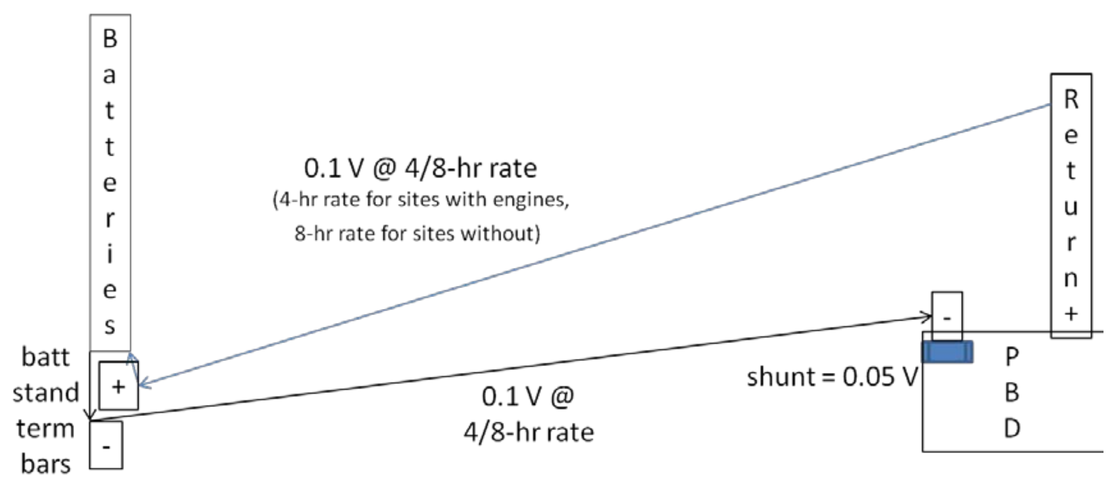



**Figure 9-2:** Batteries to DC Plant Voltage Drops where there is No Central Shunt

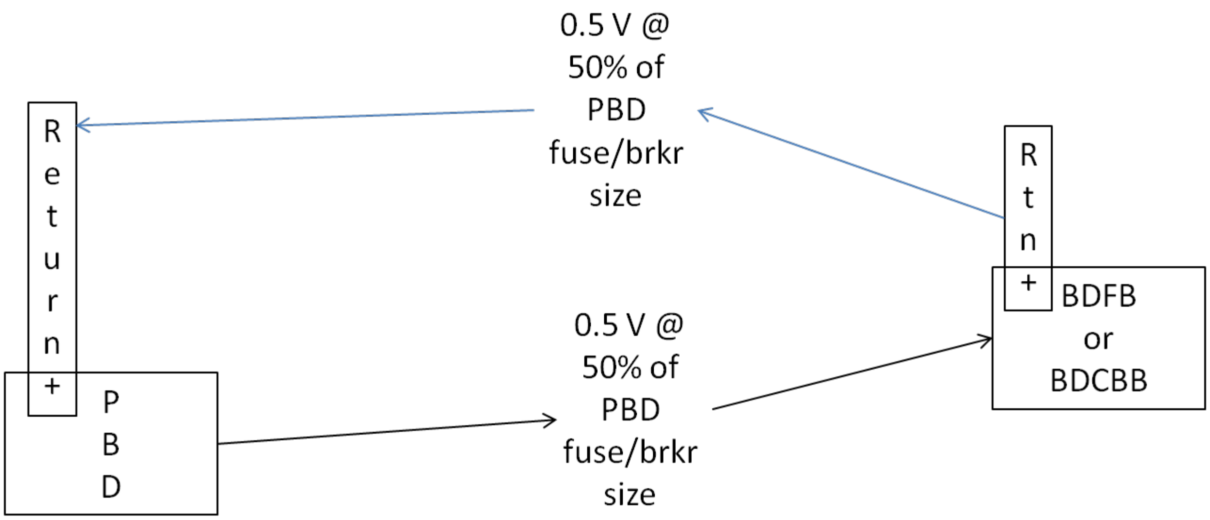



**Figure 9-3:** Power Plant Distribution to BDFB Voltage Drops

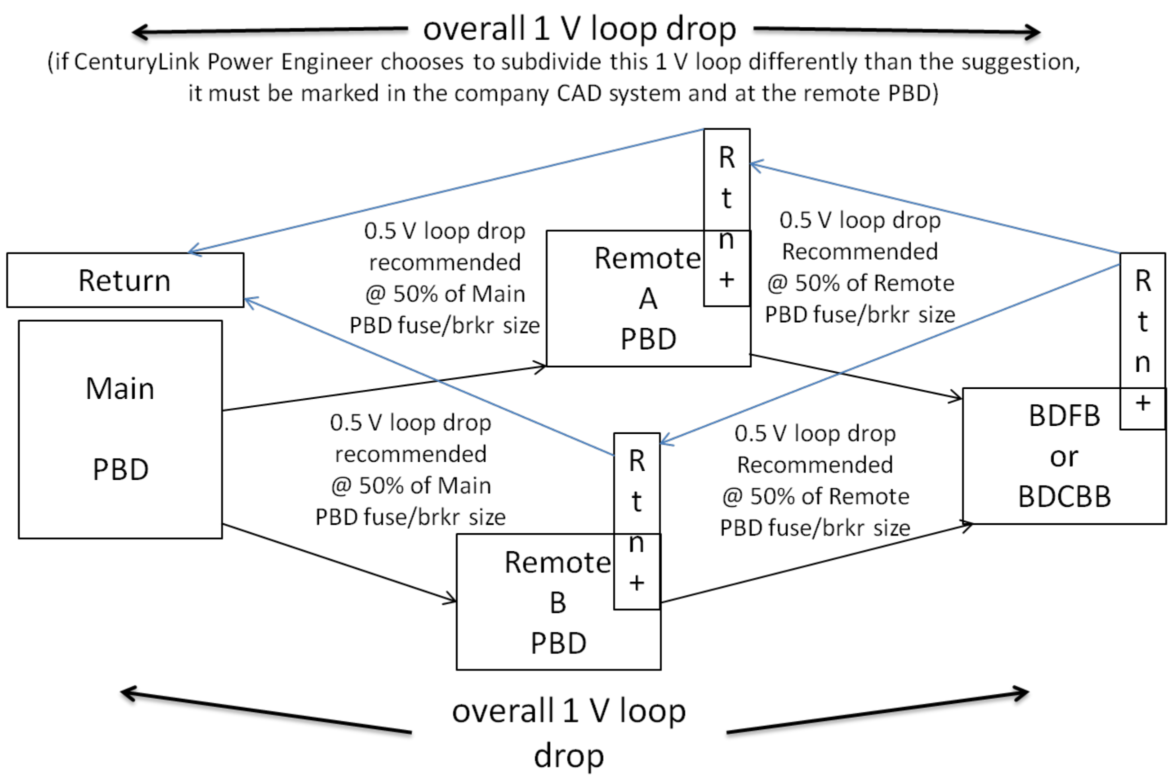



**Figure 9-4:** PBD to BDFB (via Remote A/B PBDs) Voltage Drops

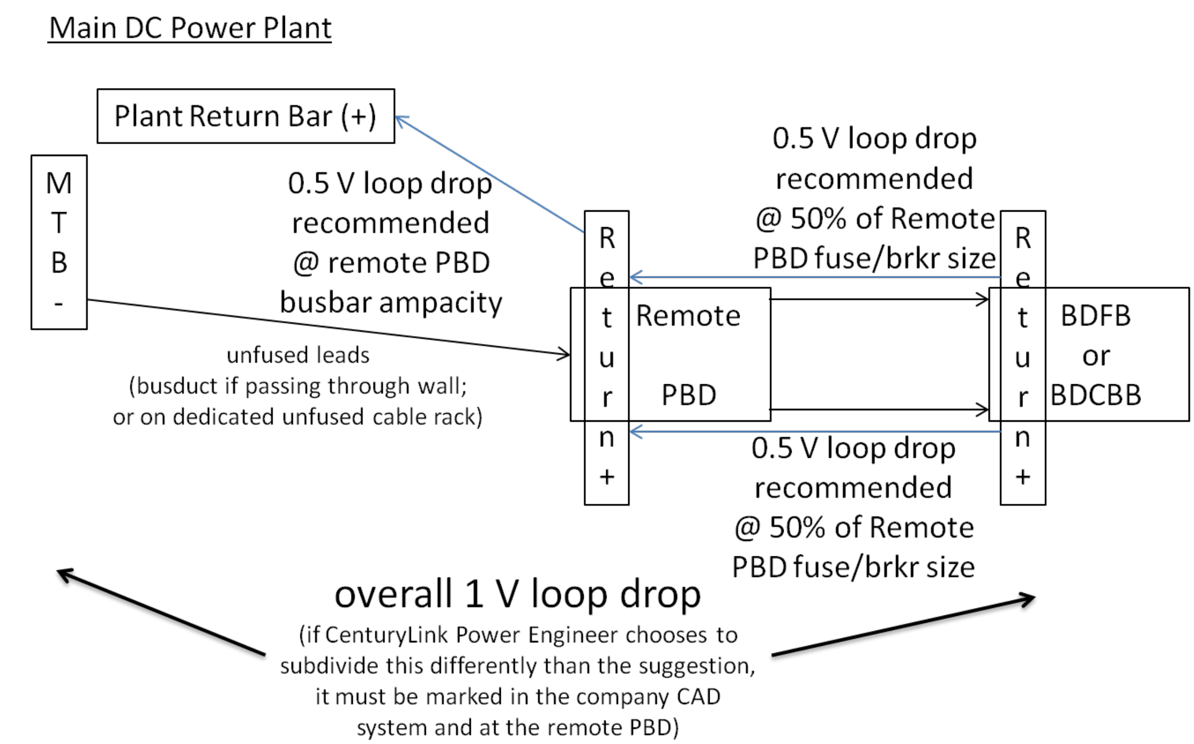



**Figure 9-5:** Power Plant to BDFB (via a Single Remote PBD) Voltage Drops

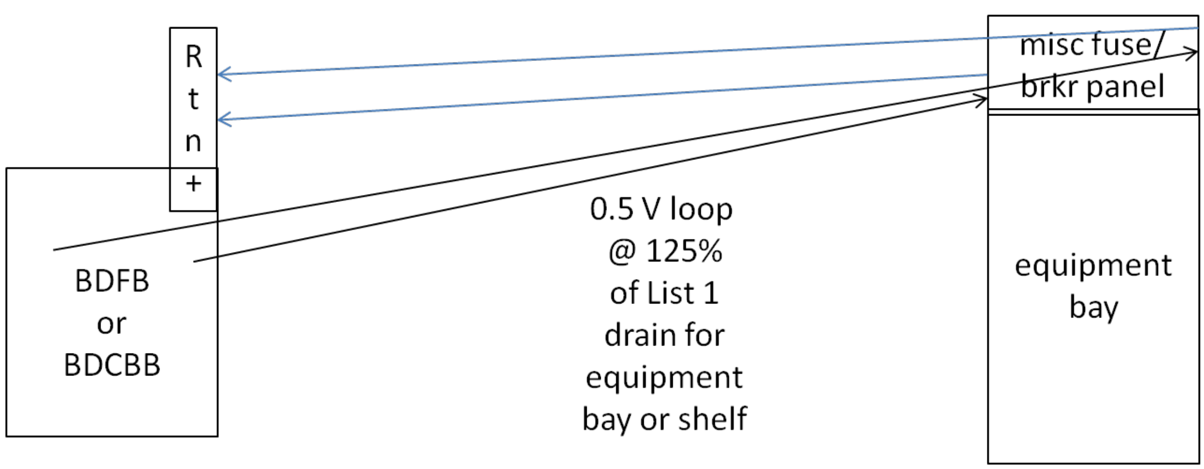



**Figure 9-6:** BDFB to Equipment Bay Voltage Drops

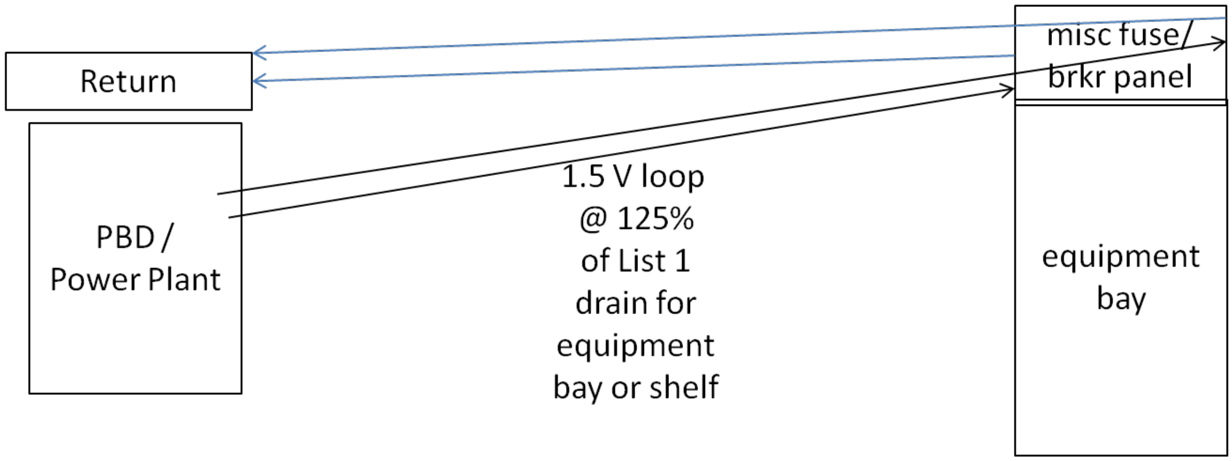



**Figure 9-7:** Power Plant Distribution Direct to Equipment Bay Voltage Drops

All new battery cables (both feed and return) from the battery bus bar to the main battery termination bus bar assembly (BTBA) chandelier (where one exists) will be sized per Figure 9-1. If a battery disconnect is required, size the battery cables using Chapter 3. It is suggested that unfused battery cables running to a battery stand term bar be sized as follows for larger batteries (realizing that the CenturyLink™ Power Engineer can change this size in order to meet the voltage drop and ampacity requirements found previously in this section):

- Flooded Batteries 840 Amp hours to 1700 Amp hours: four 4/0 AWG
- Flooded Batteries over 1701 Amp hours: four 350 kcmil

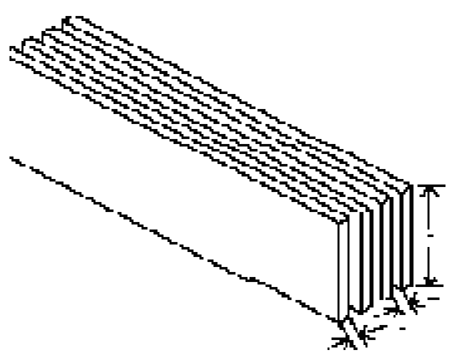


**Figure 9-8:** Bus Bars with Bar Width Vertical and Spaced ≥ Bar Thickness

**Table 9-1** Bus Bar Ampacity for Single Bars

| | | Copper ampacity | | Aluminum ampacity | | | | |
|---|---|---|---|---|---|---|---|---|
| **bar thick -ness** | **bar width** | **bar width vertical** | **bar flat or vertically run** | **bar width vertical** | **bar flat or vertically run** | **circular mils** | **Cu μΩ /ft** | **Al μΩ /ft** |
| 1/8" | ½" | 154 | 152 | 114 | 112 | 79,600 | 140 | 220 |
| | ¾″ | 215 | 212 | 159 | 157 | 119,400 | 90 | 150 |
| | 1″ | 275 | 271 | 203 | 200 | 159,200 | 70 | 110 |
| | 1½" | 390 | 385 | 287 | 283 | 238,700 | 45 | 75 |
| | 2" | 503 | 496 | 370 | 364 | 318,300 | 35 | 55 |
| ¼" | ½″ | 238 | 234 | 177 | 174 | 159,200 | 70 | 110 |
| | 1" | 409 | 403 | 302 | 297 | 318,300 | 35 | 55 |
| | 1½" | 572 | 564 | 421 | 415 | 477,500 | 25 | 35 |
| | 2" | 731 | 721 | 537 | 529 | 636,600 | 18 | 30 |
| | 2½" | 887 | 869 | 651 | 636 | 795,800 | 15 | 26 |
| | 3" | 1,040 | 1,019 | 762 | 746 | 954,900 | 12 | 20 |
| | 3½" | 1,192 | 1,152 | 873 | 841 | 1,114,000 | 10 | 16 |
| | 4" | 1,342 | 1,298 | 982 | 946 | 1,273,000 | 9 | 14 |
| | 6" | 1,931 | 1,820 | 1,408 | 1,320 | 1,910,000 | 6 | 9 |
| | 8" | 2,506 | 2,292 | 1,823 | 1,649 | 2,546,000 | 4 | 7 |
| 3/8" | 1" | 524 | 517 | 387 | 381 | 477,500 | 25 | 35 |
| | 1½" | 724 | 714 | 533 | 525 | 716,200 | 16 | 25 |
| | 2" | 919 | 906 | 675 | 665 | 954,900 | 12 | 20 |
| | 2½" | 1,110 | 1,087 | 814 | 796 | 1,194,000 | 9 | 14 |
| | 3" | 1,298 | 1,272 | 951 | 930 | 1,432,000 | 8 | 12 |
| | 4" | 1,667 | 1,612 | 1,219 | 1,175 | 1,910,000 | 6 | 9 |
| | 6" | 2,388 | 2,250 | 1,740 | 1,629 | 2,865,000 | 4 | 6 |
| | 8" | 3,092 | 2,828 | 2,248 | 2,035 | 3,820,000 | 3 | 5 |
| ½″ | 1″ | 632 | 622 | 466 | 459 | 636,600 | 18 | 30 |
| | 1½″ | 863 | 851 | 636 | 626 | 954,900 | 12 | 20 |
| | 2″ | 1,088 | 1,073 | 800 | 788 | 1,273,000 | 9 | 14 |
| | 3″ | 1,525 | 1,494 | 1,118 | 1,093 | 1,910,000 | 6 | 9 |
| | 4″ | 1,951 | 1,887 | 1,427 | 1,376 | 2,546,000 | 4 | 7 |
| | 6″ | 2,783 | 2,623 | 2,029 | 1,899 | 3,820,000 | 3 | 5 |
| | 8″ | 3,596 | 3,289 | 2,615 | 2,366 | 5,093,000 | 2 | 3.5 |

**Table 9-2** Bus Bar Ampacity for 2-4 Bars per Polarity in Parallel

| # bars | bar thick -ness | bar width | Copper ampacity: bar width vertical and spaced | Copper ampacity: bar(s) flat or laminated or vertically run | Aluminum ampacity: bar width vertical and spaced | Aluminum ampacity: bar(s) flat or laminated or vertically run | circular mils | Cu µΩ /ft | Al µΩ /ft |
|---|---|---|---|---|---|---|---|---|---|
| 2 | ¼" | 2" | 1,301 | 1,259 | 969 | 935 | 1,273,000 | 9 | 14 |
| | | 3" | 1,834 | 1,735 | 1,363 | 1,285 | 1,910,000 | 6 | 9 |
| | | 4" | 2,350 | 2,163 | 1,745 | 1,596 | 2,546,000 | 4 | 7 |
| | | 6" | 3,352 | 2,937 | 2,483 | 2,152 | 3,820,000 | 3 | 5 |
| | | 8" | 4,325 | 3,583 | 3,198 | 2,605 | 5,093,000 | 2 | 3.5 |
| | ½" | 2" | 1,961 | 1,902 | 1,458 | 1,411 | 2,546,000 | 4 | 7 |
| | | 3" | 2,715 | 2,577 | 2,015 | 1,906 | 3,820,000 | 3 | 5 |
| | | 4" | 3,445 | 3,182 | 2,555 | 2,346 | 5,093,000 | 2 | 3.5 |
| | | 6" | 4,861 | 4,275 | 3,597 | 3,131 | 7,639,000 | 1.5 | 2.3 |
| | | 8" | 6,236 | 5,189 | 4,608 | 3,770 | 10,186,000 | 1.1 | 1.7 |
| 3 | ¼" | 2" | 1,865 | 1,787 | 1,397 | 1,336 | 1,910,000 | 6 | 9 |
| | | 3" | 2,616 | 2,432 | 1,957 | 1,813 | 2,865,000 | 4 | 6 |
| | | 4" | 3,342 | 2,996 | 2,498 | 2,226 | 3,820,000 | 3 | 5 |
| | | 6" | 4,745 | 3,992 | 3,543 | 2,947 | 5,730,000 | 2 | 3 |
| | | 8" | 6,105 | 4,770 | 4,552 | 3,493 | 7,639,000 | 1.5 | 2.3 |
| | ½" | 4" | 4,918 | 4,437 | 3,670 | 3,291 | 7,639,000 | 1.5 | 2.3 |
| | | 6" | 6,902 | 5,848 | 5,146 | 4,311 | 11,460,000 | 1 | 1.6 |
| | | 8" | 8,824 | 6,950 | 6,572 | 5,083 | 15,280,000 | 0.7 | 1.2 |
| 4 | ¼" | 2" | 2,426 | 2,313 | 1,823 | 1,735 | 2,546,000 | 4 | 7 |
| | | 3" | 3,394 | 3,123 | 2,549 | 2,337 | 3,820,000 | 3 | 5 |
| | | 4" | 4,328 | 3,819 | 3,249 | 2,850 | 5,093,000 | 2 | 3.5 |
| | | 6" | 6,130 | 5,026 | 4,598 | 3,728 | 7,639,000 | 1.5 | 2.3 |
| | | 8" | 7,872 | 5,916 | 5,899 | 4,354 | 10,186,000 | 1.1 | 1.7 |
| | ½" | 4" | 6,384 | 5,679 | 4,782 | 4,228 | 10,186,000 | 1.1 | 1.7 |
| | | 6" | 8,933 | 7,392 | 6,688 | 5,473 | 15,280,000 | 0.7 | 1.2 |
| | | 8" | 11,395 | 8,659 | 8,527 | 6,362 | 20,372,000 | 0.55 | 0.9 |

**Table 9-3** Bus Bar Ampacity for 5-12 Bars per Polarity in Parallel

| # bars | bar thick -ness | bar width | Copper ampacity bar width vertical and spaced | Copper ampacity bar(s) flat or laminated or vertically run | Aluminum ampacity bar width vertical and spaced | Aluminum ampacity bar(s) flat or laminated or vertically run | circular mils | Cu µΩ /ft | Al µΩ /ft |
|---|---|---|---|---|---|---|---|---|---|
| 5 | ¼" | 4" | 5,312 | 4,637 | 3,999 | 3,471 | 6,365,000 | 1.7 | 3 |
| | | 6" | 7,512 | 6,048 | 5,650 | 4,502 | 9,550,000 | 1.2 | 2 |
| | | 8" | 9,634 | 7,041 | 7,242 | 5,202 | 12,730,000 | 0.9 | 1.4 |
| | ½" | 4" | 7,847 | 6,915 | 5,892 | 5,161 | 12,730,000 | 0.9 | 1.4 |
| | | 6" | 10,960 | 8,921 | 8,227 | 6,626 | 19,100,000 | 0.57 | 0.95 |
| | | 8" | 13,960 | 10,340 | 10,475 | 7,624 | 25,460,000 | 0.4 | 0.7 |
| 6 | ¼" | 4" | 6,295 | 5,452 | 4,748 | 4,090 | 7,639,000 | 1.5 | 2.3 |
| | | 6" | 8,891 | 7,064 | 6,702 | 5,273 | 11,460,000 | 1 | 1.6 |
| | | 8" | 11,395 | 8,154 | 8,585 | 6,043 | 15,280,000 | 0.7 | 1.2 |
| | ½" | 4" | 9,309 | 8,148 | 7,002 | 6,092 | 15,280,000 | 0.7 | 1.2 |
| | | 6" | 12,980 | 10,445 | 9,765 | 7,775 | 22,914,000 | 0.5 | 0.8 |
| | | 8" | 16,520 | 12,005 | 12,425 | 8,876 | 30,560,000 | 0.35 | 0.6 |
| 7 | ¼" | 6" | 10,270 | 8,076 | 7,753 | 6,041 | 13,370,000 | 0.8 | 1.3 |
| | | 8" | 13,150 | 9,259 | 9,926 | 6,878 | 17,822,000 | 0.6 | 1 |
| | ½" | 6" | 15,000 | 11,960 | 11,300 | 8,921 | 26,740,000 | 0.4 | 0.66 |
| | | 8" | 19,080 | 13,660 | 14,345 | 10,120 | 35,644,000 | 0.3 | 0.5 |
| 8 | ¼" | 6" | 11,645 | 9,086 | 8,804 | 6,808 | 15,280,000 | 0.7 | 1.2 |
| | | 8" | 14,905 | 10,360 | 11,265 | 7,711 | 20,372,000 | 0.55 | 0.9 |
| 9 | ¼" | 6" | 13,020 | 10,095 | 9,854 | 7,575 | 17,190,000 | 0.65 | 1 |
| | | 8" | 16,660 | 11,455 | 12,605 | 8,541 | 22,914,000 | 0.5 | 0.8 |
| 10 | ¼" | 6" | 14,400 | 11,100 | 10,905 | 8,338 | 19,100,000 | 0.57 | 0.95 |
| | | 8" | 18,415 | 12,545 | 13,945 | 9,369 | 25,460,000 | 0.4 | 0.7 |
| 11 | ¼" | 6" | 15,775 | 12,105 | 11,955 | 9,102 | 21,010,000 | 0.5 | 0.85 |
| | | 8" | 20,170 | 13,640 | 15,285 | 10,195 | 28,006,000 | 0.4 | 0.6 |
| 12 | ¼" | 6" | 17,150 | 13,110 | 13,005 | 9,866 | 22,914,000 | 0.5 | 0.8 |
| | | 8" | 21,925 | 14,725 | 16,625 | 11,025 | 30,560,000 | 0.35 | 0.6 |

**Table 9-4** Power Wire Ampacities

| Wire Size | circular mils | Copper ampacity | | Aluminum ampacity | | Copper Ω/kft | Aluminum Ω/kft |
|---|---|---|---|---|---|---|---|
| | | 60°C | 75°C | 60°C | 75°C | | |
| 26 AWG | 250 | 0.8 | | | | 46 | |
| 24 AWG | 400 | 1.3 | | | | 29 | |
| 23 AWG | 510 | 1.5 | | | | 23 | |
| 22 AWG | 640 | 2.3 | | | | 18 | |
| 20 AWG | 1,020 | 3 | | | | 12.5 | |
| 19 AWG | 1,280 | 4.2 | | | | 9.2 | |
| 18 AWG | 1,620 | 7 | | | | 7 | 11 |
| 16 AWG | 2,580 | 10 | | | | 4.5 | 7 |
| 14 AWG | 4,110 | 15 | | | | 2.8 | 4.5 |
| 12 AWG | 6,530 | 20 | | 15 | 20 | 1.8 | 2.8 |
| 10 AWG | 10,380 | 30 | | 25 | 30 | 1.1 | 1.8 |
| 8 AWG | 16,510 | 40 | 50 | 30 | 40 | 0.7 | 1.1 |
| 6 AWG | 26,240 | 55 | 65 | 40 | 50 | 0.44 | 0.7 |
| 4 AWG | 41,740 | 70 | 85 | 55 | 65 | 0.28 | 0.44 |
| 2 AWG | 66,360 | 95 | 115 | 75 | 90 | 0.17 | 0.28 |
| 1 AWG | 83,690 | 110 | 130 | 85 | 100 | 0.14 | 0.22 |
| 1/0 AWG | 105,600 | | 150 | | 120 | 0.11 | 0.17 |
| 2/0 AWG | 133,100 | | 175 | | 135 | 0.087 | 0.14 |
| 3/0 AWG | 167,800 | | 200 | | 155 | 0.069 | 0.11 |
| 4/0 AWG | 211,600 | | 230 | | 180 | 0.054 | 0.086 |
| 350 kcmil | 350,000 | | 310 | | 250 | 0.033 | 0.052 |
| 373 kcmil | 373,700 | | | | | 0.031 | |
| 500 kcmil | 500,000 | | 380 | | 310 | 0.023 | 0.037 |
| 535 kcmil | 535,500 | | | | | 0.021 | |
| 750 kcmil | 750,000 | | 475 | | 385 | 0.015 | 0.024 |
| 777 kcmil | 777,700 | | | | | 0.015 | |

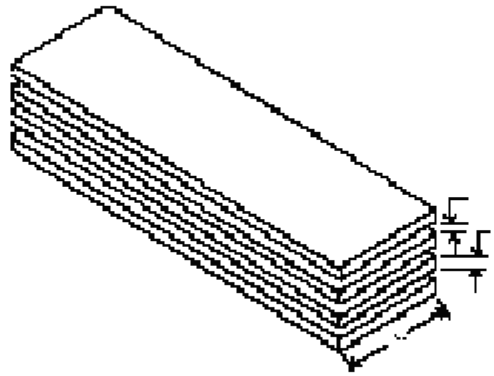


**Figure 9-9:** Bus Bars run Flat

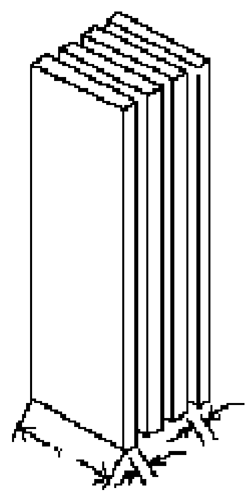


**Figure 9-10:** Vertically Run Bus Bars

## 9.3 Power Plant Distribution Characteristics

Protectors (fuses or circuit breakers) being fed from a converter plant or a ringing plant shall NOT exceed or equal the capacity of the plant. An example would be that a 2-Ampere ringing generator shall not have a fuse larger than 1.33 Amperes to the using equipment.

Distribution fuses and circuit breakers for CenturyLink™ equipment (not applicable to CLECs) shall not be multipled (e.g., daisy-chained) between loads or equipment bays. This means that a single fuse or breaker can't feed two or more separate buses (unless the buses are bonded together by bus work and labeled as a single bus). Ringing distribution is exempted, as defined in Chapter 10. Feeds to DSX bays where the power feeds only LEDs are also exempted.

Circuit breakers may be capable of being alarmed either in the tripped (known as mid-trip or electrical trip alarm), or both the tripped and off positions (the off position is referred to as alarm on mechanical trip, so a breaker capable of alarming in both conditions is sometimes referred to as mechanical and electrical trip, while a breaker that alarms only in the tripped position is sometimes referred to as electrical trip only). Breakers 100 Amps and larger should generally be both electrical and mechanical trip, while smaller breakers may be mid-trip only.

To design a distribution system, the following characteristics of a power plant must be determined:

- Plant voltage limits
- Protection requirements
- Capacity and size of charging equipment
- Ultimate current drain required of the plant
- Physical relationship of the plant components based on floor space configuration
- Grounding requirements

DC/DC converters that are placed for equipment isolation should be physically located in close proximity to the served equipment.

### 9.4 Cabling and Bus Bar

Cables or bus bar carry the current from the rectifiers to the batteries, from the batteries to the discharge panel, from the discharge panel to any converter plant or other distribution, and/or to the loads, and then back to the batteries and rectifiers in the grounded return lead(s). Whether cables or bus bars are used, each type of conductor must be capable of carrying current to or back from its loads without overheating or exceeding the voltage drop requirement.

DC circuits may be run from one RT cabinet to another cabinet within 20 feet (further if protected by DC TVSS). However, DC circuits should not be run from inside one building outside to another building or cabinet unless they are isolated from the building DC plant with an isolating DC-DC converter (the converter is optional for RT applications) and protected with a DC TVSS. For further lightning influence protection, the DC power wire can be run in metallic conduit (which should be done for physical protection reasons anyways for portions of the run that are not buried) that is only end-bonded at one end (if grounding wires are run through metallic conduit, though, it must be end-bonded at both ends). The building or cabinet they are serving should also preferably be under the zone of lightning protection of the building from which the DC circuit is being supplied.

Stranded copper wire used in AC and DC circuits operating at less than 600 Volts rms is primarily insulated with one or more of the following compounds: flame-retardant synthetic or mixed rubber, e.g., styrene butadiene rubber (SBR), ethylene propylene rubber (EPR/EPDM); chlorosulfonated polyethylene (CP); thermoplastic elastomer (TPE); polyvinyl chloride (PVC); non-halogenated materials (e.g., polyethylene-co-vinyl acetate thermosets), or EPDM-CP composite structures. The chief compositional distinctions between insulation materials that lead to functional consequences for power cable products are whether these insulations contain either lead or sulfur. Concerns about lead compounds arise from environmental regulations, pollution impacts, and high costs of landfill disposal. Elimination of lead coatings (such as traditional "tinning") and lead-based stabilizers could result in copper corrosion, reduced electrical performance in humid and moist environments, and/or thermal degradation of insulation materials (although advances are being made in non-lead materials due to RoHS requirements). Sulfur compounds are often used to promote or form cross links within rubber thermoset materials. These cross linked materials are resistant to chemical and mechanical degradation as well as dimensional distortion at high temperatures. However, the sulfur can react with the copper and accelerate corrosion. Given these considerations as well as the cold flow properties of the insulation type, two major areas of distinction are made between power cable products:

- Sulfur-containing insulations and all other insulations
- Cables with a braided cotton covering (treated for flame retardancy) and those without this covering.

Depending on the specific application, one wire or several wires in parallel may be used, and for DC application, they will generally be placed on cable rack (some small circuits may be run in conduit, or attached to the outside of cable rack, or run on cable rack hangers).

The power wire types that are approved for use by CenturyLink™ are THWN, THW, or THHN for AC: and XHHW, RHW-LS, RHH, and TFFN with cotton braid for DC wiring in the racks. For 12 AWG and smaller wiring within a bay, although RHW, RHH or XHHW is preferred, THWN, THHN, and TFFN may be used where protected from abrasion and coldflow at impingement points. TFFN without cotton braid may also be used in conduit or attached to the side of the rack (when attached to the side of the rack, it must be protected from abrasion and coldflow at points of impingement).

Single conductor, whether solid or stranded is usually called wire; whereas cable is generally an assembly of two or more conductors in a common insulating sheath.

Solid wire is sometimes used, especially in the smallest sizes; however, power cable is generally stranded. There are three primary types of stranded wire used. Class B stranding (per ASTM B8) is known as "Standard". Typically flexible power wire used in telecommunications applications is finer/smaller Class I stranding (as defined by ASTM B172). In some cases, even finer stranding is used in flexible wire, such as Class K (per ASTM B174). Class K is sometimes referred to as diesel locomotive (DLO) cable (although DLO can sometimes also be Class I stranding). DLO cable is actually an RHH-RHW type of insulation. Class K is also sometimes referred to as "super-flex" or welding cable. Although not an official designation, welding cable is also sometimes referred to as Class W.

For insulations containing halogen (soft-rubber styles of RHH or RHW), with or without the cotton braid, the conductor must be copper and tinned. All power cables used near flooded lead-acid and Ni-Cd batteries must be tinned to provide extra protection to the strands from the acid (or alkaline) vapors that may be given off by the batteries.

Non-halogenated thermoset cross-linked wire (all XHHW and some types of RHW or RHH) does not require a cotton braid or to be fiber wrapped at lacing points. Nor does it require tinning outside the power room (there are no halogenic or sulfuric compounds to attack the copper). The exception is for class I type wire, which must be tinned (since it is likely to be used in the power room, near the batteries).

DC cotton braid or XHHW wire colors shall be gray, green, black, or red. Green is for grounding, and while the other colors can be used on positive or negative leads, if the colors are different for positive and negative, the gray is preferred for the grounded return side (usually positive) in traditional gray and black power cable offices, while red and black are commonly used in traditional RUS offices.

To distinguish RHW or RHH without a cotton braid that must have fiber wrapping at tie and impingement points from RHW or RHH that does not need it at the tie points, the non-halogenated thermoset cross-linked RHW or RHH without a cotton braid may be marked from the manufacturer. The DC thermoset cross-linked RHW or RHH wire without a cotton braid may be gray marked with a blue or black tracer, black marked with a red or white tracer, and the green wire shall be marked with a yellow tracer.

Except for legacy RUS offices and those Prem locations where power wire is brought to us, red DC wire color is only allowed in in-bay wiring; in CLEC cages, bays, and drops provided by the CLEC; on wiring harnesses; and in circuits where 16 AWG or smaller wiring is used. Even then it is discouraged (in fact, the NEC®, in locations covered by the NEC®, does not allow red wire in DC systems except for those that are grounded on the negative side), and must be labeled at both ends for polarity when the wire belongs to CenturyLink™ (except for the legacy RUS offices where the red and black are very common).

Cables and bus bar must be copper. Cables must meet the requirements of Telcordia® GR-347 and ANSI/ATIS-0600017, or ANSI/ATIS-0600028. Ampacity shall be per Tables 9-1 through 9-4. Cable ampacity shall be at the 75ºC rating for wire sizes of No. 1/0 AWG or larger, and at the 60ºC rating for wire sizes No. 1 AWG and smaller (unless all terminations and wires are Listed for a higher temperature, which is almost always the case in newer equipment). The Ampacity for bus bar is at 70 ºC All wire used in RT cabinets shall be rated for at least 75°C.

The minimum distance between the bus bars and any other object shall be in accordance with CenturyLink™ Pub 77350. This includes hot, return, and grounding bus bars.

Cables from rectifiers to batteries, between battery stands, and from batteries to PBDs will be on a separate cable rack from all other cables when they are not protected by a battery disconnect. These cables are generally referred to as "un-fused" cables.

Cable rack "power cable brackets" mounted to the cable rack at eighteen inch intervals may be used for power cables fused (or breaker-protected) at less than 70 Amps, and equal to or smaller than 4/0 AWG, only when small quantities of cables are required. Adhere to the stacking height limitations for brackets listed in Tech Pub 77350. The use of segregated cable racks for power and switchboard cable is the first choice of installation in larger sites to avoid noise being induced onto the DC cables from the switchboard cables. All power cables larger than 4/0 AWG, regardless of protector size should be run on dedicated fused power cable only cable racks (in NSD, power cables smaller than 6 AWG are not generally allowed on the racks). In small sites (such as huts), where separate power cable rack may not exist, segregation of power cable from switchboard cable on the only cable rack may be used if power cables can't be run on brackets attached to the switchboard rack. The placement of any type of cable used for anything other than power on fused power cable only racks is strictly prohibited.

Dedicated fused power cable only cable racks shall not be equipped with screens, pans, or cable horns. T-intersections and/or 90 degree turns in the racks require corner brackets in order to maintain the minimum bending radius of larger size cables. All cabling on these racks shall be secured per Tech Pub 77350.

Power cables (Battery and Battery Return) on unsecured cable racks shall be closely coupled and paired securely together at 24 inch maximum intervals.

Primary DC distribution is defined as leads from the power plant to the BDFB (feeder conductors) or switch PDF, or directly to equipment bays. Secondary DC distribution is defined as power from the BDFB to the equipment bays (load conductors).

The cable between the Power Distribution Boards/Bays, Batteries, and Rectifiers should generally be of the flexible type. Drops into equipment bays 4/0 or larger should generally be of the flexible type. For entry into Power Boards the tap should be within 15 horizontal cable rack feet.

All wire shall be Listed copper conductors, have an oxygen index (LOI) of 28% minimum, and a UL® 94-V0 rating. (Wire used internal to the Power Plant bays, and the Power Plant manufacturers' recommendation for wires connected to the protection devices shall be exempted from the above rule.)

It is also a requirement in CenturyLink™ that all cable rack located in the Power room or area be engineered and installed according to CenturyLink™ Tech Pub 77351.

Armored power cable shall be no longer than 3 ft in length, except for vertical runs in manufacturer's equipment, and shall never be run on a cable rack with switchboard or other power cable. Insulation coated (liquid tight) armored power cable can be longer than 3 ft and shall be suspended beneath the power cable rack or run on a separate cable rack for power equipment applications only. When insulation coated armored power cable is suspended, it must be supported every two feet. Armored cable outside the power room must be placed in accordance with CenturyLink™ Tech Pub 77351.

Cable temperature shall not exceed 115 degrees F in any horizontal cable rack. In addition, there shall be no instance where an equipment surface temperature exceeds 115 degrees F without a highly visible warning label. Cable temperature in the vertical riser within the bay to the overhead rack may exceed 115 degrees F. However, if the cable temperature in any vertical riser within a bay is going to exceed 125 degrees F, there will be a highly visible warning label.

If the battery return bus is used as the MGB in the ground window, the bar(s) and the interconnecting copper bus must be sized to meet the ultimate Power Plant ampacity. See CenturyLink™ Tech Pub 77355 for separation and sequencing of connections.

The battery return bus should be placed above the Power Boards (or internal to them in small toll load only plants) unless it cannot physically go there (or there are cable access issues). If it can't go there, an attempt should be made to get it as close as possible, and in no case should the distance exceed 30 feet.

The battery feed and return bus bars (in the cases where they are both above the equipment rather than one or both being internal to the equipment bays) shall not be stacked. The hot and return bus bars shall be isolated on the cable rack and spaced a minimum of 1'6" from each other, per Figures 9-11 and 3-2. Exceptions are allowed for the battery return bus bar for a BDFB, for the main charge/discharge bus, battery return bus bar, battery stands (see section 3.9.4), and the ground window bars.

Battery and battery return bus bars must be labeled with the power plant potential (-48V, +130V, -130V, +24V, -24V, etc.) for the hot bus, and as battery return. Labeling shall be per the requirements of CenturyLink™ Technical Publication 77350. The battery return must not be labeled as a grounding bar, except when it is the MGB in the ground window (per CenturyLink™ Technical Publication 77355).

