Product Manual
Product H569-408

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Lucent Technologies LINEAGE® 2000 300-Ampere, -48-Volt Evolutionary Control System Battery Plant

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1 Introduction

Thank you for making the Right Choice, a Lucent 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 commitment to product and service excellence to your own system. This long-standing Lucent commitment has been gained from years of worldwide telecommunications experience in the development, manufacturing, engineering, installation and servicing of leading edge energy systems, products and services.

The ECS Battery Plant, H569-408, 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 string of LINEAGE® 2000 375-ampere hour VR Series 48-volt 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. Functionality is added to the basic controller by two optional circuit packs, one

to add microprocessor-based features and the second to add a datalogger. Additional battery reserve time may be gained through the use of supplementary bays (Figure 1-2). These bays can house up to two 48-volt strings of 375-ampere hour batteries to provide a maximum of 2625 ampere hours at the 10-hour rate.

Documentation

This document (Lucent 167-790-042) is part of a set of product manuals which provide information on the LINEAGE® 2000 Evolutionary Control System (ECS) Battery Plant and its components. This manual should be inserted after the PLANT tab in the LINEAGE® 2000 Battery Plant Binder. The binder contains tabs for the other manuals in the set, such as Controller, Rectifier and Battery manuals. Each manual contains a technical description of the product, which is followed by detailed information on engineering, installation, operation and maintenance. The contents of the documentation package are identified for ordering and reference purposes in Section 3 of this manual.

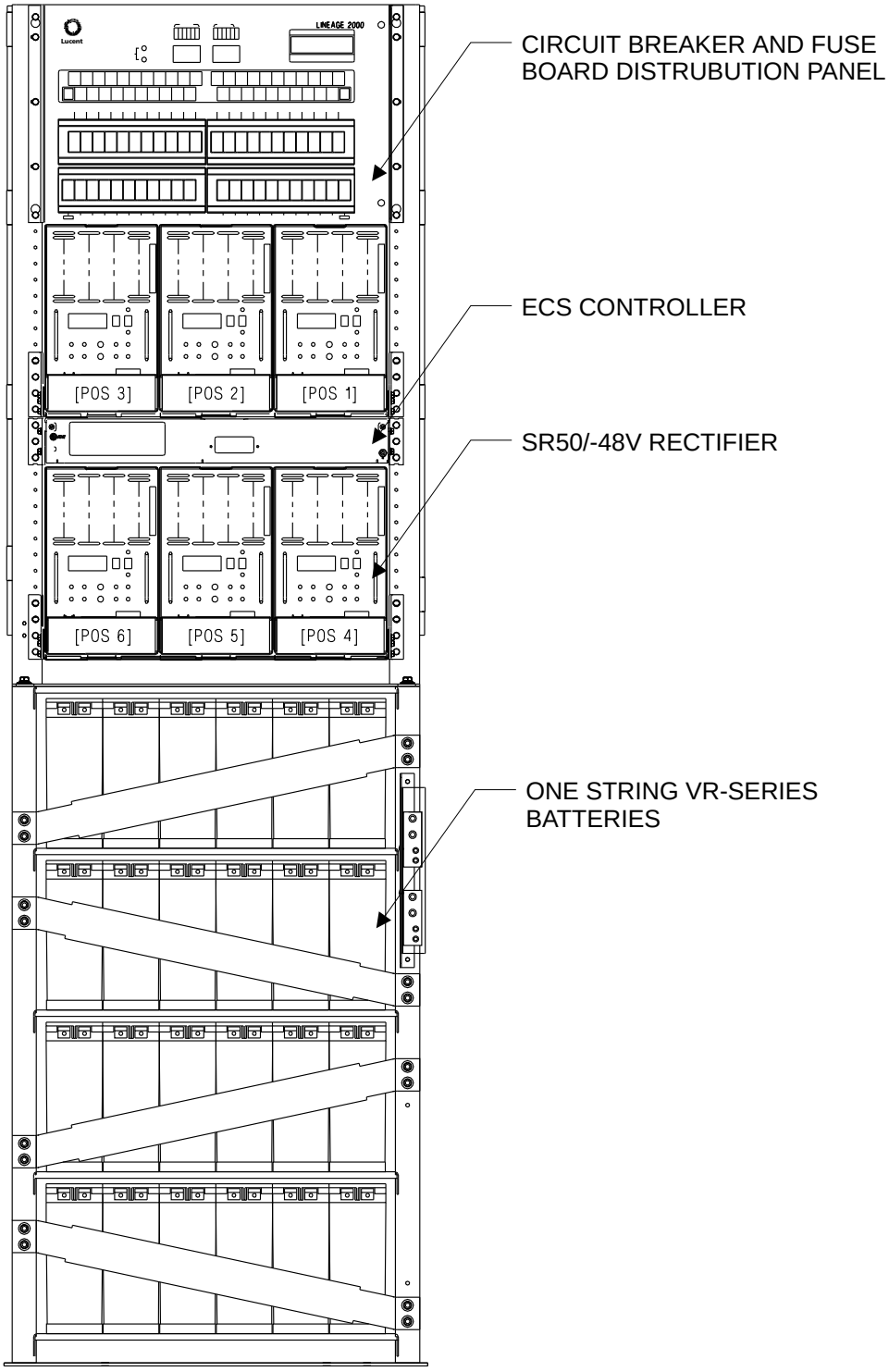


Figure 1-1: LINEAGE® 2000 ECS Battery Plant (Model H569-408, Initial Bay)

