Lucent Technologies
Bell Labs Innovations

Lineage® 2000
600A, -48V Battery Plant
J85500G-2

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1 Introduction

General Information

Thank you for making the Right Choice, a Lucent Technologies Lineage® 2000 Energy Systems product. The Lineage® 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 over 80 years of worldwide telecommunications experience in the development, manufacturing, engineering, installation and servicing of leading edge energy systems, products and services.

The ECS Battery Plant, J85500G-2, is shown in Figure 1-1a. This member of the ECS family of battery plants operates from a nominal 208/240 volt ac, 50/60 Hz source. It offers a 600-ampere total plant capacity with a nominal 48 volt dc output in a totally integrated energy system.

The basic plant consists of charge and discharge bus bars with optional low voltage disconnect, provision for breaker and fuse panels, an ECS or Galaxy controller and space for four rectifier shelf assemblies which can connect up to twelve -48-volt, 50-ampere switch mode rectifiers.

The plant's modular design facilitates installation and growth. Growth in plant output current capacity is achieved by adding Lineage® 2000 50-ampere, 48-volt rectifiers to rectifier shelf assemblies. Two optional circuit packs are available for the basic ECS controller, one to add microprocessor-based features and the second to add a datalogger. A host of optional circuit packs are available for the Galaxy controller. The ECS controller requires only front access to the plant. The Galaxy controller requires both front and rear access.

The ECS battery plant is compatible with virtually all flooded and valve-regulated batteries which float within the range of 47 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 uninterrupted power supply (UPS).

Documentation

This document (Lucent Technologies 167-790-035) is part of a set of product manuals which provide information on the Lineage® 2000 Evolutionary Control System (ECS) Battery Plant and its components. 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.

Customer Training

Lucent Technologies offers customer training on many power products. For information call 1-972-284-2163. This number is answered from 8:00 a.m. until 4:30 p.m., Central Time Zone (Zone 6), Monday through Friday.

Customer Service

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-THE-1PWR (1-800-843-1797). Services provided through this contact include initiating the spare parts procurement process for out of service emergencies, ordering Lucent Technologies documents, and providing other product and service information.

For other customers worldwide, call 001-972-840-0382. This number is answered from 8:00 a.m. until 4:30 p.m., Central Time Zone (Zone 6), Monday through Friday.

Technical Support

Technical support for Lucent Technologies customers is available around the world during the normal product warranty period and also while specific contractual agreements extend this service.

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-CAL-RTAC (1-800-225-7822) to contact a product specialist to answer your technical questions and assist in troubleshooting problems.

For other customers worldwide, contact your local field support center or your sales representative to discuss your specific needs.

Product Repair and Return

Repair and return service is provided for Lucent Technologies customers around the world. For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-255-1402 for information on returning of products for repair.

For other customers worldwide, contact your sales representative to discuss your particular circumstances.

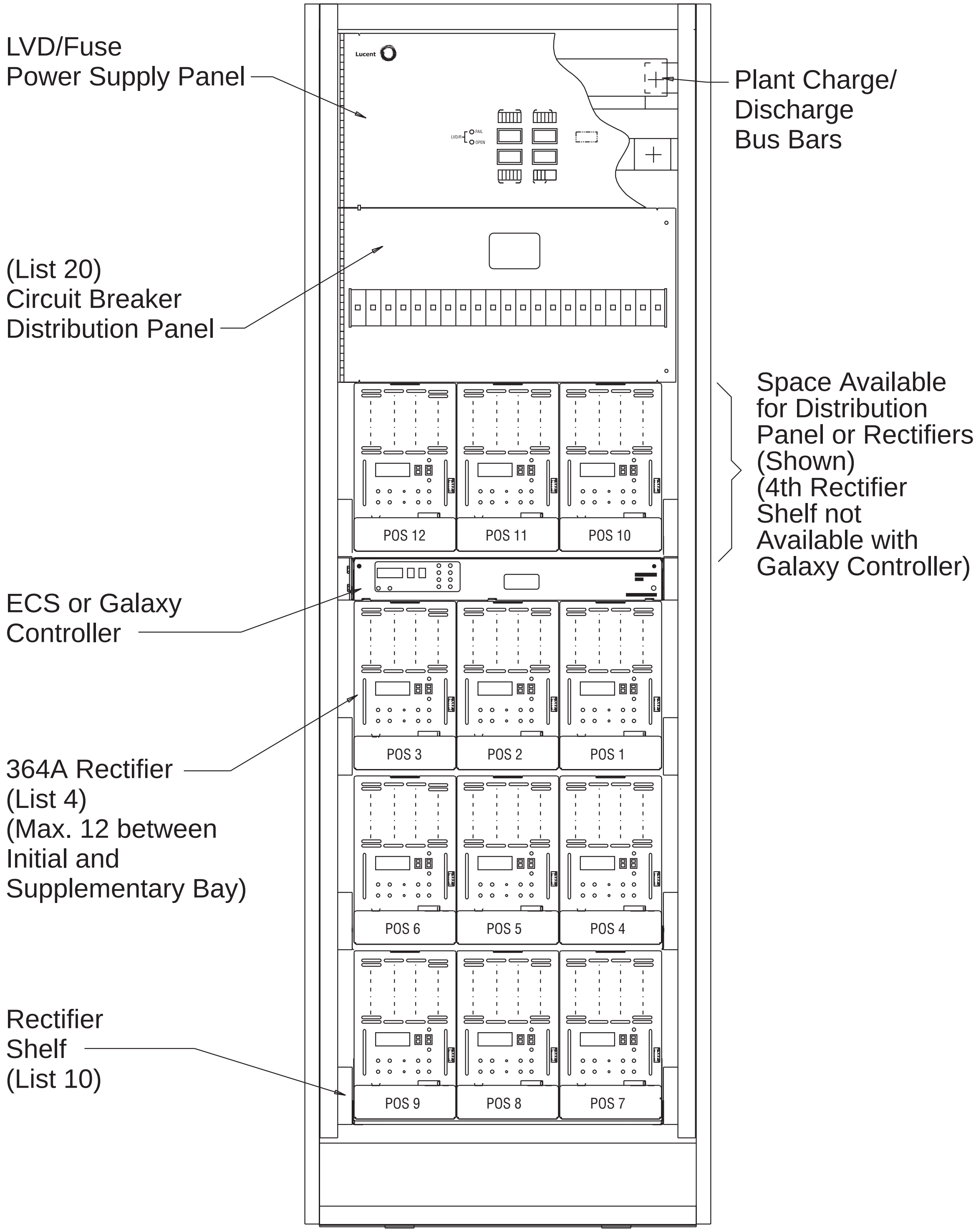


Figure 1-1a: Lineage® 2000 ECS/GPS Battery Plant (Model J85500G-2, Initial Bay)

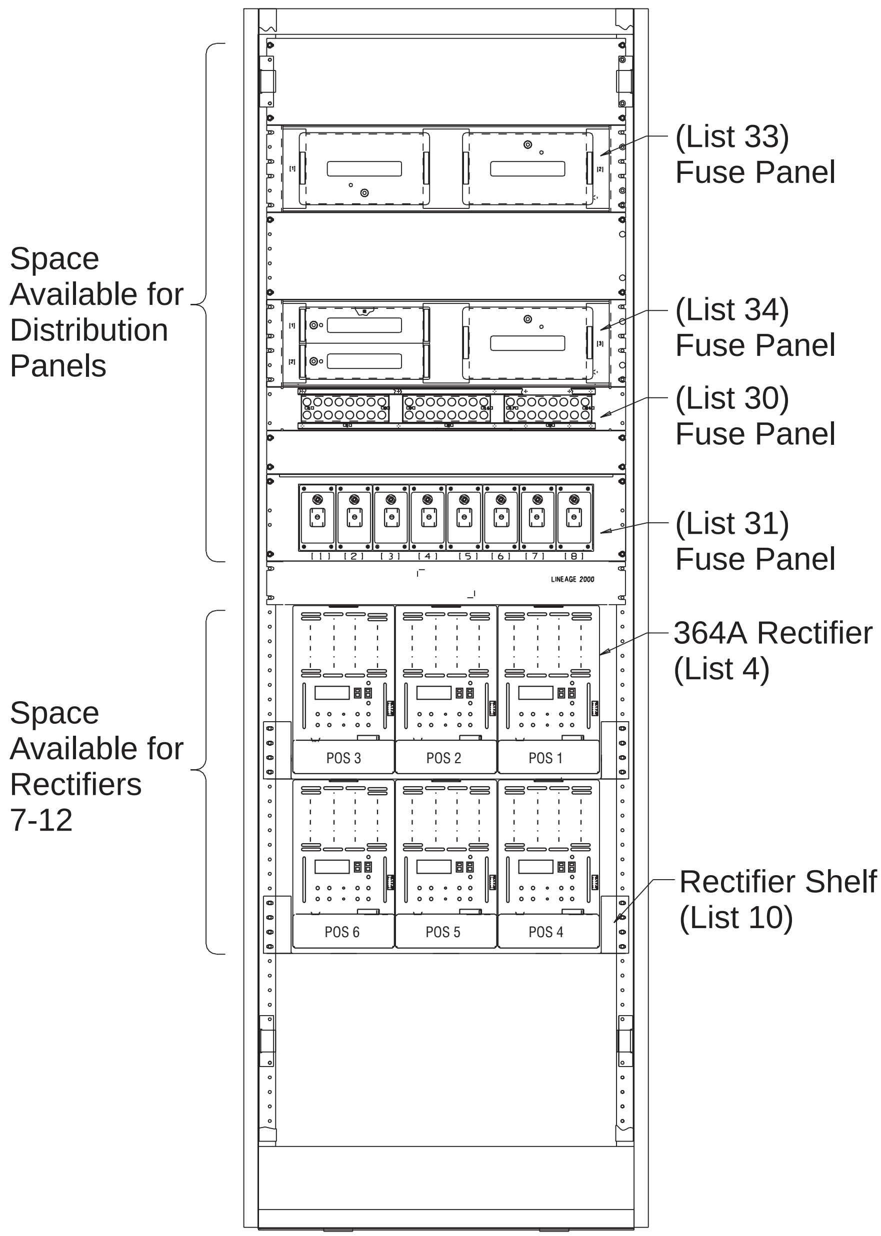


Figure 1-1b: Lineage® 2000 ECS/GPS Battery Plant (Model J85500G-2, Supplementary Bay)

2 Product Description

Plant Specifications

Table 2-A: Lineage® 2000 Battery Plant Specifications (Model J85500G-2)

Input Voltage	180-264 volts ac, single phase (208/220/240 volts ac nominal)
Input Frequency	47-63 Hertz (50/60 Hertz nominal)
Operating Voltage	40-60 volts dc (48 volts nominal)
Float Voltage	47-58.5 volts dc (48 volts dc nominal)
Plant Current Rating	600 amperes
Plant Shunt	600 amperes maximum at 50 millivolts
LVD/R Voltage Settings	40.5 or 42.5 volts dc
Controller:	ECS Basic: 113B Microprocessor option circuit pack: CP2 Datalogger option circuit pack: CP3 or Galaxy basic: 48V rectifier control
Rectifier Shelf Assembly	4 maximum, each mounts 3 rectifiers
Rectifiers	Type: Lineage® 2000 SR50/-48V Rating: -48 volts nominal, 50 amperes 12 maximum
Circuit Breakers	Type: KS22010, KS22012 Available ratings: 5, 10, 20, 30, 45, 60, 80, 100, 125, 175, 225, 300, 400, 500, 600 amperes
Fuses	Type: 74, KS-19870, cartridge, NON Available ratings: 1-200 amperes
Temperature	32-122 degrees Fahrenheit (0-50 degrees Celsius)

Table 2-A: Lineage® 2000 Battery Plant Specifications (Model J85500G-2)

Altitude	-200 to 13000 feet (-61 to 3962 meters) For altitudes of 5000 to 13,000 feet, derate maximum temperature by 3.6 degrees Fahrenheit per 1000 feet above 5000 feet. For altitudes of 1524 to 3962 meters, derate maximum temperature by 0.656 degrees Celsius per 100 feet above 1524 meters.
Framework	Type: 7 foot Central Office Framework (standard 26 inch width) Vertical mounting centers: 1.00 inches (25 mm) Horizontal mounting centers: 24.32 inches (618 mm)
Dimensions	Height: 84 inches (2134 mm) Width: 26 inches (660 mm) Depth: 18.5 inches (470 mm)
Weight	Initial bay (includes 12 rectifiers): 600 pounds (272 kilograms) Supplementary Bay (includes 6 rectifiers): 350 pounds (159 kilograms) Battery Supplementary Bay: Equipped with 1 string VR batteries: 2100 pounds (953 kilograms) Equipped with 2 strings VR batteries: 4100 pounds (1860 kilograms)
Earthquake	Initial bay: Zone 4, upper floors Bays equipped with VR batteries: See Earthquake Bracing, Section 3
Heat Dissipation	Full load: 5750 watts (19,602 BTU/hr)(Note 1) Half load: 2888 watts (9845 BTU/hr) Rectifier, full load: 475 watts (1619 BTU/hr) ECS Controller, basic and options: 26 watts (89 BTU/hr) Galaxy, with options: 100 watts
Humidity rating	10% to 95% noncondensing
Audible noise	65 dBa (Note 2)
Electrostatic discharge	IEC 801-2 Level 5 (15 KV) at 40% relative humidity
Electromagnetic immunity	10V/m over the range of 20 to 2000MHz
Note 1: Specified at 54 volts dc, 600 amperes output, and nominal input voltages and frequencies.	
Note 2: Measured at 2 feet (6 meters) from the rectifiers installed in plant (six rectifiers in initial bay).	

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 specific period of time. In normal practice, battery capacity is sized to provide three to eight hours of reserve time.

Battery Plant Subsystems

Figure 2-2 illustrates the arrangement and interconnections of the typical ECS 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.

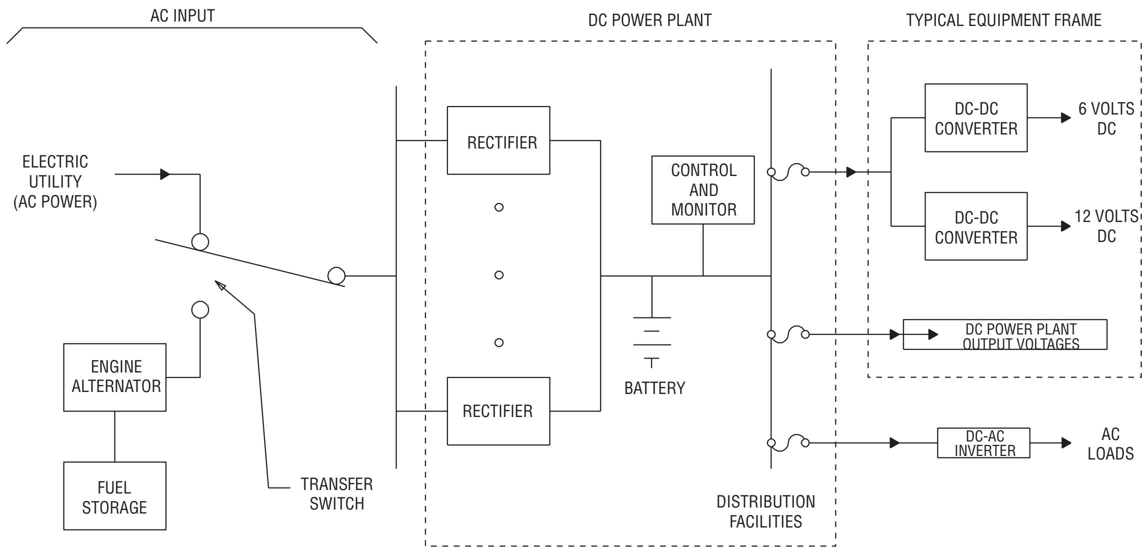


Figure 2-1: Block diagram of typical battery plant

ECS Battery Plant Physical Description

The Lineage® 2000 Evolutionary Control System (ECS) Battery Plant Model J85500G-2 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 virtually all flooded and valve regulated batteries. 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 uses state-of-the-art technology to achieve dramatic equipment size and weight reduction and to minimize maintenance. These advantages are realized by the application of Switch-Mode Rectifier (SR) and Valve-Regulated (VR) battery technologies and a unique plug-in rectifier design.

The ECS battery plant is designed as a totally integrated energy system package. It is a compact and complete system containing a controller, rectifiers, circuit breaker and/or fuse distribution panels, automatic battery disconnect/reconnect (LVD/R) feature, optional thermal slope/step compensation feature and capacitor charge panel which can all be configured in one standard equipment bay. Supplementary bays are available for additional dc output or distribution capability. The plant is a modular front-access design for ease of installation, growth and maintenance. This power system is ideal for use in confined areas and allows efficient use of valuable floor space.

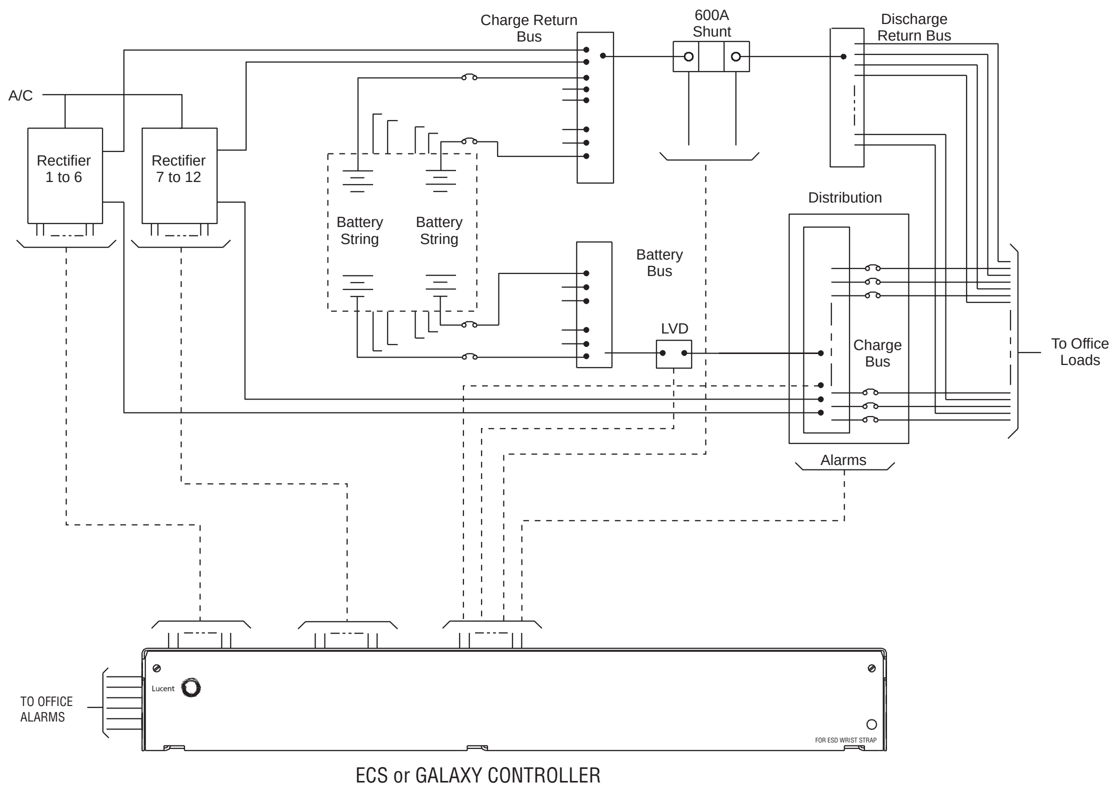


Figure 2-2: ECS/GPS Battery Plant block diagram

Initial Bay

The initial bay will accommodate up to twelve Lineage® 2000 SR Series -48 volt, 50 ampere rectifiers, an ECS or Galaxy controller, distribution panels accepting breakers and/or fuses from 5-600 amperes and 1-200 amperes, respectively, a low voltage battery disconnect/reconnect feature, optional thermal slope/step compensation feature and one capacitor charge panel for the circuit breakers. When the plant is equipped with a Galaxy Controller, the initial bay will accommodate up to nine rectifiers along with the other components listed above. Stile strips and end covers are optional appearance kits.