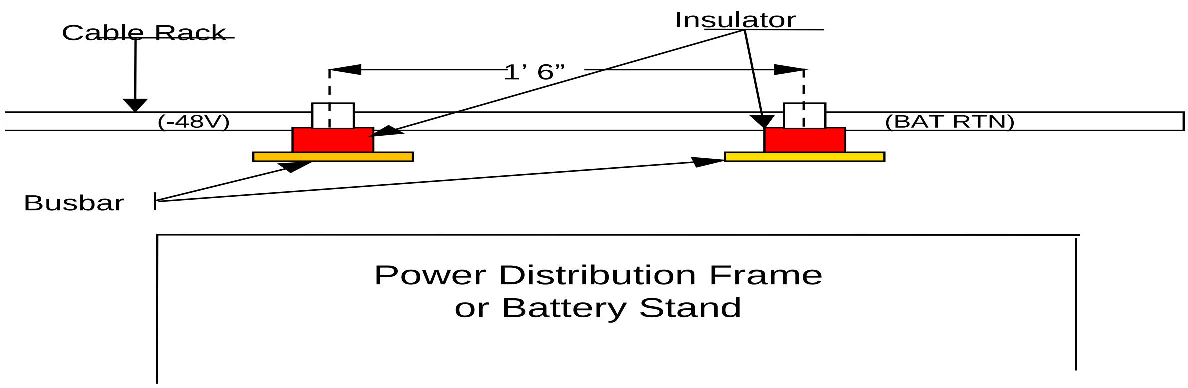



**Figure 9-11:** Typical Mounting of Bus Bar above PDFs and Battery Stands

### 9.5 Protectors and Cable Sizing

Since smaller capacity protectors will operate more quickly in the case of resistive faults, they should be sized as close to 125% of the List 2 drain or the CLEC power feed order (if the CLEC does not provide a List 2 drain) as practical (and generally should not be more than 200% of the ultimate expected List 2 drain [including failover current for A/B circuits] unless there is no standard fuse size between 125 and 200% - due to future long-term potential load growth, CLECs are exempt from the 200% maximum protector size recommendation). Protector selection also establishes the minimum allowable cable size. Cable sizes may be increased above the minimum to meet voltage drop requirements (and usually are for 24 and 48 VDC systems).

The discharge and distribution protectors must be engineered for each application and must have a current rating that will protect their cables. For example, a standard 1/0 AWG cable, which can carry 150 Amperes, should always be protected by a fuse or a circuit breaker no larger than 150 Amps.

The protector size should not be subsequently oversized if larger cables are furnished to meet the voltage drop requirements. Protectors should not be so close in size to peak loads that nuisance protector operation or overheating of the protector occurs.

These protector sizing rules do not apply to fuses or breakers which feed BDFBs from the primary PBDs (main Power Board). For rules on sizing of fuses and breakers that feed BDFBs, see Section 9.2.

Cable sizing for the battery charge cables (from battery bus bars to main chandelier or directly to the plant buses) should be based on the ampacity of the batteries at the four or eight hour rate to 1.86 Volts per lead-acid cell (unless a higher rate battery is used for DSL backup; in which case that higher rate shall be used) or equivalent for other battery types. If the battery stand is a two string stand using only one battery string, it is recommended that cabling be sized as if there are two strings on the battery stand.

It is also recommended that the feeder cable(s) from the PBD to the BDFB be sized to the full ampacity of the largest possible feeder fuse or breaker for that BDFB, (e.g., 600 Amperes) regardless of the present size of the breaker or fuse protecting the circuit.

Cables are sized in the following way. First, determine the appropriate cable path for power cables through the office following existing or new cable rack routes to determine the cable length. This length is determined by TOP TO TOP measurement. Top to Top is from the top of the power bay to the top of the use equipment bay. Then, cable sizes should be selected to meet the requirements discussed herein, including applicable voltage drop and cable ampacity (cable ampacity is based on the List 2 drain). Care should be taken with feeds and protection to devices that have A & B inputs and are switching capable, as in the case of certain fuse distribution panels (FDPs). In these cases, both A & B feeds need to be sized to handle both loads on either feed.

All fuses and circuit breakers must be Listed and rated for the available fault current.

All protection devices (fuses and circuit breakers) must be AC rated for AC circuits and DC rated for DC circuits (some are rated for both, and that is acceptable as long as the voltage to which they are exposed does not exceed their rating for that particular type of electricity). The fuses must be color coded to prevent mixing. AC rated fuses include but are not limited to FRN-R and NON types. DC rated fuses include but are not limited to TPA, TPN, TPL, TPJ, TPS, GMT, and 70 types. GMT and 70-Type fuses are not only commonly used in DC circuits, but may also be used for ringing (since they are rated for both the AC and DC voltages in ringing circuits). TPN type fuses (or another equivalent DC-rated and Listed fuse from another manufacturers that fits the fuse holder) must be used on a going forward basis (new fuses) in existing DC applications that formerly used the FRN and NON (RK1 & RK5 rated) types (although those types have DC ratings, they were not truly designed for DC).

Renewable link and H type fuses are not acceptable for use on a going forward basis.

When a DC fuse requires an accompanying alarm/indicating/pilot fuse, the pilot fuse used should be of the size and type required by the fuse block manufacturer to avoid nuisance blowing of the fuse on under sizing and overheating of the bypass resistor on over sizing.

Circuit breakers shall be of the thermal-magnetic or magnetic type and shall be Listed. They shall be trip-free types. Contacts shall not be able to be held closed during an overcurrent condition, by holding the lever in the closed position.

Circuit breakers must be DC rated for DC circuits and AC rated for AC circuits. They cannot be intermixed and must be clearly marked as either an AC or DC breaker (they may be marked as both, and that is acceptable as long as the voltage to which they are exposed does not exceed their rating for that particular type of electricity).

Switches shall meet all the requirements of the applicable UL® and ANSI Standards. Ferrous materials shall not be used for current carrying parts.

### 9.6 DC System Fuse and Breaker Sources

There are various types of fuse and breaker sources. From the DC power plant, there may be up to three fuse or breaker panels between the plant and the equipment (see below), or the equipment shelves can be fed directly from a PBD or BDFB/BDCBB:

- Primary Sources located at the power plant (PBDs)
- Secondary Sources:
    1. Battery Distribution Circuit Breaker Boards (BDCBB)
    2. Battery Distribution Fuse Board (BDFB)
    3. Power Distribution Frames (PDF) in switches (they have various names)
    4. Coded frame fuse panels associated with specific equipment
    5. Older Fuse Bays (FB)
- Secondary/Tertiary Sources:
    1. Miscellaneous fuse panels at the top of individual bays
    2. Miscellaneous breaker panels at the top of individual bays

Note that there are varying types of fuse and breaker panels now that don't fit quite neatly into either the BDFB, or the miscellaneous fuse panel category. These are sometimes known as "micro"-BDFBs, "mini"-BDFBs, or remote-switchable DC fuse/breaker panels. While traditional BDFBs take up a whole 7' relay rack, and miscellaneous fuse panels take up 1 or 2 rack units (RUs), these non-traditional fuse/breaker panel sources typically take up 3-15 rack units.

What they are called is not nearly as important as their treatment from a voltage drop perspective per section 9.2 rules. Regardless of its name or size, any fuse/breaker panel that only serves its own bay and possibly an adjacent bay (on either or both sides) is treated as a "miscellaneous fuse panel" for voltage drop purposes. This means that voltage drop from this panel to the equipment shelves it serves is negligible enough so that voltage drop calculations are not necessary. The ampacity of the wire size used (see Table 9-4) must still meet or exceed the fuse or breaker size.

However, if the micro-BDFB or other non-traditional fuse/breaker panel installed at the top of one bay serves bays/shelves further away than just the adjacent bay, then it must be treated and labeled (both in the field, and on the site drawings) differently from a voltage drop perspective. When this is the case, the normal 0.5 V loop drop (see Figure 9-6) from the BDFB (or 1.5 V from the PBD – see Figure 9-7) to the fuse/breaker panel in the bay must be split in half, as depicted in Figure 9-12, below:

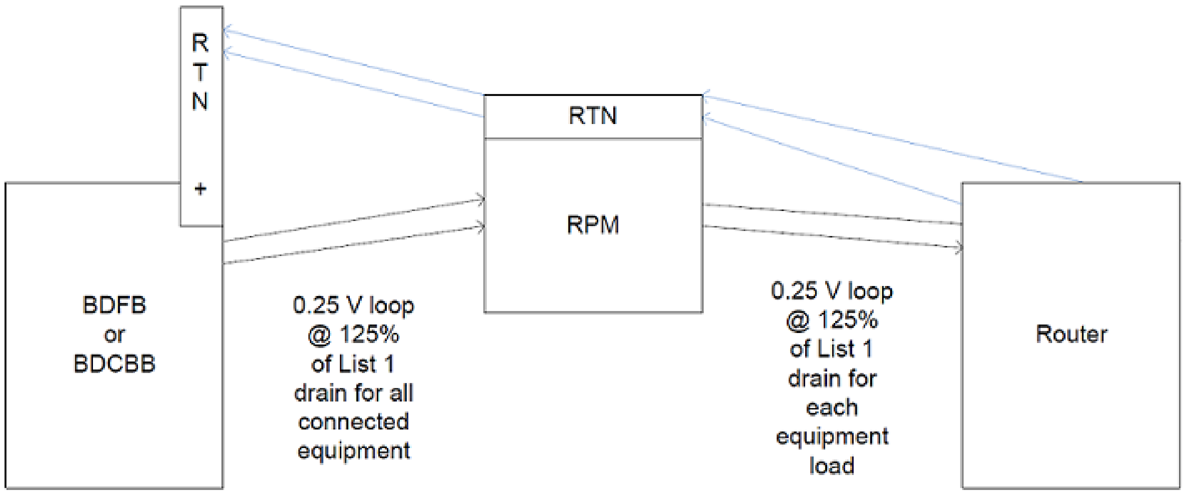



**Figure 9-12:** Splitting the Voltage Drop when a Top-of-Bay Fuse Panel Serves Equipment More Than One Bay Away

Distribution leads leaving the bay almost always leave from the top. Incoming power leads to a bay also generally enter from the top of the bay. The exceptions to this are when the secondary fuse source is mounted on a raised floor, or when CenturyLink™ Real Estate approves the drilling of the floor underneath a primary or secondary fuse source bay, in writing. CenturyLink™ Real Estate is solely responsible for core drilling floors in a Central Office environment. No installation supplier or contractor (unless hired by CenturyLink™ Real Estate) is authorized to perform the core drilling function.

Tag both ends of every power, power return, and ground lead as instructed in CenturyLink™ Technical Publication 77350, "Central Office Telecommunications Equipment Installation, and Removal Guidelines”.

A separate battery return lead will be paired and sewn together or otherwise closely coupled with each distribution or source lead whenever possible.

- This "pairing" requirement does not apply to cabling between the power plant and batteries and/or primary distribution board, or the cable within a few feet of the return bus of a secondary distribution center — e.g. BDFB.
- It is not required for RTs/Prems where DC plant size does not exceed 100 A.

- In cases of a remote ground window where served equipment with shared frame return (this is rare and generally limited to older equipment) is not on the same floor as a remote ground window, the battery feed leads do not have to be paired with the battery return leads all the way to the ground window. For the portion of the run where the battery feed and the battery return leads are not paired, the battery return lead shall be paired back on itself, (this includes going though the same cable hole). The total impedance of the battery feed and the total impedance of the battery return must be equal (i.e., the voltage drop must be divided equally between the battery feed and the battery return — 0.5 V one-way drop for both the feed and return). Refer to CenturyLink™ Pub 77355 for ground window guidelines as required.
- Between the bays and/or battery stands, internal to the power plant, paired battery and return are preferred. However, unpaired leads are allowed internal to the power plant.

The battery return lead will be separate and isolated from the building ground. Specifically, frame ground return for equipment power should not normally be allowed on new equipment. If a supplier chooses to combine the battery return with the building ground, the equipment must be:

- Electrically isolated from the floor and ceiling.
- A minimum of six feet from any other equipment.

Fuse panel vertical bus bar shall be used to interconnect the individual panels. All of the fuses connected to one supply lead must be in one group on each bay, but there may be several groups on one bay which are connected to different supply leads (A and/or B supply). Under no conditions will the "A and B" sources be tied together at a fuse panel. Interbay bus bars are available if the fuses in one group require more than one bay.

Fuse reducers will not be used in "dead front" DC fuse panels or any AC panel. A "dead front" panel is defined as a fuse block with a cover on it. Fuse reducers shall only be used on "open face" fuse panels. "Open face" is defined as fuse panels in which the fuses are on the front and external to the panel face. Double fuse reducing (using more than one pair of reducers) is not permitted.

All fuse and circuit breakers for power boards shall be numbered according to the CenturyLink™ standard configuration for that power plant (see Chapter 2).

The largest output fuse or breaker to be mounted in a stand-alone CenturyLink™-owned BDFB/BDCBB bay shall normally be 100 Amperes (up to 150 Amperes in special cases) in order to minimize cable congestion. Partial-bay BDFB/BDCBBs serving as top-of-bay miscellaneous fuse/breaker panels are exempt from this rule for high-power equipment bays because cable congestion would not be as great due to the limited number of fuse/breaker positions. Some BDFBs do not allow fuses/breakers up to 100 or 150 A, and some require spacing around the fuse or breaker for sizes larger than 60 Amps. Do not exceed the largest fuse size possible for that specific BDFB, and follow manufacturer guidelines for spare positions if necessary. Using larger fuse sizes that require sparing of surrounding positions for heat dissipation should be avoided in fuse panels because it's too difficult to ensure that the "spared" spaces will never be used; however, fuse blocks and circuit breakers that physically take up two or more positions/poles (as long as the poles are ganged together, either internally or externally) can be used.

The largest output distribution cable size to be run within the BDFB/BDCBB shall be a 1/0 AWG (BDFB/BDCBB feeder wires are exempted).

Blank panels on the BDFB/BDCBB shall be used in the following locations:

- Top panel
- Bottom panel
- Between panels, where there is a potential difference of more than 140 V between the panels
- Unequipped positions (a guard may be placed over an unequipped position in a BDCBB, or the entire BDCBB must have a cover or door if there are exposed, unequipped positions)

Fuses shall be assigned starting on the bottom panel of each group and from left to right when facing the front of the assembly. Fuse panels should be equipped from the bottom up in top fed BDFBs.

A BDFB/BDCBB located on one floor shall not be used to supply equipment located on another floor. Feeds from BDFBs to Collocators — Virtual or Physical CLECs — can be exempt from this rule.

For all new full-bay BDFB additions, configurations of battery return bus bar are encouraged to be mounted in the immediate area above the BDFB framework, (see figurers 9-9 and 9-10) in order to reduce cable congestion inside the BDFB/BDCBB. This bus bar will provide termination for calculated battery return feeders from the power plant, and for the returns from the secondary distribution leaving the BDFB.

The battery return will be sized with up to 750 kcmil cable using the same engineering criteria as the power feeders for the BDFB.

The maximum continuous drain on each feeder to a BDFB (or any A/B fuse/breaker panel) shall not normally exceed 40% of the protector (fuse or breaker) size for that BDFB due to the increase in load current while on battery discharge, and shall never exceed 50%. For example, for a BDFB protected at four hundred (400) Amperes (load A or B) the maximum continuous drain for each load (A or B) should not normally exceed 160 Amps, and shall never exceed two hundred Amperes.

Each distribution fuse panel on the BDFB shall be labeled with the voltage and polarity of that panel. Each fuse position 01 through XX on each of the panels shall be labeled both front and back to indicate its' location. Each fuse panel shall be labeled to indicate the panel's position within the BDFB, 1, 2, 3, or A, B, C, etc. Typical arrangements are shown in Figures 9-13 through 9-16.

All fuse positions (in a vertical panel BDFB) smaller than 70 Amps should be installed and assigned from the bottom up to avoid cable congestion and for equipment reliability when an installer is adding future fuses. However, fuse position numbering is from the top down.

For any additional fuse panels added to the BDFB after the initial order, the panel position, voltage, and polarity shall be labeled by the installer.

The installer shall stamp the load designations on the fuse labels and the meter load designation label. Reference loads with alphabetic characters (A, B, C, D, etc.). Panels linked together with a bus bar will have the have the same load designation.

The battery feed and battery return cables shall be labeled on both ends using a designation tag to indicate the other end of the cable, per CenturyLink™ Technical Publication 77350.

The following sign should be placed on the BDFB. The sign should be visible and clear. The size of the sign should be 3 inches by 4 inches.

***All fuse positions should be installed from the bottom up to avoid cable congestion and for the safety of the installer adding future fuses.***

**Figure 9-13:** BDFB Fuse Assignment Label

All BDFBs should be installed and labeled as Figures 9-14 through 9-16 indicate.

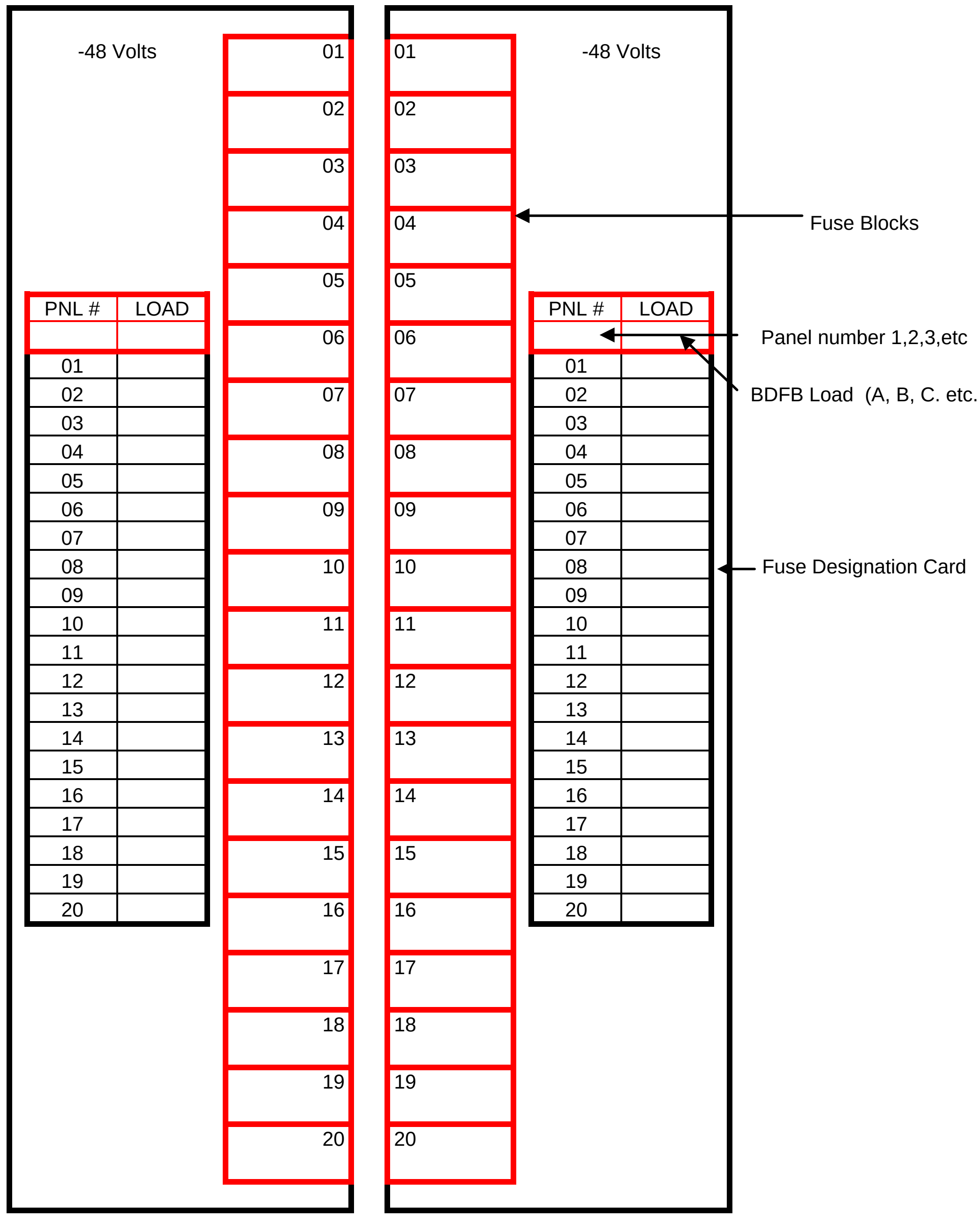



**Figure 9-14:** Typical Layout of BDFB Fuse Panels

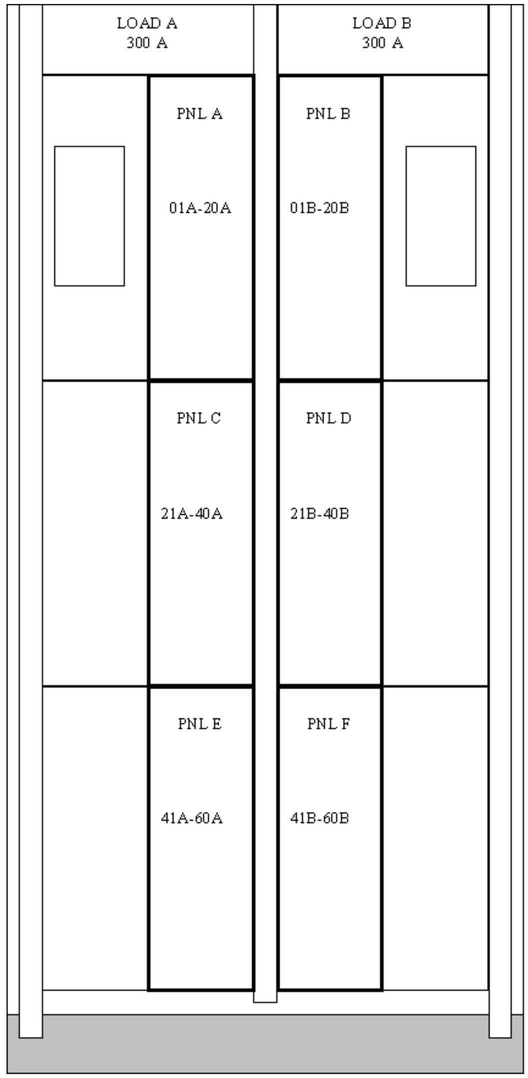



**Figure 9-15:** Typical Layout of 2 Load 600 Ampere BDFB

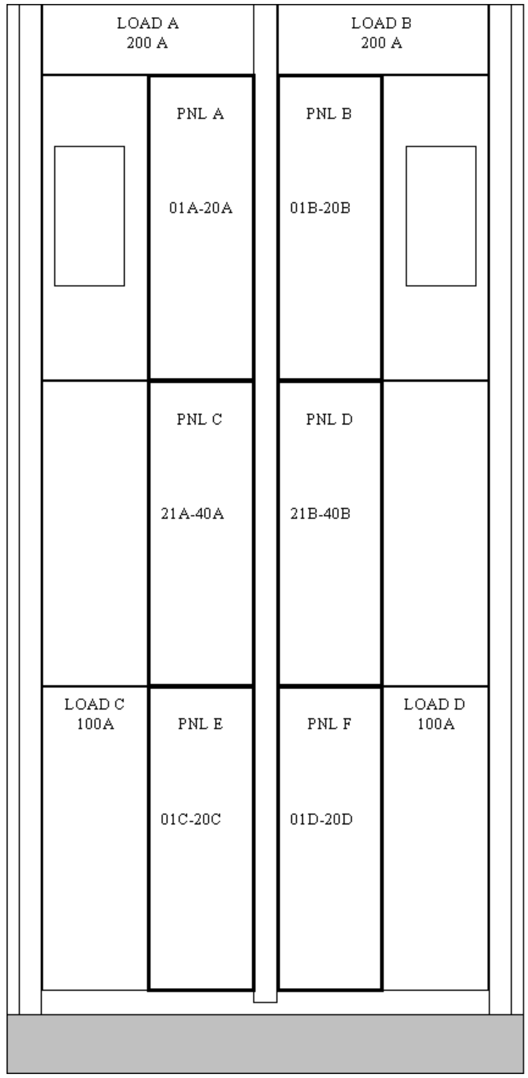



**Figure 9-16:** Typical Layout of 4 Load 400 Ampere BDFB

Battery return bus bars for the 7′-0″ BDFB should be mounted using Figures 9-17 and 9-18 as typical. Nine foot or 11′6″ BDFBs should be mounted per the CenturyLink™ Engineer's instructions, CenturyLink™ standard configurations, and Technical Publication 77351.

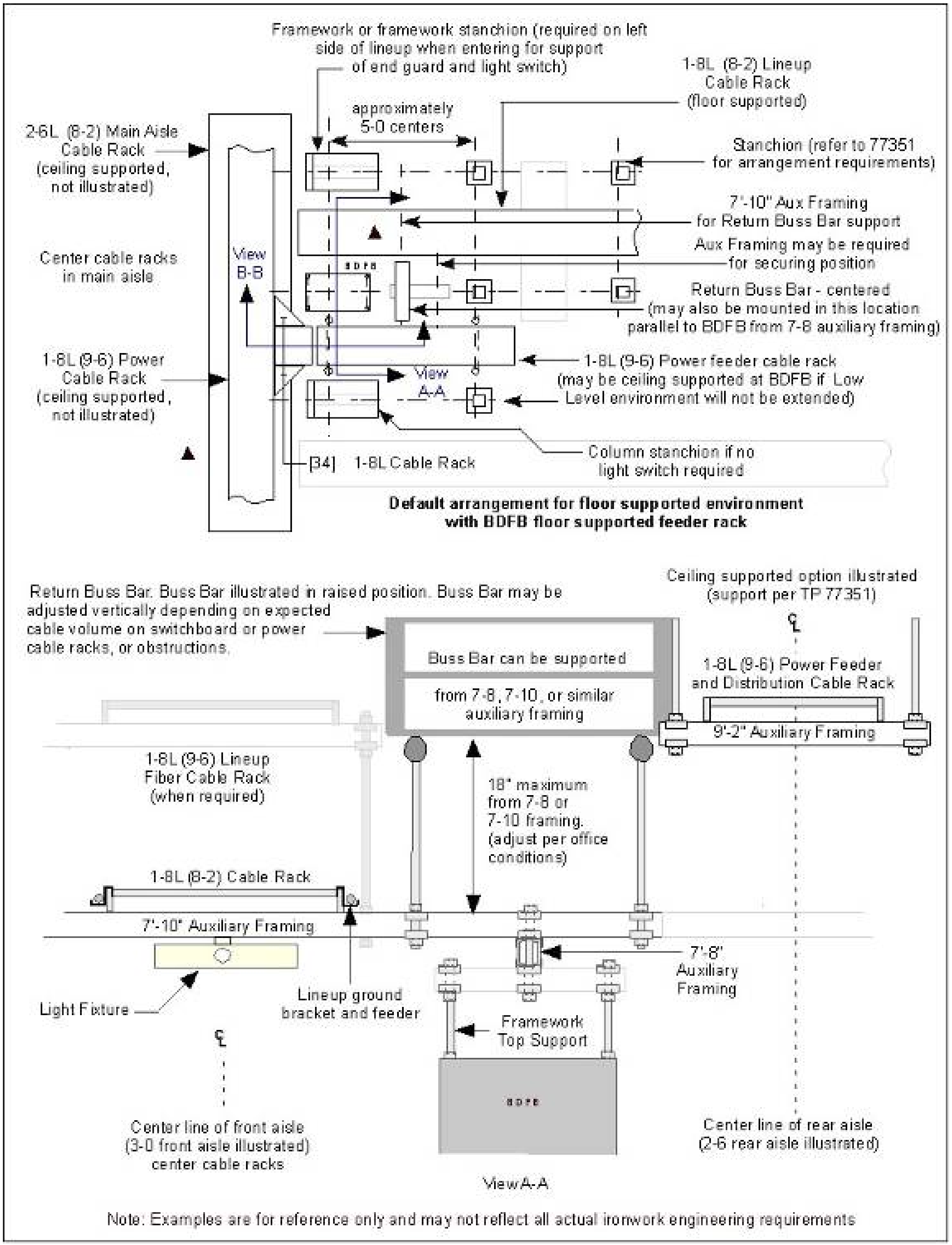
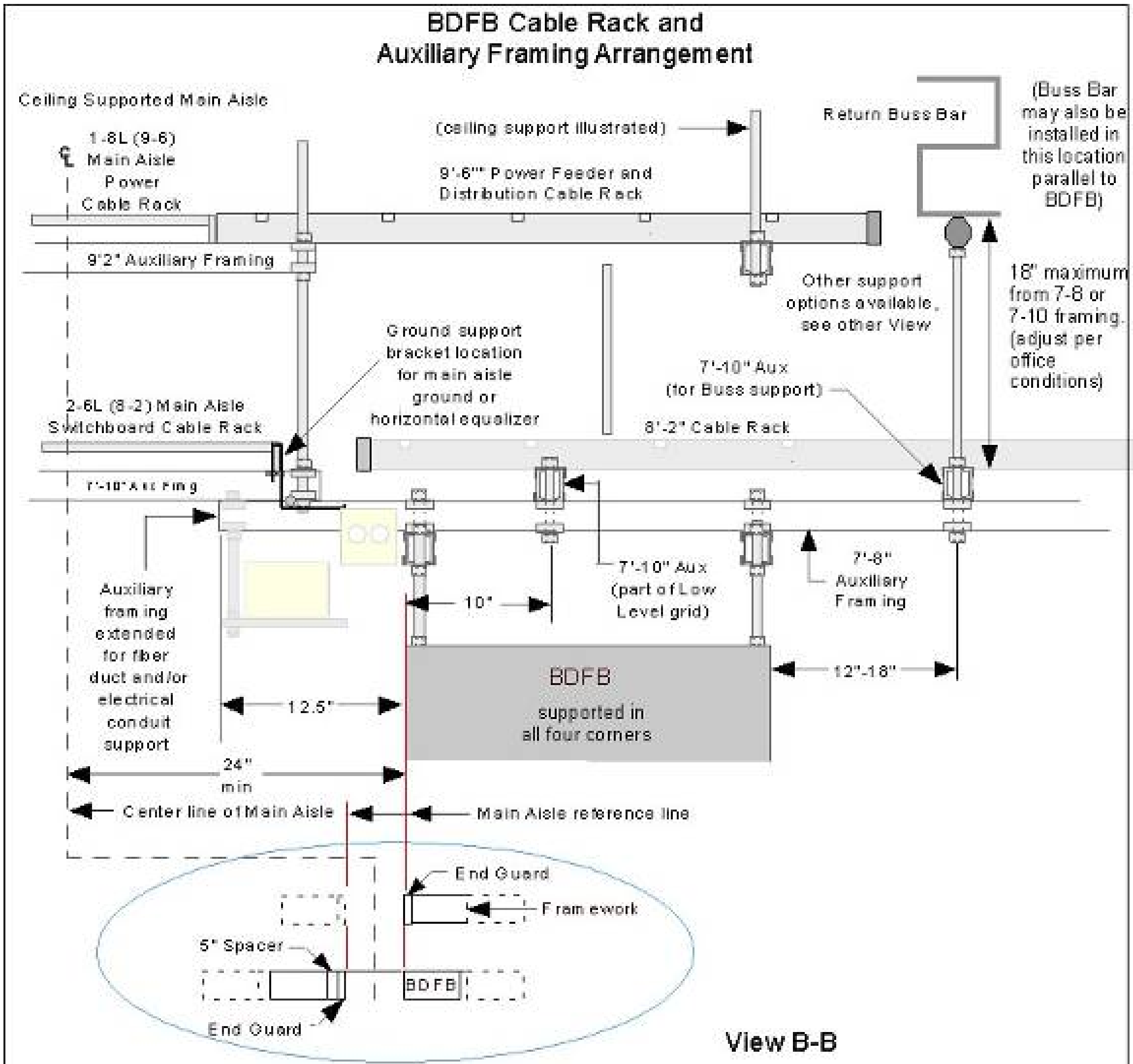



**Figure 9-17:** Typical Return Bus Bar Mounting for a 7′ BDFB (View A-A)




Main aisle cable racks are ceiling supported and centered in the main aisle.

The main aisle fiber duct and conduit arrangements are supported from the 7'-8" floor supported auxiliary framing extended 12.5" into the main aisle area. (measured from the main aisle reference line)

The conduit junction box should be aligned with the main aisle reference line.

The first lighting fixture in an equipment aisle should be located approximately 5" from the main aisle reference line.

Note: Examples are for reference only and may not reflect all actual ironwork engineering requirements

**Figure 9-18:** Typical Return Bus Bar Mounting for a 7′ BDFB (View B-B)

No loads may be added to any BDFB that has been EMBARGOED.

One or more of the following labels shall be on every BDFB:

The Maximum continuous drain on each
feeder to this BDFB is ______ Amperes

The Maximum continuous drain on each
feeder to this BDFB is 200 Amperes

The Maximum continuous drain on each
feeder to this BDFB is 112 Amperes

As of __/__/__ this BDFB has been
**EMBARGOED** for new growth due to load!

**Figure 9-19:** Load and Embargo Labels for BDFBs

Equipment shelves may receive their A and B feeds from separate power sources (e.g., two different BDFBs and/or PBDs) only when the power sources have a normal operating voltage differential of less than 0.3 V as measured at the equipment being fed, and only when the power sources ultimately use the same battery chemistry (e.g. flooded lead acid).

Fuse Bays (FBs) or miscellaneous fuse panels are designed to provide a centralized location for switching or IOF equipment to obtain power of small loads. The FBs are provided with power from a BDFB, Power Board, ringing plant, etc.

Input connections to miscellaneous fuse or breaker panels fed by a fuse or breaker greater than or equal to 50 Amps shall be two-hole lug design.

Older FBs were equipped from the bottom up with filtered supplies being located at the bottom and miscellaneous supplies directly above. Voltages increase toward the top of the bay.

Loads shall not be parallel fused (the same exact load position fed from more than one fuse or breaker). Parallel fusing violates NEC® Article 240.8.

A new BDFB/BDCBB should be added when any of the following occurs:

- The existing BDFB/BDCBB has no remaining fuse positions on the A side, B side, or both
- The actual load on any one side (A or B) or panel of a BDFB/BDCBB exceeds 50% of the protector size feeding it
- The List 1 (average busy-hour, busy-season) drains of the served equipment exceed the capacity of the BDFB. The capacity is based on the rating of the upstream breaker or fuse. As an example, a BDFB panel fed by a 400 Ampere protection device has a nominal load limit of 200 Amperes on any one side (A or B) so that their total load does not exceed the 400 Amperes fuse capacity. Every effort should be made to obtain the List 1 drains from the equipment suppliers in order to determine whether another BDFB is needed.

Any given secondary or tertiary protector in a fuse/breaker panel shall be smaller than its upstream primary/secondary protection device (it may be equal to it if it is faster responding). The engineering supplier is responsible for proper protector sizing and wiring them correctly (this is known as fuse coordination). Feeds to CLECs are exempt from this requirement. When a downstream fuse or breaker is part of a specific equipment shelf, no other fuses or breakers can be fed from the upstream fuse, and the equipment manufacturer allows a smaller upstream fuse or breaker to feed the shelf in their documentation, then that particular shelf may be exempt from fuse coordination.

When a fuse has blown or no fuse is inserted (or a breaker has tripped or is turned off), fuse/breaker positions/holders shall not have residual voltage bled to the outputs from fuse panel alarm circuitry.

## 9.7 Bus Bar Labeling and Layouts

The following bus bars should be installed, labeled and laid out in accordance with requirements herein, CenturyLink™ Tech Pubs 77350, 77351, 77355; and standard configs (note that the positions of the bars is for illustrative example purposes only, and may be different in actual practice depending on the space and needs in the site.

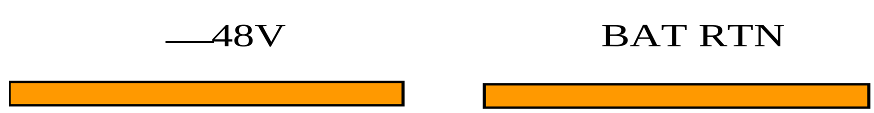



**Figure 9-20:** Example of Bus Bars (Term Bars) above a Battery Stand

Term bars above a battery stand are typically used for stands that will have more than one string. When there are stands with individual strings, they may often be cabled directly to the plant, or to the chandelier.


**Figure 9-21:** A Battery Return Bus Bar above a BDFB

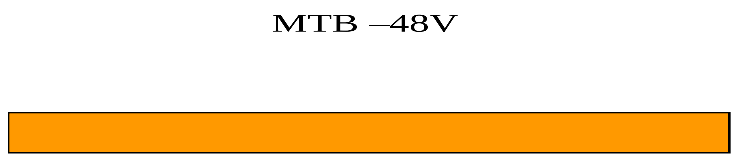



**Figure 9-22:** Chandelier Hot Side Main Terminal (Term) Bar

Depending on the size of the plant, the hot side of the chandelier may be multiple bars. In some cases no chandelier is used, and the batteries (and rectifiers when they are in separate bays) are cabled directly to the plant (PBD) hot buses.

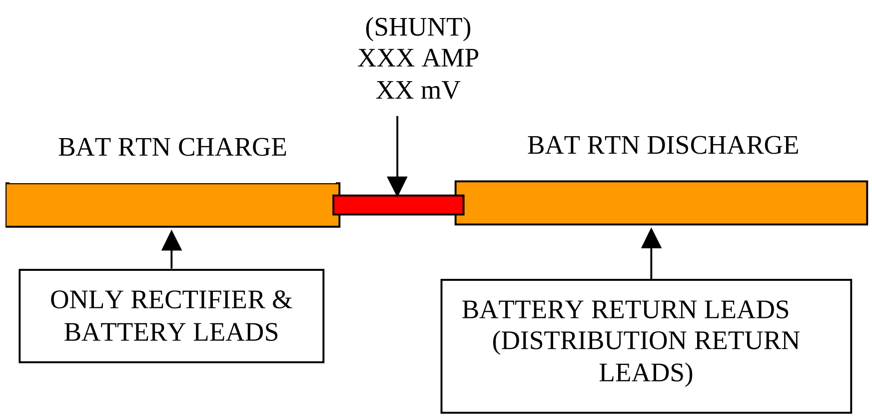



**Figure 9-23:** Chandelier Return Side Bars

There may also be a separate return bar over the PBDs (cabled to the discharge side of the chandelier), while the chandelier is typically located over the battery stands. In smaller plants, the return bar may even be internal.

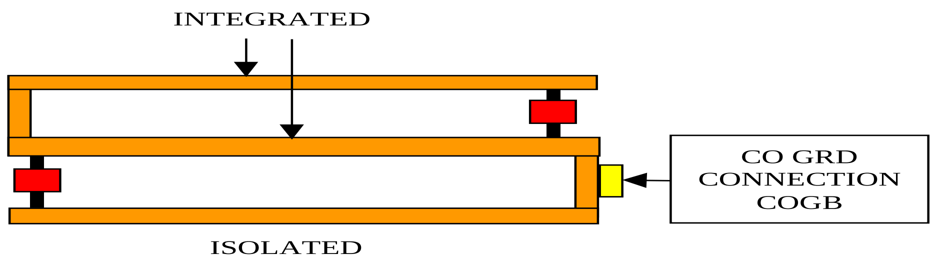



**Figure 9-24:** Example of a Remote Ground Window

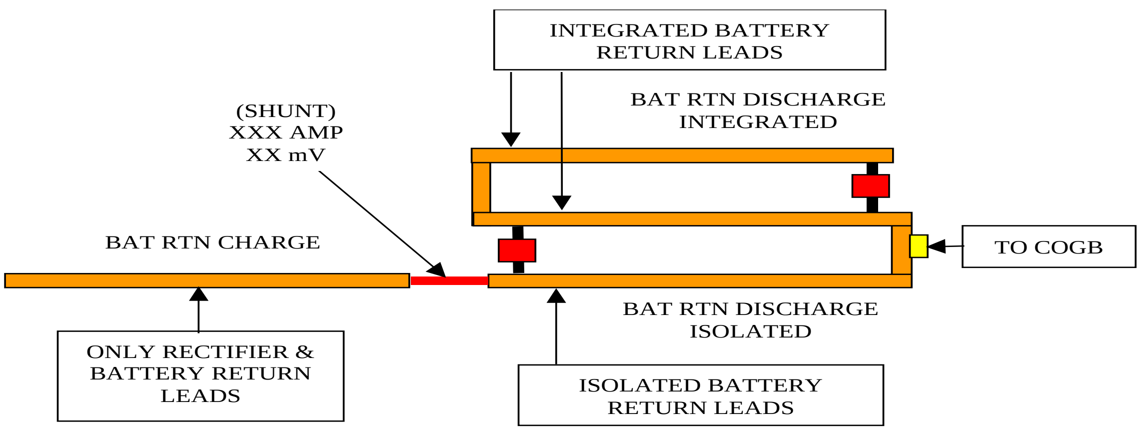
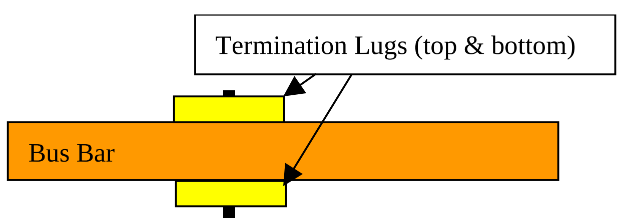



**Figure 9-25:** Example Main Return / Ground Window MGB Bar

The charge/discharge bar is often physically separated (but connected by cabling) from the return bar that is part of the isolated portion of the MGB.




> Note: Sandwiching of the battery loads and returns at the bus bars for the PBD, battery stands, ground window, and BDFBs is acceptable. Whenever possible the loads and returns should be from the same equipment location. However, the placing of two or more termination lugs under one bolt on the same size of the bus bar (also know as stacking) is prohibited without exception.

**Figure 9-26:** Example of Sandwiched Terminations

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# 10. Ring, Tone and Cadence Plants

## 10.1 General

This unit is intended to provide general information regarding:

- Ringing systems currently in use in switching and transmission systems;
- The various call progress tones furnished by ringing plants.
- General information on ring plant sizing.

