UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

February 26, 2015

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: NRC Request for Additional Information

Docket No. 50-184

Gentleman:

In response to your letter of January 30, 2015, please find enclosed the NIST Center for Neutron Research (NCNR) answers to the RAI for the license amendment request to change two technical specifications for the station battery. Any questions regarding the NCNR response should be directed to Dr. Paul Brand, Acting Chief, Reactor Operations and Engineering. Dr. Brand may be reached at paul.brand@nist.gov or (301) 975-6257.

Sincerely,

Robert M. Dimeo, Director
NIST Center for Neutron Research

I certify under penalty of perjury that the following is true and correct.

Executed on FEB 2 6 2015 By: ____________________

cc: Xiaosong Yin, Project Manager

A020
NRR

NIST

Response to RAI of January 30, 2015
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
TEST REACTOR

1. On page 1 of the LAR, you proposed to replace both NBSR's UPS that supply emergency alternating current (AC) electrical power to reactor critical loads.

   NUREG-1537, Part 1, Section 8.2, "Emergency Electrical Power Systems," states that the information contained in this section should be "commensurate with required design basis developed in other chapters of the SAR."

   a) Provide an overview of the systems that are affected by this LAR.

   b) Provide a one-line diagram that shows the current and the proposed configurations of the UPS system including the station battery, direct current (DC) Distribution Panel, and Critical Power Panel.

Answer to Questions 1a and 1b: Please see the attached drawings, Before Configuration and After Configuration. Electrical loads, motor control centers, switchboards, etc. were not affected by this change.

The two existing 20 kVA UPS, T9 and T10, were replaced with two 20 kVA UPS of a different design but of the same output capacity. The replacement UPS are designated as MAIN UPS and STANDBY UPS.

Battery power was changed from the existing 60-cell lead-antimony battery bank to the existing 60-cell lead-antimony battery bank + a 72 cell VRLA bank + a spare 72 cell VRLA battery bank. Previously, the Station Battery = 60-cell battery bank; now the Station Battery = 60-cell battery bank + one VRLA battery bank. No credit for battery power is taken for the spare VRLA battery bank.

The 60-cell battery charging capability of T9 UPS was replaced with a stand-alone battery charger and the 60-cell battery charging capability of the T10 UPS was also replaced with a stand-alone battery charger. In addition, the charging configuration for the 60-cell battery bank has been changed. T9 UPS and T10 UPS were not in service at the same time; T9 or T10 charged the 60-cell battery. The replacement chargers operate in parallel, both charging the battery, with one charger nominally the primary charger.

2. On page 1 of the LAR, it states:

   "Two redundant battery chargers will be purchased and installed to replace the function previously provided by the T-9 and T-10 UPS. The two replacement UPS are state-of-the-art systems with valve-regulated lead acid (VLRA) or sealed batteries rather than flooded or wet lead acid batteries. Each of the redundant UPS and batteries are capable of carrying the 20 kVA (design basis value for NBSR) of AC reactor critical power loads for 4 hours (assumes full 20 kVA loading) independently."

   NUREG-1537, Part 1, Section 8.2, "Emergency Electrical Power Systems," states that the information contained in this section should "present a detailed functional description and circuit diagram."

a) Clarify if the battery charger and the VLRA battery are included in the UPS unit. Also, provide a simplified block diagram that shows how the UPS, the VLRA battery, and the battery charger are interconnected.

Answer to Question 2.a: The stand-alone battery chargers are not included in the UPS unit and those battery chargers have no interaction with the UPS. A VLRA battery bank is part of an UPS and is charged only through the UPS of which the bank is part. See the excerpts, including simplified block diagrams, from the UPS manual in Attachment 2.

b) Provide manufacturer ratings and specifications of the battery chargers, UPS, and the VLRA batteries.

Answer to Question 2.b: See Attachment 3.

c) Provide a summary of the calculation performed to determine the adequacy of the new equipment (i.e. battery chargers, UPS, VRLA batteries) to supply the reactor critical loads.

Answer Question 2.c: No detailed calculation was performed for the replacement battery chargers. Each stand-alone battery charger was specified for the same input and output capability as the T9 and T10 UPS, which previously maintained the charge on the 60-cell battery bank through the output of the rectifier of the selected UPS. The adequacy of the battery charger design was confirmed after the installation of the battery chargers. After the chargers were connected to the 125 VDC distribution panel, the battery chargers had a positive DC current indicated with an output voltage of approximately 128 VDC, and the 60-cell battery terminal voltage increased to 128 VDC. The estimated current draw from the required DC loads, the motors for EF-5 and EF-6, is approximately 4 amps at 115 VDC, well within the capacity (108 amps continuous for 8 hours) of the 60-cell battery bank.

No calculation was performed for the replacement UPS. The replacement 20 kVA UPS are of a different design than the replaced UPS, but of the same output capacity. The vendor confirmed the operability of the non-battery section of the UPS during commissioning of the UPS and there was, and has been, no effect upon operability of the AC loads on the output of the UPS after the UPS were placed into service.

The lifetime of the VRLA battery bank was provided by the manufacturer as 124 Ah for 20 hours, or 24.8 Ah for 4 hours, assuming a linear discharge rate. The manufacturer's value for the necessary AC output from the battery bank was checked using a simple equation for the continuous AC power requirement for the UPS: Assuming a power factor of 1, then 20 kVA = $3^{1/2}$ x I x E, or; 20000 = $3^{1/2}$ x I x 480, or; I = 24 amps continuously. This is consistent with the manufacturer's value for the battery bank for a 4 hour minimum battery bank lifetime. The estimated current draw from the nuclear instrumentation, the only required AC load, is 3 amps at 115 VAC, well within the capacity of the VRLA battery bank.

The capability of the MAIN UPS VRLA battery bank was confirmed with a discharge test completed on September 5, 2014. The test procedure placed CP-1, CP-2, CP-3, and the Rod Drive Power and Controller as loads (see page 2 of Attachment 1) on the output of the MAIN UPS. With an AC input to the UPS, a battery voltage and current of 498 V and 0 amps was recorded from the UPS control panel, along with a battery lifetime of 481 minutes calculated by the UPS software. The battery bank was in this starting condition of peak voltage and zero amp discharge current, because the AC input was providing all of the AC output and providing a trickle charge to the VRLA battery bank. The AC input was then removed from the UPS, placing the described load on the VRLA battery bank of the MAIN UPS. An initial DC voltage and current of 455 V and 15 amps was recorded, along with a calculated battery life of 419 minutes. After 4 hours, the voltage was 446 V, the current was at 14.7 amps, and the battery lifetime was calculated at 257 minutes. The VRLA battery bank would provide an estimated 8 hours of power to *all* of the AC loads described as critical; clearly, the battery bank can power the nuclear instrumentation, the only required AC load, for at least 4 hours. A test of the STANDBY UPS VRLA battery bank was performed on November 11, 2014. Similar results were obtained.

3. The current Technical specification (TS) 4.6, "Emergency Power System" requires testing the voltage and specific gravity of each cell of the station battery annually. The proposed revised TS 4.6 does not include these requirements for the VRLA battery. You clarified that the specific gravity of the VRLA battery cannot be measured because the electrolyte of the VRLA battery is immobilized in an absorbed glass matte (AGM). However, you provided no justification for omitting testing of the VRLA battery cell voltage.

   NUREG-1537, Par 1, Section 8.2, "Emergency Electrical Power Systems," states that the information contained in this section should "also identify the . . ., important design parameters, and surveillance and inspection functions that ensure operability of the emergency electric power systems . . ."

