

SCOPE

- I ↗ 1.1 This practice covers the design of systems and equipment for supplying power to essential instrumentation and other essential services. This practice does not cover d-c power supplies internal to or integrated within instrument, control and protective systems but does cover the a-c feeds to these systems, see [IP 15-7-1](#).
- I 1.2 **An asterisk (*)** indicates that additional information is required. If a job is contracted, this additional information is furnished in the Job Specification.

SUMMARY OF ADDITIONAL REQUIREMENTS

- I 2.1 **ANSI Standard Y32.2, Graphic Symbols for Electrical and Electronic Diagrams** shall be used with this practice.
- I 2.2 **Control center power supply switchgear** and **essential services switchgear** shall be per [IP 16-12-1, Switchgear, Control Centers and Bus Duct](#), except as modified herein.
- I 2.3 **System Design Responsibility.** For the instrument and other essential services power supply, the contractor shall assume overall responsibility for the **system design including any Vendor engineered subsystems**.

DEFINITIONS

- I * 3.1 Essential Instrumentation and controls when specified include the following:
 - a. Transmitters, controllers, recorders, indicators
 - b. Computers, digital control systems, and related equipment unless otherwise specified
 - c. Stream analyzers unless otherwise specified
 - d. Startup, sequence, shutdown, and emergency trip systems
 - e. Actuators
 - f. Annunciators, monitors, alarms, telemetry
 - g. Drives in purging, pressurizing, and air conditioning systems necessary to instrumentation
- I * 3.2 When specified, **other essential services** that may be fed from the instrument and essential services power supply, include (but are not limited to) the following:
 - a. Radio or other communications equipment needed during a power outage.
 - b. Control house (or room) emergency lighting.
 - c. Drives in purging, pressurizing, and air conditioning systems necessary for maintaining a non hazardous (unclassified) building area classification.
 - d. Boiler drum gage glass lighting.
 - e. Motor operated valves in emergency service.
- I 3.3 **Non-essential services** are those loads which are not required during general power outages, and whose loss may also be tolerated during infrequent maintenance and repair of their power supply.
- I 3.4 **Tolerable transfer and outage times** are the longest supply interruption which will not have a significant effect on process or equipment operation.
- I * 3.5 **Each unit or group of units considered critical and independent** to plant operations will be specified by the Owner's Engineer. As a guide for large plants, a unit or group of units are defined as critical and independent if they can operate without the other(s) and they represent or are needed for 20% or more of plant throughput. The unit(s) can be process units, utilities, or other non process units. Facilities not meeting the 20% rule may also be defined as critical and independent for commercial reasons.

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DOCUMENTATION

- O,M 4.1 **One-line diagrams** shall cover all equipment up to and including distribution panels, and shall show the following:
- All power connections
 - Metering
 - Identification of normal and standby equipment and circuits, and means of initiating switching to and from standby
 - Transformer connections (delta, wye)
 - System grounding
 - Bus ampere ratings
 - Breaker and fuse ratings
- O 4.2 **Equipment ratings**, provided with the one-line diagram, shall include:
- Batteries:** Ampere-hour rating along with discharge rate and ambient temperature at which it applies, number of cells, recommended float voltage, maximum ambient temperature, and maximum equalize voltage.
 - Battery chargers and rectifiers:** Maximum output current at rated voltage, maximum output voltage.
 - Inverters:**
 - Output voltage, frequency, watts, and volt-amperes.
 - Maximum steady state tolerance, at any load from zero to rated, for percent harmonics, voltage deviation and frequency deviation. Also, provide the range of load power factor, input (d-c) voltage, and ambient (room) temperature for which these tolerances hold.
 - Minimum and maximum voltage, and time to recover rated voltage, upon sudden application or removal of rated load at rated power factor.
 - Stabilizers:**
 - Output voltage, watts, and volt-amperes.
 - Maximum steady state tolerance, at any load from zero to rated, for percent harmonics (a-c stabilizers) and voltage deviation. Also, provide the **range** of load power factor (a-c stabilizers), input voltage, input frequency (a-c stabilizers), and ambient (room) temperature for which these tolerances hold.
 - Minimum voltage, and time to recover rated voltage, upon sudden application of rated load at rated power factor.
 - Transfer and Bypass Switches:** Amperes, switching time
 - Generators:**
 - Voltage**, number of phases, output power, and power factor.
 - Maximum steady state tolerance, at any load from zero to rated load/phase, for percent harmonics and voltage deviation **both** for balanced load and for single-phase load only.
 - Minimum and maximum voltage, and time to recover rated voltage, upon sudden application or removal of rated load.
 - Rated voltage (saturated) subtransient, transient, and synchronous reactance; rated current (unsaturated) subtransient, transient, and synchronous reactance.
 - No load and full load current decrement curves for 3-phase, line-to-line, and line-to-ground short circuits. Curves shall be provided for operation with and without the effects of the voltage regulator.
- O 4.3 **A load list** covering each load shall include the following:
- Load classification per **Par. 5.1**.
 - Voltage, frequency, and total harmonic distortion tolerances, if critical.
 - kVA (rms) at full load, and inrush on energizing.
 - Range of power factor from no load to full load.
 - Crest factor (peak current/rms current) at full load and minimum load.
 - Peak current at full load and minimum load.
 - RMS current at full load.