In modern Class 5 switching, ringing, call procession tones, precision tones - Dual Tone Multi-Frequency (DTMF), dial tone, audible ringing tone, high tone and low tone) are provided by the switch. A separate ring plant must be provided for all non-switched services such as Foreign Exchange (FX), ring down, Interexchange Carrier (IEC or IXC) special ringing requirements, metallic facility, DLC that doesn't provide its own ring, etc. This section describes the requirements for that separate ringing plant. (All power equipment must have completed the CenturyLink™ product selection procedure.)

## 10.2 Ringing and Tone Systems Technical Requirements

Ringing signal in CenturyLink™ is 20 Hz (capable of supplying loads with power factors ranging from 0.8 leading to 0.5 lagging) ±1% (25 or 30 Hz settings are permissible for older circuits that need them). Call progress tones, such as dial and busy tones for the switched subscribers also need to be provided. In most cases, the equipment providing POTS service (switch and/or DLC) provides both the ringing and the necessary tones either on the card, shelf, or bay. In other cases, it might provide the tones but not the ringing current. When either ringing current and/or tones are not provided by a piece of equipment but are necessary, they are supplied by a residual bulk ring plant (if tones aren't needed, the plant doesn't need to be equipped with that capability).

Where practical, the bulk residual ringing supply should be installed in close proximity to the circuits that need it. However, when those circuits are found all over the site, the residual ring plant is often located in the DC power room.

When bulk residual ringing or tone (sometimes provided by interrupters) supplies are provided, they must be provided in a redundant configuration. Transfer to the reserve unit may be accomplished by use of a manual transfer switch and automatically when the online supply fails.

The ringing equipment shall operate within an input voltage range of -44 to -56 VDC (or -21.4 to -28 for nominal -24 VDC sites). The ungrounded supply lead(s) must be properly fused, and must have separate feeders for the regular and reserve units.

The input circuitry to any ringing generator shall consist of an input fuse and an input filter that prevents noise from being fed back from the generators to the batteries.

The ringing equipment shall have built-in protection against undervoltage, overcurrent, and overvoltage on both the input and output.

The ringing generator output voltage level shall be regulated to a constant voltage level (typically between 86 and 88 VAC superimposed on -48 or +48 VDC [AC/DC AUD], or nominal ±105 VAC for longer loops) within ±6%.

The wave shape of the ringing generator output must be low in harmonic content.

The efficiency of a ringing generator shall be high at light loads.

It is permissible to operate ringing generators in parallel, or in a primary-secondary configuration. Generator output power may also be increased by use of a booster.

It is permissible to use the same ringing generator for both battery and ground-connected trip circuits, provided that an isolation transformer is used.

Precise tone generators must have a frequency stability of ±0.5%, THD of 1% or less, and output voltage regulation to ±1.0 dB.

The Receiver Off Hook (ROH) generator shall be designed for fully automatic operation with permanent signal line systems. The 2600, 2450, and 2060 Hz frequencies of the ROH generator shall be stable within ±2% over the input voltage range, and output load range from no load to full load. The 1400 Hz frequency shall be stable within ±0.5% over the same input and output voltage range. Harmonics in the output frequencies of the ROH generator shall be limited to a level of 26 dB down from the level of the fundamental frequencies.

All components of the ringing equipment shall be removable through front access. The ringing equipment shall be modular.

During growth/additions, delivery of power to the using systems shall be maintained.

All ringing equipment shall have a nameplate with a minimum of the supplier’s name, model and serial numbers, and manufacturing date.

Residual ring plants should be sized at a minimum of approximately 15 VA for every 100 circuits served.

Ring plants installed in controlled environments shall meet the temperature range requirements of Telcordia® GR-63. Those designed to be used in RT cabinets must meet the temperature extremes of GR-3108.

### 10.3 Distribution

At least one distribution fuse shall be provided at a minimum. A primary or split fuse panel may also be used. The engineering supplier is responsible for proper fusing and sizing of ringing supply leads.

Protection devices (fuses or circuit breakers) being fed from a ringing plant shall NOT exceed the capacity of the plant by more than 25 percent. An example would be that a 100 VA ring plant shall not have a fuse larger than 1.33 Amperes to protect the using equipment. Load fuses shall be smaller than the plant output fuse.

All distribution from SPCS ringing and tone frames to non-SPCS equipment must be run within three feet of the ground window and have the return lead bonded to the main ground bus. When a separate residual ringing supply is provided, all of these circuits must be moved to the separate supply, and the leads rerouted.

Ringing plant distribution fuses shall not be multipled (e.g., daisy-chained) between equipment bays for new feeds, although daisy chaining of ringing distribution within a bay is permissible.

All new ring plant distribution shall be dead front.

### 10.4 Ringing Plant Alarms and Troubles

Alarms are required for all office ringing supplies. Typical alarms required are major, minor, ring machine transfer, and interrupter transfer (when there are interrupters). Alarm indications, such as major, minor, and transfer should be visual on the plant, with provisions for remote alarming (dry Form C or Form A contacts). All alarm points shall be easily accessible for connection to a PSMC.

During normal operation, if a trouble condition should occur in the regular 20 Hz ringing generator, tone generator, or the interrupter, the load shall transfer to the reserve unit after a 2 second time delay, but before the start of the next ringing cycle (given that a typical ring cycle is 2 seconds on and 4 off, a transfer between 2-4 seconds is required). A trouble lamp(s) shall light to indicate trouble and an alarm signal(s) shall be activated. After the trouble has been cleared, that unit shall transfer back to normal operation by manual transfer only. In addition, all the associated alarm lamps shall be extinguished. If some element in the reserve side of the equipment fails without an earlier failure in the regular unit, a trouble lamp(s) shall light to indicate which output has failed, and an alarm(s) shall be activated.

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# 11. Power Pedestals

## 11.1 General

This unit covers power pedestals for use in the RT environment. The power pedestal is the interface between commercial AC, the standby AC connection (portable genset hookup), and the Outside Plant enclosure (e.g., CEV, RT, etc.). The pedestal is generally separate from the RTs at the site (this is the preference in order to clearly demarcate the responsibilities of the electrical inspector on the AC side), however, with approval of the local electric utility it may be mounted to the side of the RT for right-of-way (ROW) reasons only. The separate power pedestal also gives flexibility for future growth of RTs and pedestals at the site without the need for another meter and power drop.

The power pedestal shall be designed to prevent personnel exposure to safety hazards. The pedestal will be equipped with warning signs and guards, in agreement with UL® requirements. The pedestal shall be Listed.

Due to right-of-way, roads, etc., it is not always possible to place a power pedestal next to the RT(s) it is serving. Although a power pedestal can theoretically be placed up to 1000 feet from the RT(s) it is serving, it is typically not economical to place the RT more than 150 feet from its power pedestal. A new location or an expanded ROW for the RT should be considered if this maximum 150-foot distance is exceeded. The distance rules for the power pedestal from the transformer are the same.

Each pedestal and/or framework shall have a visible nameplate with the following information: suppliers name, serial number, model number, manufacturing date, nominal input voltage(s), number of phases, rated frequency, the output voltage (if equipped with a transformer that makes it different from the input voltage, both must be Listed), the rated full load current, and the available interrupt current rating of the pedestal.

The interrupt current rating of the pedestal and its breakers must exceed the available fault current available from the serving utility company transformer.

The pedestal shall not have any openings sufficient to allow rodents, snakes, or other animals to enter and/or make their home inside the pedestal.

The pedestal shall meet the service requirements of any electric utility in CenturyLink™ territory. In practical terms, this means that different models of pedestals must be provided for different areas.

Pedestals (and all AC services to CenturyLink™ sites) should be equipped with Transient Voltage Surge Suppression (TVSS). The suppression technology can be MOV, SAD, or MOV/SAD hybrid designs. All TVSS units must be UL® 1449 3rd edition Listed, tested to the appropriate ANSI/IEEE C62 series standard, and installed in compliance with Articles 280 and 285 of the NEC® (this also applies to large site TVSS).

## 11.2 Materials

Circuit breakers should have their interrupt current rating specified.

Input breakers for the commercial AC and portable genset must be of the walking beam interlock type transfer system.

Both ring and ringless type meter sockets are used, depending on the requirements of the serving electric utility. In some cases, a particular power pedestal model may come with a meter socket. In those cases where the pre-installed meter socket isn't acceptable to the utility, the contracted electrician may remove it and replace it with one acceptable to the serving utility. In other cases, the power pedestal does not come with a meter socket. In those cases, the electrician must provide one acceptable to the local utility. In rare cases, the choice may be made to use non-metered service (when offered by the local electrical utility). This should generally be avoided (because it is usually not the least expensive option in the long run), and should only be used when the expected maximum load is small and will not grow much over the life of the overall site.

Some utilities require an external (or separately accessible) disconnect other than the meter socket itself.

## 11.3 Technical Requirements

The structural members of the power pedestal shall not carry or conduct load currents under normal operating circumstances.

All metal parts shall be grounded. Metal surfaces shall be bare metal at the points where they bolt together for bonding purposes or connect to the grounding system.

The pedestal shall be capable of being mounted in one or more of the following configurations: on a concrete pad (self-supporting), on a pole, or in a NEMA® 1A type cabinet. In practical terms, these are usually separate models.

Service entrance conductors shall be run only in conduit, and the pedestal shall be capable of overhead or underground entrance. If entrance is through the bottom of the enclosure, the supplier must provide a vented dead air space. No equipment shall be mounted in this area. The space must be a minimum of four and one half inches in depth. The load conductors shall be run only underground, and in conduit.

The enclosure shall be lockable.

The enclosure shall be equipped with either a hinged door opening to a minimum of 160 degrees, or a removable front cover.

The commercial AC feed must not be accessible to the public from the meter back towards the source. While most power pedestals have internal risers for the electric utility feeds to the meter socket, some utilities require these to be in a separate compartment (lockable by them), or external to the power pedestal.

The load center (breaker panel) must have a minimum of six (and preferably at least twelve) positions, pre-equipped with one 15-Ampere breaker to be wired to a GFCI receptacle. The GFCI receptacle will be mounted in the enclosure. Because the power pedestal has a load center, there is generally no reason (and in fact, it is uneconomical to do so, and violates the principle of keeping the AC demarcation in the separate power pedestal) to have a load center in the RT as well, unless required by the local electrical inspector or utility. The RT generally has an AC junction box instead.

Visual alarm and status indications shall be provided by colored, illuminated devices mounted directly on the power pedestal. A dedicated overcurrent device operating from the plant voltage should be provided to power the visual alarms in the subsystem that indicate that the power to the status indication and alarm overcurrent devices have operated, or that power has been removed from the status indication and alarm/control system. The device can be either a fuse or breaker in the ungrounded supply lead.

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# 12. Lighting

## 12.1 Emergency

Emergency lighting (also sometimes called stumble lighting) is required by the NEC® and Life Safety Codes (it must come on within 10 seconds of a power outage and last for 90 minutes) for egress from a building (stairwell lighting, main aisle lighting, exit signs, etc.). (Illumination levels and other detailed information can be found in NFPA® 101 and in NEC® Article 700.) It should be run off a contactor or sensor, or left on all of the time. This egress lighting is most reliable if -48 VDC powered, but the installation of this type of lighting is the ultimate responsibility of the CenturyLink™ Real Estate department.

Battery pack lights are sometimes used for emergency egress lighting, but are not the best choice, especially when their batteries are not maintained. The most reliable choice for emergency lighting is -48 VDC powered fluorescent ballasts. The second-most reliable choice is AC lighting fed by an inverter powered from a -48 VDC plant. A third choice could be "emergency/egress" ballasts with a built-in battery. Wall-mounted, ”frog eye” style lights are the fourth common type of emergency egress lighting system.

DC emergency and stumble light fixtures shall be labeled to preclude use of the wrong bulbs and/or ballasts.

## 12.2 Task

Task lighting is not code required, but is required by CenturyLink™ for the following locations when the main building is larger than 500 square feet:

- Engine Room (task lights are not required for outdoor engine enclosures)
- Transfer System Switchgear
- Indoor Engine Control Panel
- Indoor AC Service Entrance
- Main DC Power Boards (especially above the controller)

This lighting is best if it can be run on a switched circuit with a contactor or sensor that will light it up during an AC outage even if the switch is off. Other options are running off a standard light switch, or on continually.

The following methods can be used to provide this lighting:

Incandescent bulbs shall be -48 VDC types. These older systems cannot usually be maintained due to the fact that the bulbs are no longer made and are very difficult to find. There are both right and left-handed thread -48 VDC incandescent bulbs and fixtures. Also used were positive or negative 130 VDC fixtures and bulbs (standard 120 VAC bulbs can be used in these systems, but system labeling for these and for right-handed thread -48 VDC incandescent systems is critical so that maintenance personnel know whether they are dealing with an AC or DC system). These incandescent systems typically use a contactor that takes a non-essential AC source to hold the contacts open, but allow DC to flow when the AC is off. These systems should be replaced with fluorescent fixtures at the next convenient opportunity.

Fluorescent ballasts for task lighting shall be -48 VDC types (as noted previously, these same ballasts could also be used for emergency/egress lighting). They can be used in existing fixtures with existing bulbs. There are -48VDC input fluorescent ballasts that can be used in an always-on configuration, or in a switched circuit. Note however, that with these ballasts in a switched circuit, they will not automatically re-power the lights in an AC Fail condition if the switch is turned off. In addition, there are -48VDC inverter “ballasts” that do not power the tubes directly, but are instead wired in parallel with an AC input fluorescent ballast. If wired correctly, these can be used in a switched circuit that will automatically power/light the fixture in the event of an AC failure, regardless of whether the switch is "off or on".

DC lighting can be fed from the nearest -48 VDC source (main Power Board, BDFB, or even miscellaneous fuse panels). If feeding from the main Power Board or BDFB, it is permissible to run several fixtures in parallel off a single circuit (similar to AC lighting), following the provisions of the NEC.

Because of the low power drain of DC lighting fixture ballasts (1-2 Amps of -48 VDC current per fixture), and since we use the nearest DC source, and the minimum voltage of the bulbs or ballasts is typically 30 VDC, voltage drop will not normally be an issue.

The following wire and fuse or circuit breaker sizing guidelines might generally apply for -48 VDC lighting circuits.

**Table 12-1** Wire and Protector Sizing for -48 VDC Lighting Circuits

| Number of Fixtures | Minimum Wire size (AWG) | Protection Device Size (Amperes) |
|---|---|---|
| 1 | 14 | 5-15 |
| 2-3 | 14 | 10-15 |
| 4-5 | 14 | 15 |
| 6-7 | 12 | 20 |
| 8-10 | 10 | 30 |

Any circuit feeding more than three fixtures should be fed from a BDFB or main Power Board, not a miscellaneous fuse panel.

Although not required, these DC lighting circuits would generally be run in conduit. This conduit cannot contain any AC circuit wires. The DC wires cannot be white, red, blue, brown, orange, or yellow. This will generally prevent accidental connection at junction boxes to the AC system. A green wire ground shall also be run, in accordance with the NEC, and tied down to the ballast and/or bonded to any metallic fixture case it feeds. Back at the fuse source, the green wire ground can then be tied to the frame. Any conduit must be metallically bonded back to ground too, either with a bond to the green wire at the fixture case, or at the junction box, etc. The size of this ground wire does not need to be any larger than the largest -48 VDC or return conductor run in the conduit.

If the site has a power inverter with spare capacity, regular AC lighting can be provided from it (this is actually preferred because traditional AC ballasts last longer than DC ones). It can be switched or permanently on, or on a contactor, depending on whether it is emergency or task lighting (task lighting is best if switched for energy and longevity purposes). (Each fixture uses 75-100 W/VA of inverter load.) The fixture shall have a label visible from the floor identifying it as inverter fed.

If you have a site that has multiple engines in parallel, task lighting (but not emergency egress or stumble lighting) can be from the essential AC bus fed by these paralleled engines.

Standard low-level equipment lighting arrangements shall be installed per CenturyLink™ Technical Publication 77351 and CenturyLink™ Standard Configuration documents.

For external engine enclosures, task lighting (if provided at all) can be powered off of the engine start battery circuit only if it is on a timer switch so that it does not drain the battery. DC leads should not be run from the building to perform this function or to provide emergency egress lighting for a walk-in enclosure due to the risk of bringing lightning back into the DC plant. Inverter powered lighting is an option for outdoor engine enclosures for egress and/or task lighting, but the circuit must have a TVSS device at the point it enters/leaves the main building.

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# 13. Standard Alarm Messages and Threshold Settings for Power

## 13.1 General

This chapter contains CenturyLink™ standard Power messages in PSMCs, using X.25 or IP packet protocol with TL1 language. Also included are standard names for alarms connected to e-tel devices, whether those alarms use E2A or IP protocol for backhaul. Naming conventions for housekeeping alarms connected to the overhead bits of fiber muxes and other network equipment are also included. Naming standards for power alarms hooked to switch scan points (whether they report to NMA®, or eventually to an SNMP alarm management system) are also given. Finally, naming standards are given for approved MIBs (Management Information Bases) for alarms reporting directly to an SNMP management system. Standard MIB SNMP trap messages for alarms reporting to NMA® for translation to TL1 via a template may be added in the future.

There are several parts to this chapter. Section 13.2 explains the use of the AID and Condition Type fields in PSMCs that report their alarms directly to NMA®. These same AIDS and Condition Types, along with a few other messages, are also programmed in NMA against binary points that are polled or transmit to NMA from an e-telemetry device. Standard switch scan point power alarm mnemonics, along with the corresponding NMA TL1-traslation messages are also given. Section 13.3 defines the TL1 queries that may be performed on X.25 and IP-compatible Power System Monitor/Controllers (PSMCs) to extract useful information from them. In the future, this section may also include useful power-related SNMP GET messages. Section 13.4 defines the threshold settings for binary power alarms derived from analog readings. Section 13.5 provide a few examples of typical standard power messages. Section 13.6 covers some of the standard power messages found in CenturyLink™ SNMP networks.

Power and environmental alarms make their way to NMA® or to an SNMP alarm management system over one of several different transmission media. These media are listed below in order of preference. Alarms should not be sent through more than one of these mediums (except for backup generic majors and minors) due to the confusion multiple alarming causes for the surveillance technicians. Preference is based on the ease of routing and/or analysis allowed by the particular media.

- TL1 on an X.25 or IP circuit from a Power Monitor (PSMC) with backup major, minor and watchdog alarms through an e-telemetry or switch medium (environmental alarms should not generally use a PSMC, except for those specifically related to power, such as a battery room temperature)
- E-telemetry, or similar modern alarm systems that report e-telemetry (binary alarms) via an IP circuit, or via E2A polling
- X.25 overhead bitstream from Remote Terminal (RT) locations (including Customer Premises)

- SNMP Traps directly to an SNMP alarm management network loaded with the appropriate MIB that has been tested to work properly by the appropriate CenturyLink™ lab
- Through the switch scan points

Binary alarms connected to any of the above devices may be connected as closed on alarm (NO), or open on alarm (NC). Either configuration is acceptable for power and environmental alarms.

Most alarms are typically set up as closed on alarm (NO). However, critical alarms should probably be connected to open on alarm (NC). This setup (of alarming on an open condition) is also known as “guarded”. This refers to the fact that if the wiring is inadvertently cut or disconnected, or contacts get dirty, an alarm will be brought in. If alarms are connected in the “guarded” state, it is preferable that the reversal of the point be done on the alarm-monitoring device rather than in the alarm management system (such as NMA®). If the reversal is done in the alarm management system, it can cause problems for both field and center technicians by causing red lights, or bit sets (which normally mean alarmed conditions to these technicians) when there actually is no alarm.

### 13.2 Power Alarm Standard Messages Reporting to NMA®

Power alarms report to NMA® via one of the following methods:

- As an X.25 or IP packet in TL1 language coming from a power monitor; or via the overhead bitstream as an environmental/housekeeping bit connected to a fiber mux, or other Network transport or access element. Portions of the full alarm message are programmed locally (or can be done remotely for many Network elements via their software or via NMA®), usually including at least the SID (the network element System IDentifier, also known as a TID or Target IDentifier when NMA® is sending a message to the network element), the AID (Access Identifier), and the Condition Type. A partially matching template/messaging is built in the NMA® host computer, and portions of the message sent (including the SID and AID) must match the template in NMA.
- As a binary point connected to an e-telemetry device and polled from the NMA host computer via E2A protocol, or sent to the NMA host via IP packet. All of the messaging for these alarms is programmed point-by-point in the NMA host computer by the appropriate CenturyLink™ NMA® Database group in contact with a site technician who identifies exactly what the alarm is. These Power alarms may be either “Equipment” type, or “Miscellaneous” type, depending on which legacy CenturyLink company the site originally was.

- As raw switch messages that originate when an external switch scan point changes binary state. Some of the switch scan points in some switch types are pre-assigned certain messages, while others are user-programmable with text field lengths of varying characters. When the raw switch message reaches NMA®, it is run through a script. If the message matches a value in the power alarm script, a "dynamic unit" and "TL1 condition type" are assigned and forwarded to the proper ticket creation scripts and worklist(s) in NMA®.

The AID provides a "gross" definition of the equipment involved. An "n" associated with an AID indicates more than one entity of that type. The "n" will always be a number.

The second column in the AID table (normally called the sub-AID) on the following pages provides a detailed identification of the hardware involved in the message. Every message will use the first column. However, the second column (or condition type) will not be used for every alarm condition. An "m" associated with the second column indicates more than one entity of that type. The second column may or may not have an associated "m". The "m" may be numeric, alpha, or alphanumeric. For those messages with the "m", it does not have to be there (this is especially true for generic plant alarms, such as a plant rectifier fail alarm).

In e-telemetry devices reporting to NMA®, the unit shelf (for equipment type alarm databasing) or miscellaneous unit (for miscellaneous type alarm databasing) uses the same messaging standards as the AID and sub-AID.

As examples of messages, N48B1RECT4 refers to rectifier 4 in the negative 48-Volt battery plant #1; and N48B1RECT would be the overall AID for the generic plant rectifier alarm.

CONDITION TYPE (CONDTYPE) uniquely defines the condition or trouble to be provided to NMA® from the alarm reporting device, or to be programmed into NMA® for the e-tel devices. The CONDTYPE field is completely independent of the AID field, and for TL1 messages originating in a remote intelligent Network Element (NE), NMA® will take whatever is sent to it by the NE (no matching database for the CONDTYPE needs to exist in the NMA host computer).

NEs reporting TL1 messages are databased in NMA® as equipment or environmental type alarms. Unlike miscellaneous type databasing, an extra field exists, known as the relay rack (RR). For power monitors or fiber muxes, this field is populated with the relay rack location of the monitor or mux when the NMA template programming is done, and that will be the location shown on the NMA alarm ticket regardless of where the actual alarm occurs in the site. For e-tel equipment type databasing, the actual location of the originating alarm can be programmed into the NMA® host on a point-by-point basis.

In order to obtain a full description of the problem associated with a particular NMA® message, the AID and CONDTYPE must be provided. For example, a CONDTYPE of FAIL associated with an AID of N48B1RECT4 would indicate that rectifier 4 in the negative 48-Volt battery plant #1 failed.

N48B1RECT4 FAIL

Alarms are classified as minor (MN), major (MJ), and critical (CR) depending on the criticality of the alarm, and the time allowed before action must be taken. NMA® also has designations of SA (service-affecting) and NSA (non-service-affecting), which don't really apply as well to power alarms as they do to other types of equipment; so by definition, major and critical power alarms are assigned the SA designation, and minor power alarms are assigned the NSA designation.

For power monitors capable of TL1 over X.25 or IP, a generic TL1 template should be generated in NMA® against the monitor at a site (the TID of the monitor). This template generates numerous NMA® AID entities for that TID, as well as the Equipment Type field that appears on the NMA ticket. If the AIDs programmed into the monitor match the AID entities of the template that is generated against the TID no more NMA® programming needs to be done. However, each alarm must still be tested to ensure electrical and database continuity, as it is impossible to make the template large enough to include every possible power alarm. So, if an alarm is tested after the template is generated, and a ticket is not created, a specific entity for that alarm must be created, or the AID in the monitor must be changed to match one of the template AIDs.

Some smaller monitors aren't capable of holding all the characters found in Condition Type Table 13-2. Some fiber muxes, that carry power and environmental alarm messages on their overhead bitstream, can have as few as 10 characters for the TL1 condition type (often referred to in manufacturer or Telcordia® documentation as the ALMTYPE). This TL1 condition type for these messages must totally describe the event with the 10-characters. Most muxes also have a miscellaneous minimum 40-character field that can be seen by browsing the mux or sending a RTRV-ATTR-ENV or RTRV-ALM-ENV TL1 command. The shortened messages shown in Table 13-3 may be used in place of the messages of Table 13-2. If a condition type is not found in Table 13-3, that means the message of Table 13-2 is short enough. In some muxes, the ALMTYPE is limited to the standard Telcordia® set (those where the description is in quotation marks in Table 13-3).

Note that some "alarms" are really more status indications that help in alarm analysis and record-keeping, but don't necessarily require dispatch. Examples might include a transfer switch proper operation, an engine run, etc.

**Table 13-1** AID for Power Alarms (page 1 of 5)

| Eqpt or Misc Type | RR | AID + sub-AID or e-tel Unit/Shelf or Misc Unit | | Description |
|---|---|---|---|---|
| **BATTERY PLANT** (page 1 of 2) | | | | |
| power-plant | | P130Bn | | positive 130 Volt battery plant #n |
| | | N130Bn | | negative 130 Volt battery plant #n |
| | | N48Bn | | negative 48 Volt battery plant #n |
| | | P24Bn | | positive 24 Volt battery plant #n |
| | | N24Bn | | negative 24 Volt battery plant #n |
| | | PSMCn | | power systems monitor/controller |
| | | COM | | internal PSMC message |
| | | | LVD | low voltage disconnect unit or contactor |
| | | | ROOM | ambient power room temperature |
| | | | RPMm | remote monitoring module for a PSMC |
| | | | SHUNTm | shunt or sub-shunt "m", or shunt-monitoring board |
| | | | MPROC | power plant controller fail |
| DC CONTROLLER | ALARM | m | | |
| ENV | N/A | DCMINOR | | DC plant generic minor alarm |
| | | DCMAJOR | | DC plant generic major alarm |
| | | EQUAL | | batteries on equalize |
| | | HIVSHUT | | high voltage shutdown |
| | | HIFLOAT | | high DC plant voltage |
| | | RECTHIFLOAT | | |
| | | HIVOLT | | |
| BATT | VLTG | m | | high DC plant voltage or high/low voltage |
| DCVLTG | | | | high or low DC plant voltage |
| LWBATT | | | | batteries on discharge or low float voltage |
| BATDIS | ALARM | | | |
| ENV | N/A | LOWFLOAT | | |
| | | LOWVOLT | | |
| | | BATDIS | | |
| | | RECTBATDIS | | |
| | | LWVDSCHG | | very low voltage at the DC plant |
| | | RECTVLV | | |

**Table 13-1** AID for Power Alarms (page 2 of 5)

| Eqpt or Misc Type | RR | AID + sub-AID or e-tel Unit/Shelf or Misc Unit | | Description |
|---|---|---|---|---|
| **BATTERY PLANT** (page 2 of 2) | | | | |
| BATTFUSE | ALARM | m | FUSE | battery string fused disconnect open |
| | | P130Bn | | positive 130 Volt battery plant #n |
| | | N130Bn | | negative 130 Volt battery plant #n |
| | | N48Bn | | negative 48 Volt battery plant #n |
| | | P24Bn | | positive 24 Volt battery plant #n |
| | | N24Bn | | negative 24 Volt battery plant #n |
| power-bat | | | BATmLO | a cell in the lower tier of battery string "m" |
| | | | BATLIm | Li-based battery |
| | | | BATm | battery string "m" |
| | | | BATmM | battery midpoint voltage for string "m" |
| | | | BATmPC | pilot cell in string "m" |
| | | | BATmUP | a cell in the upper tier of battery string "m" |
| | | | LVD | battery low voltage disconnect |
| | | | BATCOMP | temperature compensation active |
| | | | BMS | battery management system device |
| power-fuse | | | ABS | fuse feeding alarm relays |
| | | | CNTRLm | control fuse, breaker or relay "m" |
| | | | DISTm | distribution (discharge) fuse/breaker "m" |
| power-rect | | | RECTm | rectifier |
| AC CHARGER | ALARM | m | | |
| ENV | N/A | RECTMJ | | multiple rectifiers |
| | | RECTFL | | |
| | | RECTPHSE | | input phase to a rectifier |
| | | CHARGER | | rectifier "m" |
| | | RECTMN | | |
| POWER BOARD | ALARM | FUSE | | primary power plant distribution fuse blown |
| ENV | N/A | RECTPRI | | |
| | | DISFUSE | | |
| | | CRCTBRK | | tripped breaker |
| | | DCFAIL | | Collocation DC power input failure |
| | | BDFBFUSE | | secondary distribution fuse or breaker |
| BDFB | | | | |
| POWER PANEL | ALARM | m | | secondary or tertiary distribution fuse alarm |
| ENV | N/A | LWVDISCO | | low voltage disconnect |
| | | BATDISC | | battery disconnected |

**Table 13-1** AID for Power Alarms (page 3 of 5)

| Eqpt or Misc Type | RR | AID + sub-AID or e-tel Unit/Shelf or Misc Unit | | Description of AID |
|---|---|---|---|---|
| **COMMERCIAL OR STANDBY AC** | | | | |
| power-ac | | COMACn | | commercial AC service entrance #n |
| | | ACINn | | essential AC measured on load side of xfr switch n |
| | | | CURNTm | input or output AC phase "m" current |
| | | | KWm | power produced by phase "m", or total power |
| | | | PHASEm | AC phase |
| | | | TRNSWm | input AC transfer switch "m" |
| | | | VOLTm | input AC phase "m" voltage |
| AC SURGE | AC | ROOM | | AC surge arrestor |
| environ | N/A | LIGHTN | | |
| | | LIGHTNING | | lightning detector disconnected AC & MGN |
| ENV | | TVSS FAIL | | AC surge arrestor |
| | | COMMFAIL | | commercial AC power failure |
| POWER | AC | FAIL | | |
| **INVERTER PLANT** | | | | |
| power-inverter | | 1PHINVn | | single-phase inverter plant #n |
| | | 3PHINVn | | 3-phase inverter plant #n |
| | | | TRNSW | transfer switch in _-phase inverter #n |
| | | | DIST | distribution fuse/breaker for _-phase inverter #n |
| INVERTER | ALARM | m | | any inverter alarm |
| ENV | N/A | INVERTGN | | inverter general trouble |
| | | INVERTER | | inverter fail |
| | | INVERTEROF | | inverter output fail |
| | | INVERTBR | | inverter breaker tripped |
| | | INVERTLL | | inverter line loss |
| | | INVERTEROBP | | inverter on bypass |
| | | INVERTBP | | inverter bypass not available |
| **UPS** | | | | |
| power-ups | | 1PHUPSn | | single-phase UPS plant #n |
| | | 3PHUPSn | | 3-phase UPS plant #n |
| | | | BATCHGm | battery charger "m" in _-phase UPS #n |
| | | | BATm | battery string "m" in _-phase UPS #n |
| | | | EPO | emergency power off switch/button activated |
| | | | INVm | inverter "m" in _-phase UPS #n |
| | | | TRNSWm | transfer switch "m" in _-phase UPS #n |
| UPS- | ALARM | m | | UPS alarm |
| ENV | N/A | UPSNORM | | UPS operating properly (not a transmitted alarm) |
| | | UPSONGEN | | UPS being fed by engine-alternator(s) |
| | | UPSONBP | | UPS in bypass mode |
| | | UPSBPNA | | UPS bypass not available |
| | | UPSNR | | loss of UPS redundancy |
| | | UPSBATT | | UPS on battery |
| | | UPSLOWBAT | | very low UPS battery voltage |
| | | UPSSHUT | | UPS failure |
| | | UPSSUM | | generic UPS summary/trouble alarm |
| | | UPS | | |

**Table 13-1** AID for Power Alarms (page 4 of 5)

| Eqpt or Misc Type | RR | AID + sub-AID or e-tel Unit/Shelf or Misc Unit | | Description of AID |
|---|---|---|---|---|
| **STANDBY ENGINE-ALTERNATORS** | | | | |
| power-engalt | | ENGALTn | | stand-by engine/alternator #n |
| | | | FUELPRES | fuel pressure |
| | | | BATCHG | start battery charger for standby engine #n |
| | | | BATENGm | start battery string "m" for standby engine #n |
| | | | COOLANT | standby engine coolant |
| | | | CURNTm | input AC phase "m" current |
| | | | DAYFUEL | day tank of standby engine #n |
| | | | FAN | fan for standby engine #n |
| | | | KWm | power produced by phase “m”, or total engine kW |
| | | | MAINFUEL | main fuel tank of standby engine #n |
| | | | OIL | oil level or temperature |
| | | | OILPRESS | oil pressure for standby engine #n |
| | | | PHASEm | AC phase from engine/alternator |
| | | | ROOM | ambient engine room temperature |
| | | | TRNSWm | transfer switch "m" operated |
| | | | VOLTm | engine output AC phase "m" voltage |
| | | | FAIL | optionally used for engine failure |
| GEN XFER RUN | ALARM | m | | engine run and/or transfer switch proper operation |
| EMERGENCY GEN | | | | generic engine major alarm |
| | | RUN | | engine run |
| GEN FAILED | | MJ | | standby engine failed |
| ENV | N/A | GENFAIL | | |
| | | GEN RUN | | engine running |
| | | GENLOAD | | load transferred to engine |
| | | ATSTRAN | | |
| | | ATSEME | | |
| | | GENTR | | engine-alternator trouble |
| | | GENLOWCOOL | | engine fail due to low coolant level |
| | | GENCOOL | | engine coolant heater failure |
| | | GENLOCOTMP | | engine fail due to low coolant temperature |
| | | GENHICOOL | | engine fail due to high coolant temperature |
| | | GENOIL | | engine shutdown due to low oil pressure |
| | | GENOVER | | engine shutdown due to overspeed |
| | | GENREV | | engine-alternator being back-fed (acting as motor) |
| | | GENPHSE | | alternator output phase problem |
| | | GENSGF | | alternator breaker opened due to a ground fault |
| | | GENCRNK | | engine start battery charger fail |
| | | GENBATT | | engine start battery low voltage |
| | | GENFUEL | | main tank low fuel alarm |
| | | GENDTLOW | | day tank low fuel alarm |
| | | TANK | | tank fuel leak alarm |
| | | FUELLEAK | | generic fuel leak alarm |
| | | GENAUTO | | engine controls or transfer switch not in auto |
| | | GENPARA | | engine(s) failed to parallel |
| | | OILLEAK | | engine oil leak detected |

**Table 13-1** AID for Power Alarms (page 5 of 5)

| Eqpt or Misc Type | RR | AID + sub-AID or e-tel Unit/Shelf or Misc Unit | | Description of AID |
|---|---|---|---|---|
| | | **RING PLANTS** | | |
| power-ring plt | | RNGn | | ringing generator (plant) #n |
| | | | FUSEm | ringing generator fuse "m" |
| power-ringer | | | RGENm | ringing generator "m" in ring plant #n |
| power-inter | | | INTERm | ringing interrupter "m" in ring plant #n |
| RINGING GEN | ALARM | m | | ring plant alarm |
| RING GEN INTER | | | | ring plant interrupter alarm |
| RING GEN DIST | | | | ring plant distribution fuse alarm |
| ENV | N/A | RING | | ring plant trouble |
| | | RINGTR | | |
| | | **CONVERTER PLANT** | | |
| power-cnvrter | | P130Cn | | positive 130 Volt converter plant #n |
| | | N130Cn | | negative 130 Volt converter plant #n |
| | | PN130Cn | | positive & negative 130 Volt converter plant #n |
| | | P48Cn | | positive 48 Volt converter plant #n |
| | | N48Cn | | negative 48 Volt converter plant #n |
| | | P24Cn | | positive 24 Volt converter plant #n |
| | | N24Cn | | negative 24 Volt converter plant #n |
| | | | ABS | fuse feeding alarm relays |
| | | | CONVm | converter "m" in plant #n |
| | | | DIST | distribution fuse/breaker for plant #n |
| CONVERTER | ALARM | m | | DC-DC converter plant alarm |
| 130V CONVERTER | | | | 130 V converter fail, or output fuse blown |

**Table 13-2** Power Alarm Condition Types (page 1 of 5)

| CONDTYPE | CR, MJ, or MN | Description of Condition Type |
|---|---|---|
| ALARM_CUTOFF | MN | alarm cutoff — can also indicate by adding " _ACO" to other conditions |
| ATS ON EMERGENCY | MN | load transferred to engine |
| ATS LOAD TRANSFER | | |
| GENERATOR TAKING LOAD | | |
| BATTERY ON DISCHARGE | MJ | battery on discharge |
| DISCHARGE | | |
| BATTERY ON DISCONNECT | MJ | battery disconnected |
| BATTERY ON EQUALIZE | MJ | battery being inadvertently equalize/boost-charged |
| BYPASS | MN/MJ | inverter, or UPS bypass mode |
| CAPACITY_EXCEEDEDm | MN | near/exceeding capacity of plant, rectifier, etc. (m is optional rectifier #, etc.) |
| COML_AC_FAIL | MJ | commercial AC failure |
| COMMERCIAL AC FAIL | | |
| AC_POWER | | |
| POWER_CONV(-MN/MJ) | MN/MJ | DC-DC converter plant issue — 1 converter fail is minor, multiple is major |
| CRANK_FAIL | MJ | engine has cranked too much and cannot start |
| GEN_OVR_CR | | |

**Table 13-2** Power Alarm Condition Types (page 2 of 5)

| CONDTYPE | CR, MJ, or MN | Description of Condition Type |
|---|---|---|
| CRITICAL | CR | a critical power alm. (e.g., very low voltage, temperature differential) |
| CTLLR_OK | — | internal message (used with a watchdog) |
| DC POWER FAIL | MJ | collocation DC power failure |
| DIFFERENTIAL_TEMP | MJ/CR | high/low differential temperature between batteries & ambient — criticality depends on threshold (see section of this document dealing with that issue) |
| DISCONNECT | MJ/MN/CR | any disconnect operated (minor if there is redundancy) |
| ELAPSED | MN | an alarm has timed out (elapsed) |
| EMERGENCY_STOP | MJ | standby engine emergency stop, or any other emergency stop |
| EMG_STOP_BUTTON | MJ | emergency stop button has been operated |
| FAILm | MN/MJ | any equipment or plant failure — minor for individual rectifiers, ringers, or converters, major for multiples of these (m can be rectifier #, etc.) |
| PWR_ALM | | |
| FAIL_PARALLEL | MJ | engine-alternators failed to parallel / synchronize |
| GENERATOR FAIL TO PARALLEL | | |
| FAN | MJ | rectifier, engine, or UPS fan fail alarm |
| FUEL_LEAK | MJ | any fuel tank leak |
| GEN_TANK | | |
| TANK | | |
| FUEL_SYS_TRBL | MJ | alarm from fuel system monitor. |
| BLOWN DISCHARGE FUSE | MJ | primary distribution fuse blown |
| TRIPPED BREAKER | | tripped DC distribution breaker |
| FUSE/BRKR_OPERATE | MJ/MN | any fuse or breaker operation |
| FUSE | | |
| PRIMARY FUSE BREAKER TRIP | MJ | |
| PWR_BOARD | | |
| GEN_BREAK | MJ | engine-alternator output breaker tripped |
| GEN_DAMPER | MJ | engine room/enclosure airflow damper failed |
| GEN_EXH_TE | MJ | engine exhaust temperature too high |
| GEN_FLCLOG | MJ | engine fuel line/filter clogged |
| GEN_FREQ | MJ | engine-alternator output frequency is abnormal |
| GEN_HITEMP_PRE | MN | pre-warning that engine may overheat and shut down |
| GEN_LOTEMP | MN | engine is cold (may not start), possibly because coolant heater has failed |
| GEN_LO_VLT | MJ | low engine-alternator output voltage |
| GEN_OIL_LO | MJ | low engine oil pressure / level causing an engine shutdown |
| GEN_OIL_LO_PRE | MN | pre-warning of low engine oil pressure or level |
| GEN_OILTMP | MN | high engine oil temperature |
| GEN_TRBL-MJ | MJ | generic engine major alarm |
| GEN_VLT_FQ | MJ | abnormal engine-alternator output voltage or frequency |
| GENERATOR CRANK BATTERY CHARGER FAIL | MJ | engine start battery charger fail |
| GENERATOR DAY TANK LOW FUEL | MJ | low fuel alarm from the day tank |
| GENERATOR HEATER FAIL | MJ | engine heater failure |
| GENERATOR HIGH COOLANT TEMPERATURE SHUTDOWN | MJ | engine shutdown due to high temperature |
| GEN_HITEMP | MJ | |
| GENERATOR LOW BATTERY VOLTAGE | MJ | engine start battery low voltage |