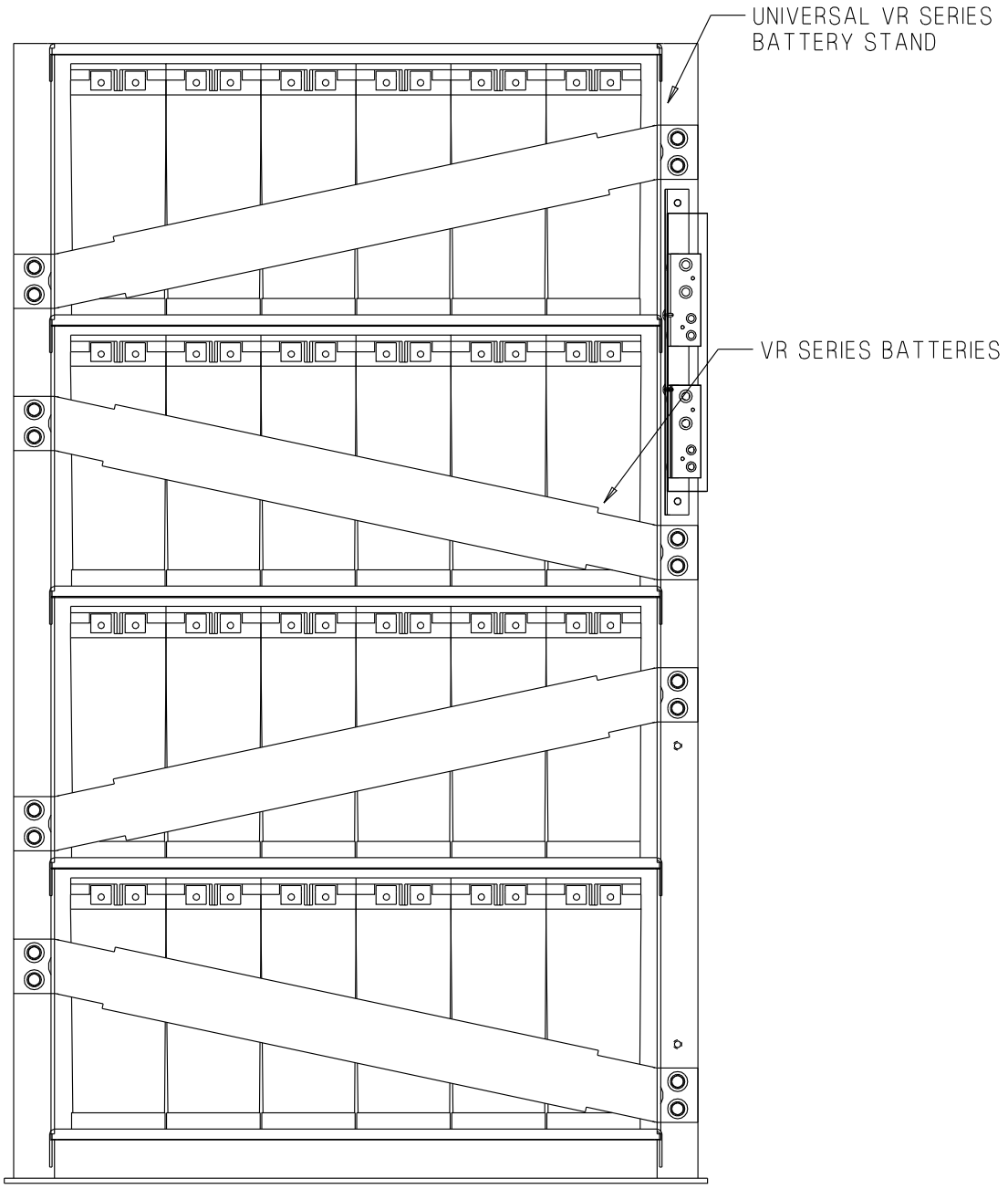


Figure 1-2: VR Battery Supplementary Bay Configurations

Technical Support

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

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

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

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

Central and South America

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

Europe, Middle East, and Africa

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

Asia Pacific Region

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

Product Repair and Return

Repair and return service for Lucent Technologies equipment is available to customers around the world.

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

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

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

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

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

Customer Service

For customer service, any other product or service information, or for additional copies of this manual or other Lucent Technologies documents, call 1-800-THE-1PWR (1-800-843-1797). Specify the select code number for manuals, or drawing number for drawings. Contact your regional customer service organization or sales representative for information regarding spare parts.

2 Product Description

Plant Specifications

Table 2-A. LINEAGE® 2000 Battery Plant Specifications -Model H569-408

Input Voltage	180-264 Vac (208/220/240 Vac nominal)
Input Frequency	47-63 Hz (50/60 Hz nominal)
Operating Voltage	40-60.0 Vdc (48 Vdc nominal)
Float Voltage	47-58.5 Vdc (48 Vdc nominal)
Plant Current Rating	300 amperes
Plant Shunt	300 amperes maximum at 50 millivolts
LVD/R Voltage Settings	40.5 or 42.5 Vdc
Controller	Basic: 113A; Microprocessor option circuit pack: BAB1; Datalogger option circuit pack: BAC1, BAC2
Rectifier Shelf Assembly	2 maximum, each mounts 3 rectifiers
Rectifiers	Type: LINEAGE® 2000 SR50/-48V Rating: -48 Vdc nominal, 50 amperes Number: 6 maximum
Batteries	Type: LINEAGE® 2000 2VR375E Rating: 375 Ah per string Number: 7 strings maximum

Table 2-A. LINEAGE® 2000 Battery Plant Specifications -Model H569-408

Circuit Breakers	Type: KS23616 Ratings: 10, 20, 30, 45, 60 amperes Interrupt capacity: 7000 amperes
Temperature	32 to 122°F (0 to 50°C)
Altitude	-200 to 13000 feet (-61 to 3962 meters) For altitudes of 5000 to 13,000 feet, derate maximum temperature by 3.8°F per 1000 feet above 5000 feet. For altitudes of 1524 to 3962 meters, derate maximum temperature by 0.656°C per 304 meters above 1524 meters.
Framework	Type: 42-inch (1067 mm) high frame (standard 23-inch relay rack width), mounted on top of a 26-inch wide 846821890 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) Depth: 26 inches (660 mm): G-1 or G-2 plant and G-41 or G-42 battery stand
Weight (approximate)	
Initial Bay (G-1 or G-2) (3 Deep Battery Module Stand)	with six rectifiers: 495 lbs (225 kg) with six rectifiers and VR Series batteries: 2370 pounds (1075 kilograms)
Supplementary Battery Bay	with one string VR 375 Ah batteries: 2085 lbs (946 kg)
Rectifiers	25 lbs (11 kg) each
Batteries	2VR375E Battery: 78 lbs (35 kg) each
Earthquake	Initial bay (including one string of batteries): Zone 4, upper floors Supplementary stands equipped with VR batteries: One string high Zone 4
Heat Dissipation	Full load: 2744 watts (9362 BTU/hr) Rectifier, full load: 451 watts (1540 BTU/hr) Controller, basic and options: 26 watts (89 BTU/hr) (note 1)
Humidity rating	10% to 95% noncondensing
Audible noise	65 dBa (note 2)

Table 2-A. LINEAGE® 2000 Battery Plant Specifications -Model H569-408

Electrostatic discharge	IEC 801-2 Level 5 (15 KV) at 40% relative humidity
Radiated/ Conducted Emissions	FCC Level A
Electromagnetic immunity	10V/m over the range of 20 to 2000 MHz

Notes:

1. Specified at 55.5 Vdc, 300 amperes output, and nominal input voltages and frequencies.
2. Measured at 6 feet (2 meters) from the rectifiers installed in 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.

