ENCLOSURE 6

CALCULATION 2003-0046
"BATTERY CHARGERS SIZING AND CURRENT LIMIT SETPOINTS"

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

(45 pages follow)

Point Beach Nuclear Plant

CALCULATION COVER SHEET

Calculation/Addendum Number:	Title of Calculation/Addendum:
2003-0046	Battery Chargers Sizing and Current Limit Set Point

System (CHAMPS Identifier Codes):	UNIT: PB0 ☒ PB1 ☐ PB2 ☐
125 Vdc	

☐ Original Calculation/Addendum
☒ Revised Calculation/Addendum Revision # 4
☐ Supersedes Calculation/Addendum # 3
☐ Canceled
☐ Placed on Administrative Hold, Ref. _____

QA Scope ☒ Yes ☐ No
Safety Related ☒ Yes ☐ No

Discipline:
☐ CIVIL
☒ ELECTRICAL
☐ INSTRUMENTATION AND CONTROL
☐ MECHANICAL
☐ NUCLEAR
☐ COMPONENTS
☐ PRA
☐ CHEMICAL AND RADIOLOGICAL
☐ SYSTEMS

This Calculation has been reviewed in accordance with NP 7.2.4. The review was accomplished by one or a combination of the following (check all that apply):	Reviewers' Initials (Qual Required)
☐ A review of a representative sample of repetitive calculations.	
☐ A review of the calculation against a similar calculation previously performed.	
☒ A detailed review of the calculation.	REJ per Telecon [illegible]
☐ A review by an alternate, simplified, or approximate method of calculation.	

Preparer (Qual Req'd)	Reviewer (Qual Req'd)	Discipline	Name	Signature	Date
☒	☐	EE	Robert J. Fletcher	Robert J Fletcher	7/14/05
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☐	☒	EE	R. E. JONES	[illegible] Per telecon for Chip Jones	07/15/05
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Approver: Printed Name: Kelly Holt
Signature: [illegible]
Date: 7-15-05

REC'D JUL 19 2005

Calculation Page Inventory

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Comments And Resolution

Reviewer Comments:	Resolution:
C01) Assumption 6.3 states that: ""...DC output current from battery chargers D-07, D-08, D-09, D-107, D-108, and D-109 from plant trending data over the past 2 years ranges from 120 amps to 150 amps. This conflicts with X-Y Graph of D-107 Battery Charger Current (Attachment A, page 20). Though it is more than 2 years ago, no explanation given for approximately 4 month period of 170 amp average.	Wording and calculation revised to utilize worse case loading (other than peaks that could be determined to be related to testing and maintenance – see response to comment 4 below)
C02) Assumption 6.3 uses source of plant trending data over the past 2 year (Reference 5.18/Attachment A). This conflicts with SOMS data contained in Attachment A which ranges from 7/28/01 to 6/28/03.	Attachment A was revised to include data for an approximately 4 year period (7/28/01 to 6/2005) and wording revised in the calculation text to reflect this.
C03) Assumption 6.3 changes 2 year battery current from 175 amps to 120-150 amps using the same graphs (Attachment A) without explanation for the new interpretation of the same data.	Peak values used and wording revised to reflect this change.
C04) Assumption 6.3 does not provide sufficient explanation why peaks in chart are not considered. What is the period (width) of the peaks and why can they be discounted.	Explanations for peaks greater than 170 amps were provided to show that these are not part of normal operation.
C05) What is the basis for assuming 5 amps per charger for EDG control loads?	Document revised to provide additional basis.
C06) What is the basis for assuming 30 amps per charger for additional annunciators?	Document revised to provide additional basis.
C07) Assumption 6.2 specifies that maximum of 925 Ah are removed (925amps for one hour) per Attachment B. There is no Attachment B to this calculation.	Revised to reference Attachment A.
C08) Assumption 6.2 specifies that maximum of 925 Ah are removed (925amps for one hour) per Attachment B. Per Attachment A the one hour rating of 60 Exide 2GN-23 battery cells is 925 Amps and the one hour rating of 60 C&D LCR-21 battery cells is 795 Amps.	It is intended (as stated in Assumption 6.2) that the most conservative number for Ah, to envelope both battery types, be used. Wording modified to clarify this.

Comments And Resolution

Reviewer Comments:	Resolution:
C09) See Comment C08. Ah = 925 is used in both section 8.1 (D-07, D-08, & D-09) and section 8.2 9D-107, D-108, & D-109). This affects section 9.0 minimum charger size required and recommended setpoint for D-107, D-108, & D-109. This also affects Design Input 7.2.	It is intended (as stated in Assumption 6.2) that the most conservative number for Ah, that enveloped both battery types, be used. Wording modified to clarify this.

1.0 Purpose

The purpose of this calculation is to determine minimum required size and the acceptable range for the current limit set point of the safety related battery chargers.

The battery charger current limit set points for battery chargers D-09, D-107, D-108 and D-109 are being changed because of the condition described in CAP033447 (Ref. 5.17). There is a potential for the main supply breaker for battery charger D-09, D-107, D-108 and D-109 to trip upon manual restoration after a loss of offsite power with safety injection signal, loss of AC voltage, or station blackout event. Therefore, the acceptable range for the current limit set point is being determined for battery chargers D-07, D-08, D-09, D-107, D-108 and D-109 in this calculation.

The purpose of this revision (Revision 4) is to modify the charger sizing portion of this calculation for consistency with LAR 239 (Ref. 5.29) for Technical Specification 3.8.4.6. This includes a change in the maximum amp-hours assumed removed from the battery prior to recharge as well as revising the maximum continuous load on the battery and charger while recharging. This change reflects the chargers' ability to recharge the battery within the specified time while carrying the maximum continuous DC system load, irrespective of the status of the plant during which these demands occur. Other aspects of this calculation, other than editorial changes, were not addressed as part of this revision.

2.0 Scope

The scope of this calculation is limited to the following battery chargers:

0D-07
0D-08
0D-09
0D-107
0D-108
0D-109

3.0 Methodology

The steps performed in determining the required battery charger size, minimum current limit set point and the maximum current limit set point are as follows:

1. The minimum battery charger size (current limit set point) required is established by the following equation:

$$A_r = \frac{Ah \times C}{t_1} + A_c \text{ (Ref. 5.3 and 5.4)}$$

A_r = required minimum charger rating in amperes
Ah = total ampere hours discharged from battery during its specified duty cycle
C = constant to allow for ampere hour efficiency = 1.10
A_c = maximum continuous DC system load while charging (in amperes)
t_1 = required maximum time for recharging

2. The maximum battery charger current limit (DC Amps) set point is established by the following equations:

$$VA_{IN} = \left(\sqrt{3} \times V_{AC} \times I_{AC}\right)$$
$$W_{OUT} = VA_{IN} \times PF \times EFF$$
$$I_{DC} = \frac{W_{out}}{V_{DC}}$$

VA_{IN} = volt-amperes (Apparent Power into Chargers)
V_{AC} = AC supply voltage in volts
I_{AC} = Maximum AC supply current
W_{OUT} = Watts (Power into DC system from Chargers)
PF = Charger power factor
EFF = Charger efficiency
V_{DC} = Charger DC output voltage
I_{DC} = Charger DC output current

3. The battery charger current limit set point is compared to the minimum allowable battery charger size (minimum current limit set point) and maximum allowable set point. A new current limit set point is determined for all battery chargers that are outside the minimum and maximum range.

4.0 Acceptance Criteria

4.1 Battery Chargers must be sized (minimum current limit set point) to recharge any of their respective partially depleted batteries within 24 hours while carrying maximum continuous DC system loads, irrespective of the status of the plant during which these demands occur (Ref. 5.1, 5.2, 5.26, 5.27, 5.28, 5.29, and 5.34). The charger size will be determined to be acceptable if the calculated size (ampere rating) is less than or equal to the installed charger ampere rating.

4.2 The battery charger current limit set points must ensure continuous operation of the chargers at their current limit setting without tripping the over-current protect device (thermal overload) during current limit. (Ref. 5.1 and 5.2)

5.0 References

5.1 FSAR (Sections 8.7 and Appendix A.1)

5.2 10 CFR Part 50.63

5.3 EPRI book "DC Distribution System", EL-5036-V9, 1987 (See Attachment A)

5.4 IEEE Std. 946-1985 "IEEE Recommended Practice for the Design of Safety Related DC Auxiliary Power Systems for Nuclear Power Generating Stations" (See Attachment A)

5.5 CIM 170 (WEST) (See Attachment A)

5.6 BECH 6118 E-5 Sh. 3B, Rev. 0

5.7 BECH 6118 E-5 Sh. 3C, Rev. 0

5.8 BECH 6118 E-2005 Sh. 3B, Rev 0

5.9 BECH 6118 E-2005 Sh. 3C, Rev. 0

5.10 CIM 1384 (EXIDE) (See Attachment A)

5.11 Calculation N-93-056, Rev. 3

5.12 Calculation N-93-057, Rev. 3

5.13 Calculation N-93-060, Rev. 3

5.14 Calculation N-91-016, Rev. 2

5.15 Procedure OI-110, Rev. 8 (See Attachment A)

5.16 Procedure RMP 9359-7, Rev. 3 (See Attachment A)

5.17 CAP033447

5.18 Operations Management System (SOMS) (See Attachment A)

5.19 BECH 6118 E-5 Sh. 2A, Rev. 5

5.20 BECH 6118 E-2005 Sh. 2B, Rev. 6

5.21 CIM 638 (PCP)

5.22 Procedure RMP 9359-8, Rev. 3 (See Attachment A)

5.23 CIM 277 (C/D) (See Attachment A)

5.24 Calculation N-93-058, Rev. 2

5.25 Calculation N-93-059, Rev. 2

5.26 Technical Specification 3.8.4 (SR 3.8.4.6)

5.27 CA052659

5.28 Technical Specification Basis B3.8.4 (SR 3.8.4.6)

5.29 PBNP License Amendment Request (LAR) 239

5.30 BECH 6118 E-6 Sh. 1, Rev. 48

5.31 BECH 6118 E-6 Sh. 2, Rev. 16

5.32 BECH 6118 E-6 Sh. 3, Rev. 2

5.33 BECH 6118 E-6 Sh. 4, Rev. 3

5.34 US NRC Regulatory Guide 1.32, Rev. 2

5.35 CIM 000710 (PANAL) (See Attachment C)

5.36 Culter-Hammer BF/BFD Technical Data Spec Sheet (See Attachment C)

6.0 Assumptions

Unvalidated Assumptions – None

Validated Assumptions:

6.1 It is assumed that for battery chargers D-07, D-08 and D-09 that the power factor is 0.72.

Basis: This assumption is technically justified in that the power factor using the nameplate information and vendor technical manual (Ref. 5.5) is approximately 0.74 at full load current. Therefore it is conservative to assume a power factor of 0.72 for battery chargers D-07, D-08 and D-09 for the conditions being evaluated in this calculation.

6.2 It is assumed that the maximum Amp-hours (Ah) discharged from the battery is 925 Ah.

Basis: The maximum coping period at Point Beach for the station batteries is one hour and then normal AC power supply is restored per the current license basis (Ref. 5.1). The two cell types used for the affected batteries are Exide GN-23 (D05, D06 and D305) and C&D LCR-21 (D105 and D106). Based on a one-hour discharge to a minimum average cell voltage of 1.75 vdc, a maximum of 925 Ah are removed (925 amps for one hour) per Attachment A. Use of 925 Ah is a conservative value to use for all of the chargers.

6.3 It is assumed that the maximum continuous DC system load during charging is 240 A_{DC}.

Basis: This assumption is technically justified because the normal DC output current from battery chargers D-07, D-08, D-09, D-107, D-108, and D-109 from plant trending data over the past 4 years ranges from approximately 120 amps to 170 amps (Ref. 5.18). Previously this was based on an "average" current value of the most limiting system. A re-review of the plant trending data revealed that excursions beyond 170 amps were brief and do not reflect normal plant operation. All charger peak loads during the past 4 years were reviewed by the PBNP DC system engineer and correlation to testing or maintenance activities on the systems were found. This correlation is documented in Attachment B. Based on this, 170 amps will be used as a conservative base loading condition during normal operation for each charger.

It is expected that the DC continuous loads during any operating condition would be similar since the major DC motor loads (such as the feedwater pump bearing oil pumps, main turbine bearing oil pumps and main generator seal oil pumps) have been placed on the non-vital batteries. Major peak loads, such as emergency diesel field flashing and breaker actuations are momentary in nature. The instrumentation loads do not significantly increase due to a Design Basis Accident or other operating scenarios since the instrumentation is normally energized and remains energized. A review of the system one-lines (Ref. 5.30, 5.31, 5.32, and 5.33) was performed and it was determined that the only significant continuous load additions that would occur, beyond those for normal plant operation, are additional annunciator loading and EDG control loads. Some control loads would increase during accident conditions, such as safeguards actuation relays (energize to actuate), while other loads are expected to decrease, such as reactor protection relays (deenergize to actuate) and containment isolation valves (deenergize to close). For conservatism, an additional load of 30 A_{DC} per charger is assumed to account for additional annunciators that may be lit during non-normal operating

conditions. This equates to more than 225 additional annunciators at a conservative value of 16 watts per window (Ref. 5.35). An additional 5 A_{DC} load per charger is assumed for EDG control loads. This equates to more than 40 additional relays at a conservative value of 15 watts per relay (Ref. 5.36). To support future load growth, 20 A_{DC} is added (approximately 11.5% of the maximum measured continuous value). Finally, an additional 15 A_{DC} conservative margin of load per charger is assumed for miscellaneous control loads. Therefore, the assumed value of 240 A_{DC} (170 A_{DC} maximum measured value for normal operating conditions plus an additional 70 A_{DC} for annunciators, EDG control loads and additional margin to allow for off-normal plant conditions and future load growth) is considered to be conservative.

6.4 It is assumed that the minimum AC supply voltage for the battery chargers while they are in current limit is 450 V_{AC}.

Basis: This assumption is technically justified in that the worst-case minimum AC supply voltage at the battery charger input terminals is 455 V_{AC} (Ref. 5.14) while loaded on the emergency diesel generators. The battery charger will be in current limit upon restoration after a loss of AC voltage to the contactors (Loss of offsite power with Safety injection signal, loss of AC voltage or station blackout). When the battery chargers are restored, the battery chargers will only be supplied on the emergency diesel generators, gas turbine, or offsite power (only if restored to normal). The voltage at the terminals of the battery charger when supplied by the gas turbine or offsite power will be between 480 to 500 V_{AC}. A review of plant trending (Ref. 5.18) demonstrates the voltage on both unit B03 and B04 normally average between 480 to 500 V_{AC}. The gas turbine will provide similar voltage ranges because the output voltage of the generator per OI 110 (Ref. 5.15) is maintained between 13.8 and 14.2 kV on the 13.8 kV bus. These voltages are equal to or greater than the voltages seen during normal operation. Therefore, it is conservative to assume a minimum AC supply voltage of 450 V_{AC} for the conditions evaluated in this calculation.

