TEST REPORT – COMPLIANCE

ANSI/CAN/UL 9540A:2019

TÜV SÜD Test Report for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems on Flow Battery

Report No.: Date of issue: Project handler:	7169012527 / 20230202 04/17/2023 Vitaliy Ilkiv
Testing laboratory: Address: Testing location:	TÜV SÜD Canada Inc. 1229 Ringwell Drive, L3Y 8T8, Newmarket, Ontario, Canada As above
Client: Client number: Address: Contact person:	Ashlawn Energy 5010938487 1229 Ringwell Drive, L3Y 8T8, Newmarket, Ontario, Canada Ms. Norma Byron
Standard:	This TÜV SÜD test report form is based on the following requirements: ANSI/CAN/UL 9540A:2019
TRF number and revision*:*	TRF ANSI/CAN/UL 9540A:2019 Rev 0
TRF originated by:	TÜV SÜD Product Service, Mr. Ryan Jin
Copyright blank test report:	This test report is based on the content of the standard (see above). The test report considered selected clauses of the a.m. standard(s) and experience gained with product testing. It was prepared by TUV SUD Product Service. TUV SUD Group takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.
General disclaimer:	This test report may only be quoted in full. Any use for advertising purposes must be granted in writing. This report is the result of a single examination of the object in question and is not generally applicable evaluation of the quality of other products in regular production.
Scheme:	☐ TUV Mark ☒ without certification ☐ AoC/CoC for EU-Directive / EU-Regulation: ☐ GS Mark ☐ NRTL Mark ☐ other:
Non-standard test method: National deviations:	☒ No ☐ Yes, see details under *Summary of testing*
Number of pages *(Report)*: Number of pages *(Attachments)*:	38 0

Compiled by: (+ signature)	Niranjan Sudhakar Digitally signed by: Niranjan Sudhakar	Approved by: (+ signature)	Jeffrey Vivian DN: CN = Jeffrey Vivian email = Jeffrey.Vivian@tuvsud.com C = CA O = TUV SUD Canada Inc. OU = PS-COM-TRN-CA

Test sample - 1: Type of test object: Trademark: Model and/ or type reference:	Vanadium Electrolyte Solution Electrolyte for Energy Storage Battery System  Vanadium Electrolyte Solution
Rating(s):	N/A
Manufacturer: Manufacturer number: Address:	Hong Jing Metal Corporation N/A No. 19 Yongxiang Rd. Fangliao Township, Pingtung County, Taiwan
Name and address of factory(ies) No. 19 Yongxiang Rd. Fangliao Township, Pingtung County, Taiwan	
Sub-contractors / tests (clause): Name:	7.3.2 - Flow battery thermal runaway determination tests TÜV SÜD Canada Inc.
Order description:	☒ Complete test according to TRF ☐ Partial test according to manufacturer's specifications ☐ Preliminary test ☐ Spot check ☐ Others:
Date of order: Date of receipt of test item: Date(s) of performance of test:	NA 03/07/2023 03/16/2023 – 03/17/2023
Test item particulars: Vanadium-based redox flow battery electrolyte.	
Purpose of the product (description of intended use): Electrolyte used in Stationary Battery Energy Storage System	
Attachments: NA	

Test sample - 2: Type of test object: Trademark: Model and/ or type reference:	Vanadium Electrolyte Solution Electrolyte for Energy Storage Battery System Vanadium Electrolyte Solution
Rating(s):	N/A
Manufacturer: Manufacturer number: Address:	U.S. Vanadium, LLC N/A 4285 Malvern Road Hot Springs, Arkansas 71901; U.S.A
Name and address of factory(ies) 4285 Malvern Road Hot Springs, Arkansas 71901; U.S.A	
Sub-contractors / tests (clause): Name:	7.3.2 - Flow battery thermal runaway determination tests TÜV SÜD Canada Inc.
Order description:	☒ Complete test according to TRF
	☐ Partial test according to manufacturer's specifications
	☐ Preliminary test
	☐ Spot check
	☐ Others:
Date of order: Date of receipt of test item: Date(s) of performance of test:	NA 04/05/2023 05/05/2023
Test item particulars: Vanadium-based redox flow battery electrolyte	
Purpose of the product (description of intended use): Electrolyte used in Stationary Battery Energy Storage System	
Attachments: NA	

Individual Cell Stack Information	
Manufacturer ..... :	Ashlawn Energy
Model name..... :	VanCharg™
Chemistry ..... :	Vanadium Redox Flow Battery
Physical configuration..... :	
Dimension (W*L*H)..... :	31.5 (W) x 30.0 (D) x 29.04 (H) (in inches)
Weight..... :	~500 lbs
Total Volume of Electrolyte…….:	420 gal
Nominal voltage ..... :	56 VDC (Open Circuit Voltage)
Rated capacity ..... :	10 kW
Electrolyte Description..... :	2 water-acid/vanadium electrolytes – one with positive charge and one with negative charge
Standard charge method	
AC Charge current..... :	~48 Amps at 208 V for each 10kW battery stack
End of charge voltage..... :	65 VDC
Cut off current ..... :	N/A
Standard discharge method	
AC Discharge current ..... :	72 A at 208V
End of discharge voltage..... :	45 VDC
Electrolyte implementation in Cell Stack	
Design description……..:	Ashlawn Energy interchangeably uses electrolytes from 2 different manufacturers for their cell stacks - Hong Jing Metal Corporation and US Vanadium
Diagram/Photograph of Cell Stack……:	NA

Complete Flow Battery System Information	
Energy storage system (ESS) technologies.....:	☒ Electrochemical ☐ Chemical ☐ Mechanical ☐ Thermal
Intended use location .....:	On and off-grid industrial, commercial, and grid-scale applications
Connection to the mains.....:	N/A
Tested Configuration .....:	N/A
Manufacturer .....:	Ashlawn Energy
Model name.....:	VanCharg™
Is Unit compliant to UL 9540?.....:	No
Enclosure Material .....:	NA
Number of cells/stacks in the system……:	2 stacks
Dimensions (W*L*H).....:	((31.5 (W) x 30.0 (D) x 29.04 (H) (in inches)) x 2
Weight.....:	~1000 lbs
Physical layout of modules in the BESS .....:	NA
Total Volume of Electrolyte……..:	840 gal
Nominal voltage……:	56 VDC (Open Circuit Voltage)
Fire protection features/detection/suppression systems within unit.....:	NA
Heating/Cooling System:	NA
Spacing between modules .....:	NA
Rated Capacity .....:	20 kW
Rated Energy .....:	NA
Nominal voltage .....:	NA
Standard charge method	
Charge current .....:	96A at 208V
End of charge voltage.....:	65 VDC
Cut-off current .....:	TBD
Standard discharge method	
Discharge current.....:	144A at 208V
End of discharge voltage.....:	45 VDC
Rest time between charge and discharge.....:	TBD
Electrolyte implementation in Cell Stack	
Design description……..:	Ashlawn Energy interchangeably uses electrolytes from 2 different manufacturers for their stack systems - Hong Jing Metal Corporation and US Vanadium
Diagram/Picture of Unit……:	NA

Summary of testing:

Verification:

An initial verification of the Pensky-Martens Closed Cup Method was performed by using 80 mL of SAE 5W-30 Motor Oil from Motomaster Canada. The Search feature in the instrument was used to get the approximate flash point of the motor oil sample. For this purpose, “SEARCH-A” program was used in the Flash Point Tester where it scanned from RT at a fast heating ramp rate until flash point was observed. Expected flash point was set in the instrument as 200°C. The observed flash point was 181.9°C. The test was repeated using “ASTM D93A” program and the flash point observed was 181.0°C. Hence, even the SEARCH-A program data with faster ramp rate of the cup reported the flash point within 0.5% accuracy in comparison to the ASTM D93-A test. With these 2 tests, the instrument was verified to be in good working condition.

Flash Point Test:

Electrolyte manufacturer: Hong Jing Metal Corporation

70 mL of the given vanadium redox flow battery electrolyte from Hong Jing Metal Corporation was measured using a graduated cylinder and added to the Pensky-Martens cup. Closed cup method was used to determine the flash point per ASTM D93A. For Sample ID: VAN-2, When the solution temperature reached ~149°C, the sulfuric acid solvent likely boiled off since the liquid temperature in the flash point tester stopped increasing thereafter. The test was continued until the temperature of the cup reached 500°C. No flash point was observed throughout the testing. As part of additional verification, the same test was performed using “ASTM D93B” program. This test was recorded as Sample ID: VAN-3. The electrolyte temperature stopped increasing at ~101°C at which point the test was point since the electrolyte was expected to boil off after this event. No flash point was observed during this test attempt as well.

Electrolyte manufacturer: US Vanadium

No flash point was observed when Flash point test per ASTM D93 (Program set on the machine: ASTM D93A) was performed on 78 mL of the given vanadium redox flow battery electrolyte from US Vanadium. The Sample ID for this test was VAN-4. The test was continued until the block temperature was ~480°C. The maximum electrolyte temperature observed during the test was ~112°C. The electrolyte did not boil off completely, ~40 mL of the electrolyte remained in the cup after the test when measured using a graduated cylinder.

Summary of Flow Battery thermal runaway determination testing – Electrolyte from Hong Jing Metal Corporation	
Electrolyte Description:	Vanadium Electrolyte Solution (Hong Jing Metal Corporation)
Electrolyte Composition:	Vanadium: 5-10 (wt %) Sulfuric Acid: 15-25 wt %
Specific Gravity of the Electrolyte:	1.3 – 1.7 g/cc
Anticipated Flash point temperature range:	No Flashpoint anticipated as per MSDS
Test Method Used:	ASTM D93
Solution of Volume Tested:	70 mL
Maximum Solution Temperature:	149.3°C (ASTM D93-A), 105.4°C (ASTM D93-B)
Flammability of Liquid observed within the boundaries of the selected test method? :	No
Diagram of the test setup:	 

☐ deviation(s) found

☒ no deviations found

Summary of Flow Battery thermal runaway determination testing – Electrolyte from US Vanadium	
Electrolyte Description:	Vanadium Electrolyte Solution (US Vanadium)
Electrolyte Composition:	Vanadyl Sulfate: < 15 (wt %) Vanadium Trisulfate: < 15 (wt %) Sulfuric Acid: < 20 (wt %)
Specific Gravity of the Electrolyte:	1.3 – 1.4 g/cc
Anticipated Flash point temperature range:	No Flashpoint anticipated as per MSDS
Test Method Used:	ASTM D93
Solution of Volume Tested:	78 mL
Maximum Solution Temperature:	112.0 °C
Flammability of Liquid observed within the boundaries of the selected test method? :	No
Diagram of the test setup:	 

☐ deviation(s) found

☒ no deviations found

Additional information on non-standard test method(s)	
Sub clause:	N/A
Page:	N/A
Rationale:	N/A

Possible test case verdicts	
test case does not apply to the test object:	N/A (not applicable / not included in the order)
test object does meet the requirement:	P (Pass)
test object does not meet the requirement:	F (Fail)

General remarks:

"(see remark #)" refers to a remark appended to the report.
"(see appended table)" refers to a table appended to the report.
*Throughout this report **a comma** is used as the decimal separator.*
The test results presented in this report relate only to the object tested.