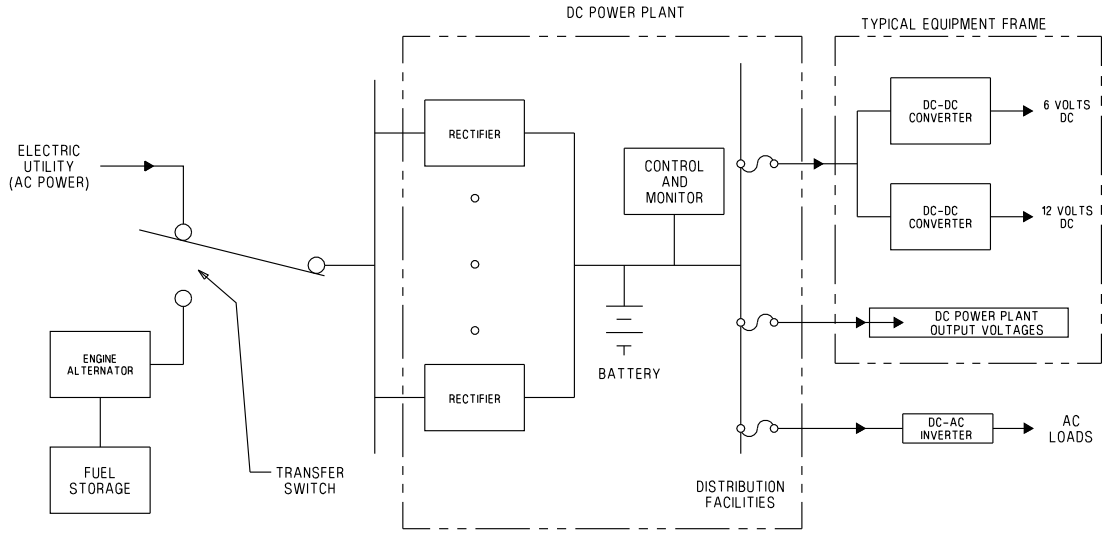


Figure 2-1: Block Diagram of Typical Battery Plant

ECS Battery Plant Physical Description

Introduction

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 is mounted on a battery stand which provides space for one 48-volt string of VR Series 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 and batteries. 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 of 10, 20, or 30 ampere capacity, or 20 circuit breakers of 45 and 60 ampere capacity, a low voltage battery disconnect/reconnect feature and one string of LINEAGE® 2000 VR Series 48-volt, 375-ampere hour 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 2VR375E batteries. A maximum of three two-string high or six one-string high bays or a total of seven strings of VR batteries can be added to the ECS battery plant providing a total battery capacity of 2625 ampere hours at a 10-hour rate.

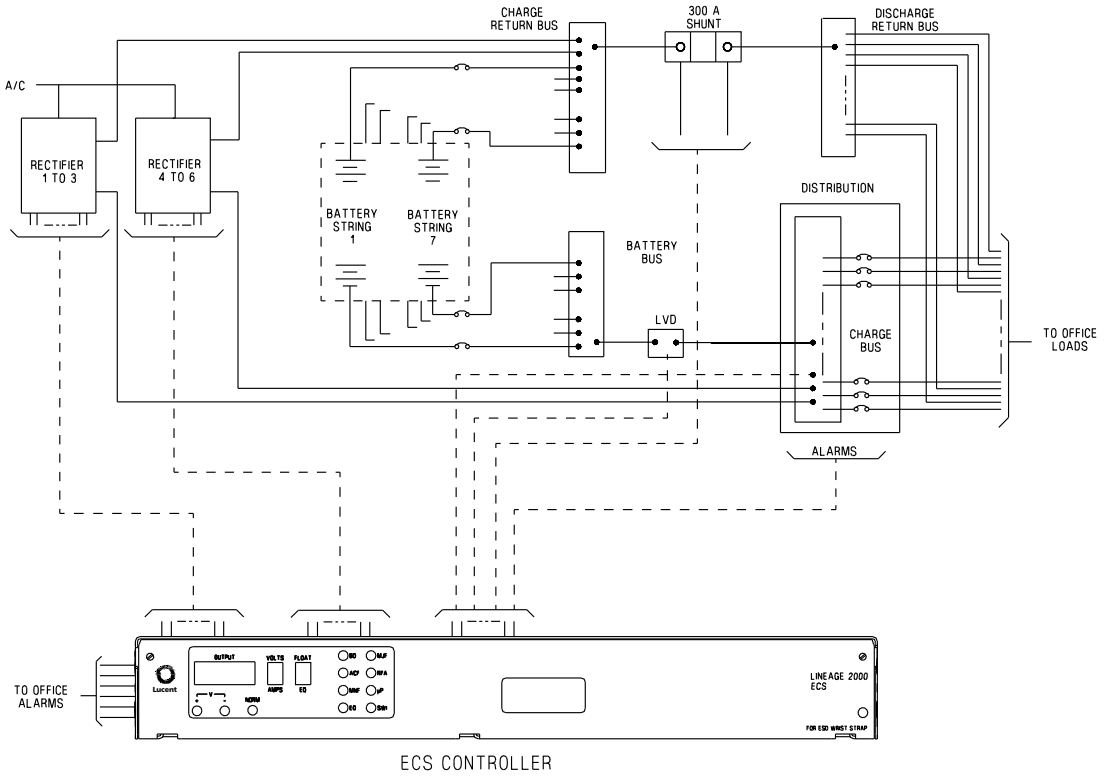


Figure 2-2: ECS Battery Plant Block Diagram

ECS Battery Plant Subsystems

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

Rectifier

The LINEAGE® 2000 SR Series rectifiers are designed specifically for applications where small size, low weight and ease of installation are of overriding importance. The rectifiers utilize a combination of switch-mode technology and forced air

cooling to achieve a significant reduction in size and weight over conventional ferroresonant rectifiers. The plug in, connectorized design of the rectifiers reduces installation time to minutes, permitting easy growth and maintenance without service interruption.

The LINEAGE® 2000 SR Series 50-ampere rectifiers operate over 208/220/240 Vac 50/60 Hz nominal single phase input range without any necessary tap changes. A power factor correction circuit incorporated in the design insures a power factor of 90 percent or greater for loads above 50 percent of the full load rating. The rectifiers provide the ECS controller with a full complement of status and alarm signals. The SR Series 50-ampere rectifier is both UL recognized and CSA certified.

The rectifier status and alarm signals, ac input, and dc output are all connectorized. The rectifiers plug into a rectifier shelf assembly that accommodates a maximum of three individual 50-ampere rectifiers. The 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. Selection of the VR Series battery enables one to maximize space efficiency and fully realize the benefits of front access, modular growth, ease of installation and maintenance offered by the ECS battery plant system design.