   Provide the TS requirement for testing the VRLA battery cell voltage. If this testing is not required for the VLRA battery, provide justification for deviating from the requirement of the current TS 4.6.

   <u>Answer to Question 3</u>: Battery cell voltage may be used as an indicator of individual cell degradation. It is not necessarily an indicator of battery bank capacity falling below minimum output. Individual cell battery failures in existing VRLA battery banks at the NCNR have been insignificant in number. A two year discharge test is sufficient to reveal failing or failed battery cells, after which any failed cell would be identified. For details, see answer to question 5.

4. On page 1 of the LAR, the licensee states: "The NCNR [NIST Center for Neutron Research] is not replacing the existing flooded lead acid battery (Vented Lead Acid or VLA), designated as the Station Battery in the Safety Analysis Report, because it is required to supply the various emergency loads that operate on 125 VDC."

a) Provide a copy of the sections of the above Safety Analysis Report (SAR) that are related to NIST emergency electrical power systems including the UPS, the battery chargers, and the station batteries. Also, provide a markup of the changes made to the affected sections as a result of this amendment request.

Answer to 4.a: See Attachment 4.

b) Clarify whether the VRLA batteries supply the various emergency loads served by the Station Battery at any time.

Answer to 4.b: The VRLA batteries do not supply all of the required loads. See the answer to question 1 for the definition of the station battery. The VRLA batteries for the MAIN UPS provide power only to the AC loads and only when the normal (MCC B6) AC input is lost to the MAIN UPS. After the MAIN UPS batteries are fully discharged, the STANDBY UPS will provide AC power to the output of the MAIN UPS. For the sequence of AC power to the AC critical loads, see section 8.1.2.4 in the SAR excerpt in the answer to question 4.a.

5. On page 1 of the LAR, you stated that the VLRA maintenance guidance found in the Institute of Electrical and Electronics Engineers (IEEE) standard 1188-2005, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications," will be used for the VLRA batteries. As described in the IEEE standard 1188-2005, a service test is a test of the battery's ability, as found, to satisfy the design requirements (battery duty cycle) of the DC system.

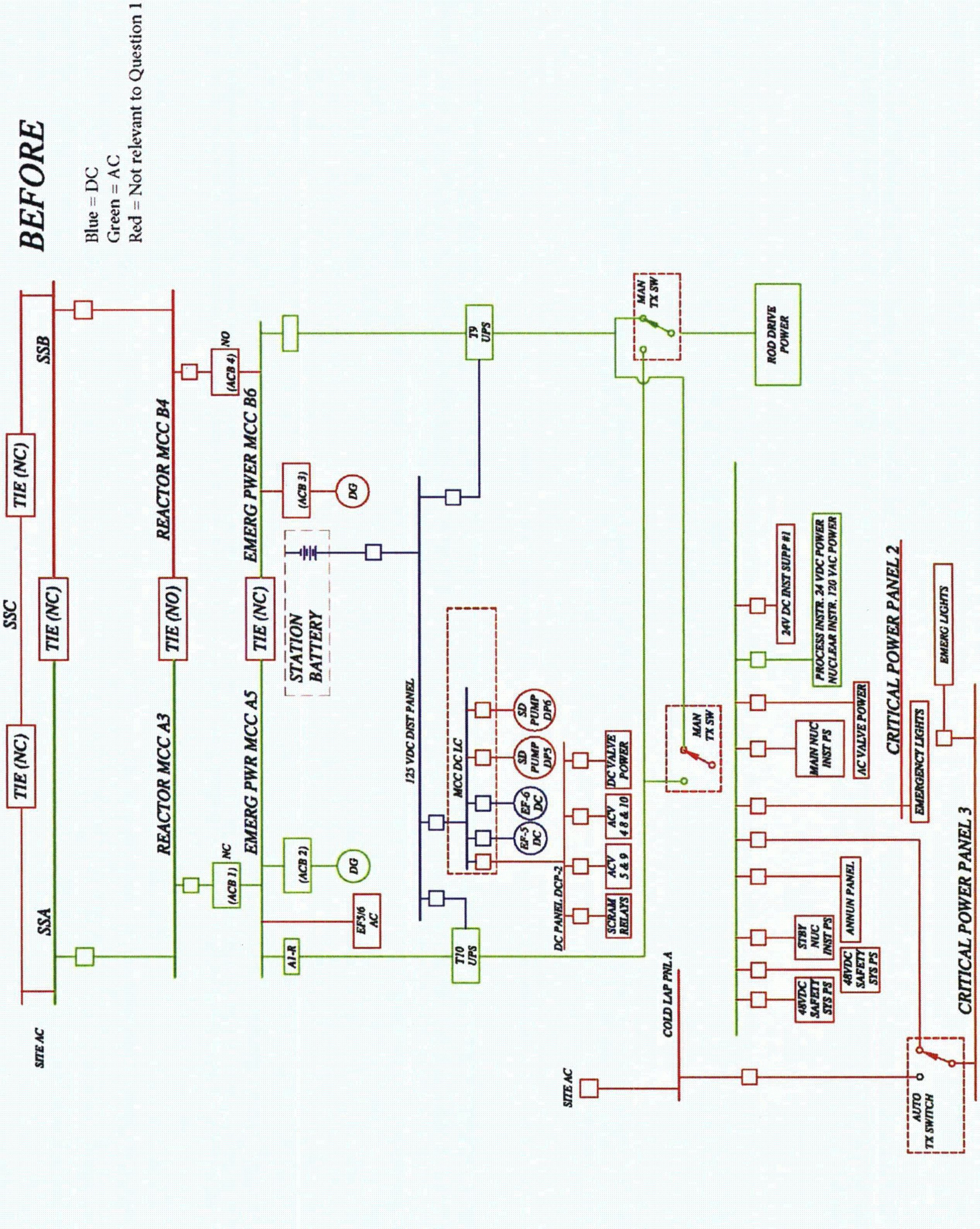
   Provide an explanation why a service test was not included in TS 4.6.

   Answer to Question 5: VRLA batteries have been used for as many as ten years in two UPS, unrelated to the UPS in the LAR, dedicated as backup power for the NCNR computers, experimental equipment, and data retention. The original and replacement battery banks have been replaced at intervals of greater than 5 years. Service records for these batteries show the banks have not degraded below their minimum capacity prior to replacement. In addition, of the 276 battery cells replaced during the three full bank replacements, 272 were in a satisfactory condition when replaced.

