MIT NUCLEAR REACTOR LABORATORY

AN MIT INTERDEPARTMENTAL CENTER

Edward S. Lau
Assistant Director
Reactor Operations

Mail Stop: NW12-122
138 Albany Street
Cambridge, MA 02139

Phone: 617 253-4211
Fax: 617 324-0042
Email: eslau@mit.edu

17 May 2021

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attn.: Document Control Desk

Subject: Supplement to MIT Response to the Request for Additional Information for Battery Upgrade License Amendment Request (EPID: L-2021-NFA-0000)

The Massachusetts Institute of Technology (MIT) hereby submits a supplement to its March 24, 2021, response to the Request for Additional Information (RAI) on the License Amendment Request (LAR) to upgrade the Emergency Electrical Power System batteries at the MIT Reactor (MITR).

Accordingly, MIT provides supplemental information in the following format: the NRC RAI discussion item summary in italics, followed by the MIT answer in normal font. Wherever necessary, MIT's responses will reference supporting documents in various Enclosures.

1. *Short circuit evaluation required by Std 1187 (Section 5.8.1) – Figure 8-1 of the SAR (and application) shows the connection of the new battery and charger to the existing wiring. This includes fused and unfused overcurrent protection devices. The NRC staff do not find information on any MIT-provided evaluation that there was a short circuit evaluation (given the larger battery and new charger) to confirm the acceptability of the existing protection devices.*

Response to **Topic #1**:

Figure 8-1 of the MIT SAR shows the connection of the new battery and charger to the existing wiring. It includes an existing 2-pole, 200-amp fused switch directly downstream of the battery and charger. The new batteries have a maximum short-circuit current of 6,038 amps (first item on page 5 of the 24 March 2021 RAI Response submittal Enclosure 2, the C&D Technologies battery calculation report), compared to 7,407 amps for the existing C&D model KCR-15 battery cells. The new charger is a HindlePower Model AT30. The exact model specification is provided in the manufacturer's Production Test Data Sheet and AT30 Specification Table (Enclosures S1 and S2). The data sheet includes a current limit test, and lists 1) an AC Input Protection provided by a standard AC circuit breaker for maximum designed current of 9 amps and trip current of 18.75 amps, and 2) a DC Output Protection provided by a standard DC circuit breaker for designed current of 30 amps and trip current of 50 amps. Both these breakers

A020
NRR

provide overcurrent protection well before the 200-amp fuse design of the existing circuitry. Therefore, the overall system overcurrent protection for short circuits is satisfactory.

2. *Technical basis of service life & replacement –*

   a. *NRC staff do not find any discussion of the point in the performance test information as to when the battery would require replacement (e.g., battery no longer passes performance test); see IEEE 1188, Section 8.*

   b. *MIT provided a manufacturer data table on battery testing. However, the NRC staff do not find any explanation on how to interpret the information in the table and any conclusions on reliability from the testing.*

Response to **Topic #2**:

MIT will apply the Std. IEEE 1188 Section 8 recommendation to replace the battery when its capacity falls below 80% of the manufacturer's rating. On their IEEE 1188-2005 test report, the manufacturer calculates the percentage of capacity using a temperature correction factor based on a time-adjustment method (as per Section 7.4 capacity test methods in IEEE 1188). The table lists the parameters that are used to produce the percentage capacity for each of MIT's 60 new battery cells, as factory-tested prior to shipment to MIT. Once the batteries are installed, MIT will track their performance closely using the battery monitoring system.

Std. IEEE 1188 Section 8 also suggests other factors and indicators for battery replacement. It lists abnormally high cell operating temperatures, unsatisfactory performance test results, and a low cell voltage that fails to respond to corrective action; all these would also be taken into consideration for battery or cell replacement.

Additionally, as listed in MIT's 24 March 2021 Response to RAI #3, a Phoenix Broadband Technologies SC4 battery monitoring unit will be installed, capable of monitoring battery voltages, internal resistance, and operating temperatures, and capable of providing data storage and alarms. This monitoring unit provides convenience in the measurement, recording, and tracking of many battery parameters. However, if it is not operable, all required parameters will be measured using handheld instruments. The continuous monitoring of battery parameters will provide early warning if the battery bank or any individual cells are developing a problem and require corrective action or replacement.

The manufacturer's IEEE 1188 test report shows the test results for each of the 60 battery cells fabricated for MIT. All 60 cells met product specifications and proved to be in excellent condition. Enclosure S3 is an updated copy of the IEEE 1188 test report, which now contains the manufacturer's associated conclusion statement. Additionally, the manufacturer provides a "Service Life – Reliability" statement for the msEndur II series VRLA battery on page 4 of C&D Technologies cut sheet #12-1016 (Enclosure S4). There is also a similar, abbreviated statement on page 1 of the cut sheet under "Features & Benefits / Advanced Service Life". The conclusion statement in the test report and the reliability statement in the cut sheet by the manufacturer provide assurance that the AT-15P battery cells will be reliable for their application at the MIT Reactor. Furthermore, with close monitoring and adherence to the manufacturer's maintenance guidelines to ensure that the battery is operating in favorable conditions per IEEE 1188, the batteries are expected to deliver their performance in a reliable manner.

3. *Battery monitoring system – what alarms are provided with the battery monitoring system? Further, please discuss the following:*
    a. *Std. 1188 says the battery should have ground fault detection, but NRC staff do not find MIT discussion on monitoring for ground faults.*
    b. *Std. 1188 also recommends H_2 monitoring. If monitoring is not required, please indicate so and why.*

Response to **Topic #3**:

The battery monitoring system monitors the string voltage, float current, ripple current, battery voltage delta, discharge status, and discharge/load current. MIT has 60 battery cells arranged in series as a single string. The battery monitoring system also monitors, for each cell, the terminal post DC voltage, terminal post temperature, battery and cell admittance. Up to four user-defined alarm thresholds can be set for each analog parameter: "High-High", "Low-High", "High-Low", and "Low-Low". (This information is under "General Specifications" on page 2 of the 24 March 2021 RAI Response submittal Enclosure 3c, the "Site Controller Unit PBT-PA-BMS-SC4" brochure.)