**Table 13-2** Power Alarm Condition Types (page 3 of 5)

| CONDTYPE | CR, MJ, or MN | Description of Condition Type |
|---|---|---|
| GENERATOR LOW COOLANT LEVEL SHUTDOWN | MJ | engine shutdown due to low coolant level |
| GENERATOR LOW COOLANT TEMPERATURE | MN | warning that engine coolant temperature is low, so it may have trouble starting |
| GENERATOR LOW OIL PRESSURE SHUTDOWN | MJ | engine shutdown due to low oil pressure |
| GENERATOR MAIN TANK LOW FUEL | MN/MJ | low fuel in the main tank |
| GENERATOR NOT IN AUTO | MN | engine controls or transfer switch not in the “auto” position |
| GENERATOR PHASE | MJ | engine-alternator output phase problem |
| GENERATOR TANK RUPTURE BASIN | MJ | fuel leak into a containment basin or the the interstitial space |
| GENERATOR TROUBLE | MJ | generic engine trouble alarm |
| GROUND_FAULT | MJ | ground fault detected and AC possibly disconnected at engine or HSP |
| GENERATOR SYSTEM GROUND FAULT | | engine alternator breaker opened due to a ground fault condition |
| HI_BAT_VLTG<br>HI_VLT<br>HIGH VOLTAGE ALARM<br>HIGH FLOAT VOLTAGE<br>RECTIFIER HIGH FLOAT VOLTAGE | MJ | high DC plant voltage |
| HIGH | MN/MJ | any high fluid level or pressure |
| HIGH_FLOAT_AMPS | MN | float current is higher than it should be; indicating batteries near end-of-life |
| HIGH_FREQUENCY | MJ | UPS or standby engine high frequency |
| HIGH_TEMPERATURE | MN/MJ/CR | any high temperature (environment or equipment) |
| HIGH_VOLTAGE | MJ | any high voltage, AC or DC |
| HIGH_VOLTAGE_HVSD<br>HIGH VOLTAGE SHUTDOWN | CR | the rectifier(s) have shut down on high voltage |
| IMBALANCE | MN | current is imbalanced between phases, battery strings, or rectifiers |
| INPUT_FAIL | MN/MJ | any AC or DC input fail |
| INTER_FAIL(-MN/MJ) | MN/MJ | ring plant interruptor fail – minor for 1, and major for both |
| INVERTER BYPASS NOT AVAILABLE<br>INV_BP_NOT_AVAIL | MJ | inverter bypass unavailable |
| INVERTER ON BYPASS | MN/MJ | inverter on bypass (major if auto-switching not possible) |
| INVTR_XFR | MN | inverter transferred to alternate source |
| INVERTER FAIL<br>INVTR_FAIL(-MN/MJ)<br>INVERTER OUTPUT FAIL<br>INVTR_FAIL_OUTPUT | MN/MJ | inverter failure (minor if N+1 redundant) or generic inverter major or minor |
| INVERTER GENERAL TROUBLE | MJ | generic inverter alarm |
| INVERTER LINE LOSS | MJ | inverter AC input fail |
| INVERTER TRIPPED BREAKER | MJ | tripped inverter breaker |
| LIGHTNING | MJ | lightning detector has disconnected AC power and MGN |
| LOCKOUT | MJ | input or output locked out (turned off or failed) |
| LOW_FUEL | MJ | Low fuel level in tank |

**Table 13-2** Power Alarm Condition Types (page 4 of 5)

| CONDTYPE | CR, MJ, or MN | Description of Condition Type |
|---|---|---|
| LO_BAT_VLTG<br>LO_BAT_VLT<br>LOW VOLTAGE ALARM<br>LOW FLOAT VOLTAGE<br>LO_VLT | MJ | battery on discharge or low float voltage |
| LO_VOLT_DISCONNECT<br>LOW VOLTAGE DISCONNECT | CR | plant, battery, or load disconnect due to low voltage |
| LOW | MN/MJ | any low fluid level or pressure |
| LOW_TEMPERATURE | MN/MJ | any low temperature, including engine block heater fail |
| LOW_VOLTAGE | MJ/CR | low voltage (AC/DC, includes battery discharge) – may be critical for UPS |
| MAJOR<br>DC MAJOR | MJ | any generic major alarm from the power plant |
| MAJOR_CRITICAL | MJ | any power major or critical — used when not enough points |
| MICROPROC_FAIL | MJ | the microprocessor in the PSMC or power plant has failed |
| MINOR<br>DC MINOR | MN | any generic minor alarm from the power plant |
| MULTIPLE_ALARMS | MJ | used when PSMC has to upgrade an alarm from minor to major |
| NORMAL | MN | any normal position (e.g., transfer switch) |
| OFF_(NORMAL) | MN | equipment normally off |
| OFF_NORMAL | MN/MJ | equipment not in a "normal" functioning condition |
| OIL LEAK | MJ | engine oil leak detected |
| OPERATE | MN/MJ | a switch or other device has operated — criticality depends on the alarm. If this is simply a status alarm, it is a minor. It is a major for all other cases |
| OUTPUT | MJ | output failure |
| OVERCURRENT | MJ | excessive current on distribution, rectifiers, etc. |
| OVERRIDE | MN | the override of any function |
| OVERSPEED<br>GEN_OVR_SP<br>GENERATOR OVERSPEED | MJ | engine overspeed (shutdown) |
| PROPER_OPERATION | MN | proper operation for any equipment |
| RECHARGE | MN | indicates batteries are recharging |
| RECTIFIER | MJ | UPS battery charger failure |
| RECTIFIER LOSS OF PHASE | MN | loss of an AC input phase to a rectifier |
| RECTIFIER MINOR<br>CHARGER FAIL | MN | single rectifier failure |
| RECTIFIER MAJOR<br>RECTIFIER FAIL | MJ | multiple rectifier failures |
| RECTIFIER | MN/MJ | rectifier failure (minor if one, major if more than one) |
| RELAY_OPERATE | MN | any relay has operated |
| RESTART | MN | equipment has restarted |
| RESET | MN | any reset condition |
| RESTORE | MN | any restored condition |

**Table 13-2** Power Alarm Condition Types (page 5 of 5)

| CONDTYPE | CR, MJ, or MN | Description of Condition Type |
|---|---|---|
| REVERSE_POWER<br>GENERATOR REVERSE POWER FAIL | MJ | alternator output power is reversed (now acting as a motor) |
| RING_FAIL(-MN/MJ) | MN/MJ | ring plant minor or major – 1 ring generator failure is minor |
| RING GENERATOR TROUBLE | MJ | ring plant trouble |
| RING_XFER | MN | transfer between ring generatorsy (usually due to a failure of one) |
| SECONDARY FUSE/BREAKER TRIP | MJ | fuse blown or breaker tripped at the BDFB (don't connect to PSMC) |
| SEQUENCE | MN | rectifiers are sequencing back on line to avoid engine overload |
| SHUNT_FAIL | MN | shunt board/communications failure |
| STBY_ENG_FAIL<br>GENERATOR ENGINE FAILURE<br>GEN_FAIL | MJ | standby engine/alternator has failed |
| STBY_ENG_RUN<br>GENERATOR RUNNING<br>GEN_RUN | MN | standby engine/alternator running |
| SURGE_ARRESTOR<br>SURGE_ARRE<br>LIGHTNING_PROTECT<br>TVSS FAILURE | MJ | AC surge protector problem |
| TEMPERATURE | MN/MJ | high or low temperature (used when unable to distinguish) |
| TEMP_PROBE | MN | temperature probe fail |
| TIMER | MN | sequence, engine, etc., timer or other type of timer problem or timeout |
| TRANSFER | MN | any transfer (ring, inverter, etc.) |
| UNABLE_FLOAT | MJ | plant voltage controller unable to switch to float voltage |
| UPS ON BATTERY<br>BAT_BACKUP | MJ/CR | UPS batteries on discharge – criticality depends on backup time & loads |
| UPS LOW BATTERY | CR | very low UPS battery voltage |
| UPS BYPASS NOT AVAILABLE | MJ | UPS bypass path is presently not available |
| UPS ON BYPASS | MN | UPS in bypass mode |
| UPS ON GENERATOR | MN | UPS being fed by engine(s) |
| UPS NO REDUNDANCY | MJ | loss of redundant UPS module(s) |
| UPS NORMAL | RO | UPS in a normal condition (doesn't create a remote alarm) |
| UPS_FAIL-MN | MN | generic UPS minor alarm |
| UPS_FAIL<br>UPS SHUTDOWN | CR | UPS has failed / shut down |
| UPS SUMMARY ALARM<br>UPS TROUBLE ALARM | MJ | generic UPS alarm |
| VERY_LOW_VOLTAGE<br>LOW VOLTAGE DISCHARGE<br>RECTIFIER VERY LOW VOLTAGE<br>LO_LO_VOLT | CR | very low voltage |
| VOLTAGE_OUT_OF_LIMIT<br>BAT_VOLT | MJ | use when alarming device can't distinguish high and low |
| WATCHDOG | CR | the PSMC is not working |

**Table 13-3** Reduced Character and Overhead Bitstream TL1 Alarm Condition Types (page 1 of 2)

| **CONDTYPE (ALMTYPE)** | **CR, MJ, or MN NTFCNCODE** | **Description of Condition Type (some of this may be used in the 40-character ALMMSG field)** |
|---|---|---|
| BATDSCHRG | MJ | "battery discharging" |
| BATT-DISCHARGE | | |
| LOVOLTAGE | | |
| LWBATVG | | "low battery voltage" |
| RECTLO | | "rectifier low voltage" |
| BATMIDVOLT | MN/MJ | battery string midpoint voltage imbalance (see Table 13-14) |
| BATTDISC | MJ | battery disconnect breaker manually or automatically operated |
| BATTERY | MJ | "battery failure" |
| BATTTEMP | MJ | high battery temperature |
| CKTBRKR | MJ | any breaker operated |
| COMLACFAIL | MJ | |
| COMM-PWR-FAIL | | |
| POWER | | "commercial power failure" |
| CPMAJOR | MJ | "centralized power plant major alarm" |
| N48B1MJ | MJ | |
| CPMINOR | MN | "centralized power plant minor alarm" |
| N48B1CR | CR | |
| DIFFTEMP | CR | high differential temperature between batteries and ambient |
| ENGINE | MJ | "engine failure" or |
| GEN | | "generator failure" |
| ENGOPRG | MN | "engine operating"/running |
| DISTFUSE | MJ | "fuse failure" |
| FUSE | | |
| FUSE-FAIL | | |
| HIFLOATAMP | MN | float current is higher than it should be; indicating battery end-of-life |
| HI-LOVOLT | MJ | high or low DC plant voltage |
| HIVOLTAGE | MJ | high DC plant voltage |
| RECTHI | | "high rectifier voltage" |
| LIGHTNING | MJ | TVSS surge arrestor alarm, or lightning detector AC/MGN disconnect |
| LOWFUEL | MJ | "low fuel" alarm for the tank feeding the engine |
| LOW_FUEL | | |
| LWFUEL | | |
| LVDDISC | CR | low voltage disconnect switch operated |
| LVDFAIL | CR | low voltage disconnect device has failed |
| N48B1MJCR | MJ | power major or critical – used when not enough points |
| N48B1MN | MN | any power minor alarm combined on this point |
| OVERCURNT | MN | |
| RECTCAP | | plant "load exceeds" 80-100% of n-1 "rectifier capacity" |
| PWR-48 | MN/MJ/CR | "48 Volt power supply fail" |
| RECT | MN/MJ | "rectifier failure" |
| RECTFAIL | | |
| RECT-FAIL | | |

**Table 13-3** Reduced Character and Overhead Bitstream TL1 Alarm Condition Types (page 2 of 2)

| CONDTYPE (ALMTYPE) | CR, MJ, or MN NTFCNCODE | Description of Condition Type (some of this may be used in the 40-character ALMMSG field) |
|---|---|---|
| RECTRINGFL | MJ | ringer in a rectifier shelf failed |
| RINGFUSE | MJ | ringing distribution fuse operated |
| RINGMN | MN | ringing plant generic minor (e.g., one ring generator failed, etc.) |
| RINGMJ | MJ | ringing plant generic major (e.g., both ringers failed, etc.) |
| WATCHDOG | MJ | battery monitor or power monitor failure |
| VHILOVOLT | CR | very high or very low voltage |

Some CenturyLink™ power alarms wire to switch scan points before routing to either NMA®, or to the NetCool™ SNMP agent (see section 13.6 for more information on SNMP Power messages), depending on the legacy company to which the site belonged.

There are essentially 4 switch types in CenturyLink™ that have power alarms routed through their scan points so that they eventually end up in NMA®, where they are translated by a script into TL1 messages, as shown in the following tables:

For DMS™10s, the SRCE field used to have only 4 characters. More recent software in these switches allows 16-characters in the SRCE field, with newer naming standards; however most power and environmental alarms were put in DMS™10s in the days of 4-character mnemonics. Scripts translate these SRCE codes to the dynamic unit and TL1 Condition Type of Tables 13-4 – 13-7, which appear on the NMA® ticket. The description shown in the last column is scripted to appear on the event log of the dynamic ticket.

External scan points 1-21 and 60-64 in the DMS™10 switches are pre-assigned (no matter what is wired to them, their name can't be changed). Table 13-4 describes those pre-assigned points that are specific to centralized power plants (there are other power points among the pre-assigned list, but they are internal switch power-related alarms; and there are other pre-assigned points not shown here which are not specific to power at all). Note that any one of these points (or all of them) may not have anything wired to them; as the power points may have been hooked up to user-assignable scan points, or to e-telemetry devices, or to power monitors with TL1 capabilities.

**Table 13-4** DMS™10 Pre-Assigned Scan Point Messages for Power Plants

| Scan Point | DMS™10 SRCE (and CLAS if relevant) | new 16-char. (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|---|
| 1 | **PWR** (MAJ) | BATPLT | BATPLT_ MJ | major power alarm |
| 7 | **SWRG** | RNG_TRANSFER | RNG_TRANSFER_MN | residual ring plant transfer |
| 9 | **PWR** (MIN) | BATPLT | BATPLT_ MN | minor power alarm |

Scan points 22-59 (and possibly additionally 60-64 in sites without an e-tel system) can be user-assigned. Once wired, the DMS™10 SRCE field can be changed in the switch (via a direct log channel) in the NMA® .monitor mode. Enter input mode by "sending": #### (re-enter if the switch interrupts the session with its own output messages). Get into the scan point overlay by sending: ovly alrm<CR>. Print all scan points by querying with: que alpt all<CR>. Once the appropriate point is found, change it by "sending" the command: redf alpt ##<CR>. The switch asks for inputs. Use appropriate messages from Tables 13-4 through 13-6 when prompted for the SRCE. If more than 1 point uses the same 4-character mnemonic, they are given sequential numbers (e.g., 1, 2, 3 …) in the IDNT field (e.g., if there are multiple rectifier fail minors from individual rectifiers).
For DMS™100s, the UNIT TYPE field (not to be confused with NMA's Unit/Shelf field) may contain up to 16 characters, and is the equivalent of the SRCE field of the DMS™10s. The present standards for these messages (as suggested by Nortel) are also found in the first column of Table 6, Parts 1-3. These will also be translated by the scripts.

An unfortunate thing about switch messages for power is that they don't specify plant voltage and polarity, nor which plant it is (some offices have more than one plant). Due to this shortcoming, a generic descriptor of BATPLT is used in the TL1 message.

Northern Telecom (the original manufacturer of the DMS™ switches) suggested different messages for essentially the same alarm. For example, in one site, a commercial AC fail might be called an ACPF, while in another site it is a PWR2. CenturyLink™ has defined both as a COML_AC_FAIL. Several of the alarms are this way.

The script applies to all DMS™ switches. Although the 4-character messages are used mostly in DMS™10 switches, the installing technician may have liked the 4-character mnemonic message and used it in a DMS™100 even though he/she had 16 available character spaces.

The messages in the first column of the tables must be met exactly for the script to recognize them. The script only looks for whole messages, as shown in the table, not partial phrases. The messages in the switch must be entered in all capitals for the scripts to recognize them.

The NMA® switch scripts assign the "dynamic type" of "power" for power messages.

DMS™ user-assignable scan-point messages follow in Table 13-5:

**Table 13-5** DMS™ User-Assignable Scan Point Power Standards for NMA® (page 1 of 3)

| DMS™ message | new 16-char. (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| ACIM | COML_AC_IMBAL | COML_AC_IMBAL_MN | imbalance between phases of commercial AC |
| BATF<br>BATPLT_FAIL | BATPLT_BAT_FAIL | BATPLT_BAT_FAIL_CR | entire battery supply failed, power lost |
| ACPF<br>ACFAIL<br>COMACFAL<br>LPF<br>PFA<br>PFM<br>PWR2 | COML_AC_FAIL | COML_AC_FAIL_MJ | commercial AC failed |
| PR001-PR005 | | | Commercial Power |
| CPF | BATPLT | BATPLT_CR<br>BATPLT_MJ<br>BATPLT_MN | any power plant alarm in a DMS™ 10. Its criticality depends on the "classification" (CLAS) field, where the input will be "CAT", "MAJ", or "MIN", respectively, or "NONE" (no alarm will come across if "NONE" is entered) |
| CRPWR | BATPLT_CRITICAL | BATPLT_CRITICAL_CR | critical power alarm |
| MJPWR | BATPLT_MAJOR | BATPLT_MAJOR_MJ | major power alarm |
| MNPWR | BATPLT_MINOR | BATPLT_MINOR_MN | minor power alarm |
| CFA<br>CONVFUSE | CONV_DIST_FUSE | CONV_DIST_FUSE_MJ | converter distribution fuse alarm |
| CFL<br>CONVFAIL | CONV_FAIL | CONV_FAIL_MJ | individual converter failure |
| CMAJ<br>CONVMAJ | CONVPLT_MAJOR | CONVPLT_MAJOR_MJ | generic converter plant major alarm |
| CMIN<br>CONVMIN | CONVPLT_MINOR | CONVPLT_MINOR_MN | generic converter plant minor alarm |
| ACG<br>ENGF<br>ENGFAIL | STBY_ENG_FAIL | STBY_ENG_FAIL_MJ | standby generator failed |
| ENGR<br>ERUN<br>DIESL_RUN | STBY_ENG_RUN | STBY_ENG_RUN_MN | standby engine running |
| PR006-PR010 | | | Generator Run |
| EAMJ<br>STBYENGMJ | STBY_ENG_MAJOR | STBY_ENG_MAJOR_MJ | generic engine major alarm |
| EAMN<br>STBYENGMN | STBY_ENG_MINOR | STBY_ENG_MINOR_MN | generic engine minor alarm |
| EBFL<br>ENGBATCHG | ENG_BATCHG_FAIL | ENG_BATCHG_FAIL_MJ | engine start battery charger failed |
| ECRK<br>CRANKFAIL | ENG_CRANK_FAIL | ENG_CRANK_FAIL_MJ | engine failed to start |
| PR011-PR015 | | | Generator Start Failure |
| ECHT<br>ENGHITEMP | COOLANT_HITEMP | COOLANT_HITEMP_MJ | engine overheating |
| ECLT<br>ENGLOTEMP | COOLANT_LOTEMP | COOLANT_LOTEMP_MN | engine coolant low temperature |
| OSPD | ENG_OVERSPEED | ENG_OVERSPEED_MJ | engine running too fast and AC frequency |

**Table 13-5** DMS™ User-Assignable Scan Point Power Standards for NMA® (page 2 of 3)

| DMS™ message | new 16-char. (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| FTBL | ENG_FUEL_TRBL | ENG_FUEL_TRBL_MJ | generic fuel system problem (e.g., leak, low fuel) |
| FUEL | ENGALT_FUEL_LOW | ENGALT_FUEL_LOW_MJ | low fuel alarm |
| LEAK<br>FUEL_LEAK | ENG_FUEL_LEAK | ENG_FUEL_LEAK_MJ | fuel leak |
| XFER<br>XFR | TRNSW_TRANSFER | TRNSW_TRANSFER_MN | AC transfer switch operated |
| PR016-PR020 | TRNSW_OFF_NORMAL | TRNSW_OFF_NORMAL_MJ | Transfer Switch Failure |
| DFA<br>PWRRMFUSE | BATPLT_FUSE_BRKR | BATPLT_FUSE_BRKR_MJ | power plant distribution fuse or breaker operated |
| NDC | BATPLT_FUSE_BRKR | BATPLT_FUSE_BRKR_MJ | DC input to a piece of equipment lost or failed |
| PR072-PR092 | BATPLT_FUSE_BRKR | BATPLT_FUSE_BRKR_MJ | Power Distribution Major Alarm |
| PR042-PR062 | BATPLT_FUSE_BRKR | BATPLT_FUSE_BRKR_MJ | Power Distribution Critical Alarm |
| PR093-PR113 | BATPLT_FUSE_BRKR | BATPLT_FUSE_BRKR_MN | Power Distribution Minor Alarm |
| HF | BATPLT_HIGH_VOLT | BATPLT_HIGH_VOLT_MN | minor power plant high voltage alarm |
| HV<br>HIGHVOLT | BATPLT_HIGH_VOLT | BATPLT_HIGH_VOLT_MJ | major high power plant voltage |
| IFL<br>INVFAIL | INV_FAIL | INV_FAIL_MJ | inverter plant fail alarm |
| PR114-PR134 | INV_FAIL | INV_FAIL_MJ | DC/AC Converter Fail Major Alarm |
| IXFR<br>INVXFER | INV_TRANSFER | INV_TRANSFER_MN | inverter transfer between AC/DC |
| BATD<br>BATT<br>LOWBATT1<br>LOWBATT2<br>LV<br>BATDISCHRG<br>DISCHG<br>DISCH<br>FLOAT<br>LVOLT | BATPLT_LOW_VOLT | BATPLT_LOW_VOLT_MJ | low power plant voltage or battery on discharge |
| 48HL | BATPLT_HILO_VOLT | BATPLT_HILO_VOLT_MJ | high or low battery plant voltage |
| LIGHTNING<br>LTNG<br>LIGTN | LIGHTNING | LIGHTNING_MJ | lightning protector failed/operated |
| LVD | LOW_VOLT_DISC | LOW_VOLT_DISC_CR | low voltage disconnect operated/failed |
| MPFL | BATPLT_MP_FAIL | BATPLT_MP_FAIL_MJ | power plant controller microprocessor failure |
| RATELMJ | BATPLT_MAJOR | BATPLT_MAJOR_MJ | generic power major coming from PSMC |
| RATELMN | BATPLT_MINOR | BATPLT_MINOR_MN | generic power minor coming from PSMC |
| PM | BATPLT_PSMC | BATPLT_PSMC_MJ | power monitor alarm |
| LAC<br>POWR<br>RECFAIL<br>RECTIFIER<br>RECT | BATPLT_RECT_FAIL | BATPLT_RECT_FAIL_MN | single rectifier fail |

**Table 13-5** DMS™ User-Assignable Scan Point Power Standards for NMA® (page 3 of 3)

| DMS™ message | new 16-char. (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| NAC | | BATPLT_RECT_FAIL_MJ | two or more rectifiers failed |
| PWR1 | | | commercial AC or multiple rectifier failure |
| PR021-PR041 | | | Charger/Rectifier Fail Major Alarm |
| FUSE | RNG_FUSE | RNG_FUSE_MJ | residual ringing plant distribution fuse alarm |
| RINGFUSE | | | |
| RINGFAIL | RNG_FAIL | RNG_FAIL_MJ | both ring generators failed |
| RINGGEN | RNG_RGEN_FAIL | RNG_RGEN_FAIL_MN | single generator on residual ring plant failed |
| RINGMAJ | RNG_MAJOR | RNG_MAJOR_MJ | ring plant major (e.g., all ring generators or fuse fail) |
| RMAJ | | | |
| RMIN | RNG_MINOR | RNG_MINOR_MN | ring plant minor (e.g., single ring generator failed) |
| RINGMIN | | | |
| RXFR | RNG_TRANSFER | RNG_TRANSFER_MN | residual ring plant transferred from primary to secondary |
| RINGXFR | | | |
| UPS | UPS_FAIL | UPS_FAIL_MJ | UPS failure |
| UPST | UPS_TRANSFER | UPS_TRANSFER_MN | UPS transferred between AC/DC |
| VLV | BATPLT_V_LO_VOLT | BATPLT_V_LO_VOLT_CR | very low battery voltage — plant loss imminent |
| WDOG | PSMC_WATCHDOG | PSMC_WATCHDOG_CR | PSMC failed |
| WATCH | | | |

DMS™100 remote locations (usually remote switches, but sometimes RTs) aren't correctly identified when the alarm messages of Table 13-5 are scripted across. In these cases, it appears as if the alarm comes from the host. To rectify this problem it is necessary that the first column message be preceded by the 4-character designation by which the host recognizes the remote (this can usually be found in the "site" table of the host in NMA®). This should be followed by underscore, and then the message of column 1. The scripts will then recognize the remote, and give the appropriate CLLI™ code on the alarm ticket.

As an example, Wilcox is a remote DMS™100 out of a Tucson host. A fire alarm in the Wilcox CO switch would be WLX1_FIRE, while it would be only FIRE in the host office.

The NMA host-remote relationship table ("ocs_hrsm_id") in NMA® may also need to be updated. This relationship table lists the 4-character (or more) remote designation, and assigns the proper CLLI™ code to it (a valid CLLI™ that is listed in the scc_clli screen of NMA®) The script calls this table when it recognizes a remote designation.

There are also RTs and/or remote switches whose alarms come to the scan points of DMS™10 switches. In this case, the 4-character designation of the remote terminal is automatically transmitted to NMA® and does not need to be made a part of the message as with the DMS™100. However, the relationship between the 4-character remote identifier and its corresponding CLLI™ code do need to be in the ocs_hrsm_id screen.

In the rare cases where DMS™10 remote scan point messages must be changed by accessing the remote through the host instead of a direct channel, each message must be preceded by the "satellite number" of the remote.

RTs (e.g., SLC®, Seiscor, DISC*S®, Litespan, e.g.) that are integrated into DMS™100s are identified differently. The alarm text is placed in the MISCTEXT field in switch table RCSINV, and severity is defined in the ALMSEVER field. The text appears in the PM128 switch messages. The PM128 message has a "pair gain" identifier which consists of the SITE name, frame number and unit number of the RCS (e.g. PG50 95 0). The NMA® script looks for this ID and goes to the host-remote relationship tables. These "pair gain" IDs (which are larger than 4-characters) need to be built in the ocs_hrsm_id screen.

All of the "remote" alarms listed so far use the messages from Table 13-5. Integrated DMS™-1 Urban power and environmental alarms in DMS™100 switches may use these, or they may use a predefined set of standards in the RCUALRMS table, as shown in Table 13-6. The first 6 points of this table should be populated automatically with these predefined standards by entering the command: NIL_TEXT. The last 6 alarms are user-assignable and should use messages from the first column of Table 13-5 (the first 6 should be filled with user-assignable messages only when the point wired to them doesn't match the description shown in the last column of Table 13-6). The Urban Remote Terminal site location is identified in the message by the 4-character identifier described above, and the host-remote relationship table must be populated.

The dynamic unit of power alarms coming from Remote Terminals is preceded by "RT_".

**Table 13-6** Power Messages for Integrated DMS™-1 Urban

| Code | present Nortel standards | new 16-char. (max) scripted standard "dynamic unit" | new 20-char. (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|---|
| 1 20 | | this is a cabinet intrusion alarm (environmental), so it is not "power" | | |
| 1 21 | LOW BATTERY VOLTAGE | RT_BATPLT_LOW_VOLT | RT_LOWVOLT_MJ | battery on discharge |
| 1 22 | | this is a cabinet temperature alarm (environmental), so it is not "power" | | |
| 1 23 | | this alarm is a sync alarm not to be sent to power worklists | | |
| 1 24 | LOSS OF POWER OR AC RECTIFIER FAILED | RT_COML_AC_FAIL | RT_ACFAIL_MJ | commercial AC fail or rectifier fail |
| 1 25 | | this is a fuse and breaker alarm that doesn't belong to power worklists | | |
| 1 26 | | these are user-assignable scan points if used for power or environmental alarms, they should use the messages of Tables 13-4 or 13-5 | | |
| 1 27 | | | | |
| 1 28 | | | | |
| 1 29 | | | | |
| 1 30 | | | | |
| 1 31 | | | | |

DMS™ switches also support the integration of other types of digital loop carrier (DLC) systems directly into the switch (without going through a universal COT bay). The most common power alarm that comes from these other types of DLC systems (especially Lucent/AT&T/Western Electric SLC® systems) is a generic power/miscellaneous alarm (which typically means that the site is on batteries — caused by an AC fail or rectifier/charger fail). This has been scripted in NMA® to flow through as a seprate power alarm if it is the first alarm to come in from that integrated DLC. If it is not the first alarm from the site to create a ticket, then it will generally show up as another condition type on a toll facilities ticket. The location field on these alarm tickets is the switch CLLI™ code. The dynamic or miscellaneous type is typically s96 (for SLC®96; although not all DLC Systems are SLC), and the dynamic unit or miscellaneous designation is the DLC system ID (e.g., sid 45). The condition type reads:

r.t. power/acfail

There are some newer types of DMS™ remote switch modules such as OPAC™, RLCM™, OPM™, and RSC™ which are capable of being installed in different environments, including cabinets. Those remote DMS™ switch modules in cabinets report their alarms through the host as OPMPES Output Messages (such as PES100, PES107, PES115, etc.), along with various text messages describing the alarm and a remote identifier (the remote is identified on the ticket using the same process described earlier in this section). The NMA® script picks out the appropriate text for power alarms and creates the messages found in Table 13-7. (The script does not search for the rectifier numbers; therefore, the 0/1 below in the messages can be ignored.)

**Table 13-7** NMA® Power Messages for Nortel Remote Switches in RTs

| OPMPES Messages Switch Message | Alm State | Clr State | new 16-char. (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION & Notes |
|---|---|---|---|---|---|
| **PES100 alarms cleared by PES107 messages** | | | | | |
| **Rectifier** 0/1 | Fail | OK | OPAC_CAB_PWR | RECT_FAIL_MN | any single rectifier fail — this becomes a RECT_FAIL_MJ if both are in |
| **Common AC** | | | | COML_AC_FAIL_MJ | AC power failure |
| **FSP State** | | | | FUSE_BRKR_OPERATE_MJ | distribution fuse failed |
| **BCC Fuse** 0/1 | | | | | rectifier fuse failed |
| **Cur Limit** 0/1 | | | | RECT_OVERCURRENT_MJ | high rectifier current |
| **High Temp.** | | | OPAC_CAB_ENV | HIGH_TEMPERATURE_MJ | high or low cabinet temperature — can cause switch failure if in too long |
| **Low Temp.** | | | | LOW_TEMPERATURE_MJ | |
| **PES104 alarm cleared by PES107 "Common AC OK" or "Rectifer 0/1 OK" message** | | | | | |
| **LOAD BUS LOW VOLTAGE ALARM** | Fail | OK | OPAC_CAB_PWR | VERY_LOW_VOLTAGE_MJ | Battery voltage below -47.0 VDC — as noted above, this alarm is cleared by return of commercial AC and rectifiers |
| **PES105 alarm cleared by PES106 message** | | | | | |
| **CHARGE BUS LOW VOLTAGE ALARM** | Fail | OK | OPAC_CAB_PWR | LOW_FLOAT_MJ | Battery charging bus voltage is too low to float the batteries — cleared by "CHARGE BUS OK" on PES 106 |
| **PES113 alarms cleared by PES107 messages** | | | | | |
| **BCC Fuse** 0/1 | Fail | OK | OPAC_CAB_PWR | FUSE_BRKR_OPERATE_MJ | internal pwr plant controller fuse fail |
| **PES115 and PES117 alarms cleared by PES107 "BCC Unit OK" message** | | | | | |
| **?** (PES115) | Fail | OK | OPAC_CAB_PWR | BAT_STRING_FAIL_MJ | any PES115 or PES117 message indicates that the batteries won't take a charge (are bad) and need to be replaced — cleared with a "BCC Unit OK" on PES107 |
| **?** (PES117) | | | | | |

For Alcatel-Lucent 5ESS™s, there are standards for some power alarms. The standards differ between hosts and remotes. Lucent's preassigned standards for these messages are on the left side of Tables 13-8 and 13-9. Scripts in NMA® translate these messages to the 16-character TL1 messages shown in the 2nd column of the Tables. The description in the last column the Tables appears on the dynamic ticket's event log. The messages of these 2 Tables are preassigned by Lucent and can't be changed on those scan points (these messages may also be applied to "user-assignable" scan points if they are short enough). If someone wishes to bring in a rectifier fail in a remote 5ESS™, it is preferable that they physically connect the alarm to scan point 37, where the message is prebuilt.

In many cases with 5ESS™s, there are alarms which do not have a standard message, or where an alternate standard message is acceptable, or where the standard message in Tables 13-8 and 13-9 is too lengthy. A "user-assignable" scan point can be programmed with a message. In these cases, the message in the 5ESS™ needs to be changed to the standards of column 1 in Table 13-10 (or Tables 13-8 and 13-9 if their message is short enough). When this is done, the scripts can do the translations as explained.

The primary power and environmental alarms for the host switches can be found on the 105 and 106 pages (another set of miscellaneous scan points viewed on the 119 page may also have power or environmental alarms) of the NMA® SCC module, and they are on the 1400 page for the remotes. Changes can be made to the messages in the hosts from a command line or the 120 page. The change message for the host would look as follows:

chg:alm,bpsc=XX,tag="MESSAGE"

Where XX designates the scan point number, and MESSAGE is the message from the column 1 of Table 13-10 in all CAPITALS. Changes in remotes can be made by going to the 196 page, and choosing options 8, then 11. This should bring up the "remote alarm assignment" screen, which has 9 fields. After identifying the remote and scan point in fields 1 and 2, the message can be changed in field 7 (TTY field) with a message from the first column of Table 13-10. User-assignable scan points for 5ESS™ hosts are 6902-6927 and 7700-7747. For remotes, it is scan points 2-31. There are 9 characters available for user-assignable scan points in hosts, and 20 characters available in remotes.

The remote scan point assignment mentioned allows the user to specify whether they are hooking up a normally open or normally closed alarm. There is no such specification for host scan points. In a host, normally open (close on alarm) contacts are connected between the NO and C (common) on the OAU (Office Alarm Unit) M00 block on the frame. (This block is wired back to the switch's OAU in switch mod M00.) Normally closed (open on alarm) alarms are connected between the NC and C contacts; and the NO and C contacts must be jumpered. For those messages in the first column of Table 13-10 that are followed by a "CR", "MAJ", or "MIN" in parentheses; this signifies that the "Alarm Level" field should be toggled appropriately. This is simply for clarification on these specific alarms since the message is the same otherwise. All alarm levels should be set at the level indicated in the third column.

**Table 13-8** 5ESS™ Standard Power Messages for Hosts

| present 5ESS™ standards | new 16-char. (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| HM69**33**MJ**RECT FAIL** | BATPLT_RECT_FAIL | BATPLT_RECT_FAIL_MJ | rectifier(s) fail |
| HM69**40**MJ**ALM BAT** | BATPLT_MAJOR | BATPLT_MAJOR_MJ | major power alarm |
| HM69**41**MJ**CO BAT DSCHG** | BATPLT_LOW_VOLT | BATPLT_LOW_VOLT_MJ | low plant voltage |
| HM69**42**MJ**STBYPLT FUEL** | ENGALT_FUEL_LOW | ENGALT_FUEL_LOW_MJ | engine fuel tank low |
| HM69**42**MJ**STBYPLT OPER** | STBY_ENG_RUN | STBY_ENG_RUN_MN | engine running |
| HM69**42**MJ**STBYPLT RECT** | ENGALT_BATCHG | ENGALT_BATCHG_MJ | engine start battery charger |
| HM69**42**MJ**STBYPLT FAIL** | STBY_ENG_FAIL | STBY_ENG_FAIL_MJ | standby engine failed |
| HM69**46**MJ**HIGH VOLTAGE** | BATPLT_HIGH_VOLT | BATPLT_HIGH_VOLT_MJ | high power plant voltage |
| HM69**47**MJ**COM PWR FAIL** | COML_AC_FAIL | COML_AC_FAIL_MJ | commercial AC failed |

**Table 13-9** 5ESS™ Standard Power Messages for Remotes

| Scan Point | present 5ESS™ standards (TTYNAME) | new 16-char. (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|---|
| 32 | DISCHARGE FUSE FAIL | BATPLT_FUSE_BRKR | BATPLT_FUSE_BRKR_MJ | power plant dist. fuse or brkr. |
| 37 | RECTIFIER FAILURE | BATPLT_RECT_FAIL | BATPLT_RECT_FAIL_MN | rectifier fail |
| 38 | ALM BATTERY FAILURE | BATPLT_MAJOR | BATPLT_MAJOR_MJ | major power alarm |
| 39 | CO BATTERY DISCHARGE | BATPLT_LOW_VOLT | BATPLT_LOW_VOLT_MJ | battery on discharge |
| 40 | HIGH VOLTAGE | BATPLT_HIGH_VOLT | BATPLT_HIGH_VOLT_MJ | high power plant voltage |
| 41 | COMM POWER FAILURE | COML_AC_FAIL | COML_AC_FAIL_MJ | commercial AC failed |
| 42 | STBY PLANT LOW FUEL | ENGALT_FUEL_LOW | ENGALT_FUEL_LOW_MJ | engine fuel tank low |
| 43 | STBY PLANT OPERATING | STBY_ENG_RUN | STBY_ENG_RUN_MN | engine running |
| 44 | STBY PLANT RECT FAIL | ENGALT_BATCHG | ENGALT_BATCHG_MJ | engine start batt. charger fail |
| 45 | STBY PLANT FAILURE | STBY_ENG_FAIL | STBY_ENG_FAIL_MJ | standby engine failed |

**Table 13-10** 5ESS™ User-Assignable Scan Point Power Message Standards (page 1 of 2)

| recommended standard 5ESS™ "user-assignable" scan point message | new 16-char. (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| ALM BAT (CR) | BATPLT_CRITICAL | BATPLT_CRITICAL_CR | generic critical power alarm |
| DIST FUSE | BATPLT_FUSE_BRKR | BATPLT_FUSE_BRKR_MJ | power plant distribution fuse or brkr. |
| -24V FA | 24VPLT_FUSE_BRKR | 24VPLT_FUSE_BRKR_MJ | 24 volt plant distribution fuse or brkr. |
| -48V FA | 48VPLT_FUSE_BRKR | 48VPLT_FUSE_BRKR_MJ | 48 volt plant distribution fuse or brkr. |
| AC IMB | COML_AC_IMBAL | COML_AC_IMBAL_MN | imbalance between phases of AC |
| AC FAIL | COML_AC_FAIL | COML_AC_FAIL_MJ | commercial AC failed |
| CONV PLT (MAJ) | xxCONVPLT_ALARM | CONV PLT (mj) | generic converter plant major or minor alarm on switch scan point xx |
| CONV PLT (MIN) | | CONV PLT (mn) | |
| CONV FUSE | CONV_DIST_FUSE | CONV_DIST_FUSE_MJ | converter distribution fuse alarm |
| CONV FAIL | CONV_FAIL | CONV_FAIL_MJ | individual converter failure |
| CONVFAIL | | | |
| CLT HIT | COOLANT_HITEMP | COOLANT_HITEMP_MJ | engine overheating |
| CLT LOT | COOLANT_LOTEMP | COOLANT_LOTEMP_MN | engine coolant low temperature |
| ENGBATCHG | ENG_BAT_CHG | ENG_BAT_CHG_MJ | engine start battery charger problem |
| ENGBATVLT | ENGBAT_HILOVOLT | ENGBAT_HILOVOLT_MJ | high or low voltage on engine start |
| ENG CRK | ENG_CRANK_FAIL | ENG_CRANK_FAIL_MJ | engine failed to start |
| ENGLOWTR | ENG_LOW_WATER | ENG_LOW_WATER_MJ | low coolant level in the engine |
| ENGWTRTMP | ENG_WATER_TEMP | ENG_WATER_TEMP_MJ | high or low engine coolant temperature |
| FUEL LOW | ENGALT_FUEL_LOW | ENGALT_FUEL_LOW_MJ | engine fuel tank low |
| FUEL LEAK | ENG_FUEL_LEAK | ENG_FUEL_LEAK_MJ | fuel leak |
| FUEL TRBL | ENG_FUEL_TRBL | ENG_FUEL_TRBL_MJ | generic fuel system problem |
| ENG OSPD | ENG_OVERSPEED | ENG_OVERSPEED_MJ | engine running too fast |
| ENGLOOIL | ENG_LO_OIL_PRES | ENG_LO_OIL_PRES_MJ | low engine oil pressure |
| DSL RUN | STBY_ENG_RUN | STBY_ENG_RUN_MN | engine running |
| ENG FAIL | STBY_ENG_FAIL | STBY_ENG_FAIL_MJ | standby engine failed while running |

**Table 13-10** 5ESS™ User-Assignable Scan Point Power Message Standards (page 2 of 2)

| recommended standard 5ESS™ "user-assignable" scan point message | new 16- character (max) scripted standard "dynamic unit" | new 20-character (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| ENG ALT (MAJ) | xxSTBY_ENG_ALARM | ENG ALT (mj) | generic engine major or minor alarm on switch scan point xx |
| ENG ALT (MIN) | | ENG ALT (mn) | |
| AC XFR | TRNSW_TRANSFER | TRNSW_TRANSFER_MN | transfer switch operated |
| AC XFR FL | TRANSFER_FAIL | TRANSFER_FAIL_MJ | transfer switch failed to operate |
| INV FAIL | INV_FAIL | INV_FAIL_MJ | inverter plant fail alarm |
| INV XFR | INV_TRANSFER | INV_TRANSFER_MN | inverter transfer |
| RECTFAIL | BATPLT_RECT_FAIL | BATPLT_RECT_FAIL_MN | rectifier fail |
| HILOVOLT | BATPLT_HILOVOLT | BATPLT_HILOVOLT_MJ | high or low power plant voltage |
| -24V HVLV | 24VPLT_HILOVOLT | 24VPLT_HILOVOLT_MJ | high or low 24 V power plant |
| -48V HVLV | 48VPLT_HILOVOLT | 48VPLT_HILOVOLT_MJ | high or low 48 V power plant |
| VOLT LOW | BATPLT_LOW_VOLT | BATPLT_LOW_VOLT_MJ | low voltage or battery on |
| VOLT VLOW | BATPLT_VLO_VOLT | BATPLT_VLO_VOLT_CR | very low battery voltage |
| VOLT HIGH | BATPLT_HIGH_VOLT | BATPLT_HIGH_VOLT_MJ | high power plant voltage |
| VOLT HI | | | |
| LIGHTNING | LIGHTNING | LIGHTNING_MJ | lightning protector failed |
| PSMC WDOG | PSMC_WATCHDOG | PSMC_WATCHDOG_CR | PSMC failed |
| PSMCWDOG | | | |
| PSMCm (MAJ) | PSMC_MAJOR | PSMC_MAJOR_MJ | backup power major from PSMC |
| PSMCm (MIN) | PSMC_MINOR | PSMC_MINOR_MJ | backup powerminor from PSMC |
| OMNI MJ | BATPLT_MAJOR | BATPLT_MAJOR_MJ | power major from PSMC |
| POWER (MAJ) | xxBATPLT_ALARM | POWER (mj) | generic power major or minor alarm on switch scan point xx |
| POWER (MIN) | | POWER (mn) | |
| RNG FUSE | RNG_FUSE | RNG_FUSE_MJ | ring plant distribution fuse alarm |
| RNG PLT (MAJ) | RNG_MAJOR | RNG_MAJOR_MJ | ring plant major |
| RNG PLT (MIN) | RNG_MINOR | RNG_MINOR_MN | ring plant minor |
| RNG GEN | RNG_RGEN_FAIL | RNG_RGEN_FAIL_MN | ring generator failed |
| RNG XFR | RNG_TRANSFER | RNG_TRANSFER_MN | ring generators transferred |
| UPS FAIL | UPS_FAIL | UPS_FAIL_MJ | UPS failure |
| UPS XFR | UPS_TRANSFER | UPS_TRANSFER_MN | UPS transferred |

For any message in Table 13-10, if there is more than one of a particular piece of equipment, such as multiple rectifiers, converters, DC plants, ring plants, etc.; a number designating the individual piece of equipment needs to be placed after the column 1 message to prevent multiple alarms from coming in against the same NMA® ticket. For example, in a site with 4 RFA alarms (one for each rectifier), the alarms would be: RECTFAIL1, RECTFAIL2, etc. In a similar fashion, where space allows, other characters may be placed before or after the first column message to indicate location in the building, or other relevant information. In either case, these alarms would route to the appropriate worklists because they contain the keywords from Table 13-10. By scanning the original message in the switch, all of the relevant information intended to be conveyed can be found.

