

***Product Manual  
H569-416***

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***Lucent Technologies  
LINEAGE<sup>®</sup> 2000  
600-Ampere, -48-Volt  
ECS Battery Plant***

Notice:

Every effort was made to ensure that the information in this document was complete and accurate at the time of printing. However, information is subject to change.

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# ***1 Introduction***

The Lineage<sup>®</sup> 2000 family name of premier energy system products is globally recognized as the right choice for the ultimate in systems performance and reliability. Selecting this product brings the Lucent Technologies commitment to product and service excellence to your own telecommunications system. This long-standing Lucent Technologies commitment has been gained from years of worldwide telecommunications experience in the development, manufacturing, engineering, installation and servicing of leading edge energy systems, products and services.

This document (Lucent Technologies 167-790-055) is part of a set of product manuals which provide information on the Lineage<sup>®</sup> 2000 Evolutionary Control System (ECS) Battery Plant and its components, such as Controller, Rectifier and Battery manuals. Each manual contains a technical description of the product, which is followed by detailed information on engineering, installation, operation and maintenance. The contents of the documentation package are identified for ordering and reference purposes in Section 3 of this manual.

The Lineage<sup>®</sup> 2000 Evolutionary Control System (ECS) Battery Plant described in this manual, H569-416, is shown in Figure 1-1. This member of the ECS family of battery plants operates from a nominal 208/240 Vac, 50/60 Hz source. It offers a 600 ampere total plant capacity with a nominal -48 Vdc output in a totally integrated energy system containing a controller, rectifiers, circuit breaker distribution panels and an optional battery disconnect/reconnect feature in one standard equipment bay. The plant's modular front-access design facilitates installation and growth. Growth in plant output current capacity

is achieved by adding Lineage<sup>®</sup> 2000 50-ampere, -48-volt rectifiers to rectifier shelf assemblies. Growth in distribution is achieved by adding plug-in type circuit breakers (10 through 60 amperes) to distribution panels. Adding functionality to the basic controller is achieved through two optional circuit packs, one to add microprocessor-based features and the second to add a datalogger.

The ECS battery plant is compatible with all flooded and valve regulated batteries which float within the range of 48 through 58.5 volts. In addition, the ECS plant is capable of operating in a batteryless mode, making it suitable for those applications where battery backup is not necessary or is achieved through the use of an uninterruptible power supply (UPS).

#### Note

The Lineage<sup>®</sup> 2000 ECS Battery Plant H569-416 is to be installed only in restricted access areas (dedicated equipment rooms, equipment closets or the like) in accordance with Articles 110-16, 110-17 and 110-18 of the National Electrical Code or in accordance with the appropriate requirements of the Electrical Code of the country in which the equipment is installed.

## **Technical Support**

Technical support for Lucent Technologies equipment is available to customers around the world.

### ***USA, Canada, Puerto Rico, and the US Virgin Islands***

On a post-sale basis, **during the Product Warranty period**, our Technical Support telephone number 1-800-CAL RTAC (1-800-225-7822) provides coverage during normal business hours. Product Specialists are available to answer your technical questions and assist in troubleshooting problems. For out-of-hours EMERGENCIES, the 800 number will put you in touch with a Regional Technical Assistance Center Engineer via our 24 hour a day, 7 day per week Help Desk.

When Technical Support is required in **the Post-Warranty Period**, the service may be billable unless you hold an extended warranty or contractual agreement.

***Central and  
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If you need product technical support, contact your local Field Support/Regional Technical Assistance Center or contact your sales representative who will be happy to discuss your specific needs.

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East, and Africa***

If you need product technical support, contact your local Field Support/Regional Technical Assistance Center or contact your sales representative who will be happy to discuss your specific needs.

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For information on returning of products for repair, customers may call 1-800-255-1402 for assistance.

***Central and  
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If you need to return a product for repair, your sales representative will be happy to discuss your individual situation.

***Europe, Middle  
East, and Africa***

If you need to return a product for repair, your sales representative will be happy to discuss your individual situation.

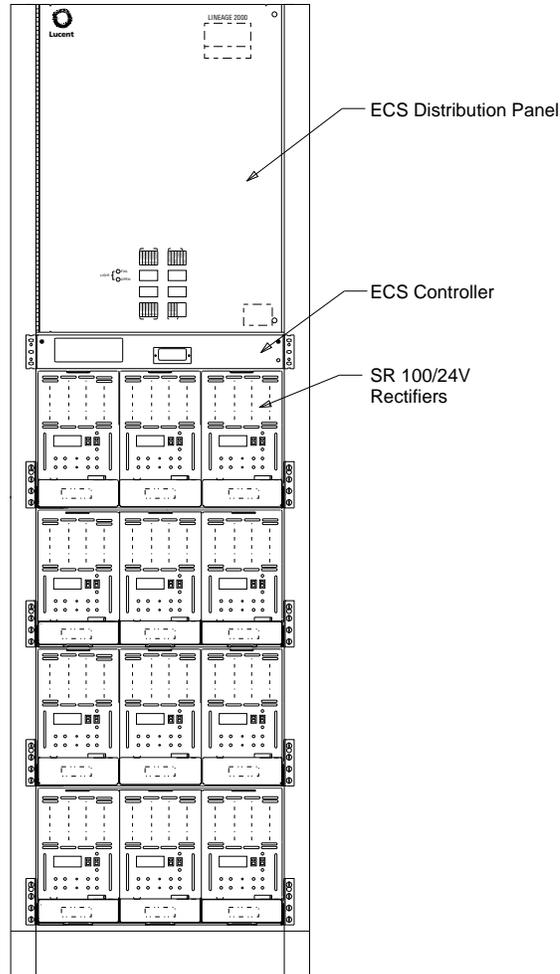
***Asia Pacific  
Region***

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***Customer  
Service***

For customer service, any other product or service information, or for additional copies of this manual or other Lucent Technologies documents, call 1-800-THE-1PWR (1-800-843-1797). Specify the select code number for manuals,

or drawing number for drawings. Contact your regional customer service organization or sales representative for information regarding spare parts.



**Figure 1-1: Lineage 2000 ECS Battery Plant (Model H569-416)**

## 2 *Product Description*

### *Plant Specifications*

**Table 2-A: Lineage<sup>®</sup> 2000 Battery Plant Specifications (Model H569-416)**

Input Voltage	180-264 Vac (208/220/240 Vac nominal)
Input Frequency	47-63 Hz (50/60 Hz nominal)
Operating Voltage	40-60 Vdc (48 Vdc nominal)
Float Voltage	47-58.5 Vdc (48 Vdc nominal)
Plant Current Rating	600 amperes
Plant Shunt	1200 amperes maximum at 50 millivolts
LVD/R Voltage Settings	40.5 or 42.5 Vdc
Controller	Basic: 113B Microprocessor option circuit pack Datalogger circuit pack
-48 Volt Distribution	3 panels accommodate up to (21) KS23616 circuit breakers each
Rectifier Shelf Assembly	Complement: 4 maximum, each mounts 3 rectifiers
Rectifiers	Type: Lineage <sup>®</sup> 2000 364A2 Rating: -48 Vdc nominal, 50 amperes Complement: 12 maximum

**Table 2-A: Lineage<sup>®</sup> 2000 Battery Plant Specifications (Model H569-416)**

Circuit Breakers	Type: KS23616 Ratings: 3, 5, 10, 15, 20, 30, 45, 60 amperes Type: KS22010, optional
Battery String Terminations	Type: Studded bus bar, accepts double-hole terminal lugs, 1-inch centers Size: Terminates 4/0 AWG conductors Complement: 12 terminal lugs maximum, back to back
System Ground Termination	Type: studded bus bar, accepts double-hole terminal, 1 inch center Size: Terminates 4/0 AWG conductor
Temperature	77°F (25°C) nominal
Altitude	-200 to 13000 feet (-61 to 3962 meters) For altitudes of 5000 to 13,000 feet, derate maximum temperature by 3.8°F per 1000 feet above 5000 feet. For altitudes of 1524 to 3962 meters, derate maximum temperature by 0.656°C per 100 feet above 1524 meters.
Framework	Type: 7 foot Network Bay Frame (standard 23 inch relay rack) Vertical mounting centers: 1.00 inches (25 mm) Horizontal mounting centers: 22.32 inches (567 mm)
Dimensions	Height: 84 inches (2134 mm) Width: 26 inches (660 mm) Depth: 18.5 inches (470 mm) Depth when equipped with VR batteries: 26 inches (660 mm)
Weight	Initial bay, equipped with 12 rectifiers: 651 pounds (296 kilograms) Rectifier Shelf Assembly: 25 pounds (11.4 kilograms) Rectifier: 25 pounds (11.4 kilograms) Controller: 20 pounds (9.1 kilograms)
Earthquake	Initial bay: Zone 4, upper floors
Heat Dissipation	Initial Bay, full load, 12 rectifiers, controller: 6482 watts (22,098 BTU/hr) (See Note 1) Rectifier, full load: 538 watts (1834 BTU/hr) Controller, basic and options: 26 watts (89 BTU/hr)
Humidity rating	10% to 95% noncondensing
Audible noise	68 dBA (See Note 2)

**Table 2-A: Lineage<sup>®</sup> 2000 Battery Plant Specifications (Model H569-416)**

Electrostatic discharge	IEC 801-2 Level 5 (15 KV) at 40% relative humidity
Radiated/ Conducted Emissions	FCC Level A
Electromagnetic immunity	10V/m over the range of 20 to 2000 MHz
Notes:	
1. Specified at a plant voltage of 54 Vdc, 600 amperes output, and nominal input voltages and frequencies.	
2. Measured at 5 feet above the floor and 2 feet from the equipment.	

***Typical Battery Plant Description***

A basic block diagram of a typical dc battery plant is shown in Figure 2-1. The battery plant accepts alternating current from the commercial utility or a standby ac power source and rectifies it to produce dc power for the using equipment. Control and alarm functions are provided by the plant to interact with the rectifiers and the office. In addition, the plant provides overcurrent protection, charge, discharge, and distribution facilities. Battery reserve automatically provides a source of dc power if the commercial or standby ac fails. This battery reserve is engineered to supply dc power for a specified period of time. In normal practice, battery capacity is sized to provide 3 to 8 hours of reserve time.

***Battery Plant Subsystems***

Figure 2-2 illustrates the arrangement and interconnections of the typical dc battery plant subsystems from the ac input to the dc output. These subsystems are defined as follows:

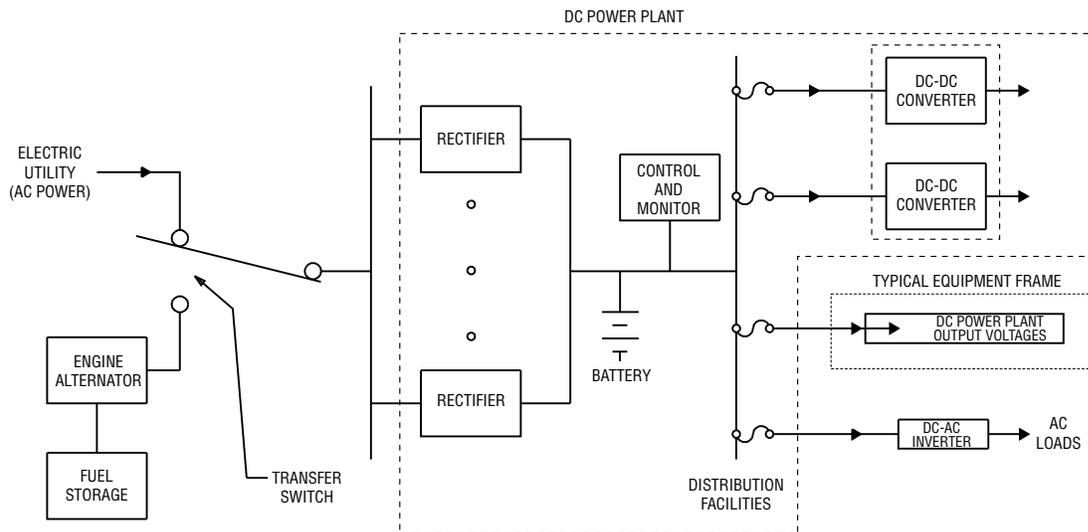
**AC Distribution:** connects the commercial and/or standby ac power sources to the rectifiers within the plant and provides overcurrent protection. This subsystem is usually supplied by the customer.

**Rectifiers:** convert an ac source voltage into the dc voltage level required to charge and float the batteries and to power the using equipment.

**Controller:** provides the local and remote control, monitor and diagnostic functions required to administer the battery plant.

**Batteries:** provide energy storage for an uninterrupted power feed to the using equipment during loss of ac input or rectifier failure.

**DC Distribution:** provides overcurrent protection, connection points for the using equipment, and bus bars used to interconnect the rectifiers, batteries, plant shunt, and dc distribution.

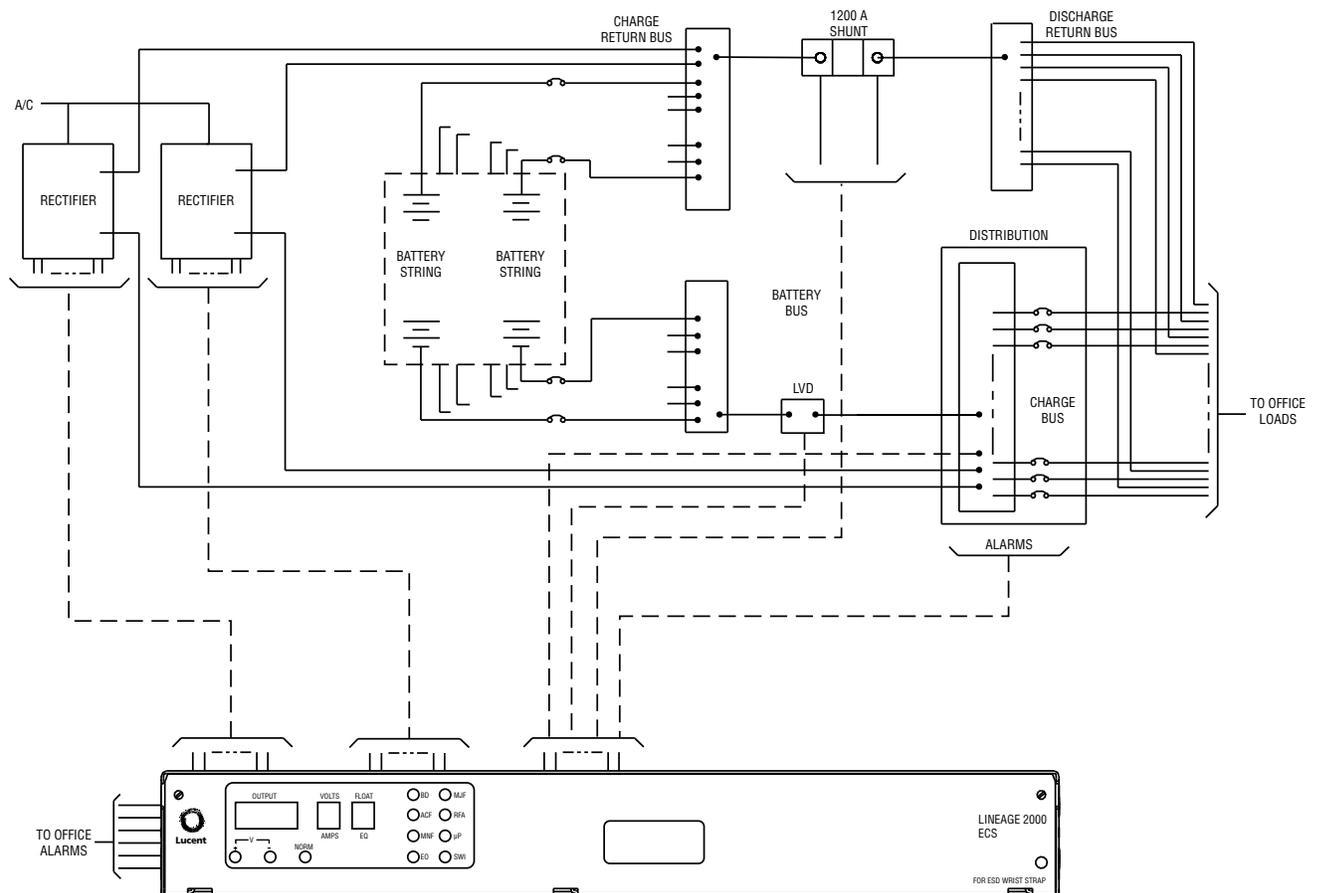


**Figure 2-1: Block Diagram of Typical Battery Plant**

## ***ECS Battery Plant Physical Description***

**Introduction** The Lineage<sup>®</sup> 2000 Evolutionary Control System (ECS) Battery Plant is shown in Figure 1-1. The ECS battery plant provides power for the using equipment as well as float and recharge capability for the battery reserve. The plant operates from a nominal 208/240 Vac, 50/60 Hz source. It offers a 600 ampere total plant capacity with a nominal -48 Vdc output. The ECS battery plant is compatible with all flooded and valve regulated batteries that have a short-circuit current rating less than 7,000 amperes. In addition, the ECS plant is capable of operating in a batteryless mode, making it suitable for those applications where battery backup is not necessary or is achieved through the use of an uninterruptible power supply (UPS).

