

Lucent Technologies
Bell Labs Innovations



Lineage[®] 2000
300-Ampere, -48-Volt
ECS Battery Plant
J85500D-3

Product Manual
167-790-064
Comcode 107418287
Issue 5
January 1999
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Table of Contents

1 Introduction

<i>General</i>	<i>1 - 1</i>
<i>Documentation</i>	<i>1 - 2</i>
<i>Customer Training</i>	<i>1 - 2</i>
<i>Customer Service</i>	<i>1 - 2</i>
<i>Technical Support</i>	<i>1 - 2</i>
<i>Product Repair and Return</i>	<i>1 - 3</i>

2 Product Description

<i>Plant specifications</i>	<i>2 - 1</i>
<i>Typical battery plant description</i>	<i>2 - 2</i>
<i>Battery plant subsystems</i>	<i>2 - 3</i>
<i>ECS battery plant physical description</i>	<i>2 - 4</i>
<i>Initial bay</i>	<i>2 - 4</i>
<i>Supplementary bays</i>	<i>2 - 4</i>
<i>ECS battery plant subsystems</i>	<i>2 - 5</i>
<i>Rectifier</i>	<i>2 - 6</i>
<i>Batteries</i>	<i>2 - 6</i>
<i>Controller</i>	<i>2 - 7</i>
<i>DC distribution</i>	<i>2 - 7</i>
<i>ECS dc distribution panel</i>	<i>2 - 10</i>
<i>Distribution bus bars</i>	<i>2 - 10</i>
<i>Plant shunt</i>	<i>2 - 10</i>
<i>Low voltage battery disconnect/reconnect (LVD/R) feature</i>	<i>2 - 11</i>
<i>Low voltage load disconnect/reconnect (LVLD/R) feature</i>	<i>2 - 12</i>
<i>Circuit breakers/fuses</i>	<i>2 - 12</i>
<i>Thermal (slope/step) compensation feature</i>	<i>2 - 12</i>

3 Engineering, Planning and Ordering

<i>General engineering calculations</i>	<i>3 - 2</i>
<i>Load equipment voltage</i>	<i>3 - 2</i>
<i>Battery voltage</i>	<i>3 - 3</i>
<i>Load drain and growth</i>	<i>3 - 4</i>

<i>Reserve capacity</i>	3 - 6
<i>Charge capacity and recharge time</i>	3 - 8
<i>Battery string voltage drop and balancing</i>	3 - 9
<i>Battery size versus voltage drop</i>	3 - 10
<i>Calculating voltage drop</i>	3 - 12
<i>Conductor ampacity</i>	3 - 12
<i>Overcurrent protection</i>	3 - 13
<i>General guidelines</i>	3 - 13
<i>Fuses</i>	3 - 13
<i>Circuit breakers</i>	3 - 14
<i>Lineage[®] 2000 engineering specifics</i>	3 - 14
<i>Rectifier sizing</i>	3 - 14
<i>Battery sizing</i>	3 - 15
<i>Initial and supplementary bays</i>	3 - 16
<i>Cable and load breaker sizing</i>	3 - 17
<i>Record wire and breaker/fuse sizes</i>	3 - 24
<i>Low-voltage battery disconnect/reconnect feature</i>	3 - 26
<i>Low-voltage load disconnect/reconnect feature</i>	3 - 26
<i>Thermal (slope/step) compensation feature</i>	3 - 26
<i>Controller options</i>	3 - 26
<i>Alarm system interface</i>	3 - 26
<i>Earthquake bracing</i>	3 - 27
<i>Planning</i>	3 - 27
<i>Floor plan data</i>	3 - 27
<i>Grounding</i>	3 - 28
<i>Growth</i>	3 - 28
<i>Ordering reference material</i>	3 - 29
<i>Coding and terminology</i>	3 - 29
<i>J-drawings</i>	3 - 30
<i>T-drawings</i>	3 - 34
<i>SD-drawings</i>	3 - 35
<i>Ordering information</i>	3 - 36
<i>Ordering guide (list numbers)</i>	3 - 37
<i>Supplementary components (field installed)</i>	3 - 38
<i>Documentation references</i>	3 - 40

4 Installation

<i>General</i>	4 - 1
<i>Installation tools and test equipment</i>	4 - 2
<i>Suggested installation sequence</i>	4 - 2
<i>Sequence of tasks</i>	4 - 4
<i>Step A: Unpacking, handling & frame installation</i>	4 - 4
<i>Step B: Battery stand assembly</i>	4 - 5
<i>Step C: Cable support and ground system</i>	4 - 5
<i>Step D: Controller and LVD set-up</i>	4 - 5

<i>Step E: AC wiring, rectifier installation and test</i>	4 - 6
<i>Step F: Battery connections</i>	4 - 6
<i>Step G: Load wiring</i>	4 - 7
<i>Step H: Initial charge</i>	4 - 12
<i>Step I: Controller test</i>	4 - 12
<i>Step J: Load turn-up</i>	4 - 12
<i>Installation procedures for plant growth</i>	4 - 13
<i>Adding a load circuit</i>	4 - 13
<i>Installing thermal compensation unit in existing plant</i>	4 - 15
<i>Tools required</i>	4 - 15
<i>Test procedure</i>	4 - 18

5 Maintenance

<i>Controls and Indicators</i>	5 - 1
<i>DC Circuit Breakers</i>	5 - 1
<i>Troubleshooting</i>	5 - 3
<i>Open Distribution Breaker</i>	5 - 3
<i>Red LVD OPEN LED Lit</i>	5 - 4
<i>Yellow LVD FAIL LED Lit</i>	5 - 4
<i>Blown Fuse on LVD/Fuse Board</i>	5 - 4
<i>Repair and Replacement</i>	5 - 4
<i>Load Circuit Breaker Replacement</i>	5 - 5
<i>LVD/R Contactor Replacement</i>	5 - 6
<i>LVD/Fuse Board (CP5) Replacement</i>	5 - 7
<i>Spare Parts</i>	5 - 7

6 Product Warranty

7 Safety

<i>Safety Statements</i>	7 - 1
<i>Warning Statements And Safety Symbols</i>	7 - 3

List of Figures

<i>Figure 1-1: Lineage[®] 2000 ECS Battery Plant (Model J85500D-3, initial bay equipped with VR battery stand)</i>	<i>1 - 4</i>
<i>Figure 1-2: VR Battery supplementary bay configurations per J85504C-1</i>	<i>1 - 5</i>
<i>Figure 1-3: Lineage[®] 2000 ECS Battery Plant (Model J85500D-3, initial bay equipped with 12IR125 battery stand)</i>	<i>1 - 6</i>
<i>Figure 2-1: Block Diagram of Typical Battery Plant</i>	<i>2 - 3</i>
<i>Figure 2-2: ECS Battery Plant Block Diagram</i>	<i>2 - 5</i>
<i>Figure 2-3: ECS distribution bus bars</i>	<i>2 - 8</i>
<i>Figure 2-4: Plug-in circuit breaker mounting</i>	<i>2 - 9</i>
<i>Figure 2-5: ECS dc distribution panel (front view)</i>	<i>2 - 10</i>
<i>Figure 3-1: Rack Construction of List 15 Bay</i>	<i>3 - 42</i>
<i>Figure 3-2a: Bay Dimensions and Clearances (List 1 equipped with List 9)</i>	<i>3 - 43</i>
<i>Figure 3-2b: Bay Dimensions and Clearances (List 1 equipped with List 10 or List 11)</i>	<i>3 - 44</i>
<i>Figure 3-3: Frame Ground Adapter Assembly</i>	<i>3 - 45</i>
<i>Figure 3-4: Typical J-Drawing A-Sheet</i>	<i>3 - 46</i>
<i>Figure 4-1: Typical floor mounting detail</i>	<i>4 - 8</i>
<i>Figure 4-2: Floor mounting template, VR battery installation (all dimensions are given in inches)</i>	<i>4 - 9</i>
<i>Figure 4-3: Floor mounting template, 12IR125 battery installation (all dimensions are given in inches)</i>	<i>4 - 10</i>
<i>Figure 4-4a: LVD/Fuse Board (BAD1) jumper locations</i>	<i>4 - 11</i>

<i>Figure 4-4b: LVD/Fuse Board (BAD10)</i>	<i>4 - 11</i>
<i>Figure 4-5: LVD/Fuse Board with thermal compensation circuitry (BID1) switch locations</i>	<i>4 - 12</i>
<i>Figure 4-6: 216A Battery Thermal Compensation Control Unit faceplate</i>	<i>4 - 19</i>
<i>Figure 4-7: Door assembly</i>	<i>4 - 20</i>
<i>Figure 4-8: VR Battery stand (placement of thermistors)</i>	<i>4 - 20</i>
<i>Figure 4-9: 216A Battery Thermal Compensation Control Unit installed on frame</i>	<i>4 - 21</i>
<i>Figure 4-10: Terminal block assembly</i>	<i>4 - 22</i>
<i>Figure 5-1: Fuse Designation and Function for LVD/Fuse Board</i>	<i>5 - 2</i>

List of Tables

<i>Table 2-A: Lineage[®] 2000 Battery Plant Specifications (Model J85500D-3)</i>	<i>2 - 1</i>
<i>Table 3-A: Initial Load Drain Information</i>	<i>3 - 6</i>
<i>Table 3-B: Anticipated Future Load Drain Information</i>	<i>3 - 6</i>
<i>Table 3-C: Reserve Capacity</i>	<i>3 - 7</i>
<i>Table 3-D: Terminal Lug Kits for Circuit Breakers or Fuse Holders</i>	<i>3 - 18</i>
<i>Table 3-E: Terminal Lugs for Flex and Stranded Wires, List 3 - 6 Distribution Panels</i>	<i>3 - 21</i>
<i>Table 3-F: Terminal Lugs For Connecting IR Battery Cables To The Distribution Panel</i>	<i>3 - 21</i>
<i>Table 3-G: VR Battery Cable and Lug Information</i>	<i>3 - 22</i>
<i>Table 3-H: Field-Installed Components For List 3 through 6 and 23 through 26 Distribution Panels</i>	<i>3 - 22</i>
<i>Table 3-I: Load Feeder Wire And Fuse/breaker Size</i>	<i>3 - 25</i>
<i>Table 3-J: Minimum Wire Gauge (Ampacity) - All Strings</i>	<i>3 - 25</i>
<i>Table 3-K: Ordering Guide J85500D-3 ECS 300 Ampere -48 Volt Battery Plant</i>	<i>3 - 37</i>
<i>Table 3-L: Supplementary Components (Field Installed)</i>	<i>3 - 38</i>
<i>Table 4-D: SW500 Reference</i>	<i>4 - 18</i>

1 Introduction

General

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 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, J85500D-3, is shown in Figure 1-1. This member of the ECS family of battery plants operates from a nominal 208/240-volt ac, 50/60-Hz source. It offers a 300-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, a distribution panel capable of accepting up to 42 circuit breakers, an ECS controller, space for two rectifier shelf assemblies which can connect up to six -48-volt, 50-ampere switch mode rectifiers and space for one 48-volt string of Lineage[®] 2000 250- or 375-ampere hour VR Series batteries or four 48-volt strings of 125-ampere hour IR Series batteries.

The plant's modular front-access design facilitates installation, growth and use in confined locations. Plant output current capacity is increased by adding Lineage[®] 2000 50-ampere, -48-volt rectifiers to the rectifier shelf assemblies. Two optional circuit packs may be added to the basic controller, one to provide microprocessor-based features and the second to provide a

datalogger. Supplementary battery bays (J85504C-1 and J85504D-1) add battery reserve time. These bays can house up to two 48-volt strings of 250- or 375-ampere hour batteries or four 48-volt strings of 125-ampere hour IR Series batteries to provide a maximum of 2625 ampere hours at the 10-hour rate.

Documentation

This document (Lucent Technologies 167-790-064) is part of a set of product manuals which provide information on the Lineage[®] 2000 Evolutionary Control System (ECS) Battery Plant and its components. See Documentation References in Section 3 for the contents of the documentation package.

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.

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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.

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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.

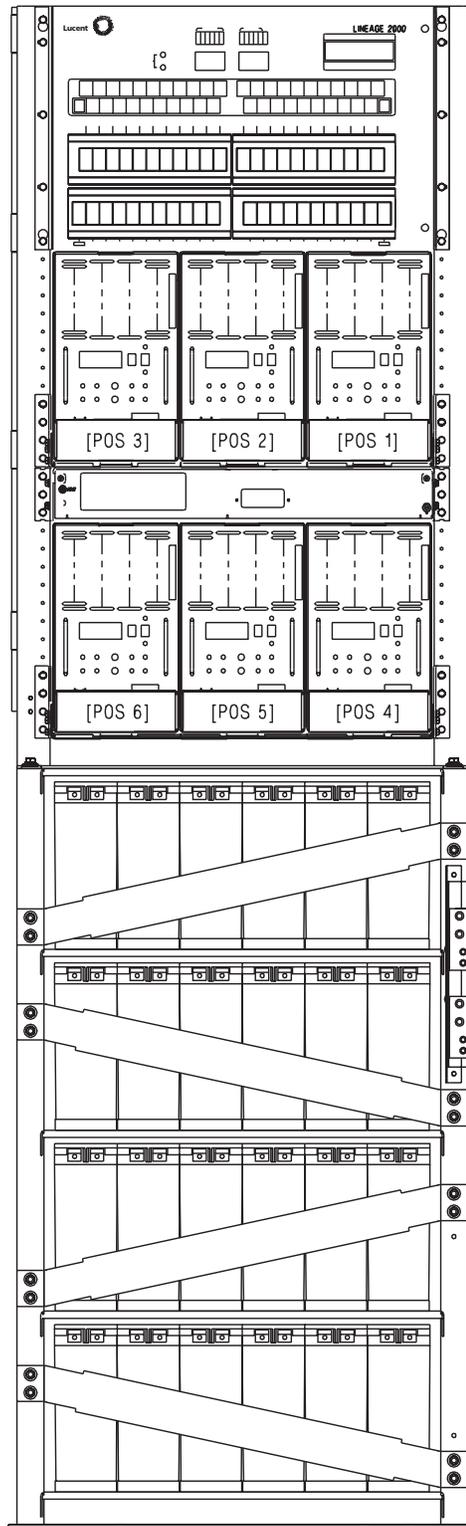


Figure 1-1: Lineage[®] 2000 ECS Battery Plant (Model J85500D-3, initial bay equipped with VR battery stand)