1.	**Scope**	/
2	**Units of Measurement**	/
3	**Normative References**	/
4	**Glossary**	/

CONSTRUCTION			
5.	**General**		
5.1	Cell		N/A
5.1.1	The cells associated with the BESS that were tested shall be documented in the test report, including cell chemistry (e.g. NMC, LFP), the physical format of the cell (i.e. prismatic, cylindrical, pouch), cell electrical rating in capacity and nominal voltage, the overall dimensions of the cell, and weight.		
5.1.2	The cell documentation included in the test report shall indicate if the cells associated with the BESS comply with UL 1973.		
5.1.3	Refer to 7.6.1 for further details to be included in the cell level test report		
5.2	Module		N/A
5.2.1	The modules associated with the BESS that were tested shall be documented in the test report, including the generic (e. g., metallic or nonmetallic) enclosure material, the general layout of the module contents and the electrical configuration of the cells in the modules and the modules in the BESS.		
5.2.2	The module documentation included in the test report shall indicate if the modules associated with the BESS comply with UL 1973.		
5.2.3	Refer to 8.3 for further details to be included in the module level test report.		
5.3	Battery energy storage system unit		
5.3.1	The BESS unit documentation included in the test report shall indicate the units that comply with UL 9540 and include the manufacturer, model, electrical ratings, and energy capacity of all BESS.		
5.3.2	For BESS units for which UL 9540 compliance cannot be determined, the documentation included in the test report shall include the number of modules in the BESS,		

	electrical configuration of the module, and physical layout of the modules in the BESS, battery management system (BMS) and other major components of the BESS. The BESS enclosure overall dimensions and generic (e. g., metallic or nonmetallic) material used for the enclosure shall be documented. Depending upon the configuration of the BESS (e.g. the power conditioning system is external to the BESS enclosure), a battery system(s) can be tested as representative of the BESS. It shall be documented as to whether the battery system complies with UL 1973 in addition to the overall BESS compliance to UL 9540.		
5.3.3	If applicable, the details of any fire detection and suppression systems that are an integral part of the BESS shall be noted in the test report.		
5.3.4	Refer to 9.7, 10.4 and 10.7 for further details to be included in the unit level and if applicable, installation level test reports.		
5.4	Flow Batteries		P
5.4.1	For flow batteries, the report will cover the chemistry (e.g. vanadium redox, zinc bromine, etc.), a generic description of the electrolyte (s), the overall dimensions of the individual stack as well as the electrical rating in capacity and nominal voltage of the cell stack. The report will also include information on the complete flow battery system including the manufacturer's name and model number of the system, the electrical rating in volts and rated storage capacity in Ah or Wh, the number of cells and stacks in the system, and the maximum volume of electrolyte(s) for the system.	Refer pages 4-5, 24	P
5.4.2	The flow battery documentation included in the test report shall indicate if the flow battery system complies with UL 1973.	Refer Pages 4, 5	N/A
5.4.3	See 7.6.2 for further details to be included in the flow battery thermal runaway determination level test report.	Refer Pages 2-8, 27	N/A
PERFORMANCE			
6.	**General**		N/A
6.1	The tests in this standard are extreme abuse conditions conducted on electrochemical energy storage devices that can result in fires, explosions, smoke, off gassing of flammable and toxic materials, exposure to toxic and corrosive liquids, and potential exposure to hazardous voltages and electrical energy.		

	See Annex B for recommended testing practices.		
6.2	At the conclusion of testing, samples shall be discharged in accordance with the manufacturer's specifications. All samples shall be disposed of in accordance with local regulations.		
9	**Unit Level**		
9.1	Sample and test configuration		N/A
9.1.1	The unit level test shall be conducted with BESS units installed as described in the manufacturer's instructions and this section. Test configurations include the following:		
	a) Indoor floor mounted non-residential use BESS;		
	b) Indoor floor mounted residential use BESS;		
	c) Outdoor ground mounted non-residential use BESS;		
	d) Outdoor ground mounted residential use BESS;		
	e) Indoor wall mounted non-residential use BESS;		
	f) Indoor wall mounted residential use BESS;		
	g) Outdoor wall mounted non-residential use BESS;		
	h) Outdoor wall mounted residential use BESS; and		
	i) Rooftop and open garage non-residential use BESS installations.		
9.1.2	The unit level test requires one initiating BESS unit in which an internal fire condition in accordance with the module level test is initiated and target adjacent BESS units representative of an installation. Tests conducted for indoor floor mounted installations shall be considered representative of both indoor floor mounted and outdoor ground mounted installations with fire propagation hazards and separation distances between initiating and target units representative of the installation. Tests shall be conducted indoors with fire propagation hazards and separation distances between initiating and target units representative of the installation. The results of such tests shall be considered to also represent an outdoor installation. Examples of potential test configurations are shown in Figure 9.1, Figure 9.2, Figure 9.3, and Figure 9.4.		

	Exception: Testing can be conducted outdoors for outdoor only installations if there are the following controls and environmental conditions in place: *a) Wind screens are utilized with a maximum wind speed maintained at ≤ 12 mph;* *b) The temperature range is within 10°C to 40°C (50°F to 104°F);* *c) The humidity is < 90% RH;* *d) There is sufficient light to observe the testing;* *e) There is no precipitation during the testing;* *f) There is control of vegetation and combustibles in the test area to prevent any impact on the testing and to prevent inadvertent fire spread from the test area; and* *g) There are protection mechanisms in place to prevent inadvertent access by unauthorized persons in the test area and to prevent exposure of persons to any hazards as a result of testing.*		
9.1.3	Depending upon the configuration and design of the BESS (e.g. the BESS is composed of multiple separate parts within separate enclosures), this testing to determine fire characterization can be done at the battery system level. The suitability of this approach shall be determined based upon the overall design of the BESS and an analysis of the battery system as representative of the overall BESS for fire characterization concerns.		
9.1.4	The initiating BESS unit shall contain components representative of a BESS unit in a complete installation. Combustible components that interconnect the initiating and target BESS units shall be included.		
9.1.5	Target BESS units shall include the outer cabinet (if part of the design), racking, module enclosures, and components that retain cells components. The target BESS unit module enclosures do not need to contain cells.		
9.1.6	The initiating BESS unit shall be at the maximum operating state of charge (MOSOC), in accordance with the manufacturer's specifications, for conducting the tests in this standard. After charging and prior to testing, the initiating BESS shall rest for a maximum period of 8 h at room ambient.		
9.1.7	If a BESS unit includes an integral fire suppression system, there is an option of providing this with the DUT. If the BESS unit is provided with an optional integral fire suppression system, the system shall not be provided on the DUT.		

9.1.8	Electronics and software controls such as the battery management system (BMS) in the BESS are not relied upon for this testing. This does not include a fire suppression control in accordance with UL 840 that is external to the BESS, but provided as part of an integral fire suppression system per 9.1.7.		
9.2	Test method – Indoor floor mounted BESS units		
9.2.1	Samples and test configurations are in accordance with 9.1. During the test, the test room environment shall be controlled to prevent drafts that may affect test results. At the start of the test, the room ambient temperature shall not be less than 10°C (50°F) nor more than 32°C (90°F).		
9.2.2	Any access door(s) or panels on the initiating BESS unit and adjacent target BESS units shall be closed, latched and locked at the beginning and duration of the test.		
9.2.3	The initiating BESS unit shall be positioned adjacent to two instrumented wall sections.		
9.2.4	Instrumented wall sections shall extend not less than 0.49 m (1.6 ft) horizontally beyond the exterior of the target BESS units.		
9.2.5	Instrumented wall sections shall be at least 0.61-m (2-ft) taller than the BESS unit height, but not less than 3.66 m (12 ft) in height above the bottom surface of the unit.		
9.2.6	The surface of the instrumented wall sections shall be covered with 16-mm (5/8-in) gypsum wall board and painted flat black.		
9.2.7	The initiating BESS unit shall be centered underneath an appropriately sized smoke collection hood of an oxygen consumption calorimeter.		
9.2.8	The light transmission in the calorimeter's exhaust duct shall be measured using a white light source and photo detector for the duration of the test, and the smoke release rate shall be calculated as described in 8.2.15.		
9.2.9	The chemical and convective heat release rates shall be measured for the duration of the test, using the methodologies specified in 8.2.11 and 9.2.12, respectively.		
9.2.10	With reference to 9.2.9, the heat release rate measurement system shall be calibrated using an atomized heptane diffusion burner. The calibration shall be performed using flows of 3.8, 7.6, 11.4 and 15.2 L/min (1, 2, 3 and 4 gpm) of heptane.		
9.2.11	With reference to 9.2.9, the convective heat release rate shall be measured using		

	thermopile, a velocity probe, and a Type K thermocouple, located in the exhaust system of the exhaust duct. See 9.2.12.		
9.2.12	With reference to 9.2.9, the convective heat release rate shall be calculated using the following equation: $HRR_c = V_e A \frac{353.22}{T_e} \int_{T_o}^{T} C_p dT$		
9.2.13	The physical spacing between BESS units (both initiating and target) and adjacent walls shall be representative of the intended installation as noted in 9.1.		
9.2.14	Separation distances shall be specified by the manufacturer for distance between:		
	a) The BESS units and the instrumented wall sections; and		
	b) Adjacent BESS units.		
9.2.15	Wall surface temperature measurements shall be collected for BESS intended for installation in locations with combustible construction. If the intended installation is composed completely of noncombustible construction in which wall assemblies, cables, wiring and any other combustible materials are not to be present in the BESS installation, then the report should note that the installation shall contain no combustible construction and that surface temperature rises can be deemed not applicable.		
9.2.16	Wall surface temperatures shall be measured in vertical array(s) at 152-mm (6-in) intervals for the full height of the instrumented wall sections using No. 24-gauge or smaller, Type-K exposed junction thermocouples. The thermocouples for measuring the temperature on wall surfaces shall be horizontally positioned in the wall locations anticipated to receive the greatest thermal exposure from the initiating BESS unit.		
9.2.17	Thermocouples shall be secured to gypsum surfaces by the use of staples placed over the insulated portion of the wires. The thermocouple tip shall be depressed into the gypsum so as to be flush with the gypsum surface at the point of measurement and held in thermal contact with the surface at that point by the use of pressure-sensitive paper tape.		
9.2.18	Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt-Boelter gauges at the surface of each instrumented wall:		