   The VRLA battery banks do not warrant a service test because of:

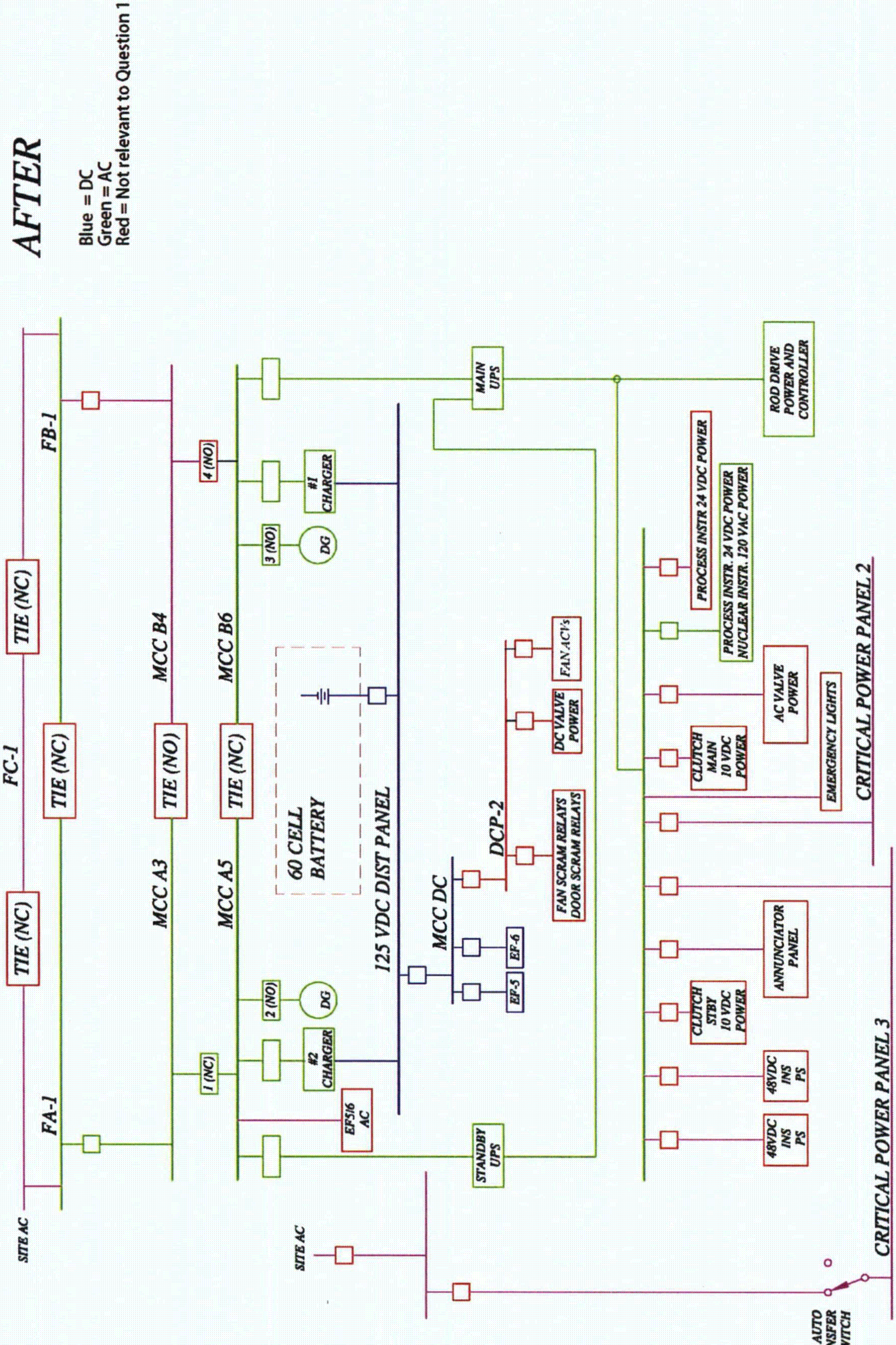
   - The small number of cell failures for a bank of VRLA battery cells.
   - The number of VRLA battery cells.
   - The increase in necessary battery power from a supply of 100 amps/hour for a load of 8 amps/hour to a supply of 100 amps/hour for a load of 4 amps/hour (see question 2 answer), i.e. a doubling of the cells available for the same load.

ATTACHMENT 1
BEFORE Configuration of UPS (battery charger) and Station Battery



ATTACHMENT 1

AFTER Configuration of UPS, Battery Chargers, and Station Battery



ATTACHMENT 2
Annotated Excerpt from EATON 9390 UPS Installation and Operation Manual

7.1.2 Normal Mode – RT

Figure 7-2 shows the path of electrical power through the UPS system when the UPS is operating in Normal mode.

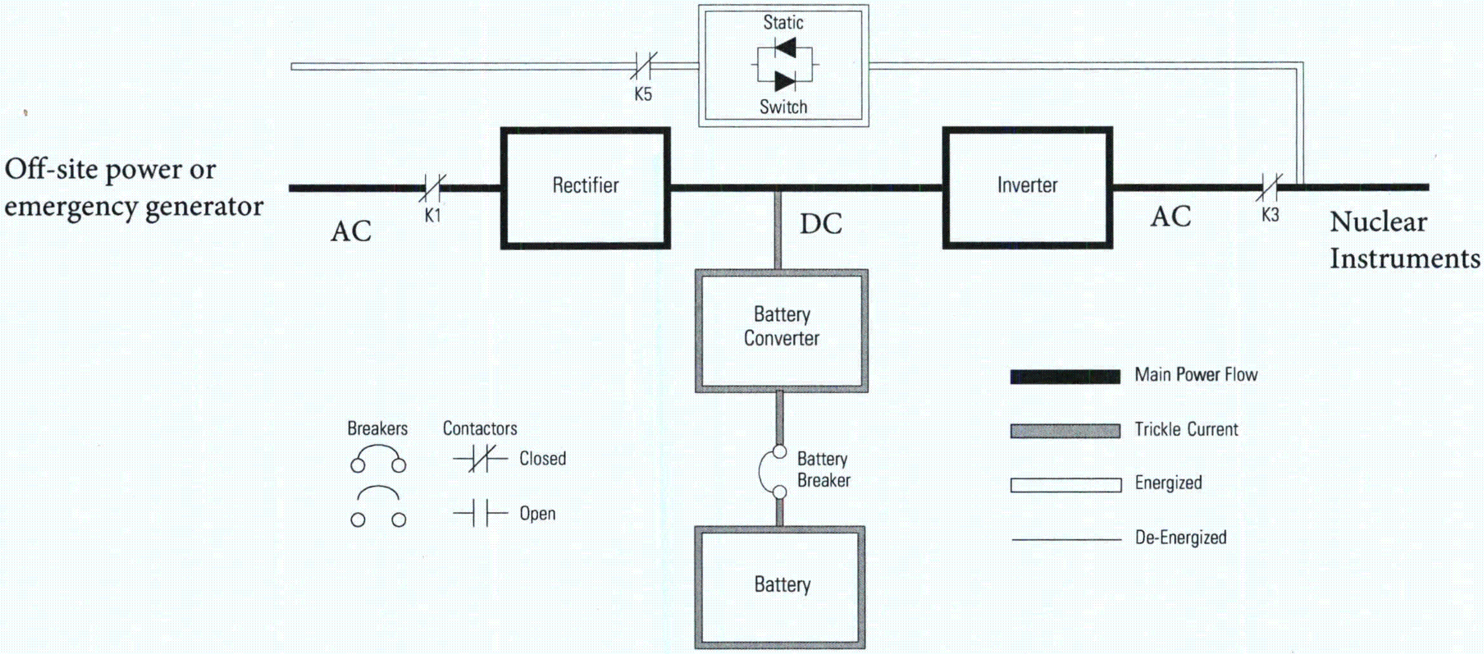


Figure 7-2. Path of Current through the UPS in Normal Mode – RT

During normal UPS operation, power for the system is derived from a utility input source through the rectifier input contactor K1. The front panel displays "Normal," indicating the incoming power is within voltage and frequency acceptance windows. Three-phase AC input power is converted to DC using IGBT devices to produce a regulated DC voltage to the inverter. The battery is charged directly from the regulated rectifier output through a buck or boost DC converter, depending on whether the system is 208V, 380V, 400V, 415V, or 480V and the size of the battery string attached to the unit.

The battery converter derives its input from the regulated DC output of the rectifier and provides either a boosted or bucked regulated DC voltage charge current to the battery. The UPS monitors the battery charge condition and reports the status on the control panel. The battery is always connected to the UPS and ready to support the inverter should the utility input become unavailable.