6.5 It is assumed that the maximum charger output voltage is 136 V_{DC} while recharging the battery and supplying the DC load.

Basis: This assumption is technically justified in that the calibration procedure for battery chargers D-07, D-08 and D-09 is set between 132.5 to 133 V_{DC} (Ref. 5.16). The calibration procedure for battery chargers D-107, D-108 and D-109 is set between 133.5 and 134.5 V_{DC} (Ref. 5.22). The normal operating range of the battery chargers is 130 and 136 V_{DC} (Ref. 5.16 and 5.22). Therefore, it is conservative to assume the maximum charger DC output voltage of 136 V_{DC} for the conditions evaluated in this calculation.

7.0 Design Inputs

The following design inputs are required to develop the allowable current limit set point range for each individual battery.

7.1 Battery Charger Ratings – D-07, D-08, and D-09

- 7.1.1 Input Voltage – 480 V_{AC} (Ref. 5.5)
- 7.1.2 Input Current (Full Load) – 92 A_{AC} (Ref. 5.5)
- 7.1.3 Output Voltage – 130 V_{DC} (float) and 140 V_{DC} (equalize) (Ref. 5.5)
- 7.1.4 Output Current – 400 A_{DC} (Ref. 5.5)
- 7.1.5 Maximum current limit setting – 110% (440 A_{DC}) (Ref. 5.5)
- 7.1.6 Efficiency (EFF) – 0.91 (Ref. 5.5)
- 7.1.7 Power Factor (PF) – 0.72 (Assumption 6.1)

7.2 Maximum Amp-hours (Ah) discharged from battery – 925 Ah (Assumption 6.2)

7.3 Maximum continuous DC system load during charging – 240 A_{DC} (Assumption 6.3)

7.4 Required maximum time for recharging battery – 24 hours (Ref. 5.1 and 5.28)

7.5 AC Input Supply

- 7.5.1 Maximum AC supply current (supply breaker rating) – 100 A_{AC} for D-07, D-08 and D-09 (Ref. 5.6, 5.7, 5.8 and 5.9)
- 7.5.2 Maximum AC supply current (supply breaker rating) – 125 A_{AC} for D-107, D-108 and D-109 (Ref. 5.7, 5.8, 5.19, and 5.20)
- 7.5.3 AC Supply voltage range – 450 to 500 V_{AC} (Assumption 6.4)

7.6 DC Output Supply

- 7.6.1 Battery Charger Output Voltage – 136 V_{DC} (Assumption 6.5)

7.7 Battery Charger Ratings – D-107, D-108, and D-109

- 7.7.1 Input Voltage – 480 V_{AC} (Ref. 5.21)
- 7.7.2 Input Current (Full Load) – 128 A_{AC} (Ref. 5.21)
- 7.7.3 Output Voltage – 135 V_{DC} (float) and 145.2 V_{DC} (equalize) (Ref. 5.21)
- 7.7.4 Output Current – 500 A_{DC} (Ref. 5.21)
- 7.7.5 Maximum current limit setting – 125% (625 A_{DC}) (Ref. 5.21)
- 7.7.6 Efficiency (EFF) – 0.925 (test data in voltage and current range, Ref. 5.21)
- 7.7.7 Power Factor (PF) – 0.751 (test data in voltage and current range, Ref. 5.21)

8.0 Calculation Analysis

Using the methodology discussed above, the battery charger size, minimum and maximum current limit set points are developed below.

8.1 Battery Chargers D-07, D-08 and D-09

1. $A_r = \frac{Ah \times C}{t_1} + A_c$

A_r = required minimum charger rating in amperes
Ah = 925 Ah
C = 1.10
A_c = 240 A_{DC}
t_1 = 24 hours

$$A_r = \frac{925 \times 1.1}{24} + 240$$
$$A_r \approx 283\ A_{DC}$$

2. $VA_{IN} = \left(\sqrt{3} x V_{AC} \times I_{AC}\right)$
$W_{OUT} = VA_{IN} \times PF \times EFF$
$I_{DC} = \frac{W_{out}}{V_{DC}}$

V_{AC} = 450 V_{AC}
I_{AC} = 100 A_{AC}
PF = 0.72
EFF = 0.91
V_{DC} = 136 V_{DC}

$$VA_{IN} = \left(\sqrt{3} \times 450 \times 100\right)$$
$$VA_{IN} \approx 77943 VA$$
$$W_{OUT} = 77943 \times 0.72 \times 0.91$$
$$W_{OUT} \approx 51069 Watts$$
$$I_{DC} = \frac{51069}{136}$$
$$I_{DC} \approx 375 A_{DC}$$

8.2 Battery Chargers D-107, D-108 and D-109

1. $A_r = \frac{Ah \times C}{t_1} + A_c$

A_r = required minimum charger rating in amperes
Ah = 925Ah
C = 1.10
A_c = 240 A_{DC}
t_1 = 24 hours

$$A_r = \frac{925 \times 1.1}{24} + 240$$
$$A_r \approx 283\ A_{DC}$$

2. $VA_{IN} = \left(\sqrt{3} \times V_{AC} x \times I_{AC}\right)$
$W_{OUT} = VA_{IN} \times PF \times EFF$
$I_{DC} = \frac{W_{out}}{V_{DC}}$

V_{AC} = 450 V_{AC}
I_{AC} = 125 A_{AC}
PF = 0.751
EFF = 0.925
V_{DC} = 136 V_{DC}

$$VA_{IN} = \left(\sqrt{3} \times 450 \times 125\right)$$
$$VA_{IN} \approx 97427VA$$
$$W_{OUT} = 97427 \times 0.751 \times 0.925$$
$$W_{OUT} \approx 67680Watts$$
$$I_{DC} = \frac{67680}{136}$$
$$I_{DC} \approx 497A_{DC}$$

9.0 Results and Conclusion

Battery chargers D-07, D-08 and D-09 are adequately sized to meet the minimum charger size required of 283 A_{DC} (400 A_{DC} rated). The recommended range for the current limit set point for battery chargers D-07, D-08 and D-09 is 283 to 375 A_{DC}. The recommended set point for battery chargers D-07, D-08 and D-09 is 350 A_{DC}. Given a -10 to +5 A_{DC} setting tolerance, this set point allows approximately 5% margin for the total tolerance (set point drift and M&TE tolerance).

Battery chargers D-107, D-108 and D-109 are adequately sized to meet the minimum charger size required of 283 A_{DC} (500 A_{DC} rated). The recommended range for the current limit set point for battery chargers D-107, D-108 and D-109 is 283 to 497 A_{DC}. The recommended set point for battery chargers D-107, D-108 and D-109 is 450 A_{DC}. Given a –10 to +10 A_{DC} setting tolerance, this set point provides more than a 5% margin for the total tolerance (set point drift and M&TE tolerance).

The calculation determined the minimum charger size required and the acceptable current limit set point range for battery chargers D-07, D-08, D-09, D-107, D-108, and D-109. The acceptance criteria will be achieved for all battery chargers when the current limit set points are within the acceptable range identified above.

Attachment A
Calculation 2003-0046
Prepared By: TML
Reviewed By: [illegible]
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hts to the sensitive t. Quite often the voltage is selected at 2% to the full-load charger output voltage rating. Most charger manufacturers can provide equipment with ripple limits of 30 mV rms. Dc systems in which the battery is temporarily disconnected function satisfactorily on the charger; however, the ripple may be greater.

GROUND DETECTION ALARMS AND VOLTMETERS

Devices to detect grounds and provide alarms are sometimes provided with the charger. A discussion of these devices can be found in Section 9.5.

INPUT AC

Three-phase input should be used when possible. A three-phase charger provides a ripple voltage with a frequency of 360 Hz, which is much easier to filter because the amount of capacitance required is proportional to the reciprocal of the ripple frequency. The output of a single-phase charger contains a ripple frequency of 120 Hz. Therefore, a three-phase charger requires one-third the capacitance of a single-phase charger of the same size, reducing the chance of capacitor failure. Capacitors are one of the most failure-prone components in chargers.

Three-phase ac input permits less waveform distortion than does a single-phase charger of the same size. Three-phase chargers that use silicon controlled rectifiers (SCRs) may be phase-rotation sensitive for timing the firing circuits. Therefore, care must be taken during installation to make correct connections.

COOLING

Convection-cooled chargers are preferred and should be used when possible. This type of cooling requires less maintenance and usually produces less noise. If forced-air cooling is required, a redundant cooling system should be considered. The capacity of either cooling system alone should be sufficient to cool the equipment properly and allow full, continuous operating capability. Fans should be monitored by airflow switches to warn if airflow is reduced by either fan failure or clogged air filters. Convection-cooled chargers are usually larger and heavier than forced-air-cooled units.

One alternative to redundant equipment in forced-cooled chargers is a load reduction, on loss of cooling, to the self-cooled rating. Full capacity would be resumed on resolution of the cooling problem. This system requires loss-of-cooling alarms and some form of automatic load shedding.

BATTERY ELIMINATORS

Battery chargers that are used for supplying load when the battery is disconnected are sometimes called battery eliminators. These chargers have additional filtering, making them more expensive.

SIZING

The minimum charge rating is established by using Equation 9-8:

$$A_r = \frac{Ah \times C}{t_1} + A_c \qquad \text{(Eq. 9-8)}$$

Where:

A_r = required minimum charge rating in amperes

Ah = total ampere hours discharged from battery during its specified duty cycle

C = constant to allow for ampere hour efficiency = 1.10

A_c = continuous dc load while charging in amperes

t_1 = required maximum time for recharging

Ah is derived by reference to the battery load cycle as outlined earlier. The ampere hours consumed in each section of the cycle are calculated and summed for the total battery.

The continuous dc load while charging, A_c, is calculated by adding up the ampere requirements of all the continuous loads on the dc bus.

Standard chargers, according to NEMA, are rated 1, 3, 6, 12, 15, 20, 25, 35, 50, 75, 100, 150, and 200 A. Ratings above 200 A are at 100-A intervals. If the value of A_r falls between two standard-size chargers, the larger size should be used.

This method assumes that the battery has just completed a duty cycle discharge and that the charger must simultaneously recharge the battery and supply the continuous load.

As an example, use the typical duty cycle illustrated in the battery portion of this volume (Figure 9-2), and assume an 8-h maximum charge time

Attachment A
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Prepared By: TML
Reviewed By: KTH
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with a 200-A normal load. The charger would be sized using Equation 9-8 as follows:

$$A_r = \frac{\left[\frac{2000}{60} + \frac{300 \times 58}{60} + \frac{1000}{60}\right] \times 1.10}{8} + 200$$

$$= \frac{374}{8} + 200 = 246.75\ A$$

The charger capacity should be 300 A, which is the next-higher standard rating above 247 A.

9.5 DISTRIBUTION SYSTEM

VOLTAGE RATING OF LOADS

The battery used in a dc distribution system is designed for cell voltages ranging from 1.75 to 2.33 V/cell. A typical 60-cell battery has a battery terminal voltage range of 105 to 140 V. The dc system design should take into consideration the voltage drop (4% maximum is typical) between the battery and the load terminals. If a 4% voltage drop is allowed, the load dc input voltage would be between 101 and 140 V, based on Equations 9-9 and 9-10:

$$L_V = (1.0 - 0.04)\,V_{sm} \times N \qquad \text{(Eq. 9-9)}$$

$$H_V = V_{mm} \times N \qquad \text{(Eq. 9-10)}$$

Where:

N = number of cells in battery

L_V = low terminal voltage at load

H_V = high terminal voltage at load

V_{sm} = minimum defined cell voltage = 1.75

V_{mm} = maximum defined cell voltage = 2.33

All equipment connected to the dc distribution system should be capable of operating continuously and properly without malfunction or overheating in the voltage range specified by the system designer. If this criterion is set early in the design process, it is usually accepted by the equipment suppliers even though the applicable standards, NEMA, ANSI, and others, may have slightly different limits.

A review of the voltage standards for various types of dc equipment reveals confusion and in-

NEMA S. This page added in Rev. 0 in-
dustrial cl[illegible] lists 80 to 100% for the voltage limits when applied to nominal voltage. However, when an analysis of the various control devices (indicating lamps, push buttons, motor starting switches, and the like) is made, the nominal voltage can be 115, 115 to 120, 120, or 125 V. Similarly, ANSI/IEEE Standard C37.90-1978 (4) for relays states a range of 100 to 140 V for nominally rated 125-V relays. ANSI/IEEE/NEMA Standard C37.16-1980 (13) uses 90 to 130 V for nominally rated 125-V control circuits.

The system designer will be challenged by these inconsistencies and may have to modify the design. Some of the options may be:

- Specify nonstandard devices, which may be difficult to obtain.
- Use a lower (less than 2.33 V/cell) equalizing charge rate with the resultant longer charge period.
- Design for a higher final voltage (more than 1.75 V/cell), thus increasing the minimum acceptable voltage.
- Add or delete resistance by modifying the length or size of cable between the battery and the load.
- Make a judgment, particularly on the intermittently energized devices, to risk a short-time overvoltage.

The maximum allowable line voltage drop between the battery terminals and the load terminals may be increased, provided the load equipment has been specified to operate with a lower input terminal voltage. Care must be taken to ensure that the maximum load terminal voltage does not exceed 2.33 × N.

Lower terminal voltages are allowed by manufacturers in some types of equipment, such as switchgear. Currently, the tripping voltage must be equal to or greater than 70 V, and the closing voltage must be equal to or greater than 90 V.

DETERMINATION OF CABLE NEEDS

All electrical systems, both ac and dc, must be designed with the understanding that voltage drop is an ever-present problem that must be factored into the design. Those loads that are voltage sensitive must be supplied with a voltage that meets

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the size of the battery (number of cells and capacity) and the operating procedures should be established as outlined in ANSI/IEEE Std 485-1983 [8] and ANSI/IEEE Std 450-1980 [7], respectively.

4.6 Physical Layout. The redundant equipment (including the cables) of the safety-related dc system shall be arranged to meet the physical separation requirements of ANSI/IEEE Std 384-1981 [6].

Consideration should be given to locating the equipment of each redundant division (that is, battery, charger, and main distribution panel) as close together as practical so as to minimize voltage drop and to accommodate maintenance and testing activities.

5. Batteries

5.1 Determination of Battery Duty Cycles and Battery Size (Capacity). The determination of the battery duty cycles is a plant-unique activity because the magnitude (total amperes) and duration of each segment of the duty cycle is the sum of the individual operating loads (amperes) over the time period required for the specific plant equipment under consideration.

