LINEAGE POWER

Lineage 2000® Battery Plant J85500A-2

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1 Introduction

System Overview

The J85500A-2 Lineage® 2000 battery plant was developed by Lineage Power as a general-use, +/-24 volt or -48 volt dc output power system for telecommunications applications requiring up to 9600 amperes of rectifier output capacity. The architecture of the system is shown in Figures 1-1 through 1-5. Figures 1-1 and 1-2 illustrate the arrangement and interconnections of the battery plant's components from the ac input to the dc output. The plant is composed of four major subsystems: rectifier, plant controller, battery equipment and dc distribution.

Rectifiers: convert a commercial or standby ac source voltage into the dc voltage level required to charge and float the batteries and to power the using equipment. An ac circuit breaker or fuse is typically used to connect ac to the rectifiers and to provide overcurrent protection.

Controller: provides the local and remote control, monitor and diagnostic functions required to administer the power system.

Batteries: provide energy storage for an uninterrupted power feed to the using equipment during loss of ac input or rectifier failure. Battery reserve is engineered to supply dc power for a specified period of time. In normal practice, battery capacity is sized to provide 3 to 8 hours of reserve time.

DC Distribution: provides overcurrent protection fuses and circuit breakers up to 600 amperes for connection to secondary dc distribution on the using equipment. It also includes the bus bar arrangements used to interconnect the rectifiers, batteries and dc distribution.

The J85500A-2 offers a family of different rectifiers, controller, batteries and dc distribution along with associated equipment such as bus bars, cables, cable racks, control cables and secondary dc distribution to create a modular and expandable battery plant. The batteries, rectifiers, and dc distribution are typically connected together with either bus bar or cable. In a cable connected system as shown in Figures 1-3 and 1-4, all rectifiers and batteries are connected together at a central point to bus bars located typically over the batteries and then from these bus bars to the dc distribution and then in turn to the system loads. Since all the system power is brought together at a centralized point, the size of the central point must be sized for the ultimate capacity of the system. Growth of the system is accomplished by adding rectifiers, batteries and dc distribution to this centralized point bus bar arrangement. This type of architecture is used for systems with a maximum load discharge current of 5200 amperes. For larger systems, bus bar is used to interconnect the system components as shown in Figure 1-5. The bus bar used in this arrangement is typically job specific and is sized and engineered for a specific application.

These Figures show typical J85500A-2 battery plants. (Note that many figures in this manual are necessarily "typical" because of the impracticability of diagramming all combinations of choices and options that exist.) The main emphasis of this manual is to provide a general product description that will familiarize the user with the main components of the system and provide an understanding of the engineering, ordering, planning, installation, operation and maintenance of the J85500A-2 battery plant.

Each of the subsystems shown will be described in more detail in Section 2, Product Specifics; however, most of the concentration will be in the dc distribution, since the rectifiers controllers and batteries are described in their own product manuals. Information of an overall plant nature will include topics such as interconnection of the components, floor plan data, equipment weights and heat loss to the environment.

Engineering and Installation Options

A customer or user can choose to fully or partially engineer and install his or her own J85500A-2 Battery Plant based on the information supplied and his or her own experience. But it is beyond the scope of this manual to give complete theoretical and tutorial information on the subject. However, Lineage Power offers complete engineering and installation services that result in "turn-key" plant operation. Contact your Lineage Power Account Representative for further information.

Documentation

This document is one of the product manuals which provide information on the Lineage® 2000 Battery Plant and its components. The other manuals describe the Controllers, Rectifiers and Batteries that may be used as part of the J85500A-2 Battery Plant. 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.

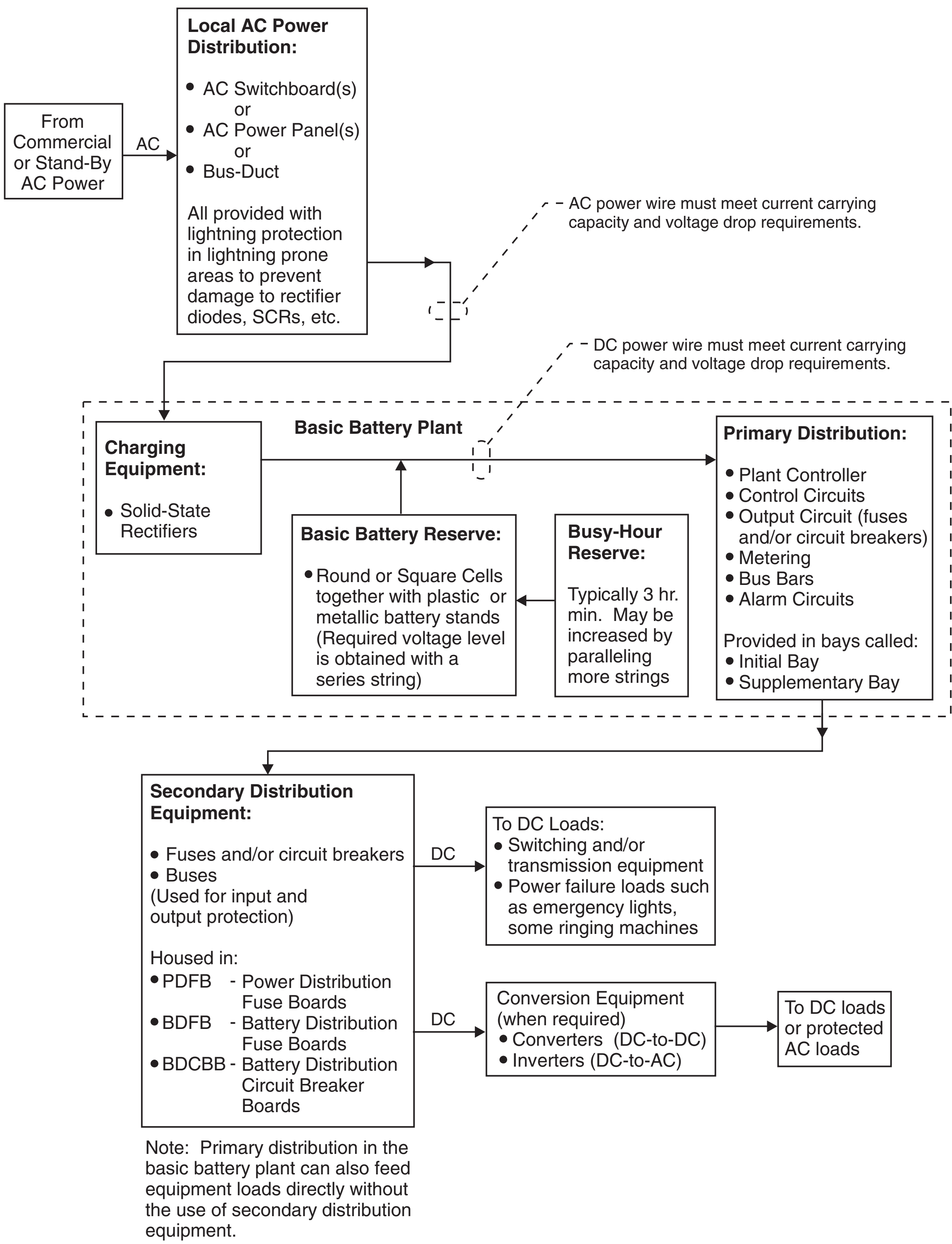

Figure 1-1: Typical battery plant block diagram

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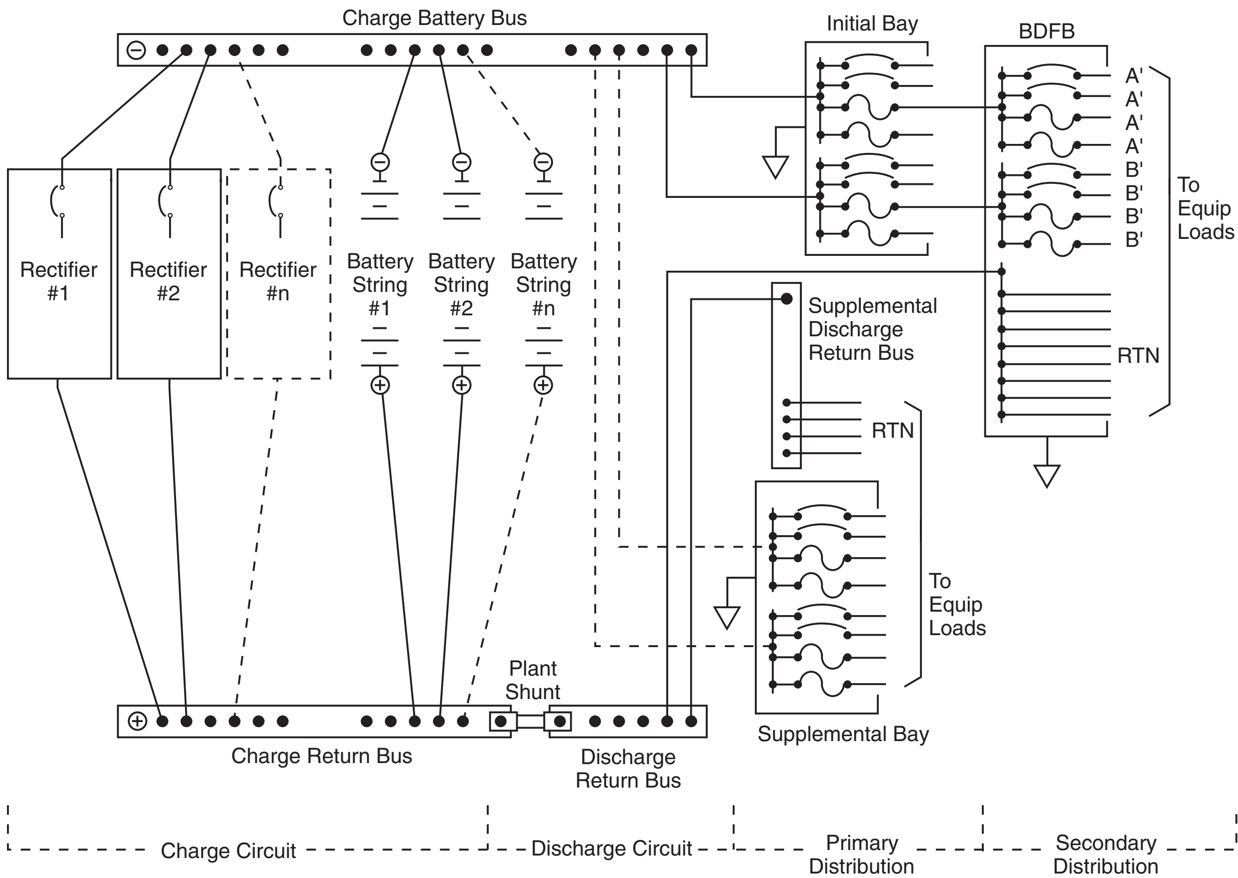