Supplementary Bays

If additional dc output or additional dc distribution panels are required, a supplementary bay is available which can house up to six rectifiers and has 36 inches of space for distribution panels. (A maximum of 12 rectifiers, included in both the initial and supplementary bays, may be used in this plant.)

If battery reserve is required, battery supplementary bays are available which can each house up to two -48 volt strings of Lineage® 2000 VR Series 375 ampere-hour batteries. A maximum of three supplementary bays or a total of six strings of VR batteries can be added to the ECS battery plant providing a total battery capacity of 2268 ampere-hours.

ECS Battery Plant Subsystems

Figure 2-2 illustrates the arrangement and interconnections of the ECS Battery Plant subsystems from the ac input to the dc output. These subsystems are described below:

Rectifier

The Lineage® 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® 2000 SR Series 50 ampere rectifiers operate over 208/220/240 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 basic ECS plant is equipped with two rectifier shelf assemblies for a total capacity of six SR Series 50 ampere rectifiers. Additional shelf assemblies and rectifiers are orderable as separate list numbers. (See the Lineage® 2000 SR Series rectifier product manual for additional information on the shelf and rectifier.)

Batteries

The ECS battery plant is compatible with virtually all flooded and valve regulated batteries. The Lineage® 2000 VR Series battery is designed specifically for use in the ECS battery plant. 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.

The Lineage® 2000 VR Series battery is a valve regulated design incorporating many of the same technologically advanced features as the highly acclaimed Lineage® 2000 Round Cell battery. It is a compact, totally front access, modular battery based on a unit cell architecture. The VR Series battery is currently available in a 2 volt, 375 or 250 ampere-hour configuration for use in the ECS plant. The compact physical dimensions of the VR battery permit the installation of up to 750 ampere-hours of 48 volt battery reserve in a single framework space. (See the Lineage® 2000 VR Series battery product manual for additional information.) For systems requiring higher capacities and/or longer reserve times, the Lineage® 2000 Round Cell Series of batteries is appropriate.

Controller

The ECS or Galaxy controller performs the centralized monitoring, control and reporting functions for the ECS battery plant.

ECS Controller

The basic ECS controller can monitor and control up to twelve 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. This board is available as List 5 or 7 on J85500G-2. List 7 is the same as List 5, with the addition of a voice response feature. 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. This board is available as List 8 or 9 on J85500G-2. List 9 is the same as List 8, with the addition of a remote termination panel allowing external connection to the board from outside the controller. (See the ECS controller manual for further information.)

Galaxy Controller

Basic Controller:

The **basic controller** provides the basic local control and monitoring functions for the battery plant. User access is by front-panel controls and display. It provides key battery plant alarms, high voltage shutdown, and plant voltage and current monitoring. The front panel includes an eight line, 40 character display, LEDs, switches and jacks.

Galaxy's basic controller section includes up to three rectifier interface boards, each handling signals from as many as eight rectifiers. Separate rectifier interface boards are needed to work with Lucent Technologies ferroresonant or switch mode rectifiers, or rectifiers manufactured by others.

Intelligent controller:

The **intelligent controller** adds many intelligent control and monitoring features:

Plant features, including plant alarms and histories, load statistics, auto boost

Rectifier features, including sequencing, energy efficiency algorithm, remote rectifier on/standby, rectifier event histories

Battery prediction, an option that predicts reserve time for batteries made by Lucent Technologies

Data Switch, an optional interface with RS-232 devices such as Lucent Technologies' XCS, ECS, RAS, and OMNIpulse units. Data Switch permits a single phone line to access four separate units in addition to the Galaxy Controller.

System features, including password security, dial-out on alarm, back up and restoration of configuration, serial system upgrade. Three password security levels are provided: User, with read-only privileges; Super-User, read/write privileges except for passwords, and Administrator, read/write including password setting and software updates. The system also provides a warning if passwords have been left at their factory default settings.

Local and remote user access to intelligent features, including the enhanced front panel display, giving access to some of the intelligent features; dial-up by modem and an RS-232 local port for a personal computer or terminal using ANSI T1.317 object oriented command language. The Galaxy also provides access for computer-to-computer interaction via an RS-485/232 port, using TL1 communications protocol.

Remote peripheral monitoring using an optional circuit pack and remote peripheral modules (J85501G1) provides two-way signaling and power for optional peripherals. Presently available are modules for dc voltage, shunt, or temperature monitoring.

DC Distribution

The ECS J85500G-2 distribution includes the plant charge and discharge bus bars, plant shunt, LVD/R contactor and associated circuitry. Space below these items can accommodate circuit breaker and fuse panels with ratings of 5-600 amperes and 1-200 amperes, respectively. A supplementary bay is also orderable and can accommodate these panels. A complete discussion of the ECS dc distribution is presented in the following section of this manual.

ECS DC Distribution Panel

Both circuit breaker and fuse protected distribution panels are available with the ECS Battery Plant. They are orderable via list numbers from J85500G-2 and can be configured in the initial List 1 or 2 bay or optional List 3 supplementary bay. The panels are shown in Figures 2-4 through 2-9. See Figures 2-3a and 2-3b for allowed distribution combinations in the inital and supplementary bays. See Table 2-B for available breaker and fuse panels and see Section 3 for fuse and circuit breaker sizing information. An alarm connection is provided on each panel to indicate an open fuse or tripped circuit breaker. The alarms for all distribution panels in a plant are paralleled and transmitted to the ECS Controller as a Major Fuse Alarm, MJF (FAJ).

Table 2-B: ECS/GPS Battery Plant Breaker and Fuse Panels

List Number	Distribution Type	Maximum Number of Fuses/Breakers	Size (Amps)	Ordering Information
20	Breaker*	17 or 21	5-100	Table 2-D
		1 to 4	125-600	
30	Fuse	24	1-30	Table 2-E
31	Fuse	8	1-60	Tab;e 2-F
32	Fuse	4	70-100	Table 2-G
33	Fuse	2	110-200	Table 2-H
34	Fuse	3	70-200	Table 2-J
35	Fuse	2	70-600	Table 2-K
36	Fuse	19	3-60	Table 2-L

*An optional capacitor charge feature/panel is available with List 20 and occupies 4 slots on the breaker panel.

Termination points: Termination information for load leads for each distribution panel is listed in Table 2-C.

Table 2-C: Load Lead Termination Points

J85500G-2 List	*Maximum Wire Size	**Output Terminal Information	
		# of Holes	Hardware
20	1 or 2 pole: 4/0 3 pole: 350 MCM	1	.375-16
30	8	1	10-32
31	4	1	.250-20
32	4/0	1	.375-16
33	4/0	1	.375-16
34	4/0	1	.375-16
35	4/0	1	.375-16
36	4/0	1	.375-16

* For larger gauge, install parallel connectors (KS-21500 or equal) outside bay.
** For corresponding Terminal Lugs, refer to Table 3-D and 3-E.

All the load lead termination points can be accessed from the front by removing the associated blank panel located above or below each fuse panel. The corresponding return for each load lead is terminated to the Plant Discharge RTN Bus.

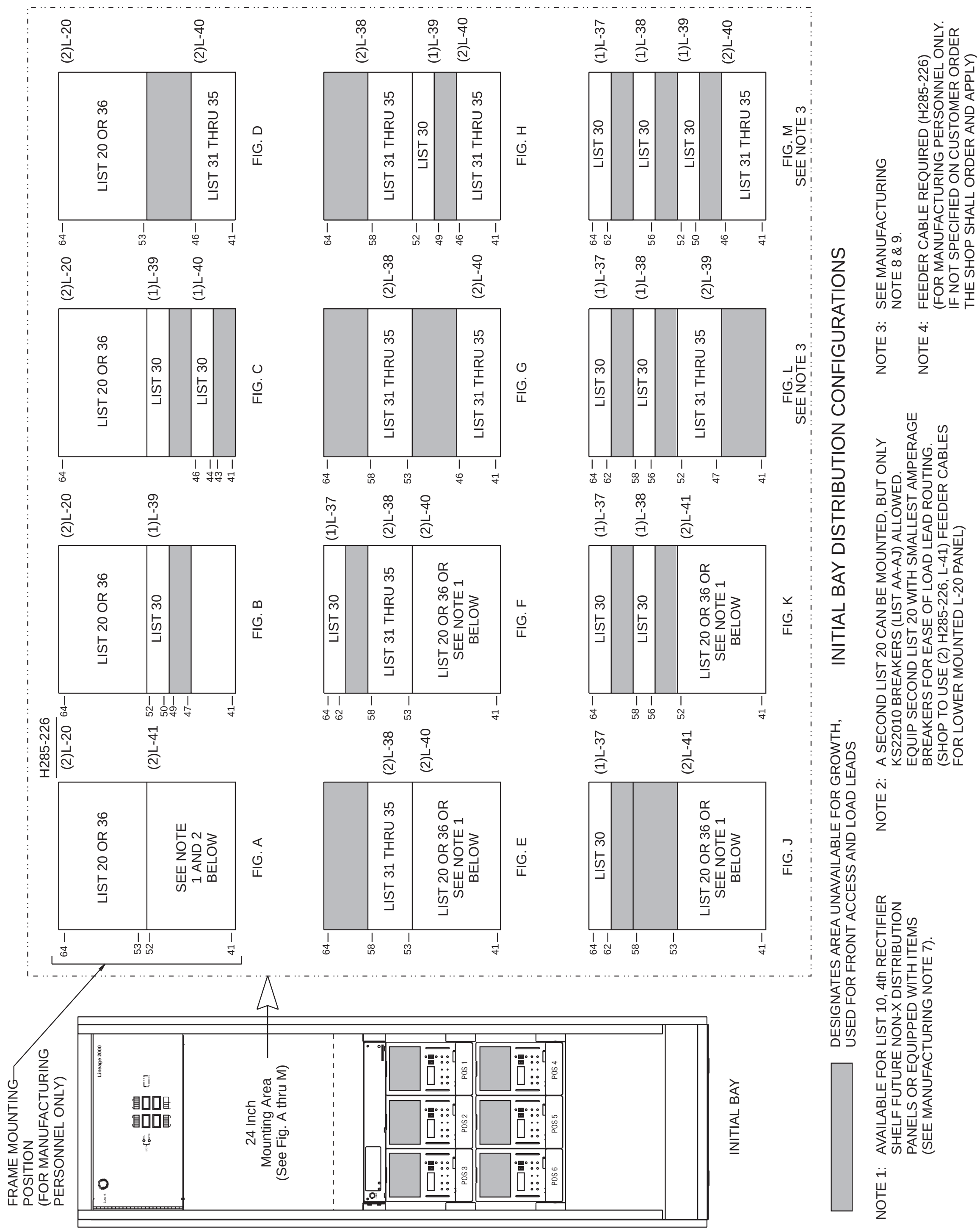


Figure 2-3a: Configurations A-M (allowed distribution options in Initial Bay)

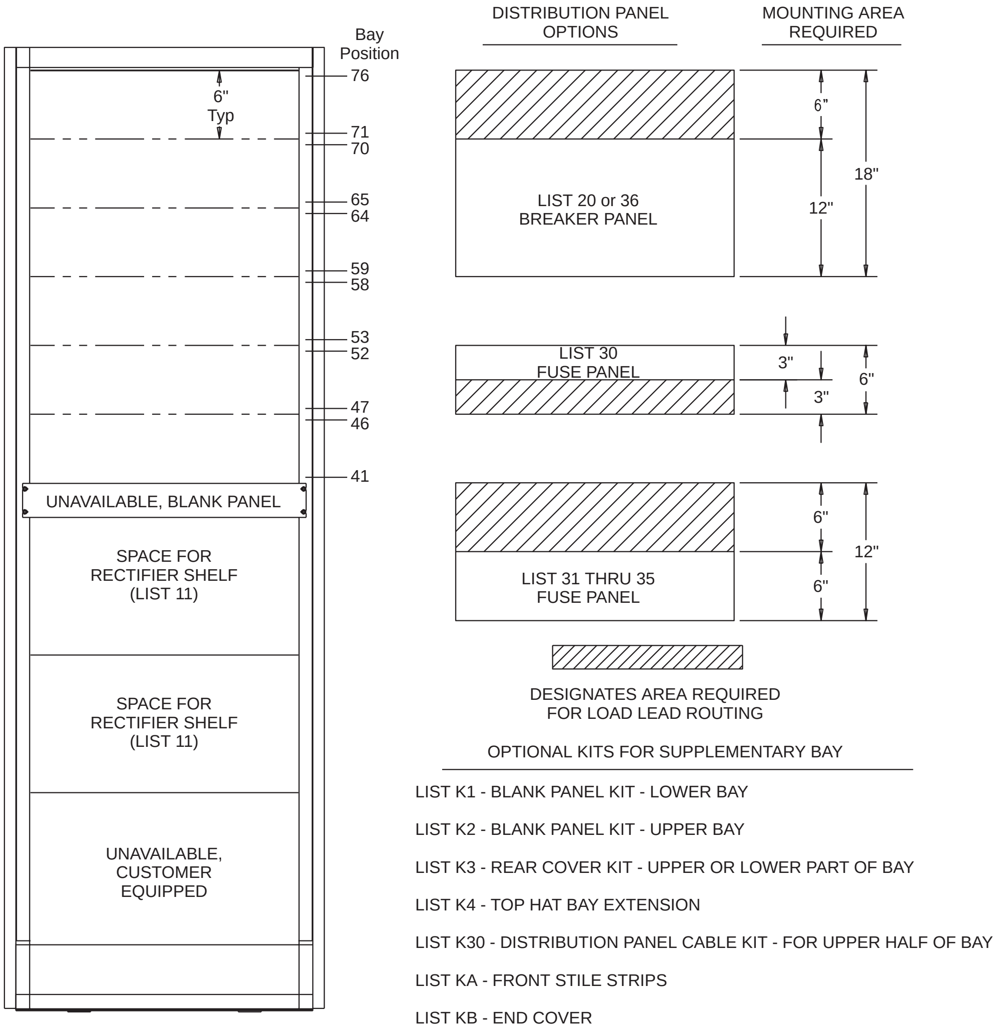


Figure 2-3b: Supplementary Bay options

Circuit Breaker Panel Description

The List 20 circuit breaker panel is shown in Figure 2-4. The specifications are listed in Table 2-D. The ON and OFF position label is molded into the front of each circuit breaker body.

If an overload occurs, the breaker will trip, and its handle will automatically move to the mid-trip position. At the same time, a closure signal for the MJF (FAJ) alarm will be provided at the breaker’s alarm contacts.

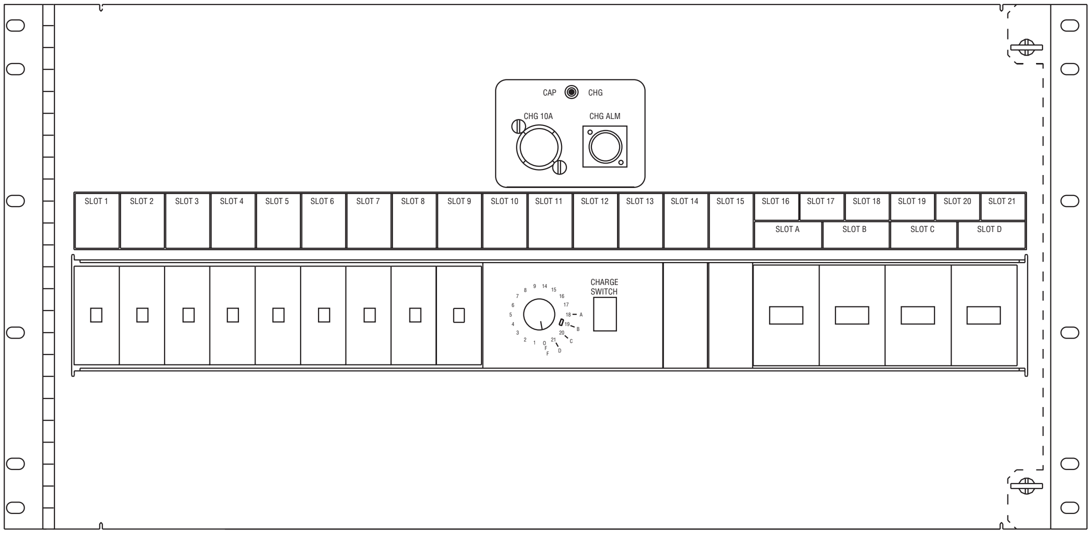


Figure 2-4: List 20 (5 to 600A circuit breaker panel

Table 2-D: List 20 Circuit Breaker Panel With Optional Capacitor Charge Feature Panel

Circuit breakers operate and provide an alarm during electrical trip. The List 20 panel contains 21 slots for circuit breakers and an optional capacitor charge feature.* The panel bus bar is sized for 600 ampere capacity.

Circuit Breaker Specification

Capacity (Amps)	Type (Heinemann)	Slots Occupied	Max. No. Per L-20 Panel	Order Information J85500G-2, L-20
5	KS220101	1	21	L-AA
10		1	21	L-AB
20		1	21	L-AC
30		1	21	L-AD
45		1	21	L-AE
60		1	21	L-AF
80		1	21	L-AG
100		1	21	L-AH
15		1	21	L-AJ
100	KS22012	1.5	4	L-AL
125		1.5	4	L-AM
175		1.5	4	L-AP
225		1.5	4	L-AR
300		3	2	L-AU
400		3	2	L-AV
500		4.5	1	L=AW
600		4.5	1	L-AX

*Capacitor charge feature occupies 4 slots on the List 20 panel and is ordered as L-CA.

Fuse panels

The List 30 through 36 fuse panels are shown in Figures 2-5 through 2-11. Refer to Tables 2-E through 2-K for fuse specifications and order information. Each load fuse position has a corresponding indicating alarm fuse. If a load fuse blows, its corresponding alarm fuse automatically opens, which issues an alarm signal MJF (FAJ) and leaves a visual indication. All indicating alarm fuses are 70 G type 1/2 amp and are furnished with the panel. Remove them by pushing in on the fuse cap and rotating it counterclockwise. Fuse ordering information is available from Tables W and Z on J85500G-2 drawing.