Additionally, the battery charger itself provides several built-in alarms: AC Input Failure, DC Output Failure, High $Volts_{dc}$, Low $Volts_{dc}$, and Positive(+) and Negative(-) Ground Faults (per "Standard Features" on page 3 of the 24 March 2021 RAI Response submittal Enclosure 4, the "AT30 Series Microprocessor Controlled Float Battery Charger" brochure.) Therefore, battery ground fault detection is monitored by the battery charger rather than by the battery monitor.

MIT determined that hydrogen monitoring is not necessary, because as described in the 24 March 2021 RAI Response submittal, the batteries are installed within the NW12-100D Utility Room, which has adequate ventilation with a continuously-operating exhaust fan on the ceiling above the batteries. The manufacturer specifies the amount of hydrogen produced during charging, based on a worst-case boost/equalize charge mode in accordance with Std. IEEE 1635-2012 Table 2, is 0.066578 $ft.^3$ of H_2 per hour for all 60 battery cells together (per page 4 of the 24 March 2021 RAI Response submittal Enclosure 2, the C&D Technologies battery calculation report). By comparison, the existing C&D KCR-15 batteries produce up to 0.0594 $ft.^3$ of H_2 per hour.

Additionally, VRLA batteries are sealed. Any hydrogen produced re-combines under pressure with oxygen inside the battery. Hydrogen gas escapes only if internal pressure exceeds the rating of the pressure relief valve, in which case 0.066578 $ft.^3$ of H_2 per hour is the maximum amount emitted. The manufacturer confirms that the amount of hydrogen produced during discharge is less than the amount produced during charging. Therefore, the amount of hydrogen produced remains small in all cases. The room is well-ventilated, so hydrogen measurement is not required. The space is inspected on a daily procedure whenever the building is open. If the room ventilation fan fails, keeping the room's main door open will promote adequate air circulation.

4. *Surveillance Requirements – MIT provides a list of monthly surveillance requirements for the battery charger system that ends in "etc." The list does not include recommended surveillance requirements listed in Section 5.2.1 of Std. 1188. The NRC staff did not find information regarding performance of subparagraph e, f, and g to Section 5.2.1 of Std. 1188.*

Response to **Topic #4**:

In the 24 March 2021 RAI Response letter, MIT mentioned four items as an example of elements for monthly inspection. These four items match the Std. IEEE 1188 Section 5.2.1 "Monthly" items (a) through (d). Items (e) through (g) will also be inspected.

Items (e) and (f) are monthly visual inspections that are recommended by the manufacturer (per Part 9 "Maintenance" in 24 March 2021 RAI Response submittal Enclosure 3a, the "Installation and Operating Manual" for C&D Technologies msEndur II batteries). Specifically, under Part 9.1, item 1 states, "Visual inspection of the battery for general appearance and connector conditions. Check for bulging jars, corrosion build up or any signs of heat damage to the jars/covers and connectors. Visually check cell spacing and cell side restraint plate gap as noted in Appendix C, Table 2." As stated in MIT's 24 March 2021 Response to RAI #5, where surveillance and performance test recommendations are in the manufacturer's "Installation and Operating Manual", we intend to follow those recommendations according to the manual. Therefore, these items will be performed monthly.

Std. IEEE 1188 Section 5.2.1 "Monthly" item (g) recommends a check and recording of the DC float current (per string). Because the battery is arranged as a single string, this was judged to be covered by the "Installation and Operating Manual" Part 9.1, item 3, which states, "Measure and record the total system float current." Therefore, likewise per MIT's 24 March 2021 Response to RAI #5, this item will be performed monthly.

5. *Charger customization – MIT provided manufacturer information (brochure) on the battery charger that includes a list of numerous options for the battery charger. NRC staff did not find any explanation of which options were purchased/included in the MIT battery charger.*

Response to **Topic #5**:

The battery charger is a HindlePower Model AT30, with the specific model number being AT30-130-030-F. Details of the options selected for MIT's application are indicated in the Enclosure S1 Production Test Data Sheet (checkboxes showing charger functions tested satisfactorily, inspection items, and order completion) and Enclosure S2, the AT30 Specification Table (selected options highlighted by red boxes marked by the manufacturer).

6. *Charger Load information – MIT provide a manufacturer data sheet that includes an (MIT) added calculation of load information in a red text box. The NRC staff did not find any explanation of the factors used in the calculation, specifically the "1.1" multiplier and the "0" addition.*

Response to **Topic #6**:

The manufacturer data sheet was delivered to MIT with a red text box already in place, containing a formula used to size the battery charger for MIT's application:

"(456Ahr*1.1)/24hrs + 0A = 21Amp min output"

The 456 amp-hours is MIT's requested battery load capacity, the product of 57 amps for 8 hours.
The 1.1 factor is the design margin based on 90% charger efficiency.
The second term is allowance for momentary loads; 0 amps represents a constant current load.

The resulting charger capacity calculation of 21 amps is the minimum capacity required to refill the batteries within 24 hours following a full-load discharge of 8-hour duration. The actual charger is rated for 30 amps DC output.

In summary, the above supplements to our RAI response, and the referenced enclosures, represent additional information identified in a telephone call on March 26, 2021, a followup NRC email message dated April 1, 2021, and an additional telephone call on April 9, 2021. The supplement letter and enclosures submitted herewith do not contain any proprietary information.

This RAI response supplement submittal contains the following four Enclosures:

Enclosure S1 "AT Series Battery Charger Production Test Data Sheet" (two pages).

Enclosure S2 "AT30 Specification Table" (one page).