Figure 1-2: Typical battery plant schematic

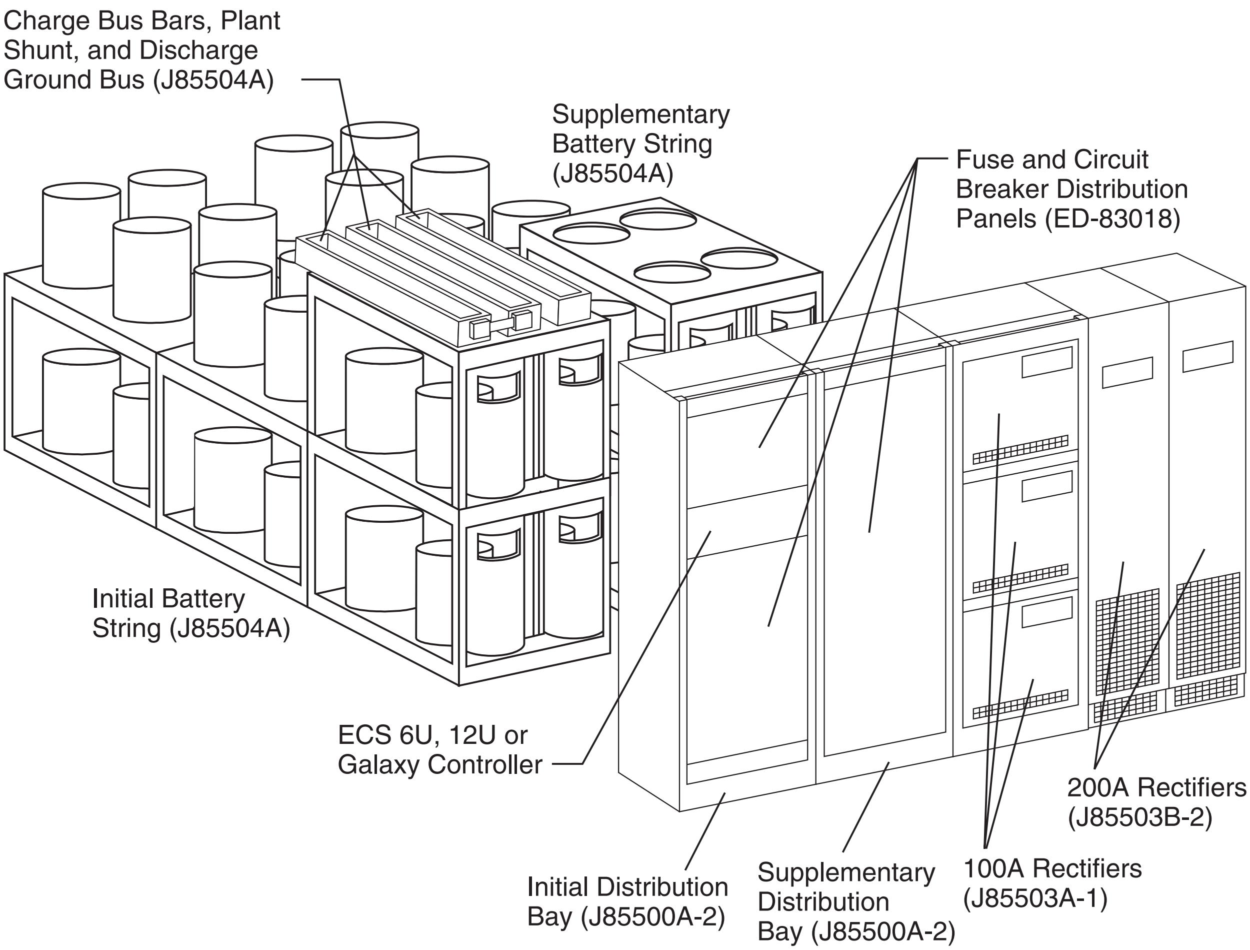

Figure 1-3: Typical J85500A-2 cabled battery plant

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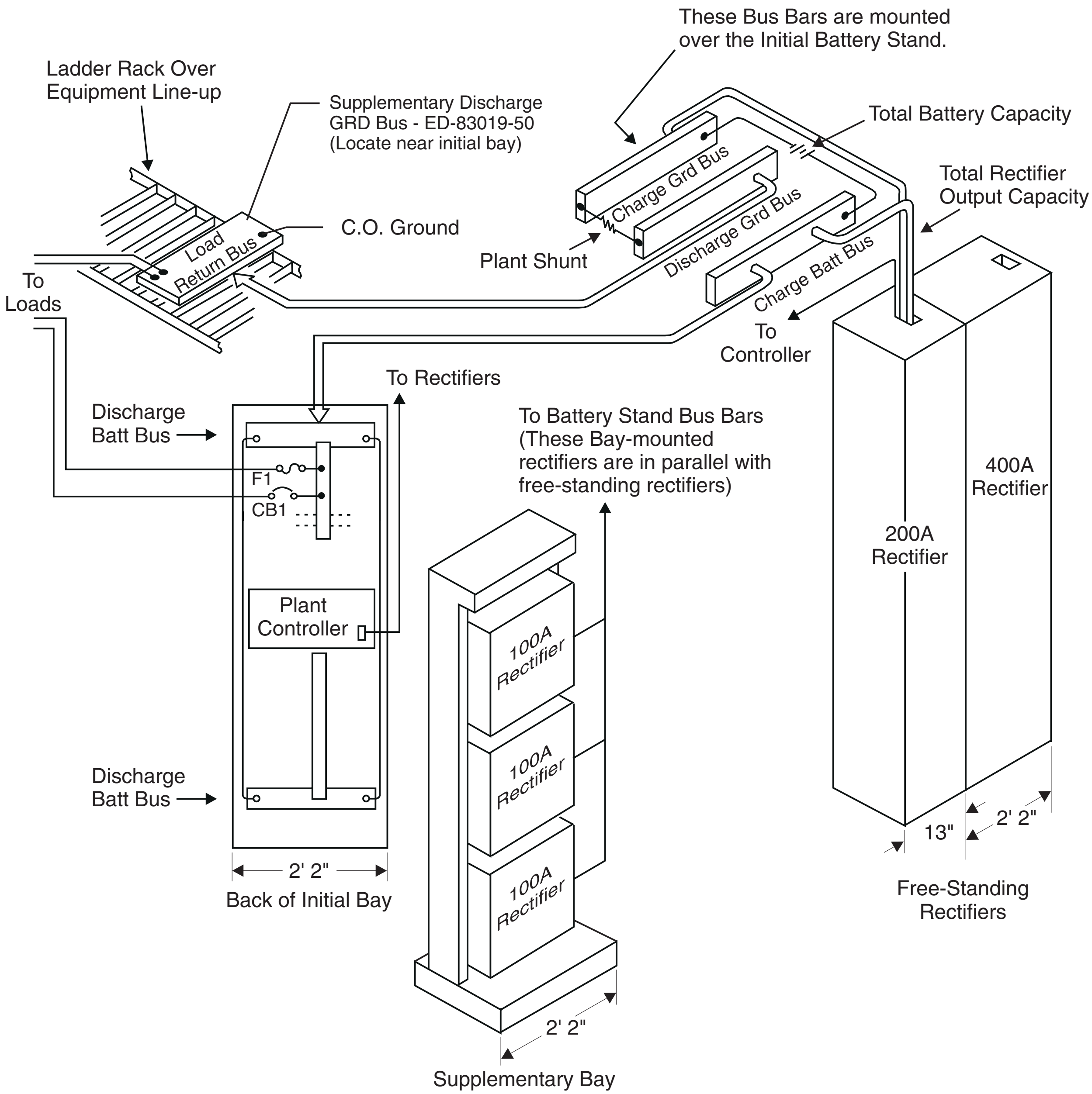

Figure 1-4: Typical J85500A-2 cabled battery plant schematic

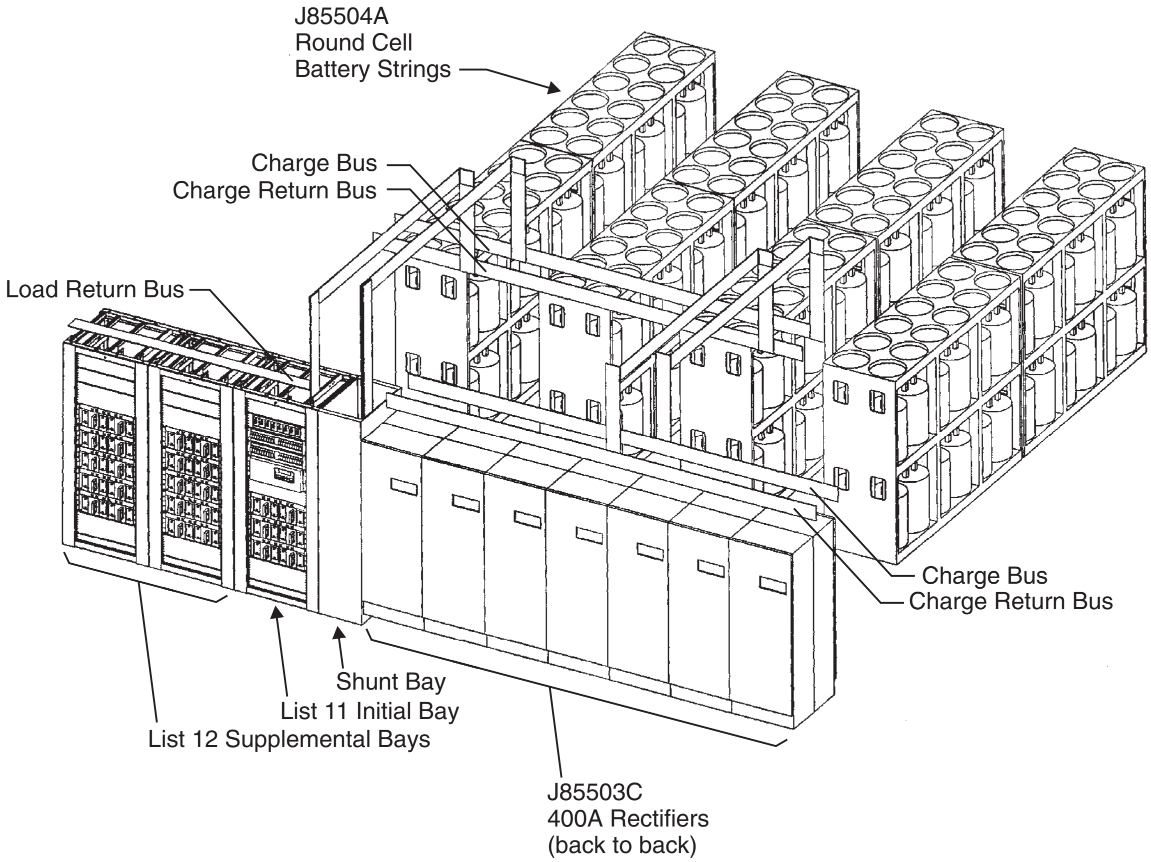

Figure 1-5: Typical J85500A-2 bus bar battery plant

Customer Service Contacts

Customer Service, Technical Support, Product Repair and Return, and Warranty Service

For customers in the United States, Canada, Puerto Rico, and the US Virgin Islands, call 1-800-THE-1PWR (1-800-843-1797). This number is staffed from 7:00 am to 5:00 pm Central Time (zone 6), Monday through Friday, on normal business days. At other times this number is still available, but for emergencies only. Services provided through this contact include initiating the spare parts procurement process, ordering documents, product warranty administration, and providing other product and service information.