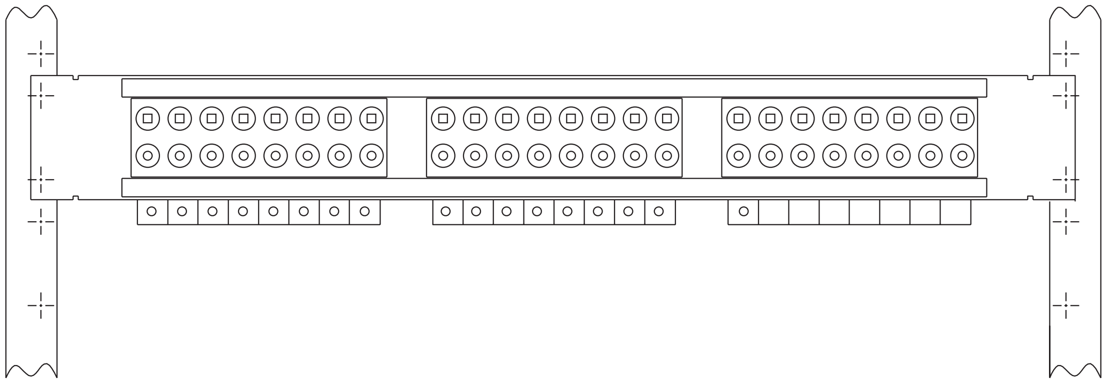


Figure 2-5: List 30 (1 to 30A) fuse panel

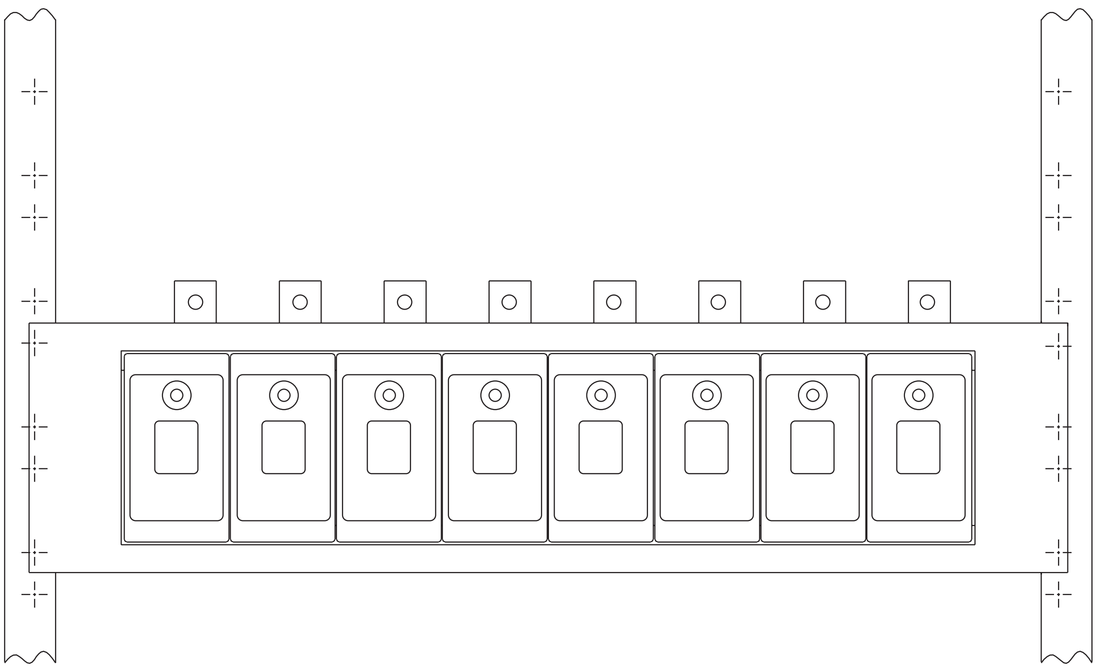


Figure 2-6: List 31 (1 to 60A) fuse panel

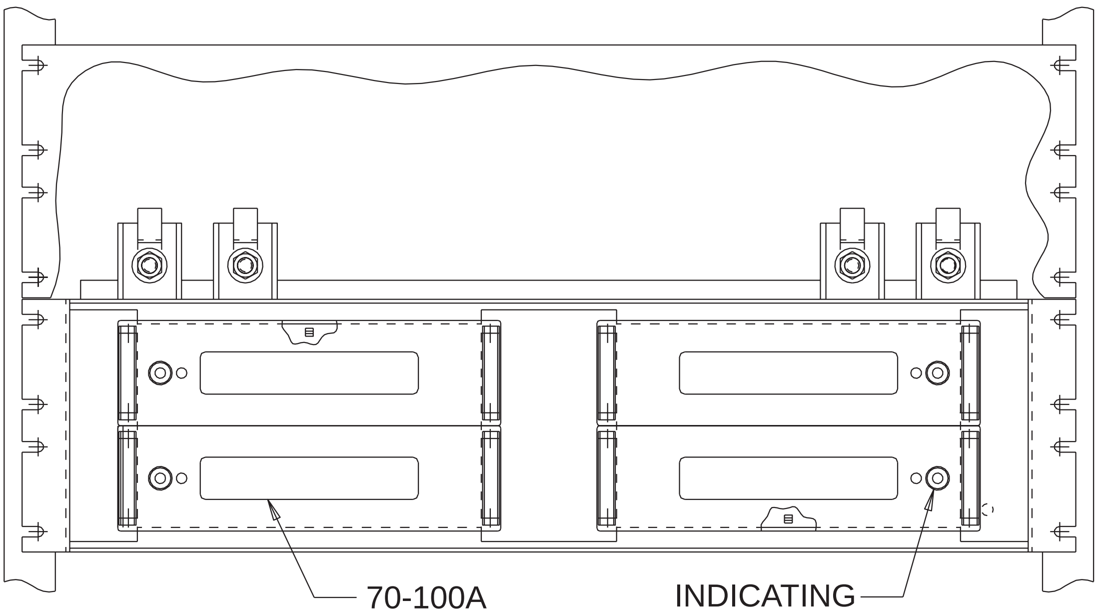


Figure 2-7: List 32 (70 to 100A) fuse panel

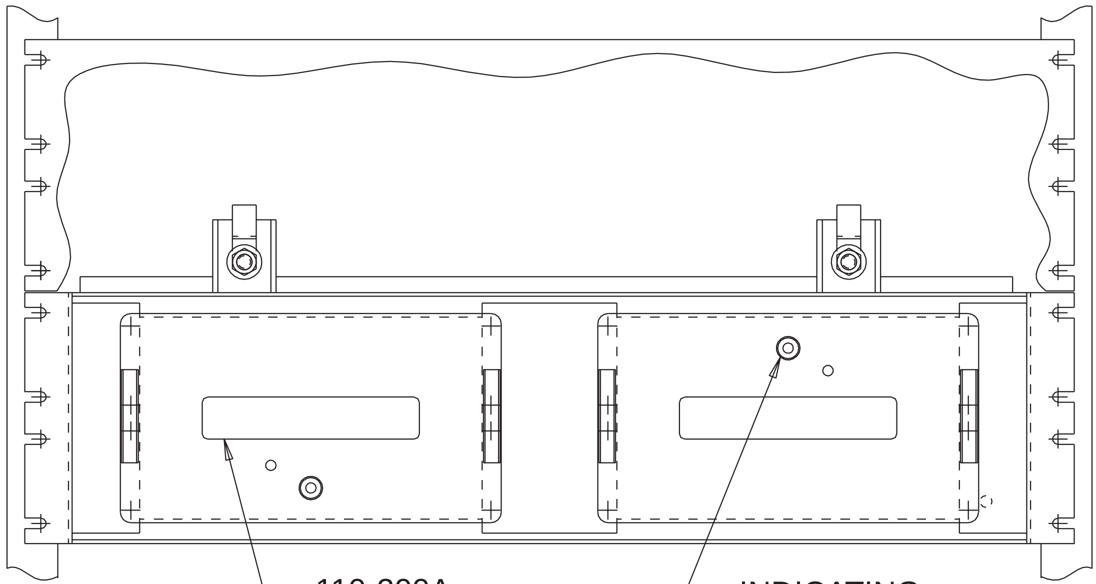


Figure 2-8: List 33 (110 to 200A) fuse panel

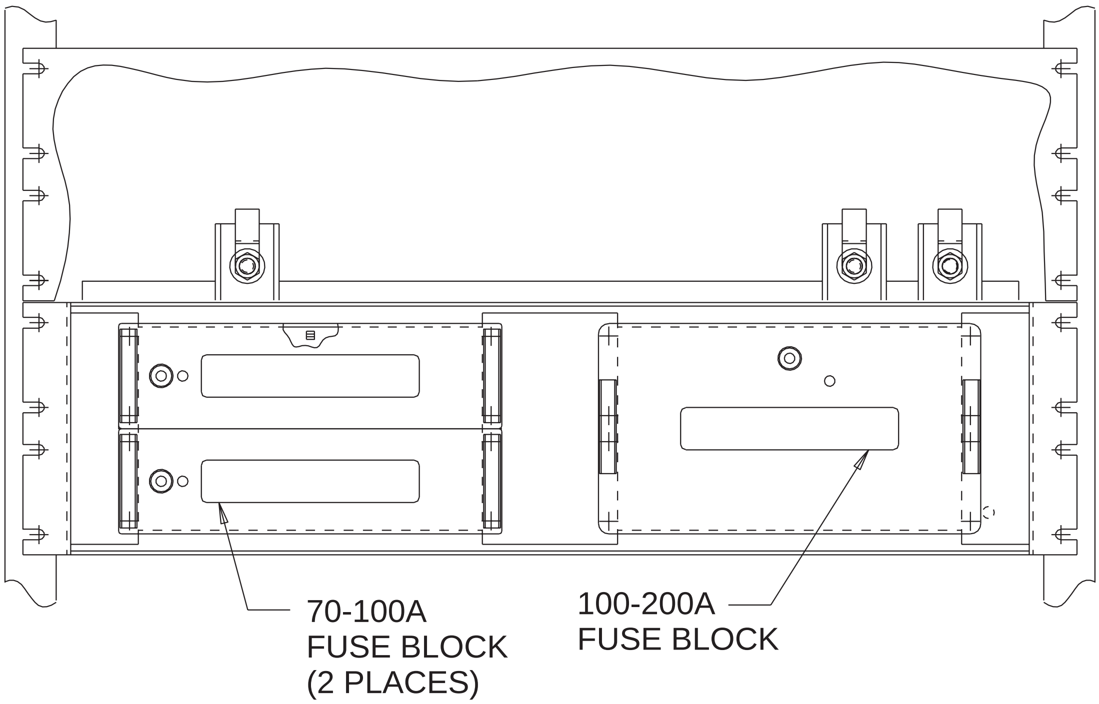


Figure 2-9: List 34 (70 to 200A) fuse panel

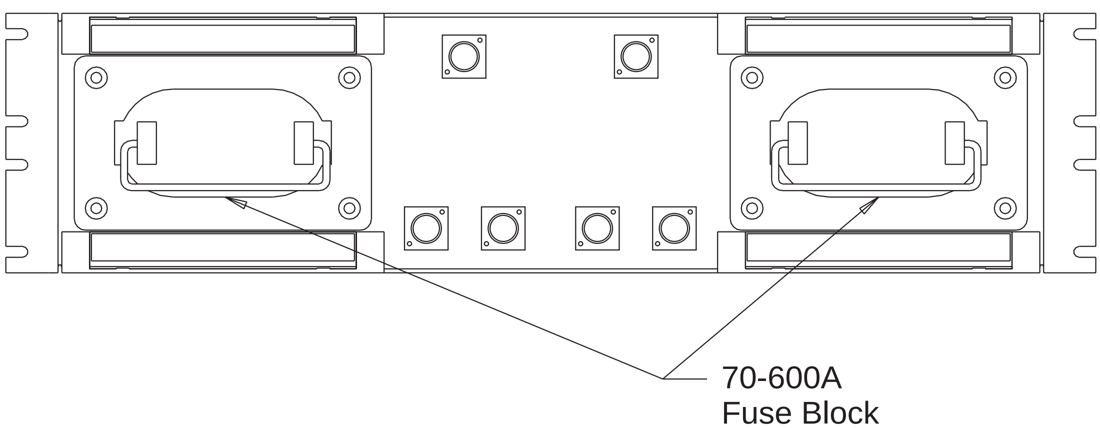


Figure 2-10: List 35 (70 to 600A) fuse panel

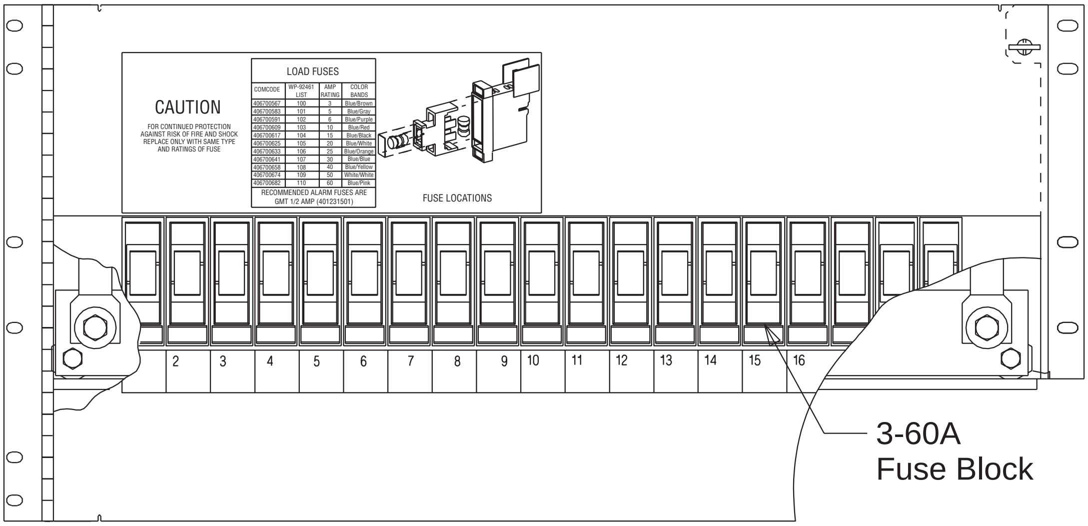


Figure 2-11: List 36 (3 to 60A) fuse panel

Table 2-E: List 30 Fuse Panel

The List 30 panel contains 3 individual fuse blocks, each of which can accommodate up to 8 load fuses for a total of up to 24 per panel. Refer below for fuse specifications. *Load fuses are ordered on a job basis, separately from the battery plant order.*

Load Fuse			
Size	Type	Range (Amps)	Order Information for a Fuse Panel
9/32x1-1/4 inch	74 KS-19870	1.25-20 2-30	J85500G-2 L-30

The following restrictions apply:
The maximum fusing for each fuse block (containing 8 load fuse positions) in general must not exceed 96 amperes (288 amperes maximum per panel).*
If fuses larger than 15 amps are used, leave any adjacent fuse block positions unoccupied.
Where possible, distribute the power evenly throughout a given fuse block.

*Refer to SD-82649-02, Note 310 for detailed guidelines for maximum fusing or talk to your account representative.

Table 2-F: List 31 Fuse Panel

The List 31 panel contains 8 individual fuse blocks, each accommodating a single fuse. Refer below for fuse specifications. *Load fuses are ordered on a job basis, separately from the battery plant order*.

Load Fuse (Five Configurations Orderable)

Type	Size	Range (Amps)	List	Quantity (maximum 8)	Order Information
Cartridge	9/16x2 inch 13/16x3 inch	1-30 35-60	H J	1-8 1-8	J85500G-2, L-21, (1-8) L-H (1-8) L-J Specify positions from left to right, numbered 1-8

Table 2-G: List 32 Fuse Panel

The List 32 panel contains 4 individual fuse blocks (70-100A), each accommodating a single fuse. Refer below for fuse specifications. *Load fuses are ordered on a job basis, separately from the battery plant order*.

Type	Range (Amps)	Order Informationfor a Fuse Panel
NON	70-100	J85500G-2, L-32

Table 2-H: List 33 Fuse Panel

The List 33 panel contains 2 individual fuse blocks (110-200A), each accommodating a single fuse and monitoring shunt. Fuses and shunts are furnished with the panel per lettered lists below.

Load Fuse

Type	Capacity (Amps)	Order Information	
NON	110 125 150 175 200	J85500G-2, L-33	L-AY L-AZ L-BA L-BB L-BC

Table 2-I: List 34 Fuse Panel

The List 34 fuse panel houses 3 individual fuse blocks,, each accommodating a single fuse. Two of the blocks take a (70-100A) load fuse which is ordered on a job basis. The third block is furnished with a fuse and shunt (110-200A) by specifying one of the letter lists below.

Load Fuse		
Type	Capacity (Amps)	Order Information
NON	70-100	J85500G-2, L-34
	110	L-AY
	125	L-AZ
	150	L-BB
	175	L-BB
	200	L-BC

Table 2-J: List 35 Fuse Panel

The List 35 fuse panel contains 2 individual fuse blocks, each accommodating a single fuse (70-600A) arranged for load monitoring shunts and head assemblies ordered by number and list from this table. *Load fuses are ordered on a job basis,separately from the battery plant order*.

Type	Capacity (Amps)	Ordering Information
Fuse Blocks		
NON	70-250	L-BP
	300-600	L-BQ
Load Monitoring Shunts		
NON	150	L-BS
	300	L-BU
	600	L-BX
Load Fuses		
Type	Capacity (Amps)	Ordering Information
TPL-BA	70	406794776
TPL-BD	100	406794784
TPL-BF	150	406794792
TPL-BH	200	406794818
TPL-BK	225	406794982
TPL-BL	250	406794842
TPL-CN	300	406794867
TPL-CR	400	406794875
TPL-CV	500	406794883
TPL-CZ	600	406794891

Table 2-K: List 36 Fuse Panel

The List 36 fuse panel contains 19 individual fuse blocks, each accommodating a single load fuse and an alarm fuse. This table lists fuse specifications. *Load fuses are ordered on a job basis, separately from the battery plant order.*

Fuse Blocks and Load Fuses

Type WP-92461 List	Capacity (Amps)	Ordering Information
100	3	406700567
101	5	406700583
102	6	406700591
103	10	406700609
104	15	406700617
105	20	406700625
106	25	406700633
107	30	406700641
108	40	406700658
109	50	406700674
110	60	406700682

Table 2-L: Initial Bay Feeder Cables for Different Configurations

(See Small Figures Included in Figure 2-3a)				
Configuration	**Mounting location**	**Associated feeder cable list**	**Qty per list**	**Ordering code**
List 20 or 36 Figure A	53-64	K20 (H285-226, L-20)	2	601286297
List 20 or 36 (1st) List 20 or 36 (2nd) Figure A	53-64 41-52	K20 (H285-226, L-20) K41 (H285-226, L-41)	2 2	601286297 601337645
List 20 or 36 List 30 Figure B	53-64 50-52	K20 (H285-226, L-20) K39 (H285-226, L-39)	2 1	601286279 601326200
List 20 or 36 List 30 List 30 Figure C	53-64 50-52 44-46	K20 (H285-226, L-20) K39 (H285-226, L-39) K40 (H285-226, L-40)	2 1 1	601286279 601326200 601326218
List 20 or 36 List 31 through 35 Figure D	53-64 41-46	K20 (H285-226, L-20) K40 (H285-226, L-40)	2 2	601286279 601326218
List 31 thriugh 35 List 20 or 36 Figure E	53-58 41-52	K38 (H285-226, L-38) K41 (H285-226, L-41)	2 2	601326192 601337645
List 30 List 31 through 35 List 20 or 36 Figure F	62-64 53-58 41-52	K37 (H285-226, L-37) K38 (H285-226, L-38) K41 (H285-226, L-41)	1 2 2	601326184 601326192 601337645
List 31 through 35 List 31 through 35 Figure G	53-58 41-46	K38 (H285-226, L-38) K40 (H285-226, L-40)	2 2	601326192 601326218
List 31 through 35 List 30 List 31 through 35 Figure H	53-58 50-52 41-46	K38 (H285-226, L-38) K39 (H285-226, L-39) K40 (H285-226, L-40)	2 1 2	601326192 601326200 601326218
List 30 List 20 or 36 Figure J	62-64 41-52	K37 (H285-226, L-37) K41 (H285-226, L-41)	1 2	601326184 601337645
List 30 List 30 List 20 or 36 Figure K	62-64 56-64 41-52	K37 (H285-226, L-37) K38 (H285-226, L-38) K41 (H285-226, L-41)	1 1 2	601326184 601326192 601337645
List 30 List 30 List 31 through 35 Figure L	62-64 56-58 47-52	K37 (H285-226, L-37) K38 (H285-226, L-38) K39 (H285-226, L-39)	1 1 2	601326184 601326192 601326200

Table 2-L: Initial Bay Feeder Cables for Different Configurations

(See Small Figures Included in Figure 2-3a)

Configuration	Mounting location	Associated feeder cable list	Qty per list	Ordering code
List 30 List 30 List 30 List 31 through 35 Figure M	62-64 56-58 50-52 41-46	K37 (H285-226, L-37) K38 (H285-226, L-38) K39 (H285-226, L-39) K40 (H285-226, L-40)	1 1 1 2	601326184 601326192 601326218

Capacitor Charge

For initial powering of high inrush loads a charge feature is available with List 20 circuit breakers. One Capacitor Charge Panel, List CA, is required for each plant in addition to the charge feature on the circuit breakers in order to provide the Capacitor Charge feature.

Load precharging procedure

Precharging is normally required before connecting loads with high inrush current characteristics through circuit breakers to avoid nuisance tripping of the breaker. These instances include startup, connection after manual disconnect, and connection after circuit breaker electrical trip.