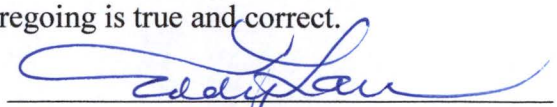
Enclosure S3 IEEE 1188 Test – Order 2516069 (Rev. 2 as updated 17 May 2021) (two pages). This replaces Enclosure 1 from MIT's 24 March 2021 RAI Response submittal.

Enclosure S4 C&D Technologies, Inc. cut sheet #12-1016 for the msEndur II series VRLA battery (4 pages).

Sincerely,

Edward S. Lau, NE
Assistant Director of Reactor Operations
MIT Research Reactor

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 05/17/2021 
Date Signature

Enclosures: As stated.

cc: USNRC – Senior Project Manager
Research and Test Reactors Licensing Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

USNRC – Senior Reactor Inspector
Research and Test Reactors Oversight Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Enclosure S1

AT SERIES BATTERY CHARGER

PRODUCTION TEST DATA SHEET

DI5008-00

(Revised 02/21/07)

CUSTOMER	MODEL No	AC INPUT VOLTAGE
PRESIDENT POWER TECHNOLOGIES	AT30-130-030-F	480
	SERIAL No 20150/268880	

Refer to test procedure (**CD5008-00**) for test conditions and instrumentation required.

DIELECTRIC WITHSTAND TEST (Section 3.1)

Disconnect PC Boards. See test procedure for other preparations.

		PASSED
AC input to chassis	2500 V_{rms}	☒
AC input to DC output	2500 V_{rms}	☒
DC output to chassis	2500 V_{rms}	☒

Reconnect all components. If the Auxiliary Relay Board is installed, ensure power supply jumper P4 is correctly placed for voltage rating of charger.

PROGRAM VERSION (Section 3.2)

6.58

FRONT PANEL FUNCTIONS (Sections 3.4 and 3.5)

- ☒ AC ON indicator
- ☒ Lamp & relay test
- ☒ CHRG MODE key
- ☒ EQLZ METH key
- ☒ Voltmeter is ±1% (see below)
- ☒ Ammeter is ±1% (see below)
- ☒ Edit mode
  - ☒ UP arrow
  - ☒ DOWN arrow
- ☒ Current limit edit mode
- ☒ HVDC shutdown select
  - ☒ Set to OFF
- ☒ Voltmeter calibration
- ☒ Front panel disable (3.5)

AMMETER ACCURACY (Section 3.4.6)

☒ Calibrated to 1% (see table below)

CURRENT LIMIT TEST (Section 3.6)

FLOAT VOLTAGE	CURRENT LIMIT PERFORMANCE	MAX. INPUT CURRENT
135 Vdc	33 Adc at 105 Vdc	8.2 Aac

- ☒ Current limit set to 110%
- ☒ Properly sized AC input wire
- ☒ AC breaker rated 125% of maximum input current

RIPPLE TEST (Section 3.7)

OUTPUT VOLTAGE	OUTPUT CURRENT	(WITH BATTERY) RIPPLE AT BATTERY	(NO BATTERY) RIPPLE AT CHARGER
136.2 Vdc	30 Adc	17.4 mV_{rms}	113 mV_{rms}

REGULATION TEST (Section 3.8)

Vac	Load Current	Vdc	Adc	Percent Regulation
110%	5%	139.93	1.50	0.0286
100%	50%	139.90	15.00	
88%	100%	139.85	30.00	

BUILT-IN ALARM FUNCTIONS (Sections 4.1.1 through 4.1.6)

- ☒ HVDC
- ☒ LVDC
- ☒ AC INPUT FAILURE
- ☒ POS GND
- ☒ NEG GND
- ☒ GND DET DISABLE (P5)
- ☒ COMMON ALARM RELAY
- ☒ HVDC SHUTDOWN
- ☒ LOW LEVEL DETECT

AUXILIARY ALARM RELAY PC BOARD

- ☒ Board and cable are QC stamped
- ☒ Jumper P4 correctly placed
- ☒ Low DC Voltage
- ☐ N/A

FINAL SETTINGS (Section 5.1)

- ☐ Parameters are set to factory default values.
- ☒ Parameters are set to customer-specified values.

AT SERIES BATTERY CHARGER

PRODUCTION TEST DATA SHEET

DI5008-00

(Revised **02/21/07**)

VOLTMETER CALIBRATION (Section 5.2)	☒ Voltmeter reads within 1% (See table below).

FRONT PANEL METER TOLERANCES

VOLTMETER		AMMETER	
Vdc	**TOLERANCE**	**Adc**	**TOLERANCE**
12	± 0.2 V	6 - 25	± 0.3 A
24	± 0.4 V	30 - 100	± 1.5 A
48	± 0.8 V	125 - 400	± 5 A
130	± 2.0 V	500 - 800	± 10 A
		1,000	± 12 A

MECHANICAL INSPECTION (Section 5.3)

- ☒ Enclosure fully painted; no chips, scratches, or other cosmetic defects.
- ☒ Unit is free of dirt, oil, handling marks.
- ☒ Nameplate agrees with order.
- ☒ Solder joints are intact.
- ☒ Crimped and bolted connections are secure.
- ☒ Harnesses are run correctly and are secured.
- ☒ Jumpers and connectors are fully seated.
- ☒ Labels are affixed in their proper locations.