	a) Both are collinear with the vertical thermocouple array; b) One is positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module; and c) One is positioned at the elevation estimated to receive the greatest heat flux during potential propagation of thermal runaway within the initiating BESS unit.		
9.2.19	Heat flux shall be measured with the sensing element of at least two water-cooled Schmidt-Boelter gauges at the surface of each adjacent target BESS unit that faces the initiating BESS unit: a) One is positioned at the elevation estimated to receive the greatest heat flux due to the thermal runaway of the initiating module within the initiating BESS; and b) One is positioned at the elevation estimated to receive the greatest surface heat flux due to the thermal runaway of the initiating BESS.		
9.2.20	For non-residential use BESS, heat flux shall be measured with the sensing element of at least one water-cooled Schmidt-Boelter gauge positioned at the mid height of the initiating unit in the center of the accessible means of egress.		
9.2.21	No. 24-gauge or smaller, Type-K exposed junction thermocouples shall be installed to measure the temperature of the surface proximate to the cells and between the cells and exposed face of the initiating module. Each non-initiating module enclosure within the initiating BESS unit shall be instrumented with at least one No. 24-gauge or smaller Type-K thermocouple(s) to provide data to monitor the thermal conditions within non-initiating modules. Additional thermocouples shall be placed to account for convoluted enclosure interior geometries.		
9.2.22	For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. The cheesecloth shall be untreated cotton cloth running 26 – 28 m2/kg with a count of 28 – 32 threads in either direction within a 6.45 cm2 (1 in2) area.		
9.2.23	An internal fire condition in accordance with the module level test shall be created within a single module in the initiating BESS unit: a) The position of the module shall be selected to present the greatest thermal exposure to adjacent modules (e.g. above,		

	below, laterally), based on the results from the module level test; and b) The setup (i.e. type, quantity and positioning) of equipment for initiating thermal runaway in the module shall be the same as that used to initiate and propagate thermal runaway within the module level test (Section 8).		
9.2.24	The composition, velocity and temperature of the initiating BESS unit vent gases shall be measured within the calorimeter's exhaust duct. Gas composition shall be measured using a Fourier-Transform Infrared Spectrometer with a minimum resolution of 1 cm-1 and a path length of at least 2.0 m (6.6 ft), or equivalent gas analyzer. Composition, velocity and temperature instrumentation shall be collocated with heat release rate calorimetry instrumentation.		
9.2.25	The hydrocarbon content of the vent gas shall be measured using flame ionization detection.		
9.2.26	The test shall be terminated if:		
	a) Temperatures measured inside each module within the initiating BESS unit return to ambient temperature;		
	b) The fire propagates to adjacent units or to adjacent walls; or		
	c) A condition hazardous to test staff or the test facility requires mitigation.		
9.2.27	For residential use systems, the gas collection data gathered in 9.2 shall be compared to the smallest room installation specified by the manufacturer to determine if the flammable gas collected exceeds 25% LFL in air.		
9.3	Test method – Outdoor ground mounted units		
9.3.1	Outdoor ground mounted non-residential use BESS being evaluated for installation in close proximity to buildings and structures shall use the test method described in Section 9.2. If intended for outdoor use only installations, the smoke release rate, the convective and chemical heat release rate and content, velocity and temperature of the released vent gases need not be measured.		
9.3.2	Outdoor ground mounted residential use BESS being evaluated for installation in close proximity to buildings and structures shall use the test method described in Section 9.2 except as noted in 9.3.3 and 9.3.4. Heat flux measurements for the accessible means of egress shall be measured in accordance with		

	9.2.20. If intended for outdoor use only installations, the smoke release rate, the convective and chemical heat release rate and content, velocity and temperature of the released vent gases need not be measured.		
9.3.3	Test samples shall be installed as shown in Figure 9.2 in proximity to an instrumented wall section that is 3.66-m (12-ft) tall with a 0.3-m (1-ft) wide horizontal soffit (undersurface of the eave shown in Figure 9.2). The sample shall be mounted on a support substrate and spaced from the wall in accordance with the minimum separation distances specified by the manufacturer. The wall and soffit shall be constructed with 19.05-mm (3/4-in) plywood installed on wood studs and painted flat black. The instrumented wall shall extend not less than 0.49-m (1.6-ft) horizontally beyond the exterior of the target BESS units. The No. 24-gauge or smaller, Type-K exposed junction thermocouple array on the walls as noted in 9.2.16 shall extend to the surface of the soffit as shown in Figure 9.2.		
	Exception: If the manufacturer requires installation against non-flammable material, the test setup may include manufacturer recommended backing material between the unit and plywood wall.		
9.3.4	Target BESS shall be installed on each side of the initiating BESS in accordance with the manufacturer's installation specifications. The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer.		
9.4	Test Method – Indoor wall mounted units		
9.4.1	Testing of indoor wall mounted BESS shall be in accordance with Section 9.2, except as modified in this section. See Figure 9.3.		
9.4.2	The test shall be conducted in a standard NFPA 286 fire test room, 3.66 × 2.44 × 2.44-m (12 × 8 × 8-ft) high, with a 0.76 × 2.13-m (2-1/2 × 7-ft) high opening. The room shall be constructed with 16-mm (5/8-in) gypsum wall board installed on wood studs and painted flat black.		
9.4.3	The initiating BESS unit shall be positioned on the wall opposite of the door opening, with the center located 1.22-m (4-ft) above the floor, and halfway between adjacent walls.		
9.4.4	Target BESS shall be installed on the wall on each side of the initiating BESS, at the same height above the floor as the initiating BESS.		

	The physical spacing between BESS units (both initiating and target) shall be the minimum separation distances specified by the manufacturer.		
9.4.5	The wall on which the initiating and target BESS units are mounted shall be instrumented in accordance with Section 9.2.		
9.4.6	The gas collection methods shall be in accordance with 9.2. For residential use systems, the gas collection data gathered in 9.2 shall be compared to the smallest room installation specified by the manufacturer to determine if the flammable gas collected exceeds 25% LFL in air.		
9.4.7	For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. The cheesecloth shall be untreated cotton cloth running 26 – 28 m2/kg with a count of 28 – 32 threads in either direction within a 6.45 cm2 (1 in2) area.		
9.5	Test Method – Outdoor wall mounted units		
9.5.1	Testing of outdoor wall mounted BESS shall be in accordance with Section 9.2, except as modified in this section. See Figure 9.4. If intended for outdoor use only wall mount installations, the smoke release rate, the convective and chemical heat release rate; and the content, velocity and temperature of the released vent gases need not be measured.		
9.5.2	Test samples shall be mounted on an instrumented wall section that is 3.66-m (12-ft) tall with a 0.3-m (1-ft) wide horizontal soffit (undersurface of the eave shown in Figure 9.4). The wall and soffit shall be constructed with 19.05-mm (3/4-in) plywood installed on wood studs and painted flat black. The instrumented wall shall extend not less than 0.49-m (1.6-ft) horizontally beyond the exterior of the target BESS units. The No. 24-gauge or smaller, Type-K exposed junction thermocouple array on the walls as noted in 9.2.16 shall extend to the surface of the soffit as shown in Figure 9.4.		
9.5.3	The initiating BESS unit shall be positioned on the instrumented wall, with its center located 1.22-m (4-ft) above the floor, and halfway between wall edges.		
9.5.4	Target BESS shall be installed on the wall on each side of the initiating BESS, at the same height above the floor as the initiating BESS. The physical spacing between BESS units (both initiating and target) shall be the		

	minimum separation distances specified by the manufacturer.		
9.5.5	The wall on which the initiating and target BESS units are mounted shall be instrumented in accordance with Section 9.2.		
9.5.6	For residential use BESS, the DUT shall be covered with a single layer of cheese cloth ignition indicator. The cheesecloth shall be untreated cotton cloth running 26 – 28 m2/kg with a count of 28 – 32 threads in either direction within a 6.45 cm2 (1 in2) area .		
9.6	Rooftop and open garage installations		
9.6.1	Testing of BESS intended for non-residential use rooftop or open garage installations shall be in accordance with 9.2.		
9.6.2	If intended for rooftop and open garage use only installations, the smoke release rate, the convective and chemical heat release rate and content, velocity and temperature of the released vent gases need not be measured.		
9.7	Unit level test report		
9.7.1	The report on the unit level testing shall identify the type of installation being tested, as follows:		
	a) Indoor floor mounted non-residential use BESS;		
	b) Indoor floor mounted residential use BESS;		
	c) Outdoor ground mounted non-residential use BESS;		
	d) Outdoor ground mounted residential use BESS;		
	e) Indoor wall mounted non-residential use BESS;		
	f) Indoor wall mounted residential use BESS;		
	g) Outdoor wall mounted non-residential use BESS;		
	h) Outdoor wall mounted residential use BESS;		
	i) Rooftop installed non-residential use BESS; or		
	j) Open garage installed non-residential use BESS.		
9.7.2	With reference to 9.7.1, if testing is intended to represent more than one installation type, this shall be noted in the report.		
9.7.3	The report shall include the following, as applicable:		
	a) Unit manufacturer name and model number (and whether UL 9540 compliant);		
	b) Number of modules in the initiating BESS unit;		

	c) The construction of the initiating BESS unit per 5.3;		
	d) Fire protection features / detection / suppression systems within unit;		
	e) Module voltage(s) corresponding to the tested SOC;		
	f) The thermal runaway initiation method used;		
	g) Location of the initiating module within the BESS unit;		
	h) Diagram and dimensions of the test setup including mounting location of the initiating and target BESS units, and the locations of walls, ceilings, and soffits;		
	i) Observation of any flaming outside the initiating BESS enclosure and the maximum flame extension;		
	j) Chemical and convective heat release rate versus time data;		
	k) Separation distances from the initiating BESS unit to target walls (e. g. distances A and C in Figure 9.1);		
	l) Separation distances from the initiating BESS unit to target BESS units (e.g. distances D and H in Figure 9.1);		
	m) The maximum wall surface and target BESS temperatures achieved during the test and the location of the measuring thermocouple;		
	n) The maximum ceiling or soffit surface temperatures achieved during the indoor or outdoor wall mounted test and the location of the measuring thermocouple;		
	o) The maximum incident heat flux on target wall surfaces and target BESS units;		
	p) The maximum incident heat flux on target ceiling or soffit surfaces achieved during the indoor or outdoor wall mounted test;		
	q) Gas generation and composition data;		
	r) Peak smoke release rate and total smoke release data;		
	s) Indication of the activation of integral fire protection systems and if activated the time into the test at which activation occurred;		
	t) Observation of flying debris or explosive discharge of gases;		
	u) Observation of re-ignition(s) from thermal runaway events;		
	v) Observation(s) of sparks, electrical arcs, or other electrical events;		
	w) Observations of the damage to: 1) The initiating BESS unit; 2) Target BESS units; 3) Adjacent walls, ceilings, or soffits; and		

	x) Photos and video of the test.		
9.8	Performance at unit level testing		
9.8.1	Installation level testing in Section 10 is not required if the following performance conditions outlined in Table 9.1 are met during the unit level test.		
Table 9.1	**Unit Level Performance Criteria**		
	Non-Residential Installations: Indoor Floor Mounted		
	a) Flaming outside the initiating BESS unit is not observed;		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation in locations with combustible constructions, surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15;		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		
	e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m^2.		
	Non-Residential Installations: Outdoor Ground Mounted		
	a) If flaming outside of the unit is observed, separation distances to exposures shall be determined by greatest flame extension observed during test.		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation near exposures, surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15;		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		
	e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m^2.		