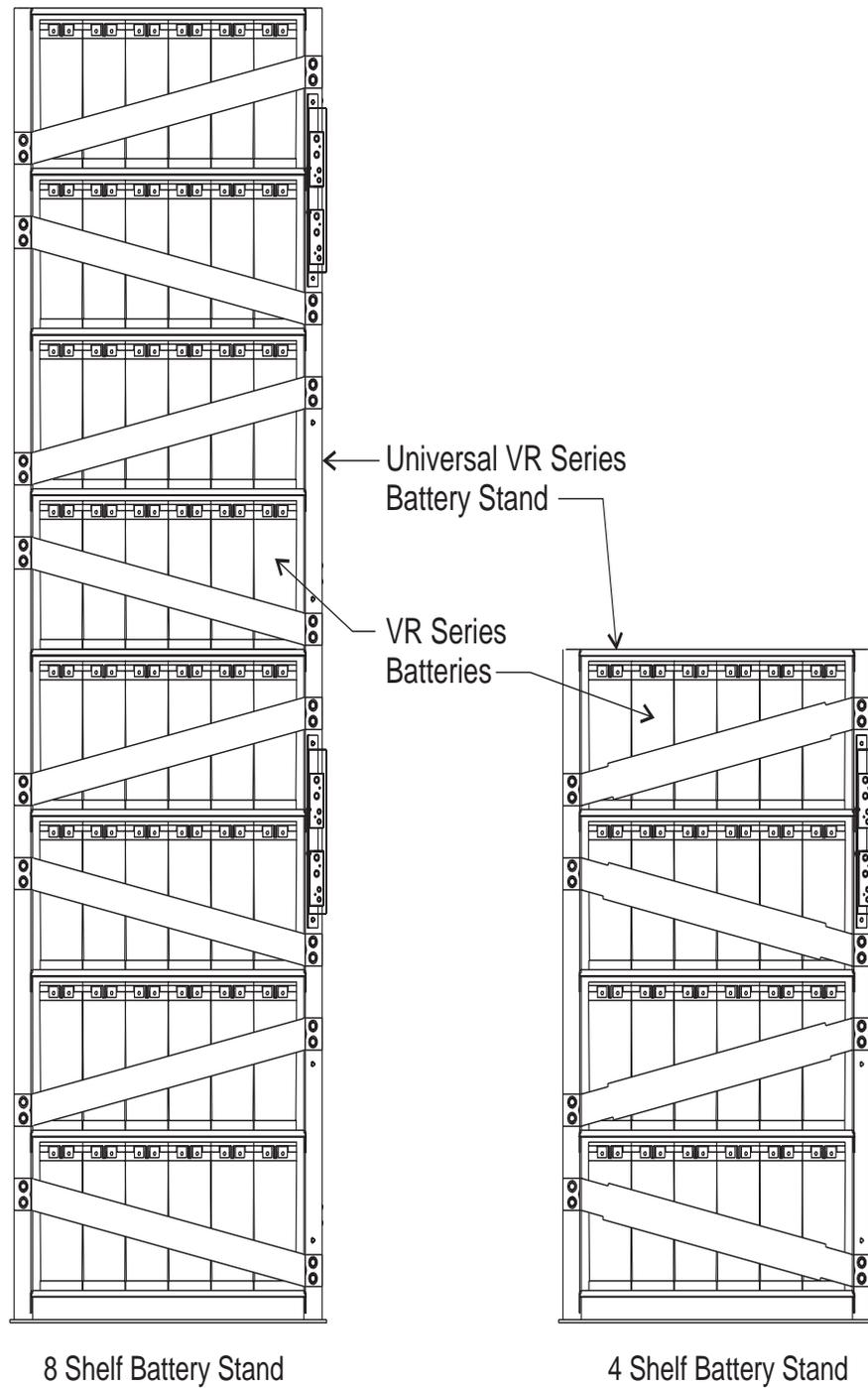


Figure 1-2: VR Battery supplementary bay configurations per J85504C-1

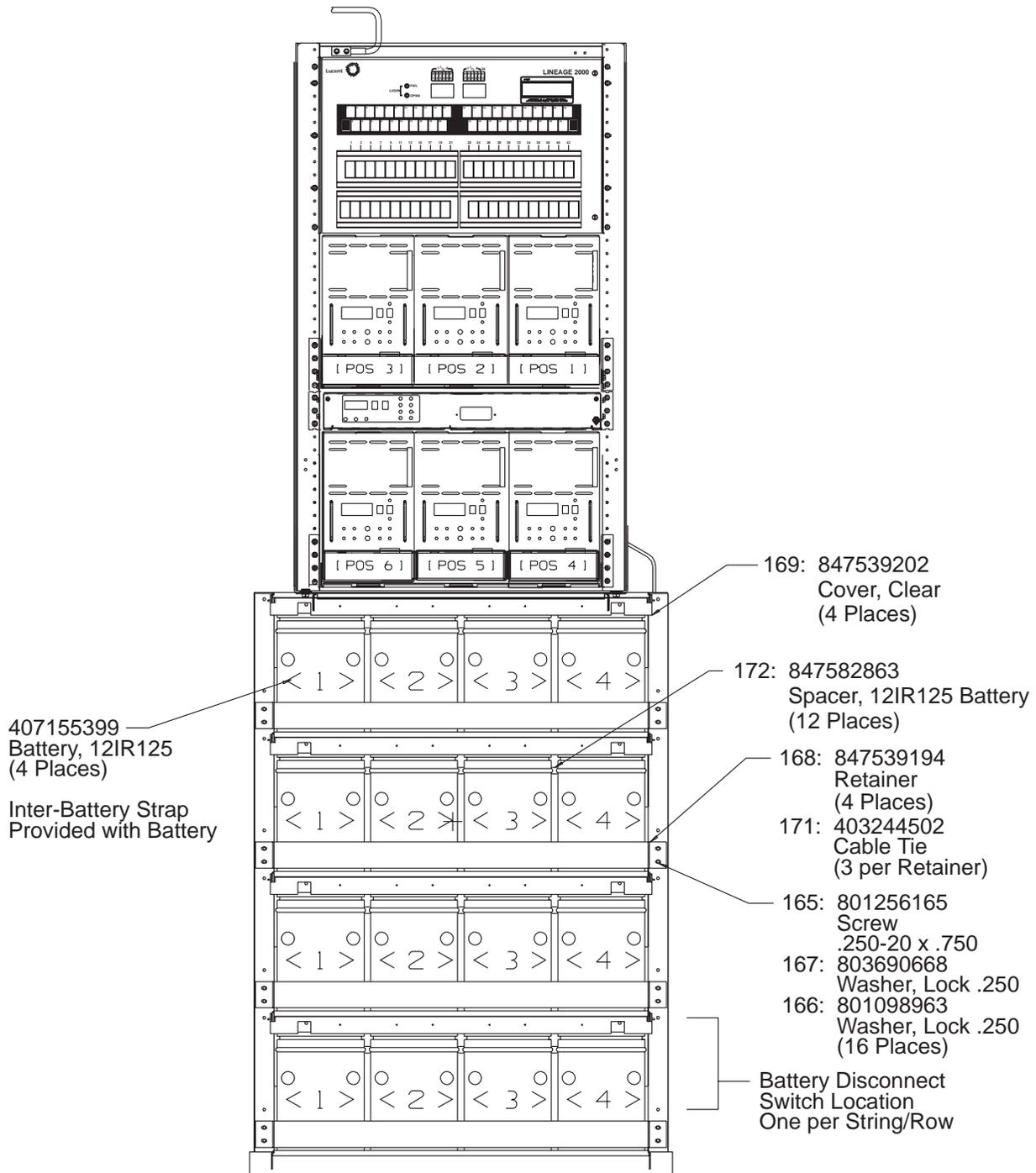


Figure 1-3: Lineage[®] 2000 ECS Battery Plant (Model J85500D-3, initial bay equipped with 12IR125 battery stand)

2

Product Description

Plant specifications

Table 2-A: Lineage[®] 2000 Battery Plant Specifications (Model J85500D-3)

Input Voltage	180-264 volts ac (208/240 volts ac nominal)
Input Frequency	47-63 Hertz (50/60 Hertz nominal)
Operating Voltage	40-60.0 volts dc (48 volts dc nominal)
Float Voltage	47-58.5 volts dc (48 volts dc nominal)
Plant Current Rating	300 amperes
Plant Shunt	300 amperes maximum at 50 millivolts
LVD/R Voltage Settings	40.5 or 42.5 volts dc $\pm 0.5V$
LVLDR Voltage	Disconnect voltage: 42V $\pm 0.5V$ Reconnect voltage: 50V $\pm 0.5V$
Controller	Basic: 113A type Microprocessor option circuit pack: CP2 Datalogger option circuit pack: CP3
Rectifier Shelf Assembly	2 maximum, each mounts 3 rectifiers
Rectifiers	Type: Lineage [®] 2000 SR50/-48V Rating: -48 volts nominal, 50 amperes Number: 6 maximum @ 16.5 Amps ac input (each)
Batteries	Type: Lineage [®] 2000 2VR375E, 2VR250E or 12IR125 Rating: 375 Ah, 250 Ah or 125 Ah per string Number: 6 strings maximum
Circuit Breakers	Type: KS23616 Ratings: 3, 5, 10, 15, 20, 30, 40, 45, 50, 60, 70, 80, 90, 100 amperes Interrupt capacity: 10,000 amperes
Temperature	32-122 degrees Fahrenheit (0-50 degrees Celsius)
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 304 meters above 1524 meters.
Framework	Type: 42 inch (1067 mm) high frame (standard 23 inch relay rack width), mounted on top of a J85504C-1 or J85504D-1 battery stand Vertical mounting centers: 1.00 inches (25 mm) Horizontal mounting centers: 22.32 inches (567 mm)

Dimensions	Height: 84 inches (2134 mm) Width: 26 inches (660 mm): L-1 e/w L-10 or L-11 32 inches (813 mm): L-1 e/w L-9 Depth: 26 inches (660 mm): L-1 e/w L-10 18.5 inches (470 mm): L-1 e/w L-11 19.5 inches (495 mm): L-1 e/w L-9
Weight (approximate)	
Initial Bay (L-1 or L-2)	with six rectifiers: 495 lbs (225 kg)
(3 Deep Battery Module Stand)	with six rectifiers and VR Series batteries: 2370 lbs (1075 kg)
(2 Deep Battery Module Stand)	with six rectifiers and VR Series batteries: 1685 lbs (764 kg)
(12IR125 Battery Stand)	with six rectifiers and IR Series batteries: 2407 lbs (1094 kg)
Supplementary Battery Bay	with one string VR 375 Ah batteries: 2085 lbs (946 kg) with two strings VR 375 Ah batteries: 4110 lbs (1864 kg) with one string VR 250 Ah batteries: 1400 lbs (635 kg) with two strings VR 250 Ah batteries: 2765 lbs (1254 kg)
Rectifiers	25 lbs (11 kg) each
Batteries	2VR375E Battery: 78 lbs (35 kg) each 2VR250E Battery: 52 lbs (24 kg) each 12IR125 Battery: 1201 lbs (546 kg) each
Earthquake	Initial bay (including one string of batteries): Zone 4 (for VR battery stands), upper floors
Heat Dissipation	Full load: 2744 watts (9363 BTU/hr) Rectifier, full load: 451 watts (1539 BTU/hr) Controller, basic and options: 26 watts (89 BTU/hr) See Note 1
Humidity rating	10% to 95% noncondensing
Audible noise	65 dBa See Note 2
Electrostatic discharge	IEC 801-2 Level 5 (15 KV) at 40% relative humidity
Radiated and Conducted Emissions	FCC Level A
Electromagnetic immunity	10V/m over the range of 20 to 2000MHz
Safety	UL Listed for use in USA and Canada (except when equipped with List 5 or List 6). See Section 7, Safety

Note 1: Specified at 55.5 volts dc, 300 amperes output, and nominal input voltages and frequencies.

Note 2: Measured at 2 feet (6 meters) from the rectifiers installed in a plant.

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 3 to 8 hours of reserve time.

Battery plant subsystems

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.

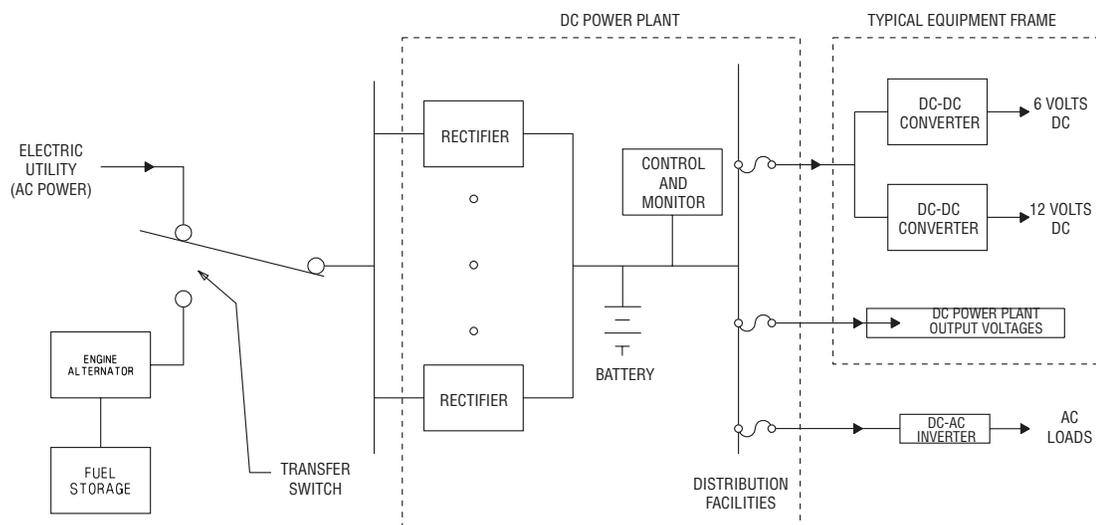


Figure 2-1: Block Diagram of Typical Battery Plant

ECS battery plant physical description

The Lineage[®] 2000 Evolutionary Control System (ECS) Battery Plant 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 300-ampere total plant capacity with a nominal -48 Vdc output. The ECS battery plant can be mounted on a battery stand which provides space for one 48-volt string of VR Series batteries or on a battery stand which provides space for four 48-volt strings of 12IR125 batteries. 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 provided by 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 and circuit breaker 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 distribution panel and optional automatic battery disconnect/reconnect (LVD/R) feature, optional low voltage load disconnect feature, batteries, and optional thermal slope/step compensation feature. 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 enables one to utilize valuable floor space in a more efficient manner.

Initial bay

The initial bay will accommodate a maximum of six Lineage[®] 2000 SR Series 50 ampere rectifiers, a Lineage[®] 2000 ECS controller, a distribution panel capable of accepting a maximum of 42 circuit breakers/fuses of 3 to 50 ampere capacity, or 20 circuit breakers of 60 to 100 ampere capacity, a low voltage battery disconnect/reconnect feature, low voltage load disconnect feature and one 48-volt string of Lineage[®] 2000 VR Series, 250- or 375-ampere hour batteries, or four 48-volt strings of Lineage[®] 2000 125-ampere hour IR Series batteries.

Supplementary bays

If additional battery reserve is required, supplementary bays are available which can each house up to two 48-volt strings of

Lineage 2000[®] 2VR250E or 2VR375E batteries or four 48-volt strings of Lineage 2000[®] 125-ampere hour IR Series batteries. A maximum of three two-string high (VR) or five one-string high (VR) bays for a total of six strings of VR batteries, or one four-string high (IR) bay (holding a maximum of two strings) for a total of six strings of IR batteries can be added to the ECS battery plant, providing a maximum total battery capacity of 2625 ampere hours at a 10-hour rate.

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:

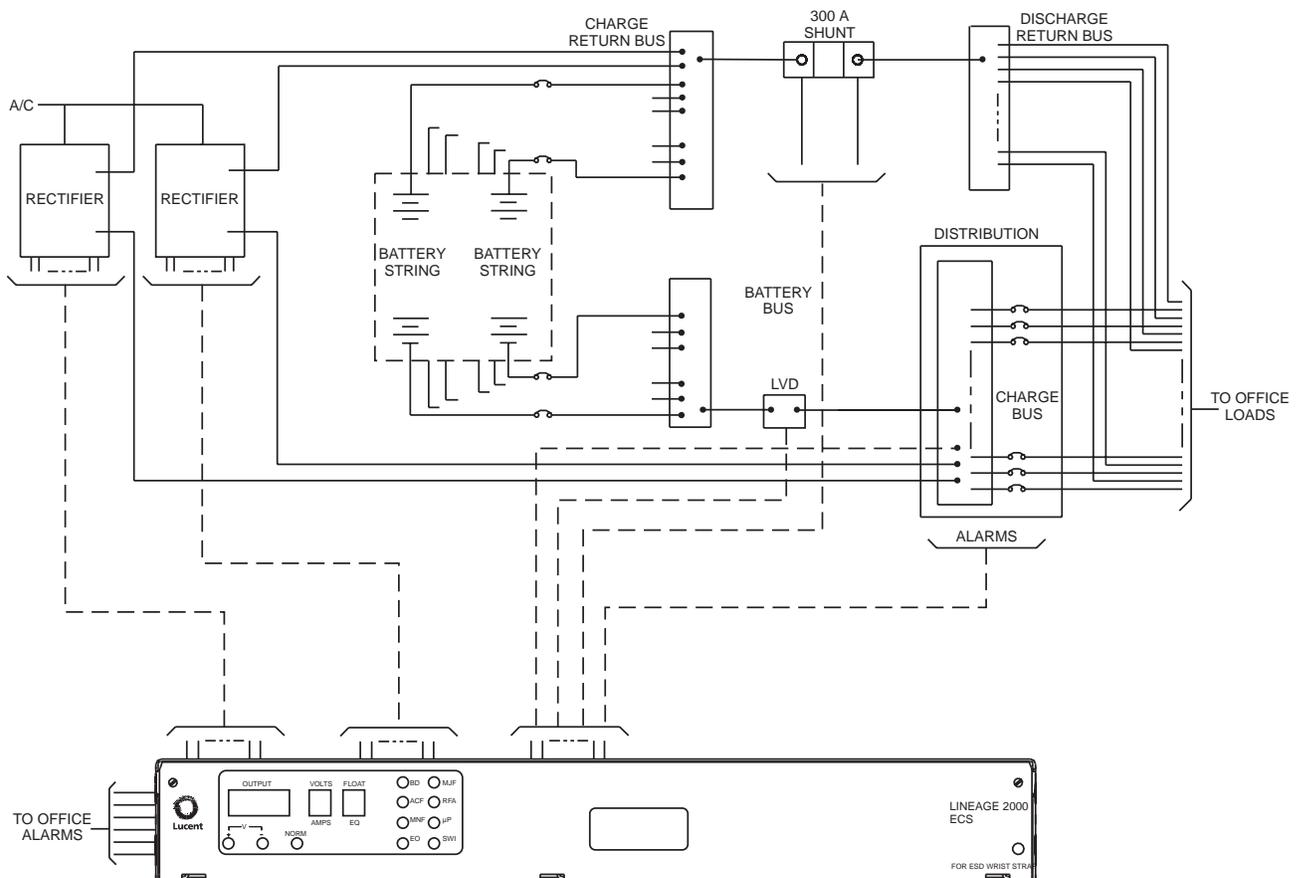


Figure 2-2: ECS Battery Plant Block Diagram

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 transformer tap changes. A power factor correction circuit incorporated in the design insures a power factor of 90 percent or greater for loads above 50 percent of the full load rating. The rectifiers provide the ECS controller with a full complement of status and alarm signals. The SR Series 50-ampere rectifier is both UL recognized and CSA certified.