- O,M 4.4 **Operation and maintenance manuals** shall be furnished by the vendor supplying each (a-c or d-c) system. Manuals shall be written specifically for the equipment being furnished and shall contain (but not be limited to) the following information:
- Procedures for the installation, commissioning, operation and shutdown of the system.
 - Procedures for maintenance and trouble-shooting of the system utilizing shop test results as a basis.
 - Results of shop tests.
 - Complete Bill of Materials, Parts List and set of final "as-built" drawings.
 - Full description of each alarm including initiating conditions, effects on transfer status and further implications.
 - Full description of all conditions that will initiate or inhibit transfer.
- R,O 4.5 **A coordination study** shall be prepared and shall demonstrate the selectivity of circuit protective devices throughout each system. The study shall consider all protective devices in the system, including those protecting individual loads and subfeeders downstream of the distribution panel in the stabilizing and distribution section. Where system components have a current limiting effect, the study shall include the bases other than time - current curves used to establish selectivity. The study shall identify any fault locations, and ranges of fault current, for which fault clearing time exceeds the tolerable outage time of any affected instrumentation (as established by the **load classification** per **Par. 5.1**). The effect of battery internal resistance shall be considered in the study. **The coordination study shall be furnished** on two occasions:
- Before final protective device characteristics are specified. This issue of the coordination study is preliminary and need only be complete and accurate enough to verify that proper ranges and types of protective devices have been selected.
 - When the coordination study is presented for final approval.
- R,O 4.6 Each designated a-c and d-c power supply vendor shall furnish the following information for **use by contractor in preparing the coordination study**:
- Time vs. current characteristic curves of all protective devices in the equipment components furnished.
 - Data to assist the contractor in selecting protective devices for the battery which will be selective with other protective devices in the stabilization and distribution sections.
 - Data to assist the contractor in selecting protective devices for the branch circuit feeders in the power distribution section panels which will be selective with upstream devices in the distribution and stabilization sections.
 - Time-current characteristics of batteries (when supplied by designated vendor), battery chargers, inverters and voltage stabilizers under short circuit conditions.

LOAD CLASSIFICATION

- R,O 5.1 **Classification of a-c essential instrumentation and other essential services loads** shall be based on the tolerable time of transfer between normal and standby supplies, as follows:

TOLERABLE TRANSFER TIME, seconds	CLASS
0.005 (approx. 1/4 cycles) or less	I
over 0.005 to 0.2 (10-12 cycles)	II
over 0.2-10 (1)	III
Transfer to Standby Not Required	Non-essential services

Note:

- (1) Nominal transfer time approximately 10 seconds for diesel driven standby generator and may be 30 seconds or more if repeat start attempts are required.

- R * 5.2 **Classification of d-c instrument power loads** shall be by specification of tolerable outage time for each. Particular attention shall be given to devices in shutdown circuits.

SOURCES OF POWER

- R,O 6.1 **Sources of power for control center power supplies** shall be selected according with **Figures 1a, 1b, and 1c**.

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- R,O ♦ 6.2 Control center power supply arrangements shall be provided per the following:
- Figure 1d for control centers without standby generation**
 - Control centers shall be provided with a standby power generator and essential services switchgear per **Figure 1e** if any of the following conditions exist:
 - Instrument power is required for the control instruments or shutdown systems of boilers. Examples of such loads are firewater, instrument air compression, or cooling water.
 - Instrument power is required for the operation of process, manufacturing, or utility units or any essential services for which continuous operation during main power supply failure is specified.
- O 6.3 **Sizing of standby generator** shall be based on total non diversified load of instruments and other loads connected to essential services switchgear Bus A and B of **Figure 1e**.
- R ♦ 6.4 A withdrawable type ASCO transfer switch, or equivalent, shall be used to supply essential services switchgear unless it is not large enough to serve the expected load.
- O,C * 6.5 Generator driver shall be a diesel engine unless otherwise specified.
- R ♦ * 6.6 The driver for the standby instrument power generator shall be arranged for automatic starting. Manually operated start and stop controls shall also be provided. Location of these controls will be specified.