The ECS battery plant is designed as a totally integrated energy system package in which modular front-access design facilitates installation and growth. One standard equipment bay will accommodate a maximum of 12 Lineage<sup>®</sup> 2000 SR Series -48-volt, 50-ampere rectifiers, a Lineage<sup>®</sup> 2000 ECS controller, standard distribution panels accepting breakers from 3 to 60 amperes, and an optional low voltage battery disconnect/reconnect feature. Style strips are an optional appearance kit.



**Figure 2-2: Typical ECS Battery Plant System Block Diagram**

**Rectifier** The Lineage<sup>®</sup> 2000 SR Series rectifiers are designed specifically for applications where small size, low weight and ease of installation are of overriding importance. The rectifiers utilize a combination of switch-mode technology and forced air cooling to achieve a significant reduction in size and weight over conventional ferroresonant rectifiers. The plug in, connectorized

design of the rectifiers reduces installation time to minutes, permitting easy growth and maintenance without service interruption.

The Lineage<sup>®</sup> 2000 SR Series 50 ampere rectifiers operate over 208/240 Vac 50/60 Hz nominal single phase input range without any necessary tap changes. A power factor correction circuit incorporated in the design insures a power factor of 90 percent or greater for loads above 50 percent of the full load rating. The rectifiers provide the ECS controller with a full complement of status and alarm signals. The SR Series 50 ampere rectifier is both UL recognized and CSA certified.

The rectifier status and alarm signals, ac input, and dc output are all connectorized. The rectifiers plug into a rectifier shelf assembly that accommodates a maximum of three individual 50 ampere rectifiers. The ECS plant can be equipped with a total of four rectifier shelf assemblies for a total capacity of 12 SR Series 50 ampere rectifiers. (See the Lineage<sup>®</sup> 2000 SR Series rectifier product manual for additional information.)

**Controller** The ECS controller performs the centralized monitoring, control and reporting functions for the ECS battery plant. The basic ECS controller can monitor and control up to 12 rectifiers. It also provides a single interface point for power alarm and status reporting.

Two optional expansion circuit packs are available to upgrade the ECS controller: a microcomputer board equipped with a powerful 16-bit microprocessor, and a datalogger board. The microcomputer board adds sophisticated firmware features such as remote communications, alarm history, and statistics. The datalogger board may be used in conjunction with the microcomputer option to provide general purpose ac and dc, voltage and current monitoring and control. (See the ECS controller manual for further information.)

**Batteries** The ECS Model H569-416 battery plant is compatible with batteries with a short-circuit current rating less than 7000 amperes. For appropriate system loads and reserve times, selection of the VR Series battery enables one to maximize space efficiency and fully realize the benefits of front access, modular growth, ease of installation and maintenance offered by the ECS battery plant system design.

**DC Distribution** The ECS dc distribution is shown in Figure 2-3. The distribution contains the plant charge and discharge bus bars, battery bus, distribution bus, circuit breaker bus, positive and negative rectifier bus, plant shunt, optional LVD/R contactor, fuse panel and circuit breaker panels.

**Distribution Bus Bars** The distribution bus bars include the charge return bus, discharge return bus, battery bus, LVD bus, distribution bus, circuit breaker bus and positive and negative buses (See Figure 2-3). Battery strings are terminated to the battery bus and the charge return bus. Negative rectifier outputs are routed to the distribution circuit breakers through the negative rectifier bus, the distribution bus and the circuit breaker bus. Positive rectifier outputs are to the discharge return bus through the positive rectifier bus, charge return bus and the plant shunt.

The load conductors are terminated on distribution strips above the circuit breaker panels and the return conductors for load circuits are terminated on the discharge return bus.

**Plant Shunt** A current shunt is a sensing device which provides a millivolt signal proportional to the current flowing through it. The millivolt-to-ampere ratio of the shunt is the dc resistance of the shunt (in milliohms), which is thermally stable and accurately known.

The current shunt in the ECS Battery Plant is connected between the Charge Return Bus and the Discharge Return Bus (see Figure 2-3). It is used to measure the total current supplied to the load from the rectifiers and/or batteries. The shunt has a full scale rating of 50 millivolts at the maximum plant current of 1200 amperes. The shunt millivolt signal is sent, via the CP5 Fuse Board, to the controller where it is translated back to amperes and displayed on the digital meter.

**Low Voltage Battery Disconnect/Reconnect (LVD/R) Feature** To prevent costly battery damage due to deep discharges, the ECS Battery Plant may be equipped with an optional automatic battery disconnect. This disconnect is designed to isolate batteries from the load when the plant voltage reaches the lowest usable battery voltage. The disconnect level is below the operating range of most load equipment, in which case service to the load would already have been lost. The disconnect does not

separate the load circuits from the rectifiers, thus enabling the rectifiers to begin powering the load as soon as ac power is restored.

The LVD/R option consists of the LVD/R Contactor, circuitry on the CP5 Fuse Board and associated wiring. Figure 2-4 is a pictorial of the contactor (K1). The LVD circuit on CP5 monitors the plant charge bus voltage, designated RB. When the RB voltage drops below a preset level, a comparator circuit on the CP5 Fuse Board senses the low voltage condition and removes power to the contactor. This opens the connection between the battery buses and LVD bus, disconnecting the batteries from the rectifiers and the load. The user has a choice of disconnect threshold voltages (40.5 and 42.5 volts).

When the contactor is open and the rectifiers are not delivering power, the controller is also unpowered. In this state, the controller displays and LEDs are extinguished and various alarms are issued to the alarm reporting center. (See the Lineage<sup>®</sup> 2000 Controller manual for further details.)

The red “LVD OPEN” and yellow “LVD FAIL” LEDs are located on the front side of the dc distribution panel as shown in Figure 2-5. The red “LVD OPEN” LED on the CP5 Fuse Board is lit whenever the contactor is open, during a normal disconnect or in the unlikely event of a contactor failure. The LVD sensing circuitry on CP5 is redundant. A failure of either voltage detector circuit lights the yellow “LVD FAIL” LED, but the contactor will stay closed. A Fuse Alarm Minor (MNF) is issued when a LVD circuit fails, lighting a yellow LED on the controller front panel and sending Power Minor (PMN) alarms to the alarm reporting center.

Once the contactor opens it remains open until the RB voltage again exceeds the set threshold voltage. Voltage does not return until ac power is restored and the rectifiers restart. Once the LVD circuit is energized, the LVD/R contactor closes the circuit, allowing the batteries to be charged.

***Distribution  
Panels/Circuit  
Breakers***

**Distribution Panels:** The battery plant is equipped with three distribution panels. Panels can accommodate up to 21 KS23616 circuit breakers each. Each bus bar in the panel is rated at 200 amperes in a 25°C ambient temperature. The unique plug-in panel and circuit breaker design makes installation and growth a snap.

**Circuit Breakers:** The KS23616 circuit breaker is available in 3, 5, 10, 15, 20, 30, 45 and 60 ampere ratings. These are plug-in rather than screw-mounted breakers. The 45- and 60-ampere circuit breakers take up two positions on the panel.

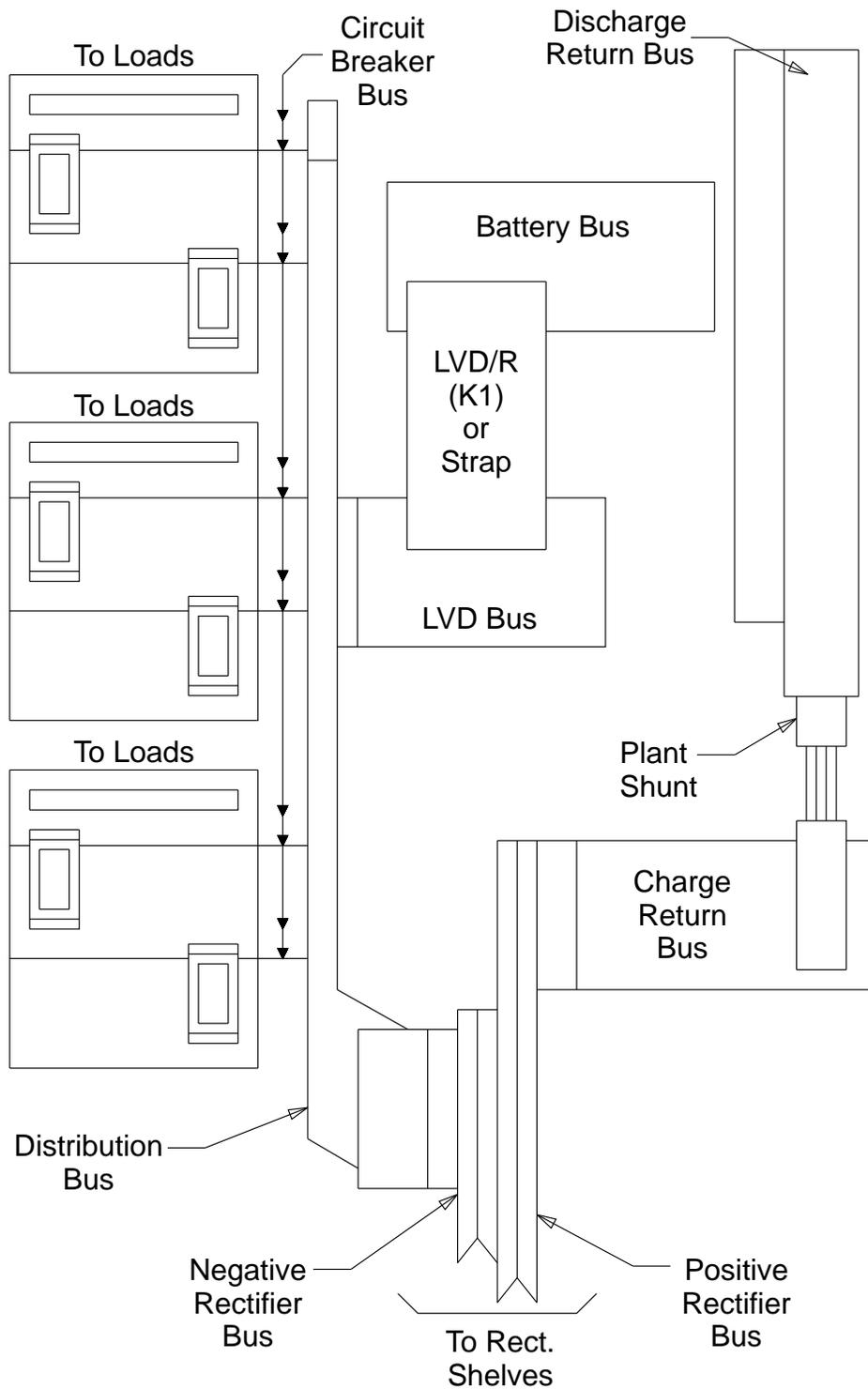
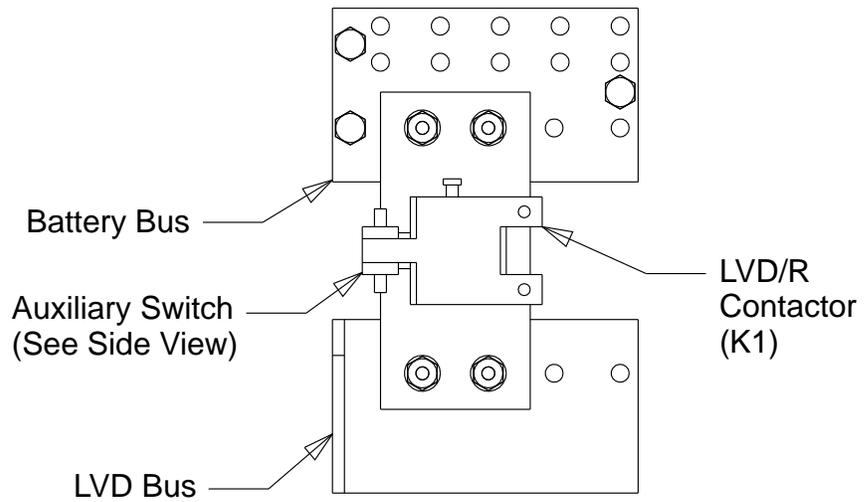
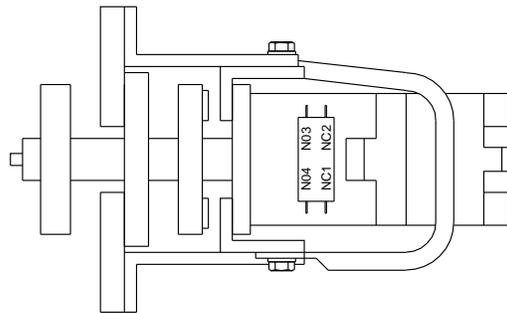