ORDER COMPLETION (Section 5.3)

ORDERED	SHIPPED	ITEM
		Wired for this ac input voltage
☐	☐	120 Vac 60 Hz
☐	☐	208 Vac 60 Hz
☐	☐	240 Vac 60 Hz
☒	☒	480 Vac 60 Hz
☐	☐	550 Vac 60 Hz (covers 525 – 600 Vac)
☐	☐	220 Vac 50/60 Hz
☐	☐	380 Vac 50/60 Hz
☐	☐	416 Vac 50/60 Hz
☐	☐	Custom: Vac 60 Hz
☐	☐	Custom: Vac 50/60 Hz
		AC Input Protection
☒	☒	Standard ac circuit breakers
☐	☐	Medium AIC ac circuit breakers
☐	☐	High AIC ac circuit breakers
☐	☐	Standard AC fuses
		DC Output Protection
☒	☒	Standard dc circuit breakers
☐	☐	Medium AIC dc circuit breakers
☐	☐	High AIC dc circuit breakers
☐	☐	Standard DC fuses
		Options
☒	☒	Standard dc output filtering
☐	☐	Battery eliminator filtering
☒	☒	Auxiliary alarm relay PC board
☐	☐	Ground bus bar/pad

ORDERED	SHIPPED	ITEM
		Options (cont'd)
☒	☒	AC input lightning arrestor
☐	☐	Fungus proofing
☐	☐	Static proofing
☐	☐	Cabinet heater
☐	☐	Barrier type terminal block for alarms
☐	☐	**Documentation**
☒	☒	User's manual
☐	☐	Custom drawings ☐ Flash Drive
☐	☐	Record drawings ☐ Certified
☐	☐	Certificate of Conformance
☐	☐	Declaration of Conformance (CE)
☐	☐	**Accessories**
☐	☐	External Tempco probe (A10)
☐	☐	Communications PC board (A12)
☐	☐	Forced load sharing (A13)
☐	☐	Drip shields
☐	☐	☐Floor/☐Rack/☐Wall mtg. brackets
☐	☐	Front door lock
☐	☐	other
☐	☐	other
☐	☐	other
☐	☐	other
☐	☐	other
☐	☐	other
☐	☐	other

TEST COMPLETED	DATE	BY
	12/2/2020	TB

AT30 Specification Table

Sample

A	B			C			D	E			F	G	H	J	K	L	M	N	P
AT30	1	3	0	0	5	0	F	4	8	0	S	X	S	X	A	X	X	X	X

Your Code

AT30	1	3	0	0	3	0	F	4	8	0	S	X	S	X	A	X	L	X	X

	DESCRIPTION	CODE	FEATURE
A		AT30	AT30 SERIES
B	Nominal DC Output Voltage	012	12Vdc
		024	24Vdc
		048	48Vdc
		130	130Vdc
C	Nominal DC Output Current	025	25Adc
		030	30Adc
		040	40Adc
		050	50Adc
		075	75Adc
		100	100Adc
		125	125Adc
		150	150Adc
		200	200Adc
		250	250Adc
		300	300Adc
		400	400Adc
		500	500Adc
		600	600Adc
		800	800Adc
		1K0	1000Adc
D	DC Output Filtering	U	Unfiltered
		F	Filtered
		E	Eliminator
E	AC Input Voltage* (3~)	208	208V 60Hz
		240	240V 60Hz
		480	480V 60Hz
		550**	550V 60Hz
		220	220V 50/60Hz
		380	380V 50/60Hz
		416	416V 50/60Hz

	DESCRIPTION	CODE	FEATURE
F	AC Input Circuit Breaker Rating***	S	Standard AIC
		M	Medium AIC
		H	High AIC
		0	No Breaker
G	AC Input Fuses	F	Installed
		X	Not Supplied
H	DC Output Circuit Breaker Rating***	S	Standard AIC
		M	Medium AIC
		H	High AIC
		0	No Breaker
J	DC Output Fuses	F	Installed
		X	Not Supplied
K	Auxiliary Alarm Relay Board	A	Installed
		X	Not Supplied
L	Copper Ground Bus	G	Installed
		X	Not Supplied
M	AC Lightning Arrestor	L	Installed
		X	Not Supplied
N	Fungus Proofing	F	Applied
		X	Not Supplied
P	Static Proofing	S	Applied
		X	Not Supplied

*** Contact factory for other AC input voltages not listed**
**** Applicable for 550 & 600Vac**
***** If you do not order an AC input or DC output circuit breaker, fuses will be provided.**

Circuit Breaker AC & DC Ratings

STANDARD	*MEDIUM*	*HIGH*
Input: 5kAIC - 120/208/240/480Vac	*Input: 25kAIC - 120/208/240/480Vac*	*Input: 65kAIC - 120/208/240/480Vac*
14kAIC - 600Vac	*18kAIC - 600Vac*	*N/A - 600Vac*
Output: 5kAIC - 125Vdc	*Output: 10kAIC - 250Vdc*	*Output: 20kAIC - 250Vdc*

Enclosure S3

C&D TECHNOLOGIES Reynosa

Standby Power Division

Date: December 9, 2020

Reynosa Facility

ATP-15 IEEE-1188-2005 test

Cut-off 1.75 V.P.C. @ 100%, 225.3 Amp at 3hrs discharge rate

For order Number: 2516069

Test date:Nov **2020**

Cell temperature at the beginning of the discharge (average): **24 °C**

Discharge time (Temp corrected) :