	Non-Residential Installations: Indoor Wall Mounted		
	a) Flaming outside the initiating BESS unit is not observed;		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15;		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		
	e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m^2.		
	Non-Residential Installations: Outdoor Wall Mounted		
	a) Flaming outside the initiating BESS unit is not observed;		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation on walls with combustible construction, surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15;		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		
	e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m^2.		
	Non-Residential Installations: Rooftop and Open Garages		
	a) If flaming outside the unit is observed, separation distances to exposures shall be determined by greatest flame extension observed during test;		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation in locations with combustible construction,		

	surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15;		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		
	e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m^2.		
	Residential Installations: Indoor Floor Mounted		
	a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator;		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15;		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		
	e) The concentration of flammable gas does not exceed 25% LFL in air for the smallest specified room installation size.		
	Residential Installations: Outdoor Ground Mounted		
	a) If flaming outside the unit is observed, separation distances to exposures shall be determined by greatest flame extension observed during test.		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for near exposures, surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15;		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		

	e) Heat flux in the center of the accessible means of egress shall not exceed 1.3 kW/m^2.		
	Residential Installations: **Indoor Wall Mounted**		
	a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator;		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15;		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases; and		
	e) The concentration of flammable gas does not exceed 25% LFL for the smallest intended room installation size.		
	Residential Installations: **Outdoor Wall Mounted**		
	a) Flaming outside the initiating BESS unit is not observed as demonstrated by no flaming or charring of the cheesecloth indicator;		
	b) Surface temperatures of modules within the target BESS units adjacent to the initiating BESS unit do not exceed the temperature at which thermally initiated cell venting occurs, as determined in 7.3.1.8;		
	c) For BESS units intended for installation in locations with combustible construction, surface temperature measurements on wall surfaces do not exceed 97K of temperature rise above ambient per 9.2.15; and		
	d) Explosion hazards are not observed, including deflagration, detonation or accumulation (to within the flammability limits in an amount that can cause a deflagration) of battery vent gases.		
ANNEX A	**(INFORMATIVE) Test Concepts And Application Of Test Results To Installations**		
A1	Introduction		
A2	Test Methodology and Purpose		
A3	Evaluating the Results		

ANNEX B	**(INFORMATIVE) Safety Recommendations for Testing**		
B1	General		

TABLE 1: Critical components information – Electrolyte from Hong Jing Metal Corporation					
CAS No.	**Manufacturer/ trademark**	**Description**	**Technical data**	**Standard**	**Mark(s) of conformity**
7664-93-9	Sigma Aldrich	Sulfuric Acid	15-25 wt%	N/A	N/A
1314-62-1	Sigma Aldrich	Vanadium	5-10 wt%	N/A	N/A
Supplementary information: The above electrolyte mixture with the above composition was prepared by Hong Jing Metal Corporation.					

TABLE 2: Critical components information – Electrolyte from US Vanadium					
CAS No.	**Manufacturer/ trademark**	**Description**	**Technical data**	**Standard**	**Mark(s) of conformity**
27774-13-6	Sigma Aldrich	Vanadyl sulfate	< 15 wt%	N/A	N/A
13701-70-7	Sigma Aldrich	Vanadium trisulfate	< 15 wt%	N/A	N/A
7664-93-9	Sigma Aldrich	Sulfuric acid	< 20 wt %	N/A	N/A
Supplementary information: The above electrolyte mixture with the above composition was prepared by US Vanadium.					

TABLE 3: Test equipment used					
Gauge ID / Part no.	**Manufacturer/ trademark**	**Type/model**	**Description / Technical data**	**Standard**	**Calibration**
PM-FPT-01	Anton Paar	PMA5	Closed cup Flash Point Tester	N/A	Verified prior to Use
BP8203-1GAL	Fischer Scientific	NA	70% v/v Denatured Ethanol Solution	N/A	N/A

TABLE 4: Flash Point Test Results					
Sample ID	**Program**	**Test type**	**Observed Flash Point (°C)**	**Observed maximum electrolyte temperature (°C)**	**Barometric Pressure (kPa)**
QC	SEARCH-A	Verification	181.9	181.2	98.5
OIL1	D93-A	Flash point test	181.1	180.2	97.9
VAN2	D93-A	Flash point test	No Flash Point	149.3	95.9
VAN3	D93-B	Flash point test	No Flash Point	105.4	96.1
VAN4	D93-A	Flash point test	No Flash Point	112.3	98.5

	TABLE 5: Critical components information – Electrolyte from Hong Jing Metal Corporation				
CAS No.	**Manufacturer/ trademark**	**Description**	**Technical data**	**Standard**	**Mark(s) of conformity**
7664-93-9	Sigma Aldrich	Sulfuric Acid	15-25 wt%	N/A	N/A
1314-62-1	Sigma Aldrich	Vanadium	5-10 wt%	N/A	N/A
Supplementary information: The above electrolyte mixture with the above composition was prepared by Hong Jing Metal Corporation.					

Flash Point Test Results Summary

ANTON PAAR

PMA 5-Version 1.20.1 Device No. 60062437 Date: 4/11/2023

OPERATOR default

SAMPLE NAME	PROG NAME	EFP C|F	SAMPLE C|F	FP STAT	FPc C|F	FPcrd C|F	BAP kPa	GRADIENT C|F/min	IGN STAT	STOP STAT	TIME HH:MM	TEMP UNIT	START HH:MM	STOP HH:MM	DATE TYPE
VAN4	D93-A	375	112.3	NoFP	----	----	98.5	1 E	Head	interrupt	8:32	°C	7:56	8:32	4/6/2023
VAN3	D93-B	345	105.4	NoFP	----	----	96.1	1 E	Key		14:55	°C	14:55		3/17/2023
VAN2	D93-A	370	149.3	NoFP	----	----	95.9	5 E	Head	interrupt	11:52	°C	11:04	11:52	3/17/2023
VAN1	SEARCH-A	900	101.4	NoFP	----	----	96.1	5 E	HW-Error	Board-Temperature	9:09	°C	8:50	9:09	3/17/2023
OIL1	D93-A	182	180.2	FPok	181.1	181	97.9	5 E	Flash	point	10:53	°C	10:21	10:53	3/16/2023
QC	SEARCH-A	237	181.2	FPok	181.9	181.9	98.5	5 E	Flash	point	15:08	°C	14:36	15:08	3/15/2023

Data log - Sample ID: QC

Date/Time	Status	Phase	Nom-BT	Corr-BT	Act-BT	Nom-BG	Act-BG	Act-ST	Nom-SG	Act-SG	Nom-HP	Act-HP	BAP	LM73	Gasindi	Time	
3/15/2023	14:36	RUNNING	0	----	0	27.3	6.2	0	23.4	5.5	0	90	90	98.5	26.3	-1	0:00:00
3/15/2023	14:37	RUNNING	0	----	0	----	6.2	0	23.9	5.5	0	90	90	98.5	26.5	31	0:01:00
3/15/2023	14:38	RUNNING	D	----	0	----	6.2	0	25.8	5.5	0	17	7	98.5	26.5	49	0:02:00
3/15/2023	14:39	TESTING:	D	----	0	----	6.2	0	29.3	5.5	3.5	18	7	98.5	26.8	105	0:03:00
3/15/2023	14:40	TESTING:	1	----	0	----	6.2	0	33.5	5.5	4.2	18	15	98.5	27.2	144	0:04:00
3/15/2023	14:41	TESTING:	1	----	0	----	6.2	8.5	37.9	5.5	4.6	19	12	98.5	27.5	127	0:05:00
3/15/2023	14:42	TESTING:	1	----	3.2	----	6.2	8.3	43.1	5.5	5.1	20	15	98.5	28	98	0:06:00
3/15/2023	14:43	TESTING:	1	----	3.2	----	6.2	8.5	48	5.5	5	21	18	98.5	28.3	126	0:07:00
3/15/2023	14:44	TESTING:	1	----	1.6	----	6.2	8	53.4	5.5	5.4	22	17	98.5	28.7	95	0:08:00
3/15/2023	14:45	TESTING:	1	----	-0.8	----	6.2	7.2	59.2	5.5	5.8	23	15	98.5	29.2	124	0:09:00
3/15/2023	14:46	TESTING:	1	----	-0.8	----	6.2	5.3	64.9	5.5	5.8	24	16	98.5	29.6	105	0:10:00
3/15/2023	14:47	TESTING:	1	----	-0.8	----	6.2	5.5	70.7	5.5	5.7	24	15	98.5	30	93	0:11:00
3/15/2023	14:48	TESTING:	1	----	-0.8	----	6.2	5.2	76.4	5.5	5.8	25	16	98.5	30.5	106	0:12:00
3/15/2023	14:49	TESTING:	1	----	-0.8	----	6.2	6.5	82	5.5	5.6	26	16	98.5	30.9	109	0:13:00
3/15/2023	14:50	TESTING:	1	----	0.5	----	6.2	4.6	87.4	5.5	5.5	26	18	98.6	31.3	109	0:14:00
3/15/2023	14:51	TESTING:	1	----	0.5	----	6.2	7.6	92.7	5.5	5.3	27	16	98.6	31.7	110	0:15:00
3/15/2023	14:52	TESTING:	1	----	0.8	----	6.2	6.4	97.8	5.5	5.1	28	19	98.6	32.1	134	0:16:00
3/15/2023	14:53	TESTING:	1	----	2.9	----	6.2	8.4	----	5.5	5.2	29	21	98.6	32.5	103	0:17:00
3/15/2023	14:54	TESTING:	1	----	3.7	----	6.2	7.7	----	5.5	5.2	30	28	98.6	33	93	0:18:00
3/15/2023	14:55	TESTING:	1	----	2.4	----	6.2	10	----	5.5	5.2	32	24	98.5	33.4	109	0:19:00
3/15/2023	14:56	TESTING:	1	----	2.4	----	6.2	8.4	----	5.5	5.3	32	19	98.6	33.7	97	0:20:00
3/15/2023	14:57	TESTING:	1	----	2.9	----	6.2	8.7	----	5.5	5.4	33	22	98.5	34.2	127	0:21:00
3/15/2023	14:58	TESTING:	1	----	0.8	----	6.2	5.7	----	5.5	5.3	34	24	98.6	34.6	132	0:22:00
3/15/2023	14:59	TESTING:	1	----	0.8	----	6.2	6.5	----	5.5	5.5	35	26	98.6	35	123	0:23:00
3/15/2023	15:00	TESTING:	1	----	0	----	6.2	7.3	----	5.5	5.3	36	23	98.6	35.5	76	0:24:00
3/15/2023	15:01	TESTING:	1	----	0	----	6.2	5.5	----	5.5	5.4	37	27	98.5	35.8	86	0:25:00
3/15/2023	15:02	TESTING:	1	----	2.9	----	6.2	10.8	----	5.5	5.2	38	22	98.6	36.2	73	0:26:00
3/15/2023	15:03	TESTING:	1	----	2.9	----	6.2	6.9	----	5.5	5.3	39	29	98.5	36.5	125	0:27:00
3/15/2023	15:04	TESTING:	1	----	1.6	----	6.2	6.5	----	5.5	5.2	40	33	98.5	36.9	74	0:28:00
3/15/2023	15:05	TESTING:	1	----	2.4	----	6.2	8.1	----	5.5	5.1	41	36	98.5	37.2	86	0:29:00
3/15/2023	15:06	TESTING:	1	----	2.4	----	6.2	8.8	----	5.5	5.1	42	29	98.5	37.6	77	0:30:00
3/15/2023	15:07	TESTING:	1	----	3.7	----	6.2	10.2	----	5.5	5.1	43	27	98.5	38	94	0:31:00
3/15/2023	15:08	TESTING:	1	----	3.2	----	6.2	7.3	----	5.5	5.3	44	36	98.5	38.3	106	0:32:00
3/15/2023	15:08	FP	1	----	3.2	----	6.2	7.4	----	5.5	5.1	44	33	98.5	38.4	118	0:32:00