The LINEAGE® 2000 VR Series battery is a valve regulated design incorporating many of the same technologically advanced features as the highly acclaimed LINEAGE® 2000 Round Cell battery. It is a compact, totally front access, modular battery based on a unit cell architecture. The VR Series battery is currently available in a 2 volt, 375-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.)

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, and statistics. This board is available as Group 5 or 7 on H569-408. Group 7 is the same as Group 5, with the addition of a voice response feature. The datalogger board may be used in conjunction with the microcomputer option to provide general purpose ac and dc, voltage and current monitoring and control. This board is available as Group 8 or 9 on H569-408. Group 9 is the same as Group 8, with the addition of a remote termination panel allowing external connection to the board from outside the controller. (See the ECS controller manual for further information.)

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 10, 20, 30, 45 and 60 ampere ratings (see Figure 2-4). The 10, 20 and 30 ampere circuit breakers occupy one position and the 45 and 60 ampere circuit breakers require two positions on the panel. The distribution panel contains the plant charge and discharge bus bars, plant shunt, LVD/R contactor and associated circuitry (see Figure 2-3).

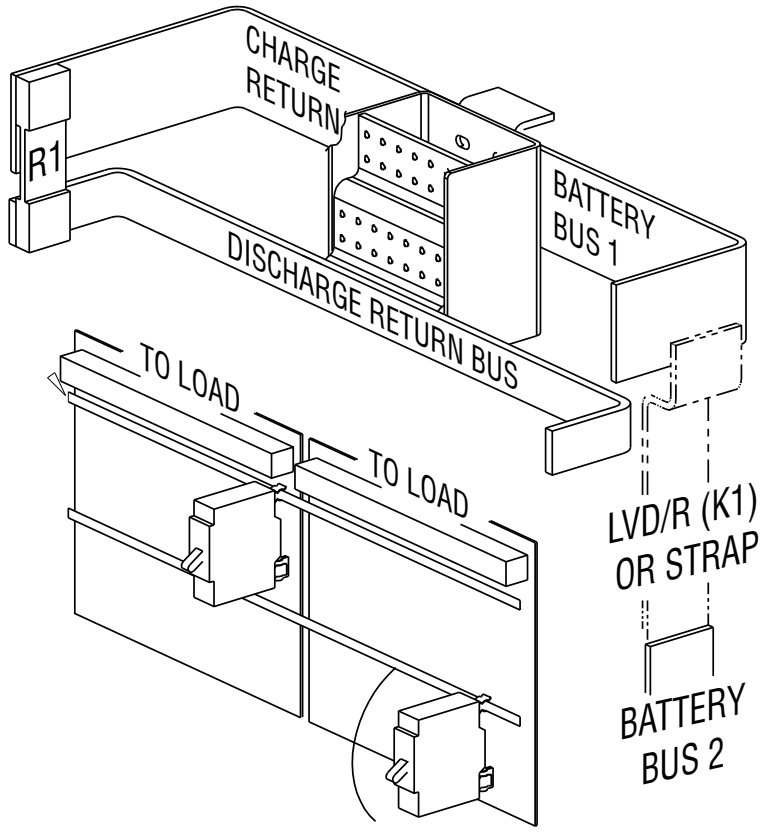


Figure 2-3: ECS Distribution Bus Bars

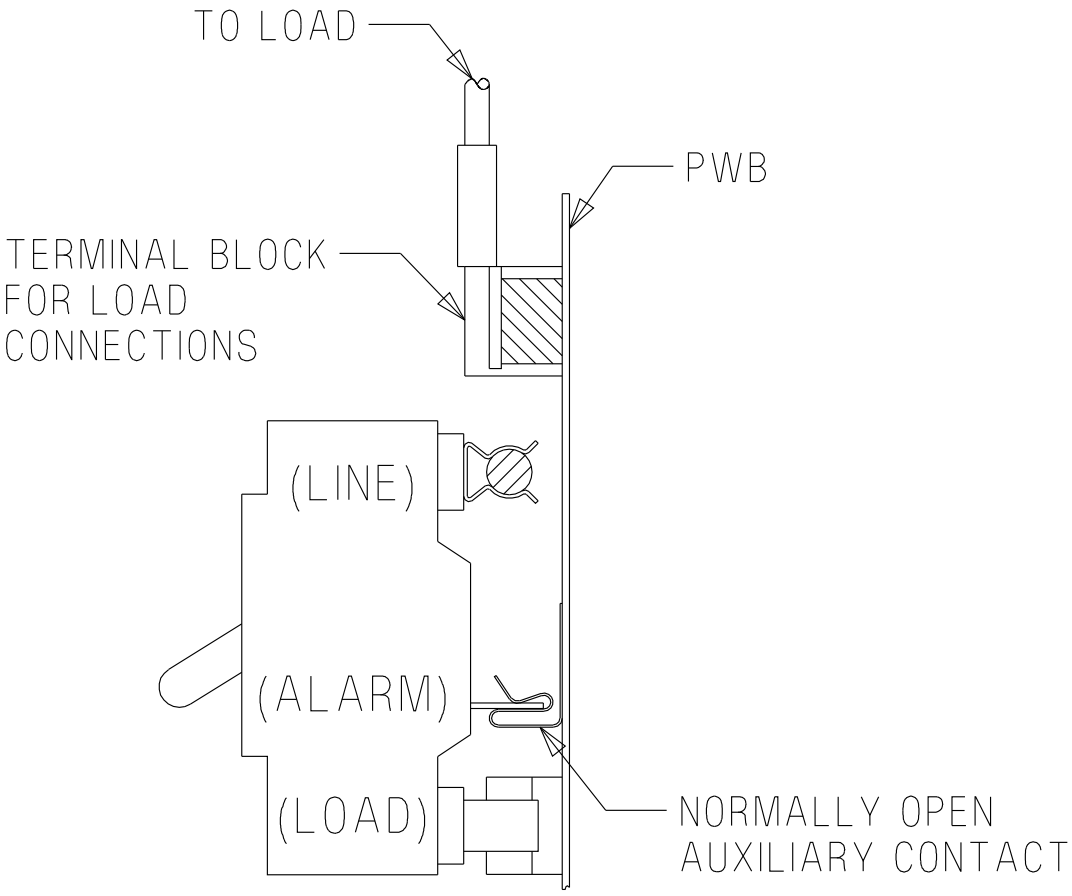


Figure 2-4: Plug-In Circuit Breaker Mounting

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.

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, though 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 back to amperes and displayed on the digital meter.