All 5ESS™ switch scan point messages report to NMA through the host switch. If the alarm comes from a remote switch, there is another field (besides the TTY message field) populated with RBPSC. This is a clue to the NMA® script to look in the remote identifier field. The remote identifier field of the raw alarm message coming to NMA uses the abbreviation SM for switch module, followed by a number (e.g., SM 19). This number uniquely identifies the remote switch. The NMA® script then goes to the ocs_hrsm_id tables to match the remote number with the CLLI™ code for that remote switch site.

In rare cases, RT site alarms will be transported over distance and wired to switch scan points. If it's a remote switch, the remote ID (switch module) field cannot be used, as this is already populated with the remote ID (SM). So, the same thing is done as with the DMS®100 switches (i.e., the first part of the message is populated with a 4-character remote identifier followed by a space and then the message per Table 7 [if you are space-limited, use the 4-character messages from Table 13-5]). The NMA® script looks at the first four characters and attempts to match them to a remote from the ocs_hrsm_id tables. If a remote designator is matched, then that CLLI™ code is populated for the ticket. If no remote designator is found, the scripts will assume that the alarm is attached to the host or remote site as the case may be.

5ESS™ switches also support the integration of other types of DLC systems directly into the switch (without going through a universal COT bay). The most common power alarm that comes from these other types of DLC systems (especially from SLC® systems) is a generic power/miscellaneous alarm (which typically means that the site is on batteries — usually caused by an AC fail). The location field on these alarm tickets is the switch CLLI™ code. The dynamic or miscellaneous type is typically the type of DLC system (e.g., s96 for SLC® 96), and the dynamic unit or miscellaneous designation is the DLC system ID (e.g., sid 45). The power condition type reads:

r.t. power/acfail

Ericsson scan points (referred to by Ericsson as "external" alarms) are easy to connect and name. Ericsson doesn't have a recommended naming standard. The CenturyLink™ standards for power plant and environmental messages are shown in the first column of Table 8. Ericsson provides two fields for describing the scan point (external) alarm in ASCII text, known as CAW1 and CAW2 (or Slogan1 and Slogan2). The standard message in the first column of Table 8 is placed in CAW1.

An NMA® script will translate and direct the power messages of the first column of Table 13-11 to the power worklists. This script will create a "dynamic" ticket in NMA®, and create the messages in the second and third columns of Table 13-11. The script will look for the full complete message (not partial message) of the first column in CAW1.

**Table 13-11** Ericsson AXE™ Standard Power Alarm Messages for NMA® (Page 1 of 4)

| Ericsson Standard (CAW1 Field) | new 16-char. (max) scripted standard "dynamic unit" | new 20-char. (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| AC FAIL<br>AC FAIL TO RECTIFIER<br>AC POWER FAIL<br>AC POWER FAILURE<br>AC REC POWER FAIL<br>COMMERCIAL POWER FAILURE<br>COMM POWER FAIL<br>COMMERCIAL POWER FAIL<br>MAINS FAILURE | COML_AC_FAIL | COML_AC_FAIL_MJ | commercial AC failed |
| -48 V POWER PLANT | BATPLT_FAIL | BATPLT_FAIL_MJ | power plant controller failure |
| +130V CONVERTOR FAIL<br>+130V MINOR<br>+130V CONV. FAIL<br>+130V CONVERTER FAIL<br>-130 V CONVERTOR FAIL<br>-130V CONV. FAIL<br>-130V MINOR<br>-130CONVFAIL | CONV_FAIL | CONV_FAIL_MN | single converter failed |
| -130PLT FAIL<br>+130V PLTFAIL<br>+130V PLANT FAIL<br>-130V PLANT FAIL | CONVPLT_FAIL | CONVPLT_FAIL_MJ | converter plant failed |
| +130V CONV MAJOR<br>-130V MAJOR<br>+130V MAJOR | CONVPLT_MAJOR | CONVPLT_MAJOR_MJ | converter plant generic major — distribution fuse or multiple converter fail |
| -130V FUSE<br>-130V FUSE ALARM<br>+130V FUSE<br>+130V FUSE ALARM | CONV_DIST_FUSE | CONV_DIST_FUSE_MJ | converter distribution fuse operated |
| -48V FUSE ALARM<br>-48V FUSE<br>48V FUSE ALM<br>FUSE MAJOR<br>-48V POWER FUSE<br>FUSE 48VOLT PLANT<br>FUSE 48 VOLT PLANT<br>POWER PLANT FUSE<br>-48V MPF<br>LINEAGE 2000 FUSE<br>MN DISTFUSE<br>DISCH FUSE | BATPLT_FUSE_BRKR | BATPLT_FUSE_BRKR_MJ | power plant distribution fuse or breaker operated |
| GENERATOR BATTERY FAIL | ENG_BAT_FAIL | ENG_BAT_FAIL_MJ | engine start battery failure |

**Table 13-11** Ericsson AXE™ Standard Power Alarm Messages for NMA® (Page 2 of 4)

| Ericsson Standard (CAW1 Field) | new 16-char. (max) scripted standard "dynamic unit" | new 20-char. (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| ENGINE RUNNING<br>ENGINE RUN NORMAL | STBY_ENG_RUN | STBY_ENG_RUN_MN | engine running |
| SBY ENG PROPER OPERATE | | | |
| COMMPOWER/DIESEL RUNNING | | | |
| GENERATOR RUN | | | |
| GENERATOR RUNNING | | | |
| GEN SET RUNNING | | | |
| ENG RUN | | | |
| DIESEL PROPER OPERATE | | | |
| DIESEL OPERATE (ENGINE) | | | |
| DIESEL OPERATE | | | |
| ENGINE FAIL | STBY_ENG_FAIL | STBY_ENG_FAIL_MJ | engine failed while running |
| SBY ENGINE ENGINE FAIL | | | |
| GENERATOR FAIL | | | |
| GENERATOR FAILED | | | |
| GEN SET FAILURE | | | |
| DIESEL FAIL(ENGINE) | | | |
| DIESEL FAIL | | | |
| SBY ENG RECT FAIL | ENG_BATCHG_FAIL | ENG_BATCHG_FAIL_MJ | engine start battery charger fail |
| ENGINE RECTIFIER FAIL | | | |
| ENGINE BATT CHG FAIL | | | |
| FUEL TANK RUPTURE | ENG_FUEL_LEAK | ENG_FUEL_LEAK_MJ | fuel tank has a leak |
| LOW GENERATOR FUEL | ENGALT_FUEL_LOW | ENGALT_FUEL_LOW_MJ | engine tank running out of fuel |
| GEN SET LOW FUEL | | | |
| HIGH VOLTAGE | BATPLT_HIGH_VOLT | BATPLT_HIGH_VOLT_MJ | high power plant voltage |
| HI VOLTAGE | | | |
| -48V PLT HIGH VOLT | | | |
| -48V L2000 HIGH VOLT | | | |
| -48V HIGH VOLTAGE | | | |
| POWER PLANT HI VOLTAGE | | | |
| 48V H/L VOLTS | BATPLT_HILO_VOLT | BATPLT_HILO_VOLT_MJ | high or low power plant voltage |
| -48V HIGH/LOW VOLTAGE | | | |
| HI/LO VOLTAGE | | | |
| LOW VOLTAGE | BATPLT_LOW_VOLT | BATPLT_LOW_VOLT_MJ | low plant voltage or battery on discharge |
| LO VOLTAGE | | | |
| -48V LOW VOLTAGE | | | |
| -48V L2000 LOW VOLT | | | |
| -48V PLT LOW VOLT | | | |
| 48V PLANT FLOAT VOLT | | | |
| 48V FLOAT VOLTAGE | | | |
| -48V BATT DISCHG | | | |
| BATTERY DISCHARGE | | | |
| BATTERY ON DISCHARGE | | | |
| BATTERIES ON DISCHARGE | | | |
| BATT DISCHARGE | | | |
| CO BATT DISCHARGE | | | |
| BATTTERY DISCHARGE | | | |

**Table 13-11** Ericsson AXE™ Standard Power Alarm Messages for NMA® (Page 3 of 4)

| Ericsson Standard (CAW1 Field) | new 16-char. (max) scripted standard "dynamic unit" | new 20-char. (max) scripted standard "TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| -48V VERY LOW VOLT<br>VERY LOW VOLTAGE | BATPLT_V_LO_VOLT | BATPLT_V_LO_VOLT_CR | very low power plant voltage |
| RATELCO MAJOR<br>RATELCO POWER MAJOR<br>RATELCO MAJ<br>RATELCO MJ<br>OMNPLSE MAJOR<br>OMNI MAJOR<br>-48V PLANT MAJOR<br>-48V PLT MAJOR<br>-48V POWER MJ<br>POWER MAJOR<br>MAJOR POWER<br>LINEAGE 2000 POWER<br>LINEAGE 2000 MAJ | BATPLT_MAJOR | BATPLT_MAJOR_MJ | power plant generic major |
| RATELCO MINOR<br>RATELCO POWER MINOR<br>RATELCO MIN<br>RATELCO MN<br>OMNPLSE MINOR<br>OMNI MINOR<br>POWER MINOR<br>POWER MN.<br>LINEAGE 2000 MIN | BATPLT_MINOR | BATPLT_MINOR_MN | power plant generic minor |
| LINEAGE 2000 PROCESSOR | BATPLT_MPROC | BATPLT_MPROC_MJ | power plant controller fail |
| 48V RECTIFIER FAIL<br>-48V RECT FAIL<br>-48V RECT G1 FAIL<br>-48V RECT G2 FAIL<br>-48V RECT G3 FAIL<br>-48V RECT G4 FAIL<br>-48V RECTIFIER FAIL<br>48V RFA<br>RECTIFIER FAIL | BATPLT_RECT_FAIL | BATPLT_RECT_FAIL_MN | single rectifier fail |
| -48V RECT MAJ<br>-48V RECTIFIER MAJOR | BATPLT_RECTS_FL | BATPLT_RECTS_FL_MJ | multiple rectifier failures |
| RING PLANT MAJ.<br>LORAIN RINGING<br>RING PLANT<br>RINGING PLT MAJOR<br>AUX RING PLANT-MJ<br>PECO RINGING MACHINE<br>RING PLANT TBL | RNG_MAJOR | RNG_MAJOR_MJ | ring plant major — both ringers failed, or ringing distribution fuse |

**Table 13-11** Ericsson AXE™ Standard Power Alarm Messages for NMA® (Page 4 of 4)

| Ericsson Standard (CAW1 Field) | new 16-char. (max) scripted standard "dynamic unit" | new 20-char. (max) scripted standard TL1 condition type" | DESCRIPTION |
|---|---|---|---|
| AUX RING PLANT-MN<br>RING PLT MN<br>RINGING PLT MINOR<br>RING PLANT MN. | RNG_MINOR | RNG_MINOR_MN | ring plant minor — single ringer failed |
| TRANSFER SWITCH OPERATE<br>TRANS SW PROPER OPERATE<br>TRANSFER SW OPER | TRNSW_TRANSFER | TRNSW_TRANSFER_MN | auto transfer switch operated properly |
| ENGINE SW OFF NORM<br>SBY ENG SWCH OFF NORMAL | TRNSW_OFF_ NORMAL | TRNSW_OFF_NORMAL_ MJ | transfer switch didn't operate properly |
| RATELCO WD<br>RATELCO WATCH DOG<br>RATELCO WATCHDOG<br>OMNI WATCHDOG<br>OMNPLSE SYS TRBL<br>WATCH DOG<br>WATCHDOG | PSMC_WATCHDOG | PSMC_WATCHDOG_CR | power monitor has failed |

The Ericsson AXE™ switch CAW2 field is used for alarm type descriptions and remote site identification (all scan point alarms come through the host). The scripts that direct and translate for power worklists look in CAW2 to determine if the alarm comes from a remote switch. If the CAW2 field matches an identifier in NMA®'s host-remote tables, the identifier will be translated to the proper CLLI™ for display on the dynamic ticket. If no remote designator is found, the script assumes the alarm is attached to the host site.

## 13.3 TL1 Query Messages for Power

A power monitor or a mux equipped for X.25 or IP communication may get messages, as well as send the SIDs, AIDs, and condition types defined earlier. The messages that these machines may get (along with a couple of "report out" messages) from NMA® in TL1 language are defined below. Each machine, depending on the manufacturer, will not accept all of the messages listed below, only the ones that have been programmed into that machine's hardware and software (the minimum required power monitor messages have been marked with an asterisk). The message shown below is not the complete message; most messages include the AID and other commands defining what the user is looking for. See the Telcordia® (Bellcore) GRs-811, 833, and associated documents (or the manuals for the monitor) for the correct and complete formats.

When the alarm device is communicating to NMA® via SNMP traps which are translated via a template to TL1 messages, the TL1 queries from NMA® (see the table below) are translated by that same template/script into SNMP "Get" messages.

**Table 13-12** TL1 Query Messages for Power

| MESSAGE | EXPLANATION |
|---|---|
| ACT-USER * | a logon (not required if software configured correctly) |
| ALW-MSG-ALL | not necessary if the software doesn't restrict messages |
| ALW-MSG-EQPT | allow an individual alarm message to be sent |
| CANC-USER * | a logoff if ACT-USER was used |
| DLT-SECU-USER | remove a TL1 user |
| ED-DAT | edit date and/or time |
| ED-SECU-USER | modify a TL1 user's privileges, passwords, etc. |
| ENT-SECU-USER | add a TL1 user |
| INH-MSG-EQPT | prevent an alarm message from being sent |
| INIT-REG-EQPT | initialize register: turn statistics on/off, erase highs and lows |
| INIT-SYS | reboots the system |
| MEAS-CUR | measure current |
| MEAS-VG | measure voltage |
| OPR-ACO-ALL | masks or removes all alarms |
| OPR-ACO-EQPT | operate alarm cutoff for individual alarm |
| OPR-EXT-CONT | operates a control relay (e.g., shutdown rectifier) |
| RLS-EXT-CONT | releases the operated control relay (e.g., turn rectifier back on) |
| RTRV-ALM-ALL * | retrieves all alarms |
| RTRV-ALM-ENV | retrieve alarm information from "environmental" alarms info for a specific overhead bitstream housekeeping alarm |
| RTRV-ALM-EQPT * | retrieve a specific alarm or all active alarms, depending on the PSMC |
| RTRV-ATTR | retrieve alarm security (major, minor, etc.) |
| RTRV-ATTR-ENV | Retrieve information for overhead bitstream alarm points |
| RTRV-ATTR-EQPT | retrieve alarm security (major, minor, etc.) for a specific alarm |
| RTRV-EQPT | retrieves the settings for a specific AID (channel) |
| RTRV-EXT-CONT | retrieve the state of an external control relay or contact |
| RTRV-HDR * | retrieves header info on site and monitor |
| RTRV-MMREPT | reports analog readings for a particular AID |
| RTRV-PM-ALL | retrieves readings, histories, and statistics for all channels |
| RTRV-PM-EQPT | retrieve current readings, statistics, or highs and lows |
| RTRV-SECU-USER | retrieve a list of authorized TL1 users |
| RTRV-TH-EQPT | retrieve alarm thresholds for a specific alarm |
| SET-ACO-EQPT | set up the alarm cutoff mode |
| SET-ATTR-ENV | Change the classification and messages of an overhead alarm |
| SET-ATTR-EQPT | change the classification (major, minor, etc.) of an alarm |
| SET-SID | set the office name or name of the alarm device |
| SET-TH-EQPT | set the thresholds for a specific alarm |
| ***REPORT MESSAGES (these precede the actual alarm message to NMA®)*** | |
| REPT^ALM^ENV | cause an environmental alarm and verify output |
| REPT^ALM^EQPT * | cause a power alarm and verify output |

### 13.4 Set Points (Thresholds) for Power Alarms and Power Routines

Analog points are derived from reading actual voltage or current levels within the system and delivering alarms based on the analog levels or combinations of various analog levels and binary states.

Analog points are based on temperature, voltage, current, or a combination of analog and binary information. The following tables describe the values that should be associated with the various analog levels.

In many cases, both minor and major alarm thresholds are listed for each type of alarm. For voltage and temperature set-points, typically only the major alarm is required (if both major and minor values are listed) and the minor alarm is optional if the monitor type allows it, and/or there are enough spare points. For capacity exceeded alarms on current, it is preferable to have both major and minor thresholds (where they exist, but as a bare minimum, the minor should be provisioned.

The tables contain values that can be programmed into a monitor, or can be measured manually with portable instruments and compared.

It is useful before setting thresholds to know the approximate float voltages or normal settings of various DC and AC plants, and the following table summarizes these:

The nominal AC voltage levels found in Table 13-13 come From Article 220.5A of the National Electric Code (NEC®), and should be used in AC computations.

Note that some older 130 V battery plants may have CEMF cells. These should be removed when the plant is replaced or at the next convenient opportunity.

This document (and others) reflects a transition from a traditional flooded lead-antimony average float voltage of -2.17 to -2.20 Volts per lead-calcium flooded cell (as recommended by flooded battery manufacturers) in order to provide more reliable batteries. The further stipulation is that all new -48 V battery plants have 24 batteries per string, providing a float voltage of approximately -52.80 V for flooded lead-calcium strings. Sites that won't function with a float voltage of -2.20 V/cell (some older plants cannot easily have the float voltage raised to -52.80 V due to HVSD settings, etc.) must be configured at the traditional -2.17 V/cell. For lead-calcium batteries that cannot be raised due to alarm or HVSD settings, perhaps the float can be raised part of the way (for example, -52.50). This is better for these batteries than the traditional -52.08.

Whole string boost or equalize charging should only be used in rare cases to quickly recover battery capacity (such as a PV application, or batteries that have been stored too long offline).

**Table 13-13** Typical Output Voltage Settings

| nominal Voltage | Description | Typical |
|---|---|---|
| -48 VDC | float voltage for 37-cell string of Ni-Cd batteries | -52.9 – -52.6 |
| | float @ 77°F with 1.215 s.g. flooded batteries or VRLAs with 1.240-1.250 s.g. | -52.80 |
| -24 VDC | float @ 77°F with 1.215 s.g. flooded batteries or VRLAs with 1.240-1.250 s.g. | -26.40 |
| -48 VDC | float @ 77°F with 1.240 s.g. flooded lead-selenium batteries | -53.52 |
| | float voltage @ 77°F for -48V plants with 1.280-1.295 s.g. VRLAs | -53.8 – -54.2 |
| | finish charge for solar systems with VRLAs (no more than 4 hrs) | -55.7 |
| | float voltage for plants with nominal 52 V float Li-ion packs; or 23-cell VRLAs | -52.08 – 52.3 |
| | float voltage for -48VDC plants with nominal 53.8 – 56 V float Li-ion packs | -53.8 – -55.2 |
| 32 VDC | float voltage @ 77°F with 1.260-1.295 s.g. batteries | 35.87 – 36.13 |
| 24 VDC | | 26.9 – 27.1 |
| 12 VDC | | 13.45 – 13.55 |
| -48 VDC | float voltage for 38-cell string of Ni-Cd batteries | -54.4 – -55.1 |
| | float voltage @ 77°F with 1.300 s.g. VRLAs (this is the most common gravity for VRLAs) | 54.0 – 54.5 |
| 32 VDC | | 36.0 – 36.33 |
| 24 VDC | | 27.0 – 27.25 |
| 12 VDC | | 13.5 – .13.68 |
| -48 VDC | float voltage @ 77°F for -48VDC plants with 1-310-1.335 s.g. VRLAs | -54.8 – -55.2 |
| | initial charge volt (100-250 hrs) for flooded lead-acid (multiply by # series cells) | 2.37 – 2.50 |
| -2 VDC | flooded round cell or lead-calcium single-cell boost/equalize charge (250 hours) | -2.50 |
| -2 VDC | Flooded lead-selenium single-cell boost/equalize charge (for 72 hours) | -2.40 |
| 24/48/130 | string equalize voltage for most plants | =float ±0.1 |
| 12/24/48/60 | Finish charge for photovoltaic/solar plants | =float + ~4% |
| -24/-48 | rectifier fallback voltage if controller fails | =float ±0.1 |
| 360 VDC | float @ 77°F for 180-cell string w/1.280-1.315s.g. VRLA; or 1.240-1.250s.g. flooded | 405 – 409 |
| | float @ 77°F for 180-cell UPS strings with 1.215 s.g. flooded lead-acid batteries | 396 – 405 |
| 480 VDC | float @ 77°F for 240-cell string w/1.280-1.315s.g. VRLA; or 1.240-1.250s.g. flooded | 540 – 545 |
| | float @ 77°F for 240-cell UPS strings with 1.215 s.g. flooded lead-acid batteries | 528 – 540 |
| 24/48 VDC | -48 to 24 V converter plant output setting | 24 |
| | 24 to -48 V converter plant or 48 to 48 V converter plant output | 48 |
| -48/130 | -48 to 130 V converter plant output setting | 130 VDC |
| | extended range -48 to 130 VDC converter plant output voltage setting | 135 – 137.5 |
| -48/145 | -48 to 145 V converter plant output setting | 145 VDC |
| -48/190 | -48 to 190 V converter plant output setting | 190 VDC |
| 120 VAC | single-phase low-line AC output (e.g., some inverters and small UPS) | 120 |
| 240/120 | split-single-phase AC | 240/120 V |
| 208 Y | three-phase wye AC for small and medium-sized buildings | 208/120 V |
| 240 Δ | three-phase high/wild-leg delta AC voltages | 240/208/120 |
| 480 Y | three-phase wye AC for most larger buildings | 480/277 V |

The points of the next table can be set at the PSMC, the conventional DC Plant Controller, and/or the Rectifiers, depending on the manufacturer and model. When the same set point can be set in multiple places, the PSMC takes first priority (uses the levels given in the table), the Plant Controller second priority, and the Rectifiers final priority. In these cases, each successive priority level should be set approximately 0.5 V above or below (depending on whether it is a high or low voltage threshold, respectively) the previous value. For example, if I set the PSMC Low Voltage at –50 V, I can set the DC Plant Controller Low Voltage at –49.4 V, and the Rectifier Low Voltage at –49 V.

The exception to this rule is for HVSD. In the case of HVSD, the controller should have the lowest voltage setting (-56.4 V, as shown in the table), and the rectifiers should be set at –56.9 V. If you want to ensure that only offending rectifiers stay off, you may need to turn off load sharing in switch mode plants, and ensure that the plant rectifier restart circuit *works.* If the switch mode rectifier plant is not capable of working without load sharing on, then it is best to set the rectifiers to the lower HVSD setting (if there are settings for both the rectifiers and controller). Generally, PSMCs (unless an integral part of the Plant Controller) are not wired for control features (per Chapter 8), so HVSD would not be set on them (or if it is set, it would be the last level of defense — e.g., at -57.4 V).

It is generally not necessary to dual wire the same alarms (although backup major and minor alarms through a separate reporting device are encouraged). For example, if each rectifier fail is directly wired to the PSMC, the rectifier minor from the plant controller is probably not necessary.

Note that it is not necessary to have alarms for each of the values in the following tables. Consult Chapter 8 for further guidance.

LVDs are generally discouraged (because they sometimes fail when they shouldn’t) unless required by the manufacturer of the served equipment, or to save Customer Prem batteries. They are required (and are sometimes built into the charge controller) for stand-alone solar sites. They should generally be in series with only the batteries (LVBD); and not directly in series with the load (unless required by an equipment manufacturer).

For all of these threshold tables where the threshold drives an output alarm, there may be a time delay before the alarm comes in to prevent nuisance alarms and to avoid premature action on “chattering” alarm relays. Almost always, time thresholds and number of reoccurrence thresholds in a certain time frame are managed by the receiving alarm management system (such as NMA® or the SNMP manager). However, for particularly troublesome “bouncing” alarms, it is permissible to set a delay of a few seconds (up to 30) at the power monitor or plant controller if it is capable of such time thresholding.

**Table 13-14** Battery Plant Voltage Alarm Set Points

| nominal | Description | Priority | Value | Notes |
|---|---|---|---|---|
| -48 VDC | high float voltage (controlled environments only) | Minor | +0.5 | above float |
| | battery plant high voltage | Major | -55.4 | -55.9 for VRLA batteries |
| 24 VDC | | | 27.6 | 27.9 for VRLA batteries |
| 12 VDC | | | 13.9 | |
| -48 VDC | -48 V battery plant HVSD | Critical | -56.4 | |
| -24 VDC | -24 V battery plant HVSD | | -28.2 | |
| 12 VDC | 12 V battery plant HVSD | | 14.1 | |
| -48 VDC | battery plant low voltage / on discharge | Major | -51.0 | no low float alarm; this value also used to start load-shed timer |
| 24 VDC | | | 25.5 | |
| 12 VDC | | | 12.9 | |
| -48 VDC | battery plant very low voltage | Critical | -46.0 | |
| | battery plant very low voltage reset | | -46.5 | rarely available |
| -24 VDC | -24 V battery plant very low voltage | | -23.0 | |
| -2 VDC | 1.215 s.g. flooded lead-acid pilot cell low voltage | Minor | -2.15 | |
| | | Major | -2.13 | |
| | 1.215 s.g. flooded lead-acid pilot cell high voltage | Minor | -2.25 | |
| | | Major | -2.27 | |
| | 1.240 s.g. flooded lead-acid pilot cell low voltage | Minor | -2.18 | |
| | | Major | -2.16 | |
| | 1.240 s.g. flooded lead-acid pilot cell high voltage | Minor | -2.28 | |
| | | Major | -2.30 | |
| | 1.300 s.g. VRLA pilot cell low voltage | Minor | -2.22 | not usually used |
| | 1.300 s.g. VRLA pilot cell high voltage | | -2.29 | |
| | | Major | -2.33 | |
| -48 VDC | battery plant low voltage load disconnect (LVLD) | Critical | -42.0 | rarely used |
| | low voltage battery disconnect (LVBD) | | -40.0 | |
| | battery plant LVD reconnect | | -49.0 | |
| | solar plant LVD disconnect/reconnect | | 46-47 | |
| -24 VDC | battery plant LVLD | Critical | -21.0 | rarely used |
| | battery plant LVBD | | -20.0 | |
| | battery plant LVD reconnect | | -24.5 | |
| 12 VDC | battery plant LVLD | Critical | 10.5 | rarely used |
| | battery plant LVBD | | 10.0 | |
| | battery plant reconnect | | 12.25 | |
| -48 VDC | 1.215 s.g. flooded lead-acid string high midpoint | Minor | -27.2 | |
| | | Major | -28.0 | |
| | 1.215 s.g. flooded lead-acid string low midpoint | Minor | -25.6 | |
| | | Major | -24.8 | |
| | 1.280-1.300 VRLA string high midpoint | Minor | -28.0 | |
| | | Major | -28.6 | |
| | 1.280-1.300 VRLA string low midpoint | Minor | -26.4 | |
| | | Major | -25.6 | |
| -24 VDC | 1.215 s.g. flooded lead-acid string high midpoint | Minor | -13.6 | |
| | | Major | -14.0 | |
| | 1.215 s.g. flooded lead-acid string low midpoint | Minor | -12.8 | |
| | | Major | -12.4 | |

Plant output of a converter plant without batteries should be set as near as possible to the nominal plant voltage. When it supports batteries, it should be set at the float voltages defined earlier in Table 13-13 with the corresponding thresholds found in Table 13-14.

**Table 13-15** Converter Plant (no batteries on output) Voltage Alarm Set Points

| nominal output Voltage | Description | Priority | Value |
|---|---|---|---|
| 12 VDC | high voltage | Minor | 12.5 |
| | low voltage | | 11.5 |
| -24 VDC | high voltage | | 24.5 |
| | low voltage | | 23.5 |
| | HVSD | Critical | 29.0 |
| 48 VDC | high voltage | Minor | 49.0 |
| | low voltage | | 47.0 |
| | HVSD | Critical | 56.0 |
| 130 VDC | high voltage | Minor | 140 |
| | low voltage | | 125 |
| | HVSD | Critical | 141 |
| 145 VDC | high voltage | Minor | 149 |
| | low voltage | | 140 |
| | HVSD | Critical | 151 |
| 190 VDC | high voltage | Minor | 199 |
| | low voltage | | 180 |
| | HVSD | Critical | 201 |

To help mitigate the possibility of thermal runaway in VRLA batteries, the charge current flowing to the batteries can be limited by automatically lowering the float Voltage as the battery temperature rises (this is temperature compensation). The recommended settings for temperature compensation devices are shown below (not all devices have each of these settings, so try to match those that apply to the particular device). An attempt should be made to get as close as possible to these settings, but not all devices will be able to match these settings. Voltage should not be lowered below open circuit (unless the extreme thermal runaway temperature is reached) in order to avoid severe loss of battery life.

Multiple temperature probes for multiple strings should be used (one per string), and compensation should be based on the highest temperature.

Not all compensation is slope compensation. An attempt should still be made to match the parameters shown in Table 13-16 (except for the slope parameter) when step compensation is all that is available.

Many existing rectifiers used with VRLA batteries have voltage-sensing circuits inaccessible by temperature compensation devices. For these, to limit battery charge current, a Current Limiting device placed in series with each battery string may be used. In addition, some devices perform both compensation and current limiting functions, offering even greater protection from thermal runaway. The acceptable limits for current limiting devices (including battery recharge current limiting settings available in some rectifier shelf controllers) are shown in Table 13-16.

**Table 13-16** VRLA Temperature Compensation and Recharge Current Limit Settings

| nominal Voltage | Description | Settings | Notes |
|---|---|---|---|
| 480 VDC | normal temp comp termination lower voltage | 520 | |
| 360 VDC | | 390 | |
| -48VDC | | -52.0 | -51.3 V for low s.g. VRLA |
| 32 VDC | | 34.6 | |
| 24 VDC | | 26.0 | -25.6 V for low s.g. VRLA |
| 12 VDC | | 12.9 | |
| 480 VDC | highest voltage where compensation should stop | 559 | |
| 360 VDC | | 419 | |
| -48 VDC | | -55.4 | |
| 32 VDC | | 36.8 | |
| 24 VDC | | 27.7 | |
| 12 VDC | | 13.85 | |
| | potential deadband where temp comp is not active | 68-86°F (20-30°C) | recommended in controlled environments |
| | lowest temp comp temperature | 30°F | ≈ -1°C |
| | maximum temperature for slope temp comp (to voltage given in first 6 rows of this table) | 135°F | ≈ 57°C |
| | final step temp comp temperature | 167°F | = 75°C |
| 480 VDC | final step temp comp voltage | 480 | |
| 360 VDC | | 360 | |
| -48 VDC | | 48.0 | -46.2 V for low s.g. VRLA |
| 32 VDC | | 32.0 | |
| 24 VDC | | 24.0 | -23.1 V for low s.g. VRLA |
| 12 VDC | | 12.0 | |
| | maximum battery disconnect temperature | 174°F | = 79°C |
| | slope of compensation | -1.3 to -3.6 mV/cell/°C | per battery manufacturer |
| | recharge current limit | C/5-C/30 A | C = 8-hr Ah rating |

For the recharge current limit, as noted, C is the Amp-hour rating of the string at the 8-hour rate to 1.75 V/cell at 77°F. For example, the current limit of a 100 A-hr battery string limited to C/20 would be 5 Amps.

Care must be taken to ensure that current limiting doesn't cause the plant to perform a High Voltage ShutDown while attempting to recharge the batteries. This can happen on certain rectifiers if current limiting is set too tightly. For example, a type of rectifier may perform an HVSD while attempting to recharge if the current limiting is set for C/20. In this case, the limits should be set for C/10. Check the documentation of the suppliers of the current limiting device and power plant to see if this may be a problem. Also, because discharge current as well as recharge current passes through the current limiting device, ensure that the discharge current capacity of the device and its cabling is sufficient to meet the portion of the projected site load that will be placed on the individual string or group of strings served by the current limiting device.

There is no need to remotely report an alarm when temperature compensation or current limiting is active. However, battery temperature alarms or battery current alarms may be set in accordance with the guidelines given in Table 13-17.

**Table 13-17** Power Temperature Alarm Set Points

| Description | Priority | Value | Notes |
|---|---|---|---|
| power room low temperature in indoor non-RT sites | Minor | 55°F | Major alarm unnecessary |
| power room high temperature in indoor non-RT sites | | 86°F | = 30°C |
| controlled environment RT power room low temp | | 52°F | |
| controlled environment RT power room high temp | | 95°F | |
| controlled environment engine room low temperature | | 47°F | |
| controlled environment engine room high temperature | | 93°F | ignore during engine run |
| flooded pilot cell low temperature | | 59°F | Major alarm unnecessary |
| flooded pilot cell high temperature | | 90°F | |
| controlled environment VRLA low temperature | | 50°F | |
| controlled environment VRLA high temperature | Minor | 95°F | = 35°C |
| | Major | 104°F | = 40°C |
| battery temperature recognizing heater pad fail | Minor | 27°F | in RT or engine room |
| diesel engine coolant high temperature | Minor | 203°F | |
| | Major | 215°F | |
| diesel engine coolant low temperature | Minor | 87°F | |
| | Major | 37°F | |
| flooded battery – room differential temperature | Minor | 8°F | |
| | Major | 12°F | |
| VRLA – ambient differential temperature | Minor | 12°F | |
| | Major | 20°F | |

Engine room low temperatures do not have to be alarmed if the engine is equipped with block/coolant heater(s) and battery heating pad(s).

Because VRLAs are susceptible to thermal runaway, whenever the ability to monitor battery and/or differential temperature exists, it should be done; and is much more useful than room temperature alone; especially a differential temperature alarm.

Current monitoring points shown below might or might not be monitored. "Major" power sources and primary DC distribution will be monitored. Table 13-18 covers all DC current monitoring, as well as AC current monitoring for breakers and fuse capacity (see Table 13-22 for AC load current capacity thresholds).

**Table 13-18** Current Thresholds

| Description | Priority | Value | Notes |
|---|---|---|---|
| battery discharge current | Minor | 80% | based on 4 or 8-hr rate |
| | Major | 100% | |
| string discharge current imbalance for the same chemistry and Ah rating | Minor | 30% | from the average |
| | Major | 50% | |
| flooded battery recharge current | Minor | C/150 | alarm in > 24 hrs before alarm center dispatches |
| VRLA battery recharge current | | C/50 | |
| Li-ion battery current | Minor | 80% | based on mfg max |
| pure lead or lead-calcium battery float current | Minor | 160% | 60% above baseline |
| pure lead or lead-calcium flooded battery float current | | 0.15 mA/Ah | avg low current over min |
| lead-calcium or pure lead-tin VRLA float current | | 1.5 mA/Ah | controlled env & comp |
| pure lead or lead-calcium battery float current | Major | 250% | 2½ times baseline |
| pure lead or lead-calcium flooded battery float current | | 0.25 mA/Ah | avg low current over min |
| lead-calcium or pure lead-tin VRLA float current | | 2.5 mA/Ah | controlled env & comp |
| lead-selenium float current | Minor | 250% | 2½ times baseline |
| | | 0.5 mA/Ah | avg low current over min |
| | Major | 400% | 4 times baseline |
| | | 0.8 mA/Ah | avg low current over min |
| low-antimony VRLA float current | Minor | 300% | 3 times baseline |
| | | 5 mA/Ah | for controlled enviro & temp comp |
| | Major | 8 mA/Ah | |
| | | 500% | 5 times baseline |
| foamed-plate Ni-Cd float current | Minor | 1000% | 10 times baseline |
| | | 5 mA/Ah | |
| UPS battery string AC ripple current | Minor | 150% | assumes similar UPS load from baseline reading |
| | Major | 250% | |
| UPS VRLA monobloc string charge current AC ripple | Minor | 1.2A/100W/cell | Approximately equal to IEEE-recommended 5 A / 100 Ah |
| UPS VRLA 2 V jar string AC ripple current | | 2.4A/100W/cell | |
| flooded UPS battery string AC ripple current | | 1.8A/100W/cell | |
| rectifier overcurrent | Minor | 101% | doesn't apply to constant-power rectifiers |
| | Major | 106% | |
| DC plant capacity | Minor | 80% | smallest of bus, shunt, n-1 rectifier or recharge |
| | Major | 100% | |
| A/B (dual) feed fuse/breaker capacity | Minor | 40% | |
| | Major | 50% | |
| true A/B (dual) feed current imbalance | Minor | 10% | from the average of the 2 |
| non-redundant feed fuse/breaker capacity | Major | 80% | AC or DC |
| AC phase current imbalance for panel loaded > 20% | Minor | 15% | from the avg for rectifier or mechanical panels |
| AC phase current imbalance for panel loaded ≤ 20% | | 30% | |

When a minor current capacity alarm is exceeded, in order to avoid a standing alarm, the threshold can be raised in 5% increments or smaller until the situation is corrected. The major alarm threshold may not be raised.

Note that float currents at high temperatures will increase significantly without temperature compensation.

AC phase current imbalances should be on at least a few second time delay to allow for startup, and are not applicable to high-leg delta systems.

A big contributor to the shorter lives of most UPS batteries is lower frequency AC ripple on the DC bus (some coming from poor charger filtering, but most being poorly-filtered feedback onto the DC bus from the inverter). Ripple voltage is easily measured and is a major contributor to the amplitude of the ripple current, but the relatively low frequency (below 667 Hz) ripple current damages the battery most. Battery manufacturers and the IEEE have recommendations on maximum ripple current allowed (see Table 13-18); however, these are relatively high, and it would be much less damaging to the battery if the levels were even lower. Setting a baseline ripple current reading for a particular UPS with a particular battery model and a relatively constant load can be useful if the change from that is tracked and used to indicate when to replace filter capacitors in the UPS.

There are both permanent and portable test sets that can periodically use a discharge or an AC signal to determine the internal resistance (resistance meters use a short DC discharge) or impedance (impedance or conductance meters use an impressed AC signal) of a battery cell or monobloc (they are also often used to determine the micro-ohm resistance of intercell connections) to determine whether it is good or close to the end of its life. While there is no direct linear correlation between an internal ohmic reading and the actual capacity of the battery, ohmic readings can be used to spot problem cells/monblocs and replace them before they cause a problem.

**Table 13-19** Battery Ohmic Thresholds

| Description | Priority | Value | Notes |
|---|---|---|---|
| UPS or long duration VRLA battery resistance/impedance | Minor | 130% | baseline = 100%; and while manufacturer-provided baselines can be used, the best baseline is read approximately 90 days after installation (for new installations, the average of all the readings can be used as a baseline) |
| | Major | 150% | |
| UPS or long duration VRLA battery conductance/admittance | Minor | 77% | |
| | Major | 67% | |
| engine start battery conductance/admittance/CCA | Minor | 50% | |
| | Major | 32% | |
| engine start battery resistance/impedance | Minor | 200% | |
| | Major | 300% | |
| intercell connection resistance/impedance | Minor | 120% | |
| | Major | 150% | |
| Intercell connection conductance/admittance | Minor | 83% | |
| | Major | 67% | |

AC voltage measurements are defined as the rms (effective) voltage difference between any two conductors of the circuit. The actual level of the voltage is determined by the phase of the circuit (single or 3 phase), configuration, and the base voltage.