The procedure to precharge a load is as follows:

1. Verify that the affected equipment is ready to accept dc power.

2. Locate the rotary slot selector and charge switch in the middle of the circuit breaker distribution panel. L-AA through AH KS22010 circuit breakers are numbered from left to right and L-AM through AX KS22012 circuit breakers are lettered from left to right and correspond to the rotary selector.

3. Select the circuit breaker with the rotary switch.

WARNING!
Do not attempt to turn the rotary switch while holding the charge button depressed. Damage to the rotary switch may result.

4. Press the charge button and observe that the **CAP CHG** LED on the Capacitor Charge Panel lights. If the LED does not light, the connected load may already be precharged or the circuit breaker may not be wired to the capacitor charge circuit.

5. The LED will dim as the precharge current diminishes. When the LED no longer changes in intensity, turn the associated breaker and then release the charge button.

Plant Bus Bars

The plant bus bars are mounted in three tiers on insulating standoffs at the top of the ECS plant. These copper bus bars (plated with a solder finish) are designed to accommodate one- or two-hole copper crimp lug connectors in many sizes up to 350MCM. Refer to Tables 3-D and Table 3-E for details.

The middle bus bar serves as the Charge Bus for both charge and discharge circuits. The lowermost bus bar serves as the Charge RTN Bus, which is connected via the plant shunt to the uppermost Discharge RTN Bus Bar. Refer to Figure 2-10.

A hinged panel covers the front of the bus bars and includes a mounting space for a LVD/Fuse Power Board (see Figure 2-11). The LVD/Fuse Board (CP5) provides circuitry for the LVD sensing (see Section 2) and regulation fuses to protect the ECS controller from overcurrent in the sense leads.

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 2-10). 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 600 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

In unattended battery plant locations, especially those without automatic back-up ac, batteries could be completely discharged during an ac power outage. The ECS Battery Plant may be equipped with an optional automatic battery disconnect to prevent costly battery damage due to unforeseen deep discharge. 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 (see Figure 2-10). The LVD/R Contactor is used either to connect or disconnect Charge Bus and Battery Bus. The LVD circuit on CP5 monitors the battery 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 Charge Bus and Battery 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 unpowered as well. In this state, the controller displays and LEDs are extinguished and various alarms are issued to the alarm reporting center. (See the Lineage® 2000 Controller manual for further details.)

The red “LVD OPEN” and yellow “LVD FAIL” LEDs are located on the dc distribution panel as shown in Figure 2-11. 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 and deliver power. The LVD circuit then restores power to the LVD/R contactor, which reconnects the batteries to the rectifiers and load. The batteries are then free to accept charging current from the rectifiers.

Thermal (slope/step) compensation feature

The 216A ECS Thermal Compensation Unit, used in conjunction with the BMD1, LVD/R Fuse circuit pack, provides reduction in plant voltage for measured temperatures above 25°C (77°F) in a slope-plus-step manner. The BMD1 reduces the plant voltage 72mV per degree Celsius for a maximum of 2.0VDC below the uncompensated voltage. The compensation stops at approximately 53°C (127.4°F). For temperatures higher than 53°C but less than 75°C (167°F), a constant voltage drop of 2.0VDC below the uncompensated voltage is maintained. For temperatures higher than 75°C the plant voltage is reduced 6 volts below the uncompensated 25°C voltage. The plant voltage is raised 4.0 VDC when the temperature returns to 65°C (149°F). A green indicator is illuminated to reflect an active module. A yellow indicator illuminates to reflect temperatures above 53°C and blinks to reflect temperatures above 75°C.

The 216A Control Unit also has the ability to increase the plant voltage for sensor temperatures below 25°C. The plant voltage is increased 72 mV per degree Celsius to a maximum of 2.0 VDC above the float voltage. The BMD1 is shipped from the factory with this margining feature disabled.

216A control unit accepts up to eight thermistors (two per battery string). Up to five 216A modules can be daisy-chained together which gives the ability to monitor up to 20 battery strings.

Two types of thermistor kits are available for use with the 216A Control Module:

1. Thermistor Kit, Paddles Comcode 847618048. Use this kit with the VR Batteries. The kit contains two thermistors that are inserted between the battery cells. Figure 4-7 shows an example of the thermistors inserted into the battery string.

2. Thermistor Kit, Rings Comcode 847618063. Use this kit when the battery cells are not adjacent to each other (e.g,. an air gap is present between cells). The ring terminal is a

1/4"diameter ring terminal. Place it on the negative terminal of the battery.

Each kit provides two thermistors and associated wiring to connect to the 216A Control Module. The retrofit kit contains two paddle thermistors to monitor one string of batteries. If more than one string of batteries is to be monitored, order a thermistor kit for each additional battery string.

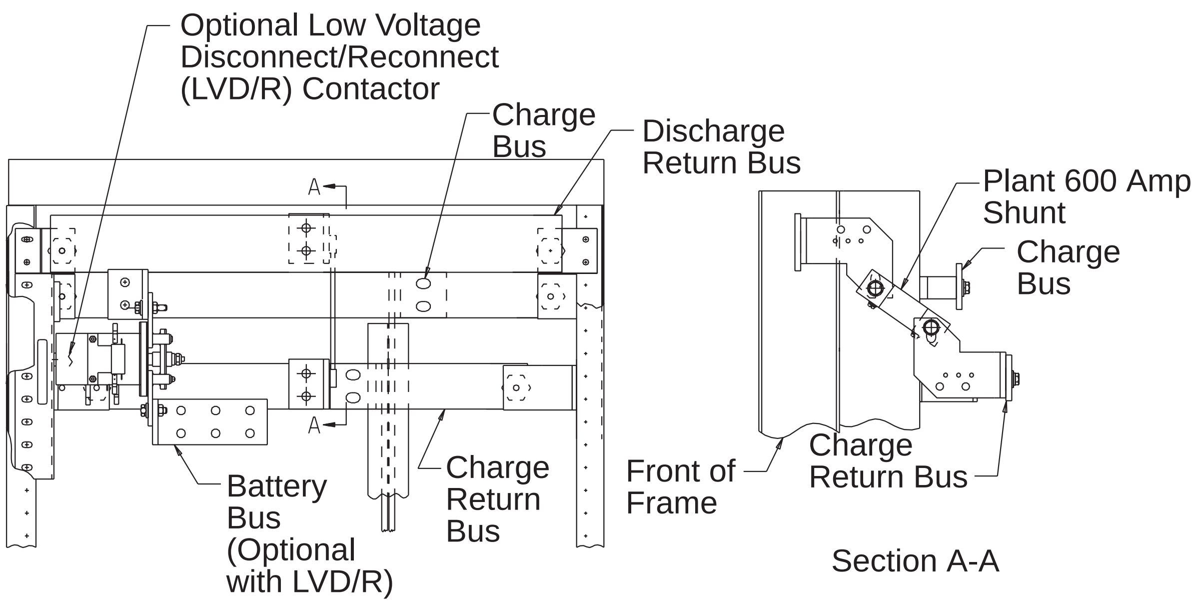


Figure 2-12: Plant Bus Bars With Optional List 2 Low Voltage Disconnect

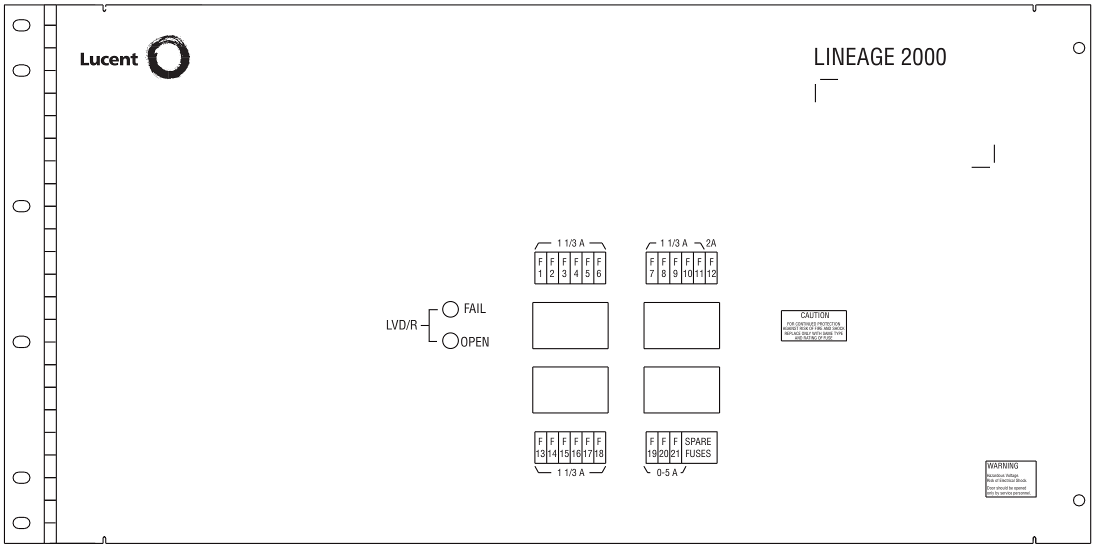


Figure 2-13: ECS Distribution Fuse Board Panel (front view)

3 Engineering, Planning and 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 engineer their battery plant completely or partially. 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 information in this manual or 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 section 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 sections.

1. Recommended operating voltage: ______ volts
2. Minimum steady-state voltage: ______ volts
3. Maximum steady-state voltage: _____ volts
4. Maximum high voltage transient: ______ volts
5. Can the load be damaged by low input voltage? ___ (yes or no)

If the answer to item (5) 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 available on this ECS battery plant.

Battery 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.

A **battery string** consists of a number of battery cells connected in series to provide the desired plant operating voltage. Although virtually any plant voltage is possible by varying the number of cells per string, this manual deals specifically with **nominal 48** volt systems.

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. Standard arrangements are more commonly available for 24-cell strings than for 23-cell strings. The Lucent Technologies VR-series battery, for example, is designed to float at 2.27 volts per cell and is available in 24-cell arrangements for float voltage of 54.48 volts per string, or 23-cell arrangements for loat voltage of 53.21 volts perstring. 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, weighing initial cost, expected life, service requirements and replacement cost against each other. Once the battery is chosen, the following information is needed for the battery plant engineering process.

6. Float voltage per cell: ____ volts

7. Minimum cell voltage at end of discharge: ____ volts

8. Is boost or equalize charging recommended? ____ (yes or no; boost or equalize charging is not recommended for the Lucent Technologies VR Series battery)

If "yes", the maximum recharging voltage per cell: ____ volts

9. Maximum initial charging voltage per cell: ____ volts

10. Number of cells per string: ____

Multiply the number of cells per string (10) by the voltages (6), (7) and (8) to find the values for (11), (12) and (13), respectively.

11. Float voltage per string: _____ volts

12. Minimum string voltage at end of discharge: ____ volts

13. Maximum charging voltage per string: ____ volts

Compare these three calculated voltages, (11), (12) and (13), against the steady-state load equipment voltages (1), (2) and (3).

If (12) is a higher voltage than (2), 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 sections.

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, as the batteries deliver power, the voltage drops steadily. 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 through engineering of the load equipment, a topic not covered in this manual. 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.

Table 3-A: Initial Load Drain Information

Load Circuit	List 1 (Amps)	List 2 (Amps)
1		
Battery Plant Total		

Table 3-B: Anticipated Future Load Drain Information

Load Circuit	List 1 (Amps)	List 2 (Amps	NC, C or A*
1			
Battery Plant Total			
*NC = No Change, C = Changed, A = Added			

Reserve Capacity

The customer’s service and maintenance strategy are important in determining reserve time. The availability of back-up ac power and accessibility of the site are usually the determining factors in battery sizing. The risk and acceptability of loss of service is another factor which will 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, however, 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.

14. Minimum battery reserve time: ____ hours

Battery capacity is usually specified in terms of **ampere-hours**, which is essentially 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, within limitations, decrease the necessary recharge time, but this calls for more current. Increasing the plant voltage after a discharge is also 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 usually called by different names. The former process is usually 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.

15. Maximum recharge time: ____ hours

16. Percent of full capacity after recharge time (15): ____ %

Refer to the Battery manual or other documentation to calculate the required recharge current to meet the requirements of (15) and (16). The recharge voltage (13) will be needed for this calculation.

17. 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.

18. 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 practices 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 in the plant.

At least 20 percent additional capacity must be included in the plant to provide recharge capacity and spares.

See below, **Lineage® 2000 Engineering Specifics, Rectifier** Sizing, for specifics on sizes and quantities of rectifiers for the ECS Battery Plant.

Battery string voltage drop and balancing

The rectifiers, while recharging or floating the batteries, maintain a constant voltage at the battery plant bus bars. When batteries are accepting recharge current after a discharge, there is a finite voltage drop from the charge bus bars inside the ECS bay to the battery string terminals. This voltage drop is, of course, 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 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 undergoes 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 below under **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, but battery capacity can be minimized. If a large voltage drop exists between batteries and load, the minimum load voltage may be reached before the batteries reach their end voltage so that their rated capacity is only partially used. 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 complex iterative calculations which are beyond the scope of this discussion. 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. Increasing the voltage drop from dc distribution to load can potentially be compensated by decreasing the voltage drop from batteries to dc distribution.

The voltage drop from the batteries to the distribution (0.25 volts) has been covered above, under **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 the next section, **Calculating voltage drop**.

Fill in the selected or calculated system voltage drops below.

19. Maximum drop (batteries to dc distribution): ____ volts

20. Maximum drop (dc distribution to load): ____ volts

21. Maximum drop (batteries to load): (19) + (20) = ____ 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 (2).

22. Actual battery string end voltage: ____ volts

23. Actual battery cell end voltage: ____ volts

Since most battery vendors provide capacity information as a function of end voltage, item (23) is important in the selection of a specific battery. If (23) 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 x I x L) / CM , or CM = (K x I x 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. 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 safely carry the intended current.

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.

General Guidelines

The peak current drain (List 2) is used to size the circuit protection for each individual load. The fuse or circuit breaker must also protect the wire connecting to it in accordance with NEC and local code regulations.

Fuses

Load fuses are not provided with the fuse panels that are supplied with the ECS power plant. The individual fuse size should be 150% of the List 2 current drain for the load that the fuse is protecting.

Circuit Breakers

All circuit breakers supplied with the ECS power plant can be loaded up to 100% of their rating only if the job engineer can determine that the user load has no short term peaks greater than 150% of its rating and not exceeding 10 milliseconds in duration. If the characteristics of the load cannot be determined, apply a factor of 125% instead of 100%.

Lineage® 2000 Engineering Specifics

The methods used in the previous section, "General Engineering Calculations", are appropriate for the engineering of any battery plant. The same methods are used in this section to select the specific types and quantities of equipment available with Lineage® 2000 ECS battery plants, including the J85500G-2.

The following topics are covered in this section.

- 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

Rectifier Sizing

The Lineage® 2000 SR 50 ampere, -48 volt switched-mode rectifier is currently available with the Lineage® 2000 ECS Battery Plant J85500D-3. The maximum number of rectifiers per plant is 12. In the absence of specific customer practices, the following procedure is RECOMMENDED.

24. Determine the smallest whole number of rectifiers that will provide the normal (List 1) plant drain in Table 3-A: ____

25. Determine the smallest whole number of rectifiers that will provide the normal plus recharge current from Table 3-A and step (17): ____

26. Provide the GREATER of step (24) +1 or step (25) rectifiers: ____

Some ECS battery plants include batteries in the same bay as the rectifiers and controller. Others, like the J85500G-2, locate the batteries elsewhere. For batteryless plants, skip to **Initial and supplementary bays**, below.

Battery Sizing

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: In general, for one vendor's family of batteries, the cost per ampere-hour decreases with increasing cell capacity. In other words, a battery that is twice as big costs less than twice as much. On the basis of initial material cost, therefore, the number of strings should be minimized.

Weight and Space Efficiency: Weight density and space efficiency increase, in general, 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 the potential compactness of the battery arrangement. Such limitations of the building structure must be clearly understood before selecting a battery arrangement.

See **Floor plan data** under **Planning**, below, 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 to simplify expansion. 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 tied to the growth in rectifier capacity, since both must increase with increasing load current. It is typically most economical to match an increase in charge capacity with an increase in battery capacity which can back up the load supported by the additional rectifiers. Since a fraction of any added rectifier capacity is needed for recharging added batteries, the matching incremental change in battery capacity depends on the desired recharge factor. Since the charge capacity of the Lineage® 2000 ECS battery plant grows in 50 ampere increments with the SR50A/48V rectifier, the optimum battery capacity increment may be approximated as follows.

A-hr increment = (50 A) x (reserve time in hours) /(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, for applications where service reliability is critical, it is a good practice to select battery size such that at least two strings are required. 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 together can occupy one framework called the INITIAL BAY. Up to 12 rectifiers, controller, capacitor charge panel, a breaker or fuse panel and bus bars will fit in this space with an ECS controller. Only nine rectifiers will fit in this space with a Galaxy controller. Additional dc output (rectifiers) and distribution panels (breakers/fuses) can be configured in a supplementary bay.

If Lucent Technologies VR batteries are used, additional framework, called **battery supplementary bays**, is necessary for strings of VR batteries, with up to two strings per bay. Such supplementary bays are engineered and ordered as part of the ECS Model J85500D-3 plant or from J85504C-1. See these drawings for typical arrangements of supplementary bays with Lucent Technologies VR batteries.

For some installations it may be desirable to order all supplementary bays for anticipated growth as part of the initial installation. Installation of supplementary framework during the initial construction and support of cabling systems will simplify the future battery plant expansion.

Other vendors’ 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 vendors’ batteries, however, are designed for mounting on stands that require special floor plan arrangements.

Specify the number of Supplementary Bays required ___

Specifiy the number of Battery Supplemental Bays required ___

Cable and load breaker sizing

In this section, 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, 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 section of the product manual. In this section, the basics are derived for the 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.

Use wire type RHW or RHH 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. Use flexible power wire (e.g. KS-20921) for sizes 1/0 and larger in applications requiring tight bends, such as small battery plants in confined locations.

The terminal lugs that may readily be attached at the dc distribution subsystem are listed in Tables 3-D and 3-E.

Table 3-D: Double Hole Terminal Lugs

KS-5482 Wire	KS-20921 Wire	WP-91412 List	Comcode	Bolt Size	Centers	Die
10	10	73	405356171	10	0.625	R5473-5
8	8	52	405348178	10	0.625	Red
8	8	75	406021626	0.250	0.625	Red
6	6	3	405347519	0.250	0.625	Blue
4	4	5	405347576	0.250	0.625	Grey
2	-	54	405348202	0.250	0.625	Brown
-	2	8	405347683	0.250	0.625	Green
1/0	-	56	405348228	0.375	1.0	Pink
-	1/0	57	405348236	0.375	1.0	Black
2/0	-	57	405348236	0.375	1.0	Black
-	2/0	77	406021725	0.375	1.0	Orange
4/0	-	59	405348251	0.375	1.0	Purple
-	4/0	27	405347923	0.375	1.0	Yellow
350MCM	-	61	405348277	0.375	1.0	Red
-	350MCM	86	406021915	0.375	1.0	Red

Table 3-E: Single Hole Terminal Lugs

KS-5482 Wire	KS-20921 Wire	WP-91412 List	Comcode	Bolt Size	Die
10	10	93	406338145	10	R5473-5
8	8	1	405347402	10	Red
8	8	74	405356189	0.250	Red
6	6	2	405347436	0.250	Blue
4	4	4	405347543	0.250	Grey
2	-	53	405348186	0.250	Brown
-	2	7	405347659	0.250	Green
1/0	-	55	405348210	0.375	Pink
-	1/0	10	405477717	0.375	Black
2/0	-	10	405477717	0.375	Black
-	2/0	17	405347790	0.375	Orange
4/0	-	58	405348244	0.375	Purple
-	4/0	78	406021741	0.375	Yellow

Order pre-engineered battery cable kits for use with VR batteries in supplemental bays can be ordered with the ECS battery plant. These kits have been engineered for the typical ECS configurations presented in the J85500G-2 drawing. The kits contain the following items:

- Appropriate length and gauge of KS20921 wire
- Appropriate lugs for termination at the battery and at the dc distribution
- Crimping information
- Heat shrink tubing

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

A wide range of circuit breakers and fuses is available for dc distribution overcurrent protection. The ratings of these circuit breakers are from 5-600 amperes and the ratings of thge fuses are from 1-200 amperes. The breaker or fuse rating for a given circuit is selected by the criteria covered above under **Overcurrent Protection**.