For other customers worldwide the 800 number may be accessed after first dialing the AT&T Direct country code for the country where the call is originating, or you may contact your local field support center or your sales representative to discuss your specific needs.

Customer Training

Lineage Power offers customer training on many Power Systems 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.

Downloads and Software

To download the latest product information, product software and software upgrades, visit our web site at http://www.lineagepower.com

2 Product Description

General Information

This section describes specific physical attributes of the J85500A-2 battery plant's components, such as the types and sizes of rectifiers, types of controllers and batteries, types and sizes of dc circuit breaker and fuse distribution equipment, and bus bar options for a cabled plant. It also supplies physical information on equipment weights, heat loss, dimensions, framework options and battery string and battery stand arrangements.

Framework Types

There are two types of equipment frameworks used with the J85500A-2. A box framework design typically used for larger bus bar type battery plants and a Uniframe rack or open framework typically used for smaller cabled type battery plants. These frames shown on Figures 2-1 and 2-2 are divided into three categories for ordering purposes.

Initial Bay: for the plant controller and dc distribution
Supplemental Bay: for additional dc distribution
Rectifier Bay: for rectifiers mounted in a Uniframe rack only.

Uniframe Rack

Figure 2-1 shows the dimensional data for the uniframe rack. Figures 2-3 through 2-8 detail various configurations for the Initial and Supplementary Bays. Figures 2-3 through 2-5 show three Initial Bay configurations, Figures 2-6 and 2-7 show Supplementary Bay configurations, and Figure 2-8 shows rack mounted rectifier Supplementary Bay configurations. Each figure gives dimensional information particular to the configuration shown.

Initial Bay Configurations (List 1A or 1A, AA) include the following:

- 1300 ampere maximum distribution (top half only)
- 2600 ampere maximum distribution (1300 amperes each for top and bottom halves)
- 1300 ampere maximum distribution (top half) and in the lower half either:
  - one 100 ampere rectifier
  - one 125 ampere rectifier
  - three 50 ampere rectifiers
  - four 25 ampere rectifiers
  - nine 50 ampere SR type rectifiers

Supplementary Bay Configurations (List 2 or List 5) include the following:

- 1300 ampere maximum distribution (top to bottom of bay)
- 2600 ampere maximum distribution (1300 amperes each for top and bottom halves)

Rectifier Bay (List 3) accommodates the following:

- three 100 ampere rectifiers
- three 125 ampere rectifiers (48 volt)
- four 125 ampere rectifiers (24 volt)
- six 50 ampere rectifiers
- nine 25 ampere rectifiers

Box Framework

Figure 2-2 shows the dimensional data for the box framework. Figures 2-9 through 2-10 detail the List 11 Initial Bay and List 12 Supplementary Bay respectively. Each figure gives dimensional information particular to the configuration shown.

Initial Bay Configuration (List 11) includes the following:

- 4800 ampere maximum distribution (1800 amperes in top half, 3000 amperes in bottom half)

- Top Feed with Cable or Bus Bar
- Intercabinet Bus Bar Connection Point at Bottom of Cabinet

Supplementary Bay Configuration (List 12) includes the following:

- 4800 ampere maximum distribution (top to bottom of bay)
- Top Feed with Cable or Bus Bar
- Intercabinet Bus Bar Connection Point at Bottom of Cabinet

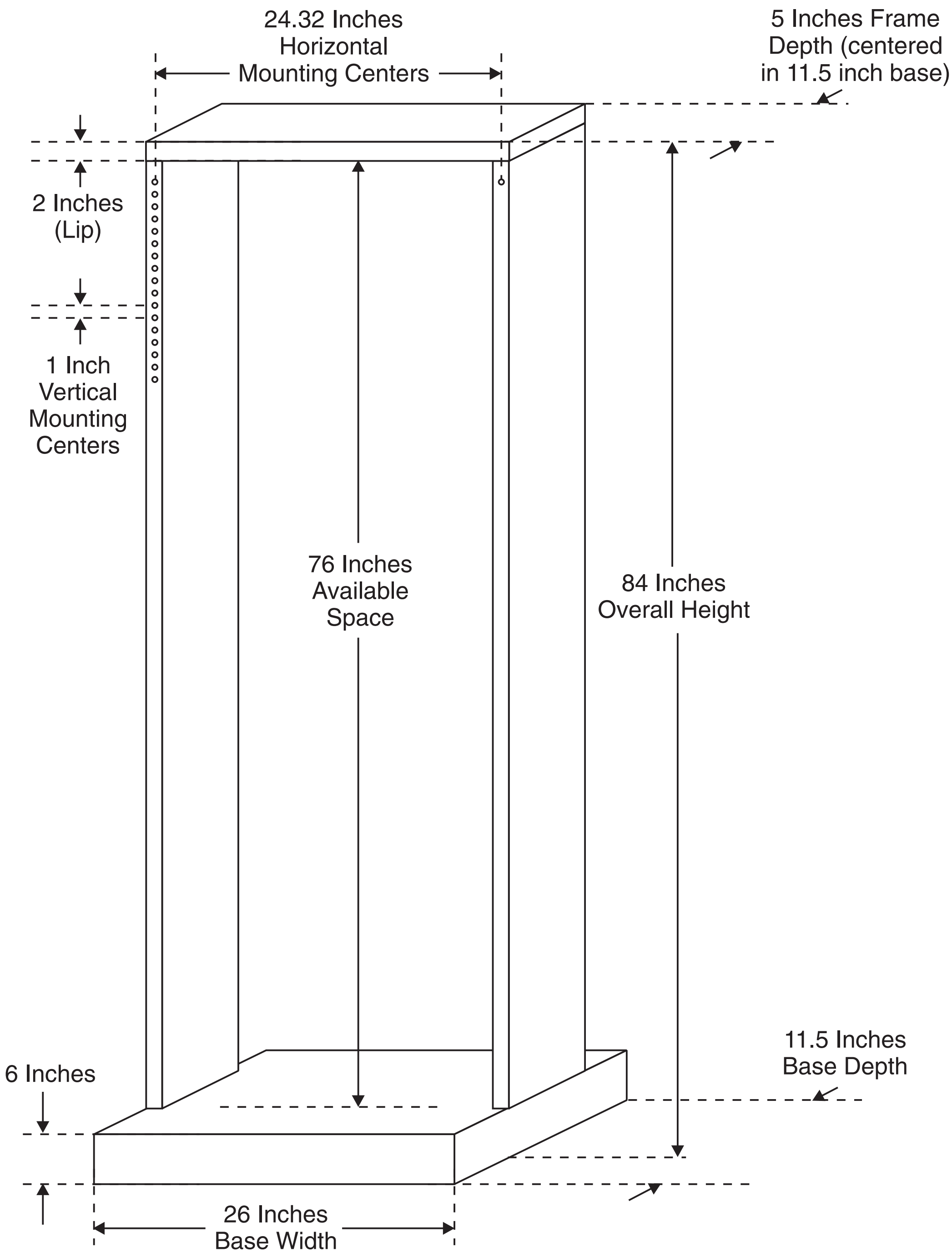

Figure 2-1: Uniframe rack (for Lists 1A, 2, 5A, 7)

series rectifiers are fan-cooled. Product manual select codes, wiring diagrams, circuit schematics and assembly and ordering drawings are listed at the end of Section 3 under Documentation References.

The number of rectifiers that can be used in the J85500A-2 battery plant depends on the type of controller selected. The next section briefly describes each of these controllers and the control cables required to communicate with each of these rectifiers. Except for the 570A, 595A and 595 rectifiers, the rectifiers use analog control signals to communicate with the controller. All settings and adjustments are made at the rectifiers.

The 570A, 595A and 595B rectifiers communicate with the controller using a digital interface. Once installed, the rectifier identifies itself to the controller, and the controller makes all the basic adjustments automatically.

As a final note, although Figure 1-4 shows a mixture of rectifiers in a typical J85500A-2 battery plant, this is shown to indicate some different possibilities, it is not always good practice to mix sizes and types of rectifiers in a battery plant. It becomes more difficult to determine the “N + 1” (the extra rectifier capacity in case one rectifier fails). There may also be some differences in features between different rectifier types.

Mixing switch mode and ferro rectifiers

SR Series 200 ampere rectifiers, 595A and 595B, that use a digital communication interface with the controller, are authorized for use with the following ferroresonant rectifiers:

Authorized configurations:

1. 200 ampere and 400 ampere ferroresonant rectifiers and 595A or B SMRs and can be connected to the same plant. The authorized ferro rectifier codes are:

   •J85503B, all series, 200 amp ferros. When mixing B1s and B2s, use cable assembly H285-226, L5, and be sure pin 21 at the rectifier end is removed for the B1 and connected for the B2.

