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SURFACE VEHICLE INFORMATION REPORT

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ELECTRIC VEHICLE TERMINOLOGY

1. ***Scope***—This SAE Information Report contains definitions for terms which typically apply to electric vehicles. It is intended that this document be a resource for those writing other electric vehicle documents, specifications, standards, or recommended practices.

2. ***References***

2.1 **Related Publication**—The following publication is provided for information purposes only and is not a required part of this document.

2.1.1 SAND PUBLICATION—Available from Sandia National Laboratories, Albuquerque, NM 87185.

SAND88-2852 * UC-212—GLOSSARY OF TESTING TERMINOLOGY FOR RECHARGEABLE BATTERIES, October 1988

3. ***Terminology***

3.1 **Related Programs and Organizations**

ANL—Argonne National Laboratory.

ANL/ADL—Analysis and Diagnostic Laboratory at ANL. Includes the National Battery Test Laboratory (NBTL).

DOE—United States Department of Energy.

EHP—Division of Electric and Hybrid Propulsion, in the Office Transportation Systems, at the US Department of Energy.

Electric Vehicle Association of the Americas (EVAA)—An organization supported by a number of electric utility companies and others to promote the commercial development electric vehicles.

EPRI—Electric Power Research Institute.

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ESD—Office of Energy Storage and Distribution at the US Department of Energy.

EV—Electric vehicle.

HEV—Hybrid Electric Vehicle.

INEL—Idaho National Engineering Laboratory.

JPL—Jet Propulsion Laboratory.

NBTL—National Battery Test Laboratory. See ANL/ADL.

NEC®—National Electrical Code®.

NFPA—National Fire Protection Association.

SAE—Society of Automotive Engineers.

UL—Underwriters Laboratories Inc.

3.2 Battery and Electric Vehicle Technical Terminology

3.2.1 ACCELERATION POWER (kW)—The electric power required to accelerate an electric vehicle from zero to a specified speed in a specified time. The system voltage must be maintained above a specified minimum.

3.2.1.1 Available Acceleration Power (kW)—The power that can be obtained from the power source(s) and used to accelerate an electric vehicle under which the following are specified:

a. The time interval for the test (e.g., 5 to 20 s)
b. The maximum system current or minimum voltage during the test
c. The condition of the source(s), such as depth of discharge and temperature

3.2.2 ACTIVE MATERIALS—The constituents of a cell that participate in the electrochemical charge/discharge reactions.

3.2.3 AMPERE—A unit of electric current flow equivalent to the motion of 1 coulomb of charge or 6.24×10^{18} electrons past any cross section in 1 s.

3.2.4 ANODE—The electrode in an electrochemical cell at which oxidation takes place. During charge, the positive terminal of the cell is the anode. During discharge, the negative terminal of the cell is the anode.

3.2.5 AQUEOUS BATTERIES—Batteries with water-based electrolytes.

3.2.6 AVAILABLE CAPACITY—See *capacity*.

3.2.7 AVERAGE POWER (kW)—Total energy withdrawn (or returned) from (or to) a cell, battery, or other energy source divided by the time of discharge (or charge). May also be specified for test regimes that include both charge and discharge.

3.2.8 AVERAGE VOLTAGE (V)—The delivered watt-hours divided by the delivered ampere-hours for a given discharge or charge. Not a simple average of voltage over time.

3.2.9 BATTERY—Electrochemical cells electrically connected in a series and/or parallel arrangement.

3.2.10 BATTERY AUXILIARIES—Components required by a battery system external to the electrochemical cell(s), such as a tray, watering subsystem, or pumps.

3.2.11 BATTERY CONTROLLER/MANAGEMENT SYSTEM—Components whose functions are to control the power to and from the battery pack, provide communications interface between the battery pack and the other components, and provide other interface and control functions. It may also monitor and/or control other battery functions (watering, temperature, electrolyte flow, etc.). It may also provide an operator interface.