The rectifier status and alarm signals, ac input, and dc output are all connectorized. The rectifiers plug into a rectifier shelf assembly that accommodates a maximum of three individual 50-ampere rectifiers. The ECS plant is equipped with two rectifier shelf assemblies for a total capacity of six SR Series 50-ampere rectifiers. (See the Lineage[®] 2000 SR Series rectifier product manual for additional information.)

Batteries The Lineage[®] 2000 VR Series battery is designed specifically for use in the ECS battery plant. The VR Series battery maximizes space efficiency. Benefits include front access, modular growth, ease of installation and maintenance.

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-ampere hour or 2 volt, 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.)

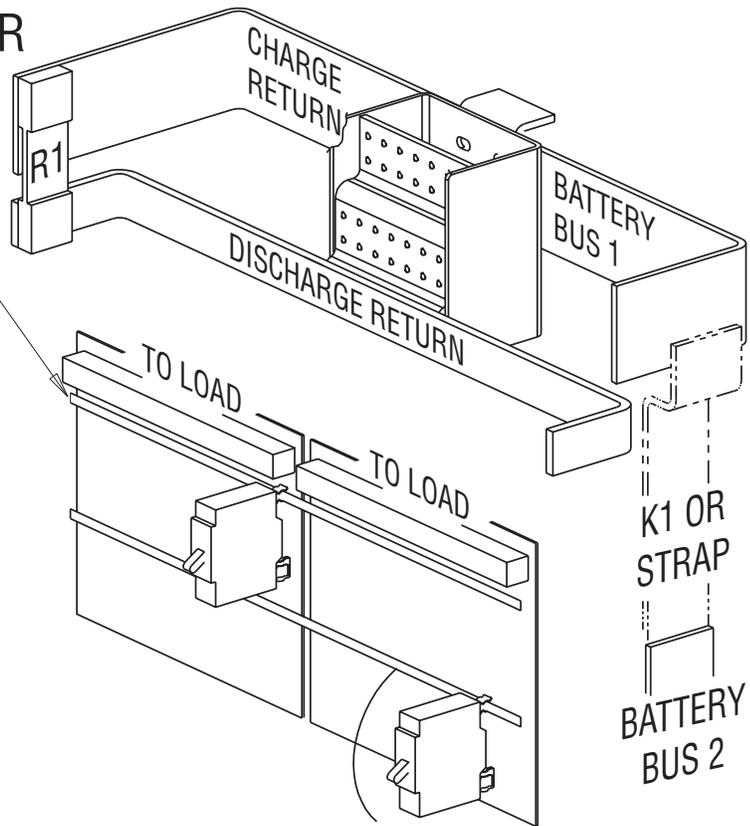
Like the VR Series batteries, the Lineage[®] 2000 IR Series batteries are ideally suited for use in the ECS battery plant. The 12-volt 12IR125 battery is used in strings of four. The battery stand (List 9) furnished with the J8500D-3 battery plant accommodates four strings of 12IR125 batteries. (See the Lineage[®] 2000 12IR125 battery product manual for additional information.)

Controller The ECS controller performs the centralized monitoring, control and reporting functions for the ECS battery plant. The basic ECS controller can monitor and control up to six 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, statistics, and voice response. 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. A remote termination panel allowing external connection to the board from outside the controller is also available with the datalogger board. (See the ECS controller manual for further information.)

DC distribution The ECS dc distribution panel has a maximum of 42 circuit breaker positions. The circuit breakers are a plug-in style, available in 3, 5, 10, 15, 20, 30, 40, 45, 50, 60, 70, 80, 90 and 100 ampere ratings. The 3 through 50 ampere breakers occupy one position and the 60 through 100 ampere circuit breakers require two positions on the panel. The distribution panel contains the plant charge and discharge bus bars, plant shunt, optional LVD/R or LVLD/R contactor and associated circuitry. The dc distribution bus bars are shown in Figure 2-3. The circuit breakers are illustrated in Figure 2-4, and the front of the distribution panel is shown in Figure 2-5.

DO NOT EXCEED 200
AMPERE LOAD PER
BUS BAR



DISTRIBUTION BUS BARS

Figure 2-3: ECS distribution bus bars

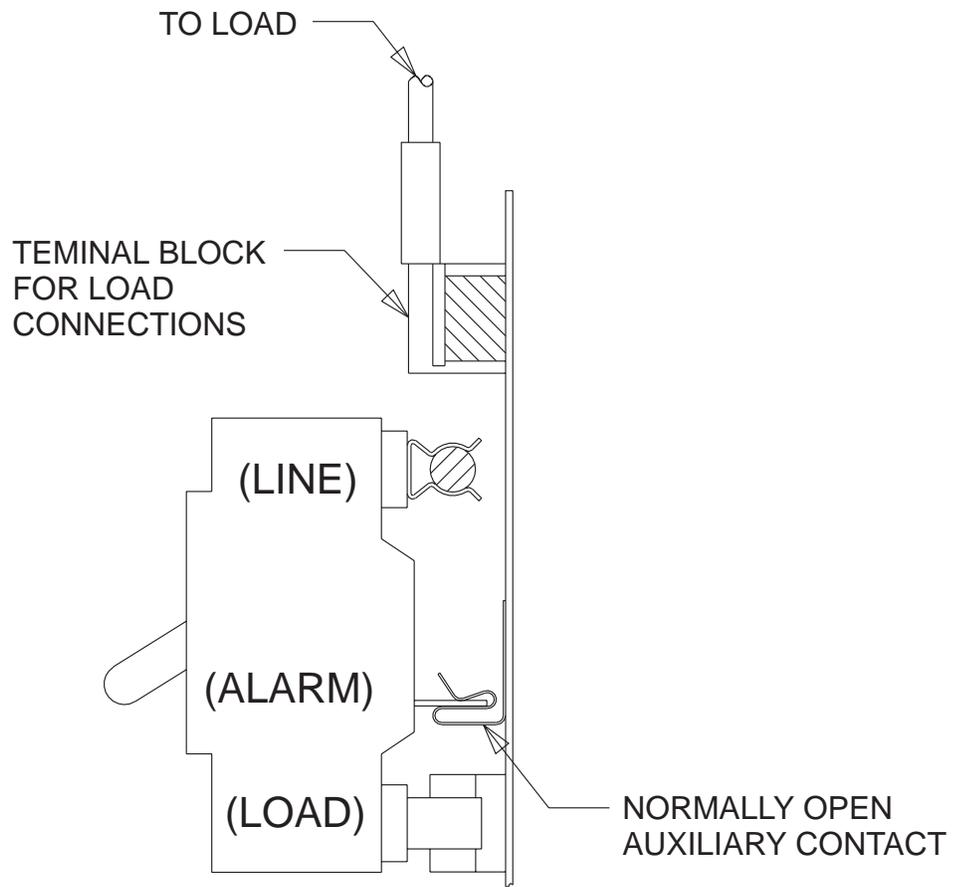


Figure 2-4: Plug-in circuit breaker mounting

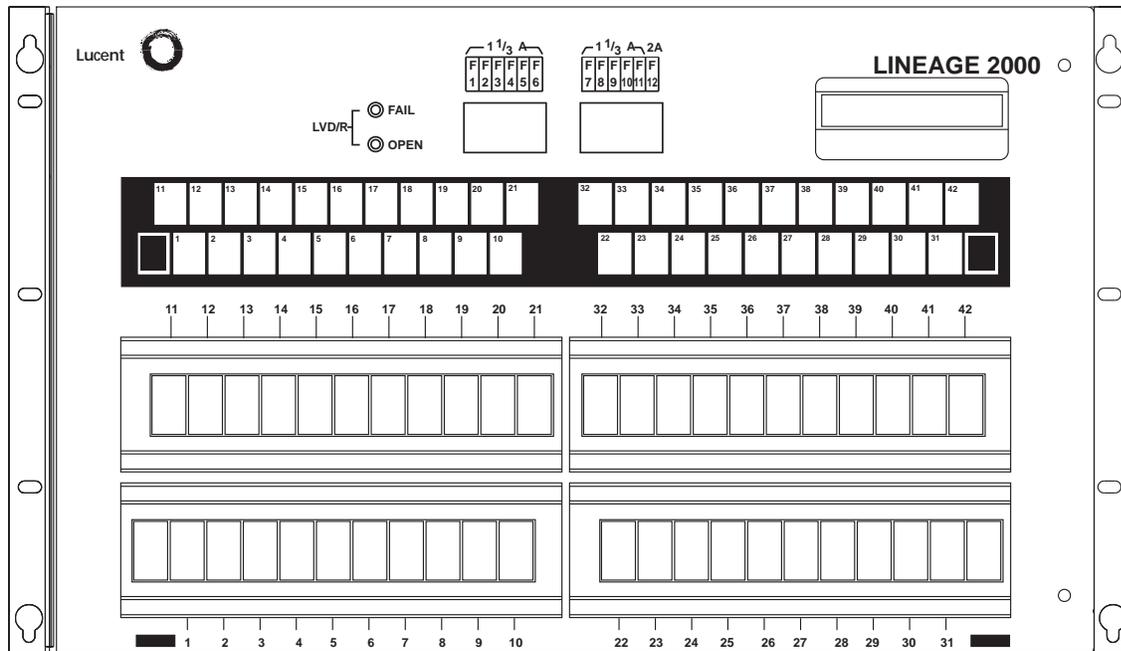


Figure 2-5: ECS dc distribution panel (front view)

ECS dc distribution panel

The ECS dc distribution elements are shown schematically in Figure 2-2 and pictorially in Figure 2-3. They are located behind the dc distribution cover panel. These elements include the distribution bus bars, the plant shunt and the optional low-voltage battery disconnect/reconnect feature or low-voltage load disconnect/reconnect feature.

Distribution bus bars

The distribution or plant bus bars include the Charge Return Bus and the Discharge Return Bus (see Figure 2-3). Battery strings are terminated to Battery Bus 1 and the Charge Return Bus. Rectifier output is terminated to Battery Bus 2 and the Charge Return Bus. Power conductors for load circuits are connected, through distribution circuit breakers, to Battery Bus 2. The return conductors for load circuits tie to the Discharge Return Bus. The Discharge and Charge Return Buses are joined via the Plant Shunt. Battery Buses 1 and 2 are interconnected by the LVD/R Contactor.

Plant shunt

The current shunt in the ECS Battery Plant is connected between the Charge Return Bus and the Discharge Return Bus (see Figure 2-3). It is used to measure the total current supplied to the load

from the rectifiers and/or batteries. The shunt has a full scale rating of 50 millivolts at the maximum plant current of 300 amperes. The shunt millivolt signal is sent, via the CP5 Fuse Board, to the controller where it is translated 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. As shown in Figures 2-3, the LVD/R Contactor (K1) is used either to connect or disconnect Battery Bus 1 and Battery Bus 2.

When the battery 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 Battery Buses 1 and 2, disconnecting the batteries from the rectifiers and the load. The user has a choice of disconnect threshold voltages (40.5 and 42.5 volts), as described in the Suggested Installation Sequence instructions in Section 3 of this manual under Controller and LVD Setup.

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.)

Red “LVD OPEN” and yellow “LVD FAIL” LEDs are located on the dc distribution panel. The red “LVD OPEN” LED is lit whenever the contactor is open, during a normal disconnect or in the unlikely event of a contactor failure. Once the contactor opens it remains open until the battery voltage exceeds the set threshold voltage. The LVD sensing circuitry 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.

***Low voltage load
disconnect/
reconnect
(LVLD/R)
feature***

The LVLD/R option (the BAD10 version of the CP5 board, List 27) is similar in circuitry to the LVD/R option, but has the following differences. LVLD/R uses contactor K1 to disconnect or reconnect plant load from the rectifiers and batteries. The load disconnect threshold voltage is 42.0V \pm 0.5V and reconnect voltage is 50V \pm 0.5V.

***Circuit breakers/
fuses***

The standard dc distribution panel (see Figure 2-5) can accommodate a maximum of 42 circuit breakers. The circuit breakers are plug-in style, KS-23616, and are available in 3, 5, 10, 15, 20, 30, 40, 45, 50, 60, 70, 80, 90 and 100 ampere ratings. These breakers have standard curve 2 trip characteristics and an interrupt capacity of 7000 amperes. The 60 through 100 ampere circuit breakers require the use of two positions on the panel.

The breakers are mounted vertically with actuators up in the ON position. Each circuit breaker is equipped with an auxiliary switch that indicates, with a closure, when the breaker has tripped due to overcurrent. The circuit breaker handle will move to a center trip position when tripped due to overcurrent. It should be noted here that customers who wish to prewire load circuits for future use may store the breaker in its installed position until service is actually required. Leaving the breaker in the OFF position in an operating battery plant will not produce an alarm condition.

***Thermal
(slope/step)
compensation
feature***

The 216A Thermal Compensation Unit, used in conjunction with the BID1, LVD/R Fuse circuit pack, reduces plant voltage for measured temperatures above 25°C (77°F) in a slope plus step manner. The BID1 reduces the plant voltage 72mV per degree Celsius for a maximum of 2.0 VDC below the uncompensated voltage. The compensation will stop 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 will be maintained. For temperatures higher than 75°C, the plant voltage will be reduced 6.0 volts below the uncompensated 25°C voltage. The plant voltage will

be raised 4.0VDC when the temperature returns to 65°C (149°F). A green indicator lights up to show an active module. A yellow indicator lights up to show temperatures above 53°C and blinks to show temperatures above 75°C.

The 216A Control Unit can also increase the plant voltage for sensor temperatures below 25°C. The plant voltage is increased 72mV per degree Celsius to a maximum of 2.0VDC above the float voltage. The BID1 is shipped from the factory with this margining feature disabled.

The 216A Control Unit accepts up to eight thermistors (two per battery string). Up to five 216A modules can be daisy-chained together, which allows monitoring 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 kits contains two thermistors that are inserted between battery cells.
2. Thermistor Kit, Rings (Comcode 847618063). Use this kit when the battery cells are not adjacent to one another (i.e., and air gap is present between cells). Place the 1/4-inch ring terminal 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. Order a thermistor kit for each additional battery string.

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 float voltage of 53.21 volts per string. Lucent Technologies KS-type flooded lead-acid batteries float at 2.17 volts per cell (52.08 volts per string).

Customers should select a battery type and vendor based on their maintenance and replacement strategies, 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

Table 3-C: Reserve Capacity

Backup 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:

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

where:

VD = allowable voltage drop, in volts

CM = conductor size in circular mils

K = 11.1 for copper at 78°F (25.5°C)

I = appropriate current drain, in amperes

L = conductor length, in feet

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

Conductor ampacity

Two criteria are used to select the actual wire gauge of a given conductor. These two criteria are **ampacity** and **voltage drop**. Ampacity is the current that may be carried safely without overheating. 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 specifications documented in Section 3.1 are used in this section to select the specific types and quantities of equipment available with the Lineage[®] 2000 ECS battery plant.

The following topics are covered in this section.

- rectifier sizing
- battery sizing
- number of bays
- cable and load breaker sizing
- low-voltage disconnect/reconnect
- low-voltage load disconnect/reconnect
- thermal (slope/step) compensation feature
- 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 6. 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: _____

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.

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

System Reliability: In most battery plants it is possible have an open circuit in the battery subsystem that could remain undetected until ac power is lost and battery power is required. Therefore, 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 six rectifiers, controller, capacitor charge panel, a breaker or fuse panel and bus bars will fit in this space. Additional dc output (rectifiers) and distribution panels (breakers/fuses) can be configured in a supplementary bay.

If Lucent Technologies VR or IR batteries are used, additional framework, called **battery supplementary bays**, is necessary for strings of VR or IR batteries. These bays are shown in Figures 1-2 and 1-3. 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 ____

Specify 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-24194 L1) and in a finer stranded "welding" type (e.g. KS-24194 L2). 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-24194 L2) 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 through 3-G.