Uncorrected test time = 180 minutes

	Serial No.	Temp. of the cell before discharge (°C)	Correction Factor	Conductance readings (Ω)	Float voltage before discharge (V)	Cell voltage at the beginning of the discharge (V)	End voltage at 3 hours (180 min)	Time to reach 1.750V (H:MM)	% of cap at 1.750V	Final Float voltage
1	H0904104	21	0.954	4064	2.221	1.988	1.824	03:06:00	108.32%	2.158
2	H0904072	21	0.954	3971	2.221	1.989	1.800	03:00:00	104.82%	2.156
3	H0904069	21	0.954	3977	2.224	1.989	1.817	03:04:30	107.44%	2.159
4	H0604338	21	0.954	4056	2.236	1.988	1.848	03:15:00	113.56%	2.157
5	H0702033	21	0.954	4023	2.227	1.978	1.822	03:08:30	109.77%	2.151
6	H0907031	21	0.954	3974	2.221	1.986	1.796	02:58:30	103.95%	2.145
7	H1023297	23	0.977	3719	2.258	1.987	1.780	03:00:00	102.35%	2.166
8	H0914045	21	0.954	3955	2.215	1.985	1.800	03:00:00	104.82%	2.162
9	H0608202	21	0.954	4086	2.239	1.993	1.854	03:18:00	115.30%	2.161
10	H1023257	21	0.954	3953	2.215	1.991	1.831	03:09:30	110.35%	2.157
11	H1023011	23	0.977	3895	2.264	1.982	1.785	03:00:00	102.35%	2.150
12	H1023240	25	1.000	3938	2.209	1.988	1.776	03:03:30	101.94%	2.166
13	H0814180	21	0.954	4003	2.215	1.984	1.807	03:00:00	104.82%	2.156
14	H1118511	21	0.954	3886	2.215	1.981	1.811	03:01:00	105.40%	2.140
15	H0608113	21	0.954	4112	2.236	1.984	1.840	03:13:00	112.39%	2.157
16	H1023333	25	1.000	3907	2.221	1.988	1.794	03:07:00	103.89%	2.161
17	H0904067	21	0.954	3958	2.227	1.986	1.815	03:02:30	106.28%	2.154
18	H1023374	25	1.000	3915	2.221	1.982	1.783	03:05:00	102.78%	2.160
19	H1023247	25	1.000	3399	2.258	2.017	1.836	03:19:00	110.56%	2.196
20	H1023304	21	0.954	3867	2.209	1.980	1.799	02:58:30	103.95%	2.156
21	H1023254	25	1.000	3861	2.215	1.984	1.766	03:01:30	100.83%	2.159
22	H1023248	25	1.000	3909	2.215	1.989	1.779	03:04:00	102.22%	2.165
23	H1023315	25	1.000	3879	2.209	1.983	1.762	03:01:30	100.83%	2.155
24	H1023381	25	1.000	3977	2.226	1.988	1.798	03:07:30	104.17%	2.159
25	H0914035	21	0.954	3949	2.221	1.987	1.819	03:04:30	107.44%	2.149
26	H1023320	25	1.000	3965	2.221	1.980	1.759	03:00:30	100.28%	2.153
27	H1023313	25	1.000	3902	2.215	1.981	1.766	03:01:30	100.83%	2.154
28	H1023191	25	1.000	3937	2.212	1.987	1.784	03:04:30	102.50%	2.155
29	H1023242	25	1.000	3831	2.219	1.987	1.784	03:04:30	102.50%	2.162
30	H1023375	25	1.000	3833	2.221	1.985	1.756	03:00:30	100.28%	2.164
31	H1023249	24	0.986	3915	2.215	1.988	1.787	03:03:00	103.11%	2.156
32	H1023332	24	0.986	3989	2.216	1.987	1.810	03:08:30	106.21%	2.160
33	H1023193	25	1.000	3927	2.215	1.983	1.769	03:02:30	101.39%	2.150
34	H1023251	24	0.986	3868	2.216	1.992	1.795	03:04:30	103.96%	2.169
35	H1023253	24	0.986	3901	2.215	1.986	1.781	03:01:30	102.27%	2.162
36	H1023335	24	0.986	3980	2.215	1.985	1.799	03:05:00	104.24%	2.153
37	H1023331	24	0.986	4016	2.215	1.986	1.816	03:10:00	107.05%	2.157
38	H0702065	23	0.977	4036	2.269	1.982	1.823	03:09:30	107.76%	2.148
39	H0702076	23	0.977	3997	2.282	1.983	1.833	03:13:30	110.03%	2.159
40	H1023334	24	0.986	4001	2.221	1.986	1.815	03:09:30	106.77%	2.162
41	H1023182	23	0.977	3862	2.267	1.984	1.803	03:04:00	104.63%	2.152
42	H1023337	24	0.986	3989	2.215	1.982	1.770	03:00:00	101.42%	2.157
43	H0702077	23	0.977	4060	2.282	1.986	1.834	03:13:30	110.03%	2.148
44	H0604335	21	0.954	4056	2.239	1.982	1.838	03:12:30	112.10%	2.158
45	H1022348	23	0.977	3973	2.269	1.989	1.822	03:08:30	107.19%	2.152
46	H1023302	23	0.977	3797	2.258	1.988	1.795	03:02:30	103.78%	2.160
47	H1023379	23	0.977	3883	2.277	1.996	1.834	03:12:30	109.46%	2.165
48	H0702156	21	0.954	3982	2.233	1.974	1.814	03:04:30	107.44%	2.149
49	H0702029	23	0.977	3858	2.302	1.998	1.843	03:19:00	113.16%	2.172
50	H1023224	23	0.977	3820	2.253	1.983	1.791	03:02:30	103.78%	2.165

Name and Signature of quality Manager

C&D TECHNOLOGIES Reynosa

Standby Power Division

Date: December 9, 2020

Reynosa Facility

ATP-15 IEEE-1188-2005 test

Cut-off 1.75 V.P.C. @ 100%, 225.3 Amp at 3hrs discharge rate

For order Number: 2516069

Test date:Nov **2020**

Cell temperature at the beginning of the discharge (average): **24 °C**

Discharge time (Temp corrected) :

Uncorrected test time = 180 minutes

	Serial No.	Temp. of the cell before discharge	Correction Factor	Conductance readings	Float voltage before discharge	Cell voltage at the beginning of the discharge	End voltage at 3 hours (180 min)	Time to reach 1.750V (H:MM)	% of cap at 1.750V	Final Float voltage
51	H0702163	21	0.954	3967	2.227	1.975	1.816	03:06:00	108.32%	2.148
52	H1023176	23	0.977	3816	2.268	1.985	1.790	03:02:00	103.49%	2.159
53	H1023373	21	0.954	3897	2.215	1.984	1.820	03:04:30	107.44%	2.162
54	H1022362	23	0.977	3949	2.270	1.988	1.834	03:14:30	110.60%	2.160
55	H0702216	23	0.977	4086	2.255	1.981	1.802	03:04:00	104.63%	2.140
56	H1023314	23	0.977	3832	2.251	1.985	1.798	03:03:00	104.06%	2.160
57	H1023171	23	0.977	3871	2.258	1.987	1.798	03:03:00	104.06%	2.158
58	H0702079	23	0.977	4025	2.267	1.988	1.830	03:12:00	109.18%	2.151
59	H1023183	23	0.977	3898	2.258	1.991	1.813	03:06:00	105.77%	2.155
60	H1109324	23	0.977	3939	2.281	2.001	1.824	03:09:30	107.76%	2.159

This IEEE-1188-2005 Test Report confirms the (60) cells of model AT-15P meets and exceeds C&D Technologies' published rate of 225.3A for 3 hours.