**Table 13-20** AC Voltage Thresholds

<table>
<tr><th>nominal AC Voltage</th><th>Description</th><th>Priority</th><th>Value</th></tr>
<tr><td rowspan="5">120 line-neutral</td><td>low voltage (& return to commercial)</td><td>Major</td><td>103 V</td></tr>
<tr><td>engine start low level</td><td></td><td>101 V</td></tr>
<tr><td>AC fail level</td><td rowspan="2">Major</td><td>100 V</td></tr>
<tr><td>high voltage (& return to commercial)</td><td>132 V</td></tr>
<tr><td>engine start high level</td><td></td><td>133 V</td></tr>
<tr><td rowspan="5">208 line-line or line-neutral</td><td>low voltage (& return to commercial)</td><td>Major</td><td>187 V</td></tr>
<tr><td>engine start low level</td><td></td><td>182 V</td></tr>
<tr><td>AC fail level</td><td rowspan="2">Major</td><td>173 V</td></tr>
<tr><td>high voltage (& return to commercial)</td><td>229 V</td></tr>
<tr><td>engine start high level</td><td></td><td>231 V</td></tr>
<tr><td rowspan="5">240 line-line</td><td>low voltage (& return to commercial)</td><td>Major</td><td>207 V</td></tr>
<tr><td>engine start low level</td><td></td><td>203 V</td></tr>
<tr><td>AC fail level</td><td rowspan="2">Major</td><td>200 V</td></tr>
<tr><td>high voltage (& return to commercial)</td><td>264 V</td></tr>
<tr><td>engine start high level</td><td></td><td>266 V</td></tr>
<tr><td rowspan="5">277 line-neutral</td><td>low voltage (& return to commercial)</td><td>Major</td><td>249 V</td></tr>
<tr><td>engine start low level</td><td></td><td>245 V</td></tr>
<tr><td>AC fail level</td><td rowspan="2">Major</td><td>242 V</td></tr>
<tr><td>high voltage (& return to commercial)</td><td>291 V</td></tr>
<tr><td>engine start high level</td><td></td><td>294 V</td></tr>
<tr><td rowspan="5">480 line-line</td><td>low voltage (& return to commercial)</td><td>Major</td><td>432 V</td></tr>
<tr><td>engine start low level</td><td></td><td>425 V</td></tr>
<tr><td>AC fail level</td><td rowspan="2">Major</td><td>418 V</td></tr>
<tr><td>high voltage (& return to commercial)</td><td>504 V</td></tr>
<tr><td>engine start high level</td><td></td><td>509 V</td></tr>
</table>

Fuel Tanks come in many sizes. Engine manufacturers will give gal/hr consumption at full-rated load, from which tank size is computed; or similarly, reserve hours remaining in the tank can be computed by dividing the consumption rate into the gallons.

**Table 13-21** Fuel Alarm Thresholds

<table>
<tr><th>Description</th><th>Priority</th><th>Value</th><th>Notes</th></tr>
<tr><td rowspan="2">low fuel alarm for the main tank</td><td>Minor</td><td>50% of tank size</td><td rowspan="2">If only 1 alarm, must be Major</td></tr>
<tr><td>Major</td><td>25% (not below 12 hrs)</td></tr>
<tr><td>Low fuel alarm for the day tank</td><td>Major</td><td colspan="2">5% below the “call to fill” sensor</td></tr>
<tr><td>high diesel fuel alarm</td><td>Major</td><td>90-95%</td><td>may only be a local alarm</td></tr>
<tr><td>Propane tank overfill</td><td>Major</td><td>80-85%</td><td></td></tr>
</table>

For example, a low fuel major alarm on a fully-filled tank with 96 run hrs at full engine load would be set at 25% of tank volume (24 full load run hours left); however, for an existing fully-filled tank with only 36 run hrs of capacity at full load, the low fuel major would be set at 12 full-load run hrs (33% of tank volume) rather than at 9 hrs (25% of tank volume) in order to have a little more time to find a refueler in disaster situations.

**Table 13-22** kW/kVA or AC Ampere Load Capacity Thresholds

| Description | Priority | Value | Notes |
|---|---|---|---|
| redundant UPS, PDU or transformer kW/kVA or AC Ampere load | Minor | 40% | |
| | Major | 50% | |
| redundant inverter or engine kW/kVA or AC Amp load | Minor | 80% | of n-1 capacity |
| | Major | 100% | |
| non-redundant kW/kVA or AC Ampere load | Minor | 80% | |

For AC load capacity, it is preferable to monitor and threshold kW or kVA due to varying power factor; however, this is not always possible, so AC Amps may be used.

## 13.5 Typical Power Alarm and Monitor Points

Due to cost, it is not feasible to alarm everything in a site. This section serves as a guide to which alarm, monitor, and control points to connect for different types of sites.

The more information that can be communicated via alarming, the better analysis and dispatch will be. A CEV, hut, Radio site, or small CO (CdO) may have one small battery plant, no engine, a ring plant, and may or may not have converters or inverters. Therefore, there will not be many alarms. Sample points for small sites are listed below in Tables 13-23 through 13-25.

**Table 13-23** Typical Power Alarm Points for Smaller Sites Without Engines

| ALARM | Criticality | Description/Notes |
|---|---|---|
| commercial AC Power Failure | Major | input power to the rectifiers has failed |
| generic Power (plant) Major | Major | power plant major or generic power major from monitor |
| generic Power (plant) Minor | Minor | power plant minor or generic power minor from monitor |
| single Rectifier Failure (RFA) | Minor | a single rectifier has failed |
| Multiple Rectifier Failures | Major | more than one rectifier has failed |
| DC Plant Fuse/Breaker Operated | Major | any fuse or breaker alarm at the DC plant |
| Battery on Discharge / Low Voltage (LVA) | Major | plant voltage is low and/or the battery is on discharge |
| High DC Plant Voltage and/or HVSD | Major | the batteries are being overcharged |
| Battery Disconnect and/or LVD | Major/Critical | individual strings, or all batteries disconnected |
| Surge Arrestor Fail | Major | the TVSS/SPD has failed |
| Ring Plant Major | Major | ring plant major (if there is a ring plant) |
| Ring Plant Minor | Minor | ring plant minor (single ringer/interrupter fail/transfer) |
| Converter Plant Minor | Minor | individual converter failure (if there is a converter plant) |
| Converter Plant Major | Major | converter plant fuse alarm, multiple converters failed, etc |

In some Prems, RTs, etc., the only transport is via fiber mux housekeeping or overhead bits. While some muxes have 16 or more hka bits for the alarms of Table 13-23, others have a limited set of overhead bits for power alarms, as per Tables 13-24 and 13-25.

**Table 13-24** Typical Power Alarm Points for Small Sites With Only 4 Overhead Bits

| ALARM(s) | Criticality | Description/Notes |
|---|---|---|
| Commercial AC Power Failure | Major | power has failed to the rectifiers |
| Low DC Plant Voltage / Battery on Discharge | Major | batteries are on discharge |
| single Rectifier Failure | Minor | one rectifier has failed |
| multiple Rectifier Failures, Fuse Fail, or other | Major | multiple rectifiers failed, fuse/breaker tripped, etc. |

**Table 13-25** Typical Power Alarm Points for Small Sites With Only 2 Overhead Bits

| ALARM(s) | Criticality | Description/Notes |
|---|---|---|
| generic Power Major | Major | AC Fail, BOD, power fuse alarm, high voltage, etc. |
| generic Power Minor | Minor | single rectifier fail, or any other power minor |

Table 13-26 lists "typical" power alarm points for larger sites, such as those with a permanent engine-alternator. Configurations for these types of sites and their alarming vary, so it would be impractical to list every possible alarm found in these locations. Therefore, this Table serves as only a guide to the most common points.

**Table 13-26** Power Points for Larger Sites with Engines (page 1 of 2)

| ALARM | Criticality | Description/Notes |
|---|---|---|
| **BATTERY/RECTIFIER PLANT** | | |
| individual Rectifier Failure (RFA) | Minor | a single rectifier has failed |
| Multiple Rectifier Failures | Major | more than one rectifier has failed |
| generic Power (plant) Major | Major | generic power plant or power monitor major alarm |
| generic Power (plant) Minor | Minor | gneeric power plant or power monitor minor alarm |
| DC Plant Fuse/Breaker Operated | Major | any fuse (FA) or breaker alarm at the main PBD(s) |
| Battery on Discharge (BOD) / Low Voltage | Major | batteries are on discharge or are not charged up |
| Very Low Voltage | Critical | nearing the end of battery discharge (optional) |
| High DC Plant Voltage (HVA) | Major | the batteries are being overcharged |
| High Voltage ShutDown (HVSD) | Critical | rectifiers have shut down due to very high voltage |
| Battery Disconnect | Major | battery disconnect device (breaker?) open (when used) |
| Battery Major/Failure | Major | available from some smart batteries or monitors |
| Battery Minor | Minor | |
| Power Monitor/Controller Watchdog | Major | power monitor/controller microprocessor failure |
| **RING PLANT** | | |
| Ring Plant Major and/or Ring Plant Fuse Alarm | Major | multiple ringers/interrupters or fuse failed |
| Ring Plant Minor or Ring Generator Failure | Minor | single ringer/interrupter failed, or ringer transfer |
| **UPS** | | |
| UPS Fail/Major | Major | UPS fail or other major UPS alarm |
| UPS on Bypass | Minor | UPS in an abnormal state (e.g., on bypass, etc.) |
| UPS Battery on Discharge / Low Voltage | Major/Critical | UPS is on battery (criticality depends on loads & time) |

**Table 13-26** Power Points for Larger Sites with Engines (page 2 of 2)

| ALARM | Criticality | Description/Notes |
|---|---|---|
| **INVERTER PLANT** | | |
| Inverter Fail/Major alarm | Major | inverter plant fail or other inverter major alarm |
| Inverter on Bypass | Minor | inverter on alternate source (when equipped) |
| Inverter Bypass Not Available | Major | inverter bypass isn't available (when equipped) |
| **COMMERCIAL AC** | | |
| Commercial AC Power Failure | Major | AC power to the site has failed |
| Surge Arrestor Fail | Major | the TVSS/SPD has failed |
| Ground Fault Detection | Major | AC source locked out due to a large ground fault |
| **STANDBY ENGINE** | | |
| standby Engine Run | Minor | the backup engine is running |
| Load Transferred to Engine | Minor | transfer switch operated properly (optional) |
| Single-Phase Lockout | Major | some transfer switches won't work if a phase fails |
| Engine Controls or Transfer Switch Not in Auto | Minor | engine controls not returned to Automatic after test |
| Engine Start Battery Charger Fail or Low Voltage | Major | engine start battery charger failed or battery low volts |
| Engine Fail | Major | the backup engine has failed |
| Engine OverCrank | Major | (optional) if these alarms are combined into generic engine fail |
| Engine Emergency Stop Button | Major | |
| engine shutdown due to Low Coolant | Major | |
| engine shutdown due to High Coolant Temperature | Major | |
| Engine OverSpeed | Major | |
| engine shutdown due to Low Oil Pressure | Major | |
| Engines Failed to Parallel | Major | One or more engines failed to sync to the bus |
| Fuel System Trouble alarm | Major | generic fuel system problem (e.g., leak, low fuel) |
| Fuel Leak | Major | (optional) if combined into generic fuel system trouble |
| Low Fuel (Main Tank) | Minor/Major | |
| Low Fuel (Day Tank – where equipped) | Major | |
| **CONVERTER PLANT** | | |
| Converter Plant Minor | Minor | use only if other alarms that make up this major and minor are not remoted to NMA® |
| Converter Plant Major | Major | |
| individual Converter Failure | Minor | generic or individual converter fail(s) |
| Converter Plant Distribution Fuse Alarm | Major | generic converter distribution fuse alarm(s) |

For further information on monitoring and optional versus required points, see Chapter 8 of this Tech Pub.

### 13.6 Power SNMP Traps

Many DSL and Ethernet based systems in the Legacy Qwest Local Network portion of CenturyLink™ report their alarms via SNMP Traps to MicroMuse's NetCool™. This is also true for CO-based alarms in Legacy CenturyTel (they often route their alarms through translation devices that create the SNMP traps). Table 13-27 lists some of the common SNMP traps for power-related alarms found in various CenturyLink™ companies.

**Table 13-27** SNMP Power Messages used in CenturyLink™

| SEVERITY | SNMP Trap Message | Description |
|---|---|---|
| Major | acFailure | commercial AC power failure |
| | PR001 - PR005 | |
| Major | batteryOndischarge | batteries on discharge |
| Minor | boostOn | batteries are on boost/equalize charge |
| Critical | communicationLost | communication lost to the controller |
| Major | FuseFailure | fuse blown |
| Critical | PR042 - PR062 | power distribution alarm |
| Major | PR072 - PR092 | |
| Minor | PR093 - PR113 | |
| Critical | PR135 - PR152 | relay rack fuse alarm |
| Major | PR153 - PR170 | |
| Minor | PR171 - PR185 | |
| Critical | lowBattery | battery is in a discharged state |
| Major | powerMajor | generic power major |
| Minor | powerMinor | generic power minor |
| Minor/Major | PR021 - PR041 | rectifier fail |
| Minor | PowerShed | some loads have been shed in order to lengthen POTS battery backup |
| Major | MS441 - MS450 | toll ring generator alarm |
| Minor | surgeArrestor | TVSS/SPD failure |
| Minor | PR006 - PR010 | generator run |
| Major | PR011 - PR015 | generator fail to start |
| Major | PR016 - PR020 | transfer switch fail |
| Major | EN081 - EN090 | fuel tank alarm |
| Major | PR114 - PR134 | inverter (DC-to-AC converter) fail |
| Major | upsBypass | UPS is on bypass |
| Major | upsBypassacabnormal | UPS is on bypass due to poor AC quality from the inverter |
| Major | upsBypassacnormal | UPS is on bypass, but the inverter is working properly |
| Major | upsBypassFreFail | UPS failed to enter bypass due to failure to sync on frequency |
| Critical | upsDischarged | UPS battery is discharged |
| Critical | upsDiagnosticsFailed | UPS self-check failed |
| Critical | upsOnBattery | UPS battery on discharge |
| Critical | upsOverload | UPS is overloaded |
| Major | upsRebootStarted | UPS reboot started |
| Major | upsRecRoterror | upsRecroterror |
| Major | upsScheduleShutdown | the UPS is in a scheduled shutdown |
| Major | upsSleeping | the UPS is in sleep mode |
| Major | upsTemp | high temperature alarm on the UPS |
| Major | upsTest | UPS is in test mode |
| Major | upsTurnedOff | UPS has been turned off |

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**Tables**

# 14. Introduction

## 14.1 Scope

This Chapter provides a procedure for auditing Power Plants in order to add or modify equipment. Depending on the scope of the job requested by the CenturyLink™ Engineer, only portions of this may be necessary.

## 14.2 Detailed DC Power Engineering Audit

This Section provides a check list for performing an audit on power plants and their associated equipment. When using this check list, an "overview" inventory of the site (using the forms in Chapter 15) may also be helpful. Copies shall be made available for the CenturyLink™ Engineers and the local Power Maintenance Engineer.

## 14.3 Check List

### 14.3.1. Power Plants

- 14.3.1.1. What type of power plant and the Manufacturer? (111A, 153, 154, 155, 302, 326, Lineage 2000 MCS, 1231H, 1231V, GPS, etc.)
  - 14.3.1.1.1. What is the model?
  - 14.3.1.1.2. If it is a WECO type plant is it a bus bar plant?
  - 14.3.1.1.3. Does the plant have main term bars (a "chandelier")?
- 14.3.1.2. PBD location?
- 14.3.1.3. Power Plant voltage, (-48, ±24, ±130V)?
- 14.3.1.4. What type of controller does the power plant have?
- 14.3.1.5. How many PBD bays?
- 14.3.1.6. How many cables (and their sizes) are there feeding each PBD bay?
  - 14.3.1.6.1. Bay number 1
  - 14.3.1.6.2. Bay number 2
  - 14.3.1.6.3. Bay number 3
  - 14.3.1.6.4. Bay number 4
- 14.3.1.7. List available fusing/circuit breaker locations, and sizes on plant.
  - 14.3.1.7.1. Fuse/CB number, PBD number
  - 14.3.1.7.2. Fuse/CB number, PBD number
  - 14.3.1.7.3. Fuse/CB number, PBD number
  - 14.3.1.7.4. Fuse/CB number, PBD number
- 14.3.1.8. Where is the plant main shunt located (if there is one)?
  - 14.3.1.8.1. Status of the main plant chandelier (if there is one)?
    - 14.3.1.8.1.1. Where is the chandelier located?
      - 14.3.1.8.1.1.1. What size is the chandelier bus bar (physical cross-sectional dimensions and laminations, or ampacity)?

14.3.1.9. Are there enough connections available for rectifier(s), battery string(s), and PBD additions?
14.3.1.10. What is the drain on the power plant?
14.3.1.10.1. Plant meter reading.
14.3.1.10.2. PSMC reading (if there is one).
14.3.1.10.3. What is the reading of the main power plant shunt in millivolts?
14.3.1.10.4. What is the millivolt and Ampere rating of the main shunt?
14.3.1.11. How many rectifiers are in the plant now?
14.3.1.11.1. What type, model number, and current output?
14.3.1.11.2. Rectifier nameplate AC input Amps, voltage, and phases (1 or 3)
14.3.1.11.3. Where are rectifiers fed from: PDSC or main AC power board?
14.3.1.11.3.1. If it is from a PDSC what type, ampacity rating and what size of circuit breaker feeds it?
14.3.1.11.3.2. Is the peak load of the rectifier(s) fed by each individual PDSC or HSP breaker/fuse ≤ 80% of the protector size?
14.3.1.11.3.3. For plants with an ultimate size of 2400 A or greater, are the rectifiers split up between 2 or more PDSCs?
14.3.1.11.3.4. Are there spare breaker positions to feed more rectifiers; if so write down the make and model # of the existing breaker/fuse and check to ensure they are still available?
14.3.1.11.4. Are the rectifiers operational, (do they turn on)?
14.3.1.11.5. Each rectifier ammeter reading.
14.3.1.11.5.1. Rectifier G1
14.3.1.11.5.2. Rectifier G2
14.3.1.11.5.3. Rectifier G3
14.3.1.11.5.4. Rectifier G4
14.3.1.11.5.5. Rectifier G5
14.3.1.11.5.6. Rectifier G6
14.3.1.11.5.7. Rectifier G7
14.3.1.11.5.8. Rectifier G8
14.3.1.11.5.9. Rectifier G9
14.3.1.11.5.10. Rectifier G10
14.3.1.12. Is there a PSMC monitoring system existing; if so name type?
14.3.1.12.1. How many available points?
14.3.1.12.2. List of analog points?
14.3.1.12.3. List of binary points?
14.3.1.12.4. Is CO equipment intranet ethernet available?
14.3.1.12.5. Have all alarms been tested and confirmed by the alarm center?
14.3.1.12.5.1. If yes what is the log number?

14.3.1.13. What type of equipment does the power plant feed?
14.3.1.13.1. IOF/Toll/Transport?
14.3.1.13.2. Isolated ground plane Switch?
14.3.1.13.3. Both?
14.3.1.13.4. If ESS™ is it 5E, DMS™, or Ericsson?
14.3.1.14. Where is the ground window (if an ESS™ or shared plant)?
14.3.1.14.1. Is the ground window also the plant return bar?
14.3.1.14.2. Is the ground window a remote ground window?
14.3.1.14.3. Can the ground window be grown?
14.3.1.14.4. How many positions are available on the:
14.3.1.14.4.1. Integrated side?
14.3.1.14.4.2. Isolated side?
14.3.1.14.5. How many and what size of cables are powering the ground window MGB bar(s) if it is doubling as the plant return bar?
14.3.1.14.6. If bar feeds distribution, can distribution be rerun to BDFB(s)?
14.3.1.15. Is the frame grounding of power bays and battery stands adequate?
14.3.1.16. Location of Power equipment
14.3.1.16.1. Is there physically enough room to add it?
14.3.1.16.2. Is it the best location?
14.3.1.16.3. Are there overhead obstructions?
14.3.1.16.4. What is the closest distance to equipment being fed?
14.3.1.16.5. Are there problems getting AC input to rectifier PDSCs?
14.3.1.16.6. Check aisle depth vs. NEC requirements for AC-fed gear.

### 14.3.2. Batteries

14.3.2.1. How many battery strings are there in the plant now?
14.3.2.2. What type and size, (MCT II 4000, LCT1680, GU45, FTC21P, KS20472L1S etc.), and installation date for each string?
14.3.2.2.1. String A
14.3.2.2.2. String B
14.3.2.2.3. String C
14.3.2.2.4. String D
14.3.2.2.5. String E
14.3.2.2.6. String F
14.3.2.2.7. String G
14.3.2.2.8. String H
14.3.2.2.9. String J
14.3.2.3. Is each battery string equipped with shunts?
14.3.2.4. What are the types of battery stands?
14.3.2.5. What cabling is needed to meet voltage drop for new stands?

**14.3.3. What cable racking is required?**

14.3.3.1. Ceiling height?
14.3.3.2. Is there any existing superstructure?
14.3.3.3. Will two levels of framing be required?
14.3.3.4. What types of connections are required to ceiling? (Ceiling inserts, or imbedded Uni-Strut™?)
14.3.3.5. If there is no existing superstructure, can everything be supported from the floor?
14.3.3.6. Are there obstructions such as air vents/duct, pipes etc.?
14.3.3.6.1. No water pipe is directly above power equipment?
14.3.3.7. Is there proper sway bracing for E/Q zone if applicable?
14.3.3.8. Is there separate fused and unfused cable racking?

**14.3.4. How much cable is piled on the rack and is it blocked?**

14.3.4.1. Are cable holes full?

**14.3.5. Floor loading of equipment.**

**14.3.6. Converter Plants**

14.3.6.1. What is the location of the converter plant?
14.3.6.2. What is the model number of the converter plant?
14.3.6.3. Who is the manufacturer of the converter plant?
14.3.6.4. What is the voltage of the converter plant? (±24V, ±130V, etc.)
14.3.6.5. What is the load on the converter plant?
14.3.6.6. What is the feeding power plant?
14.3.6.6.1. What size is the fusing feeding the converters?
14.3.6.7. What are the quantities and sizes of the converters?
14.3.6.8. Identify the existing loads on the converter plant distribution, and spare positions.
14.3.6.9. Is the converter plant properly grounded and ground-referenced

**14.3.7. Ringing Plants**

14.3.7.1. What is the location of the ring plant?
14.3.7.2. What is the model number of the ring plant?
14.3.7.3. Who is the manufacturer of the ring plant?
14.3.7.4. What is the feeding power plant?
14.3.7.5. What is the ring generator model number?
14.3.7.5.1. How many ring generators are there?
14.3.7.6. What is the tone generator model number?

14.3.7.7. What is the interruptors' model number?
14.3.7.8. Identify existing loads on the ring plant distribution, and spare positions
14.3.7.9. Is the ring plant properly grounded and ground referenced?

### 14.3.8. AC Equipment

14.3.8.1. What is the AC voltage and phases available at the main HSP?
14.3.8.1.1. 208V, 240V, or 480V, and single or three-phase?
14.3.8.2. What are the voltage and current readings at the HSP?
14.3.8.3. Can the HSP be added to safely?
14.3.8.4. Where does one go to get AC to power the rectifier(s)?
14.3.8.5. Are rectifiers powered from a step up or down transformer?
14.3.8.6. What is the circuit breaker or fuse size for the main AC entrance?
14.3.8.7. What is the cable size of the HSP conductors?
14.3.8.8. What is Ampere rating of the House Service Panel?
14.3.8.9. What is the transformer from the utility company rated at (kVA)?
14.3.8.10. What is the make and model of the transfer switch?
14.3.8.11. What is the make, model, rating, and load of the existing inverter and/or UPS?
14.3.8.12. Identify existing inverter/UPS distribution.
14.3.8.13. Is the AC equipment properly bonded and grounded?

### 14.3.9. Standby Engine-Alternator

14.3.9.1. What was the load and date at the last engine run?
14.3.9.2. What is the kW rating of the standby set?
14.3.9.3. What is the size and type (above-ground, vaulted, etc.) of the main fuel tank?
14.3.9.4. What type of fuel does the standby set use (diesel, gas, propane)?
14.3.9.5. What is the engine start battery's model and installation date?
14.3.9.6. What is the Battery charger size and type?
14.3.9.7. Is there a fuel tank monitor?
14.3.9.8. Is the Engine room/enclosure and tank properly bonded and grounded?

### 14.3.10. Lighting

14.3.10.1. Is there DC task lighting available per Chapter 12?
14.3.10.2. Is there low level AC lighting in place in the power areas?
14.3.10.3. Is any lighting required for added equipment?
14.3.10.3.1. Where is power available to add lighting, and is it 120 or 277V?

### 14.3.11. Battery Distribution Fuse Boards (BDFBs)

14.3.11.1. Is there physically enough room to add a BDFB?
14.3.11.2. Is the planned location for the BDFB the best location?
14.3.11.3. Are there overhead obstructions, both above the BDFB for potential cable entrance and return bars, and in the primary cable rack path?
14.3.11.4. What is the closest distance to the equipment being fed?
14.3.11.5. Are there available fuse positions and return bus positions in the existing BDFB?
14.3.11.5.1. Are the fuse assignments records updated for the BDFB?
14.3.11.5.2. If the BDFB is out of return bus positions, can it be expanded?
14.3.11.6. Complete Table 14-1 for each BDFB. (**Note:** There should be a minimum of 2 and a maximum of 8 feeder fuses for each BDFB)
14.3.11.6.1. If the load is greater than half the feeder fuse capacity for any BDFB, that BDFB must be immediately embargoed for growth, an MR must be generated by the Power Maintenance Engineer, and a direct call must be made to engineering to address the problem. If this is the case for any BDFB/BDCBB or dual load miscellaneous fuse/breaker panel, can any of the loads be transitioned to relieve the burden?
14.3.11.6.2. What is the make, model, and RR # of the existing BDFB?
14.3.11.6.3. Is there dedicated power rack at the BDFB?

**Table 14-1** BDFB Capacity Table

| **BDFB LOCATION:** | | | |
|---|---|---|---|
| | Feeder Fuse Location | Fuse Capacity | Load Reading at BDFB or PBD |
| A FEEDER | | | |
| B FEEDER | | | |
| C FEEDER | | | |
| D FEEDER | | | |

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**Forms**

# 15. Turn Up, Test and Acceptance Procedures

## 15.1 General

The attached forms are for use in all types of sites for performance of power turn up, test, and acceptance. The forms are self-explanatory, with listings for notes, functions, and supporting documentation. Supporting documentation for the functions will vary by site because there are many different manufacturers for each type of equipment. Copies of most of these forms can also be found in CenturyLink™ Technical Publication 77350. Three copies of each form shall be made; one shall be left on site with the job package, one shall be sent to the CenturyLink™ Engineer, and one shall be sent to the local CenturyLink™ Power Maintenance Engineer for that state. Note that the forms do not start with Form number 1. This is due to the fact that the forms originate from an internal CenturyLink™ power maintenance document, and in order to ensure that contracted installers and CenturyLink™ technicians are using the same form for the same activity, the form numbers of that document have been retained.

The installation provider is responsible for verifying that all the alarms are reporting correctly to the proper alarm center. The installer must call the alarm center and ask them whether an alarm has been generated, and whether the names(s) of the alarm(s) generated correspond(s) to the alarm the installer initiated. The installer shall then note the center response on the proper form(s).

## 15.2 Maintenance Window Guidelines for Power

A Maintenance (Installation) Window is a predetermined period during each day when specific planned maintenance and infrastructure provisioning work activities should be performed. The purpose of scheduling work during specific times is to ensure a minimal amount of disruption to CenturyLink™ customers. Although load and service conditions vary by site, nighttime is generally the time of least traffic in most CenturyLink™ sites. Therefore the official Maintenance Window is:

Monday to Friday 10:00 p.m. to 6 a.m. (12 am to 5 am for work that could affect video)

Saturday 10 p.m. to Monday 6 a.m. (12 am to 5 am for work that could affect video)

For work that could affect DSL circuits, the Maintenance Window is midnight to 6 a.m. Sunday through Thursday

If in doubt, almost all Power work that involves even the slight possibility of taking down equipment should be done in the Maintenance Window to be safe, because nothing works without Power. However, because local conditions for each site are more likely to be known locally, the final decision is left up to the local managers.

The following maintenance items should almost always be performed in the Maintenance Window:

- Battery Discharge tests of single string plants
- Building Power Blackout tests (annual engine run)

The following Power and Grounding Installation/Removal activities must be performed in the Maintenance Window. These generally only apply to in-service or "hot" equipment, or the specific times when "dead" equipment is being connected to "live" equipment. Power and Grounding Installation Guidelines are contained in Chapters 8, 9, and 10 of CenturyLink™ Technical Publication 77350.

- Any disconnections from the Ground Window MGB, CO Ground Bars, or main Horizontal or Vertical Equalizers while they are "in-service" should normally be Maintenance Window work
- Any connections or disconnections to the hot bus bars should almost always be done in the Maintenance Window (turning on a breaker or inserting a fuse/fuse-holder does not require manual or tool touching of a hot bus, and therefore, may be done outside of the Maintenance Window; however, although connection of cables to "dead" fuse or breaker positions on the rear is not technically "hot", there are nearby hot buses, which may merit consideration for moving that work to the Maintenance Window)
- Any addition or removal of batteries from "live" strings (although it's desirable to do all this work in the Maintenance Window, it's only absolutely required for single string plants)
- Any connection or disconnection on the main AC power Board (feeder side) or any work on the AC transfer switch (see the exception above for the insertion of breakers) should be done in the Maintenance Window

Remoter locations (e.g., RT Cabinets, CEVs, huts, Customer Premises, etc.) deserve special Maintenance Window consideration due to access, lighting, and affected customers. Note that, in all cases, the final decision is up to the local manager. These managers also sign installation MOPs (even though Pub 77350 is geared towards CO work, the MOP process is recommended for RT/Prem sites as well; especially Customer Premises sites, as per Pub 77368). Some guidelines for RT/Prem Power work, from NROC Power Tech Support, follow. They apply to installation and maintenance activities described above, but modified by the following paragraphs.

- RT/Prem sites/equipment with less than 96 DS-0 (POTS) customers (equivalent to 4 or less T1s), might usually be exempted from the power Maintenance Window. SHARP/SHNS and other guaranteed services should usually follow the Maintenance Window, due to significant customer refunds for outages.

- For RT cabinets, night work may not be feasible in all cases (although small jobs may be done by flashlight or headlamp); due to the disruption that lighting, running trucks, generators, etc. can cause in neighborhoods. In some neighborhoods, for some "planned" activities (especially routine maintenance), night work may cause more customer ill will than it prevents
- For outdoor DSL cabinets, in cases where lighting, noise, etc. can be issues, as described above, the Maintenance Window may be extended to 8 a.m. with the permission of the local manager.
- Customer Premises installations are supposed to allow us 7 x 24 access, but this doesn't always happen. For Customer Premises that allow 7 x 24 access, Maintenance Window guidelines should generally be followed due to the HiCap circuits/services usually located there. Any Customer Maintenance Window should supersede our own (coordinate with them).
- Controlled environment electronic equipment enclosures (EEEs) include CEVs, CEC™s, huts, UE™s, etc. generally have fiber, and/or enough POTS customers to warrant Maintenance Window guidelines being followed.

## 15.3 Forms

**CenturyLink™**

**GENERIC TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| Equipment Verification | | |
| Frames located per floor plan | | |
| Installed per drawings | | |
| Equipment is what was ordered | | |
| Equipment options are correct | | |
| Spare equipment provided per ordering spec (if applicable) | | |
| Power feed to equipment checked | | |
| Workmanship | | |
| Frame alignment and equipment mounting | | |
| Relay rack numbering | | |
| Wiring and cabling (including tagging of unused cables) | | |
| Equipment numbering and lettering | | |
| Cable openings sealed | | |
| Cable racks and other ironwork | | |
| Power and fusing (spare fuses available also) | | |
| Combustible materials removed from network eqpt areas (especially power areas) | | |
| Performance Tests | | |
| Tests per recommended equipment manual | | |
| Tests per Test & Acceptance package sent out with job | | |
| Documentation | | |
| "As-built" drawings sent back to engineering | | |
| Replacement drawings left on site | | |
| Initial battery charge reports (if applicable) | | |
| Equipment manuals received | | |
| Original test results retained | | |
| Alarms | | |
| Affected alarms tested prior to work start | | |
| Local and audible alarms (as applicable) tested prior to work start | | |
| Alarms installed and tested with Alarm Center | | |
| Name of NROC Center Contact with whom alarms were tested: | | |
| Other | | |
| | | |
| | | |

| Comments (all No answers must be commented on) |
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**Form 820** Generic Test and Acceptance Checklist

**CenturyLink™**

**POWER ROOM LIGHTING TEST & ACCEPTANCE CHECKLIST**

| | | | |
|---|---|---|---|
| Site: | Job Number BVAPP: | | |
| Engineer: | Job Number Vendor: | | |
| Date of Installation completion: | Date of Vendor Departure: | | |
| Tested by: | Date: | | |
| **ITEM** | | **YES** | **NO** |
| 1. Lighting provided in the power areas is adequate, and located in accordance with the site record lighting plan drawing | | | |
| 2. As a minimum, emergency/stumble lighting is available in stairwells; and task lighting over the control PBD, over the engine control panel and AC transfer system, over the main AC switchgear, and in the engine room | | | |
| 3. Emergency egress/stumble and task lighting works | | | |
| 4. Feeding fuse/breaker positions and emergency egress/stumble and task lighting fixtures are properly stenciled as to the equipment they feed or where they are fed from | | | |
| Test & Acceptance should be performed with the installer on site.<br>Note below all problems they fix: | | | |
| Comments (all No answers must be commented on) | | | |
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**Form 821A** Power Room Lighting Test and Acceptance Checklist

**CenturyLink™**
**ALARM AND/OR POWER MONITOR/CONTROLLER (PSMC)**
**TEST & ACCEPTANCE CHECKLIST**

| | | |
|---|---|---|
| Site: | Job Number BVAPP: | |
| Associated Power Plant: | ANTS/PNAR #: | |
| Engineer: | Job Number Vendor: | |
| Date of Installation completion: | Date of Vendor Departure: | |
| Tested by: | Date: | |
| **ITEM** | **YES** | **NO** |
| 1. Complete copy of suppliers' manuals and drawings available on site | | |
| 2. Verify accuracy of the database, and ensure an electronic backup is made where applicable | | |
| 3. Verify that analog channel readings are within 1% of the values measured by plant meters or by technician's hand-held meter | | |
| 4. Bring in **each** binary alarm associated with this monitor (or other alarming device) and verify that technicians in the NOC receive the alarm | | |
| A. There is local indication of the alarm on the monitor, if monitor is capable of this function | | |
| B. If monitor is capable and equipped, verify the difference between Minor Rectifier Fail (1 rectifier), and Major Rectifier Fail (2 or more rectifiers failed) | | |
| 5. Bring in binary alarms associated with the threshold settings of analog points (e.g., low voltage, etc.), and ensure that these alarms report locally on the monitor and remotely to the NOC | | |
| A. Analog points' binary thresholds are set properly (according to Chapter 13) | | |
| 6. If the monitor is controlling High Voltage Shutdown (HVSD), verify proper operation | | |
| 7. Ensure that all binary, analog, & control points requested on the job were provided, and ensure that there is a record left in the office on paper and/or on disk of the assignments | | |
| 8. Verify the difference between Minor Converter Fail (1 converter), and Major Converter Fail (2 or more converters failed) | | |
| 9. Verify security levels (e.g., different passwords), and dial-back numbers (if applicable) | | |
| 10. Verify that the system reboots properly after being turned off/on | | |
| 11. Verify through NOC, continuity of X.25 and/or IP link as applicable | | |
| 12. When monitor is equipped with control functions, verify proper operation of these functions (e.g., ring transfer, etc.) | | |
| 13. Verify that a laptop can communicate with the monitor over an RS-232 port | | |
| 14. Note the number of spare analog and/or binary points, and report them to Engineering | | |
| 15. Verify communication with the unit over a dialup modem | | |
| Test & Acceptance should be performed with the installer on site. Note below all problems they fix | | |
| NOTE 1: Use supplier, Telcordia®, and CenturyLink™ documentation as a guide to performing the tasks above.<br>NOTE 2: When testing alarms and functions, be sure not to interrupt service unless absolutely necessary, and done during the Maintenance Window with notification to and signoff from appropriate personnel | | |
| Comments (all No answers must be commented on) | | |
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**Form 821B** Alarm and/or Power Monitor/Controller (PSMC) Test and Acceptance Checklist

**CenturyLink™**
**BDFB, POWER BOARD, OR FUSE PANEL**
**TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Engineer: | Job Number Vendor: |
| Power Board &Fuse Numbers | BDFB Location |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. Proper equipment was ordered and is sized appropriately for the application | | |
| 2. Verify proper load bus arrangements by ensuring only 1 bus is hot with each feeder breaker on or fuse inserted | | |
| 3. Verify proper return bus options | | |
| 4. Verify accuracy & proper operation of the digital or analog meters & current shunts | | |
| 5. Test fuse alarms for proper operation and continuity to the appropriate NOC | | |
| 6. Verify proper placement, anchoring, and stenciling of the bay(s) and/or shelves | | |
| 7. Ensure that all fuse/breaker assignments are properly marked/stenciled (including fuse size) for the loads they feed, and that all incoming and outgoing cables are properly tagged | | |
| 8. Verify proper connections (including irreversible Listed crimps, and anti-oxidant of wires/cables to the distribution, ground, and battery return buses/connections | | |
| 9. Verify proper cable routing | | |
| 10. Verify proper frame and site grounding | | |
| 11. Report the number and type of spare fuse/breaker positions to Engineering | | |
| 12. Ensure that BDFBs are equipped with a sticker(s) specifying the maximum feeder load (50% of the protector size) for each feeder | | |
| 13. Ensure all positions (including unused) are labeled for position #, that the bay is marked with its PBD/RR location, and that the shelves are labelled | | |
| 14. Ensure dummy fuses, holders, or covers installed in positions that require it | | |

Test & Acceptance should be performed with the installer on site. Note below all problems they fix

NOTE: Use supplier documentation as a guide to performing the tasks above.
NOTE: Work on a Power Board or BDFB has the potential to interrupt service. Service shall not be interrupted when installing primary or secondary distribution panels. Cutover of a BDFB or Power Board should probably occur during the Maintenance Window if the power plant is already up and supporting loads.

| Comments (all No answers must be commented on — use the back of this form if necessary) |
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**Form 821C** BDFB, Power Board, or Fuse Panel Test and Acceptance Checklist

**CenturyLink™**
**BATTERIES & BATTERY STANDS TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Associated Power Plant: | Battery String #: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. Battery stands & batteries marked with install and mfg date (on batteries), string #s/letters, voltage match colors (if applicable) & cell #s (not required for 6/12 V). | | |
| 2. Batteries and connectors are free of the following defects. | | |
| A. Cases crazed, cracked, bulged, corroded, or leaking | | |
| B. Level indicators missing or incorrect (for flooded batteries only) | | |
| C. Cover or post rise, and/or post corrosion | | |
| D. Excessive positive plate growth or strap growth for flooded cells with clear jars | | |
| E. Excessive plate bowing or cracking for flooded cells with clear jars | | |
| F. Excessive needle growth for flooded cells with clear jars | | |
| G. Lead-sulfate crystals for flooded cells with clear jars (check after initial charge) | | |
| 3. Electrolyte level proper, & limits for electrolyte level are marked on wet cells. | | |
| 4. Proper wet cell vent/fill caps installed, & flame arrestors have dust covers. | | |
| 5. Battery records/logs and any manufacturer documentation is on-site and easily accessible. The Storage Battery report (RG47-0001) should have been filled out by the installation vendor for flooded cells. | | |
| 6. Neutralizing agents and protective equipment are available nearby for use as required in the battery area: eyewash, absorbent pillows, neutralizer, rubber gloves, goggles, rubber apron. (This requirement is only applicable in buildings). | | |
| 7. Thermometers and/or temperature probes are installed as required. | | |
| 8. Check batteries and intercell connection integrity by placing string on a 5-minute discharge test into a real load or load box. (This requirement is optional if the string is installed into a new plant with no real load. At a minimum, attempt to determine if connections were properly tightened with a torque wrench.). | | |
| 9. All flooded battery 1.215 s.g. cell voltages are above -2.14 on float. | | |
| 10. Batteries and connections (irreversible Listed crimps for lugs) are properly marked, coated with a thin film of anti-oxidant, and connected to +/-. | | |
| 11. Temperature compensation employed and working with VRLA batteries | | |
| 12. Spill containment (room/area or individual stand) installed for new flooded batteries in plants with at least 4 strings of 1680 Ah or 2 strings of mini-tanks | | |
| 13. Disconnects (if used) sized per Chapter 3; & wired to remote trip only if required. | | |
| 14. Battery stand is braced appropriately for earthquake zone in which site is located. | | |
| 15. Proper warning labels installed on/near stands and on room door. | | |
| 16. Batteries appear to be sized to provide appropriate reserve per this Tech Pub. | | |
| Test & Acceptance should be performed with the installer on site. Note on back all problems they fix. | | |
| Comments (all No answers must be commented on —additional room on back) | | |
| reference Routines EE200, EE201, EE202, EE757, EE758, EE759, EE660, and EE720 | | |