**Table 3-D: Terminal Lug Kits for
Circuit Breakers or Fuse Holders**

Description	Qty	Die	Used With
846746857			
8 AWG Termination Lug Kit for List 3 - 6 Distribution Panel			
54204 (T&B) double hole termination	1	red	single position circuit breaker or fuse holder
YABCL-NT6 (Burndy) single hole termination	1	R-5473-5	
8-32x5/16 screw	2	-	
6-32x5/16 screw	1	-	
WP91767 L4 3/8 tubing 2in	2	-	
847301660			
10 - 12 AWG Termination Lug Kit for List 3 - 6 Distribution Panel			
WP91412 L73 double hole termination	1	R-5473-5	single position circuit breaker
WP91412 L93 single hole termination	1	R-5473-5	
8-32x5/16 screw	2	-	
6-32x5/16 screw	1	-	
WP91767 L3 1/4 tubing 2in	2	-	
847301660			
10-14 AWG Termination Lug Kit for List 23 - 27 Distribution Panel			
WP91412 L73 double hole termination	1	R-5473-5	single position circuit breaker or fuse holder
WP91412 L93 single hole termination	1	R-5473-5	
10-32x7/16 screw	2	-	
WP91767 L3 1/4 tubing 2in	2	-	
847301678			
8 AWG Termination Lug Kit for List 23 - 27 Distribution Panel			
WP91412 L52 double hole termination	1	red	single position circuit breaker or fuse holder
WP91412 L1 single hole termination	1	red	
10-32x7/16 screw	2	-	
WP91767 L4 3/8 tubing 2in	2	-	

**Table 3-D: Terminal Lug Kits for
Circuit Breakers or Fuse Holders**

Description	Qty	Die	Used With
847301686 6 AWG Termination Lug Kit for List 23 - 27 Distribution Panel			
WP91412 L108 double hole termination	1	blue	single position circuit breaker or fuse holder
WP91412 L2 single hole termination	1	blue	
10-32x7/16 screw	2	-	
WP91767 L5 1/2 tubing 2in	2	-	
847301694 4 AWG Termination Lug Kit for List 23 - 27 Distribution Panel			
WP91412 L5 double hole termination	1	grey	single position circuit breaker or fuse holder
WP91412 L4 single hole termination	1	grey	
10-32x7/16 screw	2	-	
WP91767 L5 1/2 tubing 2in	-		
847301702 6 AWG termination lug kit with two position adapter bus bar for List 23 - 27 Distribution Panel			
Two position adapter bus bar	1	-	two position circuit breaker
WP91412 L3 double hole termination	1	blue	
WP91412 L111 double hole termination	1	blue	
10-32x7/16 screw	2	-	
.375-16 nut	2	-	
.375 flat washer	2	-	
.375 lock washer	2	-	
WP91767 L5 1/2 tubing 2in	2	-	

**Table 3-D: Terminal Lug Kits for
Circuit Breakers or Fuse Holders**

Description	Qty	Die	Used With
847659620			
4 AWG termination lug kit with two position adapter bus bar for List 23 - 27 Distribution Panel			
Two position adapter bus bar	1		two position circuit breaker
WP91412 L5 double hole termination	1	grey	
WP91412 L116 double hole termination	1	grey	
10-32x7/16 screw	2	-	
.375-16 nut	2	-	
375 flat washer	2	-	
.375 lock washer	2	-	
WP91767 L5 1/2 tubing 2in	2	-	
847301447			
2 AWG termination lug kit with two position adapter bus bar for List 23 - 27 Distribution Panel			
Two position adapter bus bar	1	-	two position circuit breaker
WP91412 L54 double hole termination	1	brown	
WP91412 L121 double hole termination	1	brown	
10-32x7/16 screw	2	-	
.375-16 nut	2	-	
375 flat washer	2	-	
.375 lock washer	2	-	
WP91767 L5 1/2 tubing 2in	2	-	

**Table 3-E: Terminal Lugs for Flex and Stranded Wires,
List 3 - 6 Distribution Panels**

Flex Class I KS24194 L2 and Stranded Class B KS24194 L3	Lug (to Load)	Lug (Load Return)	Used With
8	WP91412 L52 405348178	WP91412 L52 405348178	two position circuit breaker
6	WP91412 L3 405347519	WP91412 L3 405347519	
4	WP91412 L5 405347576	WP91412 L5 405347576	
2	WP91412 L8 405347683	WP91412 L8 405347683	

**Table 3-F: Terminal Lugs For Connecting
IR Battery Cables To The Distribution Panel**

Line	Stranded wire	Flex wire	WP91412 List	Comcode	Stud size	Die
Single Hole Angled Connectors for 12IR125 Battery or IR Disconnect						
1	8	8	76	406021642	.25	red
2	6	6	15	405347774	.25	blue
3	4	4	6	405347618	.25	grey
4	2	-	16	405347782	.25	brown
5	-	2	9	405347709	.25	green
6	1/0	-	127	406338723	.25	pink
Double Hole Connectors for Distribution Panel						
7	8	8	102	40633723	.375	red
8	6	6	111	406332940	.375	blue
9	4	4	116	406332940	.375	grey
10	2	-	121	406338665	.375	brown
11	1/0	-	56	405348228	.375	pink

Table 3-G: VR Battery Cable and Lug Information

Cable Information	Lug Information						
	Wire Gauge Flex Class I	WP Spec	Comcode	Die Color	Compression Tools		
					TBM8 Die No.	TBM5 Die No.	TBM6 Upper Die Lower Die
1/0	WP91412 L57	405348235	black	13462	13455	13474	13477
4/0	WP91412 L27	405347923	yellow	13463	13456	13473	13476

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 J85500D-3 drawing. The kits contain the following items:

- Appropriate length and gauge of KS-24194 L2 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.

The circuit breakers and fuses available for dc distribution overcurrent protection are shown in Table 3-H. The breaker or fuse rating for a given circuit is selected by the criteria covered above under **Overcurrent Protection**.

**Table 3-H: Field-Installed Components
For List 3 through 6 and 23 through 26 Distribution Panels**

Item	Size (Amperes)	Comcode	Description
List 3 through 6 Circuit Breaker Kit Options			
1	3	406746313	KS23616 L20
2	5	406746321	KS23616 L21
3	10	406746339	KS23616 L22
4	15	406746347	KS23616 L23
5	20	406746354	KS23616 L24

**Table 3-H: Field-Installed Components
For List 3 through 6 and 23 through 26 Distribution Panels**

Item	Size (Amperes)	Comcode	Description
6	30	406746362	KS23616 L25
7	45	406746370	KS23616 L26
8	60	406746388	KS23616 L27

Total of 42 positions available. The 45 and 60 ampere breakers occupy two positions and are recommended only for bottom rows (even positions from 2 to 20, odd positions from 23 to 41.) Balance load evenly between upper and lower sides. If cables larger than 8 gauge are required, order terminal adapter bus kit 846561447. If 8 gauge cable is required for a single position circuit breaker, order lug kit 846746857.

List 3 through 6 Fuse Options

9	--	406980797	Fuse Holder
10	5	407006329	Fuse, TPA-5
11	10	407006337	Fuse, TPA-10
12	15	407006345	Fuse, TPA-15
13	20	407006352	Fuse, TPA-20
14	25	407006360	Fuse, TPA-25
15	30	407006378	Fuse, TPA-30

Lists 23 through 26 Circuit Breaker Options

1	3	407098417	KS23616 L31
2	5	407098425	KS23616 L32
3	10	407098433	KS23616 L33
4	15	407098458	KS23616 L34
5	20	407098474	KS23616 L36
6	25	407098482	KS23616 L37
7	30	407098490	KS23616 L38
8	40	407098448	KS23616 L48
10	45	407098516	KS23616 L40
11	50	407098524	KS23616 L41
12	*60	407098532	KS23616 L42
13	*70	407098540	KS23616 L43
14	*80	407098557	KS23616 L44
15	*90	407098565	KS23616 L45
16	*100	407098573	KS23616 L46

*Install 60-100 ampere circuit breakers in the top level (positions 12-21 and 32-41) of the distribution panel for a maximum of 10 two-position breakers.

List 23 through 26 Fuse Options

17	--	406980797	Fuse Holder
18	5	407006329	Fuse, TPA-5

**Table 3-H: Field-Installed Components
For List 3 through 6 and 23 through 26 Distribution Panels**

Item	Size (Amperes)	Comcode	Description
19	10	407006337	Fuse, TPA-10
20	15	407006345	Fuse, TPA-15
21	20	407006352	Fuse, TPA-20
22	25	407006360	Fuse, TPA-25
23	30	407006378	Fuse, TPA-30

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-H. Use additional sheets as needed.

1. Copy List 2 drains for each load feeder from Table 3-B to Table 3-I.
2. Calculate the minimum wire size that meets the ampacity requirement based on the List 2 drain for each load feeder.
3. List the wire sizes based on ampacity in Table 3-I.
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-I.
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-I for each feeder.
8. Record in Table 3-J 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-J.
11. Calculate the minimum wire size for each battery feeder in Table 3-B to meet the voltage drop requirements outlined

***Low-voltage
battery
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)

***Low-voltage load
disconnect/
reconnect feature***

Low-voltage load disconnect/reconnect is available as an option on the ECS plant. Load disconnect voltage is 42.0V \pm 0.5V and reconnect voltage is 50V \pm 0.5V.

Are there loads which may be damaged due to high current draw at low voltage? _____ (yes or no)

***Thermal
(slope/step)
compensation
feature***

The Thermal Compensation Feature is available as an option.

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

***Controller
options***

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

Circuit Packs: Circuit pack options for the ECS controller are listed in **Table B, Supplementary Components** and in the Controller manual.

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 controller drawing and the Controller Manual for details.

***Alarm system
interface***

The standard ECS controller is equipped with connection points for a variety of battery plant alarms. The wiring from the controller alarm points to the local and remote reporting alarm systems, 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 accommodate the current requirements of the powered equipment.

Grounding

The ECS battery plant is designed for compatibility 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 3-4.

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 Section 5, “Spare Parts”.)

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

The main code number falls into one of three categories:

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

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

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

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

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

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

An equipment option is identified by a number or letter called a **List** or a **Group**. J- and H-coded equipment use Lists, while ED-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 3-5.

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

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

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

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

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

B-sheets contain the main assembly views and are numbered similarly (B1,B2,...). C-sheets are used to show assembly details and any other relevant graphical information. The stocklist is included on D-sheets.

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

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

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

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

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

(5C) Circuit Figures: There is often a Wiring Diagram (T-drawing) which is separate from the assembly drawing for equipment that incorporates factory wiring. If a List contains

wiring, the associated Figure number of the T-drawing is indicated in Table A of the J-drawing. A quantity indicates the number of multiples of the wiring in the specified figure which are required for a List. When a T-drawing figure is not listed in parentheses, everything in the figure which is not indicated as optional is provided. (See below for a detailed discussion of T-drawing options.) When a T-drawing figure is listed in parentheses, only the indicated wiring or apparatus options are provided from that figure.

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

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

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

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

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

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

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

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

(11) Change Notes: Change or Revision Notes chronicle, in abbreviated form, the history of drawing reissues and associated changes, such as additional Lists, modifications to assembly views, clerical error corrections and part number changes. 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), 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 J85500D-3 battery plant is ordered with List (L) numbers (see Table 3-K).

A sample order for a D-3 plant containing five 50-ampere rectifiers, a microprocessor board, (15) 20-ampere breakers, five 45-ampere breakers and (24) 48-volt, 375-ampere hour batteries, one eight-shelf stand including two additional strings of 2VR375E VR batteries and battery cables would look like the following. Note: “J” lists per J85500D-3 should be ordered as separate line items. Format as “equipped with” (e/w) items.

<u>ITEM</u>	<u>QTY</u>	<u>DESCRIPTION</u>
1	1	J85500D-3 L-1 e/w L-2, L-3, (2) L-8, L-10
2	5	106673502 SR50/-48V rectifier
3	1	847366788 microprocessor board
4	15	407006352 20-Amp breaker
5	5	406746370 Amp breaker
6	3	407435825 2VR375E battery string
7	3	846481257 battery cable kit
8	1	J85504C-1 eight-shelf VR battery stand

**Ordering guide
(list numbers)**

**Table 3-K: Ordering Guide
J85500D-3 ECS 300 Ampere -48 Volt Battery Plant**

List No. Description

1	42-inch frame suitable for mounting on top of a battery stand such as List 9, 10 or 11
2	Wiring and equipment required in addition to List 1 or 15 to provide one J85501D-1 ECS controller
3	Wiring and equipment required in addition to List 1 or 15 to provide one 42-position distribution panel for mounting 3- to 60-ampere circuit breakers and/or 5- to 30-ampere fuses. Replaced by List 23
4	Same as List 3 except with low voltage disconnect/reconnect feature. Replaced by List 24
5	Same as List 3 except with battery management system
6	Same as List 3 except with low voltage disconnect/reconnect feature and the battery management system
7	Wiring and equipment in addition to List 1 or 15 to provide one rectifier shelf assembly mounted in the upper position
8	Wiring and equipment required in addition to List 1 or 15 and 7 to provide a second rectifier shelf assembly mounted in the lower position
9	Equipment in addition to List 1 to provide a 44.6-inch high 4-shelf battery stand for four strings of 12R125 batteries.
10	Equipment in addition to List 1 to provide a 42-inch high 4-shelf battery stand for one string of 2VR375E batteries. Qualified for seismic Zone 4 applications
11	Equipment in addition to List 1 to provide a 42-inch high 4-shelf battery stand for one string of 2VR250E batteries or two strings of 4VR125EL batteries. Qualified for seismic Zone 4 applications
12	Wiring and equipment required to provide ac prewire for all rectifier shelves. For future growth, prewiring all ac inputs is recommended at initial installation
14	Framework transition assembly for interfacing with cable rack
15	Framework (7-foot network bay, 22.312" mounting centers)
23	Wiring and equipment required in addition to List 1 or 15 to provide one 42-position distribution panel for mounting 3- to 100-ampere plug-in circuit breakers or 5- to 30-ampere fuses
24	Same as List 23 except includes low voltage disconnect/reconnect feature
25	Same as List 23 except includes thermal (slope/step) compensation feature
26	Same as List 24 except includes thermal (slope/step) compensation feature
27	Same as List 23 except includes low voltage load disconnect/reconnect feature

Supplementary components (field installed) Table 3-L lists field installed items needed to complete a total battery plant system configuration. These items are ordered by comcode and shipped separately.