The inverter produces a three-phase AC output to a customer's load without the use of a transformer. The inverter derives regulated DC from the rectifier and uses IGBT devices and pulse-width modulation (PWM) to produce a regulated and filtered AC output. The AC output of the inverter is delivered to the system output through the output contactor K3.

If the utility AC power is interrupted or is out of specification, the UPS automatically switches to Battery mode to support the critical load without interruption. When utility power returns, the UPS returns to Normal mode.

ATTACHMENT 2
Annotated Excerpt from EATON 9390 UPS Installation and Operation Manual

7.1.5 Battery Mode – RT

The UPS automatically transfers to Battery mode if the AC input is lost. In Battery mode, the battery provides emergency DC power that the inverter converts to AC power.

Figure 7-5 shows the path of electrical power through the UPS system when operating in Battery mode.

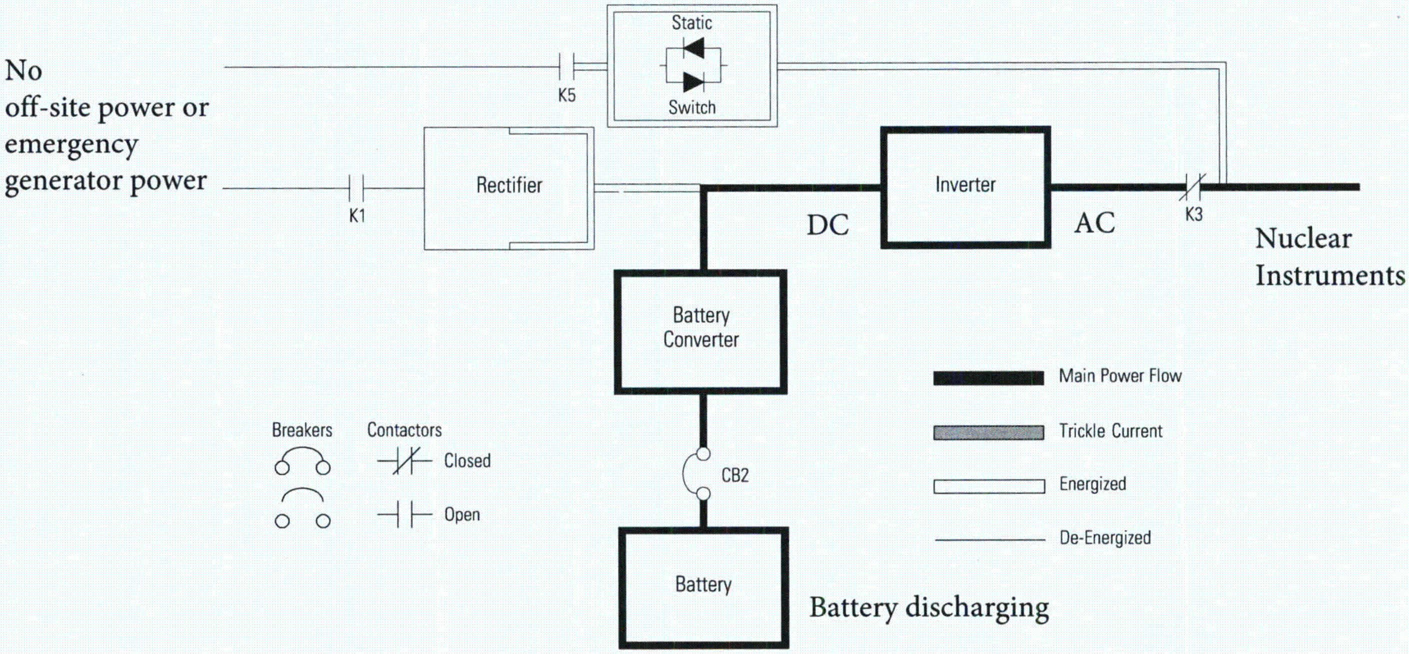


Figure 7-5. Path of Current through the UPS in Battery Mode – RT

During a loss of AC, the rectifier no longer has an AC source from which to supply the DC output current required to support the inverter. The input contactor K1 opens and the battery instantaneously supplies energy to the battery converter. The converter either bucks or boosts the voltage so that the inverter can support the customer's load without interruption. If bypass is common with the rectifier input, the backfeed protection contactor K5 also opens. The opening of contactors K1 and K5 prevent system voltages from bleeding backwards through the static switch and rectifier snubber components and re-entering the input source.

While in Battery mode, the UPS sounds an audible horn, illuminates a visual indicator lamp on the front panel (System Normal, On Battery), and creates an entry into the alarm event history. As the battery discharges, the converter and inverter constantly make minute adjustments to maintain a steady output. The UPS remains in this operating mode until the input power to the rectifier is again within the specified voltage or frequency acceptance windows.

If the input power fails to return or is not within the acceptance windows required for normal operation, the battery continues discharging until a DC voltage level is reached where the inverter output can no longer support the connected loads. When this event occurs, the UPS issues another set of audible and visual alarms indicating SHUTDOWN IMMINENT. Unless the rectifier has a valid AC input soon, the output can be supported for only two minutes before the output of the system shuts down. If the bypass source is available, the UPS transfers to bypass instead of shutting down.

ATTACHMENT 2
Annotated Excerpt from EATON 9390 UPS Installation and Operation Manual

If the UPS becomes overloaded or unavailable, the UPS switches to Bypass mode. The UPS automatically returns to Normal mode when the overload condition is cleared and system operation is restored within specified limits.

If the UPS suffers an internal failure, it switches automatically to Bypass mode and remains in that mode until the failure is corrected and the UPS is back in service.

7.1.3 Bypass Mode – RT

The UPS automatically switches to Bypass mode if it detects an overload, load fault, or internal failure. Figure 7-3 shows the path of electrical power through the UPS system when operating in Bypass mode.

CAUTION

The critical load is not protected while the UPS is in Bypass mode.