**Form 822** Batteries and Stands Test and Acceptance Checklist

**CenturyLink™**
**RECTIFIER TEST & ACCEPTANCE CHECKLIST**

| | | |
|---|---|---|
| Site: | Job Number BVAPP: | |
| Rectifier #'s: | Associated Power Plant: | |
| Engineer: | Job Number Vendor: | |
| Date of Installation completion: | Date of Vendor Departure: | |
| Tested by: | | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. Rectifiers are properly assembled, installed, and stenciled or identified. | | |
| 2. Correct type & capacity fuses are provided, & all fuses are clean & properly installed. | | |
| 3. AC power connections are properly made and labeled for feeder breaker location. Ensure proper transformer taps and phase rotation where applicable. | | |
| 4. Ensure that correct rectifier (size, type, AC input, etc.) was ordered, including correct wiring or apparatus options. | | |
| 5. Rectifiers operate per individual operation tests, and basic operational features work. | | |
| 6. Rectifier and/or Plant meters are accurate and properly adjusted. | | |
| 7. Alarm settings are adjusted to requirements, and proper alarm signals are transmitted | | |
| 8. Current limiting and partial load features of units are set and adjusted properly. | | |
| 9. High Voltage shutdown (HVSD) feature operates properly, and all other DIP switches, potentiometers, and other options are properly set, including alarm thresholds. | | |
| 10. Outputs of all units are stable (non-hunting, except for load sharing variations), & rectifier float voltages are properly set for battery type (see Chapter 13) & load sharing | | |
| 11. Simulate an AC power failure to verify that the units' auto-restart capability and current walk-in feature operate properly when AC power is restored. Ensure also that alarms clear and that the units return to float voltage. | | |
| 12. All rectifiers are capable of operating, regulating, and current limiting at full load. | | |
| 13. Ensure AC fuse/breaker panel(s) feeding rectifiers have adequate spare capacity. | | |
| 14. For multi-phase fed rectifiers, verify appropriate operation or shutdown during phase failure if possible. | | |
| 15. Ensure proper selection and routing of rectifier control cables to plant controller. | | |
| 16. Ensure rectifier frames are properly grounded & that battery return cables are properly grounded & sized, dependent on whether plant is integrated, isolated, or combined. | | |
| 17. Ensure rectifier DC output cables are properly installed, & sized according to Chapter 2 (for 200 and 400 Amp rectifiers), or manufacturers' recommendations (all other sizes). | | |
| 18. If the plant load exceeds the smallest rectifier size, ensure that each rectifier will carry full-rated load for at least 1 minute. Ensure that there is at least n+1 redundancy and a minimum of 120% (125% for VRLAs) total rectifier capacity compared to float load. | | |
| 19. Ensure that there is adequate ventilation & heat dissipation so rectifier will not overheat. | | |
| Test & Acceptance should be performed with the installer on site. Note below all problems corrected | | |
| NOTE: When testing alarms and functions, be sure not to interrupt service. Consider whether it is required to perform any of the tests in the Maintenance Window. | | |
| Comments on back of form (all No answers must be commented on) | | |

**Form 823A** Rectifier Test and Acceptance Checklist

**CenturyLink™**
**POWER/BATTERY PLANT TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Power Plant: | Location: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. All battery distribution cables are of correct size and type, and properly terminated | | |
| 2. All equipment of control and distribution bays are correctly stenciled or identified | | |
| 3. All control circuit, charge, and discharge fuses and/or circuit breakers are of the correct type and capacity, and located as shown on the drawings | | |
| 4. Alarm fuse positions are equipped with correct fuses, and fuse and circuit breakers are properly designated as to the equipment they serve | | |
| 5. Verify alarms, locally, and to the Alarm Center | | |
| 6. All DC meters are calibrated and properly adjusted | | |
| 7. All fuses are tight in their respective fuse holders, and fuses and circuit breakers are free of excessive heat | | |
| 8. The battery float voltage is correct (check after meter calibration, and initial charging of the batteries) | | |
| 9. The voltage alarm settings are correct per Chapter 13 | | |
| 10. Spare fuses are provided, and properly located & designated, near the battery plant | | |
| 11. If LVD is used (use only where required), ensure setting is -43.25 V or less. | | |
| 12. Power bays are properly labeled for PBD/RR position | | |

| Test & Acceptance should be performed with the installer on site. Note below all problems they fix |
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| Comments (all No answers must be commented on) |
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**Form 823B** Power/Battery Plant Test and Acceptance Checklist

**CenturyLink™**
**CONVERTER PLANT TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Associated Power Plant: | Location: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. The converter plant is properly assembled and installed (including properly made electrical connections), and stenciled or identified | | |
| 2. The input and output fuses are the correct type and capacity | | |
| 3. The discharge fuse alarms are operative and connected properly, and spare fuses are available | | |
| 4. The voltage alarm levels are properly adjusted to specified limits | | |
| 5. All alarms function properly, and are received by the Alarm Center | | |
| 6. High Voltage shutdown (HVSD) feature operates properly | | |
| 7. The converter plant meters are accurate, and properly adjusted, and all other LEDs or other indicators work properly | | |
| 8. The output voltage is adjusted within the specified limits, and can be accurately read from the test jacks | | |
| 9. The output current limit is properly set, as well as any other options set through DIP switches or potentiometers | | |
| 10. Verify that the converter plant functions properly under load (preferably up to the n-1 capacity, and preferably off-line on a load bank) for at least 30 minutes, and that there are no problems if the converters are switched on and off. | | |

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| Test & Acceptance should be performed with the installer on site. Note below all problems they fix. |
| NOTE: When testing alarms and functions, be sure not to interrupt service unless done during off hours and with notification to appropriate personnel |
| Comments (all No answers must be commented on) |
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**Form 824A** Converter Plant Test and Acceptance Checklist

**CenturyLink™**
**RESIDUAL RING PLANT TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Associated Power Plant: | Location: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. The ringing plant is properly assembled, installed, and stenciled or identified | | |
| 2. Ringing plant fusing is in agreement with site drawings | | |
| 3. All alarms operate properly, including transfer alarms and report to the NOC | | |
| 4. The transfer feature operates automatically when a power failure occurs (for units when Ring Generator 1 is AC powered), or if Ring Generator 1 fails. (This transfer also applies to those sites equipped with interruptors besides the ring generators) | | |
| 5. If equipped, the transfer feature operates properly by manual or test transfer | | |
| 6. All voltages, tone levels, and frequencies are within specified limits | | |
| 7. If meters are provided, they are accurate, and within adjustments | | |

| Test & Acceptance should be performed with the installer on site. Note below all problems they fix. |
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| Comments (all No answers must be commented on) |
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**Form 824B** Residual Ring Plant Test and Acceptance Checklist

**CenturyLink™**
**INVERTER TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Associated Power Plant: | Location: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. The inverter plant is properly assembled and installed (including proper electrical connections), and stenciled or identified (outlets and AC panels fed by the inverter should also be marked, and any AC voltage over 120 VAC nominal should be marked in red/vermilion if it appears at an outlet). | | |
| 2. Input, output, and alarm fuses or breakers are the correct type and capacity, and output distribution is properly sized and connected | | |
| 3. Simulate an AC power failure. Ensure proper operation and transfer. During outage, check output voltage and frequency. | | |
| 4. Verify that plant is capable of operation at full load; in either AC input or DC input modes. (Use a dummy load — e.g., load box — if necessary to fully load the plant) | | |
| 5. Verify proper operation of maintenance bypass, if equipped | | |
| 6. Alarms operate to the Alarm Center and clear properly | | |
| 7. Verify proper operation of any automatic shutdowns (e.g., low voltage, emergency. stop, etc.) | | |
| 8. Verify proper operation of all controls and indicators (meters, LEDs, etc.) | | |
| 9. Improper loads are not connected to expensive inverter power (see Chapter 5). | | |
| 10. Ensure that a new ground reference is provided from a COGB or PANI MGB, and that neutral and ACEG are tied together at the output | | |
| 11. Ensure there is adequate room and ventilation around the inverter plant | | |

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| Test & Acceptance should be performed with the installer on site. Note below all problems they fix. |
| NOTE: When testing alarms and functions, be sure not to interrupt service unless done during off hours and with notification to appropriate personnel |
| Comments (all No answers must be commented on) |
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**Form 825A** Inverter Test and Acceptance Checklist

**CenturyLink™**
**UPS TEST & ACCEPTANCE CHECKLIST**

| | | |
|---|---|---|
| Site: | Job Number BVAPP: | |
| Engineer: | Job Number Vendor: | |
| Date of Installation completion: | Date of Vendor Departure: | |
| Tested by: | Date: | |
| **ITEM** | **YES** | **NO** |
| 1. UPS is properly assembled (including any filters), installed (including clearances & leveling, and in a proper air-conditioned and ventilated environment), & stenciled/identified (including proper arc flash/blast labels) per Engineering instruction (outlets & AC panels [including PDUs] fed by UPS should also be marked as "protected", and any outlet providing more than nominal 120 VAC should be marked in red/vermilion) | | |
| 2. The correct type & capacity fuses are provided, and all fuses are clean and properly installed | | |
| 3. AC/DC power connections (including proper bolt torquing & washers) are made per Engineering instructions, & in compliance with CenturyLink™ Tech Pub 77350 and this one | | |
| 4. Transformer taps are set properly (output voltage is within the proper range) | | |
| 5. Ensure proper AC phase rotation on the output | | |
| 6. Plant meters are accurate and properly adjusted | | |
| 7. Alarm settings are adjusted to requirements, & proper alarm signals transmitted. Ensure that alarms reach the appropriate Alarm Center (and/or local terminal). The permanent battery monitor (if installed) is correctly installed and set up. | | |
| 8. Correct wiring/apparatus provided & wiring is properly routed, supported & braced | | |
| 9. Current limiting & partial load features of units set & adjusted per Engineering requirements | | |
| 10. High voltage and EPO shutdown features operate properly | | |
| 11. Outputs are stable (non-hunting, except for minor load sharing variations) | | |
| 12. Simulate AC power failure to verify unit's auto-switch capability, and that it operates properly when AC power is restored (ensure that alarms clear when AC is restored). Ensure that it synchronizes/parallels with parallel UPS units/modules, if applicable; and shares load reasonably between modules/units. Ensure static/maintenance bypasses work too. | | |
| 13. UPS works at full load for at least 1 hr (and handles step loads, as determined by step-loading and de-loading in 25% increments), & a thermal scan under full load shows no problems. Verify UPS input/output THD is within specs during this test. | | |
| 14. UPS normal load < 80% for a non-redundant UPS, or < 40% for redundant UPS setups | | |
| 15. Battery chargers are operating at the required output voltage. A commissioning battery discharge test (including IR scan) was performed to ensure at least 90% of rated capacity? | | |
| 16. Unit is properly grounded per NEC® requirements, and doors/shelves/etc are bonded | | |
| 17. Are detailed operating instructions posted at the hard maintenance bypass | | |
| Test & Acceptance should be performed with the installer on site. Note below all problems they fix. | | |
| NOTE: Use supplier documentation as a guide to performing the tasks above.<br>NOTE: When testing alarms/functions, don't interrupt service unless during off hours w/appropriate notification | | |
| Comments (all No answers must be commented on – use the back of this sheet as needed) | | |
| | | |

**Form 825B** UPS Test and Acceptance Checklist

**CenturyLink™**

**STANDBY ENGINE TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. Engine-alternators & associated equipment are located according to the floor plan drawings, & are installed according to Engineering request, & are properly sized (e.g., fuel and exhaust system piping & tubing) | | |
| 2. Engine start batteries and chargers are in good condition, and installed and operating properly | | |
| 3. Verify start batteries and charger per Forms 822, 823A, & manufacturers' documentation | | |
| 4. A remote emergency stop button is located outside but near engine room, & is properly identified & alarmed (for outdoor engine enclosures with the transfer switch indoors, there also needs to be a button indoors)5 | | |
| 5. Test records, logs, & mfg documentation on site (with combustibles in engine rm stored in a fireproof cabinet) | | |
| 6. Before operation, inspect for the obvious, like assembly; fuel or oil leaks; or loose, missing or damaged parts | | |
| 7. Fuel in main and day tanks is sufficient and free of excess water and other contaminants | | |
| 8. Oil and coolant levels are sufficient, fluids are contaminant-free, and jacket water heater is operational | | |
| 9. Engine-alternator operating instructions are posted near the engine, and are clear and easy to use | | |
| 10. Adequate ear/eye protection & spill kit available in engine room, and adequate warning labels are posted | | |
| 11. Ensure that engine, engine room metallic parts & lines, and alternator neutral are all grounded per Pub 77355 | | |
| 12. Engine crankcase breather is vented to atmosphere or discharge damper | | |
| 13. With engine mfg and installer present perform a first test of the genset with the engine at full load (use load bank) for 2-4 hrs (preferably run test on site; however, test may be at the mfg location with CenturyLink™ present). Observe all functions, readings, alarms, etc., & note abnormalities, paying attention to following: | | |
| A. Water, fuel, and oil temperatures and pressures are within limits | | |
| B. Ensure proper operation of the transfer switch | | |
| C. Frequency, current, kW, and voltage readings are correct, and within limits | | |
| D. Test all alarms during run, both locally and to the Alarm Center for proper operation | | |
| E. If provided, rectifier sequencing functions properly | | |
| F. Exhaust pressure is less than limits; no exhaust leaks; internal exhaust pipes insulated; 9" minimum exhaust clear from combustibles; hot "reachable" parts guarded/insulated and/or labeled; exhaust couplings use bolted flanges with gaskets or threaded pipe; has a flexible connection to engine and flexible supports to allow for expansion/contraction; and end of exhaust stack protected | | |
| G. Ensure proper operation of all fuel pumps, and the day tank (where applicable) | | |
| H. Intake/exhaust fans/louvers operate (and held open by spring on power loss), and are properly sized per drawings. (Check proper intake size by seeing if engine room door opens easily). Air intake filters are properly installed. (Exhaust fans to be controlled by room thermostat, if separate.) Exhaust is positioned so that its gasses & heat are not part of the intake air. | | |
| I. If provided, paralleling functions properly | | |
| J. Current load is reasonably balanced between phases | | |
| K. All required gauges, meters, and local and remote alarms are present as per Chapters 7, 8 and 13 | | |
| L. Test the emergency shutdown | | |
| 14. Check fluids and fuels after run, and visually inspect for leaks, loose parts, etc. | | |
| NOTE: Use supplier engine Test and Acceptance too; and when testing alarms and functions, don't interrupt service | | |
| Comments (all No answers must be commented on — **Please use the back of this form for comments**) | | |

**Form 826A** Standby Engine Test and Acceptance Checklist

**CenturyLink™**
**TRANSFER SYSTEM AND AC SERVICE ENTRANCE**
**TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. Ensure proper operation of the transfer system. Simulate an AC failure and return of Commercial AC. Ensure that all timers function properly. Ensure that transfer instructions are posted (including for portable genset manual transfer switches). | | |
| 2. If provided, paralleling functions properly and that there are sequencer lights or meters, which properly operate if paralleling, is to be done manually. | | |
| 3. Ensure that drawings for the transfer system are on site. | | |
| 4. Ensure that a single line-drawing is on site (it may be physically etched or drawn on the AC switchgear) | | |
| 5. Visually inspect (or thermally with a thermal gun or camera) all connections in the transfer system and AC service entrance cabinets for tightness. | | |
| 6. Ensure that the AC loads of the site do not exceed bus bar and breaker capacities in the AC switchgear. | | |
| 7. Ensure that electrical safety equipment is available for the site: electrical gloves, goggles, tags/locks for use in lockout/tag out procedures when AC work is being done, & possibly fire-retardant Nomex gear. | | |
| 8. Ensure that AC service entrance has a lightning arrestor and/or surge suppressor properly installed. | | |
| 9. Ensure that AC fail is monitored per phase, & that an AC fail alarm properly reports to the Alarm Center | | |
| 10. If the site is equipped with a power monitor (PSMC), verify that AC voltage (per phase, line-neutral) and currents (per phase) are monitored and reading properly. | | |
| 11. Ensure that the power company transformer, the engine, the engine breaker, and the main site AC breaker (and any other critical path or large HVAC AC breakers) are at least 125% of the peak summer load (recharging batteries after a building blackout test). | | |
| 12. Ensure that the AC Service Entrance and Transfer System are grounded per Pub 77355 | | |
| 13. Ensure there is kAIC coordination from the power company transformer down to the PDSCs (e.g., ensure that the kAIC of the service entrance equals or exceeds that of the power company transformer, etc.) | | |
| 14. Ensure that all AC power panels are properly labeled, including the location of the upstream panel. Ensure that unused knockouts and open breaker positions in AC panels are covered. | | |
| 15. Ensure that AC utility phone # and meter # is posted/marked at the main HSP | | |

NOTE: Use supplier documentation, for Test and Acceptance
NOTE: When testing alarms and functions, be sure not to interrupt service

| Comments (all No answers must be commented on — Please use the back of this form for additional comments) |
|---|
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**Form 826B** Transfer System and AC Service Entrance Test and Acceptance Checklist

**CenturyLink™**
**FUEL TANK, FUEL SYSTEM, AND FUEL MONITOR**
**TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. Fuel in main and day tanks is sufficient and free of excess water and other contaminants | | |
| 2. Ensure that outdoor tanks are placed so that water will not flow into them or pool on top of them. | | |
| 3. If the outdoor Diesel fuel tank is aboveground in a climate where temperatures may get below 32˚ F, ensure that the tank either is using winter blend Diesel fuel, or is equipped with a tank heater. | | |
| 4. Visually ensure that all fuel tanks (both main and day) have containment that will contain all of the fuel in the tank in case of a leak. For open containment, ensure it is free of leaks, water, and debris. For sites that have the capacity to store 1320 or more gallons of fuel on site, they are also required to have an SPCC plan. | | |
| 5. Inspect tank(s) and all fuel piping and pumps for any leaks | | |
| 6. Ensure fuel lines are connected to engine through a flexible section | | |
| 7. Fuel Lines installed and routed in accordance with the vendor-supplied Engineering specs and drawings. | | |
| 8. Verify that an anti-siphon valve is installed on the fuel suction line at the first entrance point to the generator room or enclosure when the main tank is higher than the engine or day tank. (In some jurisdictions, the fuel line is required to have a meltable link valve that closes in case of fire.) | | |
| 9. Verify that electric fuel solenoid (operating from the engine start and/or control batteries at 12 V or 24 VDC when there is no day tank), or anti-siphon valve as an alternative on sites w/o day tanks, is installed on the supply line (requirement waived when tank lower than engine). Solenoid must be connected to generator run circuit in the control panel. This solenoid should close when the emergency stop button is pushed. | | |
| 10. Verify that fuel lines running on the floor are routed so as not to create a safety hazard. (Fuel lines lying on the floor should be covered with a metal shroud painted yellow or yellow with black diagonal stripes.) | | |
| 11. Diesel fuel lines are Aeroquip/Stratoflex hose or black iron. (Aeroquip/Stratoflex lines are permitted, but must be run inside containment conduit). Galvanized pipes/fittings are permitted for LPG and natural gas. | | |
| 12. Verify that the fuel return line is free from all obstructions. (No gates, valves, or traps are permitted.) | | |
| 13. Ensure proper operation of all fuel pumps, plus any day tank valves | | |
| 14. Ensure that a low fuel alarm is reported (may be reported as a generic fuel system trouble) all the way to the Alarm Center. The low fuel alarm should report when there is 8 hours or more of fuel. | | |
| 15. If the site is equipped with a fuel tank monitor, ensure that it has at least a generic fuel system trouble alarm wired and reporting all the way to the Alarm Center. | | |
| 16. Ensure fuel tank monitor is equipped with a dialup modem and a working phone line (some radio sites and other sites where phone service is inaccessible may be exempt from this requirement), and that the Power Alarm Center and the local Power Crew have that number. | | |
| 17. Ensure that the fuel tank monitor is equipped with paper tape and ink, and a method of storing the tape. | | |
| 18. If the tank is vaulted, and the vault is an OSHA-defined "confined space", ensure that it is so marked. Also ensure that tanks are marked with the appropriate signage for the fuel type. | | |
| 19. Ensure that all fuel lines and tanks are properly grounded according to CenturyLink™ Tech Pub 77355. | | |
| NOTE: Use supplier documentation for Test and Acceptance; and when testing alarms and functions, don't interrupt service | | |
| Comments (all No answers must be commented on — **Please use the back of this form for comments**) | | |

**Form 826C** Fuel Tank, Fuel System, and Fuel Monitor Test and Acceptance Checklist

**CenturyLink™**
**RT/PREM SITE TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. Ensure that internal and external grounding is per CenturyLink™ Tech Pub 77355. | | |
| 2. Do ventilation and exhaust openings have free access | | |
| 3. Ensure that the site and all of the bays and wiring in the RT are properly tagged/stenciled | | |
| 4. Ensure proper operation of A/C, sump pump, gas monitor and other environmental systems with the vendor present for CEVs, CECs, and huts, as applicable | | |
| 5. Ensure safety equipment (e.g., fire extinguisher, first aid kit, gloves, eyewash fluid, etc.) is present, as applicable | | |
| 6. Ensure that all holes in a CEV are properly sealed | | |
| 7. Emergency lighting, gas monitors, environmental controllers, or any other device that should be powered by -48 VDC is connected to the DC Plant. | | |
| 8. Site is properly constructed, landscaped, and backfilled; and weeds are abated | | |
| 9. Portable genset connection available and sized properly. Verify that a genset can be parked within 30 ft of the transfer system, and that the soil is such that there is access under adverse weather conditions. After turn-up, transfer the site to the engine to confirm backup. | | |
| 10. Site has records/forms for proactive maintenance of the power plant. Ensure that the power plant was turned up correctly per Forms 822 through 823B. Load test the plant & batteries. | | |
| 11. Ensure continuity of power and environmental alarms, and any other alarms to the appropriate NOC. (See Chapter 13 for power and environmental alarm standards.) | | |
| 12. Lightning/surge arrestor installed in power pedestal, and power pedestal wired per NEC® | | |
| 13. Confirm that controlled environment sites are set to operate within 55-85° F. | | |

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|---|
| This checklist should be performed with the installer(s)/contractor(s) on site. Note below all problems they fix. |
| Comment below or on back (all No answers must be commented on) |
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**Form 827** RT/Prem Site Test and Acceptance Checklist

**CenturyLink™**
**BUILDING GROUNDING TEST & ACCEPTANCE CHECKLIST**

| | | |
|---|---|---|
| Site: | Job Number BVAPP: | |
| Engineer: | Job Number Vendor: | |
| Date of Installation completion: | Date of Vendor Departure: | |
| Tested by: | Date: | |
| **ITEM** | **YES** | **NO** |
| 1. The site ground is the proper size, and installed in accordance with the site record drawings, Engineering instructions, and CenturyLink™ Technical Publication 77355 | | |
| 2. Both ends of all site ground cables are tagged, and designated to show opposite end terminating location | | |
| 3. If ground leads are run through metallic conduit both ends of the conduit or sleeve are bonded to the ground lead. | | |
| 4. Isolated frames, cabinets, rectifiers, etc. containing AC service are properly grounded per Tech Pub 77355 Chapters 8 and 9 | | |
| 5. If associated switching system uses isolated grounding, integrity must meet the system requirements spelled out in CenturyLink™ Technical Publication 77355 | | |
| Test & Acceptance should be performed with the installer on site. Note below all problems they fix | | |
| For a complete grounding review, contact the CenturyLink™ Power Maintenance Engineer | | |
| Comments (all No answers must be commented on) | | |
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**Form 828A** Building Grounding Test and Acceptance Checklist

**CenturyLink™**
**POWER DISTRIBUTION BUS BAR & CABLING**
**TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Associated Power Plant: | Location: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. AC bus duct and conduit is installed in accordance with site record drawing layout, the manufacturers' specifications, and the NEC® | | |
| 2. The proper type and size fuses and/or circuit breakers are installed in AC bus duct plug-in units | | |
| 3. Warning labels are placed at all access openings and end sections of AC bus duct, as required | | |
| 4. Bus bar is installed in accordance with site record drawing layout | | |
| 5. Bus bars and risers are stenciled to properly identify CHARGE, DISCHARGE, BAT, GRD, RTN, voltage, etc. | | |
| 6. The ammeter shunt is properly mounted and stamped to indicate voltage and Ampere rating | | |
| 7. Installation meets CenturyLink™ workmanship standards, and is in accordance with Engineering standards and drawings, as spelled out in CenturyLink™ Technical Publications 77350, 77351, 77352, 77355 and this one | | |
| 8. Bus bars, joints, and terminating connections to bus bars are free of excessive heat. (Technicians may use contact thermometers, or infrared temperature guns to determine heating. If major problems are suspected, a CenturyLink™ Power Maintenance Engineer or outside thermographer may be called in to do a thermal camera scan.) | | |
| 9. Power cable is routed in accordance with site record drawings | | |
| 10. Power cable is run and secured on cable racks | | |
| 11. Adequate insulating protection is provided on cable rack straps, stringers, thread rods, auxiliary frame bars, and other metallic objects where power cable makes contact with sharp surfaces, or at tie points on soft rubber outer jackets. | | |
| 12. Power cable insulation is free of damage | | |
| 13. Terminating wires and cables are properly tagged and designated at both ends of conductors when required, and unused power cables have an insulating cap. | | |
| 14. All cables listed on power cable running list are installed with correct type and size of cable as specified, or otherwise calculated | | |

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|---|
| Test & Acceptance should be performed with the installer on site. Note below all problems they fix. |
| Comments (all No answers must be commented on) |
| |
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**Form 828B** Power Distribution Bus Bar and Cabling Test and Acceptance Checklist

**CenturyLink™**
**POWER AREA FLOOR PLAN TEST & ACCEPTANCE CHECKLIST**

| | | | |
|---|---|---|---|
| Site: | Job Number BVAPP: | | |
| Associated Power Plant: | Location: | | |
| Engineer: | Job Number Vendor: | | |
| Date of Installation completion: | Date of Vendor Departure: | | |
| Tested by: | Date: | | |
| **ITEM** | | **YES** | **NO** |
| 1. Power equipment is located and designated as shown on floor plan drawing | | | |
| 2. All cable holes appear to be closed properly (wall, ceiling, and floor type, as applicable) | | | |
| 3. Wall and column mounted equipment are properly located and shown on floor plan, cable rack plan, or other associated site record drawings | | | |
| 4. Power Equipment has adequate clear working space per the NEC® and Tech Pub 77351. | | | |
| Test & Acceptance shall be performed with the installer on site. Note below all problems they fix. | | | |
| Comments (all No answers must be commented on) | | | |
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**Form 829A** Power Area Floor Plan Test and Acceptance Checklist

**CenturyLink™**
**POWER DOCUMENTATION TEST & ACCEPTANCE CHECKLIST**

| | |
|---|---|
| Site: | Job Number BVAPP: |
| Associated Power Plant: | Location: |
| Engineer: | Job Number Vendor: |
| Date of Installation completion: | Date of Vendor Departure: |
| Tested by: | Date: |

| ITEM | YES | NO |
|---|---|---|
| 1. All new power equipment drawings furnished on this project are in acceptable condition | | |
| 2. All power drawings that were supposed to be provided with this job were provided | | |
| 3. All operating and maintenance instructions for new or added power equipment are available and accessible at the site | | |
| 4. All installer job completion reports are available | | |
| 5. Installer(s) followed written MOPs | | |
| 6. Are all necessary SDS (formerly MSDS) sheets available on site | | |

| Test & Acceptance should be performed with the installer on site. Note below all problems they fix. |
|---|
| Comments (all No answers must be commented on) |
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**Form 829B** Power Documentation Test and Acceptance Checklist

**CenturyLink™**
**LARGER SITE POWER EQUIPMENT INVENTORY**

| | | | | | |
|---|---|---|---|---|---|
| OFFICE: | | CLLI: | | DATE: | |
| ADDRESS: | | TECH: | | PHONE: | |

**BATTERY PLANTS**

| | Plant #1 | Plant #2 | Plant #3 |
|---|---|---|---|
| Voltage & Polarity: | | | |
| Plant/Controller Mfg/Mdl | | | |
| Plant Size (shunt/bus Amps) | | | |
| Rectifier Qty & Models: | | | |
| Battery Strings & A-hr Size: | | | |
| Battery Mfgs & Models: | | | |
| Battery Installation Dates: | | | |
| Plant Load in Amps: | | | |
| PDSC Bus/Feed Brkr Size: | | | |
| Add Rect. max AC loads | | | |

**CONVERTER PLANTS**

| | Plant #1 | Plant #2 | Plant #3 |
|---|---|---|---|
| Voltage & Polarity: | | | |
| Mfg & Model: | | | |
| Associated Battery Plant: | | | |
| Qty & Sizes of Converters: | | | |
| Plant Load in Amps: | | | |

| **RING PLANT(S)** | | **PSMC MONITOR and OTHER ALARM DEVICES** |
|---|---|---|
| Mfg/Model: | RR: | PSMC Mfg & Model: |
| Ringers: | Interrupters: | Software Version: |
| Tone Generators: | Installation Date: | Dial-Up #: |
| **INVERTER(S)/UPS** | | X.25/IP Ckt #: |
| Mfg & Model: | | Other Alarm Devices (e.g., Dantel, etc.): |
| Size, AC Voltage/Phase: | | **ENGINE & TANK DATA** |
| Load (AC Amp/kVA): | | Engine Mfg& Model: |
| Associated Battery Plant: | | Voltage & kW: |
| Installation Date: | | Install Date (note if not Autostart): |
| **COMMERCIAL AC** | | Fuel Type & Consumption (gal/hr): |
| Voltage & Phase: | | Actual Engine Load (in kW): |
| Size (Amps): | | Start Batt Mfg& Model: |
| Lightning Arrest Frame & Model: | | Start Batt Install Date: |
| **PORTABLE GENSET INFORMATION** | | Transfer System Type/Size: |
| Plug Frame, Mod, & Size (Amps): | | Day Tank Capacity (gal): |
| Portable Frame, Size, Fuel: | | Main Tank Type & Capacity (gal): |
| Storage Location: | | Tank Monitor Mfg & Model: |
| **NOTES & COMMENTS** (use back of sheet as needed) | | Tank Monitor Dialup: |

**Retain a copy of this form and send a copy to the CenturyLink™ Power Engineers**

**Form 840** Larger Site Power Equipment Inventory

**CenturyLink™**

**BDFB OR POWER BOARD PANEL FUSE/BREAKER ASSIGNMENT RECORD**

| | | |
|---|---|---|
| **Site:** | **CLLI:** | **Date:** |
| **Address:** | | |
| **Tech:** | **Phone/Pager:** | |
| **PBD/RR of this BDFB/PBD:** | **PANEL(s):** | |
| **Feeder Fuse/Breaker PBD & Position:** | **Feeder Fuse/Breaker Size:** | **Panel Load:** |

| Position | Equipment & Relay Rack Fed | Fuse or Brkr Size | Mfg L-2 Drain | Mfg L-1 Drain | Actual Load |
|---|---|---|---|---|---|
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| | | | **Totals** | | |

Additional panels may be placed on additional sheets.
List 2 drains are peak drains
List 1 drains are average drains
Assigning fuses from the bottom to the top of a bay or panel (or inside to outside for horizontal panels) eases future installation and reduces cable congestion as needed
Contact your Design Engineer for a fuse assignment (if those are tracked in your area)
**Please note if this Panel is "bused" or "cabled" in the rear to adjacent panels** (e.g., C, A2, etc.)
Information for all columns may not be available to you — some columns are for Engineering use, and some for the "field"

| |
|---|
| **Notes:** |
| |
| |
| |

**Form 841** BDFB/PBD Panel Fuse/Breaker Assignment Record

## CenturyLink™
## CRITICAL LARGER SITE POWER ALARM VERIFICATION

| Alarm | Alarm system ticket # | Notes |
|---|---|---|
| **Critical Power Alarms** | | |
| Commercial AC Fail | | |
| Power Major | | |
| Power Distribution Fuse/Breaker Major | | |
| Low Voltage and/or Battery on Discharge | | |
| Very Low Voltage (if applicable) | | |
| High Voltage | | |
| Rectifier Fail Major | | |
| Ring Plant Major | | |
| Low Voltage Disconnect (where applicable) | | |
| Engine Run | | |
| Engine Fail/Major | | |
| Low Fuel / Fuel System Trouble | | |
| **Alarm Center Contact Person:** | | **Alarm Center Phone:** |
| **Site CLLI:** | **Site Address:** | |
| **Alarm Telemetry System Type:** | | |
| **X.25 or IP (PSMC)** | **e-tel** (Dantel, E2A, etc.) | **Switch or other** |
| **Installer performing the test and company** | | **Phone:** |
| **NROC Tech with whom Test performed:** | | **Phone:** |
| It may not be wise to test some alarms except in the Maintenance Window due to the possibility to cause an outage if they are truly tested; and/or in some cases, it may be best to simply verify alarm continuity by shorting the alarm pins instead of actually bringing in the alarm, for the same reasons | | |
| **Additional Notes:** | | |
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| | | |

**Form 844** Critical Larger Site Power Alarm Verification

**CenturyLink™**
**SMALLER SITE POWER EQUIPMENT INVENTORY**

| | |
|---|---|
| Common Name of Location | |
| State | |
| CLLI | |
| Address | |
| Upstream Office (serving Wire Center) | |
| Access & Directions | |
| Map or GPS coordinates | |
| Customer (primarily for Customer Prem sites) | |
| Site Type (RT, CEV, UE, CEC, hut, rptr, CPE)<br>(List RTs by type: e.g., 80 cabinet, etc.) | |
| Date of this review | |
| Reviewer name & contact # | |
| Air-conditioning type & maintenance contact | |
| Power plant type (also list J-spec, KS-, or mdl ) | |
| Load (in Amps) | |
| # Rectifiers | |
| Rectifier type [also list the model number(s)] | |
| Rectifier size(s) | |
| Float voltage | |
| # Battery strings | |
| Battery type (model #, KS-spec, etc.) | |
| Battery size (A-hrs) | |
| # cells/monoblocs per string | |
| Battery installation date(s) | |
| Residual Ring plant type (model number, etc.) | |
| Comm. AC voltage, phase, and Amp rating | |
| Generator Plug Mfg., type, and size | |
| Alarm system (E-tel, X.25, overhead, etc.) | |
| Alarm Center & Center phone # | |
| **CIRCLE ALARMS THAT ARE PRESENT** (Add any others not listed here)<br>POWER MJ POWER MN RECT. FAIL AC PWR FAIL | |
| Notes: | |
| | |

**Form 845** Smaller Site Power Equipment Inventory

**CenturyLink™**
**SMALLER SITE HOUSEKEEPING ALARM VERIFICATION**

| **Alarm** | **Works?** | **Doesn't Work?** | **N/A** |
|---|---|---|---|
| Commercial AC Fail | | | |
| Power Major | | | |
| Power Minor | | | |
| High Battery Temperature | | | |
| Power Distribution Fuse/Breaker | | | |
| Low Voltage and/or Battery on Discharge | | | |
| Very Low Voltage | | | |
| High Voltage | | | |
| Rectifier Fail (list the number of these alarms if more than 1) | | | |
| Ring Plant Major | | | |
| Ring Plant Minor | | | |
| High Temperature (of the enclosure) | | | |
| Explosive Gas Alarm | | | |
| Toxic/Explosive Gas Alarm (combined) | | | |
| Ventilation/Fan Fail | | | |
| Air-Conditioner Failure | | | |

| | | |
|---|---|---|
| **Tech Performing Test:** | **Phone/Pager:** | |
| **Site CLLI:** | **Site Address:** | |
| **Alarm Telemetry System Type:** | | |
| **X.25 overhead** (fiber mux) | **e-tel** (Dantel, E2A, Westronics) | **other** (list) |
| **NROC Tech with whom Test performed:** | | **Phone:** |
| **Additional Notes:** | | |
| | | |
| | | |

**Form 846** Smaller Site Housekeeping Alarm Verification

## CONTENTS

**Chapter and Section** **Page**

## 16. Definitions and Acronyms

| | |
|---|---|
| 5E | 5ESS™ |
| A or Amp | Amperes (amount of current flow) |
| A2LA | American Association for Laboratory Accreditation |
| A/B | redundant (dual) feeds; typically referring to DC systems |
| ABC | Area Bus Centers |
| ABS | Alarm Battery Supply (small fusing at the power plant for the controller) |
| AC | 1) Alternating Current<br>2) Armor-Clad (certain cable types with a metallic wind outer jacket) |
| A/C | Air-Conditioning |
| ACEG | Alternating Current Equipment Ground |
| ach | air changes per hour |
| ACO | Alarm Cut-Off |
| ACT | Activate |
| ADSL | Assymetric Digital Subscriber Line |
| AGM | Absorbed Glass Matte (VRLA battery separator-absorbed electrolyte) |
| Ah or A-hr | Ampere-hour (rating of a battery to deliver so many Amps for so many hrs) |
| AHJ | Authority Having Jurisdiction (Fire Marshal, Electrical Inspector, etc.) |
| A.I.C. | Amps of Interrupting Current (capability to withstand) |
| AID | Access IDentifier (identifies a specific piece of equipment) |
| aka | also known as |
| alm or al or ALRMS | Alarm(s) |
| Alt | Alternator |
| ALW | Allow |
| ANTS | Abnormal Network Tracking System (CenturyLink™ outage reporting method) |
| ANSI | American National Standards Institute |
| API | American Petroleum Institute |
| ASCII | American Standard Characters for Information Interchange |
| ASHRAE | American Society of Heating, Refrigerating, and Air-conditioning Engineers |
| ASME | American Society of Mechanical Engineers |

| | |
|---|---|
| AST | Above-ground Storage Tank (includes vaulted tanks below ground) |
| ASTM | American Society of Testing Materials |
| ATIS | Alliance for Telecommunications Industry Solutions |
| ATS | 1) Automatic Transfer Switch/System<br>2) Acceptance Testing Specification |
| ATTR | Attribute |
| AUD | Audible (nominal 86 VAC 20 Hz superimposed ringing) |
| AUX | Auxiliary |
| avg | average |
| AWG | American Wire Gauge |
| AXE™ | Automatic Cross-connection Equipment |
| BAT or Batt or B | Battery |
| BCC | Bay Command Console (a type of DMS™ switch bay) |
| BDB | Battery Distribution Board — see PBD |
| BDFB or BDCBB | Battery Distribution Fuse (or Circuit Breaker) Board/Bay |
| BET | Building Entrance Terminal |
| B(r)kr or BR(K) | Breaker |
| BMS | Battery Management System |
| BOD | Battery on Discharge |
| BP | Bypass |
| bps | bits per second |
| BPSC | Building alarm Point, Scan and Control |
| BS | British Standard |
| BTBA | Battery Termination Bus Assembly (chandelier, or main term bars) |
| BVAPP | Billing Verification Authority Purchasing Project (CenturyLink™ job #) |
| BX | An older type of AC (armor-clad) cable |
| c | cells |
| C | 1) degrees Celsius<br>2) battery Capacity<br>3) Common (grounded) alarm contact |
| cab | cabinet |
| CAD | Computer-Aided Drawing |

| | |
|---|---|
| CANC | Cancel |
| cap | capacitor |
| CATV | traditional cable TV hybrid fiber-coax network |
| CB | Circuit Breaker |
| CCA | Cold Cranking Amps |
| ccs | centi-call seconds (or hundreds of call seconds — full usage is 36 ccs/hr) |
| CDC | Centers for Disease Control and Prevention |
| CdO | A small Central Office (Community Dial Office) |
| CEC™ | Controlled Environmental Cabinet (half-buried walk-in hut/vault) |
| CEM | Construction Engineering Memorandum |
| CEMF | Counter-Electro Motive Force cell |
| CEV | Controlled Environmental Vault |
| CFA | Converter Fail Alarm |
| CFR | 1) Controlled Ferro-Resonant rectifier<br>2) Code of Federal Regulations |
| char | character |
| Chg | 1) Charge(r) – sometimes known as a rectifier<br>2) change |
| Ckt or CRCT | circuit |
| CL | Confined Location |
| CLAS | Classification |
| CLEC | Collocated Local Exchange Carrier |
| CLLI™ | Common Language Location Identifier |
| Cntrl | Control |
| CO | Central Office |
| coax | coaxial waveguide cable |
| COE-FM | Central Office Equipment – Facilities Management (CAD system) |
| COGB | Central Office Ground Bus |
| COM(M) or com | 1) Communications<br>2) commercial |
| combo | combination card (both POTS and DSL on the same card) |

| | |
|---|---|
| COML or COMM | Commercial (AC) |
| comp | Compensation (as in temperature compensation) |
| COND | Condition |
| config | (standard) configuration |
| CONT | Control |
| CONV/cnvrter/C | Converter |
| COOL/CO/ C/CLT | Coolant |
| COT | Central Office Terminal |
| CP | Chlorosulfonated Polyethylene (type of cable insulation) |
| Crit or CR or CAT | Critical alarm |
| CRNK or CRK | Crank |
| CSPEC | Common Systems Planning and Engineering Center |
| CT | Current Transformer |
| CURNT or CUR | Current (in Amperes) |
| d | distance |
| D | Distribution |
| daisy chaining | running multiple bays/shelves off of a single fuse/breaker position |
| dB | deciBels |
| dBa | deciBels audible |
| dBrnC | deciBels referenced to noise weighting C (POTS voiceband) |
| DC or D.C. | Direct Current |
| delta or Δ | method of providing 3-phase power |
| demarc | demarcation point between phone company and premises wiring |
| DIESL or DSL | Diesel |
| diff | differential |
| Disc or DISCO | Disconnect |
| DISC*S | Digital Subscriber Carrier System |
| Dist or DIS | Distribution |
| DLC | Digital Loop Carrier |
| DLO | Diesel Locomotive (wire — Class K wire stranding) |
| DLT | Delete |

| | |
|---|---|
| DMM | Digital MultiMeter |
| DMS™ | Digital Multiplexing System (family of Nortel Class 5 switches) |
| drop | the smaller power wire, tapped to the main conductor, to enter a bay |
| DSCH(R)G/DIS(CH) | Discharge |
| DS-0 | Digital Signal (level) 0, a digital data rate of 64 kbp/s |
| DS-1 | Digital Signal 1, a digital data rate of 1.544 Mbps (can carry 24 DS-0s) |
| DS-3 | Digital Signal 3, a digital data rate of 50 Mbps (can carry 28 DS-1s) |
| DSL | Digital Subscriber Line (high speed copper carrying data or video) |
| DSU | Data Serving Unit (modem for packet circuits, like X.25) |
| DT | Day Tank |
| DTMF | Dual Tone Multi-Frequency |
| E2A | E-telemetry 2nd generation Alarm surveillance protocol (polled from the master alarm system via a relatively slow 4-wire data circuit) |
| EAT | Engine Alarm Termination box |
| ED | Edit |
| EDLC | Electric Double-Layer Capacitor (Super™ or Ultra™ Capacitor) |
| EEE | Electronic Equipment Enclosure |
| EMER or Em(er)g | Emergency |
| EMC | Electro-Magnetic Compatibility |
| EMI | Electro-Magnetic Interference |
| EMT | Electrical Metallic Tubing |
| EN | English (notation for IEC standards to note the language it is written in) |
| Eng or E | Engine |
| env or enviro(n) | environment(al) |
| EoCu | ethernet over copper |
| EPA | Environmental Protection Administration |
| EPO | Emergency Power Off switch/button |
| EPR/EPDM | Ethylene Propylene Rubber (a type of wire insulation material) |
| E/Q | Earthquake |
| eqpt | equipment |
| ESD | Electro-Static Discharge |