Figure 2-3: ECS Distribution Bus Bars

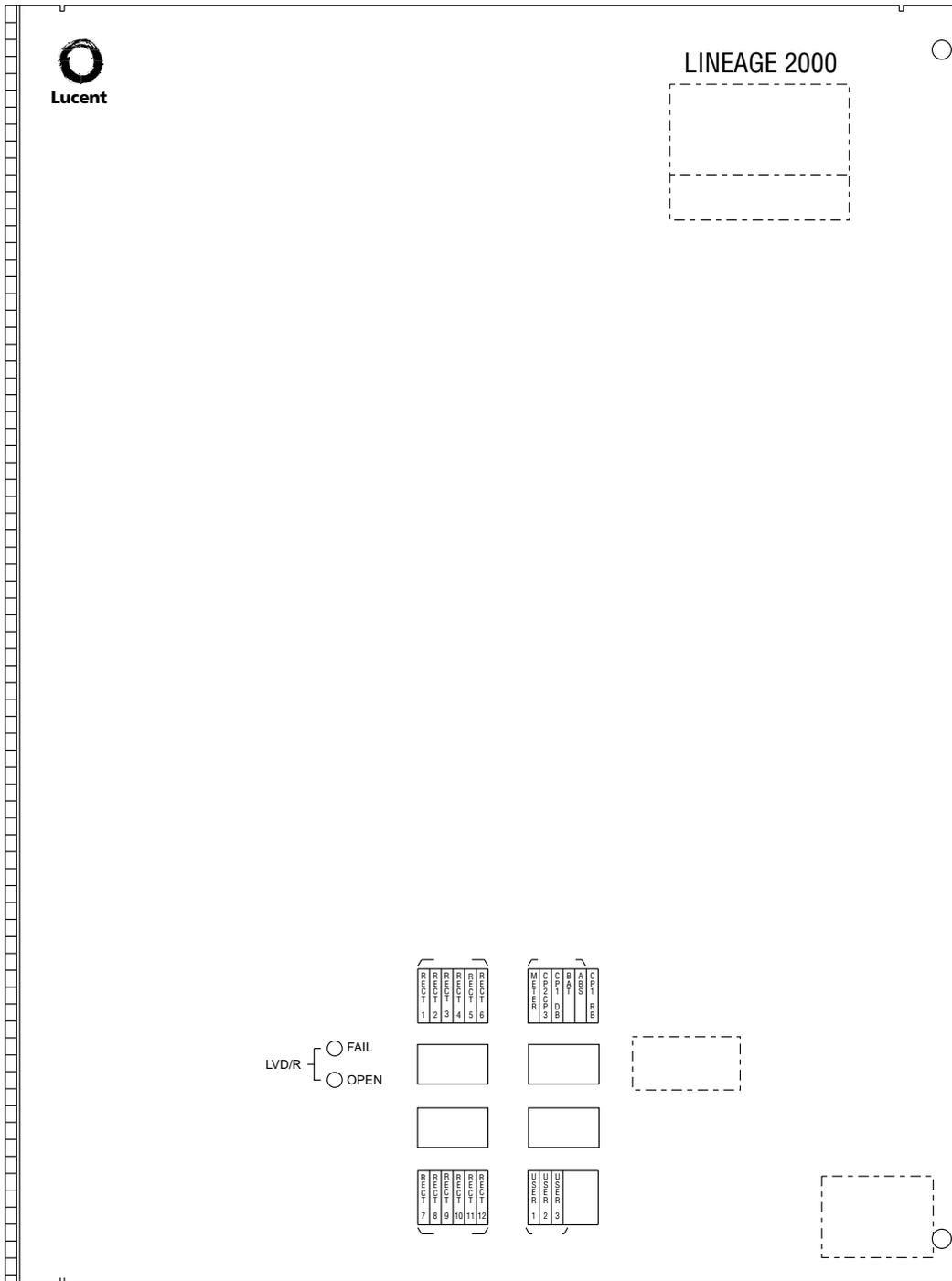


Front View

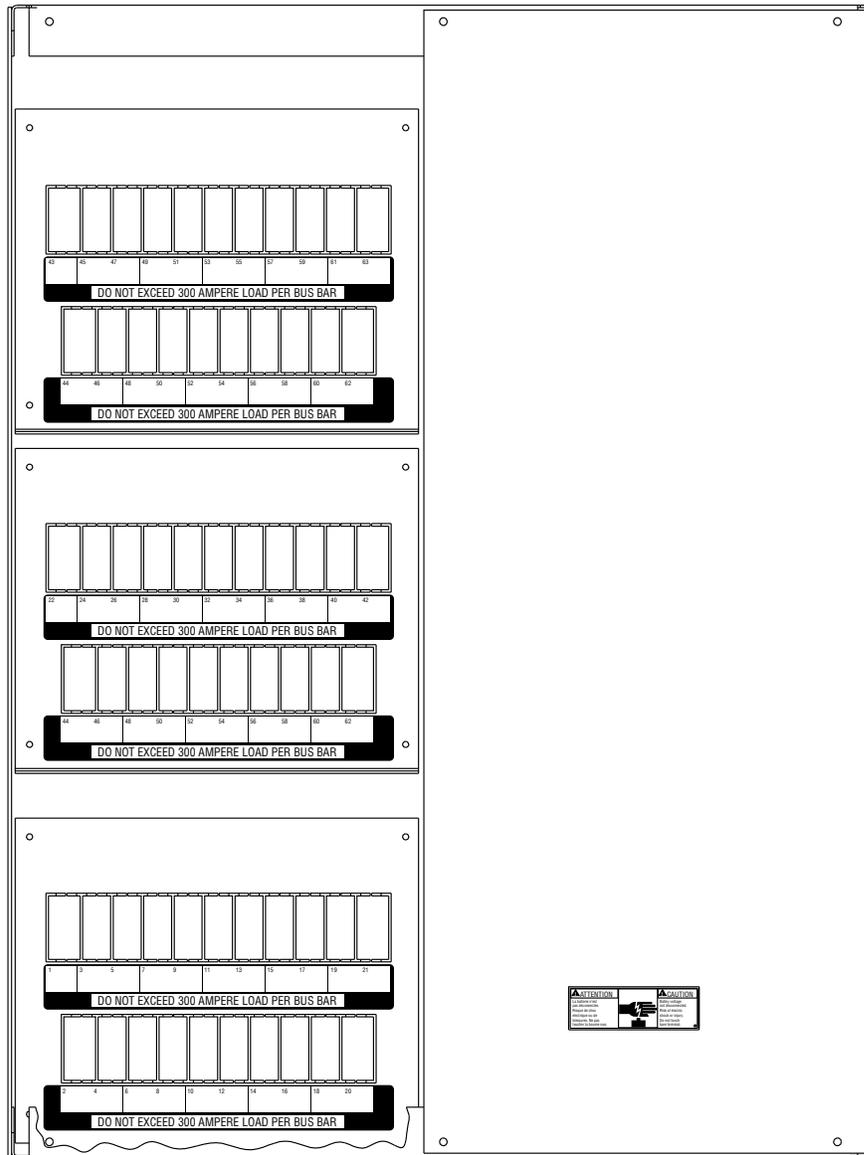


Side View

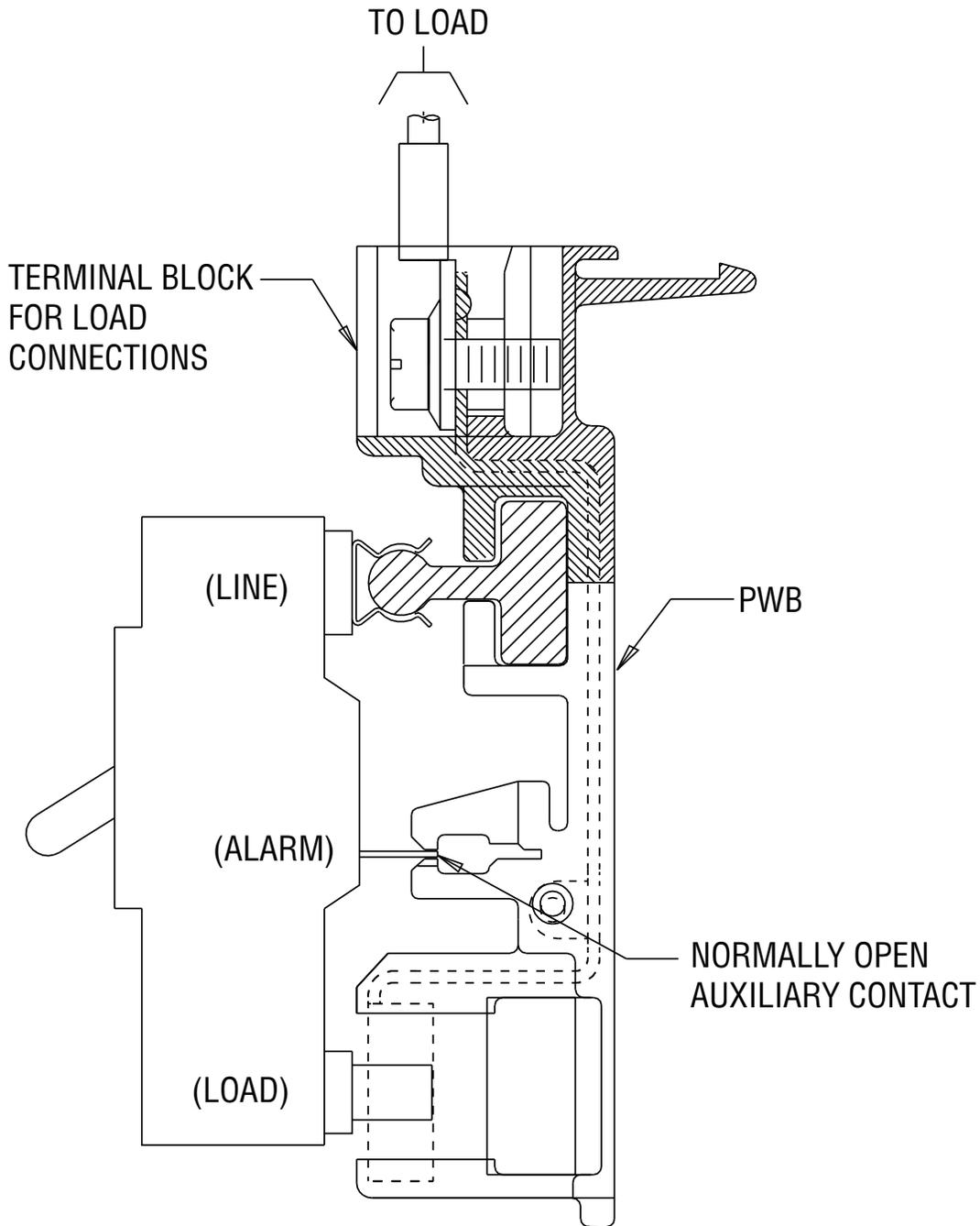
**Figure 2-4: Low Voltage Disconnect/Reconnect Contactor (K1)**



**Figure 2-5: ECS DC Distribution Panel (Front View)**



**Figure 2-6: ECS DC Distribution Panel (Front Door Removed)**



**Figure 2-7: Plug-In Circuit Breaker Mounting**

## 3 *Engineering, Planning & Ordering*

Lucent Technologies offers a wide variety of engineering services that range from complete telecommunications installations to custom modifications of in-place equipment. For more information on the type of services that best meet your engineering needs, contact your Lucent Technologies account executive.

This section of the manual is intended to provide guidance for those customers who wish to completely or partially engineer their battery plant. The detailed process of engineering a battery plant is described as it progresses through four stages. This process is essentially the same for the field modification of an existing battery plant as it is for a new installation.

The four stages are:

1. characterizing the basic power requirements,
2. determining the power equipment that satisfies those needs,
3. determining the impact on the various building systems, and
4. preparing the order using the engineering drawings.

## ***General Engineering Calculations***

The using system, also referred to as the LOAD EQUIPMENT, determines many characteristics of the power equipment. Service and maintenance strategies also affect the selection of power equipment. This paragraph describes, through the following topics, the types of basic power specifications and how they may be determined.

- load equipment voltage
- battery voltage
- load drain and growth
- reserve capacity
- charge capacity and recharge time
- battery string balancing
- voltage drop calculations
- conductor sizing
- overcurrent protection

### ***Load Equipment Voltage***

Determine the recommended operating voltage range of the using equipment. If the battery plant is used to power different types of equipment, it must meet the requirements of each. Fill in the load voltage information below. The answers to these questions will be used in engineering calculations and equipment selection in the following paragraphs.

- a. Recommended operating voltage: \_\_\_\_\_ volts
- b. Minimum steady-state voltage: \_\_\_\_\_ volts
- c. Maximum steady-state voltage: \_\_\_\_\_ volts
- d. Maximum high voltage transient: \_\_\_\_\_ volts
- e. Can the load be damaged by low input voltage?  
\_\_\_\_ (yes or no)

If the answer to (e) is “yes”, low-voltage LOAD disconnect provisions may be necessary. It is important to distinguish between low-voltage disconnects for BATTERIES and for LOADS. Low-voltage battery disconnect does NOT protect load equipment from low input voltage. Load and battery disconnect features are not available on all types of battery plants.

**Battery Plant  
Voltage**

Battery plant operating voltage is directly related to the recommendations of the battery manufacturer. These recommendations must include:

- the steady-state voltage for maximum life or FLOAT VOLTAGE,
- the END VOLTAGE after complete discharge,
- the maximum recharging voltage, and
- the initial charging method.

EQUALIZE or BOOST charging is recharge capacity greater than the float voltage.

Rectifier and load equipment voltage ranges are associated with typical battery voltage ranges. Skip to paragraph “Load Drain and Growth” for batteryless plants.

A BATTERY STRING consists of a number of battery cells connected in series to provide the desired plant operating voltage. This manual deals specifically with NOMINAL 48 VOLT systems, although any plant voltage is possible by varying the number of cells per string.

The NOMINAL CELL VOLTAGE of lead-acid-type batteries is usually defined as 2 volts. The actual recommended float voltage of lead-acid batteries differs slightly among vendors and varies with chemistry. The most common float voltages are 2.17, 2.27 and 2.35 volts per cell.

Nominal 48 volt systems typically use 23 or 24 cell battery strings for float voltages that range from 49.91 to 56.40 volts per string. Lucent Technologies KS-type flooded lead-acid batteries float at 2.17 volts per cell (52.08 volts per string).

Customers should select a battery type and vendor based on their maintenance and replacement strategies, initial cost, expected life, service requirements and replacement cost. Once the battery is chosen, the following information is needed for the battery plant engineering process.

- f. Float voltage per cell: \_\_\_\_ volts
- g. Minimum cell voltage at end of discharge: \_\_\_\_ volts
- h. Is boost or equalize charging recommended?  
\_\_\_\_ (yes or no)

If yes, the maximum recharging voltage per cell: \_\_\_\_ volts

- i. Maximum initial charging voltage per cell: \_\_\_\_ volts
- j. Number of cells per string: \_\_\_\_

Multiply the number of cells per string (j) by the voltages (f), (g) and (h) to find the values for (k), (l) and (m), respectively.

- k. Float voltage per string: \_\_\_\_ volts
- l. Minimum string voltage at end of discharge: \_\_\_\_ volts
- m. Maximum charging voltage per string: \_\_\_\_ volts

Compare these three calculated voltages, (k), (l) and (m), against the steady-state load equipment voltages (a), (b) and (c).

If (l) is a higher voltage than (b), it may be desirable to provide the low-voltage battery disconnect/reconnect feature to prevent battery damage from deep discharge. A more complete comparison of battery and load voltage ranges, involving dc voltage drops in the cabling system, is provided in the following paragraphs.

### ***Load Drain and Growth***

Under normal conditions with a constant load, battery plant voltage to the load equipment is essentially constant. During an ac power outage, however, the batteries deliver power, and their voltage drops steadily since most types of load equipment do not draw a constant current over their input voltage range. Therefore the current drain on the plant may change as the batteries discharge.

Some types of load equipment are purely resistive, in that their current drain decreases as the plant voltage decreases. Other types of loads are characterized as constant power equipment, in that the current increases as the plant voltage drops. Load equipment may have a combination of resistive and constant power characteristics.

In the telecommunications industry, List 1 and List 2 are the designations of the load current drains which have historically been used to size various elements of the battery plant. These values are normally provided for each load circuit or group of load circuits. These terms may be briefly defined as follows:

**LIST 1 drain:** the average “busy-hour” current during normal plant operation (i.e., at float voltage). This value is used to size batteries and rectifiers.

**LIST 2 drain:** the peak current under worst case conditions of voltage, traffic, etc. This current is used to size load feeder cables, plant discharge capacity and overcurrent protectors.

The summations of List 1 and List 2 drains for all the individual load circuits provide the List 1 and List 2 drains, respectively, for the entire battery plant.

Initial List 1 drains are used to size initial rectifiers and batteries since these components may be added relatively easily to operating plants. To determine the initial rectifier and battery needs, fill in the current drain information for all load circuits in the initial installation in Table 3-A. Use additional sheets, as needed.

As the customer's power needs evolve, however, load circuits may need to be added and traffic on existing circuits may increase. Ultimate List 2 drain should be used to select the initial sizes of load feeder cables and plant discharge capacity, since these cannot be readily increased once the plant is installed. In Table 3-B, fill in the anticipated future drains for the circuits listed in Table 3-A. Also include in Table 3-B any additional circuits that may be added and their drains. Recalculate the total battery plant drains.

### ***Reserve Capacity***

Service and maintenance strategy are important factors in determining battery reserve time (number of battery cells). The availability of back-up ac power, accessibility of the battery vault, calculated downtime risk, and the acceptability of loss of service are also factors which influence determination of battery reserve time. These factors will tend to vary from application to application.





Table 3-C lists reserve time practices which have been used in some telecommunications applications where maintaining power to the load is critical. The figures are not intended to be guidelines except in the absence of any specified customer practices.

**Table 3-C: Reserve Capacity**

Back-up Source	Typical Reserve Time	
	Attended Location	Unattended Location
Stationary Engine (automatic start)	3 hours	3 hours + travel time
Stationary Engine (manual start)	4 hours	4 hours + travel time
Portable Engine	4 hours + travel time	
Uninterruptible Power Supply	0 hours (batteryless)	

The noise and transient filtering capability of batteries may also be considered in selecting the minimum battery capacity. Many using systems specify the maximum allowable input noise. Applications (such as UPS-supplied ac power) which do not require batteries for dc reserve purposes may require batteries or some other means for noise filtering. Compare the input noise requirements of the using system to the ECS Battery Plant specifications in Table 2-A.

Fill in the minimum reserve time below.

n. Minimum battery reserve time: \_\_\_\_ hours

Battery capacity is usually specified in terms of AMPERE-HOURS, a measure of energy. The ampere-hour rating is the product of a constant discharge current and the time to discharge a fully charged battery to a specified end voltage. For comparison purposes, most vendors of telecommunications batteries specify ampere-hour ratings at the 8-HOUR RATE of discharge to an end voltage of 1.75 volts per cell. Many battery vendors also supply ratings at other discharge rates, such as 3, 5 and 24 hour rates.

Although ampere-hour ratings are useful for rough estimates of battery size, actual battery selection should be based on curves or tables of discharge current versus time.

**Charge Capacity  
and Recharge  
Time**

For all but batteryless applications, rectifier capacity must be provided specifically for the recharging of batteries. This rectifier capacity must be engineered into the plant in addition to that required to power the load under normal or float conditions. The sum of the normal and the recharge rectifier capacities is called the PLANT CHARGE CAPACITY.

The recharge current is a function of the recharge time and voltage. For example, increasing the plant voltage will decrease the necessary recharge time and increase current demand. Increasing the plant voltage after a discharge is recommended by some battery vendors to assure that all cells charge equally for maximum life. Although these two charging methods are essentially the same, they are called by different names. The former process is called BOOST CHARGING, while the latter is called EQUALIZE CHARGING. For the purposes of this manual, the term Equalize is used to indicate boost- or equalize-charging. Refer to the battery manufacturer's recommendations on equalize charging.

The recharging requirement is determined by customer practices and is usually specified as a maximum time to reach a minimum percent of full capacity, for example, at least 90% capacity in no more than 24 hours.

- o. Maximum recharge time: \_\_\_\_ hours
- p. Percent of full-capacity after recharge time (o): \_\_\_\_%

Refer to the Battery manual or other documentation to calculate the required recharge current to meet the requirements of (o) and (p). The recharge voltage (m) will be needed for this calculation.