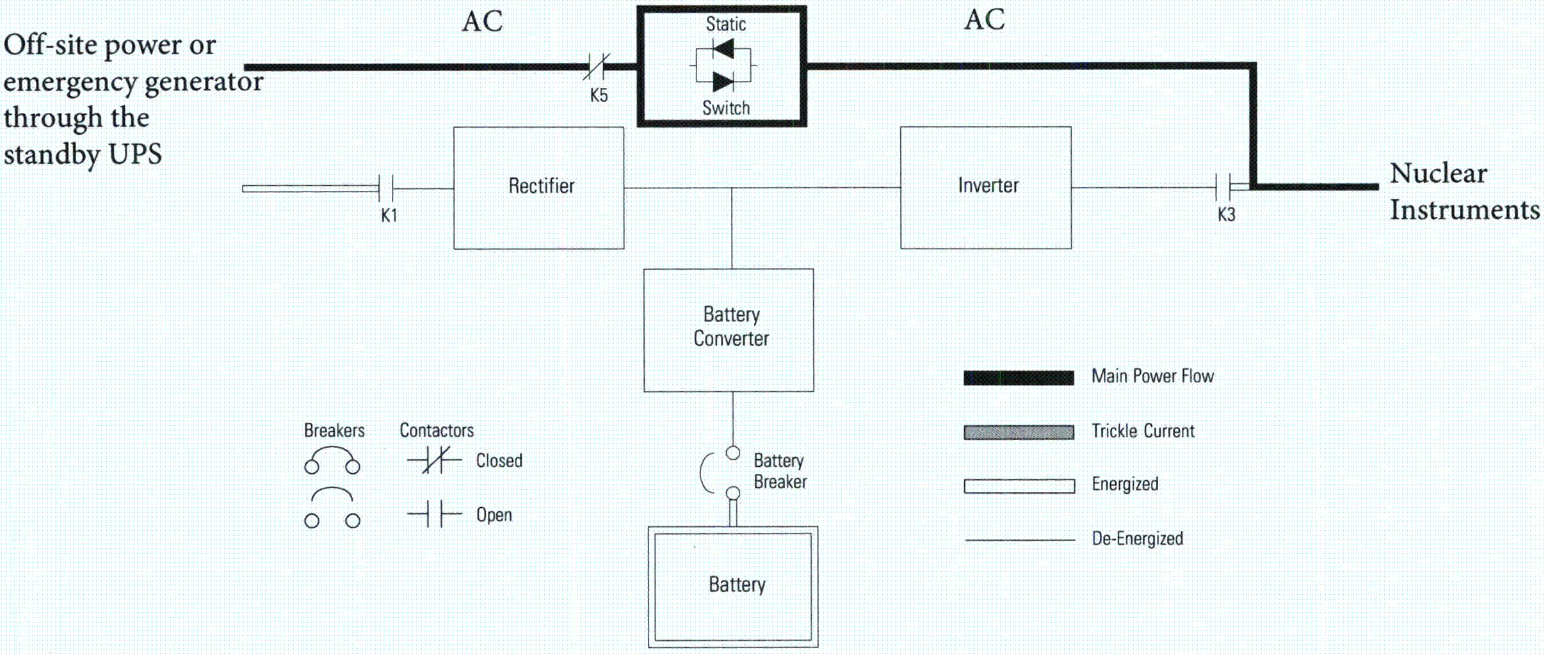


Figure 7-3. Path of Current through the UPS in Bypass Mode – RT

Battery Charger

SPECIFICATIONS (annotated)

Except as noted, all specifications apply at:

77° F / 25° C, nominal ac line voltage & nominal float voltage

<table>
<tr><th>Specification</th><th>Conditions</th><th>12 Vdc</th><th>24 Vdc</th><th>48 Vdc</th><th>130 Vdc</th></tr>
<tr><td>Output voltage regulation</td><td>Vac +10%, -12%
0 to 100% load
Temp. 32-122° F / 0-50° C
Freq. 60 ± 3 Hz</td><td colspan="4">± 0.25%
(see product literature for specific data)</td></tr>
<tr><td>Transient response</td><td>20-100% load change, with battery connected</td><td colspan="4">Output voltage change ± 4% maximum
Recovery to ± 2.0% in 200 ms
Recovery to ± 0.5% in 500 ms</td></tr>
<tr><td>Efficiency</td><td>All ratings</td><td colspan="4">82-90%</td></tr>
</table>

<table>
<tr><td rowspan="6">Output ripple voltage
(per NEMA PE5-1996)</td><td rowspan="2">Unfiltered (with battery)</td><td colspan="3">1% rms (typ.)</td><td>2% rms</td></tr>
<tr><td colspan="4">at battery terminals</td></tr>
<tr><td rowspan="2">Filtered (with battery)</td><td colspan="3">30 mV rms (max.)</td><td>100 mV</td></tr>
<tr><td colspan="4">at battery terminals</td></tr>
<tr><td>Filtered (without battery)</td><td colspan="3">1% rms (typ.)</td><td>2% rms</td></tr>
<tr><td>Battery Eliminator Filter Option (without battery)</td><td colspan="3">30 mV rms</td><td>100 mV</td></tr>
</table>

Current Limit	adjustable	50-110 % of rated output current
Soft start	0 to 100% load	4 seconds

<table>
<tr><td rowspan="4">Voltage adjustment ranges</td><td>Float</td><td>11.0-14.5</td><td>22.0-29.5</td><td>44.0-58.0</td><td>110-141</td></tr>
<tr><td>Equalize</td><td>11.7-16.0</td><td>23.4-32.0</td><td>46.8-61.0</td><td>117-149</td></tr>
<tr><td>High DC Voltage alarm</td><td>12-19</td><td>24-38</td><td>48-76</td><td>120-175</td></tr>
<tr><td>Low DC Voltage alarm</td><td>7-14.5</td><td>15-29.5</td><td>30-58</td><td>80-141</td></tr>
<tr><td>Voltmeter range (Vdc)</td><td></td><td>0 - 21</td><td>0 - 42</td><td>0 - 75</td><td>0 - 195</td></tr>
<tr><td rowspan="5">Ammeter range (Adc)</td><td>25 Adc nom. output</td><td colspan="4">0 - 30</td></tr>
<tr><td>30-100 Adc nom. output</td><td colspan="4">0 - 150</td></tr>
<tr><td>125-400 Adc nom. output</td><td colspan="4">0 - 500</td></tr>
<tr><td>500-800 Adc nom. output</td><td colspan="4">0 - 1000</td></tr>
<tr><td>1,000 Adc nom. output</td><td colspan="4">0 - 1,200</td></tr>
</table>

Surge withstand capability	test per **ANSI C37.90.1-1989**	no erroneous outputs
Reverse current from battery	ac input power failure, no options installed	90 mA maximum
Audible noise	average for four (4) sides, 5ft / 1.5m from enclosure	less than 65 dBA
Cooling		natural convection
Ambient temperature	operating	32-122° F / 0-50° C
Elevation		3,000ft / 1,000m without derating
Relative humidity		0 to 95% non-condensing

Alarm relay contact rating	120 Vac / 125 Vdc	0.5A resistive

Battery Charger

RECOMMENDED FLOAT AND EQUALIZE VOLTAGES (annotated)

This table contains suggested values for commonly used batteries. Consult your battery manufacturer's documentation for specific values and settings for your battery type.

	Battery Cell Type	Recommended Float Voltage/cell	Recommended Equalize Voltage/cell
Lead-Acid Types	Antimony (1.215 Sp. Gr.)	2.17	2.33
	Antimony (1.250 Sp. Gr.)	2.20	2.33
	Selenium (1.240 Sp. Gr.)	2.23	2.33 - 2.40
	Calcium (1.215 Sp. Gr.)	2.25	2.33
	Calcium (1.250 Sp. Gr.)	2.29	2.33
	Absorbed / Gelled Electrolyte * (sealed lead-acid type)	2.25	*
	Nickel-Cadmium (Ni-Cd)	1.42	1.47

* Sealed lead-acid battery types should not be used in ambient temperatures above 95° F / 35° C, and should not normally be equalized. Consult your battery manufacturer's documentation for specific equalizing recommendations.

TEMPERATURE COMPENSATION (annotated)

If your batteries are to see temperature variations during charging, a temperature compensation option (**EJ5033-0#**) is recommended. If this option is not part of your AT30, manual adjustments should be made. Refer to the equation and table below for temperature-adjusted voltages.

temperature-adjusted voltage = charge voltage x K

Temperature (°F)	Temperature (°C)	K (Lead-Acid)	K (Nickel-Cadmium)
35	1.7	1.058	1.044
45	7.2	1.044	1.034
55	12.8	1.031	1.023
65	18.3	1.017	1.013
75	23.9	1.003	1.002
77	25.0	1.000	1.000
85	29.4	0.989	0.992
95	35.0	0.975	0.981
105	40.6	0.961	0.970

EATON 9390-40 Product Specifications (annotated)

The UPS systems are housed in free-standing cabinets with safety shields behind the doors. The UPS systems are available in 50/60 Hz with various output power ratings.