In addition, the overall period (total battery discharge time) of the duty cycle cannot be less than the estimated time interval necessary to restore ac power (either from an on-site engine-generator source or an off-site power source) to the battery chargers and other auxiliaries following a loss of off-site power. This estimated time interval is determined by engineering judgment, which is greatly influenced by operating experience, and by the quantity, reliability, and flexibility of the specific off-site power sources (generation and transmission system network equipment) and on-site power sources (engine-generators and distribution systems).

For example, a minimum scenario may require the batteries to supply power to the system for approximately 1 min (the time between loss of off-site power and the loading of the diesel) if, after such time, the charger output and dc loads return to normal. Such a design would be the minimum period meeting the single failure criteria. More often, the overall period of the battery duty cycle is estimated at ½, 1, 2, or 4 h. The time/load current profile should consider the requirements in all operating modes. Non-regulatory criteria, such as operation while a battery r or while switches are op charger on line, should als duty cycles that require r tery loads (such as could ac power) also require th provided to allow adequa actions. Thus, several batte be required to address suc

After the magnitude and component load and the overall period have been determined, each battery duty cycle should be constructed, and the battery sized, in accordance with ANSI/IEEE Std 485-1983 [8].

5.2 Installation Design. The design of each battery installation should be in accordance with IEEE Std 484-1981 [12], and shall include provisions for installation, inspection, and testing in accordance with ANSI/IEEE Std 336-1985 [5].

5.3 Maintenance, Testing, and Replacement. Batteries should be maintained, tested, and replaced in accordance with ANSI/IEEE Std 450-1980 [7].

5.4 Qualification. Batteries shall be qualified (environmentally and seismically) in accordance with ANSI/IEEE Std 535-1979 [9].

6. Battery Chargers

6.1 General Description. The station battery chargers are used to convert ac to dc to charge the station batteries and to supply power to dc loads during normal operation.

6.2 Determination of Required Rating. The station battery chargers should be sized in accordance with the following formula:

$$I = L + \frac{1.1 \cdot Ah}{T} \qquad \text{(Eq 1)}$$

where

I = charger rated output (amperes)

L = continuous dc load (amperes)

1.1 = constant that compensates for the battery losses

Ah = ampere-hours discharged from the battery (ampere-hours). It is recommended that the 8 h ampere-hour rating of the battery be used in this formula.

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T = time to re-charge the battery to approximately 95% of capacity (hours). To minimize dc system down time, a reasonable recharge time should be selected; 8-12 h is recommended. It is recommended that the battery manufacturer be consulted for values of T less than 8 h.

It is also recommended that the ampere rating of the charger be at least equal to the continuous load plus the largest combination of noncontinuous loads (as defined in ANSI/IEEE Std 485-1983 [8], 4.2.2) that would likely be connected to the bus simultaneously during normal plant operation.

The battery charger specification should include (or account for) any abnormal service conditions (for example, ambient temperature, altitude, etc) as noted in NEMA PE 5-1983 [14].

6.3 Sample Calculations. A sample calculation of battery charger rating appears in Appendix A.

6.4 Qualification. All chargers shall be qualified in accordance with ANSI/IEEE Std 650-1979 [11].

6.5 Output Characteristics. All station battery chargers should meet the requirements of NEMA PE 5-1983 [14], and the performance characteristics descriptions that follow.

6.5.1 Output Ripple. A typical charger (without additional filtering) will produce less than 2% rms (2.6 V on a 130 V basis) ripple when connected to a fully charged battery with an Ah rating (at the 8 h rate) of at least four times the output current rating of the charger. In some cases, dc loads (for example, solid-state instruments) may require improved filtering. The maximum ripple can usually be limited to 30 mV rms by adding filters to the chargers.

6.5.2 Operation Without a Connected Battery. For some designs, it may be appropriate to disconnect the battery from the system for maintenance of the battery. Under this condition, the charger should be capable of supplying the load without a battery connected and should be so specified for these applications. However, an increase in the voltage regulation and output ripple should be expected. If the increase in voltage regulation or ripple cannot be tolerated, the maximum allowable values should be specified.

7. Distribution System and Equipment

7.1 Description and Rating. A circuit breaker, fuses, or a manual disconnecting device should be

...ls and t
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...ns incorpo
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...lead cal
...conduits
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...ity-to-polar
fault can develop. A barrier should also be provid
between the positive and negative *line* leads at t
main distribution panel. The continuous curr
rating of the protective/disconnecting dev
should be selected to accommodate the maxim
sustained current in the battery duty cycle. Wh
provided, the protective device should have a t
rating (a) sufficiently high to prevent damage
the fuse element or opening of the breaker at
1 min current rating of the battery, and (b) su
ciently low to assure opening for the short circ
current available from the battery at end-
discharge voltage.

NOTE: The (minimum) melt current of the fuse element at 1 should be above the 1 min current rating of the battery.

The main protective device should coordin
with all downstream protective devices. All de
bution bus protective devices should have a volt
rating consistent with the maximum system o
ating voltage, and should have an interrup
capacity that exceeds the maximum short-cir
current available. The distribution bus and
manual disconnecting device should have a sh
circuit current withstand capability that exc
the maximum short-circuit current available.

7.2 Typical Diagram. The optimum dc supply distribution system diagram for any given plant depend on conditions and design criteria es lished for that plant. Figure 1 is the key diagra one acceptable 125 V Class 1E dc system.

7.3 Voltage Ratings for DC Powered Compon Equipment specifications for components pow by dc systems should require the equipme operate, as designed and without damage, ov input terminal voltage range corresponding t variation in battery terminal voltage. For desi which the battery is equalized while connec the load, this range should cover the variation equalize to the final end-of-discharge volta example, from 140 V-105 V dc for a 60-cell no 125 V dc system, or from 280 V-210 V dc 120-cell nominal 250 V dc system). Because

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Appendixes

(It is part of IEEE 946-1985, IEEE Recommended Practice for the Design of Safety-Related DC Auxiliary Power Generating Stations, but are included for information only.)

Appendix A

Battery Charger Rating—Sample Calculations

A1 Introduction

This appendix outlines the method, including sample calculations for determining the required rating of battery chargers, as recommended in 6.2 and 6.3.

A2. Formula

The station battery chargers should be sized in accordance with the following formula:

$$I = L + \frac{1.1 \cdot Ah}{T} \qquad \text{(Eq A1)}$$

where

I = charger output current rating (amperes)

L = continuous dc load (amperes)

1.1 = constant that compensates for the battery losses

Ah = ampere-hours discharged from the battery (ampere-hours). It is recommended that the 8-h ampere-hour rating of the battery be used in this formula

T = time to re-charge the battery to approximately 95% of capacity (hours). To minimize dc system down time, a reasonable recharge time should be selected; 8–12 h is recommended. It is recommended that the battery manufacturer be consulted for values of T less than 8 h.

In addition, it is recommended that the ampere rating of the charger be at least equal to the continuous load plus the largest combination of noncontinuous loads (as defined in ANSI/IEEE Std 485-1983 [8], 4.2.2) that would likely be connected to the bus simultaneously during normal plant operation.

The battery charger specification should include (or account for) any abnormal service conditions (for example, ambient temperature, altitude, etc) as noted in NEMA PE 5-1983 [14].

A3. Sample Calculations

Example 1. Determine the rating of the charger required for a battery where the continuous dc load is 100 A, the largest single noncontinuous load is 80 A, and the Ah discharged from the battery is 400 Ah (rating of the battery at 8-h rate) with 12 h to recharge the battery (no abnormal service conditions.

$$I = 100 + \frac{(1.1)\ 400}{12}$$

$$I = 100 + 36.7 = 136.7\ \text{A}$$

To account for the single noncontinuous load, the following applies:

$$I = 100 + 80 = 180\ \text{A}$$

Conclusion: specify battery charger with a 180 A (or larger) rated output.

Example 2. Determine the rating of the charger required for a battery where the continuous load is 300 A, the largest single noncontinuous load is 100 A, the ampere-hours discharged from the battery is 1200 Ah (rating of the battery at 8 h rate) with 10 h to recharge the battery (no abnormal service conditions).

$$I = 300 + \frac{(1.1)\ 1200}{10}$$

$$I = 300 + 132 = 432\ \text{A}$$

To account for the single noncontinuous load, the following applies:

$$I = 300 + 100 = 400\ \text{A}$$

Conclusion: specify battery charger with a 450 A (or larger) rated output.

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EQUIPMENT DATA SHEET

Equipment - Thyristor Regulated Rectomatic Battery Charger.

2 Load - 50 Cell Lead Calcium Battery and Connected Load.

3. Westinghouse G.O. - MX-50021-AR5L-12

4. AC Characteristics

Voltage	480V
Phases	3
Frequency	50 HZ
Current (Full Load)	92 Amperes
Transformer Taps	

H1-H2-H3	480Volts
H4-H5-H6	460 Volts

5. DC Characteristics

Voltage	
Float Charge	130V*
Equalize Charge	140V*
Current	400 Amperes

*Always consult battery instruction manual for battery manufacturers recommended charging voltages rates. when to equalize and time duration of equalize charge.

6. Current Limit Setting -

110% Rated Full Load Current (440 Amperes DC)

7. Special Start-Up Instructions

01

1. With DC Load Breaker Open. Close AC Input Breaker.

2. When DC Voltmeter reads 130 volts. Close DC Load Breaker.

This procedure will prevent DC breaker trip due to filter capacitor (1C) inrush charging current.

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Rectomatic® Regulated Battery Chargers

For Floating Service
208, 230, 460 Volts, Three Phase, Ac,
60 Cycles, 24, 60, and 120 Cells,
25-1000 Amperes

Operation

A block diagram of the three phase Rectomatic is shown below. Once the ac source and the battery connections are made, the ac circuit breaker may be operated to energize the charger. The regulated dc output of the charger is obtained by silicon controlled rectifiers (thyristors) which are controlled by a transistorized regulator consisting of a constant voltage section and a current limit section.

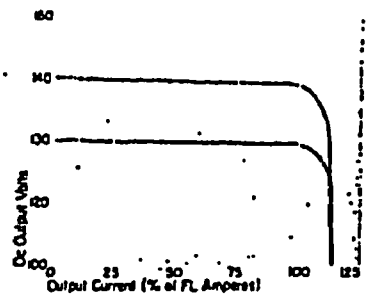
Constant Voltage

Constant voltage regulation is accomplished by comparing the dc output voltage with a zener diode constant voltage reference bridge. A voltage change due to ac voltage variation or change in dc load will cause an unbalance in the voltage reference bridge. This signal is fed to a phase shift network which pulses the gate circuit of the thyristor at the proper level to maintain dc voltage setting. It will regulate the voltage under steady state load conditions between no load and full load to ±1%, with ±10% ac line voltage variation.

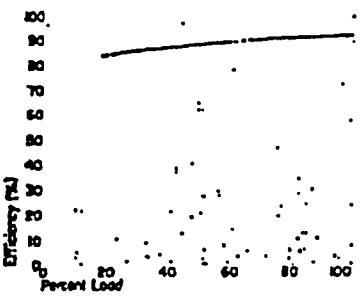
Current Limit

The current sensing circuit develops a signal voltage proportional to the load current. An increase in the load current above the current limiting setting will cause the current limit signal to overide the voltage signal, and thus control the phase shifter. This limits the output current to 110% of rated output, and protects the charger by automatically limiting the current on overloads to a safe value.

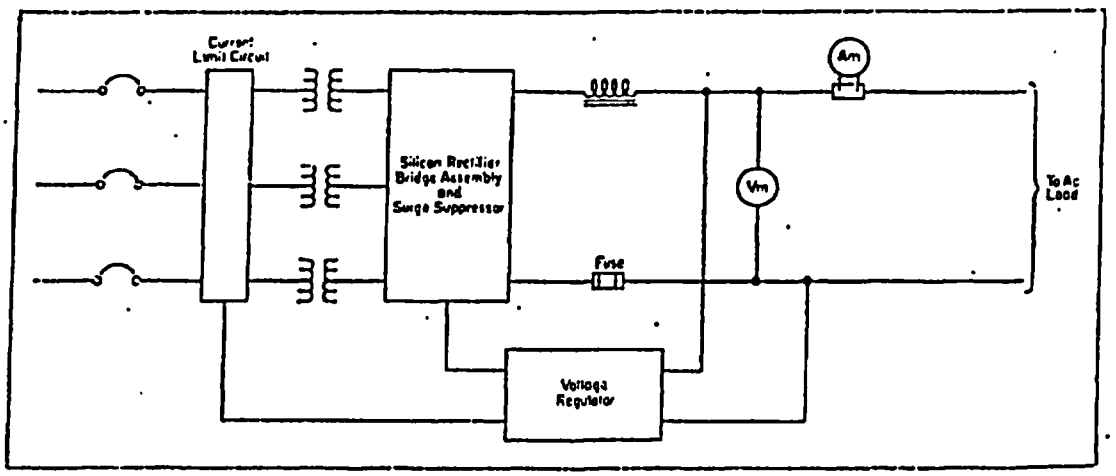
Voltage Regulation



Efficiency



Typical Block Diagram



Capacities-Dimensions-Weights

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TYPE*	NOM. A.H. CAP.	OVERALL DIMENSIONS						WEIGHTS—VC							
		LENGTH		WIDTH		HEIGHT		UNPACKED		DOMESTIC PACKED					
		in	mm	in	mm	in	mm	lbs	kg	lbs	kg				
2GN-13	1140	12.4	315	15.1	384	27.2	691	445	202	465	211				
2GN-15	1250							485	220	505	229				
2GN-17	1500	16.6	422	15.1	384	27.2	691	585	265	607	275				
2GN-19	1600							620	281	642	291	15			
2GN-21	1700							655	297	677	307	147	67	147	56
2GN-23	1800							695	315	717	325	139	63	139	53

Average Cell Performance Data*

(Discharge Rates in Amperes.
1.215 SP. GR. ELECTROLYTE AT 77° (25°C). INCLUDING CELL CONNECTORS

TYPE	NOM. A.H. CAP.	72 HR.	24 HR.	12 HR.	8 HR.	5 HR.	4 HR.	3 HR.	2 HR.	1.5 HR.	1 HR.	30 MIN.	15 MIN.	1 MIN.	TO 1.50 VPC 1 MIN.
To 1.75 VPC Final															
GN-13	1140	243	84	109	143	198	225	270	355	420	535	760	922	1090	2035
GN-15	1250	257	89	118	157	215	248	295	390	465	600	860	1046	1230	2300
GN-17	1500	300	77	135	187	255	304	365	480	560	710	880	1230	1680	3360
GN-19	1600	311	82	145	199	280	333	400	525	615	785	1075	1365	1830	3725
GN-21	1700	318	86	154	213	300	360	430	565	670	853	1160	1500	1970	4085
GN-23	1800	319	89	160	225	325	385	460	605	725	925	1240	1625	2100	4430
To 1.81 VPC Final															
GN-13	1140			103	136	185	212	250	315	370	465	610	719	817	
GN-15	1250			112	149	200	231	270	350	400	525	690	815	922	
GN-17	1500			129	175	240	284	336	430	505	625	805	965	1200	
GN-19	1600			139	189	260	310	367	474	555	685	885	1070	1315	
GN-21	1700			147	203	283	385	396	515	605	745	960	1170	1425	
GN-23	1800			155	214	303	360	422	555	650	800	1035	1265	1525	

*Rates shown depict average values and are subject to IEEE-485

ATTACHMENT C
LOCAL MANUAL CLOSURE OF H52-G05 (CONTINUED)

4.0 Dead Bus Pickup Of H01 Bus From C02R

4.1 Ensure 43LRS, Remote Local Selector Switch in REMOTE position.

4.2 Adjust frequency using Governor Speed Changer Switch to obtain 59.5 to 60.5 Hertz

CAUTION

Do NOT allow G05 Output Voltage to exceed 14.4 KV. An Over-excitation Trip will occur at 14.8 KV.