- q. Minimum recharge current: \_\_\_\_ amperes

RECHARGE FACTOR is a term that is sometimes used to describe available recharge capacity. The recharge factor is the total charge current divided by the List 1 drain. Typical recharge factors range from 1.20 to 1.50.

- r. Minimum recharge factor: \_\_\_\_

The minimum initial rectifier requirement for float operation is derived from the Plant List 1 Drains calculated in Table 3-A.

Customer preference MAY dictate any combination of the following rectifier engineering conventions:

- At least one on-line spare rectifier must be included in the plant for increased reliability.
- Any on-line spares must be the same size as the largest rectifier size in the plant.
- At least 20 percent additional capacity must be included in the plant to provide recharge capacity and spares.

The actual selection of rectifiers depends on their sizes. Different sizes of rectifiers are available in some types of battery plants, and rectifier sizes may be mixed within one plant. Refer to paragraph “Rectifier Sizing” for specifics on sizes and quantities of rectifiers for the ECS Battery Plant.

***Battery String  
Voltage Drop  
and Balancing***

The rectifiers maintain a constant voltage at the battery plant bus bars while recharging or floating the batteries. There is a finite voltage drop from the charge bus bars inside the ECS bay to the battery string terminals as batteries draw recharge current after a discharge. This voltage drop is proportional to the magnitude of the recharge current. Any voltage drop from the battery plant bus bars to the terminals of each battery string will tend to slow the rate of battery recharge and delay their readiness for future discharges. The same cable resistance responsible for voltage drop during recharge creates a voltage drop during discharge as well. Voltage drop during discharge can limit the effectiveness of the batteries in supplying the necessary reserve.

For these reasons, the engineer should minimize the voltage drop between bus bars and batteries by interconnecting them with the largest practical wire size.

In battery plants with multiple parallel strings of batteries, the cable lengths from the dc distribution subsystem to each string will be different. It is as important to balance the strings as it is to minimize voltage drop. Multiple strings are balanced by sizing cables for equal resistance (and therefore equal voltage drop) between terminals and bus bars. If battery strings are unbalanced, the string with the least voltage drop to the dc distribution provides more than its share of current during each discharge. A battery string that experiences excessive discharges may fail unexpectedly before its predicted end of life.

To both minimize AND equalize voltage drops to parallel strings, the largest practical wire size should be selected for the most distant battery string. The cable sizes for the strings nearer to the DC distribution are then selected so that the drop in each is roughly the same as that for the most distant string.

Some using systems, such as electronic switching systems or transmission systems, dictate maximum allowable voltage drops. A common rule-of-thumb is a maximum drop of 0.25 volts in the leads from battery string terminals to the dc distribution. Voltage drop calculation methods are described in paragraph "Calculating Voltage Drop." For the calculation, use the plant List 2 drain divided by the number of parallel battery strings.

For extraordinarily long runs between batteries and dc distribution, wire gauges may be called for that cannot be conveniently terminated at the equipment at either end. In such cases, the necessary larger cables may usually be tapped down to smaller ones to make the actual connections to the bus bars and battery terminals.

***Battery Size  
versus Voltage  
Drop***

The critical requirement for a battery plant is that the input voltage to the load equipment remain within the proper operating range for the prescribed reserve time. Constants imposed by the typical 48-volt battery system are the normal battery float voltage and the minimum battery end voltage.

**Note**

Engineering of plants with end cell or counter-emf cell battery arrangements is not included in this discussion.

The variables that may be adjusted to ensure service for the specified time period are battery capacity and voltage drop from batteries to the load. If the system is engineered with a relatively small voltage drop, large gauge cabling is required, minimizing battery capacity. If a large voltage drop exists between batteries and load, the minimum load voltage may be reached before the batteries reach their end voltage capacity. In this second case, additional battery capacity would be required.

The trade-off between battery size and wire size is an economic one. For systems with long cabling runs, the cost of large quantities of heavy wire should be balanced against the cost of

additional batteries. Finding the exact optimum combination of cabling and batteries involves iterative calculations. Some using systems, such as electronic switching systems or transmission systems, dictate maximum allowable voltage drops, thus simplifying the calculations. Lucent Technologies offers a computerized service to optimize the selection of cable sizes and battery capacity for any application. Contact your Lucent Technologies Energy Systems Account Executive for details on this service.

Alternatively, various rules-of-thumb are used to specify maximum voltage drops. During discharge, the critical voltage drop is the total drop from the battery terminals to the load equipment.

The voltage drop from the batteries to the distribution has been covered above in paragraph "Battery String Voltage Drop and Balancing." One rule-of-thumb specifies a maximum voltage drop of 0.75 volts in the feeder loop from the dc distribution to the load and back again, using the List 2 drain for that circuit as listed in Table 3-B. Voltage drop calculation methods are described in paragraph "Calculating Voltage Drop." Fill in the selected or calculated system voltage drops, below.

- v. Maximum drop (batteries to dc distribution): \_\_\_\_ volts
- w. Maximum drop (dc distribution to load): \_\_\_\_ volts
- x. Maximum drop (batteries to load): (v) + (w) = \_\_\_\_ volts

After the total drop from the batteries to the load is determined, the actual end voltage of the batteries can be derived from the minimum input voltage to the load (b).

- y. Actual battery string end voltage: \_\_\_\_ volts
- z. Actual battery cell end voltage: \_\_\_\_ volts

Since most battery vendors provide capacity information as a function of end voltage, item (z) is important in the selection of a specific battery. If (z) is below the manufacturer's recommended discharge voltage, low-voltage battery disconnect/reconnect may be helpful in preventing battery damage from deep discharge. In attended locations with back-up ac power, low-voltage disconnect/reconnect may not be necessary.

***Calculating  
Voltage Drop***

A useful formula to relate voltage drop, cable length and cable size is:

$$VD = (K \times I \times L) / CM, \text{ or } CM = (K \times I \times L) / VD$$

where:

VD = allowable voltage drop, in volts

CM = conductor size in circular mils

K = 11.1 for copper at 78°F (25.5°C)

I = appropriate current drain, in amperes

L = conductor length, in feet

The formula may be applied to one-way conductors or to loop circuits (i.e., paired power and return conductors). The value of K in the above expression increases with increasing conductor temperature.

***Conductor  
Ampacity***

Two criteria are used to select the actual wire gauge of a given conductor. These two criteria are ampacity and voltage drop. Ampacity is the current that may be carried safely without overheating the conductor. In relatively low voltage/high current systems, such as dc distribution, voltage drop limitations are often the determining factors in sizing conductors. In systems such as ac distribution, with relatively high voltage and low current, ampacity usually determines minimum conductor size. All conductors, however, must be large enough to carry the intended current safely.

Allowable ampacity is provided in Article 310 of the NEC (National Electrical Code), and it is a function of the following:

- wire size,
- ambient temperature
- type of insulation, and
- proximity to other conductors.

The ampacity tables are given in the National Electrical Code (NEC), starting with Table 310-16. These tables, together with the appropriate notes, determine the current that will result in the

maximum allowable operating temperature for each wiring method. For instance, for the maximum temperature for Type RHW wire is 75°C (167°F). The current that will result in that temperature (i.e., the ampacity) is less when the ambient air temperature is higher and also when conductors are bundled or side-by-side.

***Overcurrent Protection***

The rating of an overcurrent protection device (fuse or circuit breaker) should not exceed the AMPACITY of the conductor it is intended to protect. The absolute maximum rating permitted by the NEC for an overcurrent protector is the next larger standard rating above the ampacity. Overcurrent protectors may be sized smaller than this maximum rating. In general, however, protectors should be rated as high as allowable to avoid nuisance tripping due to high load conditions or inrush during start-up.

***Lineage<sup>®</sup> 2000 Engineering Specifics***

The methods used in the paragraph, “General Engineering Calculations,” are appropriate for the engineering of any battery plant. The specifications documented in the paragraph, “General Engineering Calculations,” are used in this paragraph to select the specific types and quantities of equipment available with the Lineage<sup>®</sup> 2000 ECS battery plant.

The following topics are covered in this paragraph:

- rectifier sizing
- battery sizing
- number of bays
- cable and load breaker sizing
- low-voltage disconnect/reconnect
- emergency shutdown/disconnect
- controller options
- alarm system interface
- earthquake bracing
- appearance packages

### ***Rectifier Sizing***

The Lineage<sup>®</sup> 2000 SR 50 ampere, -48 volt switched-mode rectifier is currently available with the Lineage<sup>®</sup> 2000 ECS Battery Plant. The maximum number of rectifiers per plant is twelve.

In the absence of specific customer practices, the following procedure is RECOMMENDED.

- s. Determine the smallest whole number of rectifiers that will provide the normal (List 1) plant drain in Table 3-A: \_\_\_\_\_
- t. Determine the smallest whole number of rectifiers that will provide the normal plus recharge current from Table 3-A and (q): \_\_\_\_\_
- u. provide the GREATER of (s)+1 or (t) rectifiers: \_\_\_\_\_

For batteryless plants, skip to paragraph “Initial and Supplementary Bays.”

### ***Battery Sizing***

The battery type and minimum size are determined in paragraphs “Battery Plant Voltage” and “Reserve Capacity.” Many vendors offer families of batteries that cover a wide range of ampere-hour capacities. Ampere-hour capacities of parallel battery strings are added to provide the total reserve capacity of the battery plant. To supply the necessary reserve, several strings of small capacity batteries or one or two strings of large capacity batteries may be connected in parallel.

There are several important considerations in the choice of battery size versus number of strings, namely,

- Cost,
- Weight and Space Efficiency,
- Anticipated Growth, and
- System Reliability.

**Cost:** The cost per ampere-hour decreases with increasing cell capacity. On the basis of initial material cost, the number of strings should be minimized.

**Weight and Space Efficiency:** Weight density and space efficiency increase as battery capacity increases. There can be significant differences in space efficiency, however, between

different vendors of the same capacity battery. Floor loading restrictions may limit stacking of batteries. Structural limitations of the building must be clearly understood before selecting a battery arrangement.

See paragraph “Floor Plan Data” for more information on floor loading. Applications with space restrictions such as standard aisle depths may dictate the use of more strings of smaller batteries.

**Anticipated Growth:** The growth pattern for the battery plant may dictate the battery size. It is usually easier to engineer and install additional strings of the same battery type and capacity as those already in place. The growth in battery capacity is directly related to the growth in rectifier capacity, since both must increase with increasing load current. Since only a fraction of added rectifier capacity is needed for recharging added batteries, the matching incremental change in battery capacity depends on the desired recharge factor. (See paragraph “Charge Capacity and Recharge Time” for an explanation of charge capacity and recharge factor.)

Since the charge capacity of the Lineage<sup>®</sup> 2000 ECS battery plant grows in 50 ampere increments with the SR50A/-48V rectifier, the optimum battery capacity increment may be approximated as follows.

$$\text{A-hr increment} = (50 \text{ A}) \times (\text{reserve time in hours}) / (\text{minimum recharge factor})$$

**System Reliability:** In most battery plants it is possible have an open circuit in the battery subsystem that could remain undetected until ac power is lost and battery power is required. Therefore, it is a good practice to select battery size such that at least two strings are required for applications where service reliability is critical. Multiple strings allow for easier maintenance on the battery system without jeopardizing service to the load equipment.

***Initial and  
Supplementary  
Bays***

All subsystems of the ECS battery plant, excluding batteries, can occupy the entire framework called the INITIAL BAY. The ultimate capacity of the battery plant (12 rectifiers and 63 circuit breakers) will fit in this space. For batteryless plants, the initial bay is the only necessary assembly.

Batteries must be engineered per the manufacturer's instructions. Shelf-mounted batteries, offered by some suppliers, may be integrated into a frame line-up with the ECS battery plant. Most other vendor's batteries, however, are designed for mounting on stands that require special floor plan arrangements.

Specify the number of Supplementary Bays required \_\_\_\_

***Cable and Load  
Breaker Sizing***

In this paragraph, power cabling for the dc distribution and battery subsystems is covered, including the following subtopics.

- maximum and minimum wire gauges
- wire type
- crimp lugs
- circuit breaker selection

To determine actual wire sizes, the equipment locations, cable rack and routing systems at the site must be known. Since the battery plant shares the cabling system with other building systems, cabling engineering is not completely defined by this paragraph of the product manual. This paragraph derives the basic dc power cabling which will be required as part of a complete cable engineering process. Lucent Technologies offers cabling engineering services that are separate from battery plant engineering. Contact your Lucent Technologies Account Executive for more information on available services.

Wire type RHW or RHH should be used for dc power wiring. This type of wire is commonly available in American Wire Gauge (AWG) Stranded (e.g., KS-5482) and in a finer stranded welding type (e.g., KS-20921). Flexible or Welding Wire is slightly larger than AWG stranded wire of the same gauge, which may affect the selection of crimp lugs. For example, different crimp lugs are required for AWG and Weld wire of the same gauge, for 1/0 gauge and larger.

Flexible power wire (e.g., KS-20921) should be used for sizes 1/0 and larger in applications requiring tight bends, such as small battery plants in confined locations.

The wire sizes that may be readily terminated at the dc distribution subsystem are listed in Table 3-D. The distribution allows direct termination of 4/0 wire. H taps should be used for

larger wire size requirements. Table 3-D specifies the equipment, the terminal lug requirements, the maximum wire size to be terminated directly without H taps, the terminal lug center spacing, the crimp tool to use, the required fasteners, and provisioning information.

Terminal lugs and hardware not provided may be ordered from Table 3-E.

**Table 3-D: Field Wiring Specifications**

	Load Side	Return Side	Lug Wire Size	Center Space (inches)	Crimp Die	Required Hardware	Lug Provided	Hardware Provided
3-50 A Crkt Brkr	Single Hole	Double Hole	12 AWG 10 AWG 8 AWG 6 AWG	5/8	Red	10-32 Screw	Yes	Yes
60-100A Crkt Brkr	Adapter Double Hole	Adapter Double Hole	2 AWG	5/8	Blue	10-32 Nut/ Screw	No	Yes
100A Crkt Brkr	Single Hole	Double Hole	2 AWG	5/8	Brown	1/4-20 Screw	No	Yes
225A Crkt Brkr	Single Hole	Double Hole	4/0 AWG	1	Yellow	5/16-18 Screw	No	Yes
-48V Fuse Panel	Single Hole	Double Hole	10 AWG	5/8	R5473	10-32 1/4-20 Nuts	No	Yes
Battery Leads	Double Hole	Double Hole	4/0 AWG	1	Yellow	5/16-18 Nuts	No	Yes
AC to RSA	Single Hole		12 AWG		R5473		10-32 Nuts	Yes
Controller Alarms	Terminal Block		22 AWG	N/A			N/A	
Central Office Ground	Double Hole		4/0 AWG	1	5/16 nuts		Yes	Yes

**Table 3-E: Lug And Hardware Ordering Codes**

<b>Available Double Hole Terminal Lugs</b>						
<b>STR Class B</b>	<b>Flex Class 1</b>	<b>WP-91412 List</b>	<b>Comcode</b>	<b>Bolt Size</b>	<b>Centers</b>	<b>Die</b>
10	10	73	405356171	10	5/8	R5473
8	8	52	405348178	10	5/8	Red
8	8	75	406021626	1/4	5/8	Red
6	6	3	405347519	1/4	5/8	Blue
4	4	5	405347576	1/4	5/8	Grey
2	-	54	40534 8202	1/4	5/8	Brown
-	2	8	405347683	1/4	5/8	Green
1/0		56	405348228	5/16	1.0	Pink
-	1/0	13	405347758	5/16	1.0	Black
2/0	-	13	405347758	5/16	1.0	Black
-	2/0	20	405347857	5/16	1.0	Orange
4/0	-	59	405348251	5/16	1.0	Purple
	4/0	158	406434175	5/16	1.0	Yellow
<b>Available Single Hole Terminal Lugs</b>						
<b>STR Class B</b>	<b>Flex Class 1</b>	<b>WP-91412 List</b>	<b>Comcode</b>	<b>Bolt Size</b>	<b>Die</b>	
10	10	93	406338145	10	R5473	
8	8	1	405347402	10	Red	
8	8	74	405356189	1/4	Red	
6	6	2	405307436	1/4	Blue	
4	4	4	405347543	1/4	Grey	
2	-	53	40534 8186	1/4	Brown	
-	2	7	405347659	1/4	Green	
1/0		55	405348210	5/16	Pink	
-	1/0	10	405347717	5/16	Black	
2/0	-	10	405347717	5/16	Black	
-	2/0	17	405347790	5/16	Orange	
4/0	-	58	405348244	5/16	Purple	
	4/0	76	406021741	5/16	Yellow	

For nontypical ECS configurations where the supplementary bays are not located adjacent to the initial bay, battery cables must be engineered.

Five sizes of plug-in circuit breakers are available for dc distribution overcurrent protection. The ratings of these circuit breakers are 10, 20, 30, 45 and 60 amperes. Two screw panel mount breakers with current ratings of 100 and 225 amperes are also available. The breaker rating for a given circuit is selected by the criteria covered in paragraph "Overcurrent Protection."