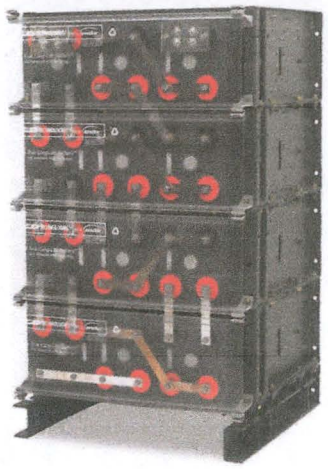
Enclosure S4

C&D TECHNOLOGIES, INC.
Power Solutions

C&D TECHNOLOGIES® SG&C

12-1016

UL-Recognized Component



THE m·s·endur® II SERIES VRLA BATTERY

THE TRUE LONG LIFE BATTERY™

For SwitchGear and Control

CAPACITIES FROM 345 TO 2180 Ampere-Hours

The msEndur II is the latest advancement in battery technology with enhanced features for Utility applications.

By combining the service life reliability of a flooded battery with the performance energy density of a valve-regulated battery, C&D has created the msEndur II — The True Long-Life Battery™.

The msEndur II series of batteries are unmatched in power density with space saving modular designs and have a 20-year design life to reduce the total cost of ownership.

With its much lower float current, the msEndur II yields significant electrical costs savings over its life making it more environmentally friendly than other 2V VRLA batteries.

APPLICATIONS

- **Electric Utility Substations**
- **Telephone Backup**
- **Microwave Sites**
- **Signaling Sites**
- **Offshore Platforms**
- **Mines**

FEATURES & BENEFITS

ADVANCED SYSTEM FEATURES

- Modular design for ease of installation and stacking flexibility
- Space saving design for the greatest amount of power in a small footprint
- Exceeds 1997 UBC Zone 4 seismic requirements for at or below grade installations
- Certified as NEBS Level 3 and compliant to Earthquake Risk Zone 4 in various system configurations
- Exceeds 2006 IBC requirements up to 300% g level and 2007 CBC compliant
- Tin-plated copper alloy connectors minimize maintenance
- New C&D Ohmic Ring® for ease of maintenance readings. With specially adapted probes only one technician is required to take readings.

ADVANCED MATERIALS

- Advanced micro-porous Absorbed Glass Mat separators for ultra-low float current — reduces grid corrosion for a long, usable service life
- Proprietary calcium alloys to minimize positive grid corrosion and growth — maximizes battery life
- Robust polypropylene container and cover — enhances product quality and improves strength of materials for safe operation with flammability rating UL94 VO, LOI>28%
- Highly efficient, proprietary plate processing for high utilization of active material — results in high energy density and low float current

ADVANCED PROCESSES

- Advanced formation process results in a narrow float voltage window making on-site float matching unnecessary
- Highly controlled manufacturing Highly processes for exceptional and consistent plate quality

ADVANCED SERVICE LIFE & WARRANTY

- Proprietary cell design and manufacturing process provides for 20 year design life and documented long-lasting service life
- Best 2V VRLA Warranty in the Market: 7 years full warranty for float service applications

ADVANCED EXPERIENCE

- Over 100 years of experience in the battery industry
- The only producer and marketer of complete battery and electronics systems for total power solutions
- Fully backed by a worldwide network for local service

CONSTANT CURRENT DISCHARGE RATINGS

FV/Cell	Model	1 min	1 hr	2 hr	3 hr	4 hr	5 hr	6 hr	8 hr	10 hr	12 hr	24 hr
1.67	AT-07P	396.6	189.3	122.7	92.5	74.8	63.0	54.5	43.1	35.6	30.4	16.2
	AT-09P	529.7	259.3	170.2	128.7	104.2	87.8	75.9	60.0	49.6	42.3	22.6
	AT-11P	662.1	324.1	212.7	160.9	130.2	109.7	94.9	74.9	62.0	52.9	28.2
	AT-13P	737.1	352.1	228.2	172.1	139.2	117.2	101.4	80.1	66.3	56.6	30.2
	AT-15P	927.0	453.7	297.8	225.3	182.3	153.6	132.9	104.9	86.3	74.1	39.5
	AT-17P	1057.6	504.8	327.2	246.8	199.6	168.1	145.4	114.8	95.0	81.1	43.3
	AT-19P	1191.9	583.4	382.8	289.6	234.4	197.5	170.9	134.9	111.6	95.2	50.8
	AT-21P	1322.0	631.1	409.0	308.5	249.5	201.1	181.9	143.5	118.8	101.4	54.1
	AT-23P	1456.7	713.0	467.9	354.0	286.5	241.4	208.9	164.9	136.4	116.4	62.1
	AT-25P	1586.4	757.3	490.8	370.2	299.3	252.1	218.1	172.2	142.5	121.6	64.9
	AT-27P	1721.6	842.6	553.0	418.4	338.6	285.3	246.8	194.9	161.2	137.6	73.4
	AT-29P	1850.8	883.5	572.7	431.9	349.2	294.1	254.5	200.9	166.3	141.9	75.8
	AT-35P		1101.9	723.3	547.1	442.8	373.0	322.8	254.8	210.8	179.9	96.0
	AT-39P		1199.0	777.2	586.1	474.0	399.2	345.4	272.7	225.6	192.9	102.8