Data log – Sample ID: OIL1

Date/Time	Status	Phase	Nom-BT	Corr-BT	Act-BT	Nom-BG	Act-BG	Act-ST	Nom-SG	Act-SG	Nom-HP	Act-HP	BAP	LM73	Gasindi	Time	
3/16/2023	10:21	RUNNING	0	----	0	23.8	6.2	0	23.8	5.5	0	90	90	97.9	29	0	0:00:00
3/16/2023	10:22	RUNNING	0	----	0	----	6.2	0	23.8	5.5	0	90	90	97.9	29	39	0:01:00
3/16/2023	10:23	RUNNING	D	----	0	----	6.2	0	25	5.5	0	17	6	97.9	29	15	0:02:00
3/16/2023	10:24	RUNNING	D	----	0	----	6.2	0	27.9	5.5	2.9	17	7	97.9	29.2	10	0:03:00
3/16/2023	10:25	RUNNING	1	----	0	----	6.2	0	31.9	5.5	4.1	18	13	97.9	29.3	26	0:04:00
3/16/2023	10:26	RUNNING	1	----	0	----	6.2	8	36.1	5.5	4.2	19	12	97.9	29.5	18	0:05:00
3/16/2023	10:27	RUNNING	1	----	3.2	----	6.2	8.3	40.8	5.5	4.7	20	15	97.9	29.7	49	0:06:00
3/16/2023	10:28	RUNNING	1	----	3.2	----	6.2	8.8	45.7	5.5	5	21	18	97.9	29.9	23	0:07:00
3/16/2023	10:29	RUNNING	1	----	3.2	----	6.2	7.8	50.7	5.5	5	22	23	97.9	30	55	0:08:00
3/16/2023	10:30	RUNNING	1	----	1.6	----	6.2	9.9	56	5.5	5.4	23	18	97.9	30.2	29	0:09:00
3/16/2023	10:31	RUNNING	1	----	1.6	----	6.2	6.9	61.6	5.5	5.6	24	17	97.9	30.5	41	0:10:00
3/16/2023	10:32	RUNNING	1	----	-0.8	----	6.2	5.7	67.3	5.5	5.8	25	17	97.9	30.6	31	0:11:00
3/16/2023	10:33	RUNNING	1	----	-0.8	----	6.2	5.5	73	5.5	5.7	25	17	97.9	30.7	38	0:12:00
3/16/2023	10:34	RUNNING	1	----	0	----	6.2	5.5	78.7	5.5	5.7	26	19	97.9	30.9	32	0:13:00
3/16/2023	10:35	RUNNING	1	----	0	----	6.2	6.3	84.3	5.5	5.7	27	20	97.9	31	38	0:14:00
3/16/2023	10:36	RUNNING	1	----	0	----	6.2	5.9	89.7	5.5	5.4	28	20	97.9	31.2	61	0:15:00
3/16/2023	10:37	RUNNING	1	----	1.3	----	6.2	8.6	95	5.5	5.3	28	18	97.9	31.3	36	0:16:00
3/16/2023	10:38	RUNNING	1	----	1.6	----	6.2	6.2	----	5.5	5.3	29	20	97.9	31.5	73	0:17:00
3/16/2023	10:39	RUNNING	1	----	2.9	----	6.2	7.5	----	5.5	5.2	31	27	97.9	31.6	39	0:18:00
3/16/2023	10:40	RUNNING	1	----	1.6	----	6.2	9	----	5.5	5.4	32	24	97.9	31.8	58	0:19:00
3/16/2023	10:41	RUNNING	1	----	1.6	----	6.2	7.8	----	5.5	5.2	32	20	97.9	32	39	0:20:00
3/16/2023	10:42	RUNNING	1	----	0.8	----	6.2	5.8	----	5.5	5.3	33	24	97.9	32.1	56	0:21:00
3/16/2023	10:43	RUNNING	1	----	1.6	----	6.2	8.1	----	5.5	5.3	34	23	97.9	32.2	42	0:22:00
3/16/2023	10:44	RUNNING	1	----	1.6	----	6.2	6.3	----	5.5	5.3	35	28	97.9	32.4	45	0:23:00
3/16/2023	10:45	RUNNING	1	----	0.8	----	6.2	7.9	----	5.5	5.4	36	26	97.9	32.5	40	0:24:00
3/16/2023	10:46	RUNNING	1	----	0.8	----	6.2	6.3	----	5.5	5.4	37	26	97.9	32.7	45	0:25:00
3/16/2023	10:47	RUNNING	1	----	2.1	----	6.2	9	----	5.5	5.2	38	25	97.9	32.9	41	0:26:00
3/16/2023	10:48	RUNNING	1	----	2.9	----	6.2	7.7	----	5.5	5.2	39	29	97.9	33	47	0:27:00
3/16/2023	10:49	RUNNING	1	----	1.6	----	6.2	6.8	----	5.5	5.3	40	34	97.9	33.2	58	0:28:00
3/16/2023	10:50	TESTING:	1	----	2.4	----	6.2	8.1	----	5.5	5.1	41	34	97.9	33.4	74	0:29:00
3/16/2023	10:51	TESTING:	1	----	2.4	----	6.2	8.9	----	5.5	5.3	42	27	97.9	33.7	93	0:30:00
3/16/2023	10:52	TESTING:	1	----	2.9	----	6.2	9	----	5.5	5.3	43	29	97.9	33.9	94	0:31:00
3/16/2023	10:53	TESTING:	1	----	2.1	----	6.2	6.5	----	5.5	5.2	44	34	97.9	34.2	109	0:32:00
3/16/2023	10:53	FP	1	----	2.1	----	6.2	8.1	----	5.5	5.3	44	29	97.9	34.2	97	0:32:16

Data log - Sample ID: VAN1

Date/Time	Status	Phase	Nom-BT	Corr-BT	Act-BT	Nom-BG	Act-BG	Act-ST	Nom-SG	Act-SG	Nom-HP	Act-HP	BAP	LM73	Gasindi	Time	
3/17/2023	8:50	STARTING ...		0	----	0	24.6	6.2	0	25.1	5.5	0	90	90	96.1	29.7	0:00:00
3/17/2023	8:51	TESTING:	0	----	0	----	6.2	0	25.6	5.5	0	90	90	96.1	29.7	145	0:01:00
3/17/2023	8:52	TESTING:	D	----	0	----	6.2	0	27.9	5.5	0	17	7	96.1	29.7	154	0:02:00
3/17/2023	8:53	TESTING:	D	----	0	----	6.2	0	31.1	5.5	0	18	7	96.1	30	137	0:03:00
3/17/2023	8:54	TESTING:	1	----	0	----	6.2	0	34.6	5.5	3.5	18	15	96.1	30.2	144	0:04:00
3/17/2023	8:55	TESTING:	1	----	0	----	6.2	9	38.3	5.5	3.8	19	12	96.1	30.3	152	0:05:00
3/17/2023	8:56	TESTING:	1	----	3.2	----	6.2	7.8	42.3	5.5	3.9	20	15	96.1	30.6	141	0:06:00
3/17/2023	8:57	TESTING:	1	----	3.2	----	6.2	9.4	46.4	5.5	4.1	21	16	96.1	30.9	131	0:07:00
3/17/2023	8:58	TESTING:	1	----	3.2	----	6.2	7.7	50.7	5.5	4.4	23	22	96.1	31.1	130	0:08:00
3/17/2023	8:59	TESTING:	1	----	3.2	----	6.2	9.2	55.2	5.5	4.5	24	24	96.1	31.5	126	0:09:00
3/17/2023	9:00	TESTING:	1	----	3.2	----	6.2	9.8	59.8	5.5	4.7	24	17	96.1	31.7	132	0:10:00
3/17/2023	9:01	TESTING:	1	----	3.2	----	6.2	9.2	64.6	5.5	4.8	26	19	96.1	32	117	0:11:00
3/17/2023	9:02	TESTING:	1	----	3.2	----	6.2	8.3	69.5	5.5	4.9	27	20	96.1	32.3	146	0:12:00
3/17/2023	9:03	TESTING:	1	----	3.2	----	6.2	8.4	74.6	5.5	5.2	28	22	96.1	32.7	105	0:13:00
3/17/2023	9:04	TESTING:	1	----	2.4	----	6.2	8.2	79.8	5.5	5.2	29	25	96.1	33	142	0:14:00
3/17/2023	9:05	TESTING:	1	----	2.4	----	6.2	8.6	85.2	5.5	5.4	30	21	96.1	33.2	109	0:15:00
3/17/2023	9:06	TESTING:	1	----	1.6	----	6.2	7.2	90.5	5.5	5.5	31	22	96.1	33.6	117	0:16:00
3/17/2023	9:07	TESTING:	1	----	0	----	6.2	6	96	5.5	5.5	32	22	96.1	33.9	103	0:17:00
3/17/2023	9:08	TESTING:	1	----	1.3	----	6.2	6.8	----	5.5	5.4	32	24	96.1	34.2	102	0:18:00