NOTE: Manual control of voltage adjust controls will adjust voltage only.

NOTE: Periodic monitoring of output voltage is required to prevent over-excitation.

4.3 Adjust voltage using G05 GT Generator Voltage Adjust to Obtain 13.8 to 14.2 KV.

NOTE: Maintain 13.8 KV System parameters as follows:
- 59.5 to 60.5 Hertz
- 13.8 to 14.2 KV

4.4 Position G-05 GT Generator Main Breaker Synchroscope to ON

4.5 CLOSE H52-G05 Output Breaker.

4.6 Turn G-05 GT Generator Main Breaker Synchroscope OFF.

4.7 At C500, Ensure 43ST, Synchronizing Mode Selector Switch in AUTO.

NOTE: PBF-2023, G05 Operating Logs should be started - including G-05 performance data.

NOTE: During snow or sleet conditions periodically monitor inlet structure for ice build up. Immediately notify Shift Management if excess build up of ice is noticed. (B-6)

4.8 Record a set of log readings every hour OR as directed by Shift Management.

4.9 IF another power supply becomes available (offsite power)
THEN parallel G05 with power supply per appropriate procedure.

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RMP 9359-7

DC STATION BATTERY CHARGER D-07, D-08 AND D-09 MAINTENANCE PROCEDURE

DOCUMENT TYPE:	Technical
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APPROVAL AUTHORITY:	Department Manager
PROCEDURE OWNER (title):	Group Head
OWNER GROUP:	Maintenance

Verified Current Copy: _____ _____ _____
Signature Date Time

List pages used for Partial Performance

Controlling Work Document Numbers

INITIALS

NOTE: "+ / -" keys to right of key pad shall be used to adjust current or use mouse to adjust current using up/down arrows on screen.

5.4.21 Adjust Charger as follows:

a. Place switch 1SW to Float position, ensuring charger float voltage is 130 to 136 volts; normal operating range AND record value on Data Sheet 3. IF required, adjust float voltage using 1P (float) potentiometer. _____ EM

b. Load charger to approximately 100 amps AND ensure there are NO current oscillations. Record amp value on Data Sheet 3. _____ EM

NOTE: Range in Step 5.4.19.c shall NOT be changed without concurrence of System Engineer. (Reference CAP050366)

c. Load charger to between 330 Amps and 350 Amps AND record value on Data Sheet 3. _____ EM

NOTE: Pressing F3 will take control to auto mode and maintain charger current at value set between 330 and 350 Amps.

d. Using Scopemeter monitor AC ripple voltage AND record ripple voltage peak to peak on Data Sheet 3. _____ EM

e. Record Start time AND initial readings on Data Sheet 4. _____ EM

f. Ensure balance loading at AC input breaker. Record AC input phase currents on Data Sheet 3. _____ EM

PMT

5.4.22 Test Coordinator shall perform the following for battery charger test:

a. Record battery charger readings every half hour for 8 hours and finish time on Data Sheet 4. _____ EM

b. Ensure battery charger data was maintained within required limits for 8 hours per Data Sheet 4. _____ EM

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		INITIALS
	c. Record final battery charger volts and amps on Data Sheet 3.	EM
	d. Review result of battery charger test **AND** ensure acceptable.	SE/SUPV
5.4.23	Using load test computer, unload Charger by decreasing load current to zero.	EM
5.4.24	Hit "F1" key to stop test.	EM
5.4.25	Ensure charger float voltage is 132.5 to 133 volts; normal operating range **AND** record value on Data Sheet 3. **IF** required, adjust float voltage using 1P (float) potentiometer.	EM
5.4.26	Place switch 1SW to Equalize position, ensuring charger equalizing voltage is 142.5 to 143.0 volts (normal equalizing range) **AND** record value on Data Sheet 3. **IF** required, adjust equalizing voltage using 2R (equalizing) potentiometer.	EM
5.4.27	Open station battery charger local DC output breaker.	EM
5.4.28	Test Air Flow switch as follows:	
	a. Open Station battery charger local AC breaker.	EM
	b. OPH de-energize battery charger by opening and locking applicable AC supply breaker.	OPH
	c. Remove fan motor overloads.	EM
	d. OPH unlock **AND** close applicable AC supply breaker.	OPH
	e. Have Unit 2 CO close applicable station battery charger AC controller with applicable control switch at 2C20.	EM
	f. Notify Operations applicable battery charger Trouble Alarm on 2C20 will be received.	EM
	g. Close station battery charger local AC breaker.	EM
	h. Check station battery charger local AC breaker trips in approximately 10 seconds.	EM

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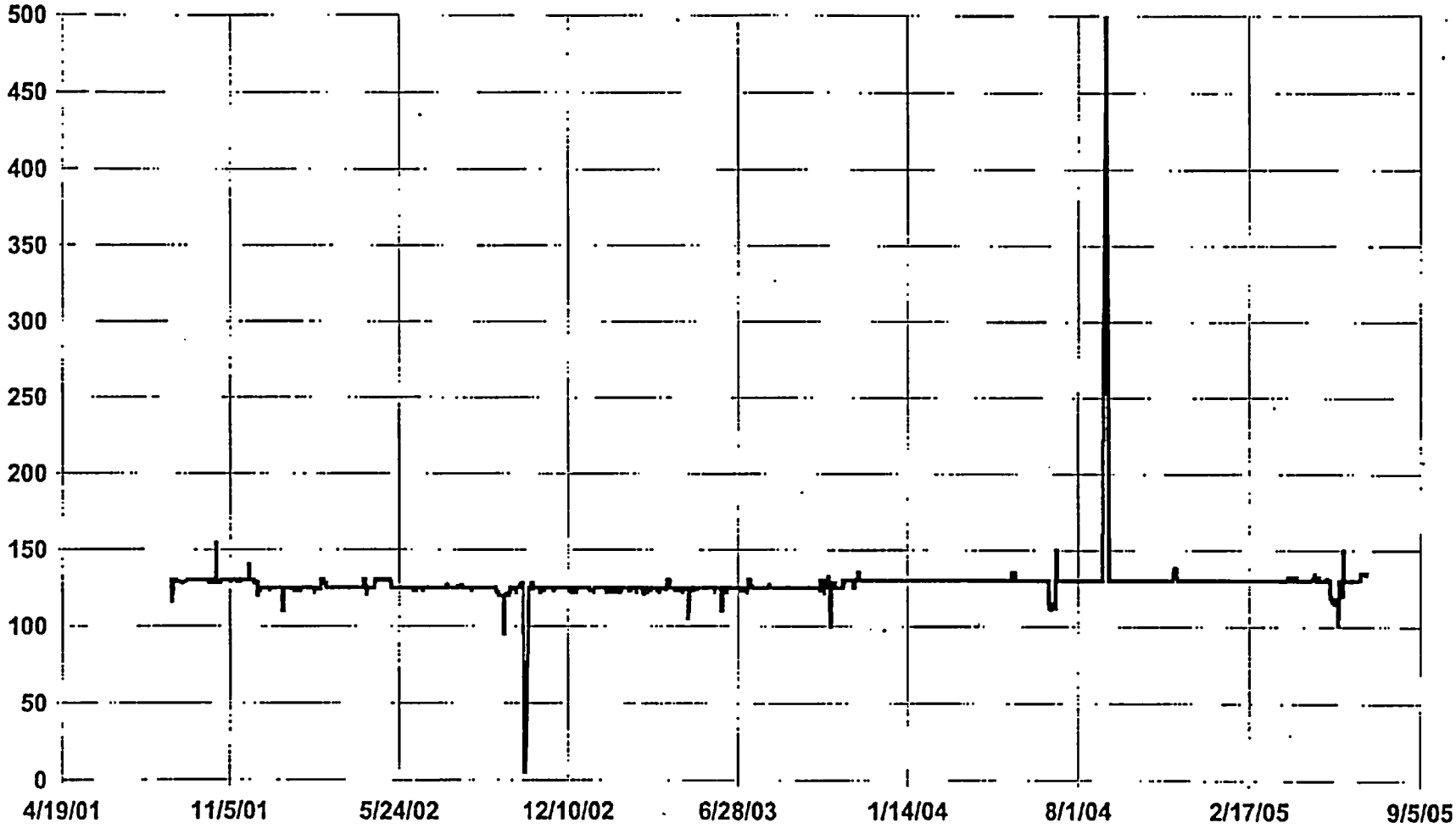
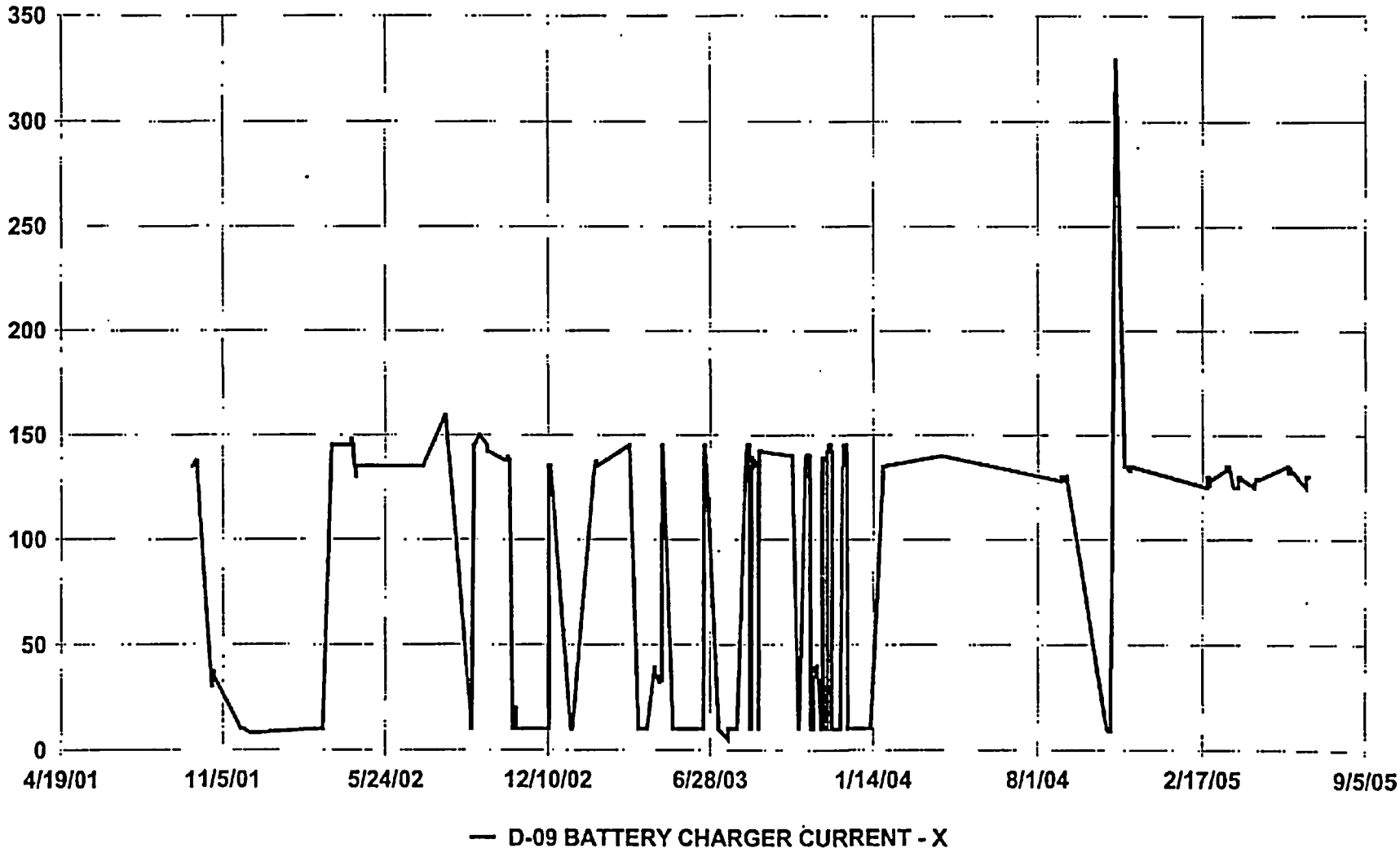
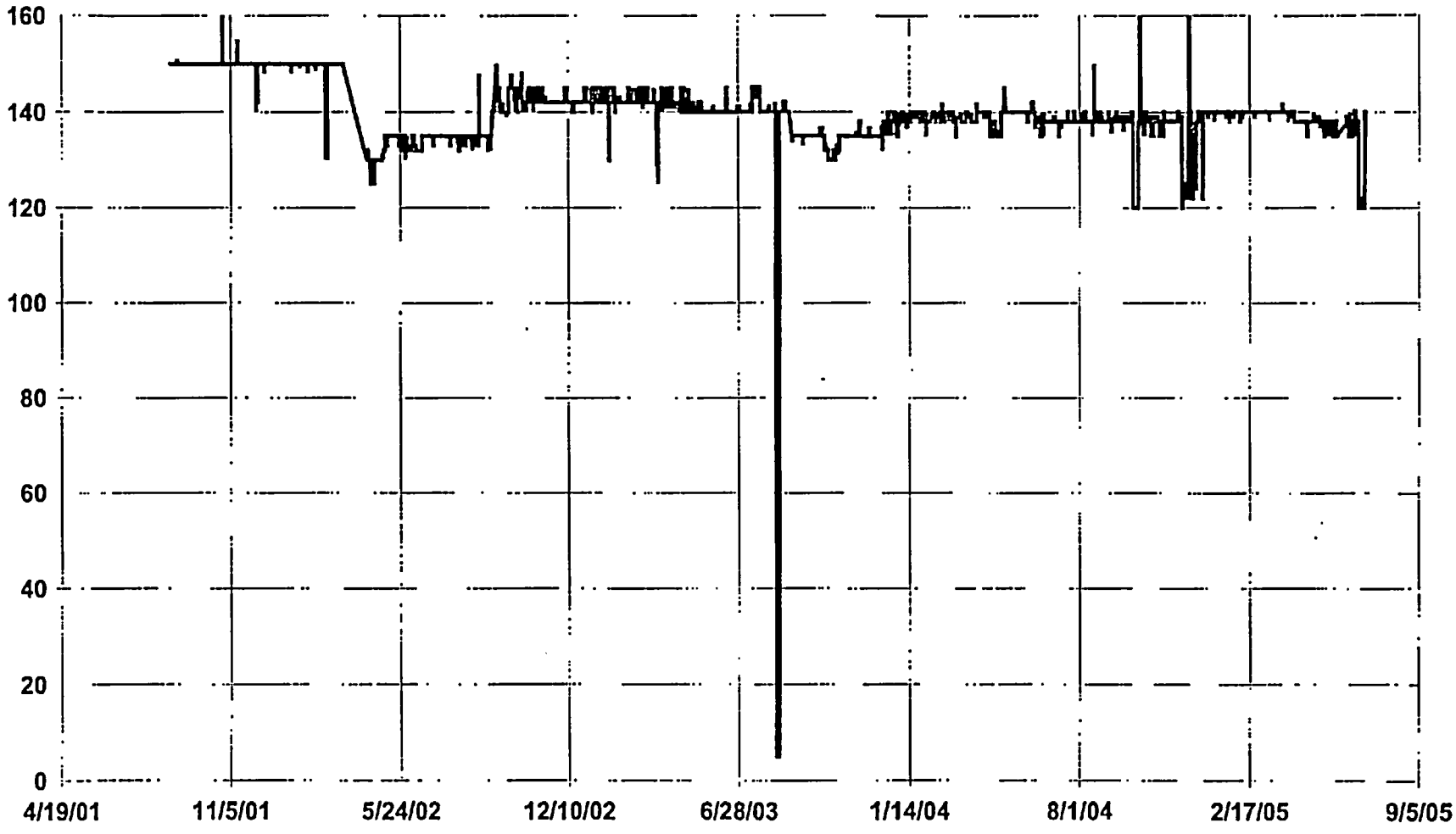
X-Y Graph of D-08 BATTERY CHARGER CURRENT