Low Voltage Battery Disconnect/ Reconnect (LVD/ R) Feature

In unattended battery plant locations, especially those without automatic back-up ac, batteries could be completely discharged during an ac power outage. The ECS Battery Plant may be equipped with an optional automatic battery disconnect to prevent costly battery damage due to unforeseen deep discharge. This disconnect is designed to isolate batteries from the load when the plant voltage reaches the lowest usable battery voltage. The disconnect level is below the operating range of most load equipment, in which case service to the load would already have been lost. The disconnect does not separate the load circuits from the rectifiers, thus enabling the rectifiers to begin powering the load as soon as ac power is restored.

The LVD/R option consists of the LVD/R Contactor, circuitry on the CP5 Fuse Board and associated wiring. As shown in Figures 2-2 and 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 Section 3 of this manual.

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. 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.

Circuit Breakers

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 10, 20, 30, 45 and 60 ampere ratings. These breakers have standard curve 2 trip characteristics and an interrupt capacity of 7000 amperes. The 45 and 60 ampere circuit breakers require the use of two positions on the panel. A two position load and return bus adapter terminal is included with the 45 and 60 ampere breakers.

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.

Ordering Information

The H569-408 battery plant is ordered with Group (G) numbers (see Table 2-B).

A sample order for a 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

G items from H569-408 should be ordered as separate line items. Do not format as “equipped with” (e/w) items.

Item	Qty	Description
1	1	H569-408 G-1 -48V, 300 AMP ECS Plant
2	5	H569-408 G-4 SR50/-48V Rectifier
3	5	H569-408 G-5 Microprocessor Board
4	15	H569-408 G-12 20-Amp Breaker
5	5	H569-408 G-14 45-Amp Breaker
6	3	H569-408 G-20 48V VR Battery String A, B, C
7	1	H569-408 G-42 Eight-Shelf VR Battery Stand
8	3	H569-408 G-K32 VR Battery Cable Kit

Table 2-B: Ordering Guide for H569-408 ECS 300-Ampere -48-Volt Battery Plant

Group No.	Description
1	Provides a battery plant, 208/240 volt input, -48 volt, 300 ampere max. output. (Includes controller, two rectifier shelves, circuit breaker distribution panel, and a stand for one string of 48 volt 375 ampere-hour batteries)
2	Same as Group 1, with low voltage disconnect feature
4	Provides one 50 ampere, -48 volt switch-mode rectifier
5	Provides an optional microprocessor circuit pack for remote and local monitoring and control functions
7	Same as Group 5, with voice response feature
8	Provides an optional datalogger circuit pack for data acquisition. Group 8 always requires a Group 5 or 7 circuit pack
9	Same as Group 8, with remote termination panel. The remote termination panel allows connection to the datalogger circuit pack external to the controller
11	Provides one 10 ampere circuit breaker
12	Provides one 20 ampere circuit breaker
13	Provides one 30 ampere circuit breaker
14	Provides one 45 ampere circuit breaker
15	Provides one 60 ampere circuit breaker
Groups 20 and 22 provide one string of batteries and interconnection material for the following:	
20	375 ampere-hour battery string (24 batteries, float voltage -54.48 volt)
22	375 ampere-hour battery string (23 batteries, float voltage -52.21 volt)
Groups 41 and 42 provide a battery stand, mounting hardware and front cover for the following:	

Table 2-B: Ordering Guide for H569-408 ECS 300-Ampere -48-Volt Battery Plant

41	Four shelf stand, front cover and mounting material for one string of 2VR375E batteries with brackets for attachment to a cable rack
42	Same as Group 41, except brackets replaced by 41 inch framework (22-5/16 inch mounting centers) which is mounted in the four shelf stand
B	Optional equipment to provide one battery string terminal plate assembly for terminating wire sizes 2 gauge to 4/0 (not required in addition to Group C)
C	Optional equipment to provide one battery string disconnect (one per battery string)
D	Optional equipment to provide one remote power off switch to be used in conjunction with Group C (one required per plant)
K2	Equipment and hardware in addition to Group 1 and 2 for rear cover in upper half of bay
K10	Optional equipment for plant controller equipped with Group 5 (CP2). Provides an upgrade kit to add the voice response feature to a plant controller in the field
K30	Battery cable kit: 30 feet of KS-20921 1/0 cable and associated hardware
K31	Battery cable kit: 30 feet of KS-20921 4/0 cable and associated hardware
K32	Battery cable kit: 21 feet of KS-20921 1/0 cable and associated hardware

Documentation References

The following documents provide the engineering, ordering and installation information for the Lucent LINEAGE® 2000 ECS battery plant.

ECS Battery Plant

Assembly and Ordering drawing:	H569-408
Wiring Diagram:	T-82670-30
Schematic Diagram:	SD-82670-01
Product Manual:	167-790-042

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

ECS Contoller

Assembly and Ordering drawing:	J85501D-1
Wiring Diagram:	None
Schematic Diagram:	SD-82669-01
Product Manual:	167-790-031
Optional Circuit Pack Product Manual:	167-790-108

SR Series Rectifiers and Rectifier Shelf Assembly

Assembly and Ordering drawing:	J85702B-2
Wiring Diagram:	T-82668-30
Schematic Diagram:	SD-82668-01
Product Manual:	167-790-117

VR Series Battery

Assembly and Ordering drawing:	J85504C-1
Wiring Diagram:	T-83110-30
Schematic Diagram:	SD-83119-01
Product Manual:	157-622-010

3 Installation

General

Lucent offers complete engineering and installation service that result in "turn-key" plant operation. Contact your Lucent Energy Systems Account Executive for further information on the complete range of installation services available from Lucent. Customers may, however, choose to make their own arrangements to fully or partially install the battery plant based on the information supplied here.

This section outlines an efficient sequence of battery plant installation steps that minimizes the installer's exposure to live circuits. 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
- 30 mm socket wrench
- 24 mm drill bit 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

General Information

1. The plant may be wired with ac from the left side or the right side. Typical routing of ac, dc and control cabling is shown on the plant assembly drawing, H569-408. Connection points and wire types are indicated on the plant wiring diagram, T-82670-30.
2. When running dc cable, care should be taken to ensure that all non-protected leads are run in a separate cable rack from protected leads. (Protected, in this sense, refers to overcurrent protection by a fuse or circuit-breaker.) Battery leads are usually the only unprotected leads. When Lucent VR Batteries are used, the battery leads may be protected. Refer to the Battery Manual for more detail on this option.

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

Sequence of Tasks

Table 3-C lists the drawings, manuals and other documentation that are necessary to complete the following sequence of tasks.

Step A: Unpacking, Handling & Frame Installation

1. 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.
2. 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.
3. 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.

Step B: Battery Stand Assembly

Warning

Do not connect batteries to the system at this time.

Assemble battery stands as described in the battery manual. Install the batteries onto their stands.