Models	Power Rating	Frequency
9390-40/20	20 kVA	50/60 Hz
9390-40/30	30 kVA	50/60 Hz
9390-40/40	40 kVA	50/60 Hz
9390-80/40	40 kVA	50/60 Hz
9390-80/50	50 kVA	50/60 Hz
9390-80/60	60 kVA	50/60 Hz
9390-80/80	80 kVA	50/60 Hz

The following sections detail the input, output, environmental, and battery specifications for the UPS.

UPS System Input

Operating Input Voltage (Nominal +10/–15%)	208 Vac for operation from 177 Vac to 229 Vac 220 Vac for operation from 187 Vac to 242 Vac 380 Vac for operation from 223 Vac to 418 Vac 400 Vac for operation from 340 Vac to 440 Vac 415 Vac for operation from 353 Vac to 457 Vac 480 Vac for operation from 408 Vac to 528 Vac
Operating Input Frequency Range	±5 Hz
Operating Input Current	See Appendix A, Table H through Table J. Reduced for Generator Adjustable
Input Current Harmonic Content	5% THD at full load
Power Factor	Minimum 0.99
Line Surges	6 kV OC, 3 kA SC per ANSI 62.41 and IEC 801-4
Battery Voltage	384 Vdc (208V/220V units only) 432 Vdc 480 Vdc

UPS System Output

UPS Output Capacity	100% rated current
Output Voltage Regulation	±1% (10% to 100% load)
Output Voltage Adjustment (Nominal +/–3%)	208 Vac nominal, adjustable from 202 Vac to 214 Vac 220 Vac nominal, adjustable from 214 Vac to 226 Vac 380 Vac nominal, adjustable from 369 Vac to 392 Vac 400 Vac nominal, adjustable from 388 Vac to 412 Vac 415 Vac nominal, adjustable from 403 Vac to 428 Vac 480 Vac nominal, adjustable from 466 Vac to 494 Vac
Output Voltage Harmonic Content	1.5% max THD (linear load) 5% max THD (nonlinear load)
Output Current	See Appendix A, Table H through Table J.
Output Voltage Balance	3% for 100% maximum load imbalance (linear load)
Output Voltage Phase Displacement	3° for 100% maximum load imbalance (linear load)
Output Transients	± 5% for 100% load step or removal
Frequency Regulation	± 0.01 Hz free running
Synchronous to Bypass	Bypass within voltage limits of +5%, –8% of output setting; bypass within ± 0.5 Hz
Frequency Slew Rate	1 Hz per second maximum
Overload Current Capability	102% for 10 minutes 100–101.9% 110% for 30 seconds 102–109.9% 125% for 10 seconds 110–124.9% >125% for 10 cycles

Environmental

Operating Temperature	0 to 40°C (32–104°F) without derating, excluding batteries. The recommended operating temperature is 25°C (77°F).
Operating Altitude	Maximum 1500m (5000 ft) at 40°C without derating
Storage Temperature	–25 to +60°C, excluding batteries (prolonged storage above 40°C causes rapid battery self-discharge)
Relative Humidity (operating and storage)	5% to 95% maximum noncondensing
Acoustical Noise	65 dB at a 1m distance, c weighted
EMI Suppression	EN62040-2:2006 CATC3
Electrostatic Discharge (ESD) Immunity	Meets IEC 801-2 specifications. Withstands up to 25 kV pulse without damage and with no disturbance or adverse effect to the critical load.

Eaton 12V 500W Battery (annotated)

Features

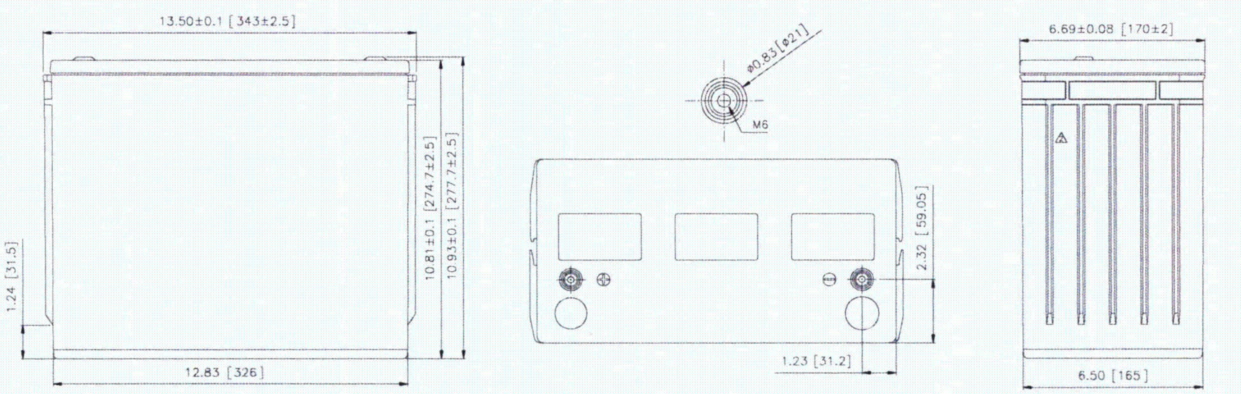
- Designed for high power density applications
- Small volume, lightweight discharge efficiency
- Can be used for more than 260 cycles at 100% discharge in cycle service
- UL-recognized components under UL924 and certified by ISO 9001 and ISO 14001
- Built to comply with IEC 896-2, DIN 473534 BS 6290 OT4, Eurobat
- Exclusive three-year battery parts coverage and one-year battery labor coverage

CONSTANT POWER DISCHARGE CHARACTERISTICS: WATTS/CELL (77°F, 25°C)

End point volts/cell	5 min	7.5 min	10 min	15 min	20 min	30 min	40 min	50 min	60 min	90 min
1.85V	561	480	433	367	327	261	220	188	163	116
1.80V	638	557	492	416	356	276	232	198	171	122
1.75V	708	625	548	458	385	290	244	206	178	126
1.70V	773	685	602	489	404	305	251	210	181	127
1.67V	813	717	632	503	415	312	253	213	182	128
1.60V	879	782	695	530	432	325	260	215	185	131

All mentioned values are average values per battery per cell.
Tolerance: X <6 min (+15% ~ -15%), 6 min X <10 min (+12%~ -12%), 10 min X <60 min (+8% ~ -8%), X 60 min (+5% ~ -5%)

DIMENSIONS [H x W x D, in (mm)]



Technical specifications

Cells per unit	6
Voltage per unit	12
Capacity	500W @ 15-minute rate to 1.67V per cell @ 77°F (25°C)
Weight	Approximately 100.75 lb (45.7 kg)
Maximum discharge current	800A (5 sec)
Internal resistance	Approximately 3.7 mΩ
Operating temperature range	Discharge: 5°F~122°F (-15°C~50°C) Charge: 5°F~104°F (-15°C~40°C) Storage: 5°F~104°F (-15°C~40°C)
Nominal operating temperature range	77°F ± 5°F (25°C ± 3°C)
Float charging voltage	13.5 to 13.8 Vdc/unit Average at 77°F (25°C)
Recommended maximum charging current limit	50A
Equalization and cycle service	14.4 to 15.0 Vdc/unit Average at 77°F (25°C)
Self discharge	Batteries can be stored for six months at 77°F (25°C). Please charge batteries before using. For higher temperatures the time interval will be shorter. Voltage test prior to battery installation is recommended.
Terminal	12-thread lead alloy recessed terminal to accept M6 bolt
Container material	Polypropylene UL94-V0/File E50955 Flammability resistance of UL94-HB/File E216959 is available upon request.