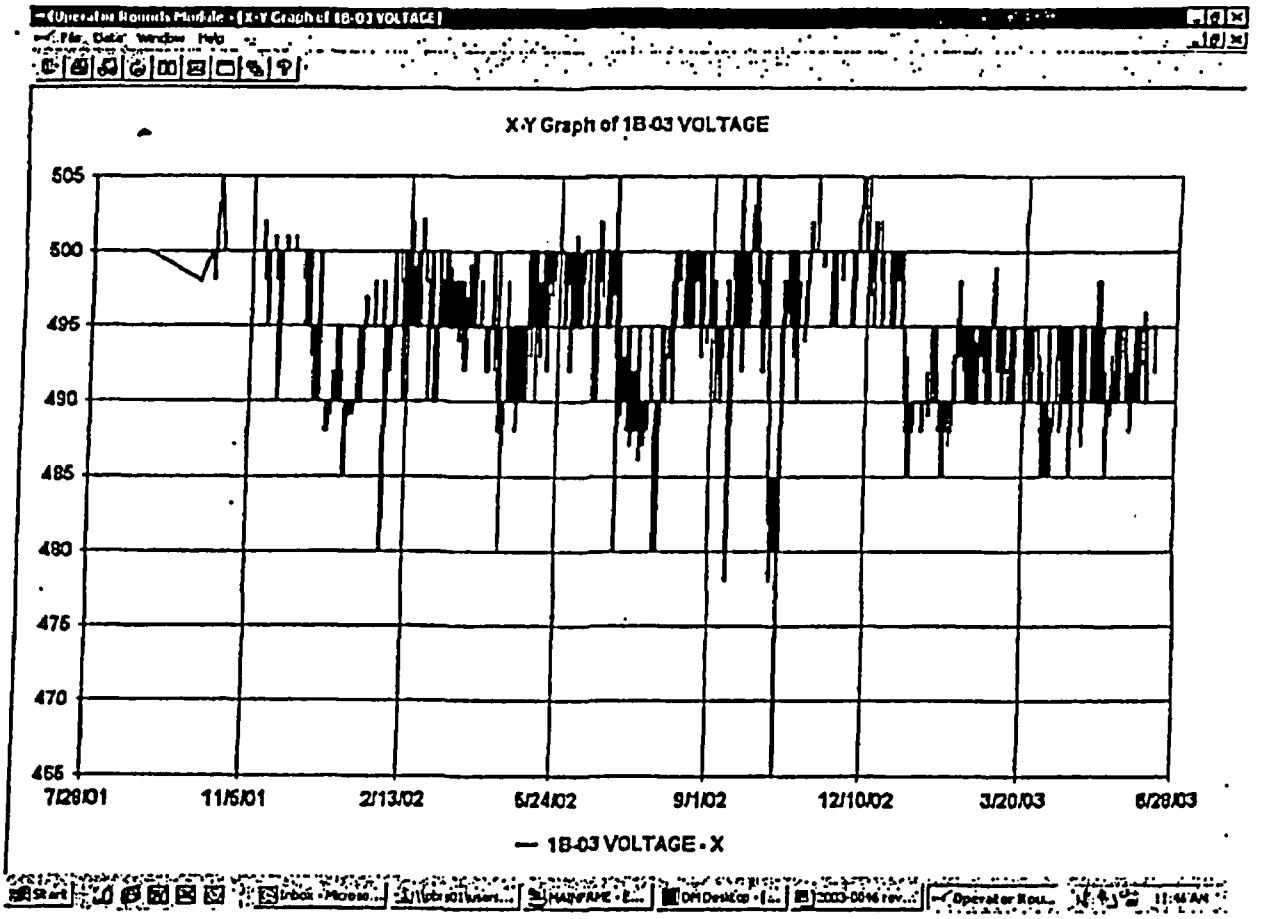


X-Y Graph of D-09 BATTERY CHARGER CURRENT



X-Y Graph of D-07 BATTERY CHARGER CURRENT





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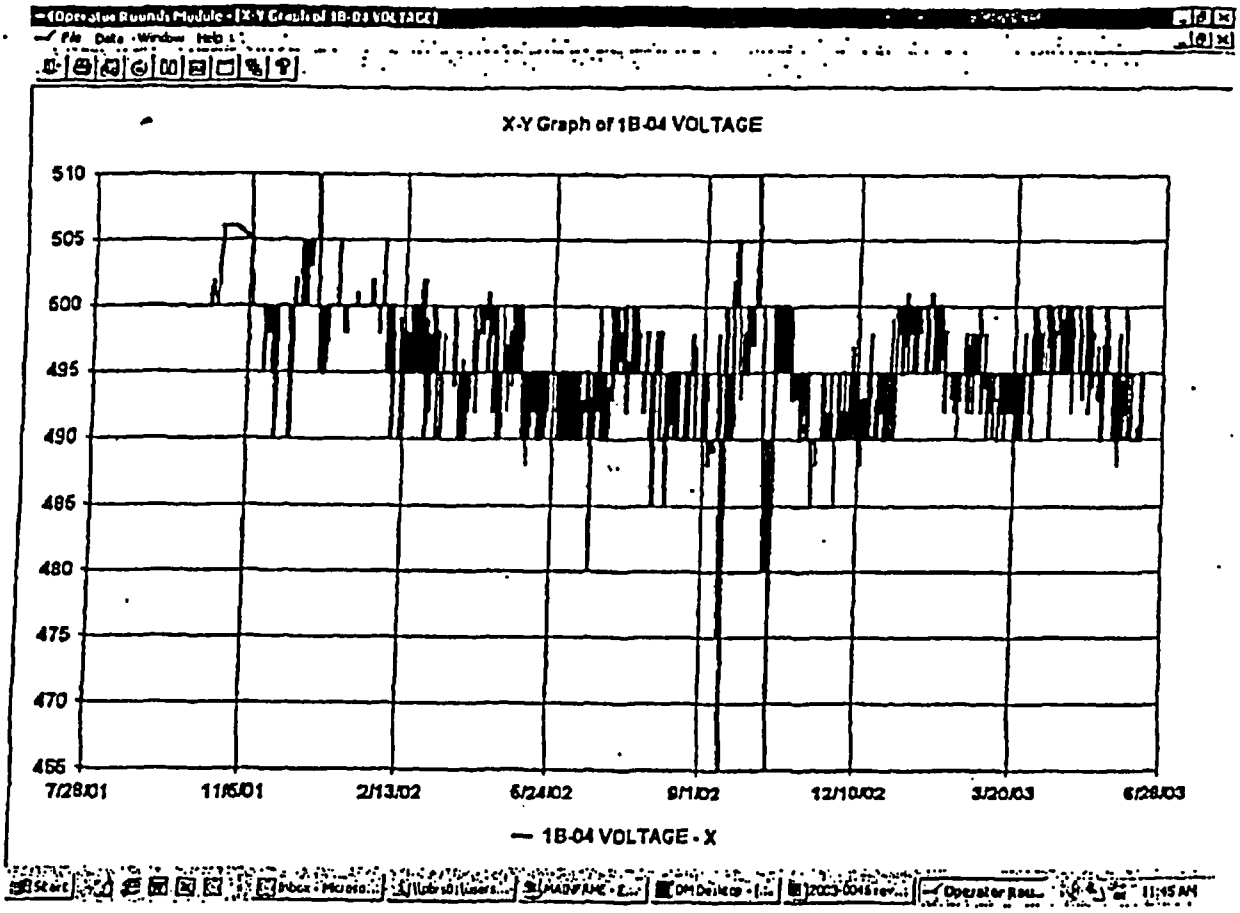

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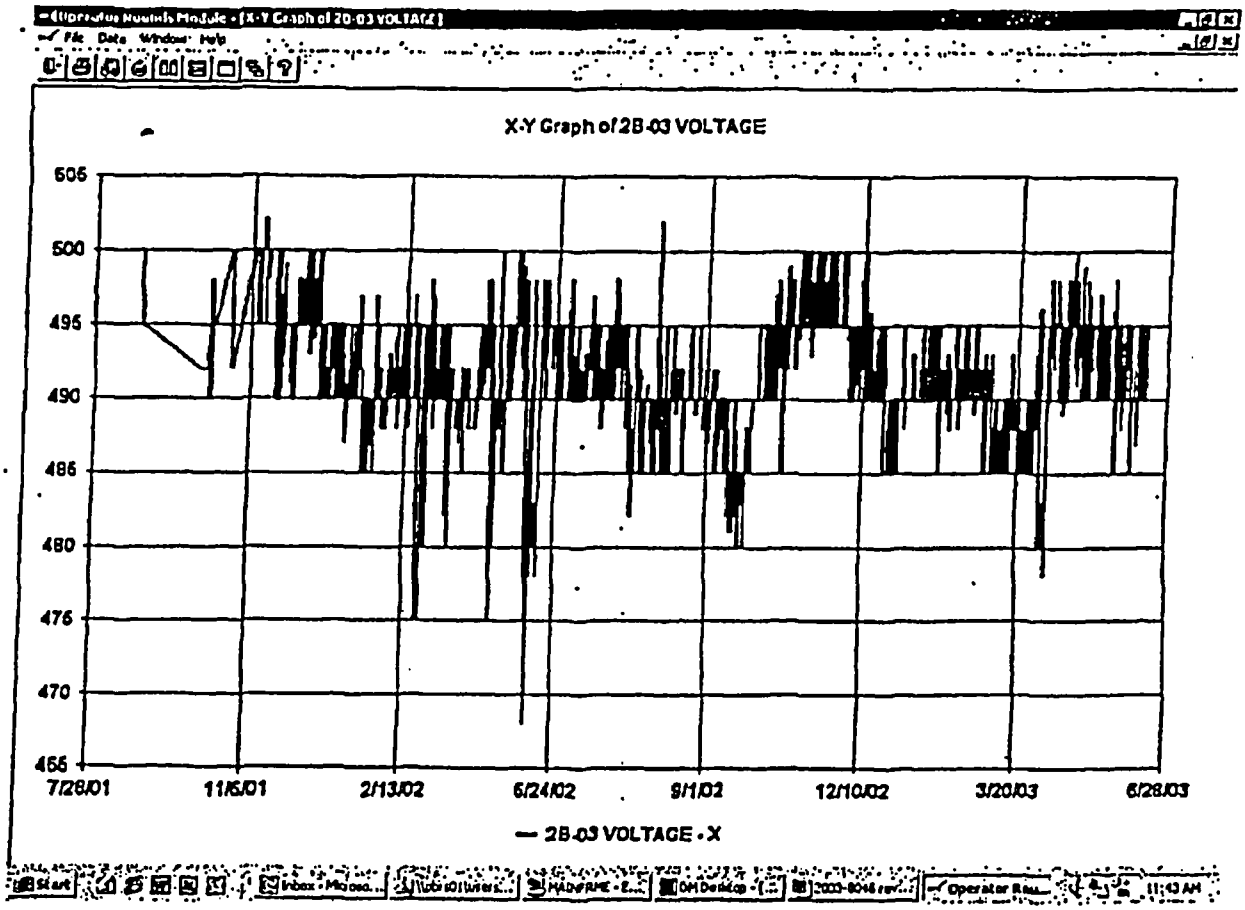