The lengths of all load and battery conductors must be known before proceeding with this paragraph. Use the following steps to record the wire and breaker sizes for each load feeder in Table 3-F. Use additional sheets as needed.

**Step A:** Copy List 2 drains for each load feeder from Table 3-B to Table 3-F.

**Step B:** Calculate the minimum wire size that meets the ampacity requirement based on the List 2 drain for each load feeder.

**Step C:** List the wire sizes based on ampacity in Table 3-F.

**Step D:** Calculate the minimum wire size for each load feeder in Table 3-B to meet the voltage drop requirements outlined in paragraph "Calculating Voltage Drop."

**Step E:** List the sizes based on voltage drop in Table 3-F.

**Step F:** Indicate the larger size for each load feeder in the column marked "Selected Wire Gauge."

**Step G:** Fill in the circuit breaker rating (10, 20, 30, 45 or 60 amperes) in Table 3-F for each feeder.

**Step H:** Record in Table 3-G the wire sizes for each battery feeder.

**Step I:** Calculate the minimum wire size that meets the ampacity requirement based on the total plant List 1 drain divided by the number of parallel battery strings.

**Step J:** Enter that wire size on the first line in Table 3-G.

**Step K:** Calculate the minimum wire size for each battery feeder in Table 3-B to meet the voltage drop requirements outlined in paragraphs “Battery Size versus Voltage Drop” and “Calculating Voltage Drop.”

**Step L:** List the sizes based on voltage drop in Table 3-G.

**Step M:** Indicate the larger size for each load feeder in the final column, “Selected Wire Gauge.”

#### Note

- Insulation on field wiring conductors should be rated no less than 75°C. Wire conductor size, determined by the formula above, should be no less than allowed by electrical codes for 75°C wire (regardless of insulation temperature rating used) and the ampacity of the associated protection device.
- In order to maintain proper spacings as required by Underwriters Laboratories when converting load conductors to the terminal block on the breaker panel, use only connectors supplied.



**Table 3-G: Minimum Wire Gauge (Ampacity) - All Strings**

String Number	Minimum Wire Gauge	Selected Wire Gauge
1		
2		
3		
4		
5		
6		

**Low-Voltage Disconnect/Reconnect Feature**

Low-voltage BATTERY disconnect/reconnect is available as an option on the ECS plant. For this feature, two disconnect levels are available: 40.5 and 42.5 volts. The tolerance on disconnect levels is +/-0.5 volts. Based on the discussion in paragraph “Battery Plant Voltage,” fill in the following information.

Is Low-Voltage BATTERY Disconnect/Reconnect required?  
 \_\_\_\_\_(yes or no)

If yes, specify the disconnect level \_\_\_\_\_(40.5 or 42.5)

**Controller Options**

The engineering of the ECS controller features involves orderable circuit packs and field-movable jumper straps.

**Circuit Packs:** Circuit pack options for the ECS controller are presented on the H569-416 battery plant drawing. Refer to that drawing and to the Controller manual for more information on the availability of optional circuit packs.

**Jumper Straps:** If requirements differ from the standard factory settings, certain controller features must be set during the installation process. The engineering process must provide the

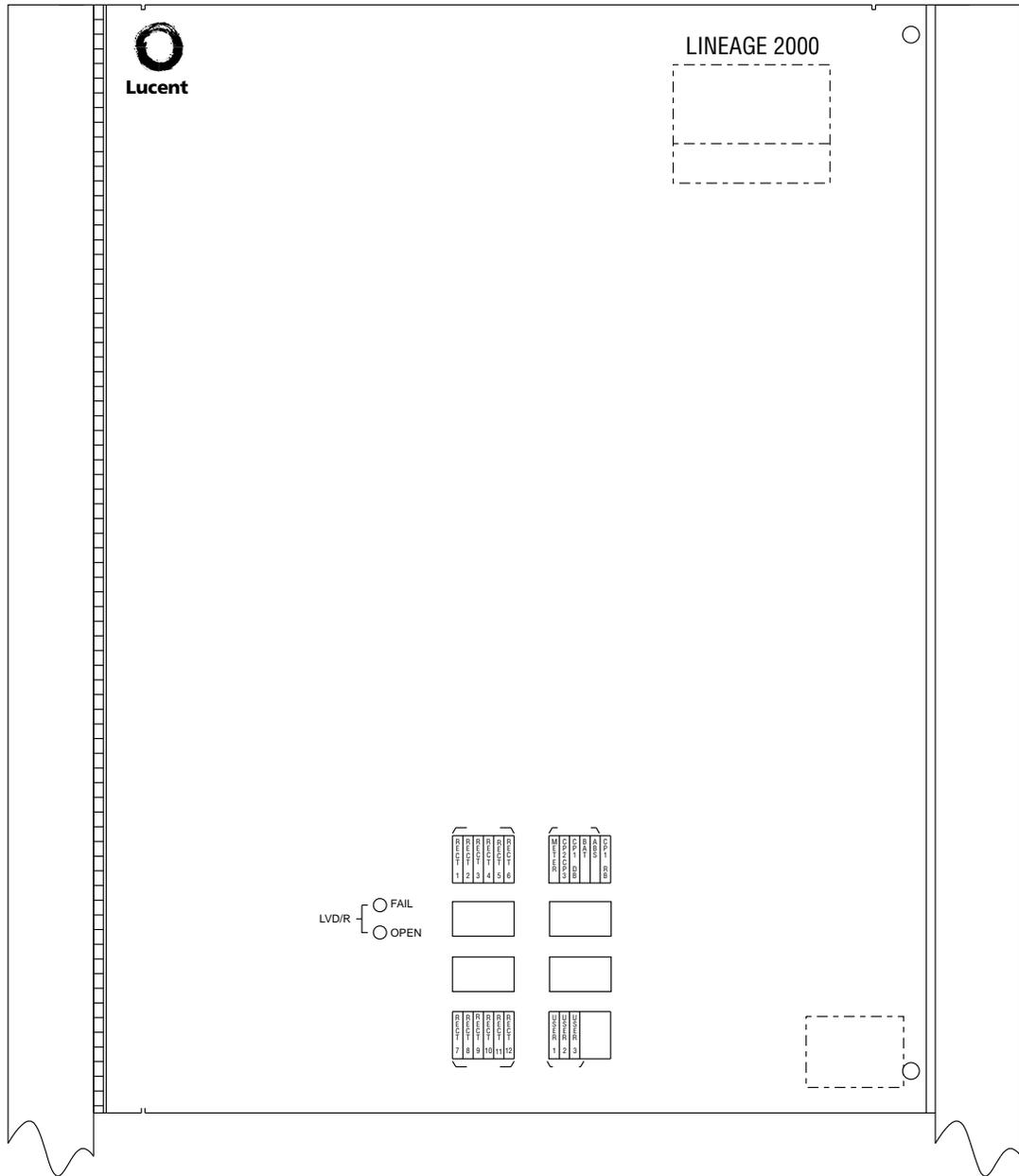
necessary instructions to the installer for the controller set-up. Refer to the J85501D-2 controller drawing and the Controller Manual for details.

***Alarm System Interface*** The standard ECS controller is equipped with connection points for a variety of battery plant alarms. The wiring from the controller alarm points to the local and remote reporting alarm systems is NOT provided with the battery plant. Such wiring must be compatible in gauge and type with the terminal blocks provided on the controller circuit packs, as detailed in the Controller Manual.

***Earthquake Bracing*** The earthquake ratings for the standard ECS battery plant is: Zone 4, upper floors, per NEBS TR-EOP-000063.

***Appearance Packages*** An appearance package option is available for the initial and supplementary bays of the ECS battery plant. This option is shown in Figure 3-1. It includes Front Style Strips (846651115 List KA), which are metal covers used to improve the aesthetics of the plant by covering the frame uprights, concealing the equipment mounting screws, and providing an enclosed cable way. A right and left style strip is provided with this option.

For additional information and installation details refer to the H569-416 drawing.



**Figure 3-1: ECS Appearance Package Option**

## ***Planning***

The equipment specified in the previous paragraph will affect various other systems within the building that serve more than just the battery plant. Some of these common systems are ac distribution, cabling, air-conditioning and ventilation and the building structure itself. For example, the ac distribution system for a building or room is not completely defined by the power equipment needs alone, but clearly the number and type of rectifiers have a direct impact.

The following topics are covered in this paragraph:

- Floor Plan Data: Floor Space, Floor Load, Heat Load, AC Service
- Cable Rack and Routing
- Grounding
- Growth

### ***Floor Plan Data***

There are several types of information that are collectively called Floor Plan Data. This information is sometimes published on Floor Plan Data Sheets. For the Lineage<sup>®</sup> 2000 ECS Battery Plant, complete Floor Plan Data is given on a sheet of the H569-416 drawing (also presented in Table 2-A of this manual). This battery plant information must be combined with the corresponding data for all other equipment in the office to engineer the appropriate aspects of the building.

The four categories of floor plan data relevant to battery plants are listed below.

**Floor Space:** Adequate space must be allocated for the battery plant footprint and for aisles.

**Floor Load:** The building structure must support the intended weight per unit floor area, and equipment must be spaced out to distribute the load, as necessary.

**Heat Load:** The air-conditioning and ventilation system is sized to maintain the environment given the heat dissipation of the equipment.

**AC Service:** The ac distribution system is sized to accommodate the current requirements of the powered equipment.

***Cable Rack and Routing***

To help plan for the routing and support of battery plant cabling, typical arrangements are shown on the H569-416 drawing.

***Grounding***

The ECS battery plant is designed for compatibility with most grounding systems. The standard discharge return bus is located in the initial bay. Alternatively, the battery plant return bus system may be mounted in the overhead cable rack.

When the discharge return bus is in the initial bay, a connection point is provided on it specifically for grounding. This point may be used to tie the battery plant to the building grounding electrode with up to 2 AWG wire. The ECS battery plant framework is equipped with a 6 AWG frame grounding conductor for connection with the aisle frame ground conductor. See the T-83171-31 wiring diagram for more information.

***Growth***

As in the selection of protector and wire sizes for load feeders, building systems should be designed for ultimate growth. Cable rack support and ac distribution cabinets should be sized for the maximum anticipated battery plant capacity. Floor space and weight capacity should also account for any increase in battery reserve.

***Ordering***

Many customers are familiar with Lucent Technologies's drawings, diagrams and other product documentation and use these tools in specifying and ordering their power equipment. This system is reviewed in paragraphs "Coding and Terminology" through "SD-drawings." The paragraph "Documentation References" is a summary of the documentation references.

***Coding and Terminology***

The two main categories of Lucent Technologies hardware are called APPARATUS and EQUIPMENT. The battery plant ordering process primarily involves Equipment for the system and Apparatus for components and replacements.

An apparatus code identifies one specific arrangement of hardware. The product is available in one form only. Lucent Technologies Coded Apparatus is always specified by the code followed by the descriptor. For example,

- BCB2 Circuit Pack

- 364A Power Unit
- 113B Control Unit

The vintage or version of coded apparatus is controlled by a SERIES NUMBER. The series number may be appended to the apparatus code for a complete description of the product, but is not necessary because only the latest vintage is orderable at any given time. Apparatus-coded components for a battery plant are, typically, replacement parts and spares. (See Section 6, “Spare Parts.”)

Equipment-coded hardware is available in different configurations with combinations of optional features. The total number of combinations and permutations of the optional features on a given product may be in the hundreds or thousands. For this reason, a unique code is NOT assigned to each combination of options. Instead, a MAIN CODE is specified, which is followed by a list of identifiably separate options with the quantities for each option.

The main code number falls into one of three categories:

- J-code
- ED-code
- H-code

J-codes take the form JxxxxxA-y and are used to specify main assemblies, stand-alone products, and units that may have multiple applications.

ED-coding, of the form ED-xxxxx-yy, identifies subassemblies that are components of main equipment assemblies. For example, an ED-coded distribution panel assembly may be a component of a J-coded battery plant.

H-coding takes the form H-xxx-xxx and is used for a variety of special applications such as field installation kits, pre-assembled cables or custom configurations of options for a J-coded product.

The xxxxx part of an equipment code is called the BASE NUMBER. The y or yy, called the DASH NUMBER, is used to identify the vintage of the base number or to indicate a close relationship with products with the same base number.

A J-, ED- or H-coded piece of equipment is controlled by a standard drawing of the same number. This drawing contains the descriptions of the optional configurations, manufacturing assembly information and any additional details for engineering or field installation.

An equipment option is identified by a number or letter called a LIST or a GROUP. J-coded equipment uses Lists, while ED- and H-coded products are equipped with Groups. For simplicity, the discussion that follows deals specifically with J-coded equipment. ED- and H-coded equipment, however, may be treated similarly.

The standard drawings for Lucent Technologies battery plants and their components are J-, T- and SD-drawings. Together these drawings provide the necessary details for engineering, planning, ordering, record-keeping, installation and repair. A thorough understanding of the construction and content of the standard drawings is, therefore, required for proper, error-free engineering and ordering of the battery plant. The drawings associated with this battery plant should be reviewed completely before preparing an order.

The generic features of J-, T- and SD-drawings are described in the following paragraphs.

### ***J-drawings***

A J-drawing consists of the following parts:

- Cover Sheet(s), containing ordering, engineering and issue information, as well as notes for manufacturing and installation.
- Assembly Views, showing details of shop and field assembly, and
- Stocklist, listing the quantity and complete ordering code for each component part used in the assembly.

The cover sheets of a J-drawing contain a wide variety of important engineering and ordering information. The important parts of the cover sheet are described below. Item numbers, below, refer to those on the typical one page cover sheet displayed in Figure 3-2.

**(1) Title Block:** This contains the official drawing title, including the input and output, if any. The title is NOT required for ordering purposes. Also included in the title block are the J-code and the issue number.

**(2) J-code:** This number must be included in the order exactly as shown on the drawing. It is always followed by at least one List number when describing an orderable piece of equipment. On its own, the J-code refers to either the drawing itself or, in generic terms only, the product.

**(3) Issue number:** Each sheet of a drawing has its own issue number, which changes whenever anything is changed on that sheet. The issue number of the first cover sheet changes whenever any sheet in the J-drawing is changed. The issue number of the cover sheet is called the DRAWING ISSUE.

The drawing issue number is one mechanism used to distinguish between vintages of the same product. Ordering information may or may not change when a J-drawing is reissued. The drawing issue must agree with the vintage of product available from Lucent Technologies. Reissued drawings are sometimes released prior to actual factory availability to provide time for engineering and order preparation. Consult your Lucent Technologies Account Executive for assistance with issue number coordination.

**(4) Sheet index:** The index lists the numbers of all sheets in the drawing and their respective issue numbers. Some drawings have sheets numbered 1, 2, 3, etc. Many, including the example shown, are divided into A-, B-, C- and D-sheets. The A-sheets are the cover sheets and are numbered A1, A2, A3, etc. The B-sheets contain the main assembly views and are numbered similarly (B1,B2,...).

C-sheets are used to show assembly details and any other relevant graphical information. The stocklist is included on D-sheets.

**(5) Table A:** Table A is the single most important entity on a J-drawing for engineering and ordering. It contains a description of each orderable feature, its ordering code, its availability and a cross-reference to the wiring diagram.

**(5A) List numbers:** The ordering codes for product features are called Lists. They may be numbers, letters or combinations thereof. A list describes a collection of parts which are (1) assembled and packaged per the assembly views and stocklist of the J-drawing and (2) wired per the referenced figures of the T-drawing.

**(5A-1) Main lists:** The list number for a basic configuration of equipment is called a Main List. A Main List describes a set of features which is a lowest common denominator or a typical arrangement. There may be several Main Lists on a given J-drawing, that share, perhaps, common components or Supplementary Lists (see below). Only one Main List number is specified for one equipment assembly, and the quantity specified for that List is one.

**(5A-2) Supplementary Lists:** Features are added to or omitted from Main Lists by specifying Supplementary Lists. A Supplementary List is not orderable by itself but must be specified in addition a main list. Different supplementary lists and multiples of individual supplementary lists may be specified for one main list. Restrictions on possible combinations of main and supplementary lists are described in the feature descriptions in Table A and/or in Engineering Notes (see below).

**(5B) Ratings:** The availability for ordering of each List is controlled by the Rating, listed in Table A. Currently there are two Rating classifications: Available (AVAIL or no marking) and Discontinued Availability (DA). The conditions on discontinued availability, such as factory repair policy, vary from product to product and from List to List. Contact Lucent Technologies for information on specific products, as needed.

**(5C) Circuit Figures:** There is often a Wiring Diagram (T-drawing) which is separate from the assembly drawing for equipment that incorporates factory wiring. If a List contains wiring, the associated Figure number of the T-drawing is indicated in Table A of the J-drawing. A quantity indicates the number of multiples of the wiring in the specified figure which are required for a List. When a T-drawing figure is not listed in parentheses, everything in the figure which is not indicated as optional is provided. (See below for a detailed discussion of T-drawing options.) When a T-drawing figure is listed in parentheses, only the indicated wiring or apparatus options are provided from that figure.