8 Electrical Power Systems

8.1 Normal Electrical Power Systems

8.1.1 Design Basis

These systems ~~is~~are designed to supply all of the electrical power necessary to operate the NBSR during both normal and shutdown conditions. This includes all of the experiments, offices and other support spaces associated with the reactor. Electrical power is supplied to the NBSR by three independent, underground, 13.8 kV primary feeders ~~(FA-1, FB-1, FC-1)~~. Each primary feeder is connected to a separate 13.8 kV/480V distribution transformer. The secondary of each transformer provides power to one of three specific sections of the main 480 V switchgear buss ~~(SB-A, SB-B and SB-C)~~. A substation independent of the three feeders provides power to the equipment in the Secondary Coolant Pump Building (SCPB) and the cooling tower cell~~s'~~ equipment. ~~Discussion of this supply is limited to this paragraph, as a secondary system failure cannot cause a reactor accident.~~ Other major components of the electrical distribution system include two independent electrical generators ~~(A and B)~~, battery power, two un-interruptible power supplies (UPS), two battery chargers, transformers, and associated distribution equipment.

The electrical generators are a source of emergency AC power and are independent of the NIST electrical distribution system, because a failure of the NIST system does not affect the reliability of the local generator~~s'~~ as a power source~~distribution equipment and the fuel supply for either generator engine~~. Battery power is provided by the station battery, described elsewhere in this chapter. The availability of multiple emergency power sources provides flexibility for operation of the facility in normal or emergency circumstances, but reactor safety requires only one operable backup power supply to ~~The redundancy of important loads and the protective scheme of the breakers in the Electrical Distribution System~~ prevent consequences from a~~ny~~ single ~~equipment~~ failure exceeding those ~~from~~ from an accident ~~causing a total loss of power for the reactor systems~~analyzed in Chapter 13. Therefore, while equipment and power sources have redundancy, redundancy is neither present nor necessary in the normal configuration of the facility distribution system.

As described below, the electrical distribution system consists of three major sub-systems: the Facility (or Building Services) Distribution System, the Reactor Distribution System and the Emergency Distribution System.

8.1.2 System Description

8.1.2.1 High Voltage Input [not applicable]

8.1.2.2 Facility Distribution System [not applicable]

8.1.2.3 Reactor and D-Wing Distribution System

[The first three paragraphs are not applicable.]

Off-site power provides AC power through the MAIN UPS to Critical Power Panel CP-1, which in turn supplies CP-2 and CP-3. The critical power panels supply power to the Reactor Control and Safety Systems. Normally, the STANDBY UPS is running and its output is directed to the main UPS reserve input.

Tables 8.4A, 8.4B and 8.4C list the loads on Critical Power Panels CP-1, CP-2 and CP-3, respectively.

Off-site power also provides AC power to maintain the lead-acid battery voltage and power to the DC loads on the 125 VDC Panel. Two battery chargers, one from MCCA-5 and one from MCCB-6, are load sharing devices and convert commercial AC power to DC power to provide a floating, or trickle, charge to the 125 VDC battery, and separately energize the 125 VDC panel. The battery chargers are designed to work with the battery, which prevents a large temporary voltage drop from occurring on the 125 VDC panel if a large DC load is energized.

The 125 VDC Distribution Panel supplies power to two other DC panels: MCC DC (Table 8.2I) which supplies Panel DCP-2; and Panel DCP-1. Tables 8.3A, 8.3B, and 8.3C list the loads on the 125 VDC Distribution Panel, DCP-1, and DCP-2, respectively.

8.1.2.4 Emergency Distribution System

~~Emergency Power MCC A-5 is fed from Reactor MCC A-3 through Automatic Circuit Breaker (ACB) No. 1. Emergency Power MCC B-6 is fed from Reactor MCC B-4, through ACB No. 4.~~ The two Emergency Power MCCs are tied together through a normally closed tie-breaker. The categorization of these motor control centers as emergency MCC is due to a single load, namely EF-5 on one MCC and EF-6 on the other MCC; both fan ~~motors~~ blowers also can be powered from the DC ~~bus~~panel.

The normal distribution lineup has ~~A~~CB#~~ No.~~1 closed and ~~A~~CB#~~ No.~~4 open in stand-by. In this configuration, switchgear bus ~~SB-A~~FA-1 supplies both MCC A-5 and B-6 via Reactor MCC A-3. Since EF-5 and EF-6 are considered to be necessary for an emergency response, provisions are made to automatically provide emergency power to the two loads. An under-voltage device monitors the ~~status~~ voltage on~~f~~ MCC A-5 and through the closed tie breaker, MCC B-6. If this device senses a loss of voltage, it automatically trips open ~~A~~CB#~~ No.~~1 and closes ~~A~~CB#~~ No.~~4.

This transfers the feed for MCC A-5 and MCC B-6 to Switchgear Bus ~~SB-B~~FB-1 via Reactor MCC B-4.

If power is not restored to MCC A-5 and MCC B-6, this same under-voltage device trips open ~~A~~CB# ~~No.~~ 4 and initiates the starting sequence of the emergency generators. Once a generator achieves the proper ~~output frequency and voltage~~electrical parameters, its associated Feeder Breaker, ~~A~~CB# ~~No.~~ 2 for Emergency Generator A or ~~A~~CB# ~~No.~~ 3 for Emergency Generator B, closes to restore power to MCC A-5 and MCC B-6. The generators are discussed in Section 8.2~~, Emergency Electrical Power Systems~~.

~~MCC A-5 and MCC B-6 provide power to all of the equipment necessary for the reactor in a shutdown or secured condition.~~ Table 8.2E lists the loads supplied by MCC A-5 while Table 8.2F lists the loads supplied by MCC B-6.

~~During normal operation, either the T-9 Reactor UPS or the T-10 Reactor UPS supplies AC power to Critical Power Panel CP-1, which in turn supplies CP-2 and CP-3. The rectifier of one of the two 20 kVA UPS will convert and condition the supplied commercial AC power to carry the loads of the 125 VDC bus and provide a floating, or trickle, charge to the station battery. The other UPS is energized, but not on-line and acts as an installed spare. The Critical Power Panels supply power to the Reactor Control and Safety Systems. Tables 8.4A, 8.4B and 8.4C list the loads on Critical Power Panels CP-1, CP-2 and CP-3, respectively. The 125 VDC Distribution Panel also supplies power to two other DC panels, MCC DC (Table 8.2I) which supplies Panel DCP-2, and Panel DCP-1. Tables 8.3A, 8.3B, and 8.3C list the loads on the 125 VDC Distribution Panel, Panel DCP-1, and DCP-2 respectively.~~

The sequence of power transfers involving the UPS to maintain power without interruption to CP-1, starting with a normal reactor electrical distribution configuration, is as follows:

1. If AC power from MCC B-6 is lost to the input of the main UPS, then the battery bank for the main UPS would provide AC power to CP-1.
2. After the main UPS battery bank is depleted, the standby UPS provides AC power to CP-1 through the reserve input of the main UPS. If AC power is restored to MCC B-6 and the main UPS battery bank is not depleted and the main UPS has not tripped on a fault, then the main UPS would return to service automatically.
3. If AC power from MCC A-5 is lost to the standby UPS, then the battery bank for the standby bank would provide AC power to the main UPS reserve input. If AC power is restored to MCC A-5 and the main UPS battery bank is not depleted and the standby UPS has not tripped on a fault, then the standby UPS would return to service automatically and provide AC power to the reserve input of the main UPS.