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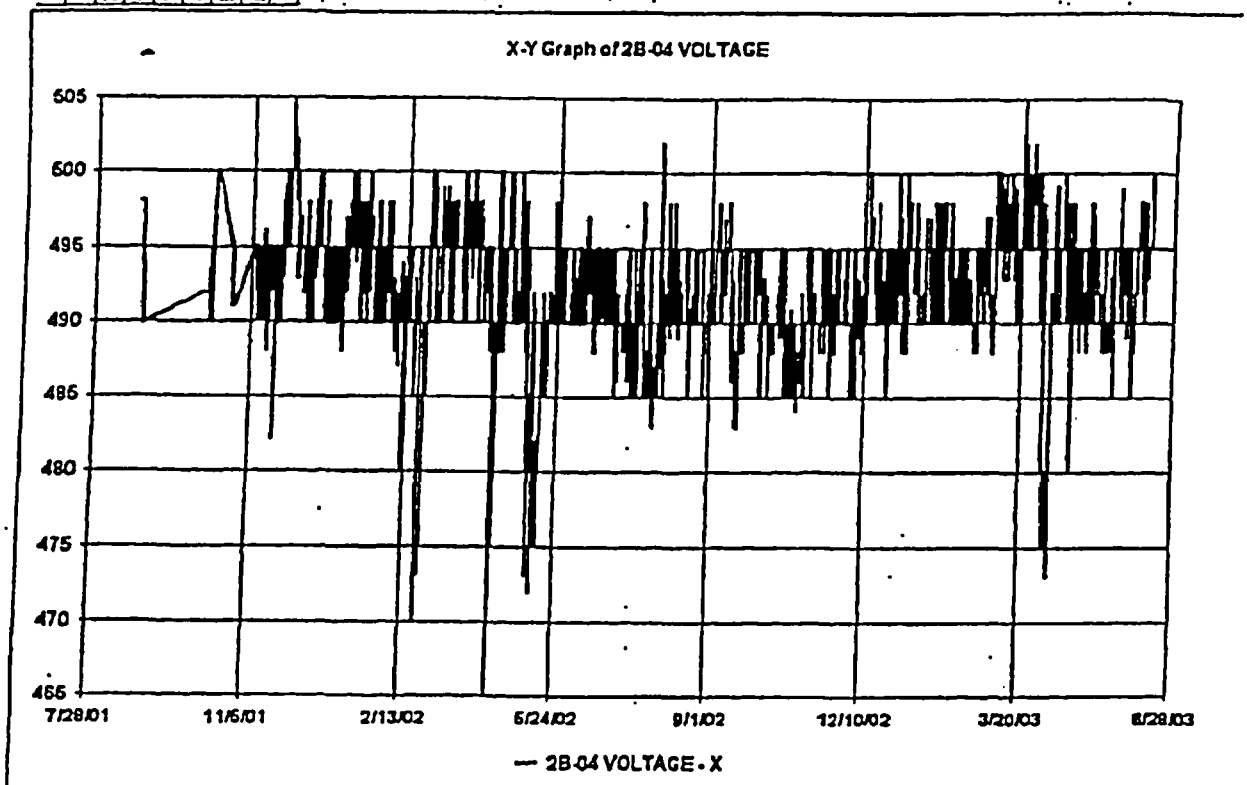

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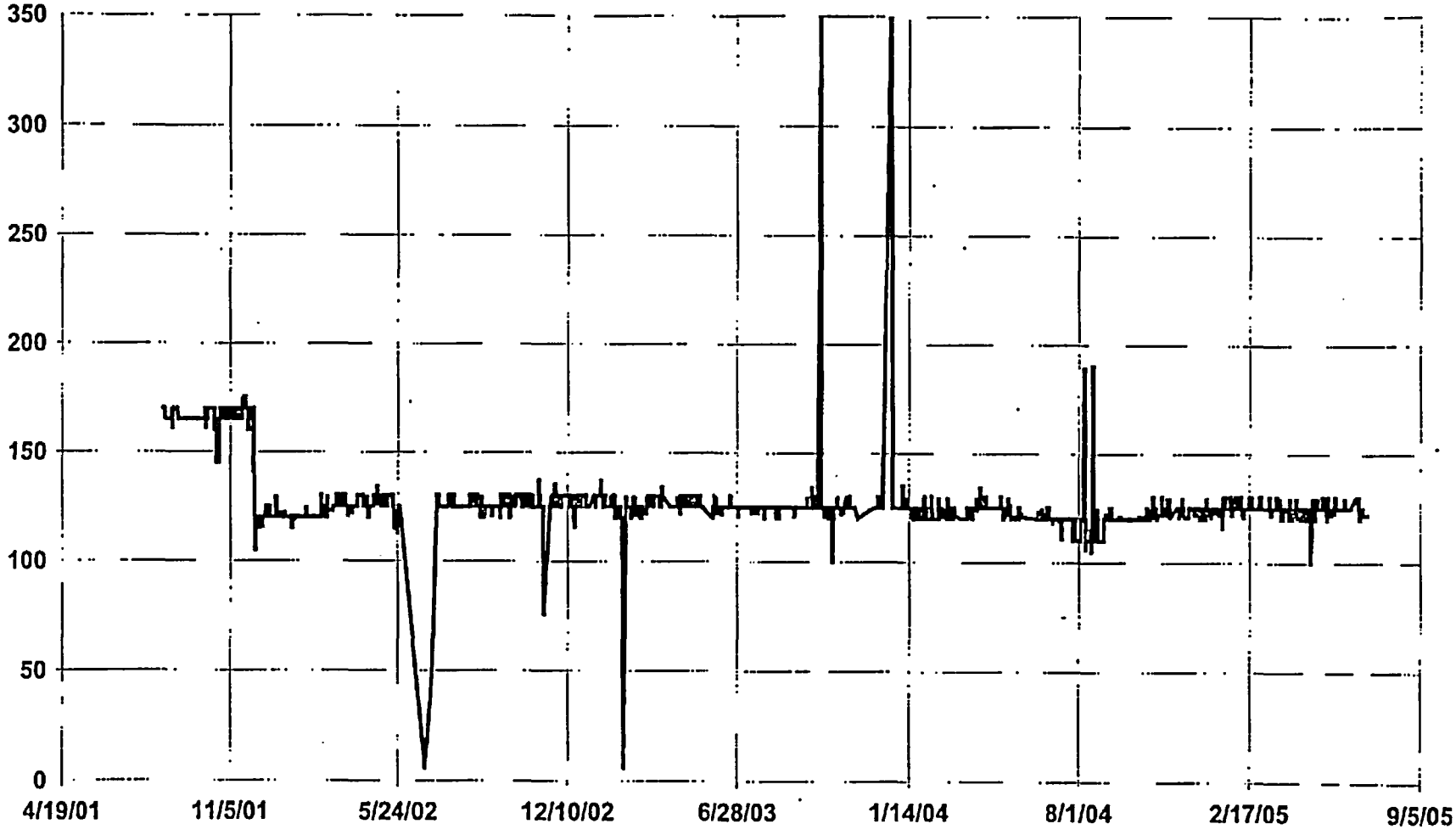
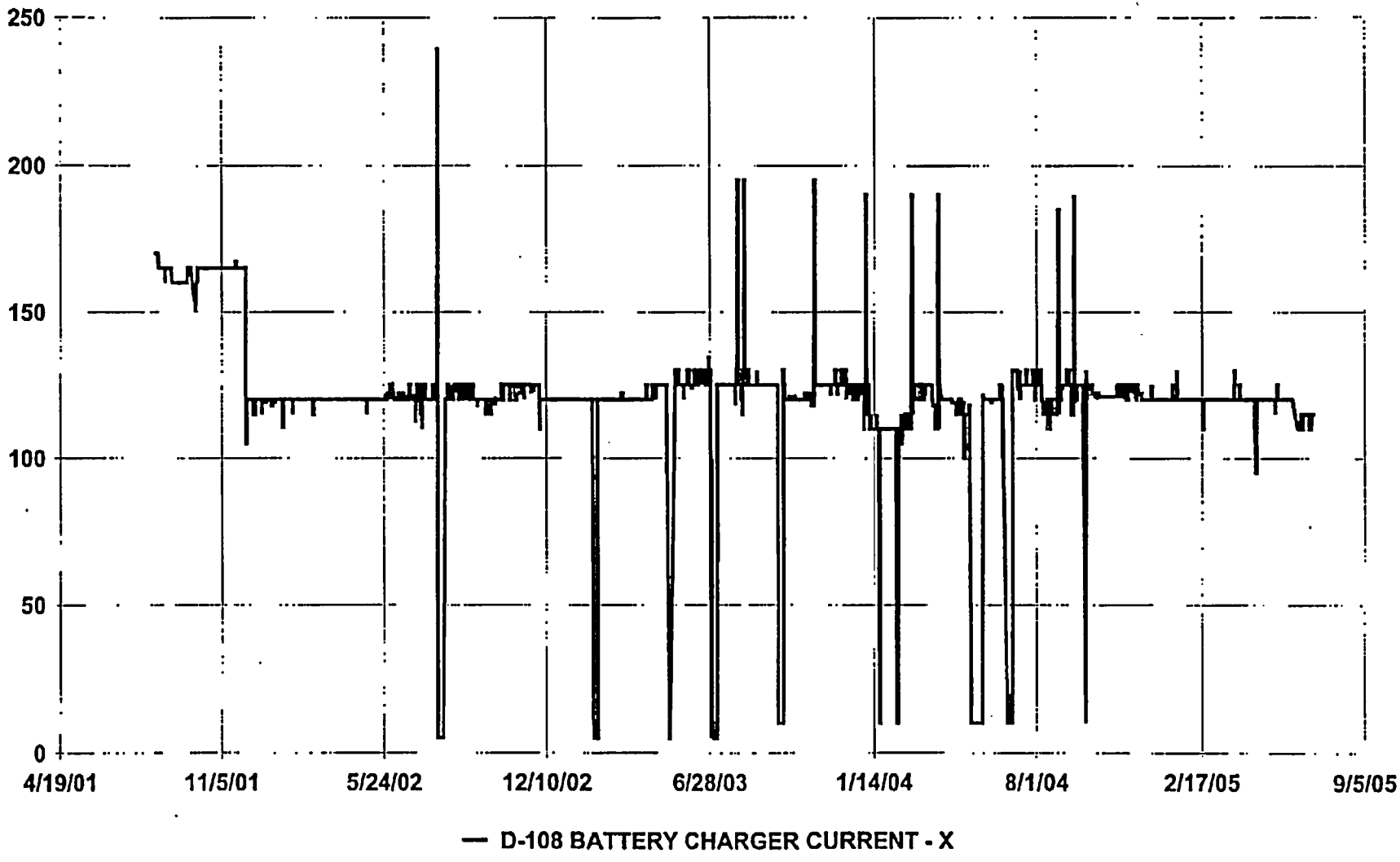
X-Y Graph of D-107 BATTERY CHARGER CURRENT

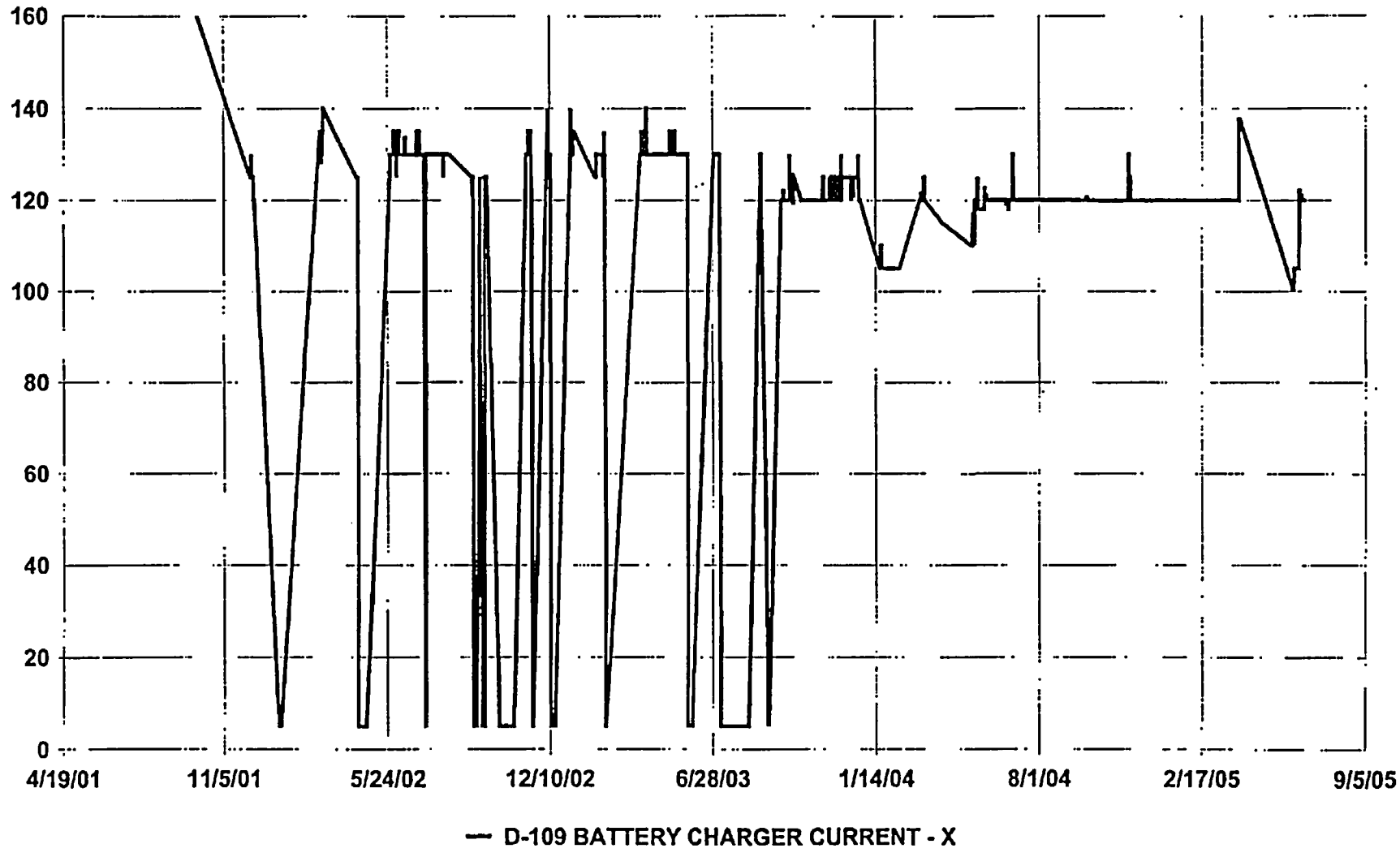


— D-107 BATTERY CHARGER CURRENT - X

X-Y Graph of D-108 BATTERY CHARGER CURRENT



X-Y Graph of D-109 BATTERY CHARGER CURRENT



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RMP 9359-8

DC STATION BATTERY CHARGER D-107, D-108 AND D-109 MAINTENANCE PROCEDURE

DOCUMENT TYPE:	Technical
CLASSIFICATION:	SAFETY RELATED
REVISION:	3
EFFECTIVE DATE:	April 7, 2004
REVIEWER:	Qualified Reviewer
APPROVAL AUTHORITY:	Department Manager
PROCEDURE OWNER (title):	Group Head
OWNER GROUP:	Maintenance

Verified Current Copy: _____ _____ _____
Signature Date Time

List pages used for Partial Performance	Controlling Work Document Numbers	

INITIALS

CAUTION

To take Manual Control of Load Test Program, right after F1 key is depressed then depress F3 and this will give manual control of load test.

5.4.16 Hit "F1" key to start test. _____ EM

NOTE: "+ / -" keys to right of key pad shall be used to adjust current or use mouse to adjust current using up/down arrows on screen.