Table 3-L: Supplementary Components (Field Installed)

Item	Quantity Required	Description	Comcode	Wiring Information
Power Unit				
A1	1 - 6	SR50/-48V Rectifier	107310187	N/A
IR Battery String Options				
B1	4	12IR125 Battery Order 4 for single string Recommended float voltage -54.48V	407155399	T83280-30 Fig H1
B2		12IR125 Battery String Disconnect (1 per battery string)	601793722	T83280-30 Fig HA
VR Battery String Options				
D1	24	2VR375E Battery Order 24 for a single 375AH string Recommended float voltage -54.48V	407435825	T82670-31 T82671-30 Fig 1
	3	Inter-Tier Cable Kit ordered separately and always required	846808764	
D2	24	2VR250E Battery Order 24 for a single 250AH string Recommended float voltage -52.21V	407435841	T82670-31 T82671-30 Fig 1
	3	Inter-Tier Cable Kit ordered separately and always required	846808764	
D3	23	2VR375E Battery Order 23 for a single 375AH string Recommended float voltage -52.21V	407435825	T82670-31 T82671-30 Fig 1
	1	Dummy Battery	407436518	
	3	Inter-Tier Cable Kit ordered separately and always required	846808764	
D4	23	2VR250E Battery Order 23 for a single 250AH string Recommended float voltage -52.21V	407435841	T82670-31 T82671-30 Fig 1
	1	Dummy Battery	407436583	
	3	Inter-Tier Cable Kit ordered separately and always required	846808764	
D5	12	4VR125E Battery Order 12 for a single 125AH string Recommended float voltage -54.48V	407435858	T82670-31 T82671-30 Fig 1
	1	Inter-Tier Cable Kit ordered separately and always required	846808764	

Table 3-L: Supplementary Components (Field Installed)

Item	Quantity Required	Description	Comcode	Wiring Information
D6		Battery String Terminal Plate Assembly for terminating wire sizes 1/0 to 4/0. Not required with item D7	601372550	T82670-31 Fig H3, HA T83119-30 Fig HA
D7		Battery String Disconnect One per battery string	601371610	T83119-30 Fig H5, HC
D8		Remote Power Off Switch for use with Item D7 One required per plant	601371628	T83119-30 Fig H6, HC
D9		Battery Cable Kit: one 30-foot length of 1/0 cable, 4 cable lugs and associated hardware	846481232	T82670-31 Fig H3
D10		Battery Cable Kit: one 30-foot length of 4/0 cable, 4 cable lugs and associated hardware	846481240	T82670-31 Fig H3
D11		Battery Cable Kit: one 21-foot length of 1/0 cable, 4 cable lugs and associated hardware	846481257	T82670-31 Fig H3
Controller Options				
E1		One microprocessor circuit pack (CP2) which provides remote/local monitoring and control functions. Item includes circuit board, backup battery and Product Manual 167-790-109	847366788	T82670-31 Fig H7
E2		Same as Item E1 with Voice Response feature	847366796	T82670-31 Fig H7
E3		BAC1 Datalogger Circuit Pack (CP3) CP3 is a data acquisition circuit pack that always requires Item E1 or E2. Includes set of current limiting resistor assemblies and Product Manual 167-790-109	845575223	T82670-31 Fig H9
E4		Same as Item E3 with remote termination panel to allow external connection to the CP3 circuit pack. Includes set of current limiting resistor assemblies, termination unit with cable set and Product Manual 167-790-109	846532982	T82670-31 Fig H10
E5		Optional field upgrade kit to add voice response to controller equipped with Item E1 (CP2). Includes two speech integrated circuits and instructions	846616894	T82670-31 Fig H10
E6		Same as Item E1 with X.25/TL1 features. Contains a CP2 board, backup battery, RS485-to-RS232 converter, and Product Manual. X.25/TL1 is a different communications protocol that may be used to access the controller.	847366820	T82670-31 Fig H7
E7		Same as Item E2 with X.25/TL1 features. Contains a CP2 board, backup battery, RS485-to-RS232 converter, and Product Manual. X.25/TL1 is a different communications protocol that may be used to access the controller.	847366838	T82670-31 Fig H7
E8		48V Pad Kit (accessory for microprocessor with X.25/TL1 features)	847074507	T82670-31 Fig H7

Table 3-L: Supplementary Components (Field Installed)

Item	Quantity Required	Description	Comcode	Wiring Information
E9		Digital Service Unit Kit (accessory for microprocessor with X.25/TL1 features)	847074531	T82670-31 Fig H7
E10		Shelf Kit (accessory for microprocessor with X.25/TL1 features)	847074549	T82670-31 Fig H7
E11		Thermal Compensation (Slope/Step) Expansion Kit (ordered with List 25 or 26 to monitor more than four strings of batteries)	847618139	T82670-31 Fig H14, H15
E12		Thermal Compensation (Slope/Step) Retrofit Kit (ordered to add thermal compensation feature to an existing J85500D-x battery plant)	847618105	T82670-31 Fig H14, H15
E13		Thermistor Kit, Paddles (See Section 2, "Thermal [Slope/Step] Compensation Feature" and Figure 4-8)	847618048	T82670-31 Fig H15
E14		Thermistor Kit, Rings (See Section 2, "Thermal [Slope/Step] Compensation Feature")	847618063	T82670-31 Fig H15
Miscellaneous Kits and Assemblies				
F1		System Ground Adapter Kit accommodates 1/0 AWG through 4/0 AWG cables	846638575	T82670-31 Fig H4
F2		AC Cable Assembly (set of 3) for Rectifier Shelf Assembly. One required per shelf; not required when List 12 is ordered	846826378	
F3		12-inch Extension for use in 8-foot tall frame environment. May be used to retrofit certain existing initial bays only	847137403	
F4				
F5		Rear Cover Kit for upper half of bay (clear)	846710661	
F6		Transition Assembly (Cable Rack) Formerly List 14, which is now discontinued availability; order Item F6 instead	846830461	

Documentation references

The following documents provide the engineering, ordering and installation information for the Lucent Technologies Lineage[®] 2000 ECS battery plant J85500D-3.

ECS Battery Plant

Assembly and Ordering Drawing:	J85500D-3
Wiring Diagram:	T-82670-31
Schematic Diagram:	SD-82670-01
Product Manual:	167-790-064

Supplementary information on the ECS 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-1
Wiring Diagram: None
Schematic Diagram: SD-82669-01
Product Manual: 167-790-031
Optional Circuit Pack Product Manual: 167-790-109

SR Series Rectifiers and Rectifier Shelf Assembly

Assembly and Ordering Drawing: J85702B-1
Wiring Diagram: T-82668-30
Schematic Diagram: SD-82668-01
Product 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

IR Series Battery

Assembly and Ordering Drawing: J85504D-1
Wiring Diagram: T-83280-30
Schematic Diagram: SD-83280-01
Product Manual: 157-622-025

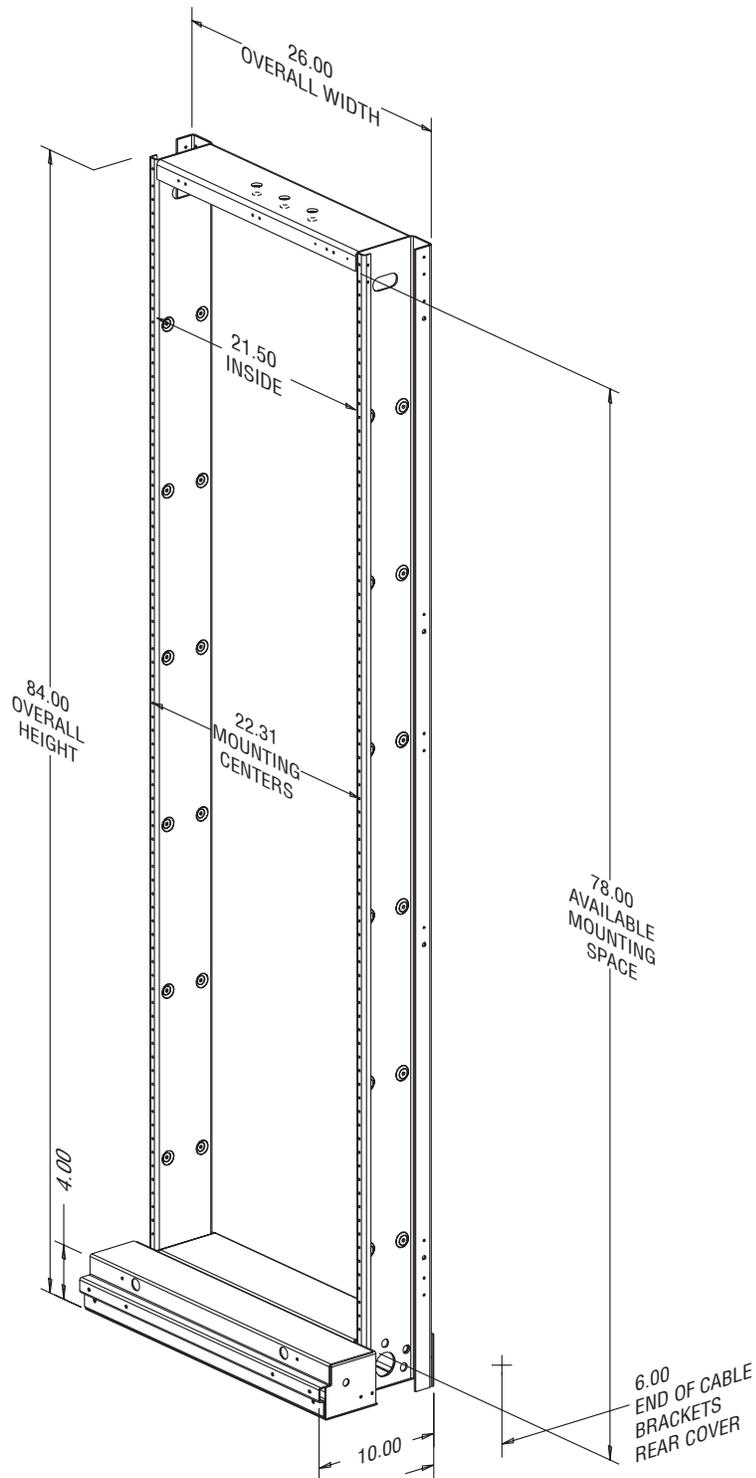


Figure 3-1: Rack Construction of List 15 Bay

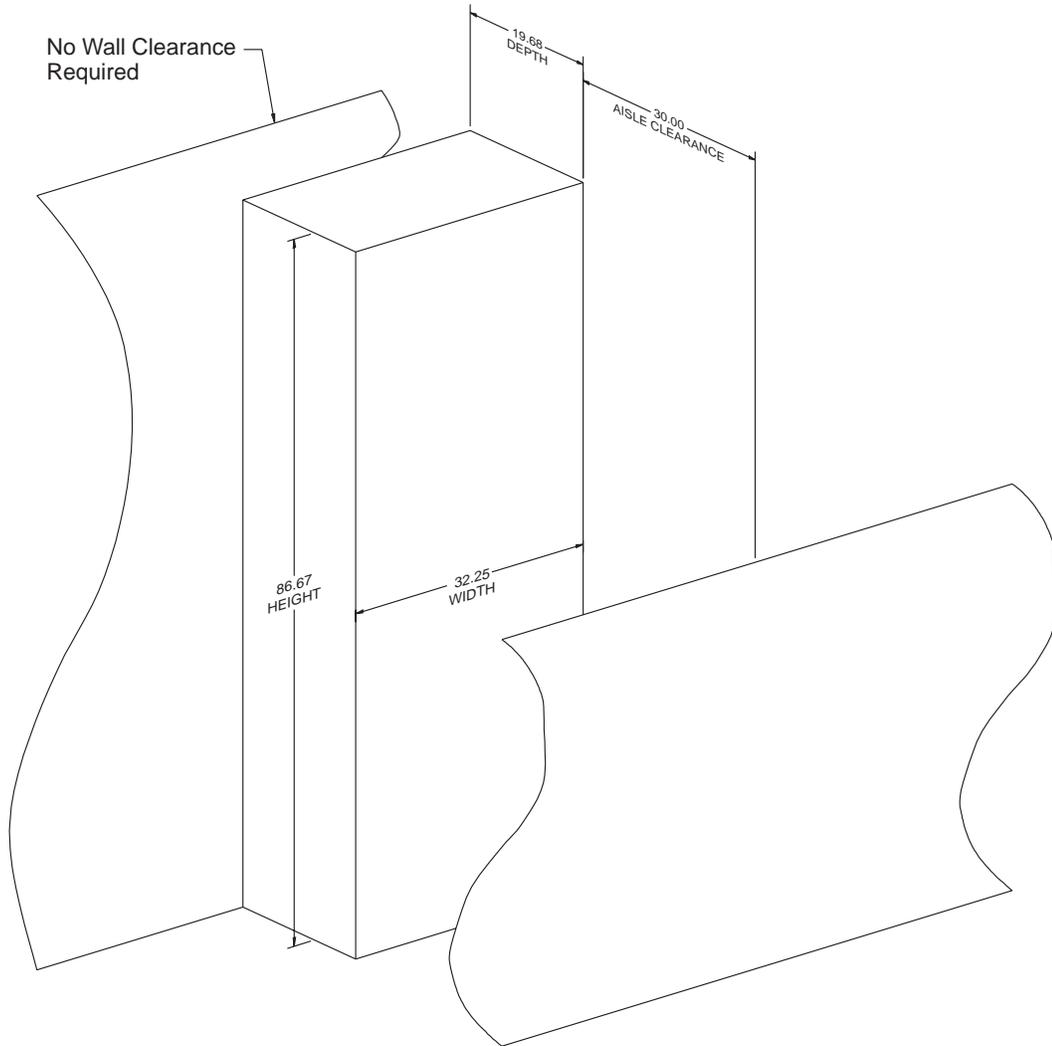


Figure 3-2a: Bay Dimensions and Clearances (List 1 equipped with List 9)

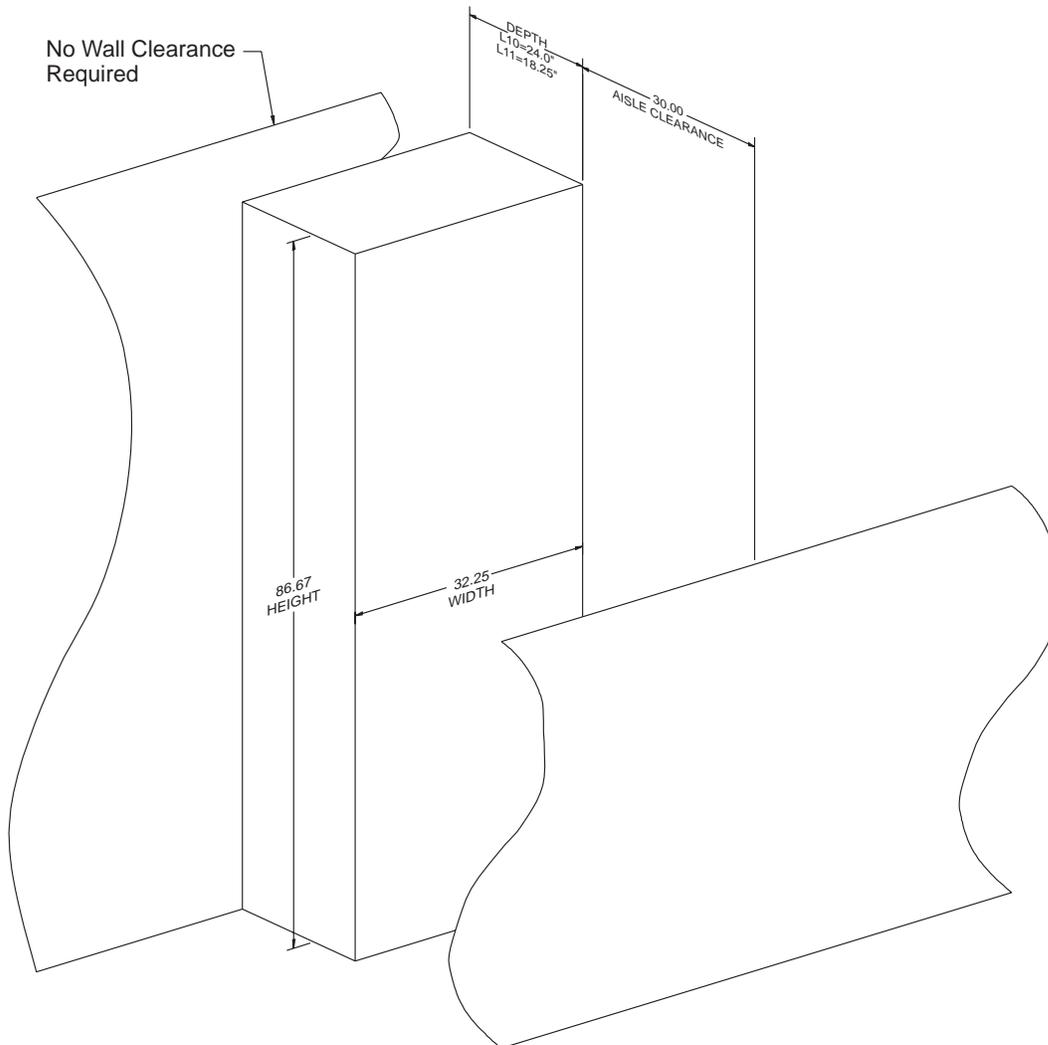


Figure 3-2b: Bay Dimensions and Clearances (List 1 equipped with List 10 or List 11)