**(5D) Wiring Options:** If portions of the wiring are connected differently among the Lists, those differences are indicated by T-drawing Wiring Options.

**(5E) Apparatus Options:** When circuit components differ from one List to another, these differences are indicated by Apparatus Options on the T-drawing.

**(6) Table C:** This table cross-references the schematic (SD) and wiring diagram (T).

**(7) Table D:** This table provides a list of all associated drawings, such as other J-, ED- or H-coded equipment that must be ordered separately. Drawings which are required for engineering or manufacturing but are not necessary for installation are indicated by an equals-sign (=).

**(8) Manufacturing Notes & Symbols:** Notes that apply to factory and/or field assembly are listed as Manufacturing Notes and are numbered from 1 to 50. The first several notes define standard symbols used on the assembly views and in the stocklist to indicate stamping and factory packaging methods. Additional manufacturing notes are specific to each J-drawing. All manufacturing notes should be read and understood by engineering, as well as installation, since they may include important installation details that the engineer must plan for.

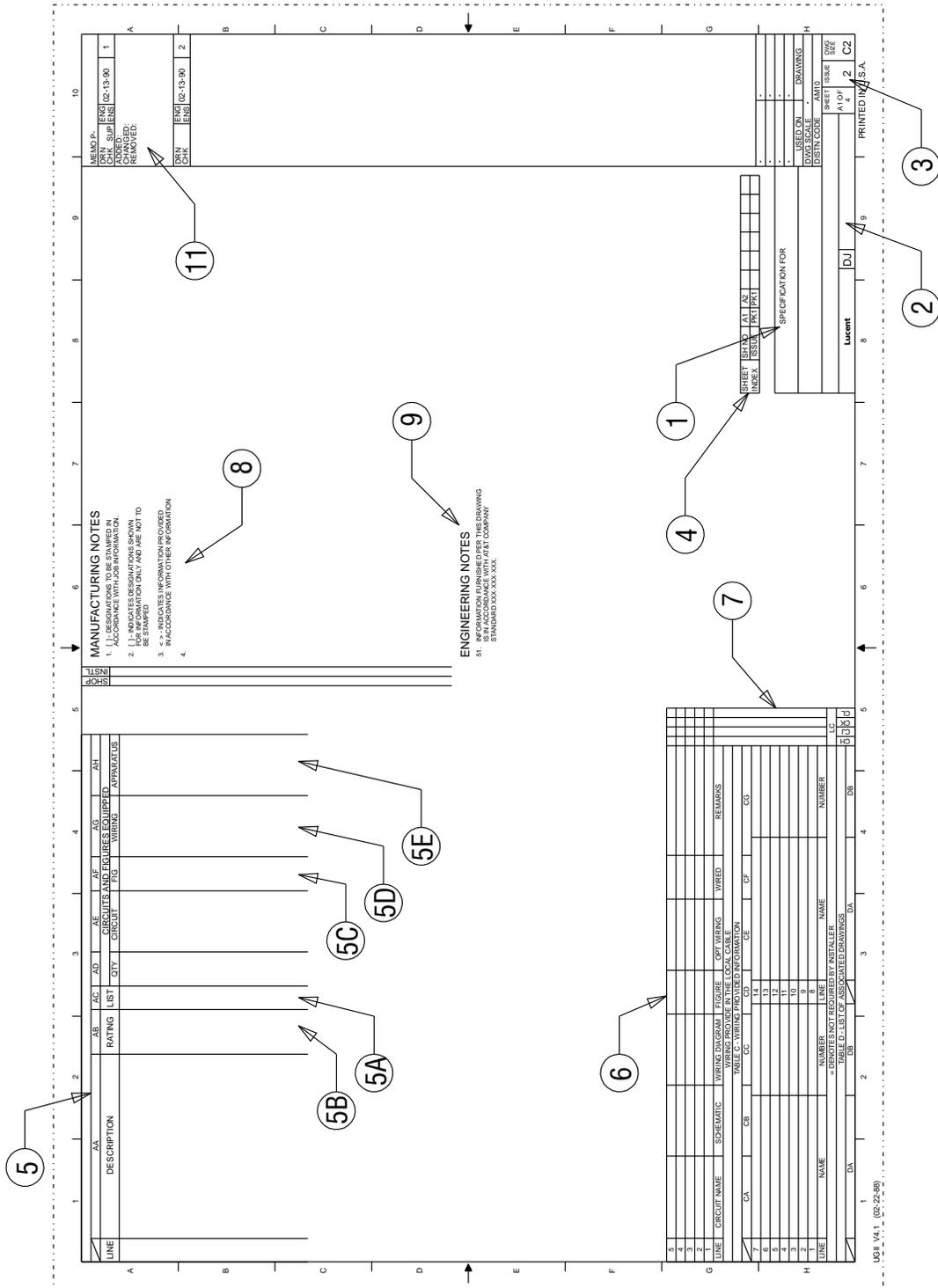
**(9) Engineering Notes:** For engineering, the second most important part of the J-drawing, after Table A, is the Engineering Notes section. These notes, starting at Note 51, provide such information as:

- Restrictions on List combinations
- Additional job-specific hardware that must be ordered
- Product manual references
- Numbering conventions for panel positions

**(10) Other tables:** Other non-standard tables may appear on the J-drawing to provide additional engineering, manufacturing and/or installation information. Each table should be referenced from an engineering or manufacturing note on the drawing.

**(11) Change Notes:** Change or Revision Notes chronicle, in very abbreviated form, the history of drawing reissues and the associated changes, such as additional Lists, modifications to

assembly views, clerical error corrections and part number changes. The Issue number and date always FOLLOW the list of changes.



### ***T-drawings***

T-drawings are used to show wiring details, such as wire colors, gauges, and routing, which cannot be conveniently shown in assembly views of the J-drawing. T-drawings are similar in format to J-drawings, with cover sheets and assembly sheets. There is no stocklist or Table A, however, on a T-drawing. The following T-drawing cover sheet features are essentially the same as those for J-drawings:

- Title Block
- Issue number
- Sheet Index
- Manufacturing Notes & Symbols
- Engineering Notes
- Change Notes

As with the J-drawing, all the notes on the T-drawing should be read completely when engineering a job. Other important features of the T-drawing cover sheet are Tables B, C and D. Table B of the T-drawing gives a historical record of the addition and elimination of options. This table corresponds to the Record of Change Table on the SD-drawing. (See below.)

As noted earlier, there is usually a close correspondence between options defined on the SD and those shown on the T-drawing. The exact correlation of options and figure numbers between the two drawings is given in Table C.

Table D gives is an index to the locations of T-drawing options on the various sheets of the drawing. There is a similar Option Index on the SD. (See below.)

The wiring information is shown graphically two ways: Shop Figures and Installer Figures. Shop figures are numbered 1, 2, 3, etc. for main figures and A, B, C, etc. for details. Installer figures are similarly numbered but with the prefix H. All connections and circuit components in a given figure, that are not indicated as optional, are provided when that figure is specified by the J-drawing. Options are indicated on the figures by a letter or letters inside a double circle.

An option is defined when alternative connections or circuit components are possible. T-drawing options are called Wiring options for connection alternatives and Apparatus options for component differences. Where possible, T-drawing options are

derived directly from those defined on the SD-drawing, using the same lettering scheme (see below). Options which are found on the T-drawing, but not on the SD, always include the prefix H. Optional wiring and hardware is provided only when the associated options are specifically called for by Table A of the J-drawing.

***SD-drawings*** The SD-drawing is the source for the circuit information that describes a product. The connectivity and options shown on the T-drawing are based on the SD. The parts on the J-drawing stocklist which are circuit components are documented on the SD. Mechanical parts, wire colors, wire routing and cable harnesses, however, are not necessarily shown on the SD.

The SD-drawing package is usually sectionalized, similar to the J-drawing, as follows:

A-sheets are cover sheets including Title Block, Supporting Information, Sheet Index, Option Index. All of this information is similar in format to that on T- and J-drawings.

B-sheets contain the Functional Schematics (FSs).

C-sheets list the Apparatus Figures (APP FIGs) (i.e. circuit component lists).

D-sheets contain drawing notes categorized as Circuit Notes (numbered 101 to 200), Equipment Notes (numbered 201 to 300) and Information Notes (301 to 400). Certain standard notes of particular interest are:

Note 102: Feature & Option Table which describes each option letter, is often duplicated in the T-drawing engineering notes.

Note 103: The Record of Change Table traces when options are added and discontinued on various drawing issues, as in Table C of the T-drawing.

SD notes often contain important details on applications of circuit features and options, so all notes should be read before completing the engineering process.

G-sheets show Cabling Diagrams (CADs), define terminal designations and wiring for installer connections. This information is duplicated in the Installer Figures of the T-drawing.

H-sheets are included in some SD-drawings to provide Block Diagrams (BDs) that are helpful in understanding complex circuits.

J-sheets are used for Circuit Pack Schematics (CPSs), if any are included in the SD. Most circuit packs, however, are documented on separate schematic drawings, some of which are proprietary and are not generally accessible.

***Documentation  
References***

The following documents provide the engineering, ordering and installation information for the Lineage<sup>®</sup> 2000 ECS battery plant, the ECS controller, the Lineage<sup>®</sup> 2000 SR series rectifier and Rectifier Shelf Assembly (RSA):

Plant Assembly and Ordering Drawing:	H569-416
Controller Assembly and Ordering Drawing:	J85501D-2
Rectifier Shelf Assembly and Ordering Drawing:	J85702B-1
Plant Wiring Diagram:	T-83171-31
Plant Schematic Diagram:	SD-83171-01
Rectifier Shelf Assembly Schematic Diagram:	SD-82668-01
Controller Schematic Diagram:	SD-82669-02
Plant Product Manual:	Select Code 167-790-055
Controller Product Manual:	Select Code 167-790-033

## **4**                      ***Installation***

### ***General***

As mentioned at the beginning of Section 3, Lucent Technologies offers complete engineering and installation service that result in turn-key plant operation. Contact your Lucent Technologies Energy Systems account executive for further information on the complete range of installation services available from Lucent Technologies. Customers may choose instead to make their own arrangements to fully or partially install the battery plant based on the information supplied here.

This section outlines an efficient sequence of battery plant installation steps that minimizes the installer's exposure to live circuits. A suggested test sequence is also provided to check the integrity of the installation effort. Upgrades, retrofits and replacement of equipment in the controller, rectifier and battery subsystems are covered in their respective manuals.

The framework, rectifier, controller and dc distribution subsystems, described in Section 2, are factory tested as a system. The controller and distribution subsystems are shipped assembled to the framework, ready for use. To improve shipping and handling, the rectifiers are packaged separately and must be plugged into their shelf assemblies during the plant installation process. The battery subsystem must also be assembled by the installer. The battery plant installation sequence that follows refers to the Rectifier, Controller and Battery manuals for details for those subsystems. Read this section and the referenced sections in other subsystem manuals completely before starting any work.

## ***Installation Tools And Test Equipment***

The following tools and test equipment are required for battery plant installation and testing.

- a. Equipment to handle shipping containers, remove framework from shipping containers, and erect framework into final position. Minimum lifting capacity: 450 lbs.
- b. Common electrician's hand tools.
- c. Proper crimping tools and dies for connectors used.
- d. Common mechanic's hand tools
- e. 3/4-inch drill to bore holes for floor anchors.
- f. DMM (Digital Multimeter) with at least 0.05% accuracy on the dc scale.
- g. DC Dummy Load Bank rated for 75 amperes minimum at 60 volts dc.
- h. For LVD/R option only: Power Supply, variable from zero to 60 volts dc at 2 amperes. Supply should have both coarse and fine output controls.
- i. For LVD/R option only: Six clip leads each capable of carrying 3 amperes.

## ***Suggested Installation Sequence***

### ***General Information***

1. The plant may be wired with ac from the left side or the right side. Typical routing of ac, dc and control cabling is shown on the plant assembly drawing, H569-416. Connection points and wire types are indicated on the plant wiring diagram, T-83171-31.
2. When running dc cable, care should be taken to ensure that all non-protected leads are run in a separate cable rack from protected leads. (Protected, in this sense, refers to overcurrent protection by a fuse or circuit-breaker.) Battery leads are usually the only unprotected leads. When Lucent Technologies VR Batteries are used, the battery leads may be protected. Refer to the Battery Manual for more detail on this option.

3. All dc leads should be separated wherever possible from ac leads to minimize electrical noise transmitted to the load.
4. Pair the battery potential lead with the associated return lead of a given circuit for as much of the run as possible.
5. All control leads and other small gauge wiring should be separated from the ac and dc power leads to prevent physical damage. (Routing of control leads within the controller is described in the Controller manual.)
6. All bolts making electrical connections should be torqued per the values in Table 4-A; all bolts for mechanical connections should be torqued per values in Table 4-B.

***Sequence of  
Tasks***

Table 4-C lists the drawings, manuals and other documentation that are necessary to complete the following Sequence of Tasks.

**Step A: Unpacking, Handling & Frame Installation:**

Before opening the packaging, carefully inspect the outside, in the presence of shipping personnel, for signs of damage. If damaged, follow the shipping carrier's procedure for filing a damage claim.

To ensure personnel safety and equipment protection use appropriate equipment during handling of crates and uncrated equipment. Use the equipment weights and dimensions, given in Section 2, as a guideline for choosing material handling tools. Move crated equipment to an area with adequate space and tools for unpacking and handling.

Carefully open the packaging to verify that the contents are complete and undamaged. If the equipment must be returned, it should be repacked in the original shipping crate.

Locate, shim and anchor the framework(s). Figure 4-2 shows typical floor mounting details for concrete floors. Other types of floor construction may require other mounting methods. Holes can be located using Figure 4-3. For multi-bay plants and for plants in aisle line-ups with compatible framework, frames may be tied together for extra rigidity. Three junction plates and screws are provided with each framework for this purpose. Assembly details for linking a multi-bay arrangement are included in the H569-416 drawing provided with the battery plant.

**Table 4-A: Minimum Torque For All Electrical Connections**

Screw Size	TORQUES - LB-IN OR (LB-FT)					
	Wire Connectors		Head Tightened		Nut Tightened	
	Slotted Machine	Hex or Socket Cap	Slotted Machine	Hex or Socket Cap	Slotted Machine or Hex Cap	Socket Cap
8-32	15	15	19	19	19	23
10-24	21	21	27	27	27	33
1/4-20	50	50	65	65	65	80
5/16-20	-	100	-	135	135	165
3/8-16	-	180	-	240	240	290
7/16-14	-	280	-	385	385	465
1/2-13	-	500	-	585	585	710
5/8 -11	-	(71)	-	(97)	(97)	(118)
3/4-10	-	(125)	-	(172)	(172)	(209)

Notes:

1. Slotted machine screws should be pan-head type.
2. Slotted machine and hex cap screws should be SAE Grade 2 steel or equivalent.
3. Socket cap screws should have 100,000 psi minimum tensile strength.
4. Steel flat washers should be furnished under heads of socket cap screws.
5. Ferrous screws and washers should have a corrosion protective finish.
6. Locking means is required only for connections subject to vibration. Belleville-type washers or jam nuts are the preferred means.
7. For less than 1/4 inch thick tapped copper bars, use No.8, No. 10, or 1/4 inch machine screws to minimize applicable torque. When larger size screws are required, provide captive-type steel nuts or reduce torque.
8. Torque recommendations are also suitable for all non-ferrous fasteners, except aluminum.
9. Where application permits, hex cap screws should be used.

**Table 4-B: Torque and Minimum Yield Strength for Mechanical Connections (Using Hex Head Cap Screws)**

Cap Screw Diameter	Grade 2	
	Minimum Yield Strength (PSI)	Torque (Ft-Lb) UNRC
1/4	57,000	5
3/16	57,000	12
3/8	57,000	22
7/16	57,000	35
1/2	57,000	54
9/16	57,000	77
5/8	57,000	107
3/4	57,000	190
7/8	36,000	193
1	36,000	290
1-1/8	36,000	410
1-1/4	36,000	580
1-3/8	36,000	760
1-1/2	36,000	1010

**Table 4-C: Installation Reference Documents**

Step	Procedure	Reference Document*
A	Unpacking, Handling and Frame Installation	H569-416 Drawing and Installation Template
C	Initial Battery Charge	Rectifier Manual
D	Cable Support and Ground System	Job Application Drawings
E	Controller Setup and LVD Test	Controller Manual
F	AC Wiring, Rectifier Installation and Rectifier Test	Rectifier Manual, H569-416 Drawing and T-82678-31 Drawing
G	Load Wiring	H569-416 Drawing and T-82678-31 Drawing
H	Battery Connections, Disconnect Installation and Test	J85500E-2 Drawing and T-82678-31 Drawing
I	Controller Test	Controller Manual

**Table 4-C: Installation Reference Documents**

<b>Step</b>	<b>Procedure</b>	<b>Reference Document*</b>
A	Unpacking, Handling and Frame Installation	H569-416 Drawing and Installation Template
J	Load Turn Up	Load Equipment Instructions
K	Converter Shelf Assembly Installation and Test	Converter Plant Manual

\* See Section 3 for Documentation References

**Step B: Battery Stand Assembly**

Assemble battery stands or shelves per the Lucent Technologies battery manual or other battery manufacturer's documentation. Install the batteries onto their stands.