4. After the standby UPS battery bank is depleted and after AC power is restored to MCC A-5, unfiltered AC power will be directed through the standby UPS to the reserve input of the main UPS.

~~If AC power is lost to the input of the on-line UPS, battery power automatically supplies the loads on the 125 VDC Distribution Panel and the Critical Power Panel loads. When AC power is restored, either from the emergency generator or from another source, the UPS automatically resumes charging the station battery and the UPS automatically resumes supplying power to the Critical Power Panel and the 125 VDC Distribution Panel.~~If AC power is lost to the input of both battery chargers, the trickle charge to the sixty cell lead acid battery bank would cease and that battery bank would assume the loads on the 125 VDC panel for at least 4 hours. After AC power is restored, the primary battery charger resumes charging the battery bank.

Emergency Lighting Panels X-1 and X-2 supply selected lights with either AC power or DC power. Panel X-1 powers emergency lights in the office spaces in the A- and B-wings. Normally, this panel receives AC power from CP-3. Upon loss of AC power, automatic transfer switch TS-1 transfers the feed from CP-3 to DCP-1. Panel X-2 powers emergency lights in the Confinement Building. Normally, this panel receives AC power from MCC A-5 via Miscellaneous Power Panel P-5, located on MCC A-5. Upon loss of AC power, an automatic transfer switch transfers the feed from MCC A-5 to DCP-1.

A simplified diagram of the Emergency Distribution System bussing arrangement is shown in Figure 8-2.

8.1.3 Electrical Power Capability [not applicable]
8.1.4 Codes and Standards [not applicable]
8.1.5 Lightning Protection [not applicable]
8.1.6 Grounding [not applicable]

8.2 Emergency Electrical Power Sources

8.2.1 Design Basis

Emergency electrical power is designed to provide power to the nuclear instruments and the emergency exhaust fans should a complete loss of off-site power occur. One of the two emergency generators is capable of supplying power to all necessary emergency equipment. Battery power is also capable of independently supplying the vital loads for a minimum of four hours. By requiring the operability of at least one emergency generator during reactor operation and requiring the availability of battery power during reactor operation, power sources will always be available for an emergency response.

8.2.2 System Description

This system consists of:

a. [not applicable]
b. The station battery~~,~~ is composed of three battery banks, two of which would be in service in a loss of AC power scenario. ~~which combines~~One bank is made up of sixty, two volt, lead-acid type ~~battery cells~~battery cells to produce a single output of 125 VDC with a capacity of 880 amp-hours. The other two banks comprise the emergency AC backup capability of the two UPS. One bank would be in-service, and the other bank would be in standby. Each bank is made up of valve-regulated lead-acid (VRLA) battery cells.
~~c. 125 volt DC bus which can supply power to the vital loads for emergency situations. The bus can be energized via the DC output of either of the 20 kVA UPS or the output of the station battery.~~

In case of a total loss of off-site power and emergency generator AC power, vital equipment would remain energized for at least four hours: EF-5 and EF-6 DC powered fans, controls, and associated valves; and nuclear instrumentation. Non-vital equipment on the critical power panels and the DC bus would remain powered for at least four hours, unless de-energized with individual controls, e.g. a local breaker. That equipment includes process instrumentation, AC and DC valve control power, effluent monitors, other critical power panel loads (see Chapter 7), and the reactor shim arm control. ~~the 125 VDC bus would remain energized for loads classified as reactor emergency equipment. These circumstances would require a DC power source and the station battery serves as the DC source to carry the emergency equipment loads for eight hoursstation battery, assuming the current needs for all of the equipment would equal approximately 100 amps, plus the amperage required by an operating 20 kVA UPS. This equipment includes the following: vital equipment (Emergency Ventilation System DC powered fans and controls, nuclear instrumentation), valve control power, emergency lighting, UPS Inverter (T9 mode or T10 mode), the reactor shim arm control, and reactor process instrumentation.~~

Table 8.1A, B, C [not applicable] and Table 8.2A, B, C, D [not applicable]

Table 8.2E: Load List MCC A-5, Emergency Power

Cubicle	Load
1B	Breaker Interface Module (BIM) & Central Monitoring Unit (CMU)
1E	TVSS
1G	D_2O Storage Tank Pump DP-7
1J	~~T-10~~Standby UPS
1M	SCV-50
2A	Door (Future)
2F	Miscellaneous Power Panel A5
2HL	Primary
2HR	Secondary
2M	15 kVA Transformer
3B	Helium Blower HB-1
3D	EF-3
3F	EF-4
3HL	Elev. & Door Cont. Power
3HR	Reactor Door Panel P8, P9
3K	Rabbit Blower
3ML	Feeder Control Air Compressor No. 2, Battery Charger 2
3MR	Spare
4B	D_2O Experimental Booster Pump DP-9
4E	D_2O Shutdown Pump DP-5
4G	Secondary Cooling Shutdown Pump
4J	Sump Pump to Hot Waste
4LL	DWV-2
4LR	Spare
4M	Door (Future)
5B	Thermal Column Pump No. 1
5D	Demin. Water Exp. Cooling Pump No. 1
5G	Thermal Shield Circ. Pump No. 1
5M	Feeder Reactor MCC A-3
6C	Subfeed Lugs to MCC B-6
6G	Relay Panel
6H	Door (Future)
6M	Feeder Emergency Generator A

Table 8.2F: Load List MCC B-6, Emergency Power

Cubicle	Load
1E	Feed From MCC A-5
1H	Relay Panel
1M	Feeder Emergency Generator B
2B	D_2O Experimental Booster Pump DP-10
2D	Demin. Water Exp. Cooling Pump No. 2
2G	Thermal Shield Circ. Pump No. 2
2H	Door (Future)
2M	Feeder Reactor MCC B-4
3A	Hot Waste Sump Pumps 1A & 1B
3D	D_2O Shutdown Pump DP-6
3FL	~~T-9~~Main UPS, Battery Charger 1
3FR	Spare
3H	Emergency Sump Pump
3KL	Feeder Control Air Compressor No. 1
3KR	DWV-1
3ML	Spare
3MR	Spare
4B	Tritium Blower
4D	Recirculation Supply Fan SF-19
4F	Dilution Exhaust Fan EF-2
4H	Hood Exhaust Fan EF-23
4K	Spare
4M	D_2O Storage Tank Pump DP-8
5C	DWV-19
5E	Helium Blower HB-2
5J	Thermal Column Pump No. 2
5M	TVSS

Table 8.2G: Load List MCC DC

Cubicle	Load
A-1	DC Power Panel 2 (DCP-2)
B-1	Exhaust Fan EF-5 (DC Motor)
C-1	Exhaust Fan EF-6 (DC Motor)
D-1	Exhaust Fan EF-5 (AC Motor)
E-1	Exhaust Fan EF-6 (AC Motor)
A-3	D_2O Shutdown Pumps DP-5
B-3	D_2O Shutdown Pumps DP-6

Table 8.3A, B, C [not applicable] and Table 8.4A, B, C, D [not applicable]

Figure 8.1: Simplified Diagram – High Voltage Input Switchgear and Bussing Arrangement [not applicable]

Figure 8.2: Simplified One-Line Diagram for the Reactor and Emergency Power Distribution System (Normal/Preferred Lineup, Essential, and Vital Loads) [See page 2 of Attachment 1]