FV/Cell	Model	1 min	1 hr	2 hr	3 hr	4 hr	5 hr	6 hr	8 hr	10 hr	12 hr	24 hr
1.78	AT-07P	357.6	181.0	118.1	89.5	72.7	61.4	53.3	42.3	35.1	30.0	16.2
	AT-09P	477.5	247.6	163.8	124.6	101.2	85.6	74.3	58.9	48.9	41.8	22.5
	AT-11P	596.8	309.5	204.6	155.7	126.6	107.0	92.8	73.6	61.1	52.3	28.1
	AT-13P	665.2	336.6	219.7	166.5	135.2	114.3	99.2	78.7	65.3	55.9	30.1
	AT-15P	835.6	433.3	286.6	218.0	177.2	149.8	130.0	103.1	85.5	73.2	39.3
	AT-17P	953.7	482.6	314.9	238.8	193.9	163.9	142.2	112.8	93.6	80.1	43.1
	AT-19P	1074.3	557.2	368.5	280.2	227.8	192.6	167.1	132.5	110.0	94.1	50.6
	AT-21P	1192.1	603.3	393.7	298.4	242.4	204.8	177.7	141.0	117.0	100.1	53.9
	AT-23P	1313.0	681.0	450.4	342.5	278.4	235.4	204.2	161.9	134.4	115.0	61.8
	AT-25P	1430.5	723.9	472.4	358.1	290.8	245.8	213.3	169.2	140.4	120.2	64.6
	AT-27P	1551.8	804.8	532.3	404.8	329.1	278.2	241.4	191.4	158.8	135.9	73.0
	AT-29P	1669.0	844.6	551.1	417.8	339.3	286.8	248.8	197.4	163.8	140.2	75.4
	AT-35P		1052.4	696.0	529.4	430.3	363.8	315.6	250.3	207.7	177.7	95.5

FV/Cell	Model	1 min	1 hr	2 hr	3 hr	4 hr	5 hr	6 hr	8 hr	10 hr	12 hr	24 hr
1.80	AT-07P	331.9	175.7	115.0	87.5	71.2	60.4	52.5	41.8	34.7	29.8	16.1
	AT-09P	442.9	240.4	159.6	121.7	99.2	84.1	73.1	48.4	48.4	41.5	22.4
	AT-11P	553.7	300.5	199.5	152.2	124.0	105.1	91.4	60.5	60.5	51.8	28.0
	AT-13P	617.4	326.8	214.0	162.7	132.5	112.3	97.6	64.6	64.6	55.4	30.0
	AT-15P	775.1	420.6	279.3	213.1	173.7	147.2	127.9	84.7	84.7	72.6	39.2
	AT-17P	885.1	468.6	306.8	233.3	190.0	160.9	139.9	92.7	92.7	79.4	43.0
	AT-19P	996.6	540.8	359.1	273.9	223.3	189.2	164.5	108.9	108.9	93.3	50.4
	AT-21P	1106.4	585.7	383.5	291.6	237.5	201.2	174.9	115.8	115.8	99.3	53.7
	AT-23P	1218.1	661.0	438.9	334.8	272.9	231.2	201.1	133.0	133.0	114.0	61.6
	AT-25P	1327.6	702.8	460.2	349.9	285.0	241.4	209.9	139.0	139.0	119.1	64.5
	AT-27P	1439.6	781.2	518.7	395.7	322.5	273.3	237.6	157.2	157.2	134.7	72.8
	AT-29P	1548.9	820.0	536.9	408.3	332.5	281.7	244.9	162.2	162.2	139.0	75.2
	AT-35P		1021.6	678.3	517.4	421.8	357.4	310.7	205.6	205.6	176.2	95.3
	AT-39P		1112.8	728.6	554.1	451.8	382.2	332.4	220.1	220.1	188.7	102.1

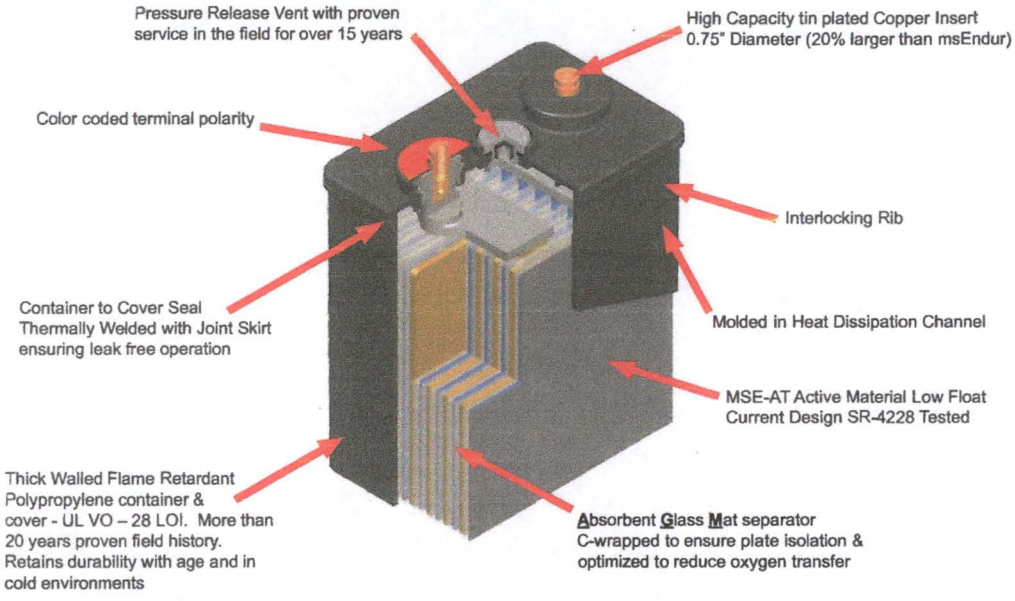
FV/Cell	Model	1 min	1 hr	2 hr	3 hr	4 hr	5 hr	6 hr	8 hr	10 hr	12 hr	24 hr
1.81	AT-07P	319.5	172.7	113.7	86.5	70.4	59.7	51.9	41.3	34.3	29.4	15.9
	AT-09P	426.5	235.8	157.5	120.3	98.1	83.1	72.3	57.5	47.8	41.0	22.1
	AT-11P	533.1	294.7	196.9	150.4	122.6	103.9	90.3	71.9	59.8	51.2	27.7
	AT-13P	594.3	321.2	211.4	160.9	131.0	111.0	96.5	76.8	63.9	54.8	29.6
	AT-15P	746.3	412.6	275.7	210.5	171.7	145.5	126.5	100.6	83.7	71.7	38.8
	AT-17P	852.0	460.5	303.1	230.6	187.8	159.1	138.4	110.1	91.6	78.5	42.5
	AT-19P	959.6	530.5	354.4	270.7	220.7	187.0	162.6	129.3	107.6	92.2	49.8
	AT-21P	1065.0	575.6	378.9	288.3	234.8	198.9	172.9	137.6	114.5	98.1	53.1
	AT-23P	1172.8	648.4	433.2	330.8	269.8	228.6	198.8	158.1	131.5	112.7	60.9
	AT-25P	1278.0	960.7	454.7	346.0	281.8	238.7	207.5	165.1	137.4	117.7	63.7
	AT-27P	1386.0	766.3	511.9	391.0	318.8	270.2	234.9	186.8	155.4	133.2	72.0
	AT-29P	1491.0	805.8	530.4	403.6	328.7	278.5	242.1	192.6	160.3	137.4	74.3
	AT-35P		1002.1	669.5	511.3	416.9	353.3	307.2	244.3	203.2	174.1	94.1
	AT-39P		1093.6	719.9	547.8	446.1	377.9	328.6	261.4	217.5	186.4	100.9