   •J85503C2 and C3, 400 amp ferros

Configurations not authorized:

1. 200 amp SMRs with any other Lineage Power ferros

   •J87439 series: older 200 amp ferros

   •J85502A, B and C: single phase ferros

   •J85503A1: 100 amp ferro

   •J85503C1: older 400 amp ferro
2. Commercial ferros and Lineage Power 200 amp SMRs
3. Commercial SMRs and Lineage Power 200 SMRs
4. Lineage Power 50 or 150 amp SMRs and Lineage Power 200 amp SMRs

Information for configuring the plant

1. If there is an MCS or CCS controller in the plant, it must be upgraded to a Galaxy Controller.
2. For information on upgrading to a Galaxy Controller, see the Galaxy product manual, 167-790-060, Section 3.
3. The 200 amp SMR should be ordered in a bay, 595A or 595B depending on the voltage, maximum of six per bay. See H569-434.
4. The SM rectifiers need not be co-located with the ferros. The controller-rectifier interface cable is good for up to 1,000 meters. The voltage drop in the cables from the rectifier to the plant bus bar must be less than two volts.

Controllers

Three types of controllers are available with the J85500A-2 battery plant:

- **ECS-6U:** Controls up to six rectifiers
- **ECS-12U:** Controls up to 12 rectifiers
- **Galaxy SC:** Controls up to 24 rectifiers

These controllers provide the centralized monitoring, control and reporting functions for the J85500A-2 battery plant. The ECS-6U and ECS-12U are identical except in the number of rectifiers controlled.

Each controller can manage rectifiers of various technologies, vintages, and vendors in the same plant.

Product manual select codes, wiring diagrams, circuit schematics ans assembly and ordering drawings are listed at the end of Section 3 under Documentation References.

ECS Controller

The ECS controller is a more basic controller that provides local monitoring and alarm features. Alarm levels are set via DIP switch settings. Enhancements to the ECS controller include:

CP2 microprocessor board: adds remote communications, voice response, diagnostics, and statistics

CP3 datalogger board: adds general purpose ac and dc voltage, current, and transducer monitoring and relay control

AKC1 shunt isolator: allows plant load shunt to be located in “hot” i.e. ungrounded lead or if the shunt size is not compatible with controllers shunt size options

- AKC1 is mounted in the ECS-12U controller and is ordered from the J85501E-2 drawing.
- AKC1 is mounted outside the ECS-6U controller and is ordered from as J85500A-2, List 4.

Rectifier Adapter Board: allows for connection of rectifiers not listed in rectifier section (570A, 595A, and 595B SR series rectifiers which use a digital interface are not compatible with ECS controller)

Galaxy Controller

Basic Controller:

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

Galaxy’s basic controller section controls up to 24 rectifiers. It includes up to three rectifier interface boards, each handling signals from as many as eight rectifiers. Separate rectifier interface boards are needed to work with Lineage Power ferroresonant or switch mode rectifiers, or rectifiers manufactured by others. Since each rectifier interface board consumes eight of the 24 rectifier ports, mixing rectifier types may limit the total number of rectifiers a plant may use. For instance, if you add three 595B rectifiers to a system, the interface board required will reserve eight positions for these rectifiers.

Intelligent controller:

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

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

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

Battery prediction, an option that predicts reserve time for batteries made by Lineage Power

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

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

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

and stands such as the plant bus bars, the plant shunt and the Low Voltage Disconnect/Reconnect feature.

Batteries and Battery Stands

The general use battery equipment designated for use in the Lineage J85500A-2 plant is available in three basic versions.

- Round Cells (designated KS-20472) mounted on plastic stands (J85504A)
- Unigy II (designated WP-93379)
- Rectangular cells (designated KS-15544) mounted on metal stands (J85504B).

A variety of cell sizes are available. For further battery equipment information, see the appropriate Product Manual listed at the end of Section 3.

Commonly Used Battery Equipment

1. 24-Cell, 2-Tier, 2-Row Plastic Battery Stand with or without Plant Bus Bars (Uses KS-20472, LlS, Round Cell Batteries).

   This battery stand has its dimensional information given in Figure 2-11. When the plant bus bars and shunt are mounted on the battery stand, it is known as an "Originating" Battery Stand; when the bars are not included, it is known as "Supplementary". This battery stand can be used for either 24- or 48-volt plants.

   Weights for this battery stand, when equipped with batteries, are as follows:

   8931 lb (238 lb/ft) with bus bars
   8786 lb (234 lb/ft) without bus bars.

   Note: The floor load for this stand is computed by averaging the load over the floor area bounded by the stand sides and the center lines of the front and rear aisles. Special precautions (such as increasing aisle widths or space from adjacent equipments) must be taken to insure that this equipment does not overload the floor on which it will be used.

When the plant bus bars and shunt are included, it is known as an “Originating” Battery Stand; when the bus bars are not included, it is known as “Supplementary.” This battery stand is used for 24-volt plants only.

Weights for this battery stand, when equipped with batteries, are as follows:

4492 lb (240 lb/ft) with bus bars
4347 lb (232 lb/ft) without bus bars.

Note: The floor load for this stand is computed by averaging the load over the floor area bounded by the stand sides and the center lines of the front and rear aisles. Special precautions (such as increasing aisle widths or space. from adjacent equipments) must be taken to insure that this equipment does not overload the floor on which it will be used.

Other Battery Stand Information

Additional plastic and metal battery stands are available with associated arrangements of bus bars. Round Cell, plastic stands are described in Table 2-C. Square cell, metal battery stands are described in Table 2-D.

For further information, see the Lineage Power Battery Equipment Product Manual listed at the end of Section 3 and/or contact your Lineage Power Account Representative.

Table 2-C: Additional Round Cell and Plastic Stand Information

Volts	Number of		Length	Width	Maximum No. of Cells per Stand	KS-20472 Battery List Numbers
	Tiers	Rows				
24V	2	1	7′6″	1′3″	12	L1S, L2S, L3S, L4S
24V	3	2	2′6″	2′6″	12	L2S, L3S, L4S
24V	3	1	5′0″	1′3″	12	L2S
48V	2	1	15′0″	1′3″	24	L1S, L2S, L3S, L4S
48V	3	2	5′0″	2′6″	24	L1S, L2S, L3S, L4S
48V	4	2	3′9″	2′6″	24	L3S, L4S

Try to determine the maximum predicted load growth of the plant before ordering the initial plant. Then, order the bus bar size that just meets or exceeds the maximum expected load for the initial plant . It is more economical, and less work, to install the bus bars sized for the maximum predicted load on the plant initially, than to wait until increased load demands require them. This principle does not apply to rectifiers, plant shunts or to battery equipment. For these, it is more economical to add capacity as the plant grows.

Details of the typical plant bus bar assembly (actually shown is the 2600-ampere bus bar assembly) are given in Figure 2-13. There are three bus bars in the assembly: the charge battery bus, the charge ground bus, and the discharge ground bus. Note that each of these bars is of a “box” construction, made up of two equal-size parts referred to as “standard” and “optional.” For example, in the 2600-ampere plant shown in the figure, the whole “box” would be used for the 2600-ampere, maximum plant capacity. The “standard” part of the bar alone is sized for 1300 amperes, as is the “optional” part, both together totaling the maximum value. Similarly, if a plant requires the 5200-ampere maximum capacity, the “standard” part of the bar would alone be capable of 2600 amperes, as would the “optional” part, both together totaling the maximum 5200-ampere value. (The 5200-ampere bus bar geometry is similar, but not shaped exactly like the 2600-ampere maximum shown in the figure.)

Again referring to the typical assembly in Figure 2-13, note that initially only the 1300-ampere, standard, bars might have been installed (for an initial, 1300-ampere, maximum capacity), and that the optional bars could have been added later. However, as noted earlier, it is better to install the maximum expected plant bus bar capacity initially. Upgrading later requires additional work on a “live” system, which can increase costs.

Note in Figure 2-13 that the sense lead terminal points (approximate positions) are shown for battery voltage (hot and ground) measurement and for plant current measurement (on the plant shunt). The optional ground bar shorting plate and its attachment location to these bars are also shown (see also Plant Shunt Information, next).

These bus details may be ordered from either the J85504A drawing, if the bus bars are to be mounted over the KS-20472 Round Cell batteries, or the J85504B drawing, if the bus bars are to be mounted over the KS-15544 rectangular cell batteries.

Distribution Panels Overview

1. Group 15: A 9-inch high panel that can accommodate a maximum of 12-circuit breaker protected circuits. None of these have internal load shunts. Seventeen breaker trip ratings, between 1 ampere and 110 amperes, are available for any breaker in the panel. In addition, breakers rated at 30-, 40-, or 100 amperes are available to accommodate high inrush current loads such as inverters used on AT&T System 85 (these three do not have charge switches).

2. Group 16: A 9-inch high panel that can accommodate:
   (a) Two 500- or 600-ampere or
   (b) Two 300- or 400-ampere and two 100 through 225 amperes or
   (c) Six 100 through 225 amperes circuit breaker protected circuits.
   Breakers rated at 175 or 400 amperes are available to handle high inrush current loads. In Group 16, all breakers are equipped with internal load shunts and capacitor charge switches, except two high-inrush types just mentioned. The shunts can be used to monitor these breakers if the plant is equipped with a J85501Fl Galaxy Controller that is, in turn, equipped with the USM (Universal Shunt Monitor) feature. ECS Controllers equipped with CP3 datalogger can also monitor shunts.

   All Group 15 and 16 panels have charge switches except the high-inrush types.

   The capacitor charge button on each breaker is effective when the initial bay is equipped with the ED-83012-30 Capacitor Charge Panel. All such breakers in supplementary bays can make this feature available by having the installer connect the Supplementary Bay's charge switch circuit to the Initial Bay. The capacitor charge switch is used on those distribution circuits that terminate in loads with large input filter capacitors. This allows the filters to be pre-charged, at a limited current, prior to closing the circuit breaker on the load. It avoids the high current inrush that could trip circuit breakers or blow fuses downstream.

3. Group 17: A 9-inch high panel that can accommodate two 125 through 250 amperes circuit breaker protected circuits with a shunt and low-voltage disconnect feature. This feature is used to protect individual circuit loads that may be damaged if left connected to a power source whose

voltage level is below some threshold voltage that the load can tolerate. Disconnected loads must be manually reconnected.

4. Group 18: A 4-inch high panel that can accommodate 16 circuits protected by 9/32- inch by 1-1/4 inch fuses with ratings between 3 and 30 amperes.

5. Group 19: A 6-inch high panel that can accommodate either eight circuits with fuse blocks rated 1 through 30 amperes, or 8 circuits with fuse blocks rated 31 through 60 amperes, or a combination of both.