Record Wire And Breaker/Fuse Sizes

Determine the lengths of all load and battery conductors before proceeding with this section. Use the following steps to record the wire and breaker/fuse sizes for each load feeder in Table 3-F. Use additional sheets as needed.

1. Copy List 2 drains for each load feeder from Table 3-B to Table 3-F.

2. Calculate the minimum wire size that meets the ampacity requirement based on theList 2 drain for each load feeder.

3. List the wire sizes based on ampacity in Table 3-F.

4. Calculate the minimum wire size for each load feeder in Table 3-B to meet the voltage drop requirements outlined above under **Calculating Voltage Drop.**

5. List the sizes based on voltage drop in Table 3-F.

6. Indicate the larger size for each load feeder in the column marked “Selected Wire Gauge.”

7. Fill in the circuit breaker or fuse rating (e.g., 10, 20 or 30 Amps) in Table 3-F for each feeder.

8. Record in Table 3-G the wire sizes for each battery feeder.

9. 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.

10. Enter that wire size on the first line in Table 3-G.

11. Calculate the minimum wire size for each battery feeder in Table 3-B to meet the voltage drop requirements outlined above under **Battery Size Versus Voltage Drop** and **Calculating Voltage Drop**.

12. List the sizes based on voltage drop in Table 3-G.

13. Indicate the larger size for each load feeder in the final column, “Selected Wire Gauge.”

Table 3-F: Load Feeder Wire And Fuse/Breaker Size

Circuit Number	List 2 Drain	Minimum Wire Gauge		Selected Wire Gauge	Fuse/breaker Rating
		(Ampacity)	(Voltage Drop)		
1					

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 above on **Battery** Sizing and Battery 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)

Emergency disconnect

(Reserved for future use.)

Thermal (slope/step) compensation

The thermal compensation feature is available as an option.

Is Thermal Compensation feature required? _____(yes or no)

Controller Options

The engineering of the controller features involves orderable circuit packs and field-movable jumper straps or DIP switches. Circuit Packs: Circuit pack options for the ECS controller are listed on the J85500G-2 drawing and in the Controller Product Manual. Circuit pack options for the Galaxy controller are listed on the Galaxy controller drawing J85501F-1 and in the Galaxy controller Product Manual.

DIP Switches and Jumper Straps: Certain controller features must be set during the installation process if requirements differ from the standard factory settings. The engineering process must provide the necessary instructions to the installer for the controller set-up. Refer to the J85501D-2 or J85501F-1 controller drawing and the Controller Manual for details.

Alarm System Interface

The standard ECS and Galaxy controllers are 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, however, 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 are given below:

- Initial bay: Zone 4, upper floors, per NEBS TR-EOP-00063
- Supplementary bay with 6 rectifiers and distribution: Zone 4, upper floors
- Supplementary bay with 1 string VR batteries: Zone 4, upper floors
- Supplementary bay with 2 strings VR batteries: Zone 2, ground level (not recommended for Zone 4 applications)

A supplementary bay equipped with two strings of VR batteries should be junctioned to adjacent frameworks when possible and should be tied to the building or vault wall for additional rigidity in Zone 3 applications. The supplementary bay equipped with

TWO strings of VR batteries is NOT recommended for Zone 4 applications..

Planning

The equipment specified in the previous section 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 section.

- 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 2000 ECS Battery Plant, Floor Plan Data are given in Figure 4-2. 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: Space must be adequate 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 systems are sized to maintain the environment given the heat dissipation of the equipment.

AC Service: The ac distribution system is sized to accomodate 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 in Figure 3-4.

Grounding

The ECS battery plant is designed for compatability with most grounding systems. The standard dc 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. Two holes for .250-20 self tap screws are provided at the rear of the top crossmember of the bay uniframe to accommodate a two-hole cable lug on .62" centers. If the frame ground lead is calculated to be larger than 2 AWG, the corresponding lug has 3/8" diameter holes on 1" centers. In this case, the adapter that is always provided with the bay should always be used. Refer to Figure 3-5.

Growth

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 Reference Material

This manual contains all the needed planning and ordering information for the ECS Battery Plant J85500D-3. Some customers may prefer to prepare plans and orders from manufacturing, wiring and schematic drawings. Read the following sections to learn how to order Lucent Technologies equipment from these drawings.

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:

- BAA1 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 "Spare Parts" in Section 5).

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-coded 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 sections.

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.
- 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 3-6.

(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 henever 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, read all the notes on the T-drawing 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 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.

Ordering Information

The J85500G-2 battery plant is ordered with List (L) numbers and Equipped With (E/W) items. See Table 3-H.

A sample order for a G-2 plant containing nine 50-ampere rectifiers, a CP2 microprocessor board, fourteen 30-ampere breakers, two 175-ampere breakers, capacitor charge switch/feature, one 24-position 1-30-ampere fuse block and stile strips in the initial bay and three 50-ampere rectifiers, a fourth rectifier shelf, two 200-ampere fuses and stile strips in a supplementary bay with blank panels covering the upper half of the bay would look like the example below.

Note: Multiple List 20, 30 through 34 distribution panels on a single bay must be itemized together. Specify breakers or fuses as part of a specific panel. Also, List 4, 5, 7, 8, 9 and K10 should be ordered separately from the equipment since they are shipped in separate containers.

Item	Qty	Description
1	1	J85500G-2 L-1 -48V, 600V ECS plant assem. per Fig. B E/W
	1	L-10
	1	L-KA
	1	L-20 circuit breaker panel
	14	L-AD circuit breaker positions 1 through 9, 14 through 18
	2	L-AP circuit breaker positions B, D
	1	L-CA L-30 fuse panel
2	1	J85500G-3 L-3 supplementary bay E/W
	1	L-11
	1	L-K2
	2	L-K30
	1	L-KA
	1	L-33 fuse panel, bay positions 65 through 70
	2	L-BC fuse positions 1, 2
3	12	J85500G-2 L-4 -48V 50 amp switch mode rectifier
4	1	J85500G-2 L-5 microprocessor board

Configurations A through M in Figure 2-3a show mounting information when List 20, 30, 31, 32, 33 and/or 34 distibution panels are ordered with a List 1 or 2 plant. Feeder cables are required; see Table 2-M for ordering. When distribution panels are ordered equipped in a List 3 supplementary bay, customer should specify bay position per Figure 2-3b.

Ordering Guide (List Numbers)

Table 3-H summarizes the various components of the J85500G-2 ECS battery plant. List and Kit items may be combined as in the sample orders above.

Table 3-H: Ordering Guide J85500G-2 ECS 600 Ampere -48 Volt Battery Plant

List Number	Description of Equipment and Features
1	Provides a battery plant, 208/220/240 volt input, -48 volt, 600 ampere maximum output (includes ECS controller, two rectifier shelves and charge and discharge bus bars.)
2	Sames as List 1, with low voltage battery disconnect feature.
3	Provides a supplementary bay for mounting additional distribution panels and a maximum of two rectifier shelves.
4	Provides 50-ampere, -48-volt SR rectifier.
5	Provides optional miocroprocessor circuit pack (CP2) for plant controller. CP2 provides remote and local monitoring and control functions.
7	Same as List 5 (CP2), with voice response feature.
8	Provides optional datalogger circuit pack (CP3) for plant controller. CP3 is a data acquisition pack that always requires a CP2 circuit pack.
9	Same as List 8, with a remote termination panel. The remote termination panel allows connection to the CP3 circuit pack from outside the controller.
10	Provide optional third or fourth rectifier shelf for initial bay with ECS controller.
11	Provide optional rectifier shelf for supplementary bay with ECS controller.
12	Optional equipment in addition to List 1 to provide thermal (slope/step) compensation feature.
13	Optional equipment in addition to List 2 to provide thermal (slope/step) compensation and low voltage battery disconnect/reconnect features.
15	Same as List 1 except with Galaxy controller.
16	Same as List 15 except with low voltage battery disconnect feature.
17	Same as List 10 except with Galaxy controller (third shelf only).
18	Same as List 11 except with Galaxy controller.
20	Circuit breaker panel for 5 to 600A breakers.
A	Optional equipment in addition to List 10 to provide ac prewire (three shelf assemblies).

Table 3-H: Ordering Guide J85500G-2 ECS 600 Ampere -48 Volt Battery Plant

List Number	Description of Equipment and Features
B	Optional equipment in addition to List A and a second List 10 to provide ac prewire to the fourth rectifier shelf assemblies.
Lists AA-AJ provide circuit breakers for List 20 with the following ampere capacity:	
AA	5 ampere breaker
AB	10 ampere breaker
AC	20 ampere breaker
AD	30 ampere breaker
AE	45 ampere breaker
AF	60 ampere breaker
AG	80 ampere breaker
AH	100 ampere breaker
AJ	15 ampere breaker
AL	100 ampere breaker with shunt
AM	125 ampere breaker with shunt
AP	175 ampere breaker with shunt
AR	225 ampere breaker with shunt
AU	300 ampere breaker with shunt
AV	400 ampere breaker with shunt
AW	500 ampere breaker with shunt
AX	600 ampere breaker with shunt
CA	Provides a capacitor charge feature for List 20 breaker panel to precharge high inrush loads.
30	Fuse panel for twenty-four 1 to 30A load fuses
31	Fuse panel for eight 1 to 60A load fuses
Lists H and J provide fuse mounting for List 31 with the following ampere range:	
H	1 to 30A fuse mounting
J	31 to 60A fuse mounting
32	Fuse panel for two 110 to 200A load fuses
33	Fuse panel for two 110 to 200A load fuses
34	Fuse panel for two 70 to 100A load fuses
35	Fuse panel for two 70 to 600A load fuses

Table 3-H: Ordering Guide J85500G-2 ECS 600 Ampere -48 Volt Battery Plant

List Number	Description of Equipment and Features
36	Fuse panel for nineteen 3 to 60A load fuses
Lists AY-BC provide one load monitoring shunt and one load fuse for Lists 33 and 34 with the following ampere capacity:	
AY	110 ampere fuse and shunt
AZ	125 ampere fuse and shunt
BA	150 ampere fuse and shunt
BB	175 ampere fuse and shunt
BC	200 ampere fuse and shunt
K1	Provides a blank panel appearance kit for lower half of supplemental bay
K2	Provides a blank panel appearance kit for upper half of supplemental bay
K3	Provides a rear cover kit for one-half of initial or supplementary bay
K4	Top Hat extension kit
K10	Provides an optional upgrade kit for plant controller to add the voice response feature to a plant controller in the field
K20	Distribution panel cable kit for List 20 or 36 initial bay - H285-226 L-20 feeder cable
K30	Provides cable kit for supplementary bay distribution panel
K36	Distribution panel cable kit for List 30 to 35 initial bay - H285-226 L-36 feeder cable
K37	Distribution panel cable kit for List 30 to 35initial bay - H285-226 L-37 feeder cable
K38	Distribution panel cable kit for List 30 to 35 initial bay - H285-226 L-38 feeder cable
K39	Distribution panel cable kit for List 30 to 35 initial bay - H285-226 L-39 feeder cable
K40	Distribution panel cable kit for List 30 to 35 initial bay - H285-226 L-40 feeder cable
K41	Distribution panel cable kit for second List 20 or 36 initial bay - H285-226 L-41 feeder cable
KA	Provides an appearance kit for office stile strips
KB	Provides an appearance kit for one end cover

Documentation References

The following documents provide the engineering, ordering and installation information for the Lucent Technologies Lineage® 2000 ECS battery plant J85500G-2.

ECS Battery Plant

Assembly and Ordering Drawing:	J85500G-2
Wiring Diagram:	T-82673-31
Schematic Diagram:	SD-82673-01
Product Manual:	167-790-035

Supplementary information on the ECS controller, Galaxy controller, Lineage® 2000 SR series rectifier and Rectifier Shelf Assembly (RSA), and the Lineage® 2000 VR series battery may be found on the following documents..

ECS Controller

Assembly and Ordering Drawing:	J85501D-2
Wiring Diagram:	None
Schematic Diagram:	SD-82669-01
Product Manual:	167-790-033
Optional Circuit Pack Product Manual:	167-790-109

Galaxy Controller

Assembly and Ordering Drawing:	J85501F-1
Wiring Diagram:	T-83217-30
Schematic Diagram:	SD-83217-01
Product Manual:	167-790-060
Peripheral Monitoring System Manual:	167-790-063

SR Series Rectifiers and Rectifier Shelf Assembly

Assembly and Ordering Drawing:	J85702B-2
Wiring Diagram:	T-82668-30
Schematic Diagram:	SD-82668-01
Product Manual:	167-790-060
Peripheral Monitoring System Manual:	167-790-117

VR Series Battery

Assembly and Ordering Drawing:	J85504C-1
Wiring Diagram:	T-83119-30
Schematic Diagram:	SD-83119-01
Product Manual:	157-622-010