Data log - Sample ID: VAN2

Date/Time	Status	Phase	Nom-BT	Corr-BT	Act-BT	Nom-BG	Act-BG	Act-ST	Nom-SG	Act-SG	Nom-HP	Act-HP	BAP	LM73	Gasindi	Time	
3/17/2023	11:05	RUNNING	0	----	0	25.8	6.2	0	22.7	5.5	0	90	90	95.9	30.1	0	0:00:00
3/17/2023	11:05	RUNNING	0	----	0	----	6.2	0	23.5	5.5	0	90	90	95.9	30.2	30	0:01:00
3/17/2023	11:06	RUNNING	D	----	0	----	6.2	0	26	5.5	0	17	7	96	30.2	12	0:02:00
3/17/2023	11:07	RUNNING	D	----	0	----	6.2	0	29.2	5.5	0	18	7	96	30.2	33	0:03:00
3/17/2023	11:08	RUNNING	1	----	0	----	6.2	0	32.7	5.5	3.6	18	16	96	30.4	16	0:04:00
3/17/2023	11:09	RUNNING	1	----	0	----	6.2	9.4	36.4	5.5	3.7	19	12	95.9	30.6	12	0:05:00
3/17/2023	11:10	RUNNING	1	----	3.2	----	6.2	7.7	40.4	5.5	4	20	15	95.9	30.7	24	0:06:00
3/17/2023	11:11	RUNNING	1	----	3.2	----	6.2	9.4	44.5	5.5	4.2	21	16	96	31	19	0:07:00
3/17/2023	11:12	RUNNING	1	----	3.2	----	6.2	7.2	48.8	5.5	4.3	22	22	95.9	31.2	53	0:08:00
3/17/2023	11:13	RUNNING	1	----	3.2	----	6.2	10	53.4	5.5	4.6	23	22	96	31.3	26	0:09:00
3/17/2023	11:14	RUNNING	1	----	3.2	----	6.2	9.3	58	5.5	4.7	24	17	96	31.3	84	0:10:00
3/17/2023	11:15	RUNNING	1	----	3.2	----	6.2	9.1	62.8	5.5	4.9	25	17	96	31.6	27	0:11:00
3/17/2023	11:16	RUNNING	1	----	3.2	----	6.2	8.5	67.8	5.5	5	27	21	95.9	31.8	70	0:12:00
3/17/2023	11:17	RUNNING	1	----	3.2	----	6.2	8.7	73	5.5	5.3	28	22	96	31.8	32	0:13:00
3/17/2023	11:18	RUNNING	1	----	0.8	----	6.2	8.2	78.4	5.5	5.3	29	20	95.9	32	69	0:14:00
3/17/2023	11:19	RUNNING	1	----	0.8	----	6.2	6.1	83.9	5.5	5.5	29	20	95.9	32.2	33	0:15:00
3/17/2023	11:20	RUNNING	1	----	0	----	6.2	6.4	89.3	5.5	5.5	30	20	95.9	32.3	46	0:16:00
3/17/2023	11:21	RUNNING	1	----	0	----	6.2	6	94.8	5.5	5.5	31	21	95.9	32.5	34	0:17:00
3/17/2023	11:22	RUNNING	1	----	-0.8	----	6.2	6	----	5.5	5.5	32	21	95.9	32.6	39	0:18:00
3/17/2023	11:23	RUNNING	1	----	1.3	----	6.2	5.1	----	5.5	5.3	33	26	95.9	32.7	37	0:19:00
3/17/2023	11:24	RUNNING	1	----	1.3	----	6.2	8	----	5.5	0.6	33	21	95.9	33	36	0:20:00
3/17/2023	11:25	RUNNING	1	----	3.7	----	6.2	10.6	----	5.5	0.3	34	22	96	33	38	0:21:00
3/17/2023	11:26	RUNNING	1	----	3.7	----	6.2	8.1	----	5.5	0.2	36	26	96	33.3	37	0:22:00
3/17/2023	11:27	RUNNING	1	----	3.2	----	6.2	7.5	----	5.5	0.3	37	32	96	33.5	34	0:23:00
3/17/2023	11:28	RUNNING	1	----	3.2	----	6.2	8.4	----	5.5	0.2	38	37	96	33.5	68	0:24:00
3/17/2023	11:29	RUNNING	1	----	3.2	----	6.2	10.2	----	5.5	0.3	39	25	96	33.7	76	0:25:00
3/17/2023	11:30	RUNNING	1	----	3.7	----	6.2	10	----	5.5	0.4	40	26	95.9	34	109	0:26:00
3/17/2023	11:31	RUNNING	1	----	3.7	----	6.2	7.6	----	5.5	0.4	41	33	95.9	34.2	68	0:27:00
3/17/2023	11:32	RUNNING	1	----	3.7	----	6.2	8.1	----	5.5	0.2	43	41	96	34.5	45	0:28:00
3/17/2023	11:33	RUNNING	1	----	3.2	----	6.2	9.2	----	5.5	0.4	44	42	96	34.7	37	0:29:00
3/17/2023	11:34	RUNNING	1	----	3.2	----	6.2	9.9	----	5.5	0.6	44	32	96	34.9	32	0:30:00
3/17/2023	11:35	RUNNING	1	----	3.2	----	6.2	9.6	----	5.5	0.5	46	34	96	35.2	33	0:31:00
3/17/2023	11:37	RUNNING	1	----	3.2	----	6.2	7	----	5.5	0.7	48	46	95.9	35.7	36	0:33:00
3/17/2023	11:38	RUNNING	1	----	3.2	----	6.2	9	----	5.5	0.8	49	49	95.9	35.9	32	0:34:00
3/17/2023	11:39	RUNNING	1	----	3.2	----	6.2	10.4	----	5.5	0.9	50	38	95.9	36.1	34	0:35:00
3/17/2023	11:40	RUNNING	1	----	3.2	----	6.2	9.3	----	5.5	1.1	51	39	96	36.4	35	0:36:00
3/17/2023	11:41	RUNNING	1	----	3.2	----	6.2	7.6	----	5.5	1.3	52	45	96	36.6	36	0:37:00
3/17/2023	11:42	RUNNING	1	----	3.2	----	6.2	7.9	----	5.5	1.6	54	51	96	36.9	36	0:38:00
3/17/2023	11:43	RUNNING	1	----	3.7	----	6.2	8.1	----	5.5	1.6	55	55	95.9	37.2	45	0:39:00
3/17/2023	11:44	RUNNING	1	----	3.7	----	6.2	11.1	----	5.5	2.1	55	43	96	37.5	37	0:40:00
3/17/2023	11:45	RUNNING	1	----	3.2	----	6.2	9.1	----	5.5	2.4	57	45	96	37.7	38	0:41:00
3/17/2023	11:46	RUNNING	1	----	3.2	----	6.2	8.2	----	5.5	3.1	58	51	95.9	38	39	0:42:00
3/17/2023	11:47	RUNNING	1	----	3.2	----	6.2	6.1	----	5.5	3.5	59	59	95.9	38.3	47	0:43:00
3/17/2023	11:48	RUNNING	1	----	3.2	----	6.2	9.9	----	5.5	4.1	60	60	95.9	38.6	38	0:44:00
3/17/2023	11:49	RUNNING	1	----	3.2	----	6.2	9.4	----	5.5	4.8	61	52	96	38.9	60	0:45:00
3/17/2023	11:50	RUNNING	1	----	3.2	----	6.2	9.4	----	5.5	5.5	62	53	95.9	39.2	51	0:46:00
3/17/2023	11:51	RUNNING	1	----	-0.8	----	6.2	3.5	----	5.5	5.5	63	59	95.9	39.6	53	0:47:00