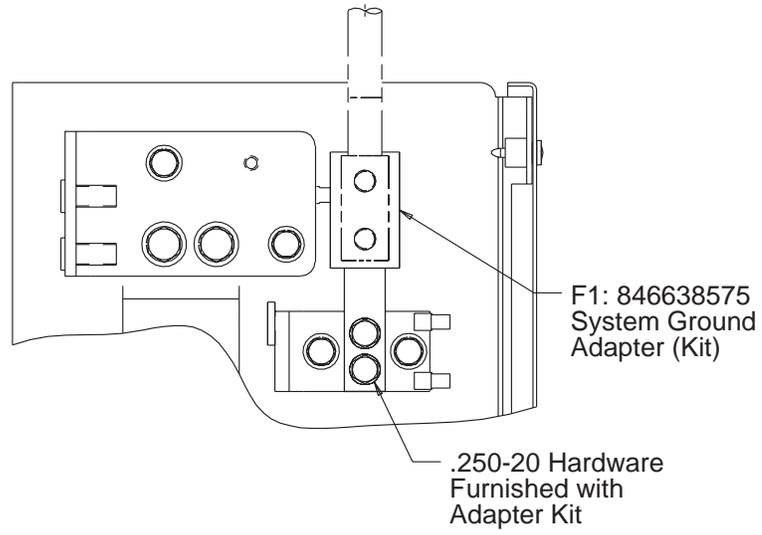
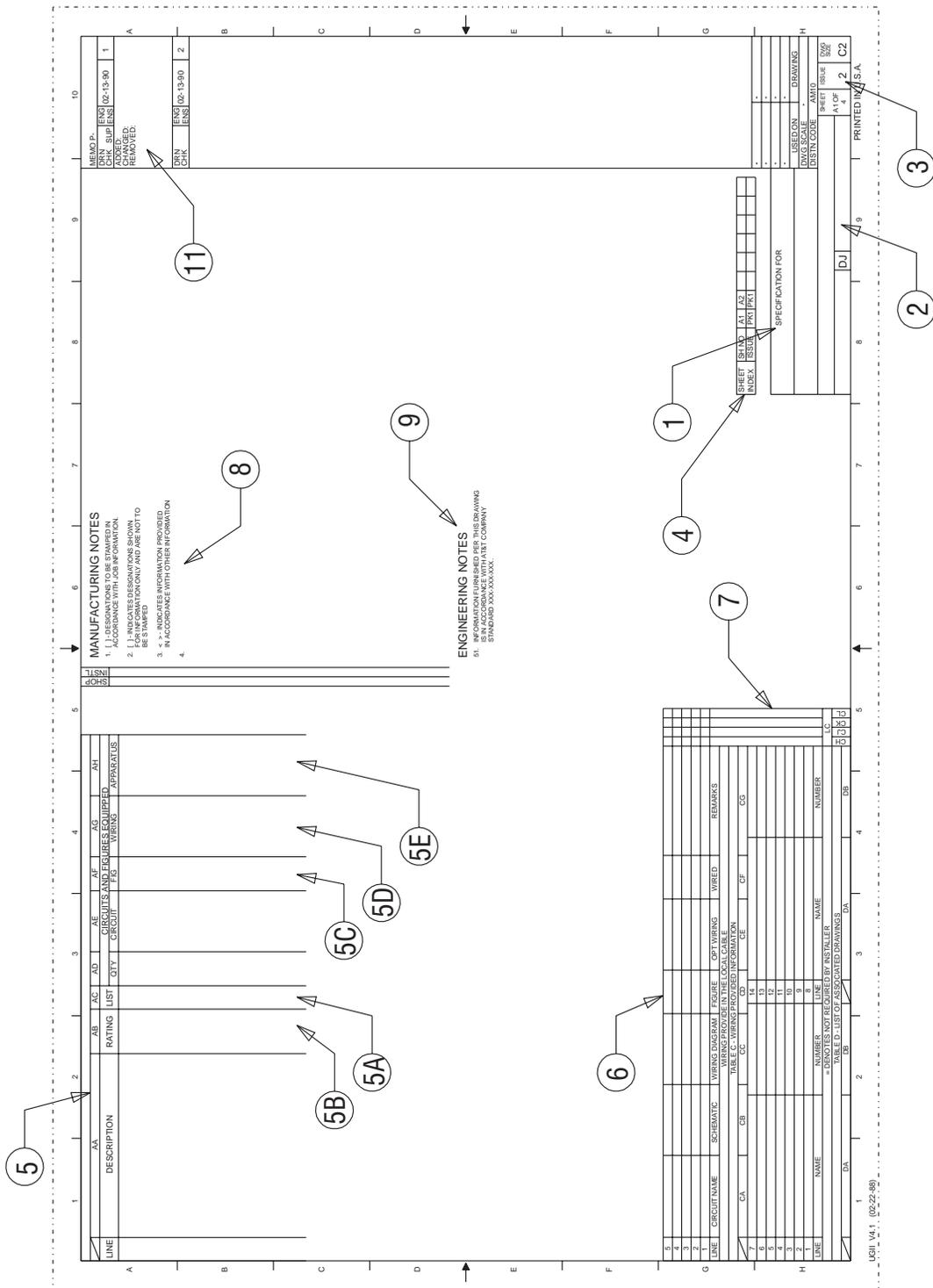


Figure 3-3: Frame Ground Adapter Assembly



4 ***Installation***

General

Lucent Technologies offers complete engineering and installation service that result in “turn-key” plant operation. Contact your Lucent Technologies Energy Systems Account Executive for further information on the complete range of installation services available from Lucent Technologies. Customers may, 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. A suggested test sequence is also provided to check the integrity of the installation effort. Upgrades, retrofits and replacement of equipment in the controller, rectifier and battery subsystems are covered in their respective manuals.

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

Installation tools and test equipment

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

- Equipment to handle shipping containers, remove framework from shipping containers, and erect framework into final position. Minimum lifting capacity: 500 lbs
- Common electrician's hand tools
- Proper crimping tools and dies for connectors used
- Common mechanic's hand tools
- 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
- Power supply, variable from zero to 60 volts dc at 2 amperes. Supply should have both coarse and fine output controls
- Six clip leads each capable of carrying 3 amperes

Suggested installation sequence

1. The plant may be wired with ac from the left side or the right side. Connection points and wire types are indicated on the plant wiring diagram, T-82670-31, Figure H4.
2. When running dc cable, be sure that all non-protected leads are run in a separate cable rack from protected leads. ("Protected", in this sense, refers to overcurrent protection by a fuse or circuit-breaker.) Battery leads are usually the only unprotected leads.
3. All dc leads should be separated wherever possible from ac leads to minimize electrical noise transmitted to the load.
4. Pair the battery potential lead with the associated return lead of a given circuit for as much of the run as possible.
5. Separate all control leads and other small gauge wiring from the ac and dc power leads to prevent physical damage. (Routing of control leads within the controller is described in the Controller manual.)
6. Torque all bolts making electrical connections to the values in Table 4-A; torque all bolts for mechanical connections to values in Table 4-B.

Table 4-A: Minimum Torque For All Electrical Connectons

SCREW SIZE	TORQUE - LB-IN OR (LB-FT)					
	WIRE CONNECTIONS		HEAD TIGHTENED		NUT TIGHTENED	
	SLOTTED MACHINE	HEX OR SOCKET CAP	SLOTTED MACHINE	HEX OR SOCKET CAP	SLOTTED MACH OR CAP	SOCKET CAP
8-32	15	15	19	19	19	23
10-24	21	21	27	27	27	33
1/4-20	50	50	65	65	65	80
5/16-18	-	100	-	120	120	120
3/8-16	-	180	-	240	240	290
7/16-14	-	280	-	385	385	465
1/2-13	-	500	-	585	585	710
5/8-11	-	(71)	-	(97)	(97)	(118)
3/4-10	-	(125)	-	(172)	(172)	(209)

Notes:

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

Table 4-B: Torque And Minimum Yield Strength For Mechanical Connections (Using Hex Head Cap Screws)

CAP SCREW DIAMETER	MINIMUM YIELD STRENGTH (PSI)	TORQUE (FT-LB) UNRC
1/4	57,000	6
3/16	57,000	12
3/8	57,000	22
7/16	57,000	35
1/2	57,000	54
9/16	57,000	77
5/8	57,000	107
3/4	57,000	190
7/8	36,000	193
1	36,000	290
R1-1/8	36,000	410
1-1/4	36,000	580
1-3/8	36,000	760
1-1/2	36,000	1010

Table 4-C: Installation Reference Documents

Step	Procedure	Reference Document
A	Unpacking	J85500D-3 Manual (167-790-064)
B	Battery Stand Assembly	Battery Manual (157-622-010) J85504C-1
C	Cable Support and Ground System	Job Application Drawings
D	Controller Setup and LVD Test	Controller Manual
E	AC Wiring, Rectifier Installation and Rectifier Test	Rectifier Manual, J85500D-3 Drawing and T-82670-30 Drawing
F	Battery Connections	Battery Manual
G	Load Wiring	J85500D-3 Drawing and T-82670-30 Drawing
H	Initial Battery Charge	Battery Manual and Rectifier Manual
I	Controller Test	Controller Manual
J	Load Turn Up	Load Equipment Documentation

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

Step A: Unpacking, handling & frame installation Before opening the packaging, carefully inspect the outside, in the presence of shipping personnel, for signs of damage. If damaged, follow the shipping carrier's procedure for filing a damage claim.

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

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

WARNING:

Do not connect batteries to the system at this time.

Step B: Battery stand assembly

Assemble battery stands per the battery manual. Install the batteries onto their stands.

Step C: Cable support and ground system

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

Step D: Controller and LVD set-up

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

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

Check and set the low-voltage battery disconnect/reconnect, if provided, at the desired voltage level. See Figure 4-4a for the location of the disconnect voltage select jumpers, J505.1 and J505.2 on LVD/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 LVD/Fuse circuit pack and the associated LVD/R option.

Check the low-voltage load disconnect/reconnect if provided. Disconnect voltage is 42.0V \pm 0.5V and reconnect voltage is 50V \pm 0.5V. See Figure 4-4b for configuration information.

***Step E: AC
wiring, rectifier
installation and
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: Prewire the ac during the initial installation for all rectifier positions that may be used in the future. Growth in rectifier capacity is as simple as plugging in an additional rectifier.

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

***Step F: Battery
connections***

Remove all fuses from LVD/Fuse Board. Confirm that the output circuit breakers of all rectifiers 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.

DANGER:

When working with battery leads, always insulate all exposed cable ends. Uncover them only when securing them to the correct polarity bus.

Run all cables from the battery and return bus bars to the battery strings by first connecting them to the batteries. The last connection should be made on the bus bars in the dc distribution. For suggested cable routing within the dc distribution see the J85500D-3 drawing. Replace the dc distribution cover panel on

the plant framework after all connections have been made at the plant bus bars.

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

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

DANGER:

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

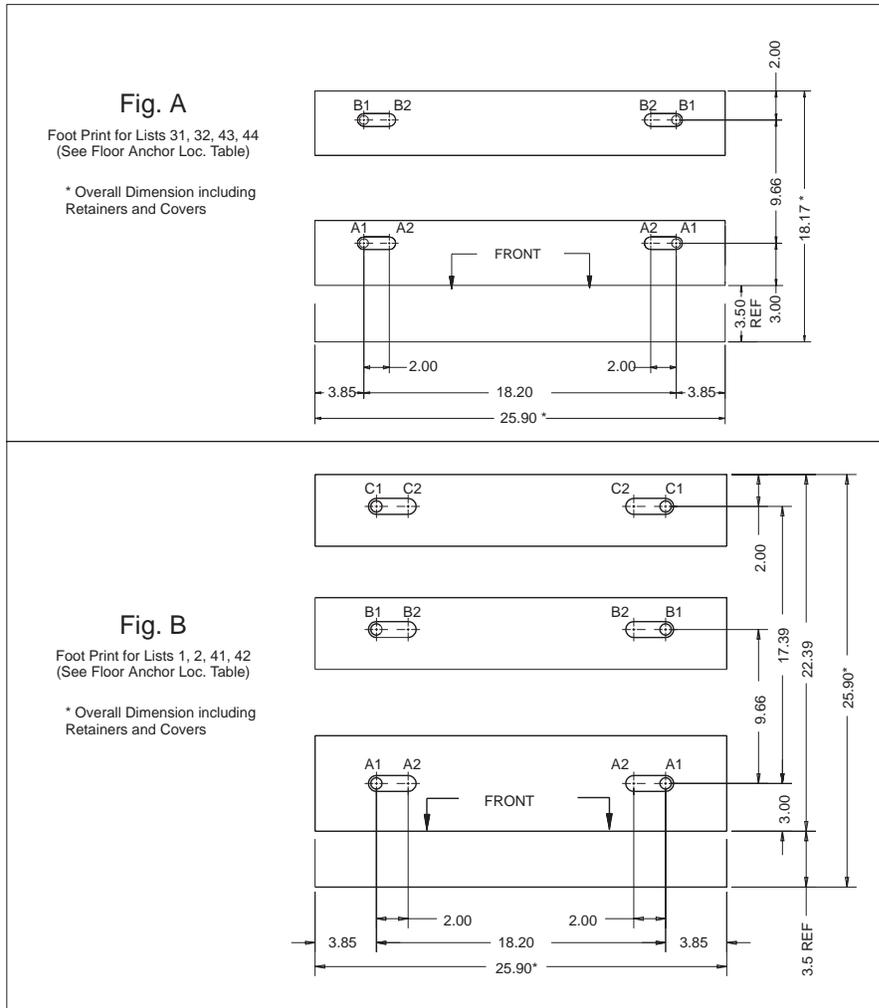
Step G: Load wiring

Open the dc distribution cover panel by turning the two 1/4 turn fasteners located on the front of the panel.

Run paired leads (supply and return) to each load from a dc distribution circuit breaker and from the discharge return bus. The load supply leads are terminated at the battery plant end on terminal blocks TB701 on the distribution printed wiring boards. The load return leads are terminated at the battery plant end on the discharge return bus, directly above the load supply lead termination. The termination points for the load leads are numbered 1 to 42, from right to left. Distribution breaker positions are also numbered 1 to 42, from left to right.

To install a circuit breaker, first verify that the circuit breaker is in the OFF position. Plug in the circuit breaker and visually verify that the line, load, and alarm connections are properly mated. (See Figure 2-4). Remove the plastic knockout from the associated position on the front cover. Mark the new circuit on the distribution front cover label. Spare circuit breakers may or may not be provided with the dc distribution panel, as ordered. Spare circuit breakers may be stored in the distribution panel if in the OFF position. Leads may be run to spare circuit breaker positions in anticipation of future growth (similarly to prewiring rectifier ac input in Step E, above).

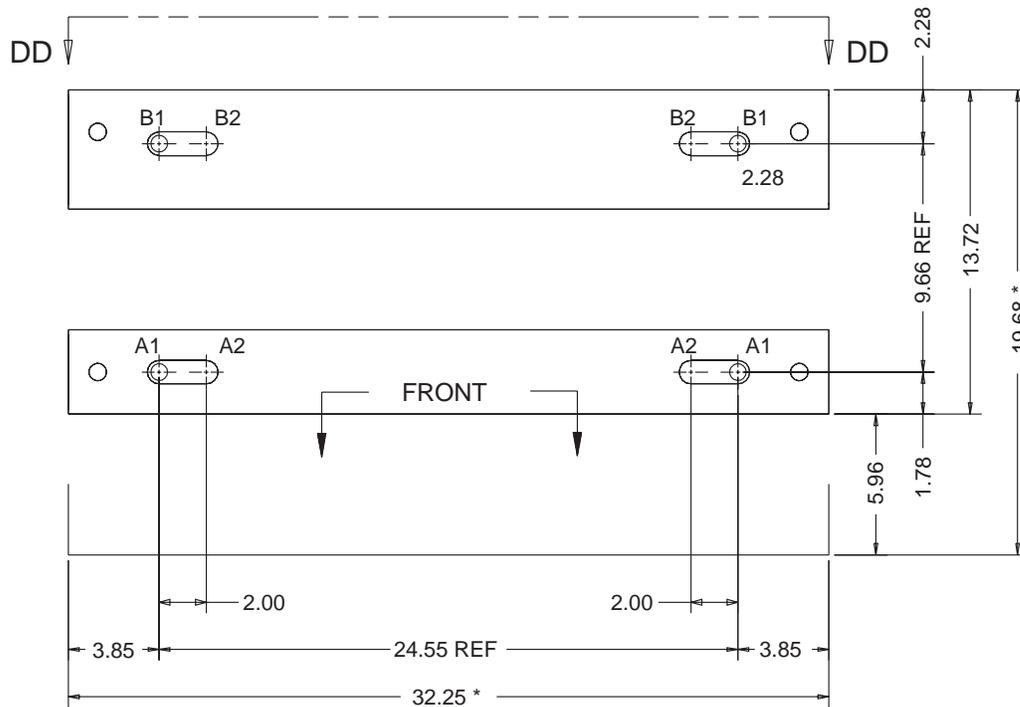
Recommendations for routing and dressing of load leads as they leave the battery plant and enter the cable rack system is shown on the plant assembly drawing, J85500D-3. Consult the job application drawings for the routing of these leads to the load



Floor Anchor Location Table							
List				Description	Primary	Alternate**	Figure
31	32	43	44	2VR250E Battery Application	A1, B1	A2, B2	A
1	2	41	42	2VR375E Battery Application	A1, B1, C1	A2, B2, C2	B

** If interference with floor reinforcing bars occurs during installation of anchoring device at primary mounting location then alternate location shall be used.