Table 3-A: Minimum Torque For All Electrical Connections

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

Notes:

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

Table 3-B: Torque and Minimum Yield Strength for Mechanical Connections (Using Hex Head Cap Screws

Cap Screw Diameter	Grade 2	
	Minimum Yield Strength (PSI)	Torque (Ft.-Lb.) UNRC
1/4	57,000	5
3/16	57,000	12
3/8	57,000	22
7/16	57,000	35
1/2	57,000	54
9/16	57,000	77
5/8	57,000	107
3/4	57,000	190
7/8	36,000	193
1	36,000	290
1-1/ 8	36,000	410
1-1/4	36,000	580
1-38	36,000	760
1-1/2	36,000	1010

Table 3C: Installation Reference Documents

Step	Procedure	Reference Document
A	Unpacking	This manual "Sequence of Tasks" Step A
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 H569-408 Drawing T-82670-30 Drawing
F	Battery Connections	Battery Manual
G	Load Wiring	H569-408 Drawing T-82670-30 Drawing
H	Initial Battery Charge	Battery Manual Rectifier Manual
I	Controller Test	Controller Manual
J	Load Turn Up	Load Equipment Documentation

Step C: Cable Support and Ground System

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

Step D: Controller and LVD Set-up

1. Follow the controller set-up procedure given in the Controller manual to complete the steps below.
    a. Enable/disable equalize charge set-up
    b. Enable/disable rectifier restart set-up
    c. Set HV shutdown level(s)
    d. Set BD alarm level
    e. Run office alarm wiring
    f. Run other controller wiring
    g. Set up other optional circuit packs

2. Check and set the low-voltage disconnect/reconnect, if provided, at the desired voltage level. See Figure 3-3 for the location of the disconnect voltage select jumpers, J505.1 and J505.2 on LVD/Fuse Board.

   a. To provide a disconnect voltage of 42.5 +/- 0.5 volts, plug the jumpers across pins 1 and 2 of their respective connectors.

   b. To provide a disconnect voltage of 40.5 +/- 0.5 volts, plug the jumpers across pins 2 and 3 of their respective connectors.

3. Refer to the ECS controller manual for acceptance testing procedures for the LVD/Fuse circuit pack and the associated LVD/R option.

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

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

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

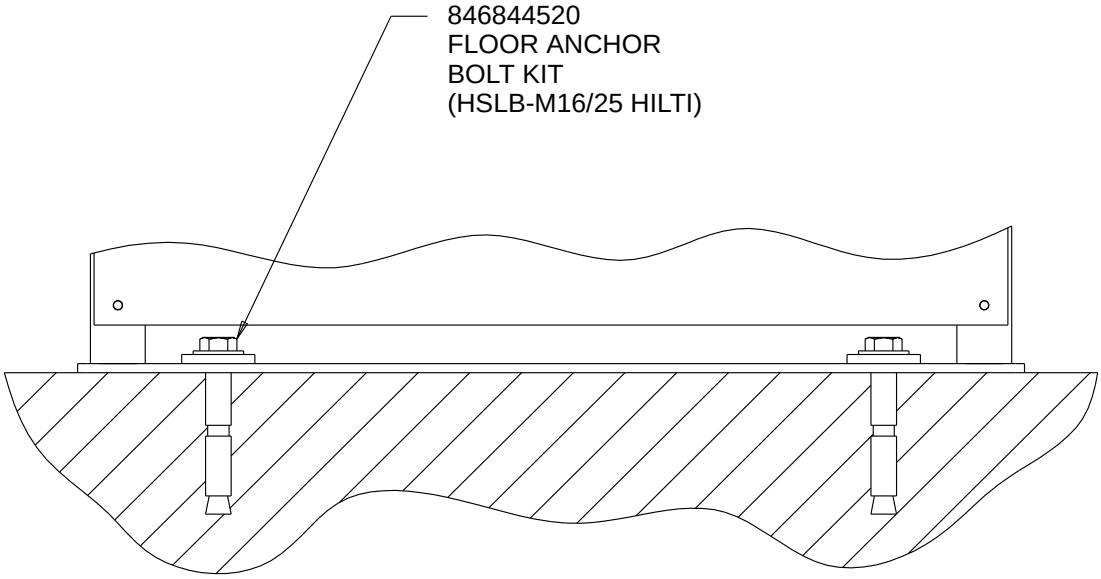
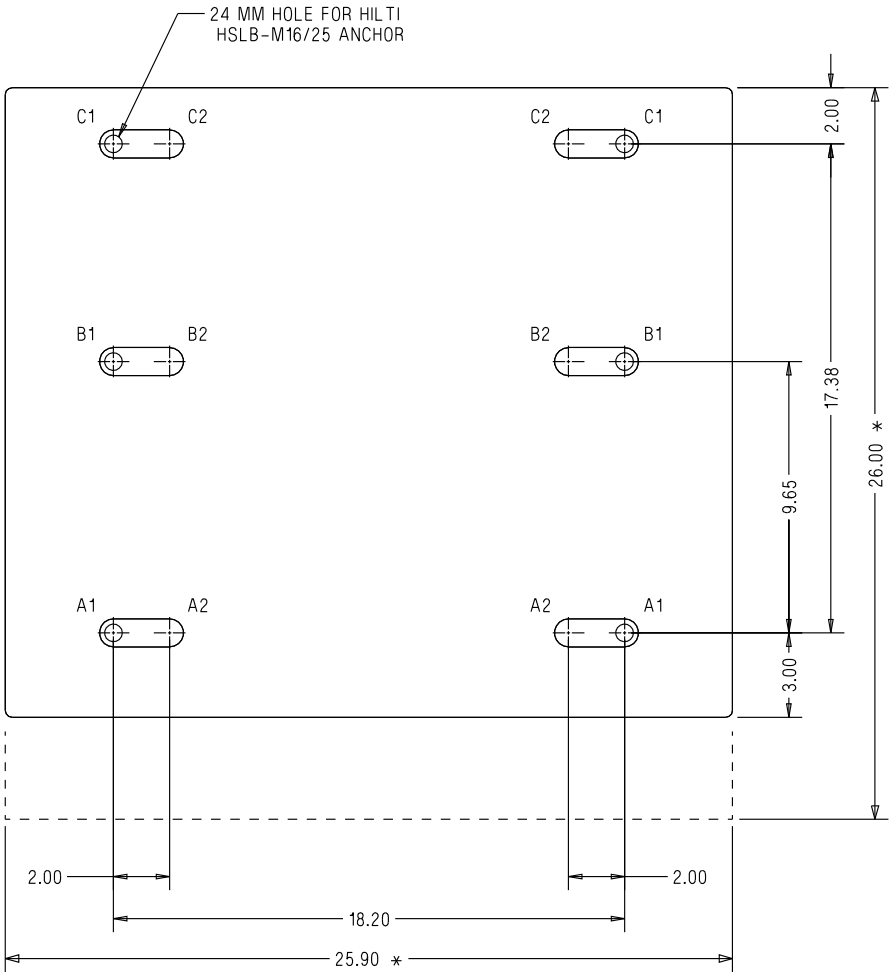


Figure 3-1: Typical Floor Mounting Detail



* OVERALL DIMENSION INCLUDING RETAINERS & COVERS.