SUPPLY TO ESSENTIAL SERVICES

- R,C 7.1 **A-c essential services**, other than instrumentation, control room (or house) emergency lighting, and boiler drum gage glass lighting, shall be supplied directly from the essential services switchgear as shown in **Figure 1(e)**. These loads shall be capable of tolerating Class III transfer times, and essential services bus(es) voltage and frequency deviations.
- R 7.2 **D-c essential services** other than instrumentation shall be served from a d-c supply similar to the supply specified in this practice for d-c instrument loads. This essential service supply shall be separate from the instrument supplies.

SUPPLIES TO D-C INSTRUMENT LOADS

- S,R ♦ * 8.1 **Each unit (or group of units) specified as critical and independent per Par. 3.5** shall have a normal dedicated d-c power supply, per **Figure 2(a)**, as required for control, alarms, and protective shut down systems.
- S,R ♦ * 8.2 **Each boiler specified as critical per Par. 3.5** shall have a dedicated normal d-c power supply per **Figure 2(a)**, as required for control, alarms, and protective shutdown systems.
- S,R 8.3 **A backup supply** shall be provided for all normal d-c power supplies, such that each d-c bus has two 100% sized sources connected in parallel, each having separate supplies from the main a-c system. Backup supply shall have adequate short-circuit current capacity or other means to ensure selective operation of the d-c system protective devices when the normal supply and its battery are out of service.
- C ♦ 8.4 **A common backup** supply is acceptable, as shown in **Figure 2(a)**, if all of the following conditions are met:
 - All normal supplies and the backup supply have the same output voltage with stabilization of the same precision and adjustability. The backup supply output voltage is to be adjusted for no load when all normal supplies are maintaining voltage.
 - Backup supply size equals at least the size of the largest normal supply backed up.
 - Coordination of protective devices assures that a single sustained short circuit anywhere in the system shuts down or causes loss of control to not more than one boiler or one critical independent process unit or group of units.
 - Backup supply is equipped with overvoltage protection (limiter or shutdown) independent of the main voltage regulator circuit.
- R,O 8.5 **Voltage stabilization** shall be provided to maintain voltage within tolerable limits of the loads served, considering battery voltage variable from fast and/or equalizing charge voltage down to end-of-discharge voltage at design load.
- R 8.6 **The d-c system** shall be **ungrounded** (isolated), and a **ground detector** shall be provided for **each load bus**. Ground detector shall be sensitive enough to operate for a ground fault having a fault resistance of 6000 ohms or less.
- O ♦ 8.7 **Metering** shall be per **Figure 3**. Voltmeters shall have accuracy of ± 1 percent.

- O,M * 8.8 **Ground fault location.** When specified by the Owner's Engineer, facilities shall be provided for each d-c instrument power supply to allow maintenance personnel to locate and repair ground faults with minimum shutdown time of operating circuits. Design of such facilities shall be approved by the Owner's Engineer.
- M ♦ 8.9 **The blocking diodes shown in Figure 2(a) for each incoming line** supplying the d-c distribution panels shall be physically **located** and **mounted** so that they may be safely removed and replaced with the panel energized.