Data log - Sample ID: VAN3

Date/Time	Status	Phase	Nom-BT	Corr-BT	Act-BT	Nom-BG	Act-BG	Act-ST	Nom-SG	Act-SG	Nom-HP	Act-HP	BAP	LM73	Gaslindi	Time	
3/17/2023	13:48	RUNNING	0	59.8	0	33.5	1.4	0	29.8	1.3	0	25	25	96	31.5	0	0:00:00
3/17/2023	13:49	RUNNING	0	60.3	0	58.6	1.4	0	30.3	1.3	0	25	25	96	31.5	38	0:01:00
3/17/2023	13:50	RUNNING D		56	0	69.9	1.4	0	31	1.3	0	4	1	96	31.5	16	0:02:00
3/17/2023	13:51	RUNNING D		56.8	0	63.9	1.4	0	31.8	1.3	0.8	4	1	96	31.5	9	0:03:00
3/17/2023	13:52	RUNNING D		57.7	0	60.9	1.4	0	32.7	1.3	0.9	4	1	96	31.5	126	0:04:00
3/17/2023	13:53	RUNNING	1	58.9	0	59.3	1.4	0	33.5	1.3	0.8	4	1	96	31.5	50	0:05:00
3/17/2023	13:54	RUNNING	1	63.5	3.2	60.6	1.4	1	34.3	1.3	0.8	5	11	96	31.7	24	0:06:00
3/17/2023	13:55	RUNNING	1	68.2	3.2	67.1	1.4	6.7	35.2	1.3	0.9	5	5	96	31.7	13	0:07:00
3/17/2023	13:56	RUNNING	1	69.6	3.2	70.7	1.4	3.6	36.2	1.3	1	5	1	96	31.9	9	0:08:00
3/17/2023	13:57	RUNNING	1	74.2	3.2	75.2	1.4	4.5	37.1	1.3	0.9	5	1	96	32	6	0:09:00
3/17/2023	13:58	RUNNING	1	77.3	1.6	76.1	1.4	0.9	38.2	1.3	1.1	6	8	96	32	5	0:10:00
3/17/2023	13:59	RUNNING	1	80.3	1.6	79.2	1.4	3.2	39.2	1.3	1	6	8	96	32.2	5	0:11:00
3/17/2023	14:00	RUNNING	1	83.4	1.6	82.4	1.4	3.2	40.4	1.3	1.2	6	6	96	32.2	6	0:12:00
3/17/2023	14:01	RUNNING	1	84.8	1.6	85.5	1.4	3.1	41.6	1.3	1.1	6	2	96	32.4	6	0:13:00
3/17/2023	14:02	RUNNING	1	87.1	0.8	86.8	1.4	1.2	42.8	1.3	1.3	6	5	96	32.4	104	0:14:00
3/17/2023	14:03	RUNNING	1	89.3	0.8	89.2	1.4	2.5	44	1.3	1.3	7	6	96	32.5	29	0:15:00
3/17/2023	14:04	RUNNING	1	90.8	0	90.8	1.4	1.6	45.3	1.3	1.3	7	4	96	32.6	16	0:16:00
3/17/2023	14:05	RUNNING	1	92.2	0	92.1	1.4	1.3	46.6	1.3	1.3	7	5	96	32.7	12	0:17:00
3/17/2023	14:06	RUNNING	1	93.7	0	93.3	1.4	1.2	47.8	1.3	1.2	7	4	96	32.7	10	0:18:00
3/17/2023	14:07	RUNNING	1	96.4	1.3	96.6	1.4	3.3	49.1	1.3	1.3	7	3	96	32.7	9	0:19:00
3/17/2023	14:08	RUNNING	1	97.8	0	96.4	1.4	0	50.4	1.3	1.2	7	7	96	32.9	9	0:20:00
3/17/2023	14:09	RUNNING	1	----	1.3	99.5	1.4	3.1	51.7	1.3	1.3	8	8	96	33	9	0:21:00
3/17/2023	14:10	RUNNING	1	----	0	----	1.4	2.4	52.9	1.3	1.3	8	5	96	33	121	0:22:00
3/17/2023	14:11	RUNNING	1	----	0	----	1.4	1.2	54.2	1.3	1.3	8	5	96	33	25	0:23:00
3/17/2023	14:12	RUNNING	1	----	-0.8	----	1.4	0	55.5	1.3	1.3	8	9	96	33.2	16	0:24:00
3/17/2023	14:13	RUNNING	1	----	1.3	----	1.4	4.3	56.8	1.3	1.3	8	4	96	33.2	12	0:25:00
3/17/2023	14:14	RUNNING	1	----	0	----	1.4	0.1	58.1	1.3	1.3	8	7	96	33.2	11	0:26:00
3/17/2023	14:15	RUNNING	1	----	0	----	1.4	2.1	59.3	1.3	1.2	8	4	96	33.3	10	0:27:00
3/17/2023	14:16	RUNNING	1	----	0	----	1.4	1.4	60.6	1.3	1.3	8	4	96	33.4	11	0:28:00
3/17/2023	14:17	RUNNING	1	----	0	----	1.4	0.6	61.8	1.3	1.3	9	9	96	33.5	11	0:29:00
3/17/2023	14:18	RUNNING	1	----	1.3	----	1.4	3.7	63.1	1.3	1.2	9	5	96	33.5	101	0:30:00
3/17/2023	14:19	RUNNING	1	----	0	----	1.4	0.9	64.3	1.3	1.3	9	7	96	33.5	25	0:31:00
3/17/2023	14:20	RUNNING	1	----	0	----	1.4	1.5	65.6	1.3	1.3	9	6	96	33.6	18	0:32:00
3/17/2023	14:21	RUNNING	1	----	0	----	1.4	1.9	66.8	1.3	1.2	9	4	96	33.7	14	0:33:00
3/17/2023	14:22	RUNNING	1	----	0	----	1.4	0.5	68.1	1.3	1.3	9	7	96	33.7	13	0:34:00
3/17/2023	14:23	RUNNING	1	----	1.3	----	1.4	2.6	69.3	1.3	1.2	9	7	96	33.7	13	0:35:00
3/17/2023	14:24	RUNNING	1	----	0	----	1.4	1.1	70.6	1.3	1.3	10	10	96	33.7	13	0:36:00
3/17/2023	14:25	RUNNING	1	----	1.3	----	1.4	3	71.8	1.3	1.2	10	8	96	33.9	13	0:37:00
3/17/2023	14:26	RUNNING	1	----	1.3	----	1.4	3.2	73.1	1.3	1.2	10	3	96	33.9	90	0:38:00
3/17/2023	14:27	RUNNING	1	----	0	----	1.4	0	74.4	1.3	1.4	10	8	96	34	25	0:39:00
3/17/2023	14:28	RUNNING	1	----	0	----	1.4	1.5	75.7	1.3	1.3	10	8	96	34	18	0:40:00
3/17/2023	14:29	RUNNING	1	----	0	----	1.4	2.8	77	1.3	1.3	10	4	96	34	16	0:41:00
3/17/2023	14:30	RUNNING	1	----	0.5	----	1.4	0.8	78.3	1.3	1.4	10	8	96	34.1	15	0:42:00
3/17/2023	14:31	RUNNING	1	----	0.5	----	1.4	1.2	79.6	1.3	1.4	10	10	96	34.2	14	0:43:00
3/17/2023	14:32	RUNNING	1	----	0	----	1.4	3.1	80.9	1.3	1.3	11	4	96	34.2	16	0:44:00
3/17/2023	14:33	RUNNING	1	----	-0.8	----	1.4	0	82.2	1.3	1.3	11	7	96	34.2	15	0:45:00
3/17/2023	14:34	RUNNING	1	----	0.5	----	1.4	1	83.5	1.3	1.3	11	10	96	34.2	39	0:46:00
3/17/2023	14:35	RUNNING	1	----	0	----	1.4	2.1	84.8	1.3	1.3	11	6	96	34.2	23	0:47:00
3/17/2023	14:36	RUNNING	1	----	0	----	1.4	1.5	86.1	1.3	1.3	11	5	96	34.4	17	0:48:00
3/17/2023	14:37	RUNNING	1	----	0	----	1.4	1.2	87.4	1.3	1.3	11	7	96	34.4	16	0:49:00
3/17/2023	14:38	RUNNING	1	----	0	----	1.4	0.4	88.6	1.3	1.3	11	8	96	34.5	17	0:50:00
3/17/2023	14:39	RUNNING	1	----	0	----	1.4	2.5	89.9	1.3	1.3	11	6	96	34.5	17	0:51:00
3/17/2023	14:40	RUNNING	1	----	1.3	----	1.4	0.4	91.1	1.3	1.2	12	10	96	34.5	16	0:52:00
3/17/2023	14:41	RUNNING	1	----	1.3	----	1.4	3.1	92.3	1.3	1.2	12	8	96	34.5	16	0:53:00
3/17/2023	14:42	RUNNING	1	----	0.8	----	1.4	1.5	93.6	1.3	1.3	12	7	96	34.5	41	0:54:00
3/17/2023	14:43	RUNNING	1	----	0	----	1.4	0.5	94.8	1.3	1.2	12	9	96	34.6	24	0:55:00
3/17/2023	14:44	RUNNING	1	----	0.8	----	1.4	1.5	95.9	1.3	1.2	12	8	96	34.7	21	0:56:00
3/17/2023	14:45	RUNNING	1	----	0.8	----	1.4	1.9	97.1	1.3	1.2	12	8	96.1	34.7	19	0:57:00
3/17/2023	14:46	RUNNING	1	----	0.8	----	1.4	1.3	98.2	1.3	1.2	12	7	96.1	34.7	17	0:58:00
3/17/2023	14:47	RUNNING	1	----	0.8	----	1.4	1.2	99.3	1.3	1	13	8	96	34.7	15	0:59:00
3/17/2023	14:48	RUNNING	1	----	1.6	----	1.4	1.2	----	1.3	1.1	13	7	96.1	34.7	15	0.083333
3/17/2023	14:49	RUNNING	1	----	1.6	----	1.4	0.1	----	1.3	1	13	9	96.1	34.7	16	0.084028
3/17/2023	14:50	RUNNING	1	----	2.4	----	1.4	2.4	----	1.3	1	13	8	96	34.7	17	0.084722
3/17/2023	14:51	RUNNING	1	----	2.4	----	1.4	1.9	----	1.3	1	14	9	96.1	34.9	48	0.085417
3/17/2023	14:52	RUNNING	1	----	2.4	----	1.4	1.9	----	1.3	0.9	14	8	96.1	35	26	0.086111
3/17/2023	14:53	RUNNING	1	----	3.7	----	1.4	1.7	----	1.3	0.8	14	10	96.1	35	22	0.086806
3/17/2023	14:54	RUNNING	1	----	3.7	----	1.4	3.2	----	1.3	0.3	15	10	96.1	35	21	0.0875
3/17/2023	14:55	RUNNING	1	----	3.7	----	1.4	3.1	----	1.3	0.1	15	10	96.1	35	20	0.088194