3.2.12 BATTERY MODULE OR BATTERY MONOBLOC—A grouping of interconnected cells in a single mechanical and electrical unit.

3.2.13 BATTERY PACK—All the electrically connected cells or modules in the propulsion system.

3.2.14 BATTERY SYSTEM DENSITY (kg/L)—Battery systems mass divided by battery system volume.

3.2.15 BATTERY SYSTEM—The battery plus all battery auxiliaries and battery controller.

3.2.16 BATTERY SYSTEM WEIGHT FRACTION—Battery system weight divided by the gross vehicle weight. Usually expressed as a percent.

3.2.17 C/N RATE—The constant current which is numerically the capacity divided by N. The result approximates the N hour rate.

3.2.18 CAPACITY {C} (Ah)—The total number of ampere-hours that can be withdrawn from a fully charged cell or battery under specified conditions.

3.2.18.1 Available Capacity (Ah)—The total number of ampere-hours that can be withdrawn from a fully charged cell or battery for a specific set of operating conditions including discharge rate, temperature, age, stand time, and discharge termination criteria.

3.2.18.2 C_n (Ah)—The capacity in ampere-hours obtained from a battery discharge at a constant current such that a specified minimum voltage is reached in precisely n hours. C is established once and is not adjusted as it changes with time.

3.2.18.3 N Hour Rate—The constant current at which a fully charged battery can be completely discharged in precisely N hours.

3.2.18.4 Battery Ampere-Hour Capacity—The charge in ampere-hours obtained from a battery discharged at a constant current until the specified minimum cut-off voltage is reached.

3.2.18.5 Deliverable Capacity—See *available capacity.*

3.2.18.6 Energy Capacity—See *energy output.*

3.2.18.7 Rated Capacity (Ah)—The manufacturer's specification of the total number of ampere-hours that can be withdrawn from a fully charged cell or battery for a specified discharge rate, temperature, and discharge cutoff voltage.

3.2.18.8 Residual Capacity (Ah)—The number of ampere-hours that can be discharged from a cell or battery at a specified discharge rate and temperature after it has been exposed to specified conditions such as driving-profile or open-circuit stand tests.

3.2.18.9 Theoretical Capacity (Ah)—The capacity of a cell's active material, assuming 100% utilization of the limiting reactant.

3.2.19 CATHODE—The electrode in an electrochemical cell at which reduction takes place. During charge, the negative terminal of the cell is the cathode. During discharge, the positive terminal of the cell is the cathode.

3.2.20 CELL—An assembly of at least one positive electrode, one negative electrode, and other necessary electrochemical and structural components. It is used to store energy in chemical form for conversion to electrical energy.

3.2.21 CHARGE (VERB)—Conversion of electrical energy into chemical potential energy within a cell by the passage of a direct current.

3.2.22 CHARGE (NOUN)—Measured in coulombs or amp-hours.

3.2.23 CHARGE CUTOFF VOLTAGE (CCOV) (V)—The cell or battery voltage at which charge is terminated.

3.2.24 CHARGE PROFILE—Schedule used for charging a cell or battery. For example:

3.2.24.1 CI—See *constant current charging.*

3.2.24.2 CV—See *constant - voltage charging.*

3.2.24.3 CI/CV—A constant current charge followed by a constant-voltage charge.

See also *finishing charge rate, float charge,* and *trickle charge.*

3.2.25 CHARGE RATE (A)—The level of current during charging a cell or battery.

3.2.26 CHARGE LEVEL 1—The charging power level when using the most common available standard outlet (120 V AC in the US).

3.2.27 CHARGE LEVEL 2—The charging power level when using dedicated equipment specifically designed for EV road vehicle charging commonly applied in home locations using 240 V AC with a 40 A branch circuit.

3.2.28 CHARGE LEVEL 3—The charging power level using dedicated equipment with the capability to supply 60 to 80% of the total EV road vehicle battery capacity in 5 to 15 min.

3.2.29 CHARGER (BATTERY)—The components or group of components whose function it is to supply and control the power required for battery charging.

3.2.30 CONSTANT CURRENT CHARGING OR DISCHARGING (CI)—The charging or discharging of a cell or battery at a controlled, constant rate of electron flow.

3.2.31 CONSTANT VOLTAGE CHARGING (CV)—The charging of a cell or battery by applying a constant voltage while allowing the current to vary.