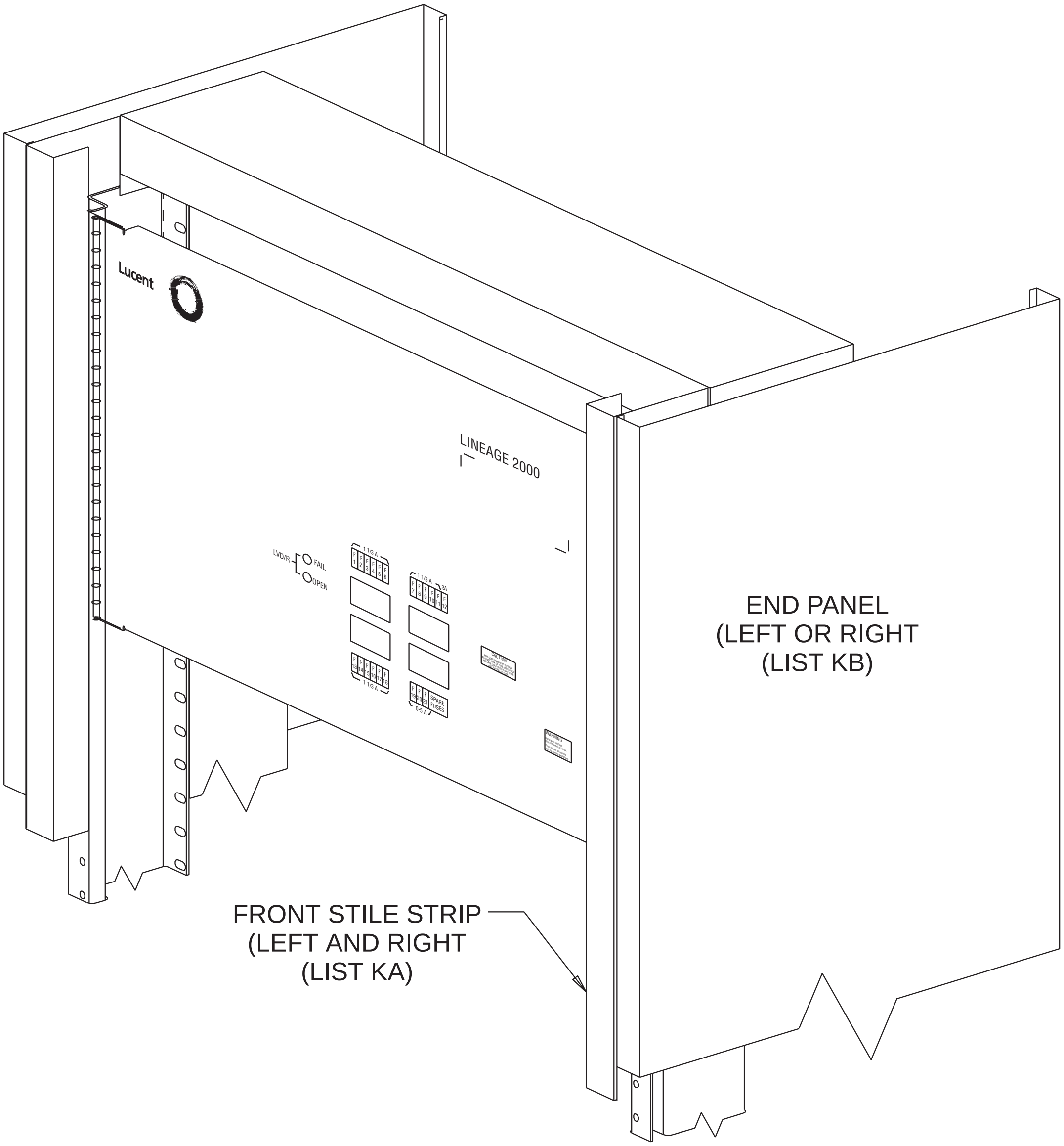


Figure 3-1: ECS Appearance Package Options

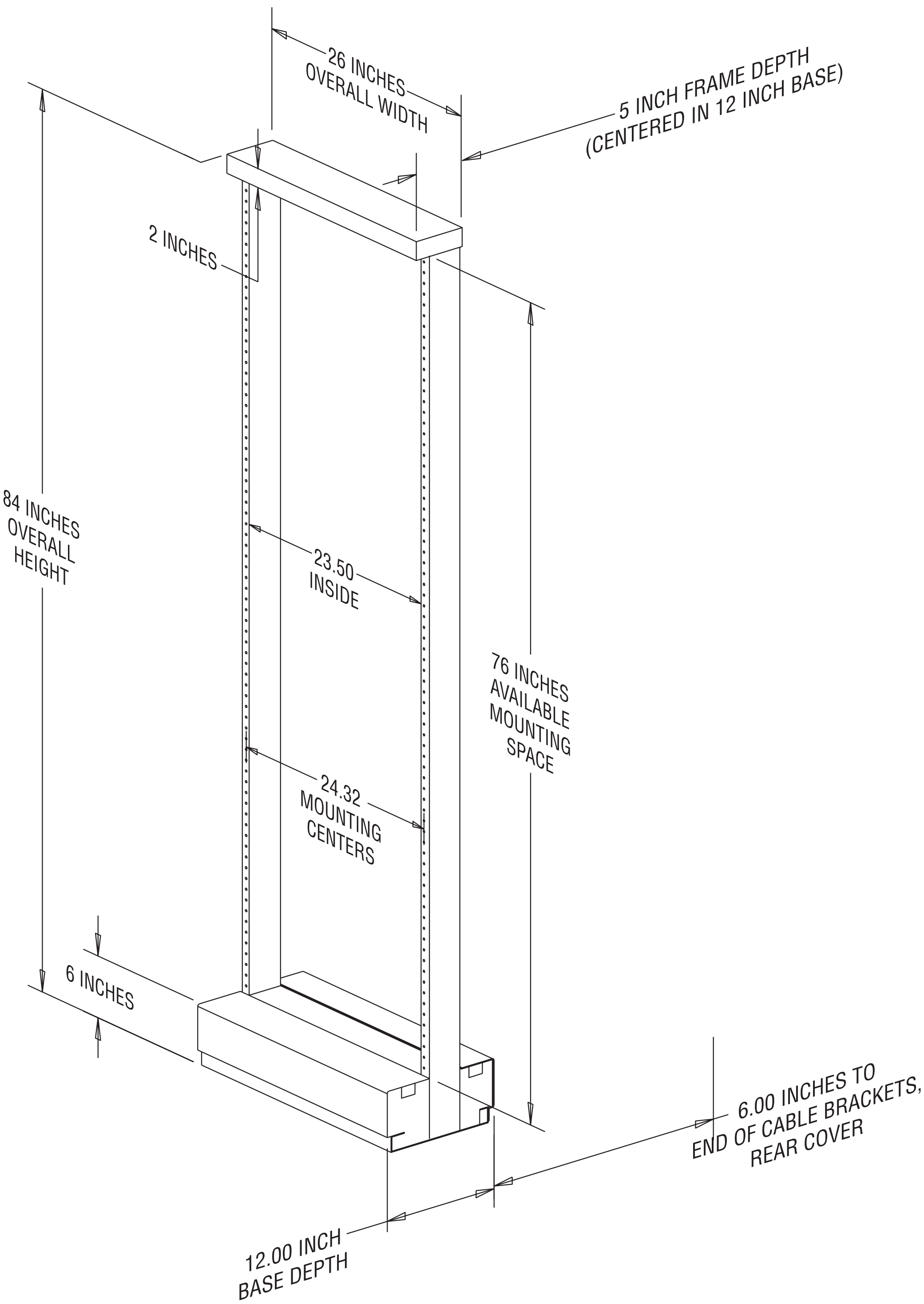


Figure 3-2: Uniframe Rack Construction of Initial and Supplementary Bay

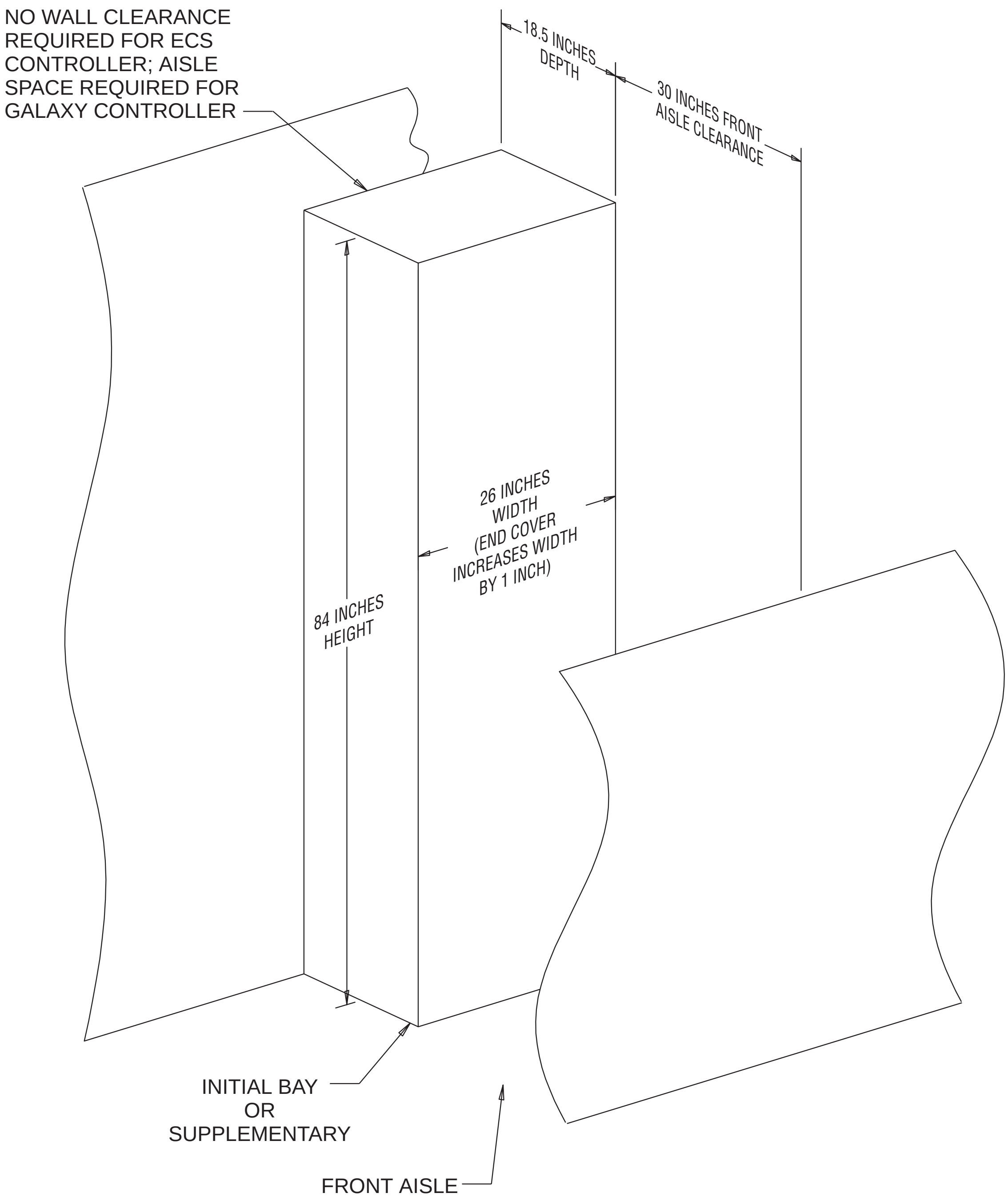


Figure 3-3: Bay Dimensions and Clearances

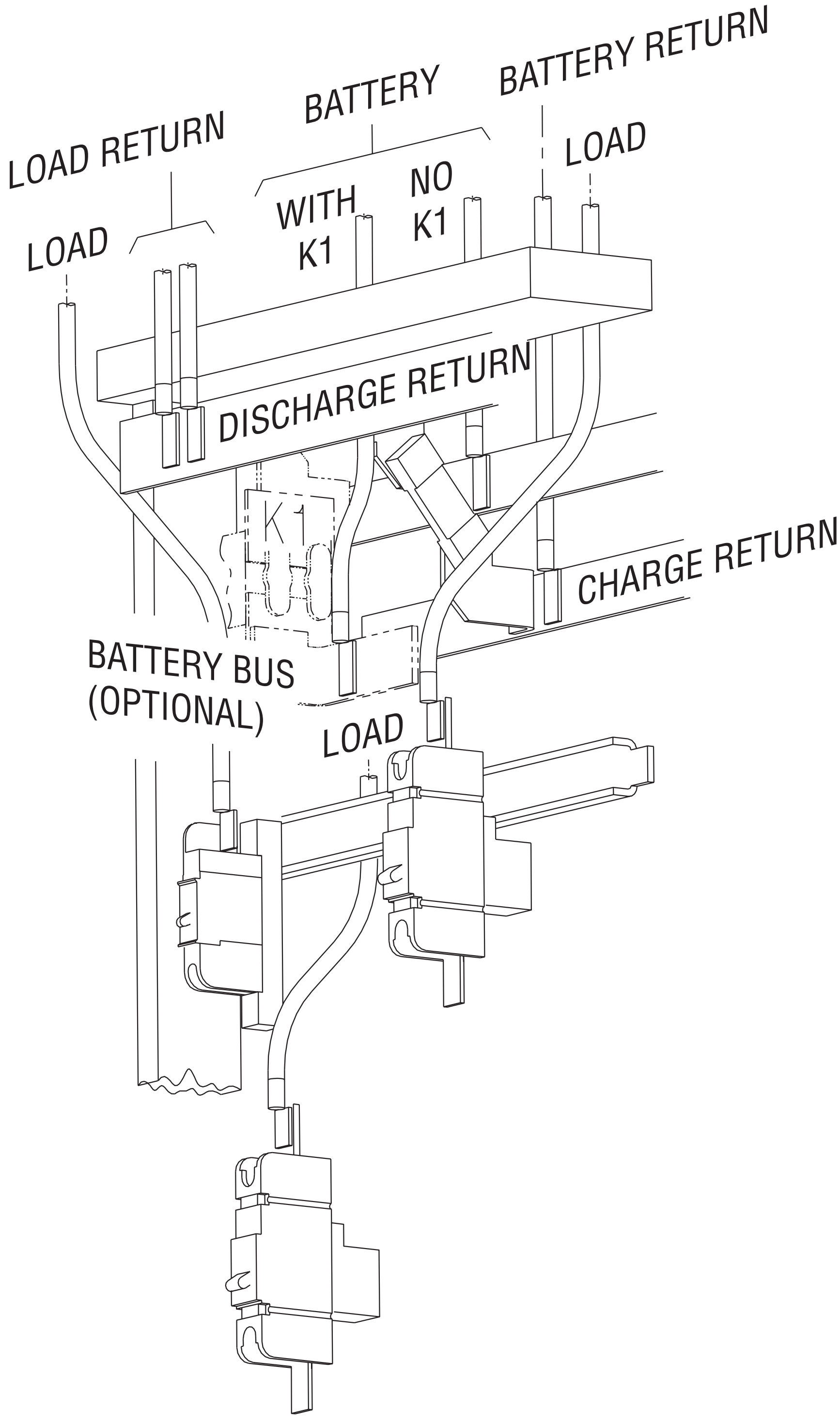


Figure 3-4: Cabling Arrangement

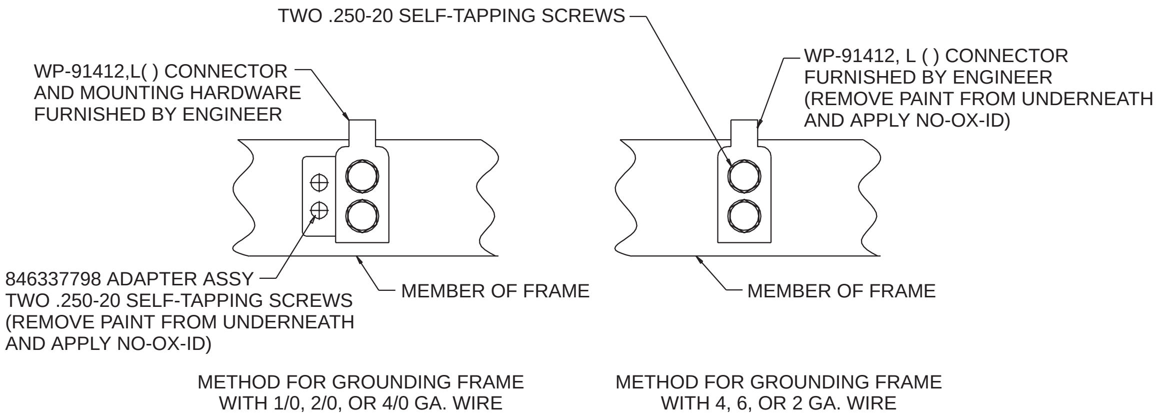


Figure 3-5: Frame Ground Adapter Assembly

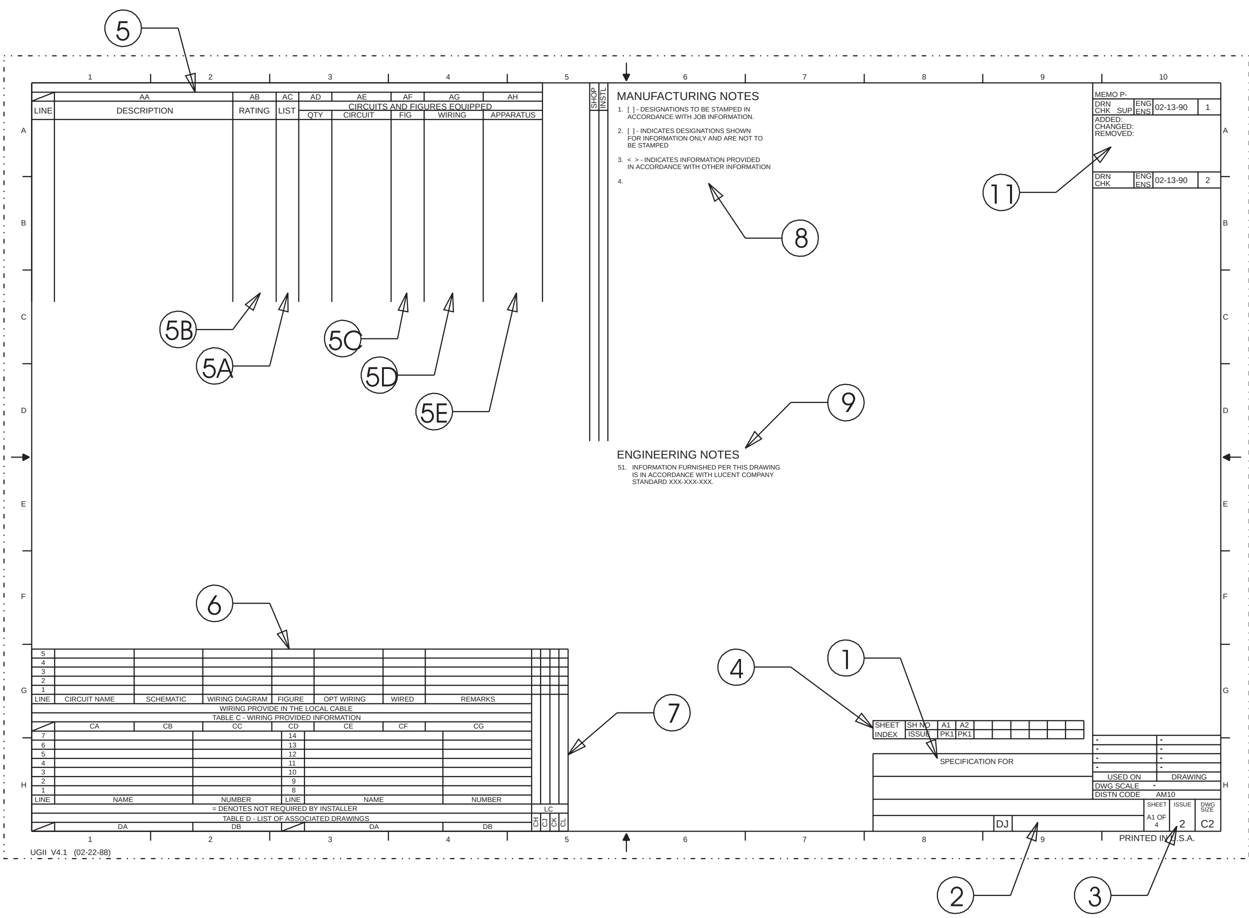


Figure 3-6: Typical J-Drawing A-Sheet

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. Customers may, however, choose 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. 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.

- Equipment to handle shipping containers, remove framework from shipping containers, and erect framework into final position. Minimum lifting capacity: 450 lbs.
- Common electrician's hand tools.
- Proper crimping tools and dies for connectors used.
- Common mechanic's hand tools.
- 18mm or 3/4-inch drill to bore holes for floor anchors.
- DMM (Digital Multimeter) with at least 0.05 % accuracy on the dc scale.
- DC Dummy Load Bank rated for 75 amperes minimum at 60 volts dc. For LVD/R option only: Power supply, variable from 0 to 60 volts dc at 2 amperes. Supply should have both coarse and fine output controls.
- For LVD/R option only: Six clip leads each capable of carrying 3 amperes.

Suggested installation sequence

1. The plant is wired with ac from the right side. Typical routing of ac, dc and control cabling is shown on the plant assembly drawing, J85500G-2. Connection points and wire types are indicated on the plant wiring diagram, T-82673-31.

2. All dc leads should be separated wherever possible from ac leads to minimize electrical noise transmitted to the load.

3. Pair the battery potential lead with the associated return lead of a given circuit for as much of the run as possible.

4. 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.)

5. All bolts making electrical connections should be torqued to the values in Table 4-A; all bolts for mechanical connections should be torqued to 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.

Unpacking, handling & frame installation

Before opening the packaging, carefully inspect the outside, in the presence of shipping personnel, for signs of damage. If you find damage, 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 2.1, 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, repack it in the original shipping crate.

Locate, shim and anchor the framework(s). Figure 4-1 shows typical floor mounting details for concrete floors. Other types of floor construction may require other mounting methods. Holes can be located using Figure 4-2. Note that primary mounting locations are at the outermost corners of each set of four holes (four anchoring devices per bay). Select alternate locations if primary locations would interfere with floor reinforcing bars. For multi-bay plants and for plants in aisle line-ups with compatible framework, frames may be tied together for extra rigidity.

Table 4-A: Minimum Torque For All Electrical Connections (e.g. Bus Bars)

Screw Size	Torques - Lb-in Or (Lb-ft)	
	Wire Connectors	**Mechanical Connectors**
8-32	15	19
10-24	21	27
1/4-20	50	65
5/16-18	100	135
3/8-16	180	240
7/16-14	280	385
1/2-13	(42)	(49)
5/8-11	(71)	(97)
3/4-10	(125)	(172)

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. Bellevile-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 For All Non-Electrical Connections (e.g. Floor Anchors)

Cap Screw Diameter	Torque (Ft-Lb) UNRC
1/4	6
3/16	12
3/8	22
7/16	35
1/2	54
9/16	77
5/8	107

Table 4-B: Torque For All Non-Electrical Connections (e.g. Floor Anchors)

Cap Screw Diameter	Torque (Ft-Lb) UNRC
3/4	190
1	290
1-1/4	580
1-1/2	1010

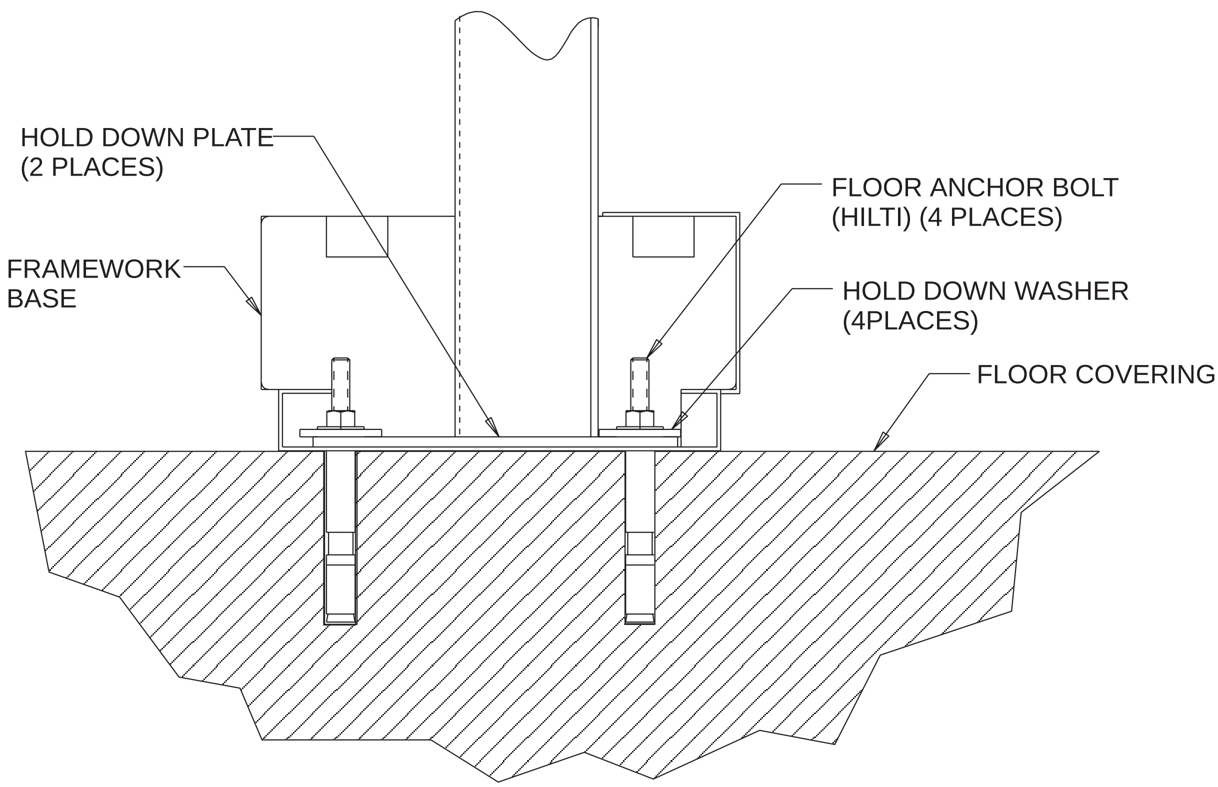


Figure 4-1: Typical floor mounting detail

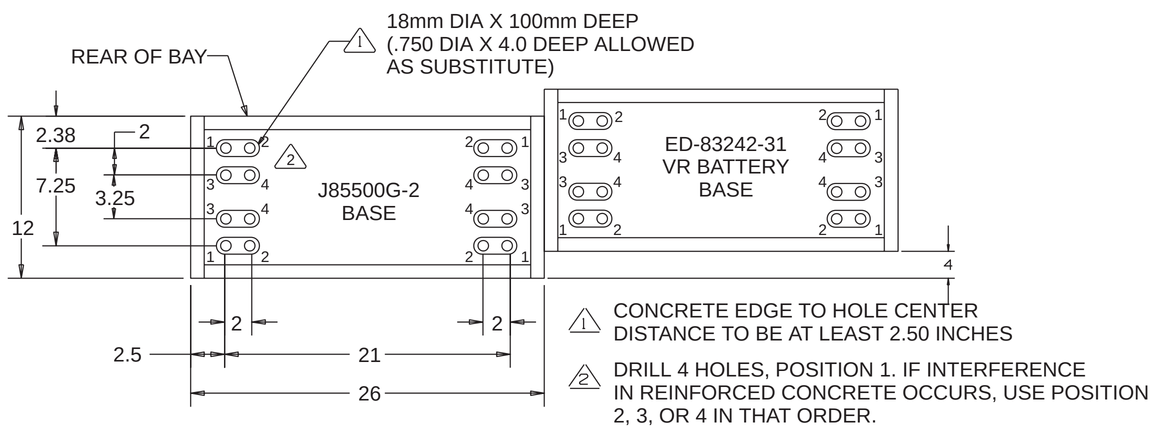


Figure 4-2: Floor mounting template (all dimensions are given in inches)

Battery stand assembly

WARNING:
DO NOT CONNECT BATTERIES
TO THE SYSTEM AT THIS TIME.