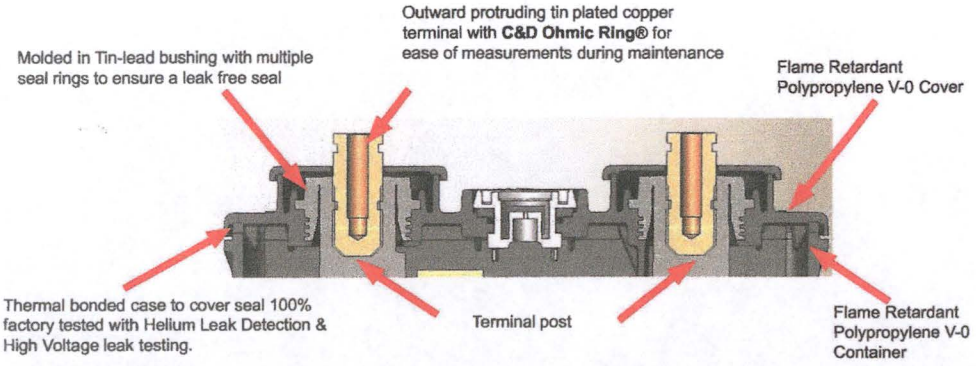
Please refer to the **msEndur II Performance Specifications Brochure, 12-1015,** for an expanded list of constant power and constant current ratings and end voltages.

You may also access the product ratings by logging onto the **C&D Battery Sizing Program** at **www.cdstandbypower.net**

SPECIFICATIONS AND CHARACTERISTICS

Cells, Voltage per Unit	1 cell, 2 VDC Nominal
Recommended Operating Temperature	77°F (25°C)
Recommended Float Charging Voltage	2.25 - 2.27 VPC at 77°F (25°C)
Charger Compensation Temperature / Voltage	-2mV/cell/°F above 77°F (-3.6mV/cell/°C above 25°C) +2mV/cell/°F below 77°F (+3.6mV/cell/°C below 25°C)
Connection Torque	Initial: 160 in-lbs (18 N-m) Re-torque: 125 in-lbs (14 N-m)





MODULES

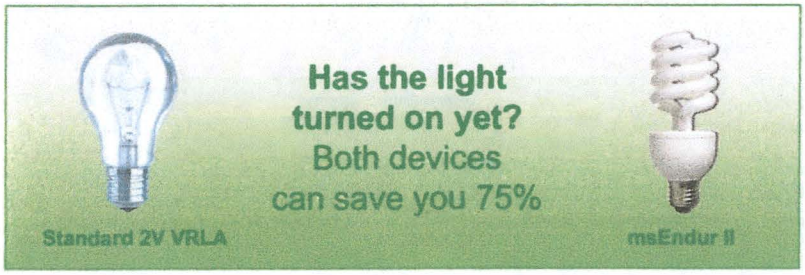
msEndur II cells are designed to be mounted in stackable modules of either 3, 4, 5, 6, 8 or 10 cells.

The specific system configuration is flexible and can be configured to best match the physical requirements of the customer's site.

Detailed system dimensions and combinations are available in the **msEndur II Module Brochure 12-1014.**

SERVICE LIFE - Reliability

The msEndur II is the latest advancement in battery technology. By combining the service life reliability of a flooded battery with the performance energy density of a valve-regulated battery C&D has created the msEndur II — The True Long-Life Battery™. The msEndur II series of batteries are unmatched in power density with space saving modular designs and have a 20-year design life to reduce the total cost of ownership.



The msEndur II VRLA battery is the environmentally friendly battery that saves you money in normal operation.

The same low float current that ensures a twenty year life, is good for the environment and saves money

- Up to 75% lower float current
- Consumes up to 75% less electricity
- Lower float current generates less heat
- Less heat generated reduces required air conditioning
- Less electricity consumed in float charging and air conditioning = reduce carbon emissions

C&D TECHNOLOGIES, INC.

1400 Union Meeting Road
P.O. Box 3053 • Blue Bell, PA 19422-0858
(215) 619-2700 • Fax (215) 619-7899 • (800) 543-8630
customersvc@cdtechno.com
www.cdtechno.com