3.2.32 COULOMB—The unit of electric charge in SI units (international system of units). The coulomb is the quantity of electric charge that passes any cross section of a conductor in 1 s when the current is maintained constant at 1 A.

3.2.33 COULOMBIC EFFICIENCY—See *efficiency*.

3.2.34 CURRENT (A)—The rate of flow of electrons in a circuit.

3.2.35 CURRENT COLLECTOR—A part of an electrode that conducts electrons.

3.2.36 CURRENT DENSITY (mA/cm^2)—The current per unit electrode area. Determined by dividing the charge or discharge current by the total geometric area of the positive or negative electrode.

3.2.37 CUTOFF TERMINAL VOLTAGE (V)—The cell or battery voltage at which charge or discharge is terminated.

3.2.38 CYCLE—The period commencing from the start of one charge/discharge to the start of the next charge/discharge where said period includes discharge time, open-circuit time, and charge time.

3.2.39 CYCLE LIFE—The number of cycles, to a specified discharge termination criteria, such as depth of discharge, under a specified charge and discharge regime, that a cell or battery can undergo before failing to meet its specified capacity or efficiency performance criteria.

3.2.40 DEEP DISCHARGE—A qualitative term indicating the withdrawal of a significant percentage of capacity (50% or more).

3.2.41 DEPTH OF DISCHARGE (DOD) (%)—The ampere-hours discharged from a cell or battery at a given rate divided by the available capacity under the same specified conditions. Usually expressed as a percent.

3.2.42 DERIVED PEAK POWER (kW)—An estimate of the maximum power capability of a cell or battery calculated from the results of power profile tests.

3.2.43 DISCHARGE—Conversion of chemical energy into electrical energy within a cell or battery by the passage of direct current.

3.2.44 DISCHARGE CUTOFF VOLTAGE (DCOV) (V)—The cell or battery voltage at which discharge is terminated.

3.2.45 DISCHARGE PROFILE—Schedule used for cell or battery discharge that follows a particular current (or power) versus time sequence.

3.2.46 DISCHARGE RATE (A)—The current during discharge of a cell or battery.

3.2.47 DRIVETRAIN—The elements of a propulsion system (such as motor, transmission, axle, and wheels) that produce and transmit mechanical power to the drive wheels of a vehicle.

3.2.48 DRIVETRAIN EFFICIENCY—The mechanical output energy from the drivetrain divided by the electrical energy input to the drivetrain.

3.2.49 DRIVING PROFILE—A vehicle speed-versus-time schedule that is used to test vehicle and battery characteristics.

3.2.50 EFFICIENCY (%)—The output divided by the input usually expressed as a percent:

3.2.50.1 Coulombic (Ampere-Hour) Efficiency (%)—The ampere-hours removed from a cell or battery during a discharge divided by the ampere-hours required to restore the initial capacity.

3.2.50.2 Voltaic Efficiency (%)—The average voltage during discharge of a cell or battery divided by the average voltage during charge required to restore the initial capacity.

3.2.50.3 Energy (Watt-Hour, Round Trip) Efficiency (%)—The energy delivered by a cell or battery during a discharge divided by the total energy required for restoration of the initial capacity.

3.2.51 ELECTRODE—The conducting body that contains active materials and through which current enters or leaves a cell.

3.2.52 ELECTROLYTE—The medium that provides ion transport between the positive and negative electrodes of a cell. It may participate directly in the charge/discharge reactions.

3.2.53 END-OF-CHARGE VOLTAGE {EOV} (V)—The cell or battery voltage when charge is terminated. Also see *charge cut-off voltage*.

3.2.54 END-OF-DISCHARGE VOLTAGE {EODV} (V)—The cell or battery voltage when discharge is terminated. Also see *discharge cut-off voltage*.

3.2.55 END OF LIFE—When a cell or battery fails to meet its capacity or performance criteria when operated under a specific charge/discharge regime.