5.4.17 Ensure Charger Setup as follows:

a. Ensure charger float voltage is 130.0 to 136.0 volts (normal operating range) AND record value on Data Sheet 3. IF required adjust float voltage using 1P (float) potentiometer. _____ EM

NOTE: Range in Step 5.14.18.b shall NOT be changed without concurrence of System Engineer. (Reference CAP050366)

b. Load charger to between 340 Amps and 360 Amps AND record value on Data Sheet 3. _____ EM

NOTE: Pressing F3 will take control to auto mode and maintain charger current at value set between 330 and 350 Amps.

c. Record Start time AND initial readings on Data Sheet 4. _____ EM

d. Using Scopemeter monitor AC ripple voltage AND Record ripple voltage peak to peak on Data Sheet 3. _____ EM

e. Ensure balance loading at AC input breaker. Record AC input phase currents on Data Sheet 3. _____ EM

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		INITIALS
PMT		
5.4.18	Test Coordinator shall perform the following for battery charger test.	
	a. Record battery charger readings for 8 hours and finish time on Data Sheet 4.	EM
	b. Ensure battery charger data was maintained within required limits for 8 hours per Data Sheet 4.	EM
	c. Record final battery charger volts and amps on Data Sheet 3.	EM
	d. Review result of battery charger test **AND** ensure acceptability.	SE/SUPV
5.4.19	Decrease load on charger to between 35 and 205 amps **AND** ensure there is **NO** current oscillations. Record amp value on Data Sheet 3.	EM
5.4.20	Using load test computer, unload Charger by decreasing load current to zero.	EM
5.4.21	Hit "F1" key to stop test.	EM
5.4.22	Place switch 1SW to Equalize position, ensuring charger equalizing voltage is 142 to 143.0 volts (normal equalizing range) **AND** record value on Data Sheet 3. **IF** required adjust equalizing voltage using 2R (equalizing) potentiometer.	EM
5.4.23	Place switch 1SW to Float position, ensuring charger float voltage is 133.5 to 134.5 volts; normal operating range **AND** record value on Data Sheet 3. **IF** required adjust float voltage using 1P (float) potentiometer.	EM
5.4.24	Open station battery charger Local DC output breaker.	EM
5.4.25	De-energize station battery charger by opening Local AC input breaker.	EM
5.4.26	Notify control operator to open contactor from 2C20.	EM
5.4.27	OPH open applicable Battery Charger AC supply breaker.	OPH
		CC

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CONTROL #: 000277 Supersedes Section 12-237

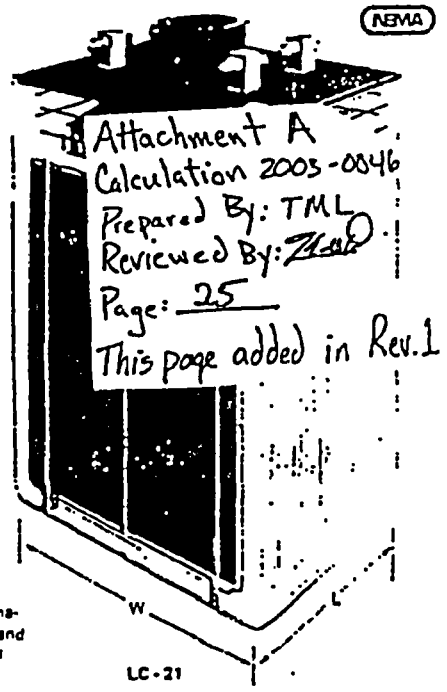
LC - Lead Calcium
LA - Lead Antimony

NEMA

SPECIFICATIONS

PLATES	Height	Width	Thickness
Positive	15" (381 mm)	12" (305 mm)	0.312" (7.9 mm)
Negative	15" (381 mm)	12" (305 mm)	0.210" (5.3 mm)
Outside Negative	15" (381 mm)	12" (305 mm)	0.130" (3.3 mm)

SPECIFIC GRAVITY ..... 1.210 nominal at 77°F (25°C)
CONTAINER† ..... Transparent thermoplastic
CELL COVER ..... Thermoplastic
SEPARATORS ..... Microporous
RETAINERS ..... Fibrous glass mats
ELECTROLYTE HEIGHT ABOVE PLATES ..... 2.88" (73 mm)
WITHDRAWAL TUBES .... Two per cell
SEDIMENT SPACE ..... 0.63" (16 mm)
TERMINALS ..... Four 1" (25 mm) square posts per cell. (Copper inserts are used on cells with 19 thru 33 plates.)
VENT CAPS ..... Flame arrestor type
†OPTIONS
Container ..... Transparent polycarbonate containers. Flammability—self extinguishing per ASTM D635-68 and ULT group 94 VE-2. Oxygen Index per ASTM D2863-70 is 25.0.



LC-21

Attachment A
Calculation 2005-0046
Prepared By: TML
Reviewed By: [illegible]
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Type of Cell		Nominal Capacities to 1.75 VPC @ 77°F (25°C) (Includes Connector Voltage Drop)*						Overall Dimensions			Approx. Wt. (lbs) (kgs)		Elect. per Cell (lbs) (kgs)
		Ampere Hours			Amperes								
Calcium	Antimony	8 Hrs.	3 Hrs.	1 Hr.	30 Min.	15 Min.	1 Min.	L (in.) (mm)	W (in.) (mm)	H (in.) (mm)	Net Filled	Dom. Packed	
LC-13	LA-13	900	737	480	668	827	1060	7.63 194	14.13 359	22.63 575	196 88.9	211 95.7	65 29.5
LC-15	LA-15	1050	860	560	780	965	1223	7.63 194			210 95.3	225 102.1	60 27.2
LC-17	LA-17	1200	983	636	890	1081	1400	7.63 194			224 101.6	240 108.9	58 26.3
LC-19	LA-19	1350	1106	716	1000	1216	1572	8.88 226			254 115.2	274 124.3	70 31.8
LC-21	LA-21	1500	1228	795	1115	1352	1747	8.88 226			270 122.5	290 131.5	67 30.4
LC-23	LA-23	1650	1350	875	1190	1480	1888	10.63 270			310 140.6	330 149.7	84 38.1
LC-25	LA-25	1800	1475	954	1297	1615	2060	10.63 270			325 147.4	345 156.5	82 37.2
LC-27	LA-27	1950	1600	1034	1405	1750	2230	13.19 335			350 158.8	373 169.2	98 44.5
LC-29	LA-29	2030	1690	1068	1454	1810	2330	13.19 335			367 166.5	390 176.9	96 43.5
LC-31	LA-31	2175	1811	1145	1558	1940	2500	13.19 335			384 174.2	407 184.6	94 42.6
LC-33	LA-33	–	1932	1221	1662	2052	2660	13.19 335			401 181.9	424 192.3	92 41.7

-105
-106

Note: *Electrolyte weighs approximately 10 lbs. per gallon (1.210 kgs. per liter).
*Data based on discharge from float at 77°F (25°C) for a minimum of 72 hours.

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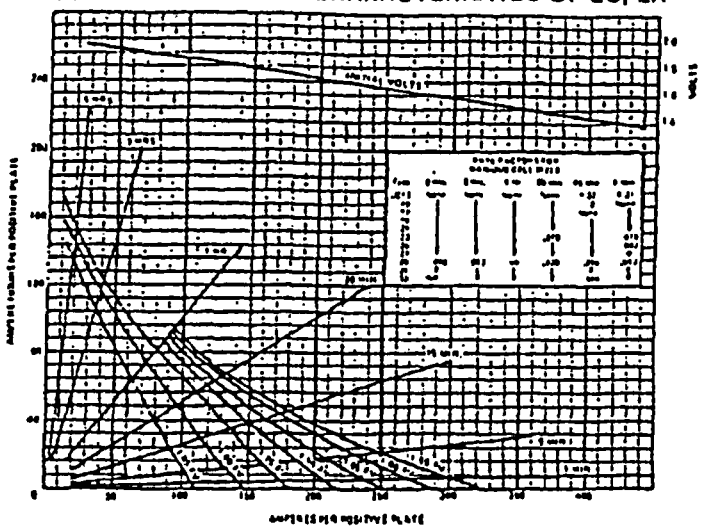
TYPICAL DISCHARGE CHARACTERISTICS OF LC, LA



Data based on discharge from float at 77°F (25°C) and a specific gravity of 1.210 for a minimum of 72 hours.

RACK SPECIFICATIONS

60 CELL BATTERY

	TWO-TIER Model RD-901-(L) Width: 20.3 in. (516 mm) Height: 42.7 in. (1084 mm)					TWO-STEP Model RD-903-(L) Width: 38.0 in. (762 mm) Height: 29.7 in. (754 mm)					THREE-TIER Model RD-902-(L) Width: 20.3 in. (516 mm) Height: 72.7 in. (1847 mm)				
Battery	Length (L) ft.	Length (L) mm	Weight lbs.	Weight kgs	No. Req'd.	Length (L) ft.	Length (L) mm	Weight lbs.	Weight kgs.	No. Req'd.	Length (L) ft.	Length (L) mm	Weight lbs.	Weight kgs	No. Req'd.
LC/LA-13 LC/LA-15 LC/LA-17	11	3353	235	107	2	11	3353	185	84	2	14	4267	454	206	1
LC/LA-19 LC/LA-21	12	3658	273	124	2	12	3658	211	96	2	16	4877	541	245	1
LC/LA-23 LC/LA-25	14	4267	291	132	2	14	4267	230	104	2	10	3048	352	160	2
LC/LA-27 LC/LA-29 LC/LA-31 LC/LA-33	12	3658	273	124	3	12	3658	211	95	3	12	3658	426	193	2

Notes: 1. Above data is for C&D standard racks only. For seismic zones, C&D type EP racks are available. See Section 12-550.

2. Rack lengths for other than 60-cell batteries can be calculated by the formula:
Number of cells per tier or step x (L + 0.5) – 0.5 = Total Rack Length
(Where "L" is length of cell.)
Where dimensions are critical, check with C&D engineering.

3. Rack width does not include thickness of crossbracing. Increase width by 0.5" this dimension is critical.

C&D BATTERIES
3043 WALTON ROAD, PLYMOUTH MEETING, PA. 19462
an Eltra company

C&D BATTERIES OF CANADA
150 CONNIE CRESCENT, UNIT 15, CONCORD, ONTARIO L4K 1B6
an Eltra company

Attachment A
Calculation 2003-0046
Prepared By: TML
Reviewed By: [illegible]
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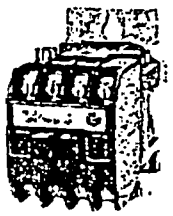
Printed in U.S.A.
10M/180

Correlation of Battery Charger Peak Currents to Testing and Maintenance Activities

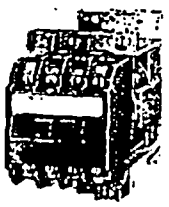
Charger	*Date(s)*	*Current*	*Comment*
D08	9/2/04	500A	Battery charger maintenance (Service Test) per RMP 9359-7, WO #0305276. Activity correlated with OPS logs.
D09	11/4/04	330A	Battery charger maintenance (Service Test) per RMP 9359-7, WO #0307405. Activity correlated with OPS logs.
D107	10/3/03	350A	Battery charger maintenance (Service Test) per RMP 9359-8, WO #0305860. Activity correlated with OPS logs.
D107	12/24/03	350A	Battery charger troubleshooting/maintenance. Repair of current limit board and performance of load test, WO #0311808.
D107	8/7 – 8/9/03	190A	Load testing of DY-0C inverter performed after troubleshooting and repair under WO #0301989. Validated in OPS logs.
D107	8/17 – 8/18/03	190A	Load testing of 2DY-03 inverter per RMP 9045-3 under WO #0301992. Activity correlated with OPS logs.
D108	7/30/02	240A	Support recovery from D-106 station battery performance test per RMP 9200-4, WO #9943006. Activity correlated with OPS logs.
D108	8/2 – 8/4/03	195A	Attributable to troubleshooting / testing of DY0D inverter under WO #0306598. Activity correlated with OPS logs.
D108	8/10 – 8/11/03	195A	Load testing of 1DY-04 inverter per RMP 9045-5 under WO #0203835. Activity correlated with OPS logs.
D108	11/4/03	195A	Akin to above troubleshooting / repair entries, subsequent load testing of DY-0D inverter under WO # 0309957.

			Activity correlated with OPS logs.
D108	1/4 -1/5/04	190A	Akin to above troubleshooting / repair entries, subsequent load testing of DY-0D inverter under WO #0400034. Activity correlated with OPS logs.
D108	3/1/04	190A	Load testing of DY-0D inverter per RMP 9045-4 under WO #0301990. Validated in OPS logs.
D108	4/2-4/3/04	190A	Akin to above troubleshooting / repair entries, DY0D inverter 24 Hr load test after repairs under WO #0407316. Activity correlated with OPS logs.
D108	8/28/04	185A	Load test performed on DY-0D inverter after troubleshooting / repair under RMP 9045-4 and WO #0400359. Activity correlated with OPS logs.
D108	9/16/04	190A	Load testing of 2D-Y04 instrument bus inverter per RMP 9045-6 under WO #0216189 after overhaul / repair under WO #0216188. . Activity correlated with OPS logs.

BF/BFD Series — Fixed Contact Industrial Control



Type BF



Type BFD

Product Description

Type BF is AC operated, 300V maximum, and the BFD is DC operated, 250V. Fixed contact relays are available in any combination of NO and NC from two to twelve poles. BF and BFD relays have captive clamp terminals fully accessible from the front, a molded coil with low operating temperature and silver alloy contacts suitable for low voltage circuits.

Standards and Certifications

- UL recognized, UL File No. E19223 (AC relays only)
- CSA certified, File No. LR39402-6, LR28548-10, 11 (AC and DC relays)

Technical Data

Table 49-75. Specifications

BF Relay Electrical Ratings — NEMA A300					
Volts	Maximum Current			Maximum VA	
	Cont.	Make	Break	Make	Break
120	10	60	6	7200	720
240	10	30	3	7200	720

Horsepower Ratings (UL Recognized)			DC Rating — NEMA P300				
Phase	AC Volts		Volts	Maximum Current			Max. Make or Break VA
	115	230		Cont.	Make	Break	
1	1/6	1/2	125	5.0	1.1	1.1	138
3	—	1	250	5.0	0.55	0.55	138

Resistive Rating	Coil Power Requirements
125V DC: 3A 250V DC: 1.5A	AC: 72 VA open, 12 VA closed DC: 12 watts (nominal), 250V max.

Options

Table 49-76. Options

Description	Code Letter or	Catalog Number	Price U.S.$
FASTON Push-On Terminals Insert letter F after relay type designation in listed Catalog Number. Example: BFF20F or BFDF20S	F	—	①
Overlapping Contacts NO contact closes before corresponding NC contact opens — supplied as NO/NC set(s). Insert letter A after relay type designation in listed Catalog Number. Example: BFA22F or BFDAF22S	A	—	①
NEMA 1 Enclosure for Relay Types BF, AR — all poles BFD — 4 – 8 poles ARD — 4 – 6 poles	—	 4977D40G04 4977D40G04 4977D40G04	 55.50 55.50 55.50

① Consult Customer Support Center for pricing.