**Warning**

Do not connect batteries to the system at this time.
--

**Step C: Initial Charge**

Batteries may undergo initial charging at this time, according to the manufacturer's recommendations. One of the rectifiers may be used for initial charging. Refer to the procedure given in the Rectifier manual.

**Step D: Cable Support and Ground System**

Hang all cable support systems, as well as any auxiliary ground bus bars, as dictated by the job application drawings.

**Step E: Controller and LVD Set-up**

Follow the controller set-up procedure given in the Controller manual to complete the steps below.

1. Enable/disable equalize charge set-up
2. Enable/disable rectifier restart set-up
3. Set HV shutdown level(s)
4. Set BD alarm level
5. Run office alarm wiring
6. Run other controller wiring
7. Set up other optional circuit packs

Check and set the low-voltage disconnect/reconnect, if provided, at the desired voltage level. See Figure 4-4 for the location of the disconnect voltage select jumpers, J505.1 and J505.2 on CP5 Fuse Board. Plug these jumpers across pins 1 and 2 of their respective connectors to provide a disconnect voltage of 42.5 +/-0.5 volts. To provide a disconnect voltage of +40.5 +/-0.5 volts, plug the jumpers across pins 2 and 3 of their respective connectors. Refer to the ECS controller manual for acceptance testing procedures for the CP5 circuit pack and the associated LVD/R option.

#### **Step F: AC Wiring, Rectifier Installation & Test**

Refer to the installation and start-up procedure in the Rectifier manual for the following steps.

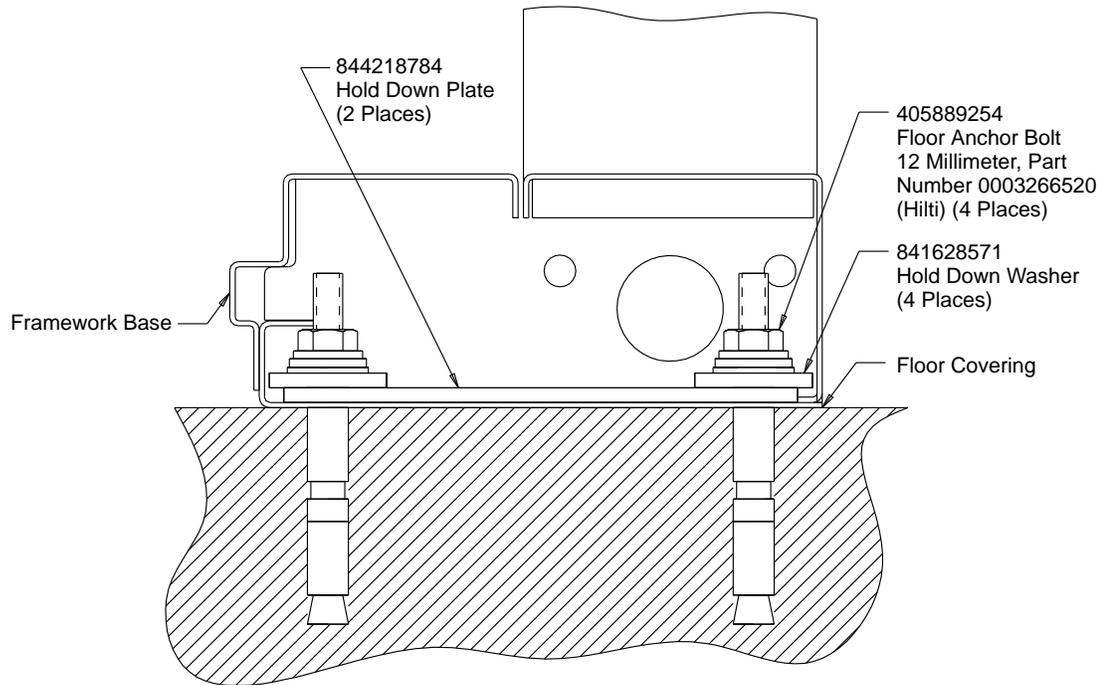
- Wire AC
- Set up
- Plug in
- Test

#### **Note**

It is recommended that ac be wired during the initial installation for all rectifier positions that may be used in the future. If ac is prewired in this way, growth in rectifier capacity is as simple as plugging in an additional rectifier.

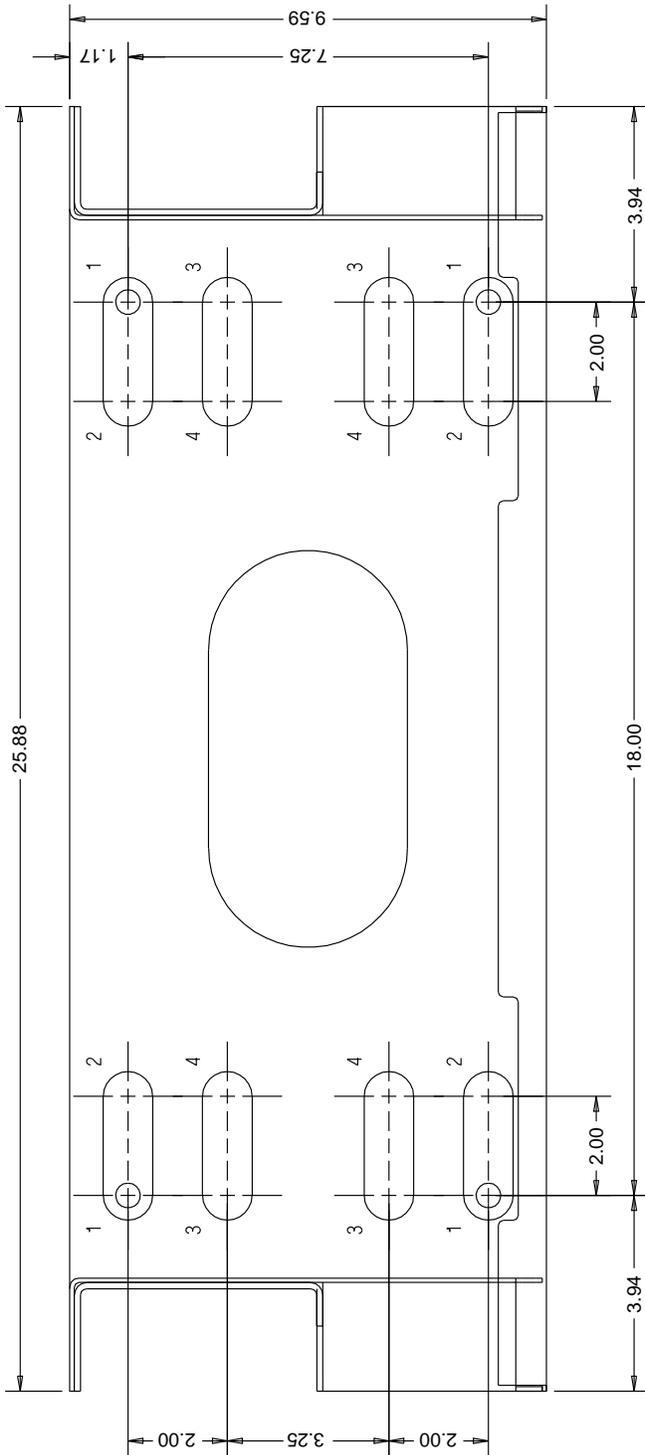
Before proceeding, verify that all rectifier output circuit breakers are in the OFF position.





Note: Use 3/4 Inch Drill for Floor Anchor Bolts.  
The Required Minimum Drill Depth is 4 Inches.

**Figure 4-2: Typical Floor Mounting Detail**



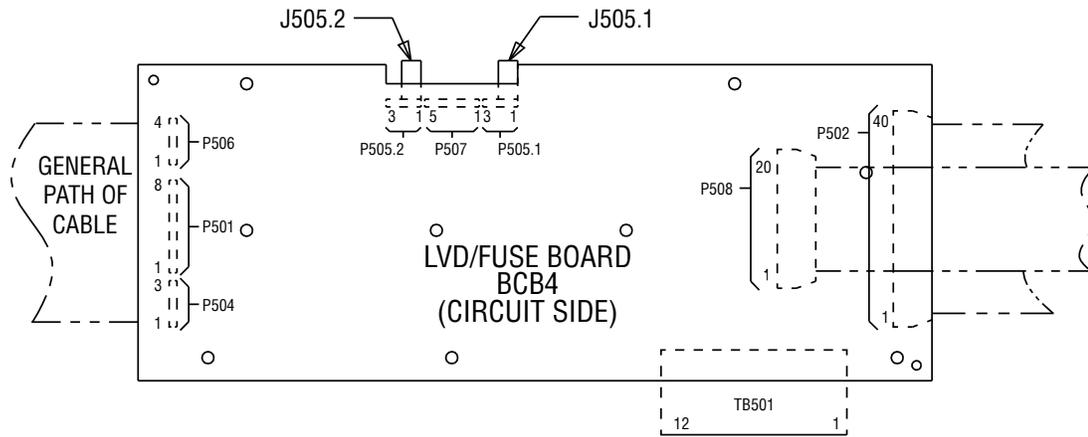
**Figure 4-3: Floor Mounting Template**

If interference with floor reinforcing bars occurs during installation of anchoring device at mounting position "1" (primary mounting position), then alternate locations "2", and "4" shall be selected as follows:

Location "2" - If interfering bar at "1" runs perpendicular to equipment lineup.

Location "3" - If interfering bar at "1" runs parallel to equipment lineup.

Location "4" - Permitted only if two reinforcing bars, running perpendicular and parallel respectively, cross at "1".



**Figure 4-4: LVD/Fuse Board (CP5) Jumper Locations**

### **Step G - Load Wiring:**

Open the dc distribution cover panel by turning the two 1/4 turn fasteners located on the front of the panel and remove the circuit breaker panel covers and discharge return cover.

#### **DANGER**

Verify that no voltage is present on the dc distribution bus bars and that all dc circuit breakers are off before connecting any load leads.
--

Run paired leads (supply and return) to each load from a dc distribution circuit breaker and from the discharge return bus. The load supply leads are terminated at the battery plant end on terminal blocks TB701 on the distribution printed wiring boards. The load return leads are terminated at the battery plant end on the discharge return bus, directly above the load supply lead termination. The termination points for the load leads are numbered 1 to 63, from left to right. Distribution breaker positions are also numbered 1 to 63, from left to right.

Cable sizes of 2 through 8 AWG may be terminated in the distribution with the use of a terminal adapter. This terminal adapter requires the use of two termination positions.

To install a circuit breaker, first verify that the circuit breaker is in the OFF position. Plug in the circuit breaker and visually verify that the line, load, and alarm connections are properly mated. (See Figure 2-7). Remove the knockout from the associated position on the cover. Mark the new circuit on the distribution cover label. Spare circuit breakers may or may not be provided with the dc distribution panel, as ordered. Spare circuit breakers may be stored in distribution panel if in the OFF position. Leads may be run to spare circuit breaker positions in anticipation of future growth (similarly to prewiring rectifier ac input in Step D, above).

Recommendations for routing and dressing of load leads as they leave the battery plant and enter the cable rack system are shown on the plant assembly drawing, H569-416. Consult the job application drawings for the routing of these leads to the load equipment. A label is provided on the dc distribution cover that may be marked to indicate each load breaker's use.

Before proceeding, verify that all load circuit breakers are in the OFF position.

## **Step H - Battery Connections, Disconnect Installation & Test:**

Remove all fuses from CP5 Fuse Board. Confirm that the output circuit breakers of all rectifiers and all distribution breakers are open.

### **DANGER**

The next step in this procedure will apply battery power to the battery plant. Before contacting any uninsulated conductor surfaces, always use a voltmeter to insure that no voltage, or the expected voltage, is present.

Interconnect the battery strings as instructed by the battery manual or other manufacturer's documentation.

### **Important**

Leave one intercell connection out so that there is an open circuit between the two terminals of each string before proceeding.

Run all cables from the battery and return bus bars to the battery strings by first connecting them to the bus bars in the dc distribution subsystem. For suggested cable routing within the dc distribution see the H569-416 drawing. Replace the dc distribution cover panel on the plant framework after all connections have been made at the plant bus bars.

Terminate the cables from the dc distribution at each battery string according to the manufacturer's documentation. Measure the resistance between the two ends of any battery string to verify that the circuit is open. Close the last remaining part of the battery circuit on each string (intercell connector).

Reinsert all fuses in CP5 Fuse Board. Match the fuse ratings and positions as indicated on the distribution cover panel.

### **Note**

The white indicators on F1 through F11 represent a 1-1/3 amp rating and the orange indicator on F12 represents a 2 amp rating.

### **Step I - Controller Test**

Follow the controller test procedure given in the ECS controller manual to complete the steps below.

1. Test Enable/disable equalize charge feature.
2. Test Enable/disable rectifier restart feature.
3. Test HV shutdown level(s).
4. Test BD alarm levels.
5. Test other optional circuit packs.

### **Step J - Load Turn-up:**

Turn on and adjust all rectifiers for normal operation according to the Rectifier manual.

#### **Warning**

Before applying power to any individual load, follow the powering up instructions as provided in the associated load equipment documentation.
---

Connect all loads, one at a time, by turning on the load circuit breakers. A circuit breaker may trip immediately due to inrush current when the plant is initially turned on. This does not necessarily indicate a fault condition. Attempt to close the circuit breaker a second time. If the breaker trips again, check the wiring to the load circuit.

### **Step K - Converter Shelf Assembly:**

Follow the Initial Start-up and Checkout procedure given in the ECS FPS DC/DC Converter Plant manual to complete the steps below:

1. Test PMJ and PMN alarms
2. Test MJF alarm
3. Test converters

## ***Installation Procedures For Plant Growth***

As your power needs evolve, equipment may be readily added to the battery plant to provide any of the following.

- expanded controller features
- additional rectifier capacity

- increased battery capacity
- additional load circuits

Procedures for adding controller features, rectifiers and batteries to an operating plant are described in the installation sections of the associated subsystem manuals. The procedure to add load circuits, since they are part of the dc distribution subsystem, is described below.

### ***Adding a Load Circuit***

#### **Warning**

Procedures in this section may cause power alarms to be issued temporarily. Notify the alarm reporting center before starting any installation procedure on an operating battery plant.

The following procedure provides the steps to add a new load circuit to an operating battery plant.

**Step A:** See Section 3 for details on sizing and obtaining additional circuit breakers.

**Step B:** Alarms may be issued during the installation process (e.g., by a new circuit breaker in the OFF position). Notify the alarm reporting center that alarms may be received.

**Step C:** Open the dc distribution cover panel, taking care not to disturb any load-carrying circuit breakers.

#### **DANGER**

Battery voltage is present behind the distribution cover panel. Remove all jewelry before working in this area. Use insulated tools only.

#### **Caution**

Accidentally or intentionally turning a circuit breaker off may affect service to load equipment. Take care not to disturb load-carrying circuits.

**Step D:** Locate the intended new breaker position. Spare circuit breakers may or may not already be in place on the dc distribution panel, as ordered. Alternatively, spare distribution leads may or may not have been run to the new load location.

- If a spare circuit breaker is already plugged in the next available position, verify that the breaker is OFF.
- If a new breaker must be added, switch it to the OFF position. Plug in the new breaker. If possible, visually verify that line, load and alarm connectors are properly mated. (See Figure 2-7).

### **DANGER**

Do not plug a closed circuit breaker into a circuit which may be connected. Arcing may result in personnel injury and equipment damage.

**Step E:** If leads have NOT already been run to the intended load from a spare circuit breaker position (e.g., during the initial plant installation), install these leads by following Installation Step G in paragraph “Sequence of Tasks” above.

**Step F:** Mark the new circuit on the distribution cover panel label.

**Step G:** For safety, close the dc distribution front cover before proceeding to the next step.

### **Warning**

Before applying power to any individual load, follow the powering up instructions as provided in the associated load equipment documentation.

**Step H:** Turn on the load circuit breaker. If the circuit breaker trips immediately when turned on, it may be due to inrush current and does not necessarily indicate a fault condition. Attempt to close the circuit breaker a second time. If the breaker trips again, check the wiring to the load circuit.

**Step I:** When all work on the dc distribution is complete, close the distribution cover and notify the alarm reporting center.

## 5 *Maintenance*

### *Controls and Indicators*

Operating controls and indicators on the battery plant are listed below.