3.2.56 ENERGY CAPACITY—See *energy output*.

3.2.57 ENERGY DENSITY (Wh/L)—The energy output from a cell, battery, or battery system divided by its volume.

3.2.58 ENERGY EFFICIENCY—See *efficiency*.

3.2.59 ENERGY OUTPUT—The total number of watt-hours that can be withdrawn from a fully charged cell or battery. The energy output varies with temperature, rate, age, stand time, and discharge cutoff voltage.

3.2.60 EQUALIZATION—The process of restoring all cells in a battery to an equal state-of-charge. This can consist of a prolonged charge or a completed discharge to a shorted condition, depending on the battery technology.

3.2.61 EV CORD—The off-board cable containing the conductors to connect the EV Plug with the EV Power Controller to provide power for the vehicle and communications during charge.

3.2.62 EV CONNECTOR—Off-board component used to interface with the vehicle-mounted EV inlet to supply power and provide communication interface. (The power interface may be conductive, inductive, or other.)

3.2.63 EV INLET—Vehicle-mounted component which interfaces with the EV connector to receive power and provide communication interface.

3.2.64 EV POWER CONTROLLER—Premise located components which control power to the vehicle battery controller through the EV connector and EV inlet in response to communications signals either manual or automatic or both. It also may provide communication and control interface between the vehicle and utility.

3.2.65 FAILURE CRITERIA—Specific cell or battery performance characteristics that indicate the cell or battery can no longer perform in its intended function.

3.2.66 FINAL VOLTAGE—See *discharge cutoff voltage.*

3.2.67 FINISHING CHARGE RATE (A)—The current specified for completing the charging of a cell or battery that is nearing the fully charged condition.

3.2.68 FLOAT CHARGE—Charging a cell or battery at a fixed voltage for extended periods of time to obtain or maintain the fully charged condition.

3.2.69 FLOWING ELECTROLYTE BATTERIES—Batteries having at least one liquid electrolyte stored outside the cell(s). Circulation of this liquid to the cell(s) is required. The electrolyte may contain active materials.

3.2.70 FORMATION—The initial charging process, during manufacture or installation, by which cell or battery active material are transformed into the constituents required for proper electrochemical operation.

3.2.71 GASSING—The evolution of gas from one or both of the electrodes in a cell.

3.2.72 GRID—The framework for a plate or electrode that supports or retains the active materials and acts as a current collector.

3.2.73 GROSS VEHICLE WEIGHT {GVW}—Manufacturer's rating for maximum vehicle operating weight.

3.2.74 HERMETICALLY SEALED BATTERIES—See *nonvented batteries.*

3.2.75 HIGH-RATE DISCHARGE—A qualitative term indicating a discharge rate that is usually greater than the average expected discharge rate.

3.2.76 HIGH-TEMPERATURE BATTERIES—Batteries requiring an operating temperature much higher than ambient temperature (i.e., greater than 100 °C).

3.2.77 INTERNAL IMPEDANCE (OHM)—The opposition to the flow of an alternating current at a particular frequency in a cell or battery at a specified state-of-charge and temperature.

3.2.78 INTERNAL RESISTANCE (OHM)—Opposition to direct current flow in a cell or battery. Its value may vary with the current, state-of-charge, age, and temperature. It is the sum of the ionic and electronic resistances of the cell components.

3.2.79 MAXIMUM POWER—See *peak power.*

3.2.80 MODULE—See *battery module.*

3.2.81 N—The number of hours over which a battery is charged or discharged.

3.2.82 NEGATIVE ELECTRODE—Of the two electrodes composing a cell, the electrode with an excess of electronics; it is negative in voltage compared to the other electrode of the cell.

3.2.83 NOMINAL OPERATING VOLTAGE (V)—The average voltage of a cell or battery discharging at a specified rate and temperature.

3.2.84 NONAQUEOUS BATTERIES—Cells or batteries with electrolytes that are not water based, such as those with molten salts or organic electrolytes.

3.2.85 NONVENTED BATTERIES—A hermetically sealed battery comprised of one or more rechargeable cells that has no provision for venting, or the addition of water or electrolyte, or for the external measurement of specific gravity.

3.2.86 OHM—The unit of resistance (and of impedance) in the international system of units (SI). One ohm is the resistance of a conductor such that a constant current of 1 A in it produces a voltage of 1 V between its ends.