Assemble battery stands or shelves as instructed in the Lucent Technologies VR Battery manual or other battery manufacturer’s documentation. Install the batteries onto their stands or into their shelves.

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.

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.

Controller and LVD set-up

Follow the controller set-up procedure given in the ECS or Galaxy 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)

Table 4-C: Installation Reference Documents

Step	Procedure	Reference Document*
A	Unpacking, handling and frame installation	J85500G-2 drawing
B	Battery stand assembly	Battery manual
C	Initial battery charge	Battery manual 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, J85500G-2 drawing and T-82673-31 drawing
G	Load wiring	J85500G-2 drawing and T-82673-31 drawing
H	Battery connections, disconnect installation and test	J85500D-2 drawing, T-82670-31 drawing, T-82673-31 drawing and battery manual
I	Controller test	Controller manual
J	Load turn-up	Load equipment documentation
*See Section 3, Documentation References		

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 Figures 4-3 or 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.

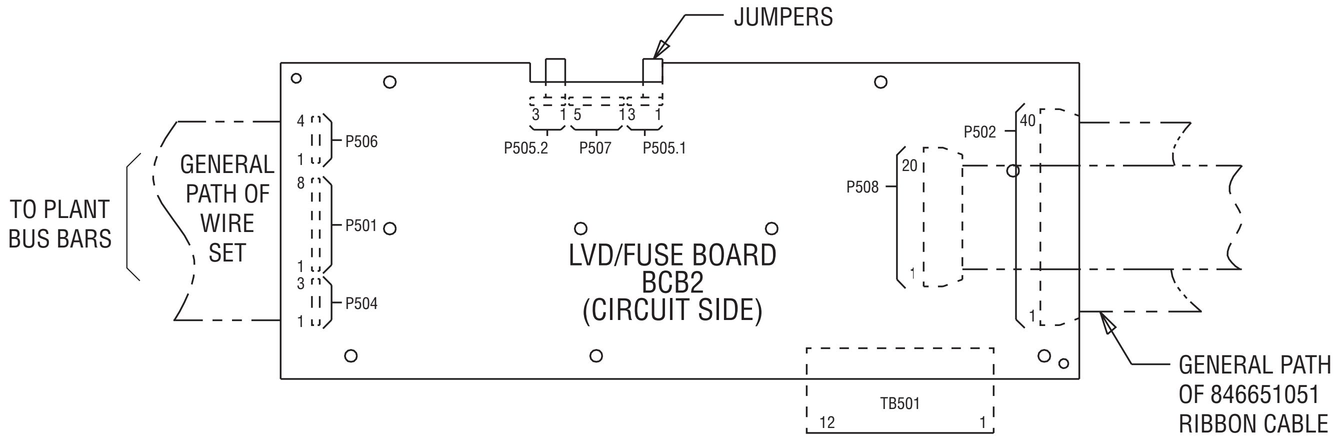


Figure 4-3: LVD/fuse board (CP5) jumper locations

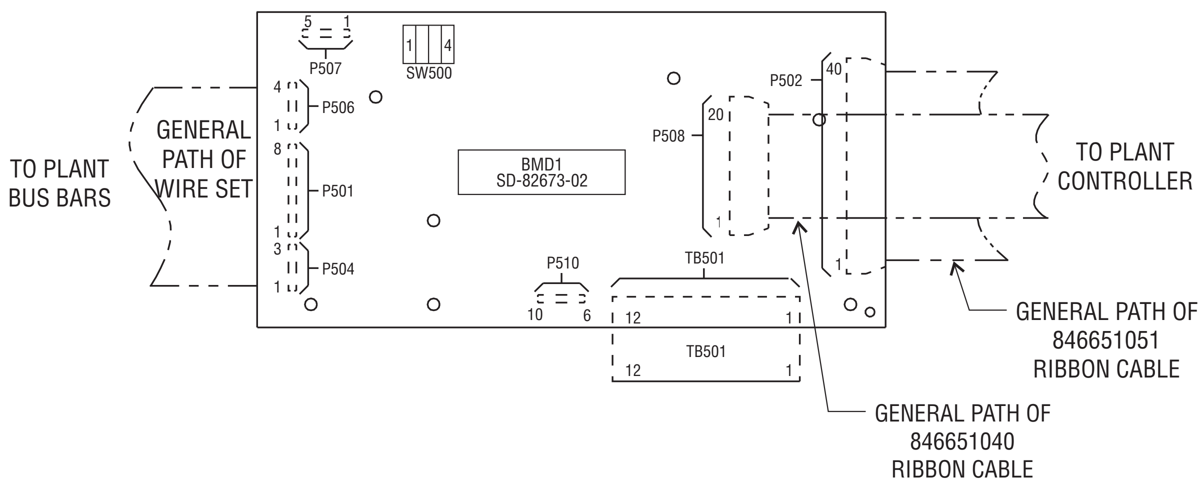


Figure 4-4: LVD/fuse board with thermal compensation circuitry (BMD1) switch locations

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:
AC wiring should be completed 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. It will also be possible to add a rectifier without shutting down adjacent rectifiers to gain access to space for additional ac wiring.

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

Load wiring

For the initial bay, open the dc distribution cover panel by turning the two 1/4 turn fasteners located on the front of the panel.

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 or fuse and from the discharge return bus. The load supply leads are terminated at the breaker and fuse panels (directly to the breaker or fuse terminal end). The load return leads are terminated at the battery plant end on the discharge return bus, located at the top front of the bus bar arrangement.

For the supplementary bay, terminate the charge feeder cable to the initial bay charge bus bar. As in the initial bay, run load supply cable from the breaker and fuse panels and load return leads to the discharge return bus in the initial bay.

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, J85500G-2 or in Figure 3-4. Consult the job application drawings for the routing of these leads to the load equipment.

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

Battery connections, installation and test

For an ECS controller, remove all fuses from CP5 Fuse Board. For a Galaxy controller, remove all controller fuses, which are located inside the controller. Confirm that the output circuit breakers of all rectifiers and that 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.

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 J85500G-2 drawing or Figure 3-4. 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 (either intercell connector or disconnect breaker).

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

Note:
The white indicators on F1 through F11 and F13 through 18 represent a 1-1/3 amp rating, the orange indicator on F12 represents a 2 amp rating and the green indicator on F19 through 21 represents a 5 amp rating.

Controller test

Follow the controller test procedure given in the ECS or Galaxy 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.

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. If a 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.

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 (associated with additional rectifier 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.

1. See Section 3 for details on sizing additional circuit breakers.

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

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.

3. Locate the intended new breaker or fuse panel. Blank panels must be removed. Some can be reused to cover empty space after installation. Ensure that breakers are switched to the OFF position or that fuses are not loaded.

4. Install the load leads by following item on Load Wiring, above.

5. Mark the new circuit on the distribution cover panel label.

6. For safety, mount 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.

7. Turn on the load circuit breaker or install the fuses. If the circuit breaker trips or the fuse blows 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 or add another fuse. If the breaker trips or the fuse blows again, check the wiring to the load circuit.

8. When all work on the dc distribution is complete, close the distribution cover and notify the alarm reporting center.

Installing thermal compensation unit in existing plant

The 216A ECS Thermal Compensation Unit described in Section 2 can be retrofitted into a J85500G-2 battery plant. The Kit (Comcode 847732088) contains the circuit packs, wiring and hardware the monitor one string of batteries. Read the instruction blow before beginning, observe all the safety warnings and notes, and follow the instructions step by step.

Tools Required:

- 5/16″ Nutdriver
- 7/16″ Nutdriver
- Jeweler’s Screwdriver
- Wire Strippers (22 AWG)
- Heat Gun

OBSERVE ALL SAFETY WARNINGS AND NOTES BEFORE BEGINNING INSTALLATION.

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

1. **For use with Lucent VR Batteries:**

   Mount the VR Module bracket to any one of the available 1/4-20 Pem-nuts in the battery stand upright. Then attach the Terminal Block Assembly Base to the VR Module bracket with the 10-32 screws provided. (See Figure 4-9.)

   For use with alternate vendor batteries, three options are recommended.

   Option 1: Mount the VR Module bracket to the plant frame work (List 1 or List 3): (a) below the lowest Rectifier shelf if 2 or less shelves are present, using (2) 10-32 screws provided or (b) on the frame work in an unused end rectifier position , using (2) 10-32 screws provided. Consider further plant growth (rectifier shelves/rectifiers) before choosing this option. (See Figure 4-8 for Option 1).

Option 2: Mount the 216A Control Unit on the distribution door panel (lower left corner) using the adhesive backed Velcro strips provided. Make sure the surface of the distribution door is clean before peeling the backing off the Velcro hooks and affixing to the distribution door. Make sure the back surface of the Terminal Block Assembly is clean before peeling the backing off the Velcro loops and affixing to the Terminal Block Assembly. Mount the Terminal block Assembly on the distribution door. Consider the protrusion of the 216A Control Unit before choosing this option. (See Figure 4-9 for Option 2).

Option 3: Mount the 216A Control Unit on the battery stand (not the batteries) in any convenient location using either the VR Module bracket and 1 or 2 10-32 screws, or using the Velcro strips. If the Velcro strips are used, affix the Velcro hooks to a clean surface on the battery stand and the Velcro loops to the back of the Terminal Block Assembly (must be cleaned). Consider the distance between the battery plant and the battery stand before choosing this option.

2. Temporarily insert the thermistors in the battery locations to be monitored. See Figure 4-7 for suggested locations between the AT&T VR Batteries. Dress the thermistor wire sets from the Terminal Block Assembly to the thermistors and cut to proper length. The thermistors will need to be removed from the battery string during testing so do not secure them into place at this time.

3. Connect all thermistor wire sets (max. = 8 per 216A) to terminal blocks TB101 & TB102 as shown in Figure 4-11. **The ambient temperature of the thermistor must be between 0°C (32°F) and 53°C (127.4°F)** when the wire set is connected to the Terminal Block Assembly in order for the proper temperature to be sensed by the 216A Control Unit.

4. Mate the 216A Control Unit to the Terminal Block Base Assembly. See Figure 4-10. Latch the two units together with the clips on the base.

5. Repeat steps 1-3 for additional battery strings.

WARNING:
The batteries will be disconnected from the Load Bus during the replacement of the LVD/FUSE Board (Steps 7 - 12). If commercial power fails during this procedure, -48VDC will be lost to the using equipment. If this causes concern, a generator should be utilized.

6. Open distribution door.

Note:
Step 7 will cause the LVD/R Contactor to OPEN.

7. Unplug the following connectors from the BCB2 LVD/Fuse Board. Leave the cables dressed.

   * P502 from J502
   P506 from J506
   P501 from J501
   P504 from J504

   * Slide the ribbon cable removed from P502 so the connector is against the plastic holder. Dress the excess cable into the distribution. Be sure to leave enough cable to allow the door to open completely.

8. Remove the cover over the BCB2 LVD/Fuse Board and then remove the insulated standoffs to free the board.

9. Set SW500 on the BMD1 LVD/Fuse Board for the desired configuration. SW500.2 should be placed in the open position (Compensation Disabled) at this time. See Table 4-D.

10. Remove Fuses F507, F508, F509, F511 and F512 from the BMD1 LVD/R Fuse Circuit Pack.

11. Mount the BMD1 LVD/Fuse board to the distribution door assembly as shown in Figure 4-6.

Note:
Step 12 will cause the LVD/R Contactor to CLOSE.

12. Reconnect the following connectors in order listed below:

- P502 to J502
- P506 to J506
- P501 to J501
- P504 to J504

13. If you are installing more than one 216A Control Unit use Cable Assembly 847586815 to interconnect each unit. The 216A Control Units will be daisy-chained from P512 to P511 up to a maximum of five units. The last unit connected will need Terminator Plug 847631363 inserted into P512.

14. Connect the 216A Control Unit Interface Cable Assembly (847586815) to P510 on the BMD1 LVD/Fuse Board and dress cable out of the distribution and down to the 216A Control Unit connecting to P511.

15. Close all doors and ensure all covers are installed properly.

16. Replace F507, F508, F509, F511 and F512 with their respective fuses into the BMD1 LVD/R Fuse Circuit Pack. **NOTICE F512 HAS ORANGE TAB (2 AMP).**

17. Place the WARNING label on the controller face close to the output display

18. Locate the INFORMATION label approximately as shown in Figure 4-9 (option 2) to cover the original label. This INFORMATION label (Comcode 847754835) is for Thermal Slope/Step Compensation Without LVD feature ONLY.

Table 4-D: SW500 Reference

Conditions		**216A Status**	**Plant Voltage**				
Compensation enabled	**Margin level**	**Compensation**	**Temperature in degrees Celsius**				
SW500.2	**SW500.4**		**0 - 25**	**25 - 53**	**53 - 75**	**75+**	**+75 to <65**
1	0	Enabled	V FLT +72mV/°C	V FLT -72mV/°C	V FLT -2.0VDC	V FLT -6.0VDC	V FLT -2.0VDC
1	1	Enabled	No Change	V FLT -72mV/°C	V FLT -2.0VDC	V FLT -6.0VDC	V FLT -2.0VDC
*0	*1	Disabled	No Change				
0	0	Disabled	No Change				
SW500.1	SW500.3	Low Voltage Disconnect/Reconnect Voltage Levels					
*1	*1	-42.5 VDC					
0	0	-40.5 VDC					

"1" represents switch in closed position
"0" represents switch in open position
"V FLT represents uncompensated plant float voltage
Notice that "+" or "-" determines which direction the voltage compensates
* indicates factory default

Test Procedure

Note: Reset the BD alarm on the controller to 3.0 VDC below the float voltage. Reset the HVSD level to 3.0 VDC above the float voltage when the margining feature is enabled. See J85500D-x assembly drawing for DIP switch settings.

1. Open the distribution door and set SW500.2, on the BMD1 LVD/R Fuse Circuit Pack to the closed position. This will enable the compensation feature. Close the distribution door.

2. Check to see that the green LED on the 216A Control Unit is ON.

3. Verify that there are no alarms being generated on the ECS Controller.

4. Heat thermistors with **INDIRECT** airflow from a heat gun. Heat applied directly to the thermistor could cause damage.

5. Observe the following steps:
   A minor fuse alarm (MNF) should be issued at

approximately the same time that the yellow LED on the 216A Control Unit is turned on which should correspond to a two-volt drop in the float voltage.

A major fuse alarm (MJF) should be issued at the same time as the yellow LED on the 216A Control Unit begins blinking. The six-volt drop will not be seen because the batteries will not discharge that quickly.

6. Allow the thermistors to cool, then insert and secure them into the battery string.

7. Verify that no alarms are present at this time.

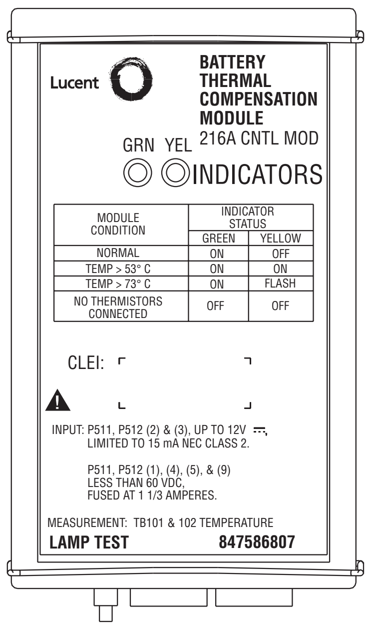


Figure 4-5: 216A Battery Thermal Compensation Control Unit faceplate

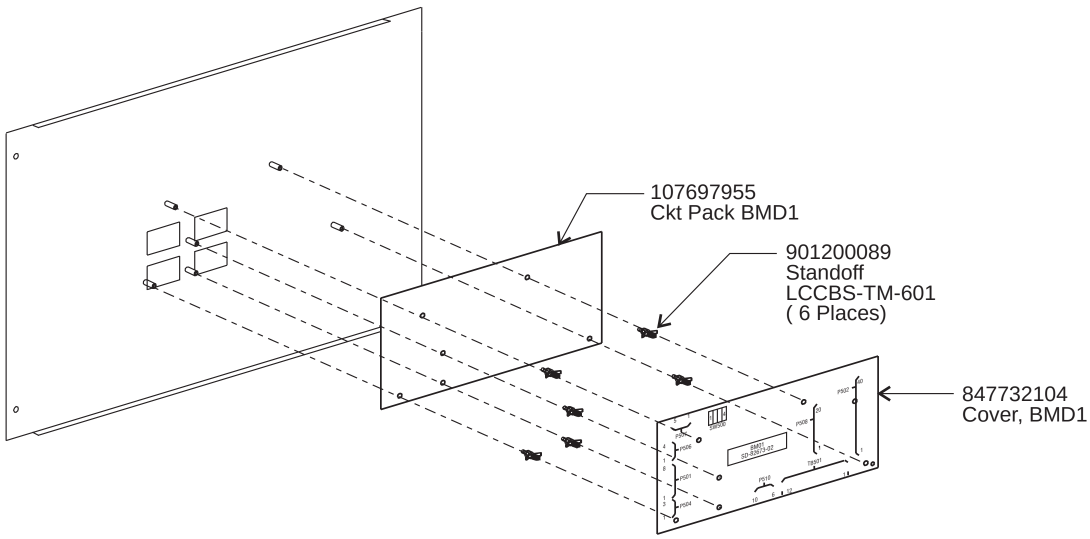


Figure 4-6: Door assembly

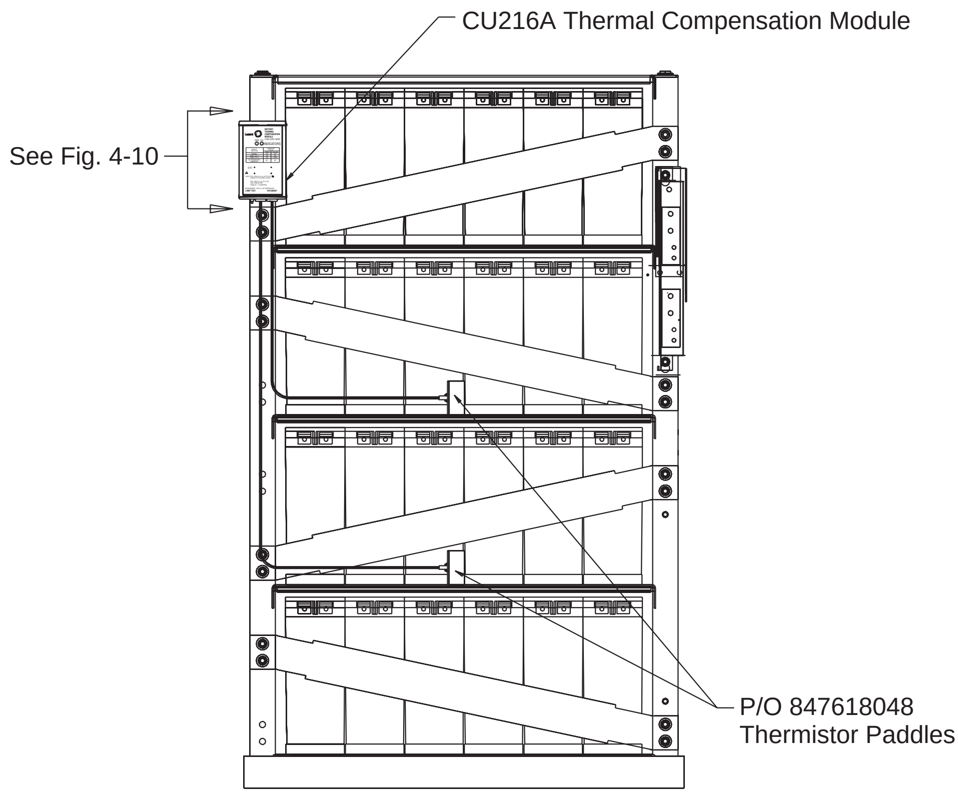


Figure 4-7: VR Battery stand (placement of thermistors)