SUPPLIES TO A-C INSTRUMENT LOADS

- R,O ♦ * 9.1 **A control center or remote instrument building serving a single unit, a group of units, or multiple units specified as critical and independent** shall have a-c instrument power supplied per **Figure 2(b)**.
- R,S ♦ 9.2 **Boiler flame detectors requiring a-c power** shall be supplied per **Figure 2(b)**. The two flame detectors provided for each burner shall be supplied one each by individual branch circuits fed from distribution panels as shown.
- O 9.3 **Voltage stabilization** shall be provided in the normal and alternate supplies, to maintain voltage within tolerable limits of the loads served, taking account of the calculated variation of a-c source voltages and of voltage drop variations due to load changes.
- S,R ♦ 9.4 **Transfer switches** shall operate immediately upon drop of voltage below lower tolerable limit of the loads served.
- O 9.5 **Transfer switches shall have the capability** of manual initiated transfer and automatic retransfer. When specified, automatic retransfer of all transfer switches back to the normal supply after a transfer to the standby supply shall operate as follows:
- A two-position "AUTO-STANDBY" retransfer selector switch shall be provided for each transfer switch to control the automatic retransfer operation.
 - When the retransfer selector switch is in the "AUTO" position, retransfer back to the normal supply shall occur automatically whenever the normal supply voltage has returned and has been sustained for two seconds.
 - When the retransfer selector switch is in the "STANDBY" position, retransfer back to the normal supply shall occur automatically only if the standby supply voltage has been lost and normal voltage is present on the normal supply.
- O,M ♦ 9.6 **Manual bypass switches shall** be provided for all automatic transfer switches per **Figure 2(e)**. Bypass switches for Class II and III **electromechanical transfer switches shall have break-before-make operation**, with a switching time of less than 200 milliseconds.
- * Bypass switches for Class I **solid-state transfer switches shall have make-before-break operation**. Alternative bypass switch designs must be approved by the Owner's Engineer.
- O ♦ 9.7 **A white "sources synchronized" pilot light** shall be provided adjacent to the operating handle of the manual bypass switch serving each solid-state transfer switch. Light shall be energized when normal and standby sources are in synchronism. **A nameplate per Figure 4** shall be mounted near the operating handle.
- S,R ♦ 9.8 **The a-c system** shall be **grounded** per **Note 5 of Figure 2(d)**.
- R 9.9 **Convenience outlets** shall **not** be used in circuits supplied from Class I & II instrument load distribution panels.

BATTERY SIZING

- R,S ♦ 10.1 **Design load for battery sizing purposes** shall be:
- For a-c systems.** The full load rating of the inverter. Batteries supplying inverters shall not supply other loads.
 - For d-c systems.** The maximum demand of all loads supplied from the normal supply power distribution panel of **Figure 2(a)**.
- S,R * 10.2 **Batteries shall be sized for 1 hour operation** at the end of design life (10 years minimum), without charger, at design load, starting fully charged, and at specified minimum design ambient (1/2 hour is sufficient if a standby generator is provided).

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ALARMS

- O,R ♦ 11.1 The following **main power failure** or **standby power failure** alarms shall be provided:
- Loss of a-c to battery charger. The detecting device shall be connected to the load side of the protective device or switch (including devices internal to the charger) closest to the charger in the supply circuit.
 - Loss of a-c to d-c power supplies (same as for chargers).
 - Low battery voltage as measured on the charger side of the battery main fuse and switch.
 - Low a-c or d-c output voltage for voltage stabilizers.
 - Generator/driver trouble. Provide alarms for conditions of the generator and driver which could prevent starting or cause improper operation or shutdowns (e.g., local generator breaker open, if any; regulator switch off; low fuel supply, low lube oil pressure; high engine temperature; etc., as applicable. Provide time delay alarms where necessary to prevent nuisance operations of alarms during driver startup).
 - Generator running
 - Generator startup failure
 - Transfer switch in "alternate" position (alarm for each switch)
 - Ground on battery or charger d-c circuits
 - Ground on load bus of d-c power supplies
 - Loss of synchronization for inverters
 - Essential services switchgear bus or generator fault
 - Essential services switchgear normal source or standby generator breaker out of position or cable tie switch open.
 - Essential services switchgear transfer to generator
 - Essential services switchgear automatic transfer to normal source
 - Low battery charger or rectifier d-c output voltage
 - High battery charger or rectifier d-c output voltage
 - Bypass switch off normal position (alarm for each switch)
 - Battery discharging
- S,O 11.2 **Alarms specified in Par. 11.1** shall be supervised by **local annunciators**. A single alarm for each annunciator shall be located in the control house (or room). Annunciators shall be provided with lamp test facility for all alarms and with reflash facility to prevent initial alarm from blocking subsequent alarms. Local annunciation shall be provided by one of the following:
- Annunciator panels located in the instrument power supply equipment room and in the generator or essential services switchgear room (associated alarms only).
 - When approved by the Owner's Engineer, one annunciator located in the instrument power supply equipment room, if in close proximity to the generator and essential services switchgear.
 - The alarms displayed as an integral part of a vendor's equipment package and supplemental annunciation, if necessary. Vendor displayed alarms need not be duplicated in any supplementary annunciator except for a common supervisory alarm.
- S,R 11.3 **Ionization type smoke detectors** shall be provided per the following:
- Location.** Smoke detectors shall be provided in each room containing control center or remote instrument building essential services switchgear or instrument power supplies. The location and number of smoke detectors shall be approved by the Owner's Engineer.
 - Installation. Smoke detectors shall be classified as safety critical devices.** A common alarm for each building's smoke detectors shall annunciate in the main control house (or room).