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Discount Symbol 1CD1

PANALARM DIVISION

ANNUNCIATOR ENGINEERING DATA

ANNUNCIATOR COMPONENT	POWER CONSUMPTION				CONTACT CAPACITY*
	VOLTAGE	STAND-BY	MAXIMUM	MINIMUM	
Self-Policing Plug-Ins	120 AC 125 DC	6.5 VA 3.7 Watts	8.5 VA 7.4 Watts	0 0	2.0 amps 0.5 amps
No-Drain Plug-Ins	120 AC 125 DC	0 0	7.2 VA 4.3 watts	0 0	2.0 amps 0.5 amps
Flashers, All Models	120 AC 125 DC	0 0	2.7 VA 5.0 Watts	0 0	1200 watts lamp load** 500 watts lamp load**
Auxiliary Relays (Model ACS-X1)	120 AC 125 DC	0 0	5.0 VA 3.5 Watts	0 0	10.0 amps 2.0 amps
Backlighted Nameplates 2¼" x 2¾" 1" x 1½"	 Any Any	 0 0	 12.0 Watts 3.0 Watts	 0 0	 — —
Bullseye Lamps	Any	0	3.0 Watts	0	—
Pushbuttons Models SI-10, SI-41	120 AC 125 DC	— —	— —	— —	6.0 amps 2.0 amps
Model SI-11	120 AC 125 DC	— —	— —	— —	20.0 amps 10.0 amps
Models 51-PB, 51-PB41 Models ACS-PB, ACS-PB41	120 AC 125 DC	— —	— —	— —	6.0 amps 2.0 amps
Horn Model HSA Model HSD	120 AC 125 DC	0 0	20.0 VA 13.0 Watts	0 0	— —

*All contact ratings are for non-inductive loads at 120/60 for AC applications and at 125 volts for DC applications.

**The number of lamps handled by one flasher is a function of this rating and lamp wattage. Consider total wattage of maximum number of lamps flashing at any one time. Where lamp load exceeds flasher contact rating, an auxiliary flasher relay is required, not an additional flasher.

In most cases, plug-in relays are designed for use on either 50 or 60 cycles. Nameplates so designate, for example 120/50-60. Flashers must be ordered for exact frequency however.

ATTACHMENT C
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ENCLOSURE 7

CIRCUIT BREAKER TRIP CURVES

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

(3 pages follow)

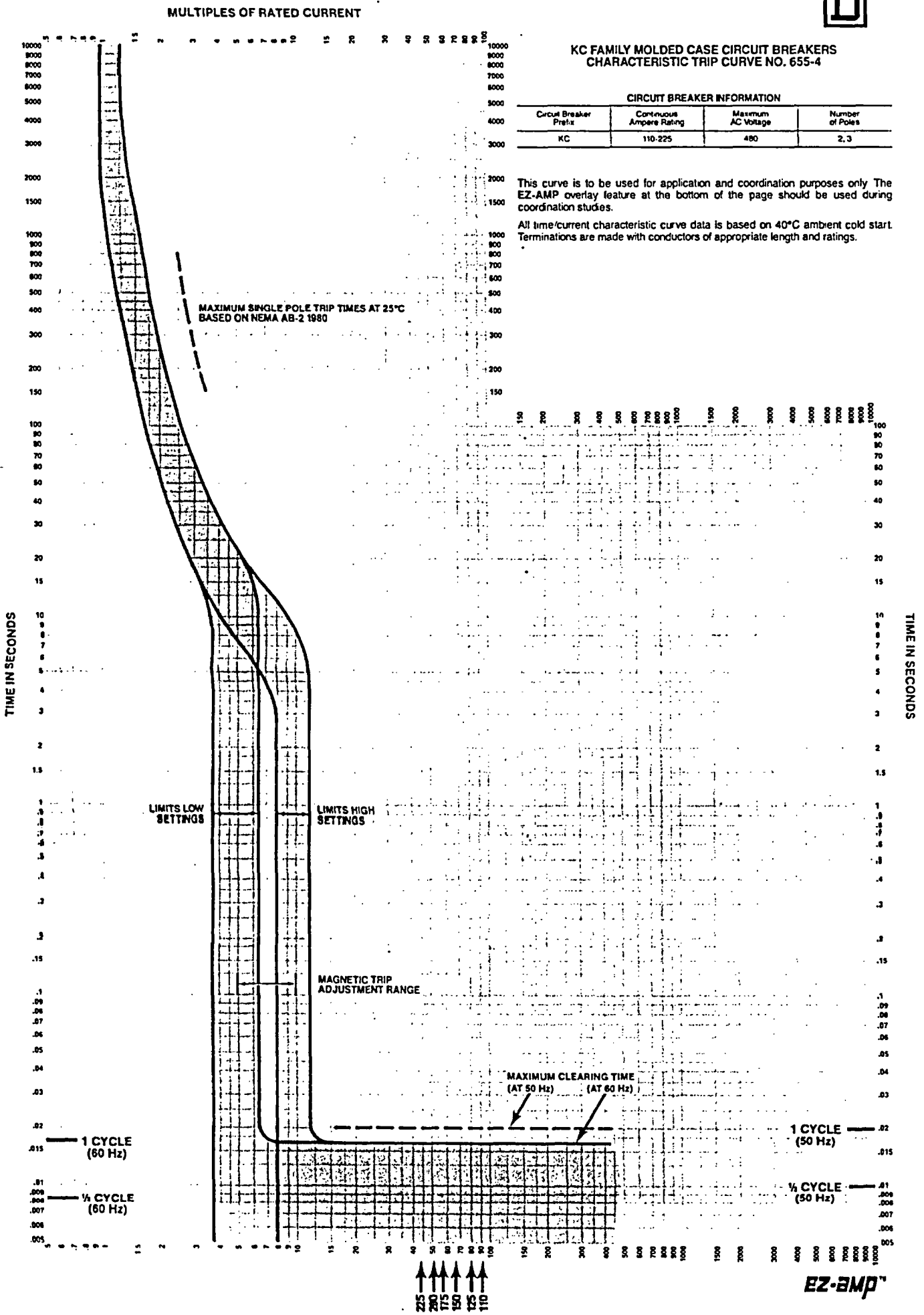
KC FAMILY MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO. 655-4

CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum AC Voltage	Number of Poles
KC	110-225	480	2, 3

This curve is to be used for application and coordination purposes only. The EZ-AMP overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.



SQUARE D COMPANY

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MULTIPLES OF RATED CURRENT

Curve No. 655-4
April, 1989

MULTIPLES OF RATED CURRENT

FA/FH/FC FAMILY MOLDED CASE CIRCUIT BREAKERS CHARACTERISTIC TRIP CURVE NO. 650-5

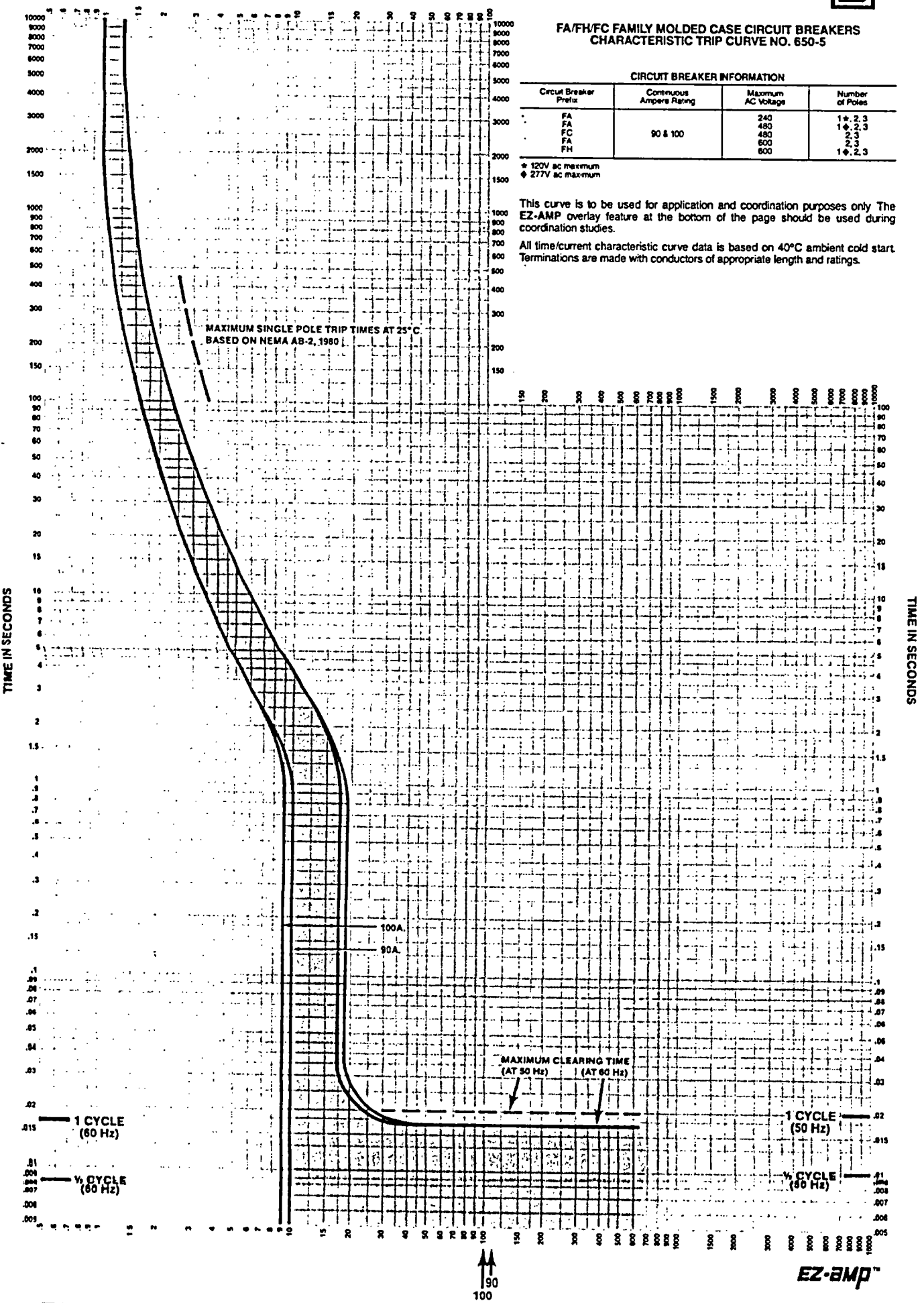
CIRCUIT BREAKER INFORMATION

Circuit Breaker Prefix	Continuous Ampere Rating	Maximum AC Voltage	Number of Poles
FA	90 & 100	240	1★, 2, 3
FA		480	1♦, 2, 3
FC		480	2, 3
FA		600	2, 3
FH		600	1♦, 2, 3

★ 120V ac maximum
♦ 277V ac maximum

This curve is to be used for application and coordination purposes only. The EZ-AMP overlay feature at the bottom of the page should be used during coordination studies.

All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.



MULTIPLES OF RATED CURRENT

SQUARE D®

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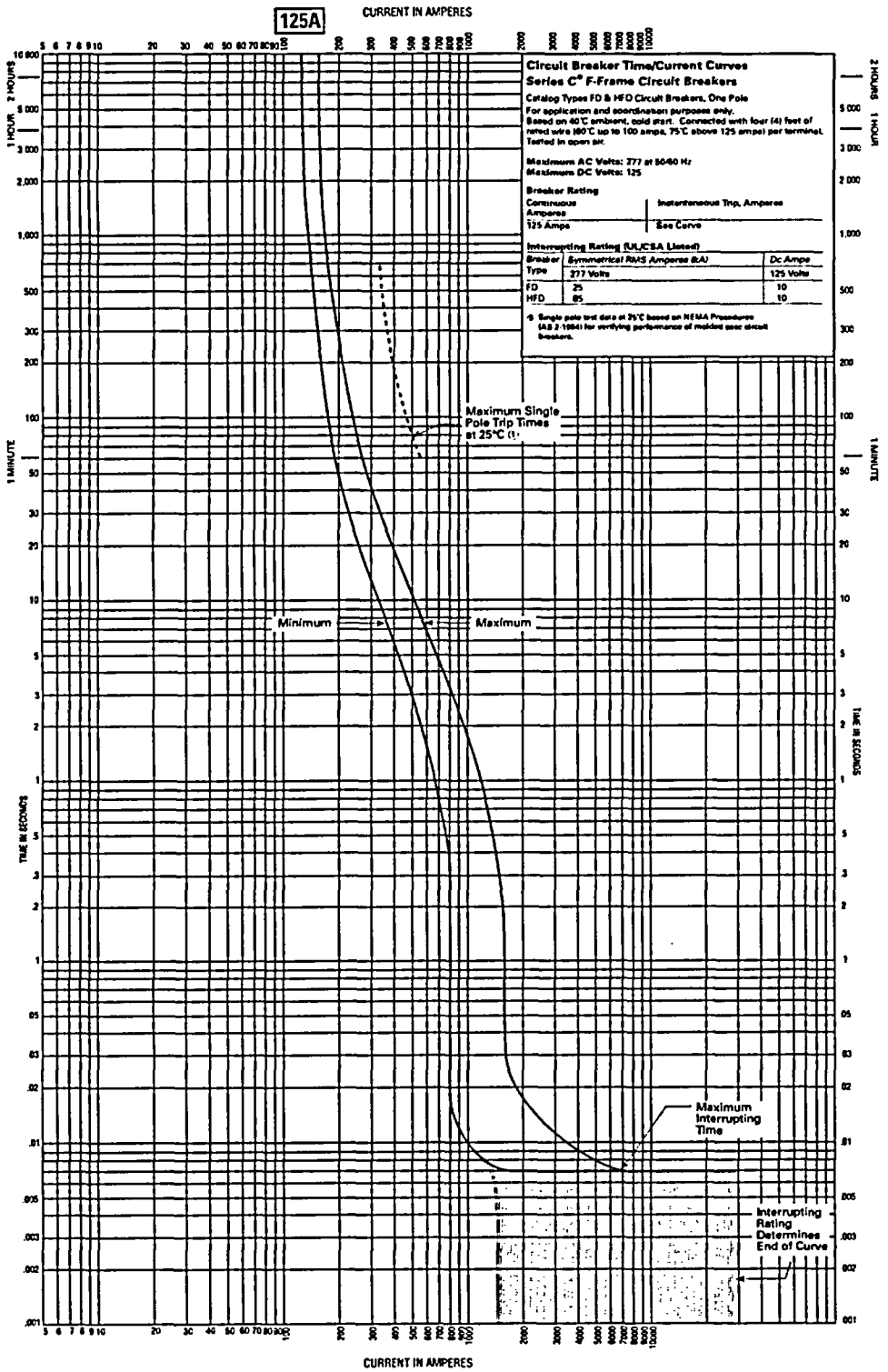
Curve No 650-5
April, 1990

AB DE-ION Circuit Breakers

Types FD and HFD 125 Amperes



Curve No. SC-4437-88A

October 1997