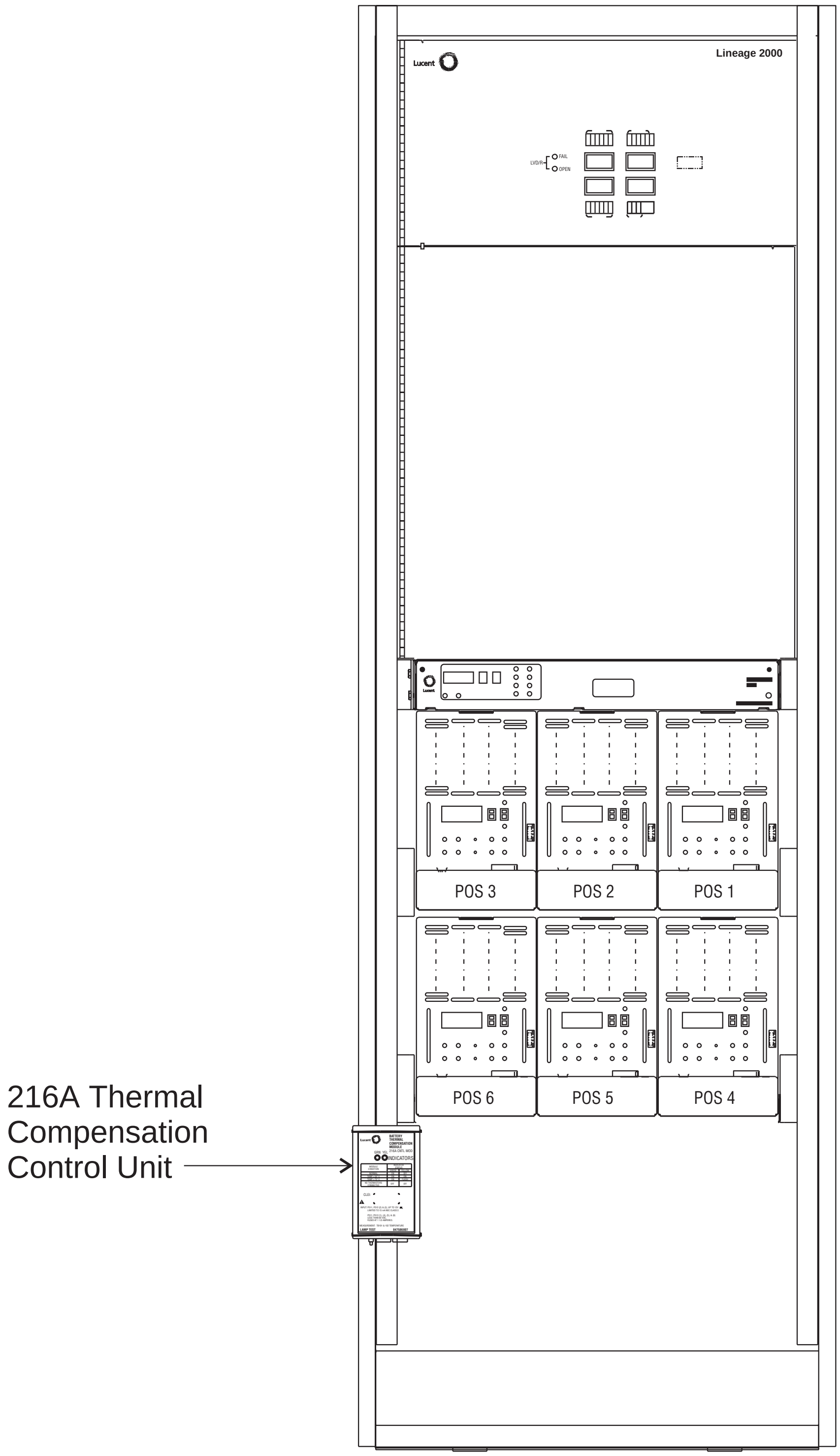
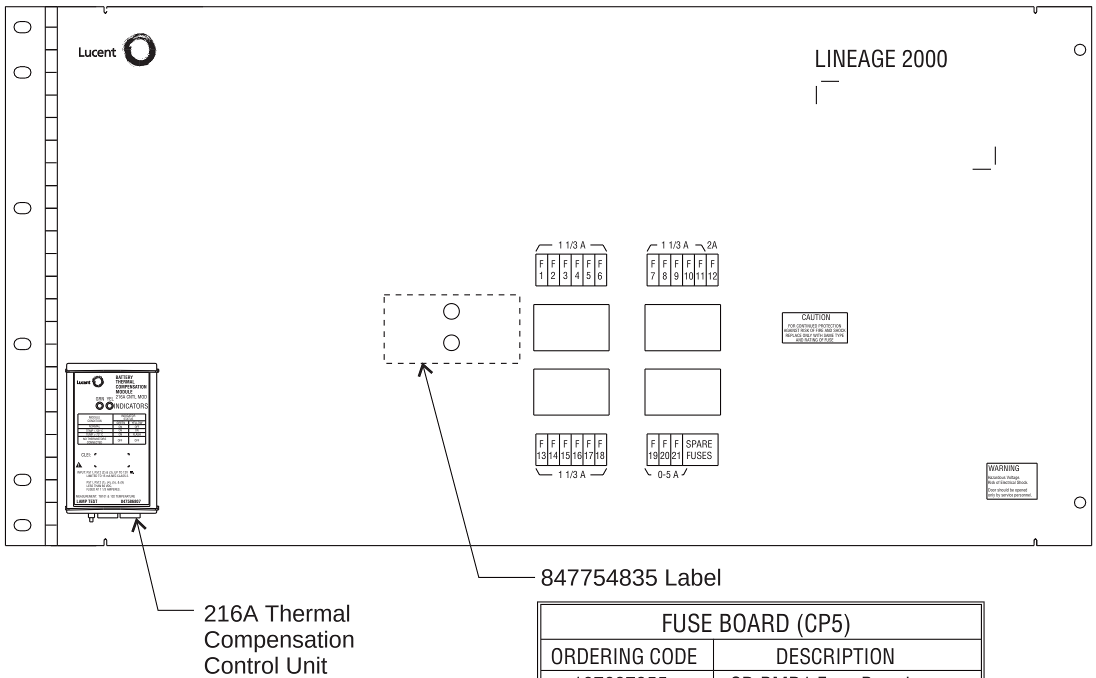


Figure 4-8: Plant frame work (placement of control unit, option 1)



FUSE BOARD (CP5)	
ORDERING CODE	DESCRIPTION
107697955	CP-BMD1 Fuse Board
405673146	1 1/3 A Fuse (WP90247 L7)
405181983	2A Fuse (WP90247 L9)
406195061	5A Fuse (WP90247 L13)

Figure 4-9: Door panel (placement of control unit, option 2)

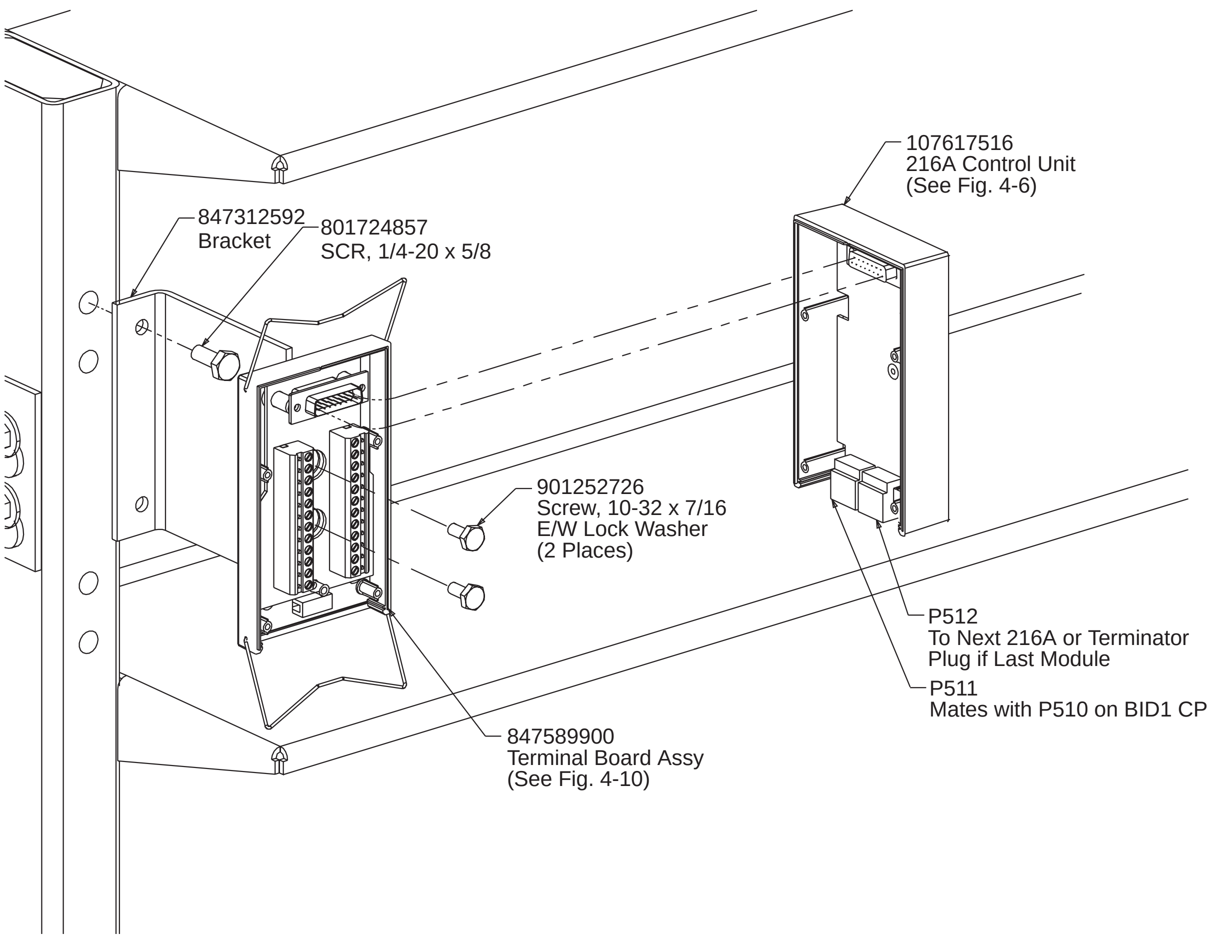


Figure 4-10: 216A Battery Thermal Compensation Control Unit installed on frame

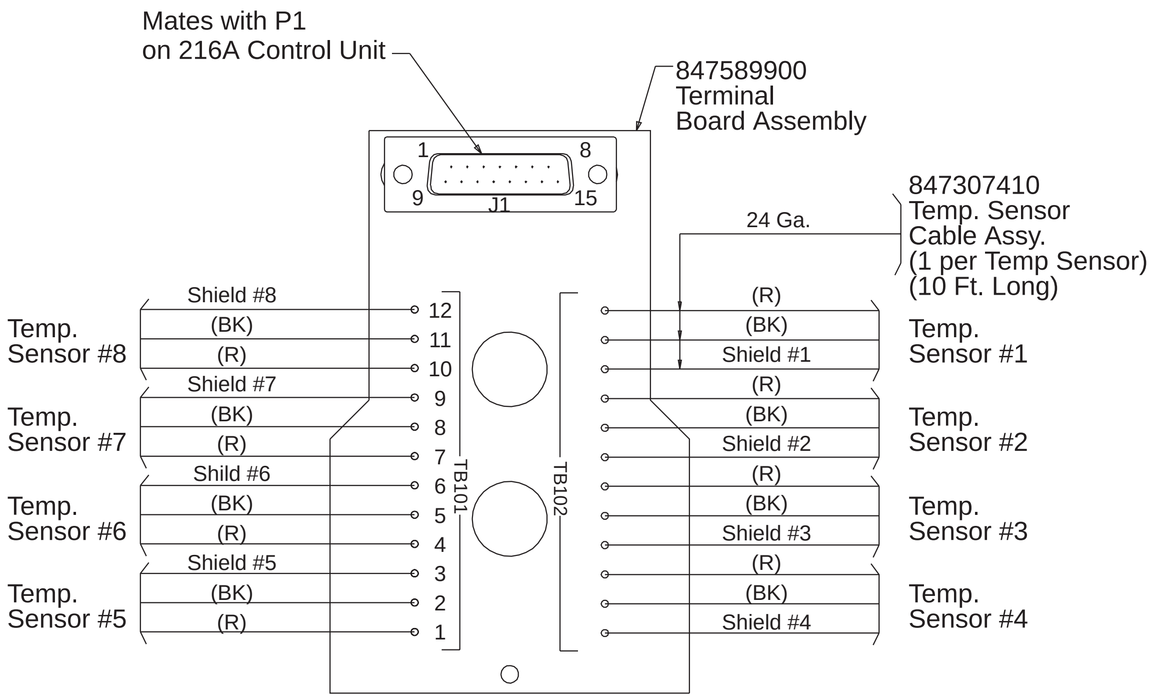


Figure 4-11: Terminal block assembly

5 Maintenance

Controls and Indicators

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

For Controller LEDs and switches, see Controller Manual.

For Rectifier LEDs and switches, see Rectifier Manual.

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.

1. 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.

2. 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 F21 are also located on the CP5 LVD/Fuse Board for an ECS controller. They provide power for controller functions and rectifier regulation. When a fuse blows the colored indicator (white, orange or green) pops up and an alarm signal is transmitted to the controller. The fault should be cleared before replacing a blown fuse. Refer to the ECS Controller manual for troubleshooting procedures.

DC Circuit Breakers/Fuses

Any circuit breaker mounted in the List 20 panel 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. All fuse blocks in the battery plant have indicating fuses that allow a red element to pop out when a fuse blows (opens). If a breaker has tripped off or a fuse blows, the overcurrent problem should be cleared before restoring power to the load by resetting the breaker or replacing the fuse. See "Troubleshooting," below, for information on tripped breakers or blown fuses.

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.

Table 5-A: Troubleshooting

Observed Condition	Probable Cause	Procedure
Controller Subsystem		
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	
Rectifier Subsystem		
Red or yellow LEDs lit No LEDs or Display lit No output/low output Oscillation Open output breaker	See "Troubleshooting" in Rectifier Manual	
DC Distribution Subsystem		
Open distribution breaker or fuse	a. Breaker manually turned off b. overcurrent trip (open) c. breaker or fuse failure	Open distribution breaker or fuse, below
"LVD OPEN" LED lit	a. failed LVD contactor b. low voltage c. faulty wiring d. LVD circuit failure	Red LVD OPEN LED lit, below
"LVD FAIL" LED lit	a. low voltage b. LVD circuit failure	Yellow LVD FAIL LED lit, below

Open Distribution Breaker or Fuse

A distribution breaker or fuse 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 or fuse may be open due to a short circuit in the load equipment or wiring. The fault must be cleared before resetting the breaker, except when the open 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. A failed fuse must always be replaced. See procedure for Load Circuit Breaker or Fuse 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 for 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 (see drawing T-82673-31).

4. Both redundant LVD sensing circuits have failed. The CP5 circuit pack must be replaced. See procedure for 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 for LVD/Fuse Board (CP5) Replacement, below.

Repair and Replacement

Notice:
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 or Fuse Replacement

Procedure: (Refer to Figures 2-4 through 2-9 and T-82673-31 drawing)

1. Obtain a replacement circuit breaker. See “Spare Parts,” below.

2. Verify that the faulty breaker is in the OFF position or that a blown fuse is actually in the fuse block.

3. Unscrew the panel cover.

4. Measure the voltage at the load connection associated with the faulty breaker or fuse, to verify that the breaker or fuse is truly open. The voltage relative to the battery bus bars or distribution panel bus bar should be approximately the float voltage of the plant. With a blown fuse, the indicating fuse can be replaced to verify that the fuse is truly open. If the faulty breaker or fuse is, in fact, still closed, the load equipment which it powers must be shut down so that no current flows through the breaker/fuse arrangement during the following replacement steps.

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

5. Disassemble the faulty breaker from the panel or remove the load fuse and indicating fuse from the fuse block.

6. Switch the new circuit breaker, if applicable, to the OFF position before plugging it in.

7. Assemble the new breaker or fuse, ensuring that line, load and alarm connectors are properly mated.

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

8. Turn on the load circuit breaker, if applicable. If the circuit breaker trips immediately when turned on, or the fuse blows when installed, this may be due to inrush current and does not necessarily indicate a fault condition. Attempt to close the circuit breaker or add another fuse a second time. If the breaker or fuse trips or opens again, check the wiring to the load circuit.

9. Note that Fuse Alarm Major, FAJ (MJF) and its associated alarms retire.

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 Figures 2-10 and 4-3 and T-82673-31 drawing)

1. Remove rectifier in position directly beneath LVD/R contactor (position 1), if present.

2. Open LVD/fuse panel door and unplug connector P501 from J501 on LVD/Fuse board (CP5). Leave cable dressed.

3. Disconnect and label the 5 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 rectifier and turn on.

8. Close LVD/fuse panel door and verify that LVD FAIL and LVD OPEN lights are not lit.

LVD/Fuse Board (CP5) Replacement

The following equipment is required:

- standard screwdriver

Procedure: (Refer to Figure 4-3 and T-82673-31 drawing)

WARNING: Failure to follow procedure could result in service interruption.

1. Remove control cable from front of rectifiers so rectifiers will remain on.

2. Strap out low voltage contactor (if equipped) to keep batteries connected.

3. Open distribution panel.

4. Unplug the following connectors from the LVD/Fuse Board (CP5). Leave the cables dressed.

   J502 from P502
   J508 from P508
   J506 from P506
   J501 from P501
   J504 from P504
   Wires from TB501

5. Remove the 6 mounting screws.

6. Set jumpers J505.1 and J505.2 on replacement LVD/Fuse Board (CP5). See J85500G-2 drawing for desired disconnect voltage.

7. Mount the replacement board to the distribution panel using the hardware from Step 3.

8. Reconnect the following connectors:

   J502 to P502
   J508 to 508
   J506 to P506
   J501 to P501
   J504 to P504
   Wires to TB501

9. Close distribution panel.

Spare Parts

The following equipment may be ordered as spare parts. For exact ordering codes, refer to recommended spares information on the J85500G-2 drawing.

- Rectifiers and fans
- Circuit Breakers (Refer to ED83119-30)
- Fuses (1-200 ampere)
- LVD/Fuse Board (CP5)
- Fuses (F1 to F21)
- Controller Circuit Packs (Refer to the Controller manual)
- LVD/Fuse Thermal Compensation Board (BMD1)
- CU-216A Thermal Compensation Control Unit

In addition to these items, any piece part may be ordered that is identified in the assembly views and stocklist on the J85500G-2 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.

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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