6. Group 20: A 6-inch high panel that can accommodate four circuits protected by fuse blocks that accept fuses rated 70 through 100 amperes.

7. Group 21: A 6-inch high panel that can accommodate two circuits protected by fuse blocks that accept fuses rated 110 through 200 amperes. Each circuit is equipped with a load shunt.

8. Group 22: A 6-inch high panel that can accommodate two circuits protected by fuse blocks that can accept fuses rated 70 through 100 amperes and one circuit protected by a fuse block that accepts fuses rated 110 through 200 amperes, and has a load monitoring shunt.

9. Group 23: A 15-inch high panel that can accommodate two circuits protected by switch and fuse units that accept fuses rated 225 through 600 amperes. Each switch and fuse unit has a load monitoring shunt.

10. Group 24: This group equips Group 23, above, with the second switch and fuse unit.

11. Group 25: A 4-inch high fuse panel equipped with fuse mountings for 48 70-type fuses, 9/32x1-1/4 inches, 0 to 5 amperes.

12. Group 26: A 15-inch high fuse panel arranged for load monitoring and equipped with 2 KS-19393 fuse mountings and two additional fuse mountings for 225- to 600-ampere fuses.

13. Group 27: Required in addition to Group 26 to provide 2 additional 225 to 600 ampere fuse mountings with shunts.

14. Group 31: A 6-inch high fuse panel equipped with 2 70- to 600-ampere fuse mountings arranged for load monitoring shunts.

15. Group 32: A 6-inch high fuse panel equipped with 20 3- to 70-ampere fuse mountings.

16. Group 33: A 9-inch high switch and fuse panel arranged for load monitoring and equipped with two 600-ampere switch and fuse units.

Circuit Breaker and Fuse Distribution Specifics

The following material, given in figures and tables, provides the detailed information on the circuit breakers and fuses used to equip the distribution bay panels. The panels are shown in Figures 2-15 through 2-28 give information on circuit breaker and fuse sizes, group, positions occupied on panel, wire and terminal connection specifications. The figures and tables are preceded by General Notes. Please read these first.

General Notes For Figures 2-15 through 2-28

Figures associated with Groups 15 Through 33 Circuit Breaker/ Fuse Panels include a drawing of the front of each panel and various tables of details of each configuration.

1. Load lead connections for circuit breakers and fuses is per CL-B cable up to and including 2/0 size. The maximum size allowable in distribution bays is either 4/0 or 750 Kcmil per CL-I flexible power cable, depending upon the group furnished. If larger gauge is required, the installer must cable tap outside of the bay using KS23836 cable taps or equivalent. Load leads, and some connectors and associated hardware, are not supplied. Refer to the “Wire And Terminal Specifications” table, under each group, to determine what items are supplied. Items not supplied need to be ordered separately.

2. All fuse panels (Groups 18 through 33), except for Groups 23 and 26, are always fully equipped with fuse blocks or fuse mountings. Fuse positions (specified in the tables in each figure) must be indicated on an order.

Alarm System Interface

The Alarm Indicator Panel feature for -48 volt plants provides a red light at the top of the Initial and Supplementary Distribution Bays for quickly locating bays with blown fuses or operated circuit breakers. The panel is equipped with an alarm circuit board for connecting the frame alarm signal from the distribution bays back to the controller. This 6-inch high panel, coded ED-83117-30, mounts at the top of the J85500A-2, List 1A Initial Distribution Bay and the List 2, List 5A, and List 7 Supplementary Distribution Bays as shown in Figures 2-3 through 2-7. It is ordered per J85500A-2 List 6 and lettered List R, S or T. The J85500A-2 List 11 Initial Bay and List 12 Supplemental Bay include the alarm light and alarm circuit board. Refer to Section 4 for wiring the fuse and circuit breaker alarms to the controller.

3 Engineering, Planning and Ordering

Lineage Power 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 Lineage Power 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 the J85500A-2 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 24 or 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. Some common float voltages are 2.17, 2.27 and 2.35 volts per cell. Refer to your battery manuals for correct float voltages.

Nominal 24 volt systems typically use 12 cell battery strings for float voltages ranging from 26.04 to 28.20 volts per string. 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.

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 Lineage Power 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.

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, **J85500A-2 Engineering Specifics, Rectifier Sizing**, for specifics on sizes and quantities of rectifiers for the J85500A-2 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 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. Figure 3-1 shows the voltage drop specifications for 48-volt J85500A-2 battery plant. The figure lists typical values required for voltage drop calculations.

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.

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 point. 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 are usually 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. Lineage Power offers a computerized service to optimize the selection of cable sizes and battery capacity for any application. Contact your Lineage Power 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 point (0.25 volts) has been covered above, under **Battery string voltage drop and balancing**. One rule of thumb specifies a maximum voltage drop of 2.00 volts in the feeder loop from the dc distribution point 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 backup ac power, low-voltage disconnect/reconnect may not be necessary.

Ampere Rating, J85500A-2 Battery Plant

The J85500A-2 Battery Plant is designed to be easily expanded in capacity, over time, by the addition of additional rectifiers and multiple battery strings, and by additional distribution. As previously noted, a maximum of 9600 amperes of rectifier capacity, using twenty-four 400-ampere rectifiers, is available. (This would necessarily be a 48-volt plant because the 400-ampere rectifier is designed for this plant voltage.) Cabled battery plants are typically configured with a maximum of 6400 amperes of rectifier capacity, 5200 amperes of load discharge current, and 1200 amperes is available for battery charging. Larger systems are typically configured as bus bar plants with the bus bars sized for the specific application.

Rectifier and battery capacity (i.e., adding parallel strings) should be increased as the loads grow. Installing the ultimate capacity initially does not usually prove to be as economical as planning a specified capacity growth rate for the plant over time. The following general sizing guidelines should be observed in order to achieve the most economic plant design.

Plant bus bars (whether in a cabled battery plant as shown in Figure 1-4 or in a bus bar plant as shown in Figure 1-5), and main conductors and feeders to secondary distribution power boards (bays) in the plant, should normally be sized for their ultimate capacity because:

- Adding capacity in this portion of the plant can be risky to both personnel and equipment. It is rare that the plant could be de-energized while upgrading.

- The cost is generally high because special working conditions must be devised to insure safety and guard against a failure in the live plant.

- Adding paralleled feeders at a future date can result in a resistance mismatch because of differences in cable lengths. This would be true if alternate routing is required due to “cable fill” in the original ladder rack. Undesirable imbalance in current sharing between the feeders can result in this situation.

A Supplementary Bay should be added only as needed. However, the input cabling or bus bar for this type of bay should be sized for its ultimate capacity during the initial installation. Distribution equipment such as fuses and circuit breakers can be added as needed.

The battery and ground charge and discharge bus bars for this plant are available in 1300-, 2600-, or 5200-ampere capacities for a cabled plant. Larger bus bar systems are engineered for each job. As described above, it is better to order these bars initially for the ultimate capacity of the plant.

The load shunts for the cabled plant are available in sizes ranging from 400 through 6000 amperes. In general, the smaller values are for plant capacities up to 2600 amperes, and the larger values for plant capacities up to 5200 amperes. (See Figure 2-13 and Table 2-D in Section 2 for plant shunt values and ordering designations.) In order to enhance plant current measuring accuracy, it is recommended that the shunt be ordered for approximately 120 percent to 140 percent of the near term current load. As the load grows over time, a larger shunt must be ordered and substituted for the existing shunt. These shunts are safely changed in an operating plant by either installing the new shunt before removing the old, or using a "shorting bar" temporarily while removing the old shunt and installing the new. The former method works with shunts that are 800 amperes or smaller; the latter method must be used for larger shunt values. See Figure 2-13, and the Plant Shunt Replacement procedure in Section 6, for detailed information.

Calculating Voltage Drop

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

VD = (K x I x L) / CM, or CM = (K x I x L) / VD

where:

VD = allowable voltage drop, in volts

CM = conductor size in circular mils

K = 11.1 for copper at 78°F (25.5°C)

I = appropriate current drain, in amperes (List 2 current)

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 power plant. The individual fuse size should be 150% of the List 2 current drain for the load that the fuse is protecting. Refer to Section 2 for suggested fuses for each fuse panel.

Circuit Breakers

All circuit breakers supplied with the 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%. Refer to Section 2 for types and sizes of circuit breakers offered.

J85500A-2 Engineering Specifics

The methods used in the previous section, “General Engineering Calculations”, are appropriate for the engineering of any battery plant. The same methods are used in this section to select the specific types and quantities of equipment available with the J85500A-2.

The following topics are covered in this section.

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

Rectifier Sizing

All the rectifier options available with the J85500A-2 are listed in Section 2. Rectifiers can be of mixed sizes in a given plant, and may be added to an operating plant as the load growth requires. All of the SR type rectifiers are for 48-volt plants. All of the ferroresonant rectifiers are usable for either 24- or 48-volt plants except the 400A rectifier, which is only for 48-volt plants.

Additional information on sizing of the rectifier subsystem, relative to load and recharge capacity, is given in the individual rectifier Product Manuals. These manuals also cover rectifier specifications, installation, testing, operation, troubleshooting, and spare parts information. Select Codes for these rectifier manuals, wiring diagrams, circuit schematics, and assembly and ordering drawings are listed at the end of Section 3 under Documentation References.

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: ______

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 J85500A-2 depends on the rectifier chosen, the optimum battery capacity increment may be approximated as follows.

> A-hr increment = (amperage of rectifier) x (reserve time in hours) / (minimum recharge factor)

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

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. Lineage Power offers cabling engineering services that are separate from battery plant engineering. Contact your Lineage Power 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 L3 Class B) and in a finer stranded “welding” type (e.g. KS-24194 L2 Class I Flex). 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. CL-I) for sizes 1/0 and larger in applications requiring tight bends, such as small battery plants in confined locations.

Terminal lugs for each of the dc distribution panels are listed on Figure 2-15 through 2-28. Terminal lugs that may be readily attached to the plant bus bars are listed in Tables 3-D and 3-E.

Table 3-D: Double Hole Terminal Lugs

CL-B Wire	CL-I Wire	WP-91412 List	Comcode	Bolt Size	Centers	Die
10	10	73	405356171	10	0.625	**R5473-5**
8	8	52	405348178	10	0.625	**Red**
8	8	75	406021626	0.250	0.625	**Red**
6	6	3	405347519	0.250	0.625	**Blue**
4	4	5	405347576	0.250	0.625	**Grey**
2	-	54	405348202	0.250	0.625	**Brown**
-	2	8	405347683	0.250	0.625	**Green**
1/0	-	56	405348228	0.375	1.0	**Pink**
-	1/0	57	405348236	0.375	1.0	**Black**
2/0	-	57	405348236	0.375	1.0	**Black**
-	2/0	77	406021725	0.375	1.0	**Orange**
4/0	-	59	405348251	0.375	1.0	**Purple**

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 J85500A-2 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.