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



* Overall Dimension including Retainers

FLOOR ANCHOR LOCATION TABLE			
LIST	PRIMARY	ALTERNATE *	FIGURE
10	A1, B1, C1	A2, B2, C2	AA
11	A1, B1	A2, B2	1
15	1	2	BB
	A1, B1	A2, B2	CC

* If interference with floor reinforcing bars occurs during Installation of anchoring device at primary mounting location then alternate location shall be used.

Figure 4-3: Floor mounting template, 12IR125 battery installation (all dimensions are given in inches)

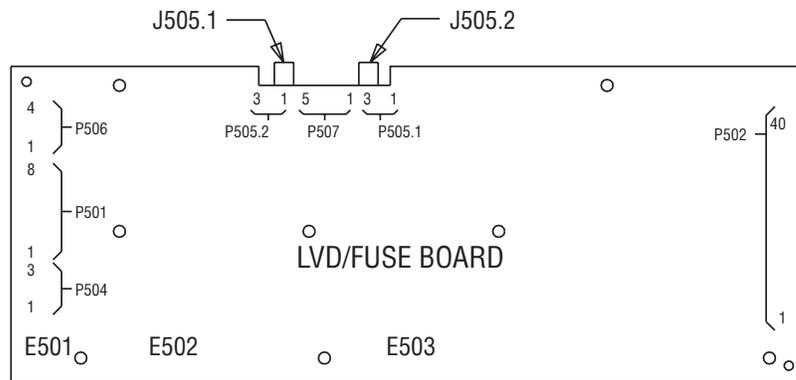


Figure 4-4a: LVD/Fuse Board (BAD1) jumper locations

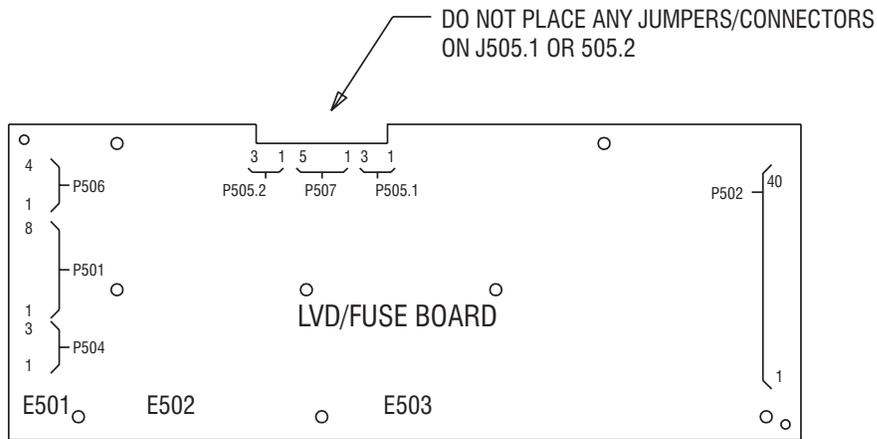


Figure 4-4b: LVD/Fuse Board (BAD10)

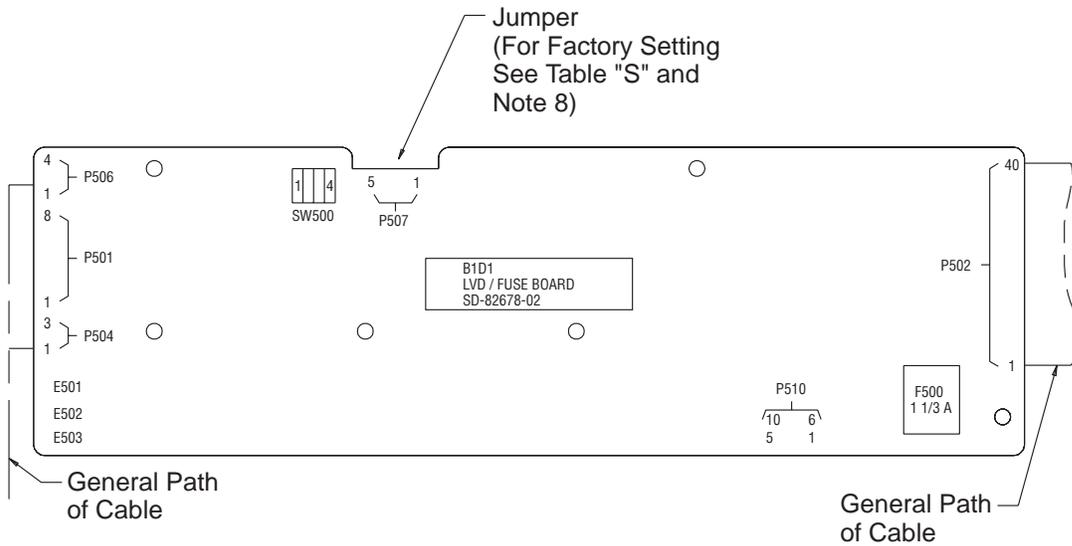


Figure 4-5: LVD/Fuse Board with thermal compensation circuitry (B1D1) switch locations

Step H: 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 procedures given in the Battery and Rectifier manuals.

Step I: Controller test

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

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

Step J: Load turn-up

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

WARNING:

Before applying power to any individual load, follow the

powering up instructions as provided in the associated load equipment documentation.

Connect all loads, one at a time, by turning on the load circuit breakers. 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 and the instructions for powering up that load.

***Installation
procedures for
plant growth***

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

- expanded controller features
- additional rectifier capacity
- increased battery capacity
- additional load circuits

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

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.

***Adding a load
circuit***

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

Step A: See Section 2 under Ordering Information for details on obtaining additional circuit breakers.

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

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

DANGER:

Battery voltage is present behind the distribution cover

panel. Remove all jewelry before working in this area. Use insulated tools only.

CAUTION:

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

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

If a spare circuit breaker is already plugged in the next available position, verify that the breaker is OFF.

DANGER:

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

If a new breaker must be added, switch it to the OFF position. Plug in the new breaker. If possible, visually verify that line, load and alarm connectors are properly mated. (See Figure 2-4).

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

Step F: Remove knockout in front panel and mark the new circuit on the distribution cover panel label.

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

WARNING:

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

Step H: Turn on the load circuit breaker. If the circuit breaker trips immediately when turned on, 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.

Installing thermal compensation unit in existing plant

The 216A ECS Thermal Compensation Unit described in Section 2 can be retrofitted into a J85500D-x battery plant. The kit (Comcode 847618105) contains the circuit packs, wiring and hardware to monitor one string of batteries. Read the instructions below before beginning, observe all the safety warnings and notes, and follow the instructions step by step.

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.

Tools required

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

1. 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.)
2. Temporarily insert the thermistors in the battery locations to be monitored. See Figure 4-8 for suggested locations between the Lucent Technologies 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 (maximum = 8 per 216A) to terminal blocks TB101 & TB102 as shown in Figure 4-10. 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 4-9. 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 - 13). If commercial power fails during this procedure, -48VDC will be lost to the using equipment. If this causes concern, use a generator during the procedure.

6. Open distribution door.

Note:

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

7. Unplug the following connectors from the BAD1 LVD/
Fuse Board. Leave the cables dressed.

- * P502 from J502
- P506 from J506
- P501 from J501
- P504 from J504
- Quick Connect from E501.

- * 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 BAD1 LVD/Fuse Board and then remove the insulated standoffs to free the board.
9. Set SW500 on the BID1 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 BID1 LVD/R Fuse Circuit Pack.
11. Mount the BID1 LVD/Fuse board to the distribution door assembly as shown in Figure 4-7.
12. Use the #6-32 nut to secure the sixth standoff in place on the BID1 circuit pack. (See Figure 4-7). Mount the clear cover provided to the BID1 LVD/Fuse Board standoffs.

Note:

Step 13 will cause the LVD/R Contactor to CLOSE.

13. Reconnect the following connectors in order listed below:

P502 to J502
P506 to J506
P501 to J501
P504 to J504
Quick Connect to E501

14. 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.

15. Connect the 216A Control Unit Interface Cable Assembly (847586815) to P510 on the BID1 LVD/Fuse Board and dress cable out of the distribution and down to the 216A Control Unit connecting to P511.

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

17. Replace F507, F508, F509, F511 and F512 with their respective fuses into the BID1 LVD/R Fuse Circuit Pack.
NOTICE F512 HAS ORANGE TAB (2 AMP).

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

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 BID1 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 there are no alarms present at this time.

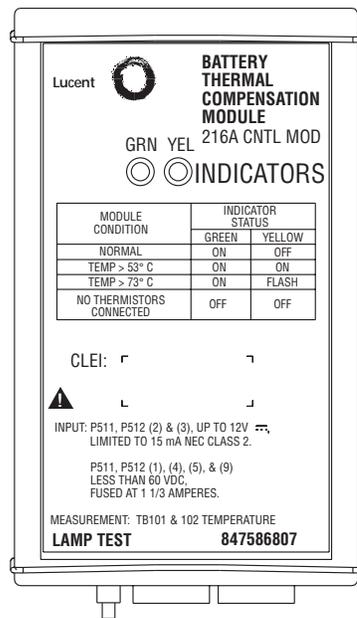


Figure 4-6: 216A Battery Thermal Compensation Control Unit faceplate

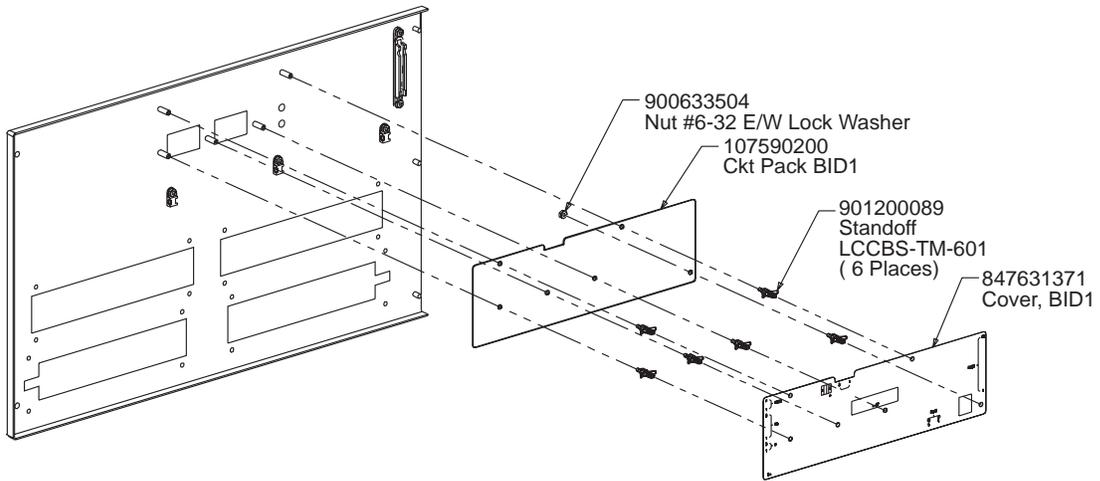


Figure 4-7: Door assembly

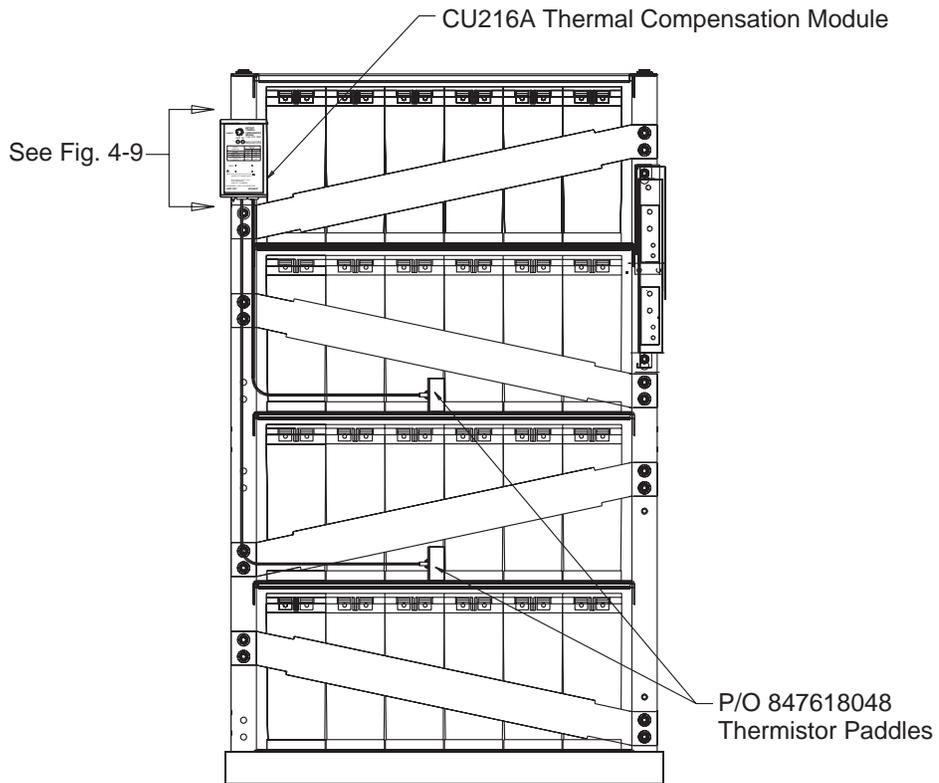


Figure 4-8: VR Battery stand (placement of thermistors)