FIG. A

FOOT PRINT FOR GROUP 1, 2, 41 AND 42
(SEE FLOOR ANCHOR LOCATION TABLE)
SCALE: NONE

FLOOR ANCHOR LOCATION TABLE						
GROUP			DESCRIPTION	PRIMARY	ALTERNATE*	FIGURE
1	2	41	SEISMIC SHELF FOR 2VR375E BATTERY	A1, B1, C1	A2, B2, C2	A
42						
*IF INTERFERENCE WITH FLOOR REINFORCING BARS OCCURS DURING INSTALLATION OF ANCHORING DEVICE AT PRIMARY MOUNTING LOCATION THEN ALTERNATE LOCATION SHALL BE USED.						

Figure 3-2: Floor Mounting Template (All Dimensions in Inches)

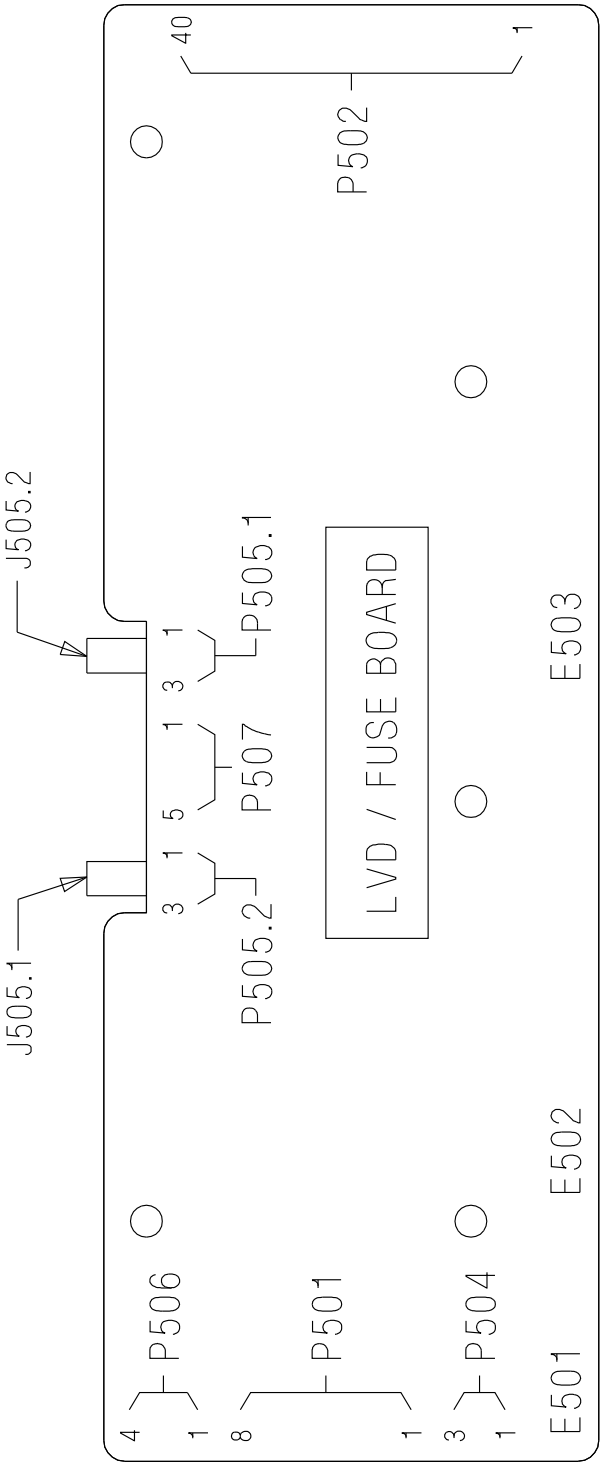


Figure 3-3: LVD/Fuse Board (CP5) Jumper Locations

Step F: Battery Connections

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

DANGER

- The next steps 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.
- 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 to the bus bars in the dc distribution subsystem. For suggested cable routing within the dc distribution see the H569-408 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 CP5 Fuse Board. Match the fuse ratings and positions as indicated on the distribution cover panel.

Note

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

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 maybe stored in distribution panel if in the OFF position. Leads may be run to spare circuit breaker positions in anticipation of future growth (similarly to prewiring rectifier ac input in Step 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, H569-408. Consult the job application drawings for the routing of these leads to the load equipment. A label is provided on the dc distribution cover that may be marked to indicate each load breaker's use.

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

Step H: 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.

Adding a Load Circuit

Warning

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

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

Step A: See "Ordering Information" in Section 2 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 that alarms may be received.

DANGER

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

Caution

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

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

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 Step G in paragraph "Sequence of Tasks" above.

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

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

Warning

Before applying power to any individual load, follow the power-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.

4 Maintenance

Controls and Indicators

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

Controller and Rectifier

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

CP5 Fuse Board LEDs and Fuses

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

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

Fuses F1 through F12 are also located on the CP5 LVD/Fuse Board and provide power for controller functions and rectifier regulation (see Figure 4-1). When a fuse blows the colored indicator (white or orange) pops up and an alarm signal is transmitted to the controller. The fault should be cleared before replacing a blown fuse. See paragraph "Troubleshooting" for details on replacing blown fuses.

DC Circuit Breakers

Circuit breakers CB1 through 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 overcurrent problem should be cleared before restoring power to the load by resetting the breaker. See paragraph "Troubleshooting" for information on tripped breakers.

Troubleshooting

Table 4-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.