Floor anchors are provided with all uniframe racks to secure the initial and supplementary distribution bays to the floor as shown in Figure 4-3. Order anchors for List 11 or 12 box frames from Table 3-H. Figure 3-2 gives dimensions and clearances for initial and supplemental distribution bays. Figures 2-11 and 2-12 provide dimensions required for the KS-20472 Round Cell battery. Refer to the appropriate product manual for other battery types or any free-standing rectifiers.

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. Rectifiers are the primary source of heat in a

Power 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.

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

The main code number falls into one of three categories:

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

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

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

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

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

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

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

The standard drawings for Lineage Power 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 3-4**.

(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 Lineage Power. Reissued drawings are sometimes released prior to actual factory availability to provide time for engineering and order preparation. Consult your Lineage Power 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. F-sheets are used to show field installation information. G-sheets are used to show floor plan data.

(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 Lineage Power for information on specific products, as needed.

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

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

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

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

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

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

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

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

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

(11) Change Notes: Change or Revision Notes chronicle, in very abbreviated form, the history of drawing reissues and the associated changes, such as additional Lists, modifications to assembly views, clerical error corrections and part number changes. The Issue number and date always follow the list of changes.

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

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

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

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

An option is defined when alternative connections or circuit components are possible. T-drawing options are called Wiring options for connection alternatives and Apparatus options for component differences. Where possible, T-drawing options are derived directly from those defined on the SD-drawing, using the same lettering scheme (see below). Options which are found on the T-drawing, but not on the SD, always include the prefix "H". Optional wiring and hardware is provided only when the associated options are specifically called for by Table A of the J-drawing. SD-drawings

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

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

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

B-sheets contain the Functional Schematics (FSs).

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

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

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

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

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

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

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

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

Ordering Information

The J85500A-2 battery plant is ordered with List (L) numbers and Equipped With (E/W) items. See Table 3-J.

A sample order for a J85500A-2 plant would look like the example below.

ITEM	QTY	DESCRIPTION
1	1	J85500A-2, L1A (Initial Bay) -48V power plant assem. per Fig. 12 E/W
	1	L-6
	1	L-AA
	1	L-E panel 61-66
	1	L-R
	1	L-KA
	2	L-KD lt and rt side
	1	ED83117-30 G1 alarm indicator panel
	1	J85501F-1 L-1 Galaxy Controller panel 19-27 E/W
	1	L-11
	2	L-21 Rect mod A, B
	2	L-32 Rect mod A, B
	1	L-AA
	1	L-AE Slot 1
	1	L-AG Slot 2
	1	ED83102-30 G-1 Cap chg & data set panel Panel 31-33 E/W
	1	G-2
	1	C-C
	1	G-E
	1	ED83018-31 G-15 CB pnl Panel 52-60 E/W
	5	G-Q Cktbkr 1, 2, 3, 4, 5
	1	G-R Cktbkr 6
	1	G-S Cktbkr 9
	3	G-T Cktbkr 10, 11, 12
	1	ED83018-31 G-15 CB pnl 1-9 E/W
	1	G-AC Cktbkr 6
	2	G-AG Cktbkr 1-2, 4-5
2	1	J85500A-2 L-3 -48V suppl rect bay assem per fig 4 E/W
	2	L-J
	1	L-KD left side
	1	J85503A-1 L-2 100A rectifier E/W
	1	L-10
	1	L-16

Ordering Guide (List Numbers)

Table J summarizes the various components of the J85500A-2 battery plant. List and Kit items may be combined as in the sample orders above.

Table 3-J: Ordering Guide
J85500A-2 Battery Plant

<table>
<tr><th>List No</th><th>Description of Equipment and Features</th></tr>
<tr><td>1A</td><td>Initial distribution bay equipped with a 1300 ampere capacity distribution feeder bus mounted on the top half of the bay</td></tr>
<tr><td>11</td><td>Initial distribution bay box framework equipped with 4800 ampere capacity distribution feeder buses for distributing 1800 amperes to panels mounted above the controller and 3000 amperes to panels mounted below the controller</td></tr>
<tr><td colspan="2">Note: The J85500A-2 List 1A or 11 battery plant may be ordered equipped with
A controller per:
J85501F-1 (Galaxy)
J85501E-1 (ECS-6U)
J85501E-2 (ECS-12U)
A controller peripheral monitoring system per:
J85501G-1
A rectifier per: (List 1A only)
J85502A-1 (25A)
J85503A-1 (100A)
J85502B-1 (50A)
J85502C-1 (125A)
A rectifier shelf per: (List 1A only)
J85702B-2
Fuse and circuit breaker panels per:
ED-83018-31
A capacitor charge panel per:
ED-83012-30</td></tr>
<tr><td>2</td><td>Supplementary distribution bay equipped with a 1300 ampere capacity distribution feeder bus running from the top to the bottom of the bay</td></tr>
<tr><td>3</td><td>Supplementary rectifier bay arranged for a maximum of:
3 J85503A-1 3-phase ±24V or -48V, 100A rectifiers
3 J85502C-1 single phase -48V, 125A rectifiers
4 J85502C-1 single phase ±24V, 125A rectifiers
6 J85502B-1 single phase ±24V or -48V, 50A rectifiers
9 J85502A-1 single phase ±24V or -48V, 25A rectifiers, or
18 364A3 single phase -48V, 50A rectifiers (6 J85702B-2 rectifier shelves)</td></tr>
<tr><td>4</td><td>Equipment required in addition to List 1A to provide one AKC1B circuit pack and associated mounting hardware for outboard retrofit in plants with ECS-6U controller and plant load shunt in battery instead of ground lead</td></tr>
</table>

Table 3-J: Ordering Guide
J85500A-2 Battery Plant

List No	Description of Equipment and Features
5A	Supplementary distribution bay for maximum 2600A capacity equipped with two 1300A capacity distribution feeder panel buses
6	Equipment and wiring required in addition to List 1A, 2, 5A or 7 to provide alarm indicator panel LED for "FAJ" alarm for -48V plant when specified
7	Framework assmebly, wiring and equipment for one 15 inch deep supplementary distribution bay for a split bus bar with two 1300 ampere capacity distribution panel feeder buses
12	Supplementary distribution bay box framework equipped with 4800 ampere distribution feeder buses running from he top to the bottom of the bay
A	Equipment required in addition to List 1 for a 1300A capacity distribution panel feeder bus assembly mounted in lower half of bay
AA	Equipment required in addition to List 1A for a 1300A capacity distribution panel feeder bus assembly mounted in lower half of bay
B	Equipment required in addition to List 1A, 2, 5A, 7, 11 or 12 to provide blank panel for unequipped fuse or circuit breaker positions of 2 inches in height
C	Equipment required in addition toList 1A, 2, 5A, 7, 11 or 12 to provide blank panel for unequipped fuse or circuit breaker positions of 3 inches in height
D	Equipment required in addition to List 1A, 2, 5A, 7, 11 or 12 to provide blank panel for unequipped fuse or circuit breaker positions of 4 inches in height
E	Equipment required in addition to List 1A, 2, 5A, 7, 11 or 12 to provide blank panel for unequipped fuse or circuit breaker positions of 6 inches in height
F	Equipment required in addition to List 1A, 2, 5A, 7, 11 or 12 to provide blank panel for unequipped fuse or circuit breaker positions of 9 inches in height
G	Equipment required in addition to List 1A to provide 7 inch blank panel for space directly below J85503A rectifier (1 required)
J	Equipment required in addition to List 3 to provide 26 inch blank panel for one unequipped J85503A rectifier position (max. 2)
K	Equipment required in addition to List 1A to mount one 100A 3-phase J85503A-1 rectifier or one 50A 1-phase J85502B rectifier in lower half of bay. (Omits panel and brackets to accommodate rectifier and provides baffle assembly)
L	Equipment required in addition to List 3 to provide a baffle for use with 100A J85503A rectifier or in addition to Lists 1A or 3 to provide a baffle for use with 50A J85502B rectifier

Table 3-J: Ordering Guide
J85500A-2 Battery Plant

List No	Description of Equipment and Features
M	Equipment required in addition to List 1A to mount one 24 or 48V 125A J85502C-1 rectifier in lower half of bay. (Omits panel and brackets to accommodate rectifier and provides a new panel and a 6-inch baffle assembly)
N	Equipment required in addition to List 3 to provide a 2-inch baffle when more than one 48-volt 125A rectifier is equipped in the supplementary bay
P	Equipment required in addition to List 3 to provide a 6-inch baffle when more than one 48-volt 125A rectifier is equipped in the supplementary bay
Q	Equipment required in addition to List 3 to provide additional cable brackets when the 24V 125A rectifiers are used in the supplementary bay
R	Initial 1300A or 2600A bay (apparatus always required in addition to List 6 when specified in a -48V plant)(L1)
S	Supplementary 1300A bay (apparatus always required in addition to List 6 when specified in a -48V plant)(L2)
T	Supplementary 2600A bay (apparatus always required in addition to List 6 when specified in a -48V plant)(L5A, 7)
U	Equipment required in addition to List 1A, 2, 5A or 7 to provide a 12-lead connection to discharge bus bar
V	Equipment required in addition to List 1A when equipped with Galaxy controller and J85702B-2 rectifier shelf, provides appropriate rear brackets and cover
W	Equipment required to mount one J85702B-2 rectifier shelf.
X	Adds three inches depth to rear of bay to allow additional room for cabling inside bay. Requires side panels, List KF
Y	Equipment required in addition to Lists 1A, 2, 5A, 11 or 12 to provide a spare fuse holder panel to accommodate 12 TPS/TPA and 12 GMT fuses. List Y is equipped with only four of a possible 12 spare fuse holders, enough to accommodate a fully loaded J85500A-2 bay. Additional spare fuse holders of various types may be ordered nd mounted in the field as required.
CG	Control cables for J85702B-1 rectifier shelf mounted in first position below Galaxy
CH	Control cables for J85702B-1 rectifier shelf mounted in second position below Galaxy
CK	Control cables for J85702B-1 rectifier shelf mounted in third position below Galaxy
KA	Stile strip appearance package for a bay per List 1A, 2, 5A or 7 (bottom arranged for distribution or blank space)
KB	Stile strip appearance package for a bay per List 1A (bottom arranged for rectifier space)

Table 3-J: Ordering Guide
J85500A-2 Battery Plant

List No	Description of Equipment and Features
KC	Stile strip appearance package for a bay per List 3
KD	End cover appearance package for a List 1A, 2, 3, 5A or 7 bay (1 per side)
KE	Stile strips appearance package for a List 1A, V bay equipped with a Galaxy controller and J85702B-2 rectifier shelf
KF	End cover appearance package for a List 1A, V bay equipped with a Galaxy controller and J85702B-2 rectifier shelf. Also required with List X option
KG	End cover appearance package for a List 11 or 12 box framework

Documentation References

The following documents provide the engineering, ordering and installation information for the Lineage Power Lineage® 2000 battery plant J85500A-2. Documents are available from Customer Service.