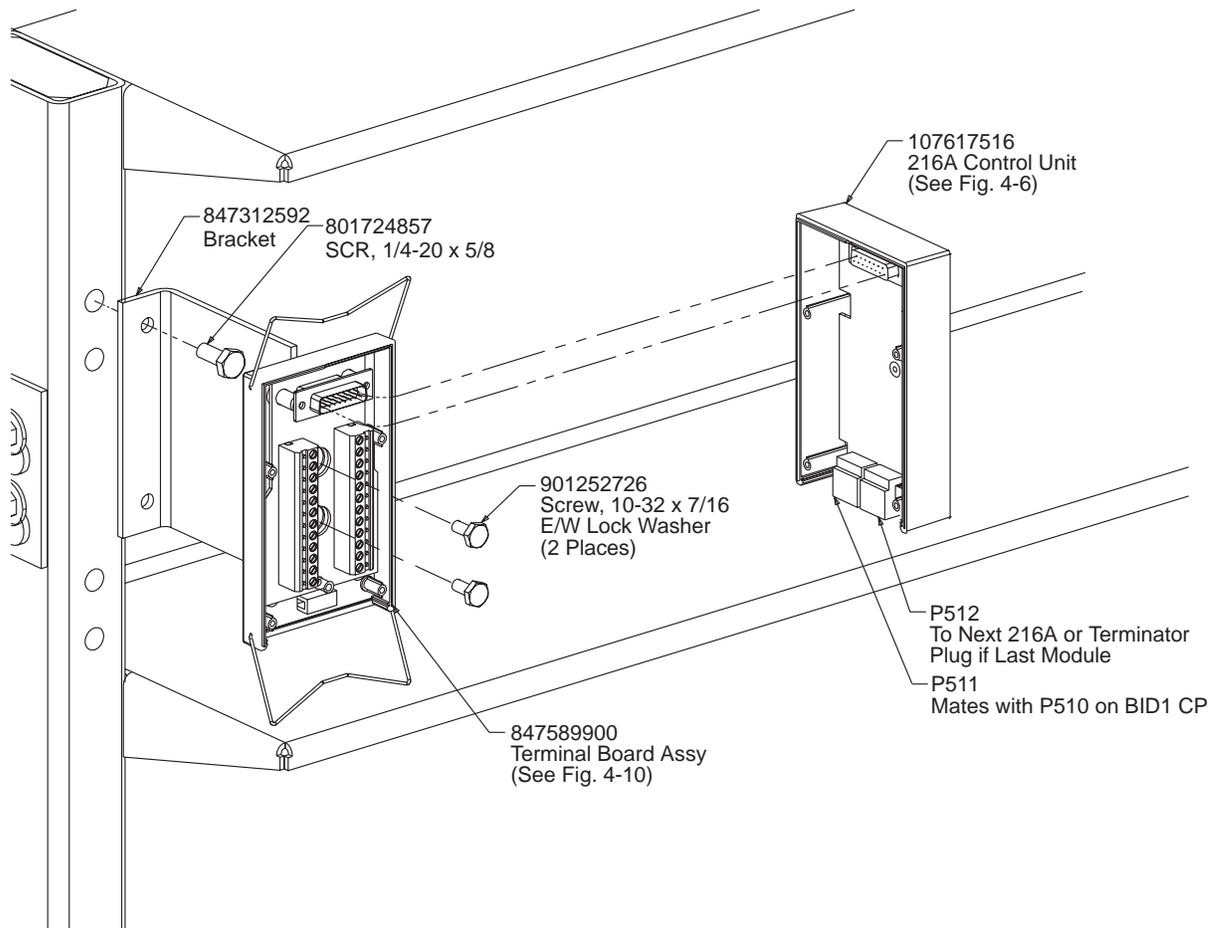


Figure 4-9: 216A Battery Thermal Compensation Control Unit installed on frame

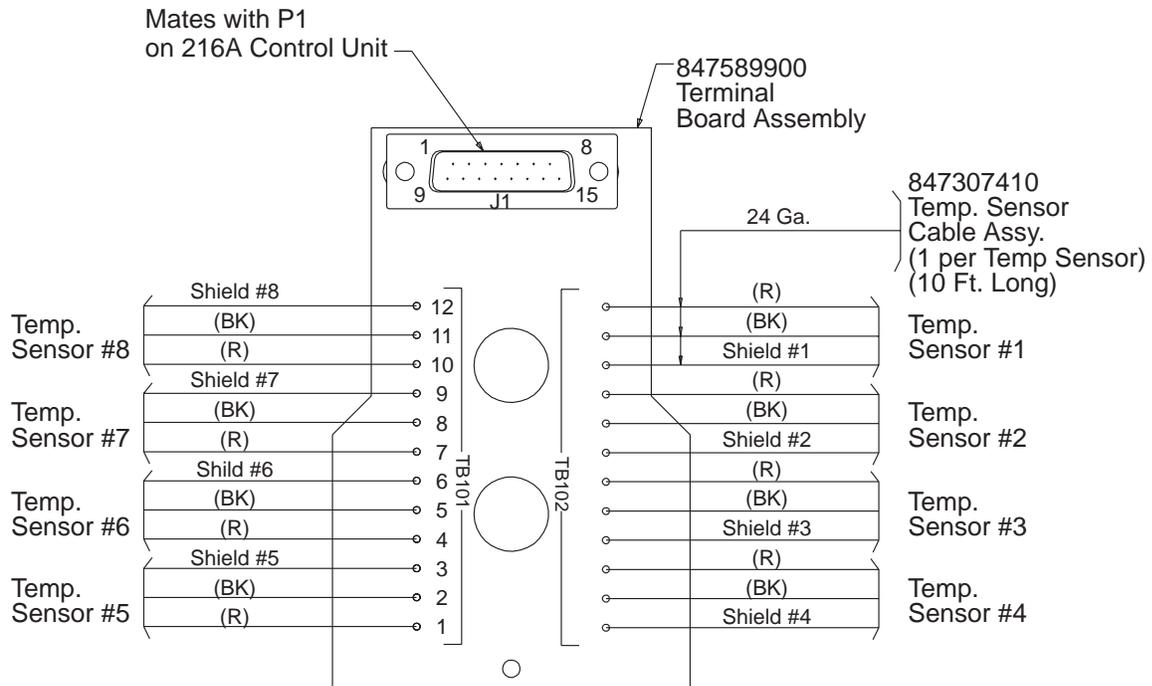


Figure 4-10: Terminal block assembly

5 *Maintenance*

Controls and Indicators

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

- Controller LEDs and switches (see Controller Manual)
- Rectifier LEDs and switches (see Rectifier Manual)
- LVD/Fuse Board LEDs and fuses

Two LEDs on the LVD/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. The contactor, however, is still closed.

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

DC Circuit Breakers

Circuit breakers CB1 through CB42 are located in the DC distribution.

Any circuit breaker in the battery plant is ON (or closed) when the handle is in the Up position, and OFF (or open) in the Down

position. A circuit breaker which is supplying a load may be turned off manually, but this may affect service to the load. If a breaker has tripped off (the handle will be between the ON and OFF positions), the overcurrent problem should be cleared before restoring power to the load and resetting the breaker. See “Troubleshooting,” below, for information on tripped breakers.

FUSE DESIGNATIONS	
F1	REG LEAD RECTIFIER 6
F2	REG LEAD RECTIFIER 5
F3	REG LEAD RECTIFIER 4
F4	REG LEAD RECTIFIER 3
F5	REG LEAD RECTIFIER 2
F6	REG LEAD RECTIFIER 1
F7	113A METER
F8	CP2 AND CP3
F9	CP1 RECTIFIER INTERFACE POWER
F10	RECTIFIER CP1 INTERFACE POWER
F11	ALARM BATTERY SUPPLY
F12	CP1

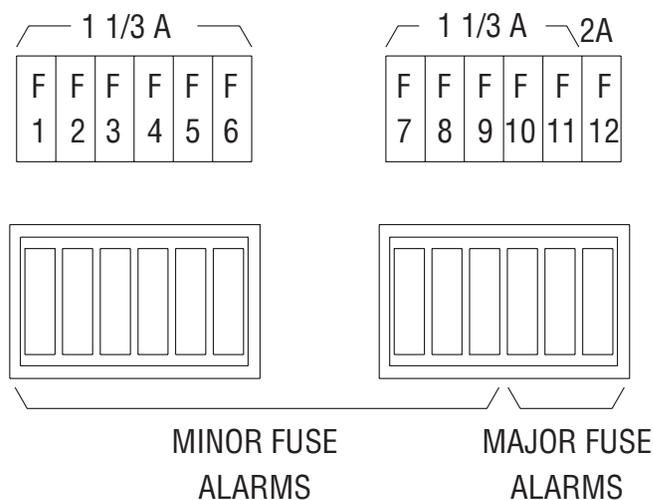


Figure 5-1: Fuse Designation and Function for LVD/Fuse Board

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		
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		
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	1. manually turned of 2. overcurrent trip 3. breaker failure	See "Open Distribution Breaker" section below
"LVD OPEN" LED lit	1. failed LVD contactor 2. low voltage 3. faulty wiring 4. LVD circuit failure	See "Red LVD OPEN LVD Lit" section below
"LVD FAIL" LED lit	1. low voltage 2. LVD circuit failure	See "Yellow LVD FAIL LED Lit" section below

**Open
Distribution
Breaker**

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

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

3. A circuit breaker may fail such that it cannot be reset. Replace a failed distribution breaker as described below, "Load Circuit Breaker Replacement."

***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 section on LVD/R Contactor Replacement under Repair and Replacement, below.
3. There is an open circuit in the wiring that powers the contactor. Check the cable assembly from the LVD/Fuse Board to the contactor (see drawing T-82670-30).
4. Both redundant LVD sensing circuits have failed. The LVD/Fuse circuit pack must be replaced. See section on LVD/Fuse Board (CP5) Replacement under Repair and 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 LVD/Fuse circuit pack. See section on LVD/Fuse Board (CP5) Replacement under Repair and Replacement, below.

***Blown Fuse on
LVD/Fuse Board***

Refer to ECS controller manual for trouble shooting procedures.

Note: Replace with fuse of same rating only.

***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
Replacement***

STEP A: Obtain a replacement circuit breaker. See below, "Spare Parts."

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

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

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

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

DANGER:

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

STEP E: Unplug the faulty breaker from the printed wiring board.

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

STEP G: Plug in the new breaker, ensuring that line, load and alarm connectors are properly mated (see Figure 2-4).

STEP H: For safety, close the dc distribution door before proceeding to the next step.

WARNING:

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

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

STEP J: Note that Fuse Alarm Major (MJF) and its associated alarms have retired.

***LVD/R
Contactor
Replacement***

The following assumptions are made:

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

The following equipment is required:

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

Procedure: (Refer to Figure 2-3)

1. Remove rectifier in position directly beneath LVD/R contactor (position 1), if present.
2. Open distribution panel 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 the new contactor (406066472 JCA-4032D Contactor) and then mount the contactor using the hardware from Step 4.
6. Plug P501 into J501 on LVD/Fuse board and verify that contactor closes.
7. Replace rectifier and turn on.
8. Close distribution panel and verify that LVD FAIL and LVD OPEN lights are not lit.

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

Procedure: (Refer to Figure 4-4)

1. Open distribution panel.
2. Unplug the following connectors from the LVD/Fuse Board. Leave the cables dressed.

P502 from J502

P506 from J506

P501 from J501

P504 from J504

Quick Connect from E501

3. Remove the cover over the LVD/Fuse Board and then remove the insulated standoffs to free the board.
4. Set jumpers J505.1 and J505.2 on replacement LVD/Fuse Board per J85500D-1 drawing for desired disconnect voltage.
5. Mount the replacement board to the distribution panel using the hardware from Step 3.

6. Reconnect the following connectors:

P502 to J502

P506 to J506

P501 to J501

P504 to J504

Quick Connect to E501

7. Close distribution panel.

Spare Parts

The following equipment may be ordered as spare parts. For exact ordering codes, refer to recommended spares information in Section 3 or on the J85500D-3 drawing.

- Rectifiers and fans
- LVD/Fuse Board
- Fuses (F1 to F12)
- Load Circuit Breakers (CB1 to CB42)
- Controller Circuit Packs (e.g. 113A/CU. Refer to the Controller manual for details on spare controller circuit packs.)

In addition to these items, any piece part may be ordered that is identified in the assembly views and stocklist on the J85500D-3 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:

C. If, under normal and proper use during the applicable Warranty Period, a defect or nonconformity is identified

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.

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

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

- D. If Seller has elected to repair or replace a defective Product, Customer shall have the option of removing and reinstalling or having Seller remove and reinstall the defective or nonconforming Product. The cost of the removal and the reinstallation shall be borne by Customer. With respect to Cable and Wire Products, Customer has the further responsibility, at its expense, to make the Cable and Wire Products accessible for repair or replacement and to restore the site. Products returned for repair or replacement will be accepted by

Seller only in accordance with its instructions and procedures for such returns. The transportation expense associated with returning such Product to Seller shall be borne by Customer. Seller shall pay the cost of transportation of the repair or replacing Product to the destination designated by Customer within the Territory.

- E. The defective or nonconforming Products or parts which are replaced shall become Seller's property.
- F. If Seller determines that a Product for which warranty service is claimed is not defective or nonconforming, Customer shall pay Seller all costs of handling, inspecting, testing, and transportation and, if applicable, traveling and related expenses.
- G. Seller makes no warranty with respect to defective conditions or nonconformities resulting from actions of anyone other than Seller or its subcontractors, caused by any of the following: modifications, misuse, neglect, accident, or abuse; improper wiring, repairing, splicing, alteration, installation, storage, or maintenance; use in a manner not in accordance with Seller's or vendor's specifications or operating instructions, or failure of Customer to apply previously applicable Seller modifications and corrections. In addition, Seller makes no warranty with respect to Products which have had their serial numbers or month and year of manufacture removed, altered, or with respect to expendable items, including, without limitation, fuses, light bulbs, motor brushes, and the like.
- H. The foregoing warranties are exclusive and are in lieu of all other express and implied warranties, including but not limited to warranties of merchantability and fitness for a particular purpose. Customer's sole and exclusive remedy shall be Seller's obligation to repair, replace, credit, or refund as set forth above in this warranty.

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7

Safety

Safety Statements

Please read and follow all safety instructions and warnings before installing, maintaining, or repairing the power system. Reference the individual module product manuals for additional safety statements specific to the modules.

The J85500D-3 ECS Power System is Underwriters laboratories (UL) Listed per: Subject Letter 1801, DC Power Distribution Centers for Telecommunications Equipment for use in the USA; and CSA C22.2 No. 225 for use in Canada. Rectifiers are individually UL Recognized and/or CSA Certified to UL1950 and CSA C22.2 No. 234/950. Note: J85500D-3 equipped with List 5 or 6 does not have safety agency Listing.

Install only in restricted access areas (dedicated equipment rooms, equipment closets, or the like) in accordance with articles 110-16, 110-17, and 110-18 of the U.S. National Electrical Code (NEC), ANSI/NFPA No. 70, and pursuant to applicable local codes.

This equipment is to be used in controlled environments (an area where the humidity is maintained at levels that cannot cause condensation on the equipment, the contaminating dust is controlled, and the steady-state ambient temperature is within the range specified).

This equipment must not be installed over combustible surfaces.

For installations in the U.S. and Canada, Listed/Certified compression connectors are to be used to terminate Listed/Certified field-wired conductors where required. For all installations, the appropriate connector is to be applied only to the correct size conductor as specified by the connector

manufacturer using only the connector manufacturer's recommended tooling or tooling approved for that connector.

If the proper connector for the country of installation is not provided, obtain appropriate connectors and follow manufacturer's and all local requirements for proper connections. All national and local rules and regulations are to be followed when making field connections.

The field wiring connections have been evaluated for connection of minimum 90°C conductors sized per the U.S. National Electrical Code using 75°C ampacity tables.

Torque electrical connections to the values specified on labels or in the product documentation.

Battery input cables must be dressed to avoid damage to the insulation (caused by routing around sharp edges or routed in areas where wires could get pinched) and undue stress on the connectors.

The short circuit current capability of the battery input to the distribution panel must not exceed 10,000 amperes.

Fuses/circuit breakers may not be provided with the equipment. Refer to the product documentation for the proper hardware. Use only the parts specified in the equipment documentation. Installing fuses or circuit breakers not specified for use in this equipment may result in injury to service personnel or equipment damage.

External loading must not exceed 80% of its fuse/circuit breaker current rating.

AC branch circuits to this equipment must be protected with either fuses or circuit breakers sized as required by the National Electric Code (NEC) and/or local codes. Refer to the equipment ratings to assure rating of equipment will not exceed 80% of the value of the protector chosen. Reference drawing T-82670-31 for recommended circuit protection for the different options.

An accessible ac disconnect/protection device to remove ac power from the equipment in the event of an emergency must be provided. This device must open all poles and be connected together.

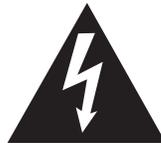
Warning Statements And Safety Symbols



This symbol identifies the need to refer to the equipment instructions for important information.



These symbols (or equivalent) are used to identify the presence of hazardous ac mains voltage.



This symbol is used to identify the presence of hazardous ac or dc voltages. It may also be used to warn of hazardous energy levels.

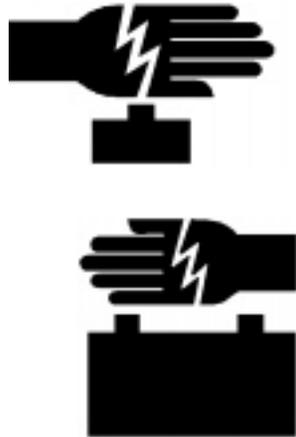
The symbols may sometimes be accompanied by some type of statement; e.g., “Hazardous voltage/energy inside. Risk of injury. This unit must be accessed only by qualified personnel.”

When working on or using this type of equipment, the following precautions should be noted:

- This unit must be installed, serviced, and operated only by skilled and qualified personnel who have the necessary knowledge and practical experience with electrical equipment and who understand the hazards that can arise when working on this type of equipment.
- The ECS Power System can be powered by multiple ac inputs. Ensure that the appropriate circuit protection device for each ac input being serviced is disconnected before servicing the equipment.
- For equipment connected to batteries, disconnecting the ac alone will not necessarily remove power to the equipment. Make sure the equipment is not also powered by the batteries or the batteries are not connected to the output of the equipment.
- High leakage currents may be possible on this type of equipment. Make sure the equipment is properly safety earth grounded before connecting power.
- Hazardous energy and voltages are present in the unit and on the interface cables that can shock or cause serious injury. Follow all safety warnings and practices when servicing this equipment. Exercise care when servicing this area.



This symbol is used to identify the need for safety glasses and may sometimes be accompanied by some type of statement, for example: “Fuses can cause arcing and sparks. Risk of eye injury. Always wear safety glasses.”



One of these two symbols (or equivalent) may be used to identify the presence of rectifier and battery voltages. The symbol may sometimes be accompanied by some type of statement, for example: “Battery voltage present. Risk of injury due to high current. Avoid contacting conductors with uninsulated metal objects. Follow safety precautions.”

When working on or using this type of equipment, the following precautions should always be noted:

- Batteries may be connected in parallel with the output of the rectifiers. Turning off the rectifiers will not necessarily remove power from the bus. Make sure the battery power is also disconnected and/or follow safety procedures while working on any equipment that contains hazardous energy/voltage.
- In addition to proper job training and safety procedures, the following are some basic precautions that should always be used:
 - Use only properly insulated tools.
 - Remove all metallic objects (key chains, glasses, rings, watches, or other jewelry).
 - Wear safety glasses.
 - Test circuits before touching.
 - Lock out and tag circuit breakers/fuses when possible to prevent accidental turn on.
 - Be aware of potential hazards before servicing equipment.
 - Identify exposed hazardous electrical potentials on connectors, wiring, etc. (note the condition of these circuits, especially wiring).
 - Use care when removing or replacing covers; avoid contacting circuits.



These symbols are used to identify the safety earth ground or bonding point for the equipment.