3.2.87 OPEN CIRCUIT AFTER CHARGE {OCAC} (h)—The period during which the battery is placed on open-circuit following a charge.

3.2.88 OPEN CIRCUIT AFTER DISCHARGE {OCAD} (h)—The period during which the battery is placed on open-circuit following a discharge.

3.2.89 OPEN-CIRCUIT VOLTAGE {OCV} {V}—The voltage of a cell or battery at a specified state-of-charge and temperature in the absence of charge or discharge current. It varies with the length of time following a charge or discharge. See also *rated open-circuit voltage*.

3.2.90 OVERCHARGE (Ah)—The amount by which the charge ampere-hours exceed the ampere-hours removed on the previous discharge.

3.2.91 OXIDATION—A chemical process that results in the release of electrons by an electrode's active material.

3.2.92 PACK—See *battery pack*.

3.2.93 PEAK POWER (kW)—The power obtained from a cell or battery when discharged at constant current. The current is chosen so that discharge is started at 50% of the open-circuit voltage measured at the prevailing depth of discharge. The discharge is conducted at constant current for a short period of time (15 to 30 s), and the power is calculated based on the current and the average discharge voltage. The depth of discharge of the cell or battery at the start of the test must be specified.

3.2.94 PEAK POWER DENSITY (W/L)—The peak power available from a cell or battery divided by its volume.

3.2.95 PEUKERT CURVE—Plot of the logarithm of the discharge current versus the logarithm of discharge time to a specified end-of-discharge voltage.

3.2.96 POLARIZATION (BATTERY) {V}—The electrical potential deviation from equilibrium open-circuit voltage caused by the flow of current in a cell or battery.

3.2.97 POWER ELECTRODE—Of the two electrodes composing a cell, the electrode with deficiency of electronics; it is positive in voltage compared to the other electrode of the cell.

3.2.98 POWER DENSITY (W/L)—The rated power available from a cell or battery divided by its volume.

3.2.99 POWER PROFILE TEST—A cell, battery, or battery system charge/discharge test that uses a sequence of different power levels applied for a defined time duration to simulate battery operation in a vehicle. For example, profile tests have been derived from the UDS and the HWFET driving profile tests.

3.2.100 POWER-TO-ENERGY RATIO (h^{-1})—Ratio of the peak power obtained under specified conditions, such as depth of discharge, to the energy output obtained under specified discharge conditions.

3.2.101 POWERTRAIN—The elements of a propulsion system that convert electrical energy from a battery to mechanical energy at the wheels of a vehicle. It includes all drivetrain components plus an electrical power inverter and/or controller, but not the battery system.

3.2.102 PROPULSION SYSTEM—The combination of the powertrain and battery system, which converts stored electrical energy into mechanical energy in a vehicle.

3.2.103 RAGONE CURVE—Plot of the specific energy as a function of the continuous specific power at which the battery is discharged. Originally defined as the set of curves ranging between the high-power design and the high-energy design for a particular technology.

3.2.104 RANGE (km)—The maximum distance that an electric vehicle can travel on a single battery charge over a specified driving cycle. Alternatively, the distance reached when a specified minimum level of performance or other characteristic (such as battery depth of discharge) is attained.

3.2.105 RATED CAPACITY—See *capacity*.

3.2.106 RATED OPEN-CIRCUIT VOLTAGE (V)—The manufacturer's specification for the open-circuit voltage of a fully charged cell or battery.

3.2.107 RATED POWER (kW)—The manufacturer's specification of power capability; for example, the discharge power of a cell or battery.

3.2.108 RECHARGE FACTOR—The inverse of the coulombic efficiency, expressed as a ratio, for a cycle.

3.2.109 REDUCTION—A chemical process that results in the acceptance of electrons by an electrode's active material.

3.2.110 REGENERATIVE BRAKING—The recovery of some fraction of the energy normally dissipated in braking into energy that can be used or stored.

3.2.111 RESIDUAL CAPACITY—See *capacity*.

3.2.112 REVERSAL—Forced discharge of a cell or battery to the point that the cell's electrical terminals change polarity and beyond the point where the active material can usefully deliver energy.