Lineage® 2000 Battery Plant

Assembly and Ordering Drawing:	J85500A-2
FS/CB Panel	ED-83018-31
Wiring Diagram:	T-82603-31
Schematic Diagram:	SD-82603-01
Product Manual:	167-790-032

Batteries

Round Cell Battery Ordering:	KS-20472
Round Cell Stand And Plant Bus Bars:	J85504A
Round Cell Product Manual:	157-629-700
Rectangular Cell Battery Ordering:	KS-15544 or KS-5553
Rectangular Cell Stand and Plant Bus Bars:	J85504B
Product Manual:	None
Unigy® II Battery Ordering:	WP-93379
Product Manual:	157-622-030

Supplementary information on the ECS-6U and ECS-12U controller, Galaxy controller J85501F-1, Lineage® 2000 SR series rectifier and Rectifier Shelf Assembly (RSA), and the Lineage® 2000 rectifiers may be found on the following documents.

ECS-6U Controller

Assembly and Ordering Drawing:	J85501E-1
Wiring Diagram:	T-83122-30
Schematic Diagram:	SD-83122-01
Product Manual:	167-790-045
Optional Circuit Pack Product Manual:	167-790-109

ECS-12U Controller

Assembly and Ordering Drawing:	J85501E-2
Wiring Diagram:	T-83181-30
Schematic Diagram:	SD-83181-01
Product Manual:	167-790-056
Optional Circuit Pack Product Manual:	167-790-109

Galaxy Controller

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

SR Series Rectifiers and Rectifier Shelf Assembly

Assembly and Ordering Drawing:	J85702B-2 (364A3, 50A)
Wiring Diagram:	T-82668-30
Schematic Diagram:	SD-82668-01
Product Manual:	167-790-117

Single Phase Ferroresonant Rectifiers

Assembly and Ordering Drawing:	J85502A-1 (25A)
Wiring Diagram:	T-82604-30
Schematic Diagram:	SD-82604-01
Product Manual:	169-790-122
Assembly and Ordering Drawing:	J85502B-1 (50A)
Wiring Diagram:	T-82604-31
Schematic Diagram:	SD-82668-01
Product Manual:	169-790-123
Assembly and Ordering Drawing:	J85502C-1 (125A)
Wiring Diagram:	T-82659-30
Schematic Diagram:	SD-82659-01
Product Manual:	169-790-121

Three Phase Ferroresonant Rectifiers

Assembly and Ordering Drawing:	J85503A-1 (100A)
Wiring Diagram:	T-82605-30
Schematic Diagram:	SD-82605-01
Product Manual:	169-790-119
Assembly and Ordering Drawing:	J85503B-2 (200A)
Wiring Diagram:	T-83281-31
Schematic Diagram:	SD-83281-01
Product Manual:	169-790-128
Assembly and Ordering Drawing:	J85503C-3 (400A)
Wiring Diagram:	T-83102-32
Schematic Diagram:	SD-83102-03
Product Manual:	169-790-132
Assembly and Ordering Drawing:	J85603C-2 (400A 50Hz)
Wiring Diagram:	T-82658-31
Schematic Diagram:	SD-82658-02
Product Manual:	169-791-113

Three Phase 595A and 595B 200 Ampere Rectifiers

Ordering Drawing:	H569-434
Assembly Drawing:	J85582C-1
Wiring Diagram:	T82603-31
Product Manual:	167-792-155

4 Installation

General

This section contains a suggested sequence of plant installation activities that minimizes the installer's exposure to live circuits, and results in an efficient installation effort. It also describes test procedures to be performed during installation which are not covered in the documentation for the rectifiers, batteries or controllers. Post-installation testing is based in the controller and rectifier subsystems (see Controller and Rectifier Product Manuals). Read this section in its entirety before starting any work.

Engineering

You may choose to fully or partially engineer and install your own J85500A-2 Battery Plant based on the information supplied and your own experience. Lineage Power also offers complete engineering and installation services that result in "turn-key" plant operation. Contact your Lineage Power Account Representative for further information.

Installation Tools and Test Equipment

You will need the following tools and test equipment for installation and testing of the battery plant.

- Material handling equipment to unload bays and rectifiers at site, remove bays and rectifiers from shipping containers, and erect bays and rectifiers into final positions.
- Common electrician's and mechanic's hand tools.
- Proper crimping tools-and dies for connectors used.
- Drill to bore holes for floor anchors.

- DMM (Digital Multimeter) Fluke 8060A or equivalent, accurate to 0.02 percent on the dc scale.
- DC Dummy Load Bank, 26-volt (for 24-volt plants) or 52-volt (for 48-volt plants). Must be adjustable in order to provide a load equivalent to 125 percent of the output capacity of the largest rectifier in the plant.
- Power Supply, variable from zero to 60 volts dc at 2 amperes for LVD/R (Low Voltage Disconnect/Reconnect) Option Test. Supply should have both coarse and fine output voltage controls.
- Six clip leads each capable of carrying 3 amperes (for LVD/R test).

Suggested Installation Sequence

1. **When running dc cable, make sure that all unfused leads are run in a separate cable rack segregated from fused leads. Run all dc leads in a separate wiring system segregated from ac leads. Separate all control leads from the main dc power leads. Pair the ground and return leads of a given circuit for as much of the run as practical.**
2. Torque all bolts making electrical connections to the values in Table 4-A; torque all bolts for mechanical connections to the values in Table 4-B.
3. Run all leads within the bays according to the information supplied in Figure 4-1.
4. Refer to wiring diagram (T-82603-31) for all lead terminations in the plant.

Unpacking and Handling

Use appropriate material handling equipment when moving all crated or uncrated bays or rectifiers to insure personnel safety and equipment protection. Some units have “off-center” centers of gravity. (Dimensions of various components in the plant is also supplied throughout Section 2.)

When unpacking any rectifier or distribution bay:

- Inspect exposed exterior of equipment for shipping damage.

- Remove any parts packages from container and set aside for subsequent use.
- If material is damaged, contact the shipping company and process claims form.

Sequence of Tasks

DANGER:
Do not connect the batteries or ac service, during the following procedure, until told to do so.

1. Locate, install, shim, and anchor all of the equipment. See Figures 4-2, 4-3 and 4-4. Anchor material for Uniframe racks is furnished with the bay as shown in Figure 4-3. Anchor material for the List 11 or List 12 box framework is provided separately. See Table 3-H. See the Rectifier Product Manuals for rectifier anchoring information.

2. Place batteries into the battery stands using the procedures outlined in the battery manufacturer's documentation supplied with the battery equipment. (For Lineage Power battery equipment, refer to the appropriate product manuals.) Using approved intercell connectors, interconnect the individual cells to provide a string of the appropriate voltage but do not connect the battery string to the charge and discharge bus bars at this time.

3. Hang all cable support systems, as well as any auxiliary ground bus bars that will be used.

4. (a) For a cable plant, install the charge and discharge bus bar assembly over the battery stand. If Lineage Power battery stands are not being used, follow job drawing to erect bus bar assembly. If the plant is to be equipped with the LVD/R Option, install and verify its operation, at this time, as described in this section.

   (b) For a typical bus bar plant as shown in Figure 1-5, install all bus bar details per the job specification drawing.

5. Run all leads between charge and discharge bus bars and Initial and Supplementary Bays. **Do not connect batteries or rectifiers to the charge and discharge bus bars at this time!**

6. Run the ac input and dc output power leads to each rectifier (see rectifier manuals). **Do not connect batteries to the charge and discharge bus bars, or turn on ac service to the rectifier at this time!**

DANGER
Before connecting leads to shunts external to this power

Controller	Product Manual Select Code
J85501F-1 Galaxy	167-790-060
J85501E-1 ECS-6U	167-790-045
J85501E-2 ECS-12U	167-790-056

8. Run distribution leads between the power plant circuit breakers and/or fuses and the loads. Pair the leads. (Consult the job drawings and T-drawings for routing of these leads.) Figure 4-5 shows the routing scheme for the List 11 and List 12 box framework. Always route dc load cables to the back of the framework for lower mounted panels and to the front for higher mounted panels.

9. Refer to job drawing and T-drawings and run all remaining plant interconnect leads and office alarms as dictated by the drawings. Refer to “Wiring” later in this section.

10. Perform initial charge of the batteries at this time. If one of the rectifiers that are included in the plant is to be used for the initial battery charge, proceed to Step 11. If a separate rectifier is to be used (a less complex procedure) connect it to the battery string, (observing proper safety precautions), power the rectifier, adjust its output voltage to the proper initial charge voltage, and charge the batteries for the recommended interval. **Do not connect the batteries to the plant charge and discharge bus bars at this time.** Refer to the manufacturer’s documentation for recommended initial charge voltage and interval for the batteries. See the appropriate battery product manual.

11. If one of the rectifiers that is part of the battery plant is used to supply the initial battery charge, proceed as follows:

- Select the rectifier to be used to supply the initial charge. Only one rectifier is necessary since 5 amperes per battery string is all the rectifier capacity required.

- On the selected rectifier, disconnect the battery and ground output cables that run between the rectifier and the charge and discharge bus bars, at the rectifier terminations. Insulate the cable ends. Disconnect the plant control cable from the rectifier (see appropriate rectifier manual). Open the output circuit breaker of the rectifier.

- On a temporary wiring basis, and using the same gauge cable as the ones just disconnected, run a cable between the (+) output of the rectifier and the (+) terminal of the battery and the second cable between the (-) output of the rectifier and the (-) terminal of the battery. Again verify that the rectifier's output circuit breaker is OPEN. Make both cable terminations at the rectifier first and then terminate the cables on the battery. **Do not close rectifier output circuit breaker**.