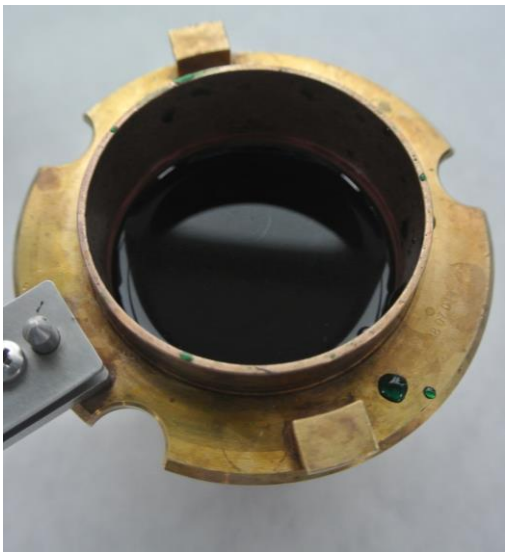
Data log - Sample ID: VAN4

Date/Time	Status	Phase	Nom-BT	Corr-BT	Act-BT	Nom-BG	Act-BG	Act-ST	Nom-SG	Act-SG	Nom-HP	Act-HP	BAP	LM73	Gasindi	Time	
4/6/2023	7:56	RUNNING	0	----	0	23.2	6.2	0	24.3	5.5	0	90	90	98.4	24.2	0	0:00:00
4/6/2023	7:57	RUNNING	0	----	0	----	6.2	0	24.9	5.5	0	90	90	98.4	24.3	34	0:01:00
4/6/2023	7:58	RUNNING	D	----	0	----	6.2	0	27.1	5.5	0	17	7	98.4	24.5	12	0:02:00
4/6/2023	7:59	RUNNING	D	----	0	----	6.2	0	30	5.5	3	18	7	98.4	24.7	9	0:03:00
4/6/2023	8:00	RUNNING	1	----	0	----	6.2	0	33.2	5.5	3.2	18	15	98.4	25	104	0:04:00
4/6/2023	8:01	RUNNING	1	----	0	----	6.2	8.6	36.7	5.5	3.5	19	12	98.4	25.2	21	0:05:00
4/6/2023	8:02	RUNNING	1	----	3.2	----	6.2	8.4	40.4	5.5	3.7	20	15	98.4	25.7	17	0:06:00
4/6/2023	8:03	RUNNING	1	----	3.2	----	6.2	8.6	44.2	5.5	3.9	21	16	98.4	25.9	29	0:07:00
4/6/2023	8:04	RUNNING	1	----	3.2	----	6.2	8.4	48.2	5.5	4	22	21	98.4	26.2	26	0:08:00
4/6/2023	8:05	RUNNING	1	----	3.2	----	6.2	9	52.4	5.5	4.2	24	24	98.4	26.5	26	0:09:00
4/6/2023	8:06	RUNNING	1	----	3.2	----	6.2	10	56.7	5.5	4.4	24	17	98.4	26.8	29	0:10:00
4/6/2023	8:07	RUNNING	1	----	3.2	----	6.2	9.3	61.1	5.5	4.5	25	18	98.4	27.1	22	0:11:00
4/6/2023	8:08	RUNNING	1	----	3.2	----	6.2	8.3	65.8	5.5	4.7	27	20	98.4	27.4	35	0:12:00
4/6/2023	8:09	RUNNING	1	----	3.2	----	6.2	8.5	70.6	5.5	4.8	28	22	98.4	27.7	28	0:13:00
4/6/2023	8:10	RUNNING	1	----	3.2	----	6.2	8	75.6	5.5	5	29	28	98.4	28	37	0:14:00
4/6/2023	8:11	RUNNING	1	----	3.2	----	6.2	10.2	80.6	5.5	5.1	30	21	98.4	28.2	35	0:15:00
4/6/2023	8:12	RUNNING	1	----	3.2	----	6.2	8.4	85.7	5.5	5.2	31	22	98.4	28.5	37	0:16:00
4/6/2023	8:13	RUNNING	1	----	2.4	----	6.2	7.8	91	5.5	5.3	32	24	98.4	28.8	37	0:17:00
4/6/2023	8:14	RUNNING	1	----	1.6	----	6.2	6.9	96.3	5.5	5.4	33	27	98.4	29	42	0:18:00
4/6/2023	8:15	RUNNING	1	----	0.8	----	6.2	7.8	----	5.5	5.4	34	25	98.4	29.4	41	0:19:00
4/6/2023	8:16	RUNNING	1	----	0.8	----	6.2	6.8	----	5.5	4	35	24	98.4	29.7	44	0:20:00
4/6/2023	8:17	RUNNING	1	----	3.7	----	6.2	11.1	----	5.5	0.3	36	25	98.5	29.9	43	0:21:00
4/6/2023	8:18	RUNNING	1	----	3.7	----	6.2	8.5	----	5.5	0.2	37	28	98.4	30.1	43	0:22:00
4/6/2023	8:19	RUNNING	1	----	3.2	----	6.2	6.6	----	5.5	0.2	38	34	98.4	30.5	38	0:23:00
4/6/2023	8:20	RUNNING	1	----	3.2	----	6.2	9.6	----	5.5	0.2	39	35	98.4	30.8	37	0:24:00
4/6/2023	8:21	RUNNING	1	----	3.2	----	6.2	9.1	----	5.5	0.2	40	27	98.5	31	38	0:25:00
4/6/2023	8:22	RUNNING	1	----	3.2	----	6.2	9.7	----	5.5	0.2	41	28	98.4	31.4	34	0:26:00
4/6/2023	8:23	RUNNING	1	----	3.7	----	6.2	7.8	----	5.5	0.3	43	34	98.4	31.6	41	0:27:00
4/6/2023	8:24	RUNNING	1	----	3.2	----	6.2	7.4	----	5.5	0.4	44	42	98.5	32	37	0:28:00
4/6/2023	8:25	RUNNING	1	----	3.2	----	6.2	8.7	----	5.5	0.3	45	44	98.5	32.2	37	0:29:00
4/6/2023	8:26	RUNNING	1	----	3.2	----	6.2	10.1	----	5.5	0.3	46	33	98.4	32.5	35	0:30:00
4/6/2023	8:27	RUNNING	1	----	3.2	----	6.2	8.8	----	5.5	0.5	47	33	98.5	32.7	37	0:31:00
4/6/2023	8:28	RUNNING	1	----	3.2	----	6.2	7.2	----	5.5	0.5	48	40	98.4	33	34	0:32:00
4/6/2023	8:29	RUNNING	1	----	3.7	----	6.2	7.3	----	5.5	0.6	49	46	98.5	33.4	36	0:33:00
4/6/2023	8:30	RUNNING	1	----	3.2	----	6.2	10.4	----	5.5	0.7	50	47	98.4	33.6	40	0:34:00
4/6/2023	8:31	RUNNING	1	----	3.2	----	6.2	9.1	----	5.5	0.8	51	38	98.5	33.9	35	0:35:00
4/6/2023	8:32	RUNNING	1	----	3.2	----	6.2	8.4	----	5.5	1	52	42	98.5	34.2	35	0:36:00

Vanadium Redox Flow Battery Electrolyte from Hong Jong Metal Corporation

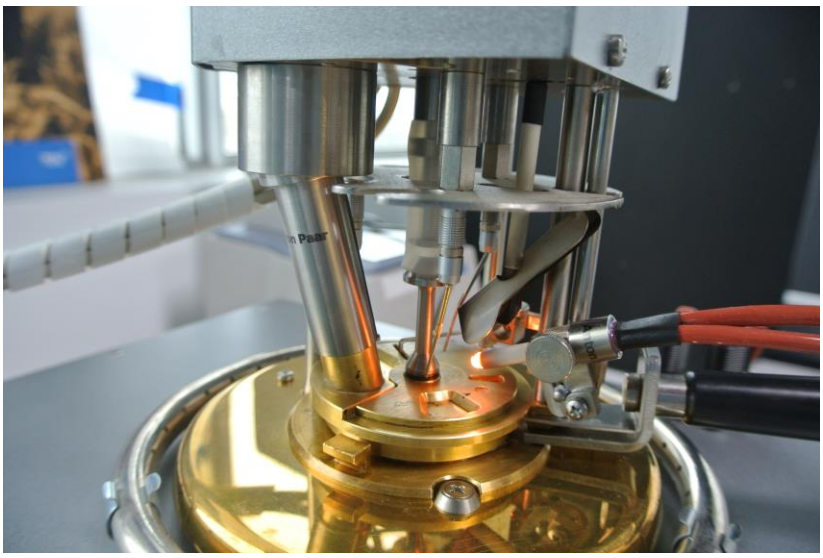
Pre-test and Post-test Photographs

Photograph 1 - Closed cup for flash point testing



Photograph 2 - Electrolyte measured using a graduated cylinder

Photograph 3 - Flash point test setup - View 1



Photograph 4 - Flash point test setup with Igniter - View 2

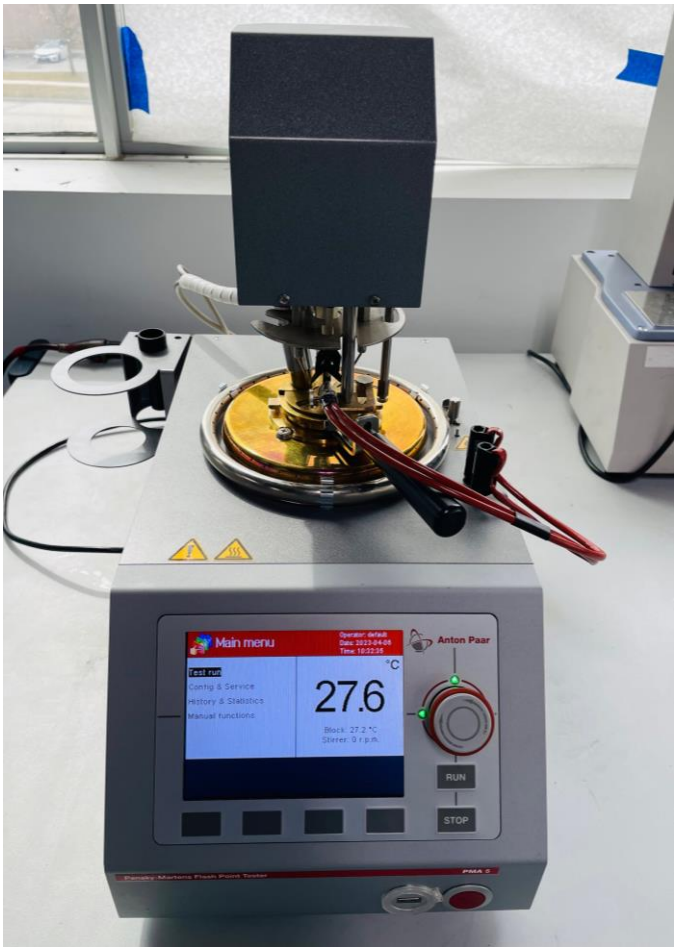
Photograph 5 - Electrolyte in the cup after flash point test - View 1

Photograph 6 - Electrolyte in the cup after flash point test - View 2

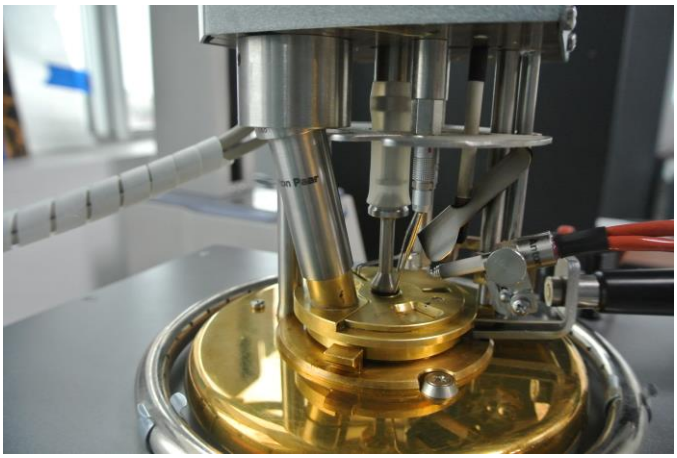
Pre-test and Post-test Photographs

Photograph 7 - Closed cup with electrolyte for flash point testing

Photograph 8 - Electrolyte measured using a graduated cylinder



Photograph 9 - Flash point test setup



Photograph 10 - Flash point test setup with Igniter

Photograph 11 - Electrolyte in the cup after flash point test