#### *Controller and Rectifier*

Operating controls and indicators for the controller and rectifier include switches and LEDs described in the Product Manuals for these units.

#### *CP5 Fuse Board LEDs and Fuses*

Two LEDs on the CP5 Fuse Board are used to indicate the status of the low-voltage disconnect/reconnect circuit.

- The red “LVD OPEN” LED indicates that the disconnect/reconnect contactor is open and therefore that batteries are disconnected from the rest of the battery plant.
- The yellow “LVD FAIL” LED indicates that only one of the two redundant low-voltage detectors has directed the contactor to open and that the disconnect circuit may have failed.

Fuses F1 through F12 are also located on the CP5 LVD/Fuse Board and provide power for controller functions and rectifier regulation (see Figure 5-1). When a fuse blows the colored indicator (white or orange) pops up and an alarm signal is transmitted to the controller. The fault should be cleared before replacing a blown fuse. See paragraph “Troubleshooting” for details on replacing blown fuses.

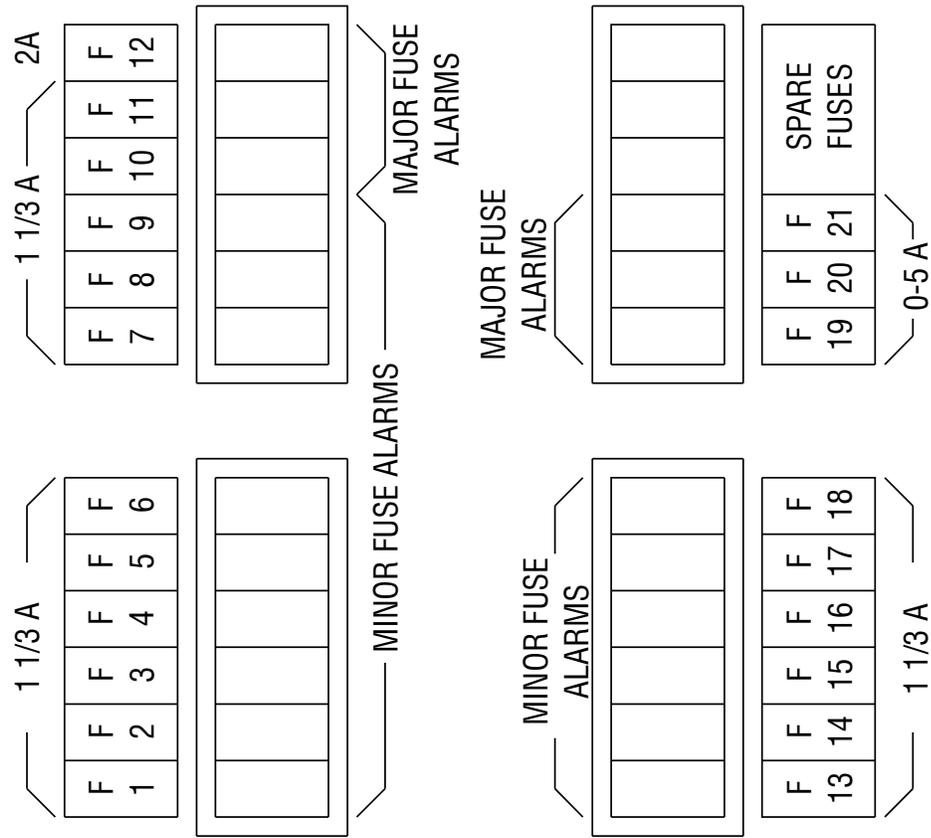
***DC Circuit  
Breakers***

Circuit breakers CB1 through CB63 are located in the dc distribution.

Any circuit breaker in the battery plant is ON (or closed) when the handle is in the Up position, and OFF (or open) in the Down position. A circuit breaker which is supplying a load may be turned off manually, but this may affect service to the load. If a breaker has tripped off, the overcurrent problem should be cleared before restoring power to the load by resetting the breaker. See paragraph "Troubleshooting" for information on tripped breakers.

***Troubleshooting***

Table 5-A provides a list of observable trouble conditions, their possible causes and the necessary corrective action for each cause. The table is organized by the subsystem in which the trouble is observed. Trouble indicated by the office alarm system is covered in the Table 5-A under the Controller subsystem.



FUSE DESIGNATIONS	
F1	REG LEAD RECTIFIER 1
F2	REG LEAD RECTIFIER 2
F3	REG LEAD RECTIFIER 3
F4	REG LEAD RECTIFIER 4
F5	REG LEAD RECTIFIER 5
F6	REG LEAD RECTIFIER 6
F7	113B METER
F8	CP2 AND CP3
F9	CP1 RECTIFIER INTERFACE POWER
F10	RECTIFIER CP1 INTERFACE POWER
F11	ALARM BATTERY SUPPLY
F12	CP1
F13	REG LEAD RECTIFIER 7
F14	REG LEAD RECTIFIER 8
F15	REG LEAD RECTIFIER 9
F16	REG LEAD RECTIFIER 10
F17	REG LEAD RECTIFIER 11
F18	REG LEAD RECTIFIER 12
F19	LOW POWER DISTRIBUTION
F20	LOW POWER DISTRIBUTION
F21	LOW POWER DISTRIBUTION

Figure 5-1: Fuse Designation and Function for LVD/Fuse Board (CP5)

**Table 5-A: Troubleshooting**

Observed Condition	Probable Cause	Procedure #
<b>Controller</b>		
Red or yellow LEDs lit No LEDs or Display lit Meter inaccuracy Office alarms issued False alarms issued Blown fuse on LVD/Fuse board	See "Troubleshooting" in Controller Manual	
<b>Rectifier</b>		
Red or yellow LEDs lit No LEDs or Display lit No output/low output Oscillation Open output breaker	See "Troubleshooting" in Rectifier Manual	
<b>DC Distribution Subsystem</b>		
Open distribution breaker	a. manually turned off b. overcurrent trip c. breaker failure	Open Distribution Breaker
"LVD OPEN" LED lit	a. failed LVD contactor b. low voltage c. faulty wiring d. LVD circuit failure	Red "LVD OPEN" LED Lit
"LVD FAIL" LED lit	a. low voltage b. LVD circuit failure	Yellow "LVD FAIL" LED Lit

***Open  
Distribution  
Breaker***

A distribution breaker which should be closed may be in the open position for one of three reasons:

1. A distribution breaker may have been inadvertently turned off manually. If this is the case, follow the proper procedure to restore power to the load equipment. If a distribution breaker is no longer needed, it may be unplugged from the panel or left in the OFF position.
2. A distribution breaker may trip due to a short circuit in the load equipment or wiring. The fault must be cleared before resetting the breaker, except when the trip is suspected to be caused by inrush current during equipment start up.

3. A circuit breaker may fail such that it cannot be reset. Replace a failed distribution breaker per procedure “Load Circuit Breaker Replacement” below.

***Red “LVD OPEN” LED Lit***

The Red “LVD OPEN” LED indicates that the LVD Contactor is de-energized, i.e., open. The contactor may be open due to one of four reasons:

1. Plant voltage is below the disconnect threshold.
2. The contactor has failed and must be replaced. See procedure “LVD/R Contactor Replacement” below.
3. There is an open circuit in the wiring that powers the contactor. Check the cable assembly from CP5 to the contactor.
4. Both redundant LVD sensing circuits have failed. The CP5 circuit pack must be replaced per procedure “LVD/Fuse Board (CP5) Replacement” below.

***Yellow “LVD FAIL” LED Lit***

The Yellow “LVD FAIL” LED indicates that one or both of the LVD circuits has attempted to open the contactor, but the contactor is closed. This may occur in two situations:

1. The plant voltage is right at the disconnect level and is within tolerances of the redundant detector circuits, but only one detector has operated. No action is required.
2. The LVD circuit has partially failed. Replace the CP5 circuit pack per procedure “LVD/Fuse Board (CP5) Replacement” below.

***Blown Fuse on CP5***

Refer to ECS controller manual for troubleshooting procedures.

**Note**

Replace with fuse of same rating only.

***Repair and Replacement***

**Note**

Procedures in this section may cause power alarms to be issued temporarily. Notify the alarm reporting center before starting any repair procedure.

**Load Circuit  
Breaker  
Replacement**

**Step A:** Obtain a replacement circuit breaker. See Section 5.4, Spare Parts.

**Step B:** Verify that the faulty breaker is in the OFF position.

**Step C:** Loosen the 1/4 turn fasteners and open the dc distribution cover.

**Step D:** Measure the voltage on terminal block TB701 at the load connection associated with the faulty breaker, to verify that the breaker is truly open. The voltage on TB701 relative to the battery bus bars or circuit breaker bus bar should be approximately the float voltage of the plant.

If the faulty breaker is, in fact, still closed, the load equipment which it powers must be shut down so that no current flows through the breaker.

**DANGER**

Do not attempt to unplug a circuit breaker which may be carrying current. Arcing may result in personnel injury and equipment damage.

**Step E:** Unplug the faulty breaker from the printed wiring board.

**Step F:** Switch the new circuit breaker to the OFF position before plugging it in.

**Step G:** Plug in the new breaker, ensuring that line, load and alarm connectors are properly mated. (See Figure 2.7)

**Step H:** Remove the knockout from the associated position on the cover panel.

**Step I:** For safety, close the dc distribution door before proceeding to the next step.

**Warning**

Before applying power to any individual load, follow the powering up instructions as provided in the associated load equipment documentation.

**Step J:** Turn on the load circuit breaker. If the circuit breaker trips immediately when turned on, this may be due to inrush current and does not necessarily indicate a fault condition. Attempt to close the circuit breaker a second time. If the breaker trips again, check the wiring to the load circuit.

**Step K:** Note that Fuse Alarm Major (MJF) and its associated alarms retire.

**Step L:** When all work on the dc distribution is complete, refasten the cover panel.

***LVD/R  
Contactor  
Replacement***

The following assumptions are made:

- contactor coil has failed
- THE CONTACTOR IS OPEN
- the rectifiers are carrying the load (off battery) with excess capacity available for charging the batteries.
- battery string(s) are at a voltage below the rectifier voltage in a state of partial or complete discharge.
- LVD OPEN LED is lit on the distribution front panel.

The following equipment is required:

- socket wrench with insulated handle
- 1/2 inch socket

Procedure: (Refer to Figure 2-4 and T-83171-31 drawing)

**Warning**

Procedures in this section may cause power alarms to be issued temporarily. Notify the alarm reporting center before starting any replacement procedure on an operating plant.

1. Open distribution panel and remove front cover.
2. Unplug connector P501 from J501 on LVD/Fuse board (CP5).
3. Disconnect and label the five quick connects from the contactor coil and auxiliary switch.
4. Unbolt and remove contactor.

5. Reconnect quick connect leads to new contactor and then mount new contactor using hardware from Step 4.
6. Plug P501 into J501 on LVD/Fuse board (CP5) and verify that contactor closes.
7. Replace covers, close distribution door and verify that “LVD FAIL” and “LVD OPEN” lights are not lit.

***LVD/Fuse Board  
(CP5)  
Replacement***

**Warning**

Procedures in this section may cause power alarms to be issued temporarily. Notify the alarm reporting center before starting any replacement procedure on an operating plant.
--

The following equipment is required:

- standard screwdriver

Procedure: (Refer to Figure 4-3 and T-83171-31 drawing)

1. Open distribution panel.
2. Unplug the following connectors from the LVD/Fuse Board (CP5). Leave the cables dressed.
  - P502 from J502
  - P506 from J506
  - P501 from J501
  - P504 from J504
  - TB501 from J501
3. Remove the 5 mounting screws.
4. Unplug P508 from J508 connector. Leave the cable dressed.
5. Set jumpers J505.1 and J505.2 on replacement LVD/Fuse Board (CP5) per H569-416 drawing for desired disconnect voltage.
6. Reconnect P508 and J508 connector.
7. Mount the replacement board to the distribution panel using the hardware from Step 3.
8. Reconnect the following connectors:
  - P502 to J502

- P506 to J506
  - P501 to J501
  - P504 to J504
  - TB501 to J501
9. Close distribution door.

## ***Spare Parts***

The following equipment may be ordered as spare parts. For exact ordering codes, refer to recommended spares information on the H569-416 drawing.

Rectifiers and fans

LVD/Fuse Board (CP5)

Fuses (F1 to F18)

Load Circuit Breakers (CB1 to CB63)

Controller Circuit Packs (e.g., 113B/CU)

(Refer to the Controller manual for details on spare controller circuit packs.)

In addition to these items, any piece part may be ordered that is identified in the assembly views and stocklist on the H569-416 drawing. When ordering, please specify the Description and Comcode as shown in the stocklist.

## 6 *Product Warranty*

### A. Seller warrants to Customer only, that:

1. As of the date title to Products passes, Seller will have the right to sell, transfer, and assign such Products and the title conveyed by Seller shall be good;
2. Upon shipment, Seller's Manufactured Products will be free from defects in material and workmanship, and will conform to Seller's specifications or any other agreed-upon specification referenced in the order for such Product;
3. With respect to Vendor items, Seller, to the extent permitted, does hereby assign to Customer the warranties given to Seller by its Vendor of such Vendor Items, such assignment to be effective upon Customer's acceptance of such Vendor Items. With respect to Vendor items recommended by Seller in its specifications for which the Vendor's warranty cannot be assigned to Customer, or if assigned, less than Sixty (60) days remain of the Vendor's warranty or warranty period when the Vendor's items are shipped to Customer or when Seller submits its notice of completion of installation if installed by Seller, Seller warrants that such Vendor's items will be free from defects in material and workmanship on the date of shipment to Customer. In such an event, the applicable Warranty Period will be sixty (60) days.

- B. The Warranty Period listed below is applicable to Seller's Manufactured Products furnished pursuant to this Agreement, unless otherwise stated:

**Warranty Period**

Product Type	New Product	Repaired Product or Part*
Central Office Power Equipment**	24 Months	6 Months
* The Warranty Period for a repaired Product or part thereof is as listed or, in the case of Products under Warranty, is the period listed or the unexpired term of the new Product Warranty Period, whichever is longer.		
** The Warranty Period for Products ordered for Use in Systems or equipment Manufactured by and furnished by Seller is that of the initial Systems or equipment.		

- C. If, under normal and proper use during the applicable Warranty Period, a defect or nonconformity is identified in a Product and Customer notifies Seller in writing of such defect or nonconformity promptly after Customer discovers such defect or nonconformity, and follows Seller's instructions regarding return of defective or nonconforming Products, Seller shall, at its option attempt first to repair or replace such Product without charge at its facility or, if not feasible, provide a refund or credit based on the original purchase price and installation charges if installed by Seller. Where Seller has elected to repair a Seller's Manufactured Product (other than Cable and Wire Products) which has been installed by Seller and Seller ascertains that the Product is not readily returnable for repair, Seller will repair the Product at Customer's site.

With respect to Cable and Wire Products manufactured by Seller which Seller elects to repair but which are not readily returnable for repair, whether or not installed by Seller, Seller at its option, may repair the cable and Wire Products at Customer's site.

- D. If Seller has elected to repair or replace a defective Product, Customer shall have the option of removing and reinstalling or having Seller remove and reinstall the defective or nonconforming Product. The cost of the removal and the reinstallation shall be borne by Customer. With respect to Cable and Wire Products, Customer has the further

responsibility, at its expense, to make the Cable and Wire Products accessible for repair or replacement and to restore the site. Products returned for repair or replacement will be accepted by Seller only in accordance with its instructions and procedures for such returns. The transportation expense associated with returning such Product to Seller shall be borne by Customer. Seller shall pay the cost of transportation of the repair or replacing Product to the destination designated by Customer within the Territory.

- E. The defective or nonconforming Products or parts which are replaced shall become Seller's property.
- F. If Seller determines that a Product for which warranty service is claimed is not defective or nonconforming, Customer shall pay Seller all costs of handling, inspecting, testing, and transportation and, if applicable, traveling and related expenses.
- G. Seller makes no warranty with respect to defective conditions or nonconformities resulting from actions of anyone other than Seller or its subcontractors, caused by any of the following: modifications, misuse, neglect, accident, or abuse; improper wiring, repairing, splicing, alteration, installation, storage, or maintenance; use in a manner not in accordance with Seller's or Vendor's specifications or operating instructions, or failure of Customer to apply previously applicable Seller modifications and corrections. In addition, Seller makes no warranty with respect to Products which have had their serial numbers or month and year of manufacture removed, altered, or with respect to expendable items, including, without limitation, fuses, light bulbs, motor brushes, and the like.
- H. THE FOREGOING WARRANTIES ARE EXCLUSIVE AND ARE IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. CUSTOMER'S SOLE AND EXCLUSIVE REMEDY SHALL BE SELLER'S OBLIGATION TO REPAIR, REPLACE, CREDIT, OR REFUND AS SET FORTH ABOVE IN THIS WARRANTY.

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