- Refer to the Rectifier Product Manual for the procedure to supply an initial charge voltage.

- Refer to the appropriate rectifier manual and power up the rectifier to supply the initial charge only.

- Remove rectifier regulation fuses in the controller:

Controller	Fuse Positions
Galaxy SC	A1-A8, B1-B8, C1-C8
ECS-6U	F1-F6
ECS-12U	F1-F12

- With the DMM (Digital Multimeter), measure the voltage at the battery terminals. Adjust the rectifier's output Volts Adj potentiometer to the desired initial charge voltage. As current tapers off, readjust the potentiometer to maintain the proper initial charge voltage. During all potentiometer adjustments, observe the battery voltage and do not exceed 31 volts (for a 24-volt string) or 62 volts (for a 48-volt string) at the battery terminals.

When the initial charge is completed:

Turn off the rectifier.
Open the rectifier Output Circuit Breaker.
Disconnect the temporary cables (remove at battery first and then at the rectifier), and remove them from the system.
Reconnect permanent output cables to the rectifier.

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.

12. To connect battery to the plant:

- Turn off all rectifiers.

- For each and every rectifier in the plant, open the Output Circuit breaker **and** disconnect the Plant Control Cable.

- On the Initial and Supplementary Bays, open all load distribution circuit breakers.

- On the Initial and Supplementary Bays, remove all load distribution fuses **and** their associated alarm fuses.

- Connect cables between the battery and the plant charge and discharge bus bars by first connecting them to the bus bars and then to the battery terminations.

13. Set the DC Dummy Load Bank (the test load) to zero (i.e., maximum resistance). Connect the test load to the plant charge and discharge bus bars. Adjust load as directed in the rectifier manual.

Caution
Whenever the rectifiers are not supplying the load, set test load to zero load to prevent the battery from discharging.

14. Check out each rectifier according to the procedures given in the rectifier manual. Make sure that all the plant load circuit breakers are in the OFF position (or plant fuses are removed) while running any test on an individual rectifier.

15. Check out and set up controller according to its Product Manual.

16. Disconnect and remove the dc dummy load bank.

17. Verify the operation of the fuse and circuit breaker alarms and load charging circuit:

- **Test for load charge circuit (optional)**: Select a circuit breaker with a load charge switch and place it in the OFF position. Remove the load lead. Connect a DMM between the circuit breaker output terminal and ground. Press the circuit breaker switch (charge button) and look for approximate battery voltage reading on the DMM. Release the charge button and disconnect the DMM. Reconnect the load lead removed above.

- **Fuse or circuit breaker alarm test:** On a load circuit breaker, short the alarm leads connected to Terminals 8 and 9 and verify that the fuse alarm lamp (on the controller front panel) lights. Repeat for each load circuit breaker. To verify the operation with a fuse panel, insert a blown fuse in the alarm fuse position. Verify that the same fuse alarm lamp lights. Repeat for each alarm fuse position, including the capacitor charge panel.

Do not turn on the load circuit breakers or install load fuses at this time.

Caution
For capacitive load circuits requiring precharge, before operating the load circuit breaker, follow the precharge instructions given in section 5 of this manual.

Warning
Before applying power to any individual loads, follow the powering up instructions for each load. Since the loads are not part of the battery plant, the instructions cannot be included in this manual.

18. Connect all loads, one at a time, by turning on the load circuit breakers and/or inserting the load (and associated alarm) fuses for each circuit.

19. Add stile strips and/or end covers and rear covers to the initial and supplementary bays. Figure 4-6 shows the side cover attachment for the List 11 or List 12 box frameworks.

Remove the test equipment from the circuit and continue the power plant installation.

8. If Step (5) or (6) produced improper operation, perform Steps (9) and (10) to resolve the problem.

9. If the solenoid operated, but at the wrong voltage, replace the ED-83104-30 circuit module and re-run the test from the beginning.

10. If the K2 contactor did not operate, perform the following four sub-steps (first remove the access panel by removing its six screws).

- Check the wiring of the actual circuit against the diagram given in Figure 4-7. If correct, continue.

- To check the K2 contactor, apply approximately 50 volts dc to the coil of K2 (negative to K1, pin 7 and positive to TB2, pin 5) in an attempt to operate the solenoid. If K2 is working properly, continue.

- Check the K1 relay by applying approximately 24 volts dc between Terminals A and B of K1. (These letters are marked on the relay. A and B, the relay coil, should be the lowest two tabs). If K1 is working properly, continue.

- Replace the ED-83104-30 circuit module board, or any other suspected part, and re-run the test from the beginning.

ED83018-31 Group 17 LVLD circuit breaker panel

WARNING:
Interruption of the Discharge Ground wiring to the ED83018-31 Group 17 LVD panel may cause the breakers on the LVD to trip.

If it is necessary to interrupt the ground path to the LVD panel, disconnect connector P1 on circuit module 118A located on the LVD panel. Reconnect P1 only after the ground path is again secure.

In a bay with no frame alarm light, connect a 20 gauge stranded wire from the plant discharge ground (DG) bus bar to TB1-7 on the panel. When the frame alarm light is present, discharge ground is factory connected to terminal E9 on the CM2 circuit pack. Discharge ground is supplied to the circuit breaker panel through the frame alarm circuit.

Connecting capacitor charge to supplemental bays

In order for the capacitor charge buttons on ED83018-31 Group 15 or 16 circuit breaker panels to work in a supplemental bay, battery capacitor charge (CC) must be connected back to the ED83012-30 capacitor charge panel located in the initial bay. Battery alarm (FA), which provides battery for the circuit breaker alarm must also be connected to the initial bay. Battery alarm (FA) and battery capacitor charge (CC) may be connected in several ways.

Typically, the FA lead is connected with a 20 gauge stranded wire from TB1-6, 7, 8 or 9 of one of the ED83018-31 Group 16 circuit breaker panels of the supplementary bay to TB1-6, 7, 8 or 9 of a ED83018-31 Group 16 circuit breaker panel of the initial bay. The CC lead is a 16 gauge stranded wire connected from TB1-11 or 12 of one of the ED83018-31 Group 16 circuit breaker panels of the supplementary bay to TB1-11 or 12 of a ED83018-31 Group 16 circuit breaker panel of the initial bay.

If only ED83018-31 Group 15 circuit breaker panels are located in one or both of the bays, connect FA at terminal 8 and connect CC at terminal 10 or 11 of one of the KS22010 circuit breakers on a panel in the supplemental bay to the corresponding point on one of the KS22010 circuit breakers on a panel in the initial bay.

5 Operating Controls and Displays

Controllers and rectifiers

All of the displays and most of the operating controls in the plant are contained on either the controller or the rectifiers. See the individual controller and rectifier product manuals. These are listed at the end of Section 3.

Additional controls

Depending on the types of equipment ordered, the following additional plant controls may be operational. All circuit breakers furnished in the distribution panels have capacitor charge switches. If the ED-83012 Capacitor Charge Option is ordered, then all circuit breaker capacitor charge switches in the Initial Bay are factory wired to make them operational. If the installer terminates the daisy-chain switch wiring from the Supplementary Bays to the ED-83012 distribution panel, then all breaker switch circuits in these bays are operational.

The basic capacitor charge circuit is plant voltage connected through a fuse, a resistor, and the charge switch that shunts current around the open circuit breaker, of which the switch is a part. The circuit allows a limited current source to charge load input filter capacitors prior to closing the circuit breaker. Without such a circuit, the circuit breaker could instantly trip out (for at least some capacitor input loads) due to the high inrush current available, and downstream circuit breakers could trip (or fuses blow).

When the button-switch on the circuit breaker is operated, a light on the face of the ED-83012 panel glows and current passes to the load capacitor. As the capacitor charges, the light continues to grow dimmer. **When the light finally goes out, release the switch immediately**.

If the switch is used for a load that does not have capacitors on the input (e.g., a resistive load), the light on the face of the ED-83012 panel remains at some constant level of brilliance for as long as the switch is held. **If the lamp does not begin to dim after two seconds, release the switch. Otherwise, one or both of the following could happen:**

1. The load could be damaged by being powered by a sub-voltage supply.

2. The fuse in the capacitor charge circuit will blow to protect the series resistor from overheating.

Note: If lamp does not light at all when switch is pressed, an open circuit probably exists or the capacitor charge switch is not working.

Warning:
Do not pre-charge distribution circuits that do not have capacitor input filters. Close circuit breakers directly on such loads.

6 Maintenance

Plant shunt replacement

When increases in plant capacity require changing the value of the existing plant shunt to a higher value (see the plant shunt discussion in Section 3), follow this procedure, and see Figure 2-15.

DANGER!
Perform the steps of this procedure in the exact order given. The bus bars are at battery potential, so observe standard safety precautions.

1. If replacement (new) shunt is larger than 800 amperes, proceed to Step (3).

2. For new 800 amperes, or smaller, shunts:

- Before removing the existing plant shunt, mount the new shunt directly above (or below) the existing shunt, wherever there is room. If this is not possible because of lack of room, proceed to Step (3), and use the "shorting bar" approach.

- Once the new shunt has been secured (bolted down), transfer the shunt leads to the new shunt. Then remove the old (existing) shunt.

3. For new shunts larger than 800 amperes:

- On the opposite end of the Charge/Discharge Ground Buses (opposite the Plant Shunt; see Figure 2-15), securely install a shorting plate(s) of equal ampacity to the existing Charge/Discharge Ground Buses. This will require two separate shorting bars for plant capacities larger than 1300 amperes.

- Once the shorting plates have been secured, transfer the shunt leads to the new shunt. Then remove the old (existing) shunt.

- Install the new (higher capacity) shunt, and secure.

- Remove the shorting bar(s) from the opposite end of the Ground Buses.

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.

This document is intended to be grounded (earthed) in accordance with all applicable local codes.

Install only in restricted access areas (dedicated equipment rooms, equipment closets, or the like) in accordance with all 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 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.

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

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 repaired or replacing Product to the destination designated by Customer.

E. Except for batteries, the defective or nonconforming Products or parts which are replaced shall become Seller's property. Customer shall be solely responsible for the disposition of any batteries.

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 experimental products or prototypes or with respect to expendable items, including, without limitation, fuses, light bulbs, motor brushes, and the like. Seller's warranty does not extend to any system into which the Product is incorporated. This warranty applies to Customer only and may not be assigned or extended by Customer to any of its customers or other users of the Product.

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.