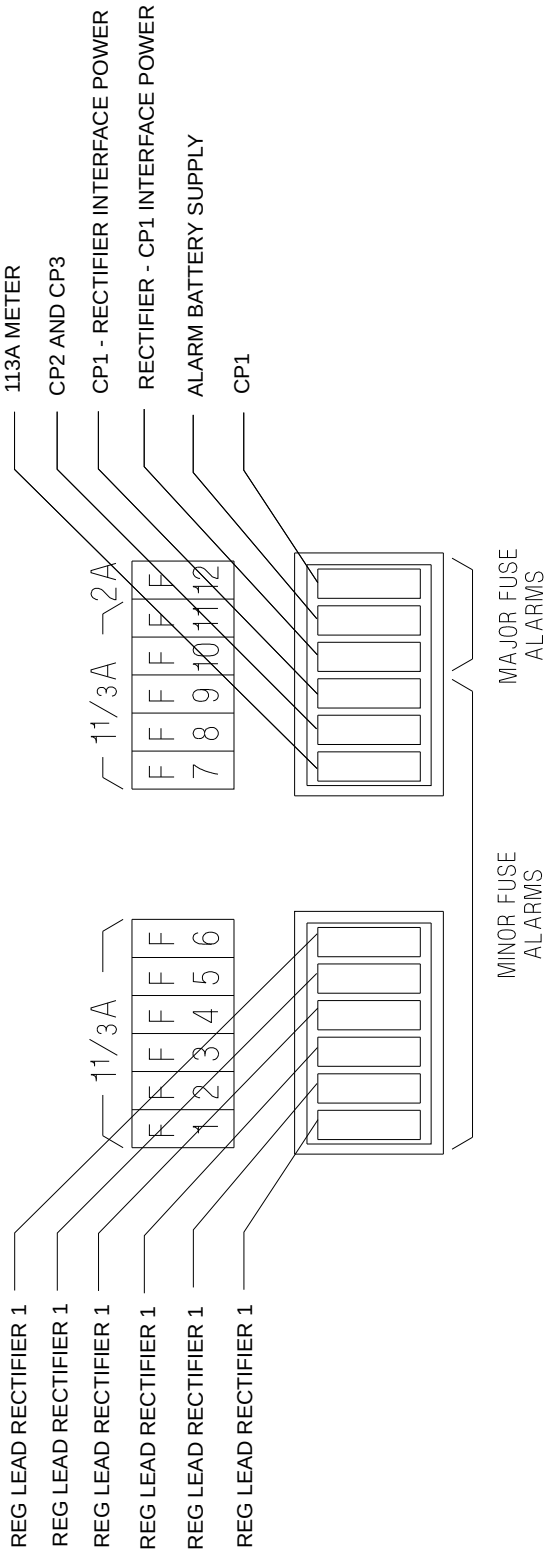


Figure 4-1: Fuse Designation and Function for LVD/Fuse Board (CP5)

Table 4-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	a. manually turned off b. overcurrent trip c. breaker failure	Open Distribution Breaker
"LVD OPEN" LED lit	a. failed LVD contactor b. low voltage c. faulty wiring d. LVD circuit failure	Red "LVD OPEN" LED Lit
"LVD FAIL" LED lit	a. low voltage b. LVD circuit failure	Yellow "LVD FAIL" LED Lit

Open Distribution Breaker

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

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

Red LVD OPEN LED Lit

A lit red "LVD OPEN" LED indicates that the LVD Contactor is de-energized, i.e., open. The contactor may be open due to one of the following reasons:

- Plant voltage is below the disconnect threshold.
- The contactor has failed and must be replaced. See procedure "LVD/R Contactor Replacement" below.
- There is an open circuit in the wiring that powers the contactor. Check the cable assembly from CP5 to the contactor (see drawing T-82670-30).
- Both redundant LVD sensing circuits have failed. Replace the CP5 circuit pack per procedure "LVD/Fuse Board (CP5) Replacement" below.

Yellow LVD FAIL LED Lit

A lit 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 due to one of the following reasons:

- 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.
- The LVD circuit has partially failed. Replace the CP5 circuit pack per procedure "LVD/Fuse Board (CP5) Replacement" below.

Blown Fuse on CP5

Refer to ECS controller manual for troubleshooting procedures.

Note

Replace with fuse of same rating only.

Repair and Replacement

Note

Procedures in this paragraph 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 paragraph "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 at the load connection associated with the faulty breaker, to verify that the breaker is truly open. The voltage 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.

DANGER

Before applying power to any individual load, follow the power-up instructions 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 retire.

LVD/R Contactor Replacement

The following assumptions are made:

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

The following equipment is required:

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

Procedure: (Refer to Figure 2-3 and T-82670-30 drawing.)

Warning

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

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 five quick connects from the contactor coil and auxiliary switch.
4. Unbolt and remove contactor.
5. Reconnect quick connect leads to new contactor and then mount new contactor using hardware from Step 4.
6. Plug P501 into J501 on LVD/Fuse board (CP5) and verify that contactor closes.
7. Replace 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

Warning

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

The following equipment is required:

- standard screwdriver

Procedure: (Refer to Figure 3-3 and T-82670-30 drawing)

1. Open distribution panel.
2. Unplug the following connectors from the LVD/Fuse Board (CP5). Leave the cables dressed.

   P502 from J502
   P506 from J506
   P501 from J501
   P504 from J504
   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 (CP5) per H569-408 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 on the H569-408 drawing.

Rectifiers and fans
LVD/Fuse Board (CP5)
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 H569-408 drawing. When ordering, please specify the Description and Comcode as shown in the stocklist.

5 Product Warranty

A. Seller warrants to Customer only, that:

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

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

Warranty Period

Product Type	New Product	Repaired Product or Part*
Central Office Power Equipment**	24 Months	6 Months

* The Warranty Period for a repaired Product or part thereof is as listed or, in the case of Products under Warranty, is the period listed or the unexpired term of the new Product Warranty Period, whichever is longer.

** The Warranty Period for Products ordered for Use in Systems or equipment Manufactured by and furnished by Seller is that of the initial Systems or equipment.

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

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

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

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

E. The defective or nonconforming Products or parts which are replaced shall become Seller's property.

F. If Seller determines that a Product for which warranty service is claimed is not defective or nonconforming, Customer shall pay Seller all costs of handling, inspecting, testing, and transportation and, if applicable, traveling and related expenses.

G. Seller makes no warranty with respect to defective conditions or nonconformities resulting from actions of anyone other than Seller or its subcontractors, caused by any of the following: modifications, misuse, neglect, accident, or abuse; improper wiring, repairing, splicing, alteration, installation, storage, or maintenance; use in a manner not in accordance with Seller's or Vendor's specifications or operating instructions, or failure of Customer to apply previously applicable Seller modifications and corrections. In addition, Seller makes no warranty with respect to Products which have had their serial numbers or month and year of manufacture removed, altered, or with respect to expendable items, including, without limitation, fuses, light bulbs, motor brushes, and the like.

H. THE FOREGOING WARRANTIES ARE EXCLUSIVE AND ARE IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. CUSTOMER'S SOLE AND EXCLUSIVE REMEDY SHALL BE SELLER'S OBLIGATION TO REPAIR, REPLACE, CREDIT, OR REFUND AS SET FORTH ABOVE IN THIS WARRANTY.

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