| | |
|---|---|
| ESS™ | Electronic Switching System |
| e-tel | e-telemetry (an alarm protocol for edge devices using E2A or IP transport) |
| ETP | Electrolytic Tough Pitch (hard-drawn copper) |
| EXT | External |
| F | 1) degrees Fahrenheit<br>2) Farad (unit of capacitance)<br>3) Float (as in voltage or charge) |
| FA | Fuse Alarm |
| FB | Fuse Bay |
| FCC | Federal Communications Commission |
| FL or F | Fail |
| FR | Family of Requirements |
| FRP | Fiber-Reinforced Polymer |
| FS | fuse |
| FSP | Fuse Supply Panel |
| ft | feet |
| FTTB | Fiber to the Business |
| FTTC | Fiber to the Curb |
| FTTH | Fiber to the Home |
| FTTP | Fiber to the Premise |
| FX | Foreign Exchange |
| G | rectifier Group (number) |
| gal | gallon |
| GEN or G | Generator |
| genset | standby engine-alternator (typically the portable type) |
| GF(C)I | Ground Fault (Circuit) Interrupter |
| GN | General |
| GND or GRD | Ground |
| GPDF | Global Power Distribution Frame for a Lucent 5ESS™ switch |
| GPS | Galaxy™ Power System (from Lineage Power) |

| | |
|---|---|
| GR | Generic Requirements |
| Hardened Equipment | Equipment that must operate at the temperature extremes of -40 to +65° C |
| HDR | Header |
| HDSL | High bit-Rate Digital Subscriber Line |
| HI or H | High |
| hka | housekeeping (environmental or power) alarm |
| hp | horsepower |
| HM | Host Message |
| hr or h | hour |
| hrsm | host-remote switch module |
| HSP | House Service Panel |
| html | Hyper-Text Markup Language |
| HVA | High Voltage Alarm |
| HVAC | Heating, Ventilation and Air-Conditioning |
| HVSD | High Voltage Shut Down |
| Hz | Hertz (frequency — cycles per second) |
| I | 1) current (in Amperes)<br>2) Inverter |
| IACS | International Annealed Copper Standard |
| ICA | InterConnection Agreement |
| ICC | International Code Council |
| ICEP | Inductive Coordination and Electrical Protection |
| ICS | Industrial Controls and Systems |
| ID or IDNT | IDentifier |
| IEC | International Electro-Technical Commission |
| IEEE | Institute of Electrical and Electronic Engineers |
| INH | Inhibit |
| INIT | Initialize |
| inter | interruptor (part of some residual ring plants) |
| inv or INVERT | inverter |
| INV | Inventory |

| | |
|---|---|
| IOF | Inter Office Facilities |
| IP | Internet Protocol |
| IR | infrared |
| ISDN | Integrated Services Digital Network |
| IT | Information Technology (computer room) |
| ITU-T | International Telecommunications Union (Telecom standardization sector) |
| IXC | IntereXchange Carrier |
| J | Joules |
| k | kilo (1000) |
| K | constant representing the resistance of copper or aluminum |
| kcmil | kilo circular mils (a circular mil is the area of a circle with a dia. of $^{1}/_{1000}$") |
| KS | Kearney Specification (a manufacturing standard from Western Electric) |
| L | Low |
| L- | List number (part of the end of some telecommunications part numbers) |
| LATA | Local Access Transport Area (separates local from long distance carrier call) |
| LED | Light Emitting Diode |
| LEL | Lower Explosive Limit |
| Li | Lithium |
| LIGTN or LTNG | Lightning |
| LMP | Lithium Metal Polymer (battery) |
| LNS | Local Network Services (a CenturyLink™ internal division) |
| LO or LW or L | Low |
| LOI | Limiting Oxygen Index |
| LPDU | Load Power Distributing Unit for a 5ESS™ switch |
| LPG | Liquid Propane Gas |
| LS | Low-Voltage Surge |
| LSSGR | LATA Switching System Generic Requirements |
| LVA | Low Voltage Alarm |
| LVBD | Low Voltage Battery Disconnect |
| LVD | Low Voltage Disconnect |
| LVLD | Low Voltage Load Disconnect |

| | |
|---|---|
| m | 1) milli (thousandth)<br>2) meter |
| M | 1) mega (million)<br>2) Module/Main<br>3) Micro (as in microprocessor)<br>4) midpoint |
| Maj or MJ | Major alarm |
| max | maximum |
| MC | Metal-Clad cable (a specialized type of armored cable that is sealed to gas) |
| MCM | thousand circular mils (old designation — modern one is kcmil) |
| MCS™ | Microprocessor Controlled System (Trademark of Lineage Power) |
| MDed | Manufacturer-Discontinued |
| Mdl | Model (number) |
| MEAS | Measure |
| Megger™ | megohmmeter |
| Mfg | Manufacturer |
| MG | Main Generation or Motor Generator |
| MGB | Main Ground Bus (in the Ground Window) |
| MGN | the power company's Multi-Grounded Neutral |
| MI | Mineral Insulated cable (copper and magnesium-oxide outer jacket) |
| MIB | Management Information Base (vendor-provided SNMP manager template) |
| $\mu$ | micro (millionth, or precursor to processor) |
| mil | thickness or diameter of one-thousandth of an inch |
| min | 1) minute<br>2) minimum |
| Min or MN | Minor alarm |
| misc | miscellaneous |
| mod | module |
| MOP | Method of Procedure (used to define installation steps) |
| MOV | Metal-Oxide Varistor |
| MP | Micro-Processor |
| MSG | Message |

| | |
|---|---|
| MTB | Main Term Bar(s) |
| mux | multiplexer |
| MVPC or mvpc | minimum Volts per Cell |
| $\eta$ | efficiency |
| N or n | number |
| N | Negative |
| N81 | No parity, 8 bits, 1 stop bit (modem communications protocol setting) |
| N/A | Not Applicable |
| NA | Not Available |
| NACE® | National Association of Corrosion Engineers |
| N.C. or NC | Normally Closed contacts (open on alarm) |
| NE | intelligent Network Element |
| NEBS™ | Network Equipment – Building System |
| NEC® | National Electrical Code |
| NEMA® | National Electrical Manufacturer's Association |
| NETA™ | National Electrical Testing Association |
| NESC® | National Electrical Safety Code |
| NFPA® | National Fire Protection Association |
| Ni-Cad or NiCd | Nickel Cadmium |
| NID | Network Interface Device (demarc between company and premises wiring) |
| NIL | none |
| NIOSH | National Institute for Occupational Safety and Health |
| NMA® | Network Monitoring and Analysis |
| NMH or NiMH | Nickel-Metal Hydride |
| NNS or NSD | National (Network) Services (Division) - long-haul CenturyLink™ division |
| N.O. or NO | Normally Open contacts (close on alarm) |
| NOC | Network Operations Center (generic term for alarm center) |
| NORM | Normal |
| NR | No Redundancy |
| NROC | Network Reliability and Operations Center (CenturyLink™ Alarm Center) |
| NRTL | Nationally Recognized Testing Laboratory |

| | |
|---|---|
| NTA | National Telecommunication Association |
| NSA | Non-Service Affecting |
| NUM or N or n | Number |
| NVLAP | National Voluntary Laboratory Accreditation Program |
| Ω | Omega (the greek letter representing Ohms, the unit of electrical impedance) |
| O | On |
| OAU | Office Alarm Unit |
| ocs | Operation Communications System |
| OCV | Open-Circuit Voltage |
| OF | Output Fail |
| OMNPLSE | Omnipulse™ (an older AT&T/Lucent power monitor) |
| ONU | Optical Network Unit |
| OPAC™ | Outside Plant Access Cabinet |
| OPGP(B) | Office Principal Ground Point (Bus) |
| OPM™ | Outside Plant Module |
| OPR | Operate |
| ORM™ | Optical Remote (switching) Module |
| OSHA | Occupational Safety and Health Administration |
| OSMINE™ | Operations Systems Modifications for the Integration of Network Elements (Ericsson Telcordia® process for ensuring equipment and equipment peripheral system compatibility with Telcordia's OSS systems) |
| OSP | Outside Plant |
| OSS | Operational Support Systems |
| OVER or O | 1) Overcrank<br>2) Overspeed |
| ovly | overlay |
| p | pairs |
| P | 1) Positive<br>2) Power |
| PAD | Packet Assembler/Disassembler |
| PBD | Main DC Power Distribution Fuse/Breaker Board |

| | |
|---|---|
| PC | Pilot Cell |
| PDC/F | Power Distribution Cabinet/Frame (switch secondary distribution point) |
| PDSC | Power Distribution Service Cabinet (AC cabinet feeding the rectifiers) |
| PDU | AC Power Distribution Unit (data center floor mount cabinet or rack shelves/strips) |
| P.E. | Professional Engineer |
| PEI™ | Petroleum Equipment Institute |
| PES | Power and Environment System (a type of DMS™ remote switch message) |
| pf (power factor) | the cosine of the phase angle between AC Voltage and current peaks |
| PFC | Power Factor Correction |
| PF(D) | Power Fuse (Distribution) Bay for a switch |
| PG | Pair Gain |
| ph or Ø or PHSE | Phase (of AC) |
| PLC | Programmable Logic Controller |
| plt | plant |
| PM | 1) Power Message<br>2) Power Monitor |
| PoE | Power over Ethernet |
| POTS | Plain Old Telephone Service |
| Prem | commercial Customer Premises |
| PRES or PRESS | Pressure |
| PRI | Primary (power plant or distribution) |
| PROC | Processor |
| PSAP | Public Safety Answering Point |
| PSMC | Power System Monitor Controller |
| pt | point |
| PT | Potential (voltage) Transformer |
| PTC | Positive Temperature Coefficient (variable resistor) |
| Pub | Publication |
| PV | Photo-Voltaic |
| PVC | Poly-Vinyl Chloride (plastic) |

| | |
|---|---|
| Pwr or POWR | Power |
| Q&A | Question and Answer (CenturyLink™ Engineering tool) |
| R | 1) Resistance<br>2) Run<br>3) Ring(ing)<br>4) Remote<br>5) Rated capacity |
| Ratel | Ratelco (a former manufacturer of rectifiers, power monitors, etc.) |
| RCS | Remote Concentrator – Subscriber |
| RCU | Remote Carrier – Urban |
| Rect or REC | Rectifier |
| redf | redefine |
| Reg | Regulation |
| Regen | regeneration |
| REPT | Report |
| REV | Reverse |
| RFA | Rectifier Fail Alarm |
| RG | Regional (part of a standard practice or form # for CenturyLink™ LNS) |
| RHH | Rubber, extra-High temperature (wire insulation) |
| RHW | Rubber, High temperature, Water resistant (wire insulation) |
| RLCM™ | Remote Line Concentrator Module |
| RLS | Release |
| Rm | room |
| rms | Root Mean Square ("effective", "average" AC voltage and current) |
| RNG | Ringing (plant) |
| RO | Record Only |
| ROH | Receiver Off Hook |
| RoHS | Reduction of Hazardous Substances |
| ROW | Right-of-Way |
| rpm | Revolutions per minute |
| RPM | Remote Peripheral Monitor |

| | |
|---|---|
| rptr | repeater |
| RR | Relay Rack |
| RS | 1) Reverse Service<br>2) Re-Start<br>3) Recommended Standard |
| RSC™ | Remote Switching Center |
| RT | Remote Terminal |
| RTN or Rtn | Return (bus) |
| RTRV | Retrieve |
| RTU | Right-to-use |
| RU | Rack Unit |
| RUS | Rural Utilities Service |
| s96 | SLC®96 (DLC system where 4 T-1s backhaul 96 DS-0 POTS lines) |
| s | string |
| s or sec | second(s) |
| SA | Service Affecting |
| SAD | Silicon Avalanche Diode |
| SBR | Styrene Butadiene Rubber (cable insulation) |
| SCC | Switching Control Center |
| (M)SDS | (Material) Safety Data Sheet |
| SECU | Secure |
| SELV | Safety Extra Low Voltage |
| SEVER | Severity |
| s.g. | Specific Gravity |
| SHARP™ | Self Healing Alternate Route Protection (CenturyLink™-sold architechture) |
| SHNS™ | Self Healing Network Services (architecture sold by CenturyLink™) |
| SHUT | Shutdown |
| SI | Système International (d'unités) – the metric system |
| SID | System ID |
| SLC® | Subscriber Loop Carrier |

| | |
|---|---|
| SM | Switch Module |
| SMR | Switch-Mode Rectifier |
| SNMP | Simple Network Management Protocol |
| SONET | Synchronous Optical Network |
| SPCC | Spill Prevention, Containment, and Control |
| SPCS | Stored Program Control Switching System |
| SPD | 1) Surge Protective Device<br>2) Speed |
| spec(s) | specification(s) |
| SR | Special Report |
| SRCE | Source |
| Stby or SBY | Standby |
| STI® | Steel Tank Institute |
| SUM | Summary |
| SW | Switch |
| sync | synchronize |
| Sys or S | System |
| T | 1) Terminate or stop<br>2) Transfer<br>3) Temperature |
| T1 (or T-1) | T-carrier rate 1 — physical standard for carrying a DS-1 signal |
| TA | Technical Advisory |
| Tech or tech | 1) Technical<br>2) technician |
| telecom | telecommunications |
| Temp or TMP or T | Temperature |
| term | termination or terminal (bar) |
| TFFN | Thermo-plastic, Flexible, Fixture wire, with Nylon jacket |
| TH | Threshold |
| THD | Total Harmonic Distortion (in the AC source or fed back to it) |
| THHN | Thermoplastic, extra-High temperature, Nylon-jacketed (wire insulation) |
| 3D Condo | A co-location building that is jointly owned. |

| | |
|---|---|
| THWN | Thermoplastic, High temperature, Water resistant, Nylon-jacketed insulation |
| TIA® | Telecommunications Industry Association |
| TID | Target IDentifier (the network element to which a TL1 message is sent) |
| TIF | Telephone Influence Factor |
| TL1 | Transaction Language 1 (NE to NMA® communication, Telcordia-defined) |
| TLE | Telecommunications Load Equipment |
| TLPU | Telecommunications Line Protector Unit |
| TLS | Tape Library System |
| TNV | Telecom Network Voltage |
| top to top | from the top of one equipment bay to another, not including drops |
| TP | Test Point |
| TPE | Thermo-Plastic Elastomer (wire insulation) |
| TR | 1) Technical Reference<br>2) Terminate Rectifier (shutdown signal)<br>3) Transfer<br>4) Trouble |
| TRAN or TRN | Transfer |
| Trbl or TBL | Trouble |
| TSGR | Transport System Generic Requirements |
| TTY | teletype |
| TVSS | Transient Voltage Surge Suppression (see also SPD) |
| UBC™ | Uniform Building Code |
| UE™ | Universal Enclosure (half-buried walk-in hut/vault) |
| UFC™ | Uniform Fire Code |
| UL® | Underwriter's Laboratory |
| UNS-C | Unified Numbering System for metal (C=Copper) alloys |
| UP | Upper |
| UPS | Uninterruptible Power Supply |
| USB | Universal Serial Bus |
| USE | Underground Service Entrance (cable) |
| UST | Underground Storage Tank (direct-buried) |

| | |
|---|---|
| V or VLT | Volts |
| VA | Volt-Amps |
| VDSL | Very-high-bit-rate Digital Subscriber Line |
| VFD | Variable Frequency Drive (rectified variable speed motor for HVAC) |
| VG/VLTG/VOLT | Voltage |
| VLV | Very Low Voltage |
| VOM | Volt-Ohmmeter |
| VRLA | Valve Regulated Lead Acid |
| VT100 | Virtual Terminal Emulation with 100 defined keys |
| w/ | with |
| W | 1) Watt (equal to Volt-Amps for DC, but reduced by power factor for AC)<br>2) Watch |
| (Class) W | Welding wire stranding (actually correctly known as Class K) |
| WD | Wiring Devices |
| WECO | Western Electric Company (manufacturing arm of the former Bell System) |
| WFCA | Western Fire Chiefs Association |
| WTR | Water |
| wye or Y | three-phase power, where the center tap is grounded neutral |
| Xfr or XFER | Transfer |
| XHHW | Cross-linked, thermoset, extra-High temperature, Water resistant insulation |
| XLP | Cross-Linked Polyethylene (wire insulation) |

**CONTENTS**

**Chapter and Section** **Page**

# 17. Bibliography

The following references are bibliographical for referential purposes only, and not binding. All binding requirements are specifically contained in this document. All referenced documents are the latest available issue.

## 17.1 Telcordia® and Bell Labs Publications



| | |
|---|---|
| BR-790-100-656 | DC Distribution |
| GR-26 | Controlled Environmental Vaults (CEVs) |
| GR-27 | Environmental Control Systems for Electronic Equipment Enclosures |
| GR-63 | NEBS™ Requirements: Physical Protection |
| GR-78 | General Physical Design Requirements for Communications Products and Equipment |
| GR-151 | 24-, 48-, 130-, and 140-Volt Central Office Power Plant Rectifiers |
| GR-209 | Product Change Notices (PCNs) |
| GR-221 | Interface and Functional Requirements for Microprocessor Control of 24-, 48-, 130-, and 140-Volt Central Office Power Plants |
| GR-230 | Engineering Complaints |
| GR-232 | Lead-Acid Storage Batteries |
| GR-295 | Mesh and Isolated Bonding Networks: Definition and Application to Telephone Central Offices |
| GR-347 | Generic Requirements for Central Office Power Wire |
| GR-513 | Power Requirements in Telecommunications Plant |
| GR-811 | TL1 Messages Index |
| GR-833 | TL1 Surveillance and Maintenance Messages |
| GR-947 | Generic Requirements for a -48 Volts Telecommunications Switchmode Rectifier/Power Supply |
| GR-974 | Telecommunications Line Protector Units (TLPUs) |
| GR-1089 | Electromagnetic Compatibility and Electrical Safety for Network Telecommunications Equipment |
| GR-1275 | Central Office / Network Environment Equipment Installation/Removal |

| | |
|---|---|
| GR-1500 | Powering Telecommunications Load Equipment (TLE) in Telecommunications Systems |
| GR-1502 | Central Office / Network Environment Detail Engineering |
| GR-1515 | Detection and Control of Thermal Runaway in VRLA Batteries |
| GR-2832 | Walk-in Cabinets |
| GR-2834 | Basic Electrical, Mechanical, and Environmental Criteria for Outside Plant Equipment |
| GR-3020 | Nickel Cadmium Batteries in the Outside Plant |
| GR-3108 | Network Equipment in the Outside Plant (OSP) |
| GR-3150 | Secondary Non-Aqueous Lithium Batteries |
| GR-3168 | Nickel Metal Hydride Battery Systems for Use in Telecommunications |
| GR-4228 | VRLA Battery String Certification Levels Based on Requirements for Safety and Performance |
| TA-NWT-000370 | Generic Requirements for Mechanized Power Room Operations Monitor (MPROM) |
| TA-NWT-000406 | DC Bulk Power System for Confined Locations |
| TA-NWT-001360 | Generic Requirements for Power Systems Messages at the OS/NE Interface |
| TR-NWT-000154 | 24-, 48-, 130-, and 140-Volt Central Office Power Plant Control and Distribution Equipment |
| TR-NWT-001011 | Surge Protective Devices (SPDs) on AC Power Circuits |
| TR-NWT-001223 | DC Power Board Fuses |
| TR-NWT-001293 | Permanent Engine-Generators for Remote Electronic Sites |
| TR-TSY-000757 | Uninterruptible Power Systems (UPS) |
| TR-TSY-000967 | Low-Power Telecommunications Power Supply Rectifier |
| SR-3580 | Network Equipment-Building System (NEBS™) Criteria Levels |
| SR-5263 | Code Requirements and Fire Protection Issues for Stationary Storage Battery Systems in Telecommunications Equipment, Video Headend and IT Buildings |

## 17.2 CenturyLink™ Technical Publications


| | |
|---|---|
| PUB 77350 | Central Office Telecommunications Equipment Engineering Installation and Removal Guidelines |
| PUB 77351 | CenturyLink™ Engineering Standards |
| PUB 77354 | Guidelines for Product Change Notices |
| PUB 77355 | Grounding - Central Office and Remote Equipment Environment |
| PUB 77368 | Commercial Customer Premises Electronic Equipment Environmental Specifications and Installation Guide |


## 17.3 Miscellaneous Publications


| | |
|---|---|
| API 1615 | Installation of Underground Petroleum Storage Systems |
| API 1632 | Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems |
| ASME B31 | Code for Pressure Piping |
| ASTM A-53 | Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless |
| ASTM B-3 | Specifications for Soft or Annealed Copper War |
| ASTM B-8 | Standard Specification for Concentric-Lay-Stranded Copper Conductor, Hard, Medium-Hard, or Soft |
| ASTM B-33 | Specifications for Tinned Soft or Annealed Copper Wire for Electrical Purposes |
| ASTM B-172 | Standard Specification for Rope-Lay-Stranded Copper Conductor Having Bunch-Sheath Members, for Electrical Conductors |
| ASTM B-174 | Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors |
| ASTM B-187 | Standard Specification for Copper, Bus Bar, Rod, and Shapes, and General Purpose Rod, Bar, and Shapes |
| ASTM B-193 | Standard Test Method for Resistivity of Electrical Conductor Materials |
| ASTM B-258 | Standard Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Uses as Electrical Conductors |
| ASTM D-975 | Standard Specification for Diesel Fuel Oils |

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| ASTM E-1004 | Standard Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method |
| ASTM E-1430 | Standard Guide for Using Release Detection Devices with Underground Storage Tanks |
| ATIS-0600003 | Battery Enclosure and Rooms/Areas |
| ATIS-0600015 | Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting DC Power Plant – Rectifier Requirements |
| ATIS-0600017 | DC Power Wire and Cable for Telecommunications Power Systems |
| ATIS-0600028 | DC Power Wire and Cable for Telecommunications Power Systems – for XHHW and DLO/Halogenated RHW/RHH Cable Types |
| ATIS-0600311 | DC Power Systems – Telecommunications Environment Protection |
| ATIS-0600315 | Voltage Levels for DC-Powered Equipment Used in the Telecommunications Environment |
| ATIS-0600317 | Uniform Language for Accessing Power Plants – Human-Machine Language |
| ATIS-0600328 | Protection of Telecommunications Links from Physical Stress and Radiation Effects and Associated Requirements for DC Power Systems (a Baseline Standard) |
| ATIS-0600330 | Valve-Regulated Lead-Acid Batteries Used in the Telecommunications Environment |
| ATIS-0600332 | Electrical Protection of Network-Powered Broadband Facilities |
| ATIS-0600337 | Maximum Voltage, Current, and Power Levels in Network-Powered Transport Systems |
| ATIS-0600418 | Hi-Bit Rate Digital Subscriber Line-Second Generation (HDSL2/HDSL4) |
| Enersys AE-080123.4 | Temperature Compensation Factors for OCV (Open-Circuit Voltage), Float Voltage, and Electrolyte Specific Gravity |
| EPA 40CFR | Part 60, Standards of Performance for New Stationary Sources; Part 63, Air Programs, National Emission Standards for Hazardous Air Pollutants for Source Categories; Part 94, Control of Emissions from Marine Compression-Ignition Engines; Part 112, Water Programs, Oil Pollution Prevention and Response; and Parts 280-281, Underground Storage Tanks Containing Petroleum |

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| ICBO UBC™ | the Uniform Building Code |
| ICC IBC | International Building Code |
| ICC IFC | International Fire Code |
| ICC IMC | International Mechanical Code |
| IEC 60228 | Conductors of Insulated Cables |
| IEC 60309 | Plugs, Socket-Outlets, and Couplers for Industrial Purposes |
| IEC 60417 | Graphical Symbols for Use on Equipment |
| IEC 60479 | Effects of Current on Human Beings and Livestock |
| IEC 61000-3 | Electromagnetic Compatibility (EMC) – Part 3: Limits |
| IEC 61204-7 | Low Voltage Power Supplies, D.C. Output – Part 7 |
| IEC 62602 | Conductors of Insulated Cables – Data for AWG and kcmil Sizes |
| IEC BS EN 13636 | Cathodic Protection of Buried Metallic Tanks and Related Piping |
| IEEE 115 | Test Procedures for Synchronous Machines |
| IEEE 484 | Recommended Practice for the Design and Installation of Vented Lead-Acid Batteries for Stationary Applications |
| IEEE 485 | Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications |
| IEEE 519 | Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems |
| IEEE 937 | Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for PhotoVoltaic (PV) Systems |
| IEEE 946 | Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Systems |
| IEEE 1013 | Recommended Practice for Sizing Lead-Acid Batteries for PhotoVoltaic (PV) Systems |
| IEEE 1106 | Recommended Practice for Installation, Maintenance, Testing and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications |
| IEEE 1115 | Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications |
| IEEE 1184 | Recommended Practice for the Selection and Sizing of Batteries for Uninterruptible Power Systems |

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| IEEE 1187 | Recommended Practice for the Design and Installation of Valve-Regulated Lead-Acid Storage Batteries for Stationary Applications |
| IEEE 1189 | Guide for the Selection of Valve-Regulated Lead-Acid Batteries for Stationary Applications |
| IEEE 1361 | Guide for Selection, Charging, Test and Evaluation of Lead-Acid Batteries Used in Stand-Alone PhotoVoltaic (PV) Systems |
| IEEE 1375 | Guide for the Protection of Large Stationary Battery Systems |
| IEEE 1491 | Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications |
| IEEE 1562 | Guide for Array and Battery Sizing in Stand-Alone PhotoVoltaic (PV) Systems |
| IEEE 1578 | Recommended Practice for Battery Spill Containment and Management |
| IEEE 1635 | Guide for the Ventilation and Thermal Management of Stationary Battery Installations (aka ASHRAE 21) |
| IEEE 1657 | Recommended Practice for Personnel Qualifications for the Installation and Maintenance of Stationary Batteries |
| IEEE C2 | National Electrical Safety Code (NESC) |
| IEEE C37.2 | Electrical Power System Device Function Numbers and Contact Designations |
| IEEE C37.13 | Low-Voltage AC Power Circuit Breakers Used in Enclosures |
| IEEE C37.16 | Low Voltage AC Power Circuit Breakers and AC Power Circuit Protectors – Preferred Ratings, Related Requirements, and Application Recommendations |
| IEEE C37.29 | Low Voltage AC Power Circuit Protectors Used in Enclosures |
| IEEE C62.11 | Metal-Oxide Surge Arrestors for Alternating Current Power Circuits |
| IEEE C62.22 | Guide for Application of Metal-Oxide Surge Arresters for Alternating-Current Systems |
| IEEE C62.34 | Standard for Performance of Low-Voltage Surge-Protective Devices (Secondary Arresters) |
| IEEE C62.35 | Standard Test Specifications for Avalanche Junction Semiconductor Surge Protective Devices |

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| IEEE C62.36 | Standard Test Methods for Surge Protectors Used in Low-Voltage Data, Communications, and Signaling Circuits |
| IEEE C62.41 | Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits |
| IEEE C62.41.1 | Guide on the Surge Environment in Low-Voltage (1000V and Less) AC Power Circuits |
| IEEE C62.41.2 | Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits |
| IEEE C62.45 | Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits |
| IEEE C62.62 | Standard Test Specifications for Surge-Protective Devices for Low Voltage AC Power Circuits |
| IEEE C62.64 | Standard Specifications for Surge Protectors Used in Low-Voltage Data, Communications and Signaling Circuits |
| IEEE C84.1 | Electrical Power Systems and Equipment — Voltage Ratings (60 Hz) |
| ISO 8528-5 | Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets |
| ITU-T K.50 | Safe Limits of Operating Voltages and Currents for Telecommunications Systems |
| NACE® RP0169 | Control of External Corrosion on Submerged or Underground Metallic Piping Systems |
| NACE® RP0285 | Corrosion Control of Underground Storage Tank Systems by Cathodic Protection |
| NEMA® ICS 10 | Part 1: Electromechanical AC Transfer Switch Equipment |
| NEMA® LS 1 | Low Voltage Surge Suppression Devices |
| NEMA® MG 1 | Motors and Generators |
| NEMA® WD 6 | Wiring Devices – Dimensional Specifications |
| NEMA® Z535 | Safety Color Code – Environmental Facility Signs – Criteria for Safety Symbols – Product Safety Sign and Labels, and Accident Prevention Tags |
| NETA™ ATS | Acceptance Testing Specification |
| NFPA® 1 | (Uniform) Fire Code |
| NFPA® 30 | Flammable and Combustible Liquid Code |

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| NFPA® 37 | Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines |
| NFPA® 58 | Liquified Petroleum Gas Code |
| NFPA® 70 | National Electrical Code |
| NFPA® 70E | Standard for Electrical Safety in the Workplace |
| NFPA® 76 | Standard for the Fire Protection of Telecommunications Facilities |
| NFPA® 101 | Life Safety Code |
| NFPA® 110 | Standard for Emergency and Standby Power Systems |
| NFPA® 111 | Standard on Stored Electrical Energy Emergency and Standby Power Systems |
| NFPA® 704 | Standard System for the Identification of Hazards of Materials for Emergency Response |
| NIOSH 98-131 | Worker Deaths by Electrocution |
| OSHA 29CFR | Part 1910, Department of Labor, Occupational Safety and Health Standards |
| PEI™ RP100 | Recommended Practices for Installation of Underground Liquid Storage Systems |
| RUS 1751F-810 | Electrical Protection of Digital and Lightwave Telecommunications Equipment |
| RUS 1753E-001 | General Specification for Digital, Stored Program Controlled Central Office Equipment |
| STI® F894 | ACT-100® Specification for External Corrosion Protection of FRP Composite Steel USTs |
| STI® F961 | ACT-100-U Specification for External Corrosion Protection of Composite Steel USTs |
| STI® R972 | Recommended Practice for the Installation of Supplemental Anodes for STI-P3® USTs |
| TIA® 942 | Telecommunications Infrastructure Standard for Data Centers |
| UL® 4 | Armored Cable |
| UL® 6 | Electrical Rigid Metal Conduit – Steel |
| UL® 21 | LP-Gas Hose |
| UL® 44 | Thermoset-Insulated Wires and Cables |

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| UL® 50 | Enclosures for Electrical Equipment |
| UL® 58 | Safety for Steel Underground Tanks for Flammable and Combustible Liquids |
| UL® 62 | Flexible Cords and Cables |
| UL® 67 | Panelboards |
| UL® 83 | Thermoplastic Insulated Wires and Cables |
| UL® 94 | Test for Flammability of Plastic Materials for Parts in Devices and Applications |
| UL® 98 | Enclosed and Dead-Front Switches |
| UL® 142 | Steel Aboveground Tanks for Flammable and Combustible Liquids |
| UL® 144 | LP-Gas Regulators |
| UL® 231 | Power Outlets |
| UL® 248 | Low Voltage Fuses |
| UL® 310 | Electrical Quick-Connect Terminals |
| UL® 347 | Medium-Voltage AC Contactors, Controllers, and Control Centers |
| UL® 360 | Liquid-Tight Flexible Steel Conduit |
| UL® 363 | Knife Switches |
| UL® 414 | Meter Sockets |
| UL® 429 | Electrically Operated Valves |
| UL® 444 | Communications Cables |
| UL® 452 | Antenna – Discharge Units |
| UL® 486 | Wire Connectors |
| UL® 489 | Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures |
| UL® 497 | Protectors for Paired-Conductor Communications Circuits |
| UL® 498 | Attachment Plugs and Receptacles |
| UL® 514A | Metallic Outlet Boxes |
| UL® 514B | Conduit, Tubing, and Cable Fittings |
| UL® 514C | Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers |
| UL® 514D | Cover Plates for Flush-Mounted Wiring Devices |

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| UL® 536 | Flexible Metallic Hose |
| UL® 644 | Container Assemblies for LP Gas |
| UL® 651 | Schedule 40 and 80 Conduit |
| UL® 719 | Nonmetallic-Sheathed Cables |
| UL® 746C | Polymeric Materials – Use in Electrical Equipment Evaluations |
| UL® 746E | Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used In Printed-Wiring Boards |
| UL® 797 | Electrical Metallic Tubing |
| UL® 810 | Capacitors |
| UL® 817 | Cord Sets and Power-Supply Cords |
| UL® 842 | Valves for Flammable Fluids |
| UL® 845 | Motor Control Centers |
| UL® 854 | Service-Entrance Cables |
| UL® 857 | Busways |
| UL® 860 | Pipe Unions for Flammable and Combustible Fluids and Fire-Protection Service |
| UL® 869A | Service Equipment |
| UL® 870 | Wireways, Auxiliary Gutters, and Associated Fittings |
| UL® 891 | Switchboards |
| UL® 916 | Energy Management Equipment |
| UL® 924 | Emergency Lighting and Power Equipment |
| UL® 935 | Flourescent-Lamp Ballasts |
| UL® 943 | Ground-Fault Circuit-Interrupters |
| UL® 971 | Non-Metallic Underground Piping for Flammable Liquids |
| UL® 977 | Fused Power-Circuit Devices |
| UL® 1004-1 | Rotating Electrical Machines – General Requirements |
| UL® 1004-4 | Electric Generators |
| UL® 1008 | Transfer Switch Equipment |
| UL® 1012 | Power Units Other Than Class 2 |

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| UL® 1053 | Ground-Fault Sensing and Relaying Equipment |
| UL® 1059 | Terminal Blocks |
| UL® 1066 | Low Voltage AC and DC Power Circuit Breakers Used in Enclosures |
| UL® 1072 | Medium-Voltage Power Cables |
| UL® 1236 | Battery Chargers for Charging Engine Start Batteries |
| UL® 1244 | Electrical and Electronic Measuring and Testing Equipment |
| UL® 1316 | Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products |
| UL® 1437 | Electrical Analog Instruments – Panel Board Types |
| UL® 1441 | Coated Electrical Sleeving |
| UL® 1446 | Systems of Insulating Materials |
| UL® 1449 | Transient Voltage Surge Suppressors |
| UL® 1479 | Fire Tests of Through-Penetration Firestops |
| UL® 1558 | Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear |
| UL® 1561 | Dry-Type General Purpose and Power Transformers |
| UL® 1562 | Transformers, Distribution, Dry-Type – Over 600 Volts |
| UL® 1564 | Industrial Battery Chargers |
| UL® 1581 | Wires, Cables, and Flexible Cords |
| UL® 1598 | Luminaires |
| UL® 1642 | Lithium Batteries |
| UL® 1653 | Electrical Nonmetallic Tubing |
| UL® 1659 | Attachment Plug Blades for Use in Cord Sets and Power-Supply Cords |
| UL® 1681 | Wiring Device Configurations |
| UL® 1682 | Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type |
| UL® 1686 | Pin and Sleeve Configurations |
| UL® 1703 | Flat-Plate Photovoltaic Modules and Panels |
| UL® 1741 | Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources |

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| UL® 1746 | External Steel Corrosion System for Steel Underground Storage Tanks |
| UL® 1773 | Termination Boxes |
| UL® 1778 | Uninterruptible Power Systems |
| UL® 1863 | Communications-Circuit Accessories |
| UL® 1977 | Component Connectors for Use in Data, Signal, Control and Power Applications |
| UL® 1989 | Standby Batteries |
| UL® 1993 | Self-Ballasted Lamps and Lamp Adapters |
| UL® 1994 | Luminous Egress Path Marking Systems |
| UL® 2024 | Signaling, Optical Fiber and Communications Raceways and Cable Routing Assemblies |
| UL® 2075 | Gas and Vapor Detectors and Sensors |
| UL® 2080 | Fire Resistant Tanks for Flammable and Combustible Liquids |
| UL® 2085 | Protected Aboveground Tanks for Flammable and Combustible Liquids |
| UL® 2196 | Tests for Fire Resistive Cables |
| UL® 2200 | Stationary Engine Generator Assemblies |
| UL® 2201 | Portable Engine Generator Assemblies |
| UL® 2239 | Hardware for the Support of Conduit, Tubing, and Cable |
| UL® 2245 | Below-Grade Vaults for Flammable Liquid Storage Tanks |
| UL® 2344 | Material Lifts |
| UL® 2367 | Solid State Overcurrent Protectors |
| UL® 2556 | Wire and Cable Test Methods |
| UL® 4248 | Fuseholders |
| UL® 5085 | Low Voltage Transformers |
| UL® 60947-1 | Low-Voltage Switchgear and Controlgear – Part 1: General rules |
| UL® 60974-4-1A | Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters |

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| UL® 60947-7 | Low-Voltage Switchgear and controlgear – Part 7: Ancillary equipment – Terminal blocks |
| UL® 1950/60950-1 | Information Technology Equipment – Safety – Part 1: General Requirements |
| UL® 60950-21 | Information Technology Equipment – Safety – Part 21: Remote Power Feeding |
| UL® 60950-22 | Information Technology Equipment – Safety – Part 22: Equipment to be Installed Outdoors |
| UL® 61131-2 | Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests |
| WFCA UFC™ | Uniform Fire Code |

## 17.4 Ordering Information

All documents are subject to change and their citation in this document reflects the most current information available at the time of printing.

**Obtain:**

**Alliance for Telecommunications Industry Solutions (ATIS) documents from:**

Alliance for Telecommunications Industry Solutions
1200 G St. NW
Washington, DC 20005
Phone: (202) 628-6380
Fax: (202) 393-5453
www.atis.org

**American Petroleum Institute (API) documents from:**

American Petroleum Institute
1220 L St. NW
Washington, DC 20005-4070
Phone: (202) 682-8000
www.api.org

**American Society of Mechanical Engineers (ASME) documents from:**

American Society of Mechanical Engineers
3 Park Ave.
New York, NY 10016
Phone: (800) 843-2763
www.asme.org

**American Society for the Testing of Materials (ASTM) documents from:**

American Society for the Testing of Materials
100 Bar Harbor Dr.
P.O. Box C700
West Conshohocken, PA 19428
Phone: (610) 832-9585
Fax: (610) 832-9555
www.astm.com

**CenturyLink™ Technical Publications from:**

www.centurylink.com/techpub

**Enersys documents from:**

www.enersysreservepower.com

**Federal Regulations from:**

www.gpo.gov/fdsys

**International Building and Fire Code documents from:**

International Code Council
5203 Leesburg Pike, Ste. 600
Falls Church, VA 22041
Phone: (703) 931-4533
www.iccsafe.org

**IEC documents from:**

International Electrotechnical Commission
3, rue de Varembé
P.O. Box 131
CH – 1211 Geneva 20
Switzerland
Phone: +41 22 919 02 11
Fax: +41 22 919 03 00
www.iec.ch

**IEEE documents from:**

IEEE Customer Service Center
445 Hoes Lane
Piscataway NJ, 08855-1331
Phone: (800) 678-4333
Fax: (732) 981-9667
www.ieee.org

**ISO documents from:**

International Organization for Standardization
1, ch. De la Voie-Creuse
CP 56 – CH-1211 Geneva 20
Switzerland
Phone: +41 22 749 01 11
Fax: +41 22 733 34 30
www.iso.org

**ITU documents from:**

International Telecommunications Union
Place des Nations
1211 Geneva 20
Switzerland
Phone: +41 22 730 6141
Fax: +41 22 730 5194
www.itu.int

**NACE® documents from:**

NACE Headquarters
1440 S. Creek Dr.
Houston TX, 77084-4906
Phone: (800) 797-6223
Fax: (281) 228-6300
www.nace.org

**NEMA® documents from:**

National Electrical Manufacturers Association
www.nema.org

**NETA™ documents from:**

InterNational Electrical Testing Association
3050 Old Centre Ave., Ste. 102
Portage MI, 49024
Phone: (269) 488-6382
Fax: (269) 488-6383
www.netaworld.org

**NFPA® documents from:**

NFPA Customer Sales
1 Batterymarch Park
Quincy, MA 02269-9101
Phone: (800) 344-3555
Fax: (617) 770-0700
www.nfpa.org

**NIOSH documents from:**

the National Institute for Occupational Safety and Health
1600 Clifton Rd.
Rm. 4505, MS E-20
Atlanta, GA 30333
Phone: (800) 232-4636
Fax: (513) 533-8347
www.cdc.gov/niosh

**Petroleum Equipment Institute (PEI™) documents from:**

Petroleum Equipment Institute
P.O. Box 2380
Tulsa, OK 74101-2380
Phone: (918) 494-9696
Fax: (918) 491-9895
www.pei.org

**RUS documents from:**

United States Department of Agriculture Rural Development
1400 Independence Ave. SW
Washington, DC 20250-0107
Phone: (202) 720-8674
www.rurdev.usda.gov/RDU_Bulletins_Telecommunications.html

**Telcordia® documents from:**

Telcordia - Customer Services
8 Corporate Place
Piscataway, NJ 08854-4196
Telex: (201) 275-2090
Fax: (908) 336-2559
Phone: (800) 521-2673
www.telcordia.com

**TIA® documents from:**

Telecommunications Industry Association
2500 Wilson Blvd., Ste. 300
Arlington, VA 22201
Fax: (703) 907-7727
Phone: (703) 907-7700
www.tiaonline.org

**UL® documents from:**

Underwriters Laboratories
Phone: (888) 853-3503
www.ul.com