

Voltaiq Data Format - for Import to Voltaiq

Version 1.2

Voltaiq supports many commercial battery tester data formats out of the box. Many of our customers need to import data into the system from other sources, such as vehicle CANbus, un-supported commercial testers, custom battery testers, or remote/field data.

Voltaiq provides a standard data format as an export target for these use cases. Data in this format can be imported into Voltaiq to be managed and analyzed alongside other data.

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Overview

The Voltaiq Data Format requires the following assumptions to be true.

- Data files are CSV format with a "Tab" delimiter, and files end with the extension .csv.
- Each data file represents one and only one test – tests will not be split across data files and data files will not contain data from multiple tests.
- Uniqueness for a test will be determined by the data file name: all datafiles should have a unique file name to be imported correctly.
 - To help create unique filenames, we recommend including relevant metadata in the naming convention.
 - An example convention might be "{date}_{channel number}_{test name}.csv" -> "2000-01-01_2_CyclingData.csv"
 - A subsequent check on "Start Time", "Channel Number", and "Tester ID" (if present) will be conducted to guarantee uniqueness on those constraints

Metadata Header

Each data file should begin with a specially formatted **Metadata Header** which can be any number of lines, in which **each line contains a single "key: value" pair representing one piece of metadata (with a ":" delimiter)**. There are a set of required fields, but any amount of metadata can be included in the header, up to 1024 key: value pairs. The termination of the header is indicated by a line containing only the string "[DATA START]". **If the "REQUIRED" metadata are not present, the data file will not be imported.**

Metadata (REQUIRED)

- ❑ "Start Time"
 - ❑ UTC timestamp for the start of this test. Either of these formats is allowed:
 - ❑ Unix epoch timestamp- in milliseconds.
 - ❑ ISO 8601 standard: ("yyyy-MM-ddT'HH:mm:ssZ").
- ❑ "Timezone"
 - ❑ The timezone where the test is being run. Either of these formats is allowed:
 - ❑ International timezone format ("America/New_York").

- ❑ UTC offset ("4:00").

Metadata (STRONGLY RECOMMENDED)

- ❑ "Channel Number"
 - ❑ Which equipment channel number (or similar identifier) was used to run this test.
 - ❑ Is **required** for the Lab Management Dashboard (LMD).
- ❑ "Tester ID"
 - ❑ An identifying string unique to the tester running the test across the organization.
 - ❑ Some examples for this might be appending on a lab location to a tester name: "SF_Maccor1" or "sf_xyz123" where xyz123 is the serial number for the tester
 - ❑ Is **required** for the Lab Management Dashboard (LMD).
- ❑ "Device ID"
 - ❑ An identifying string unique to the device/cell/pack being tested across the organization.
- ❑ "Format Version"
 - ❑ A version string that changes when the file format (required column list, etc.) changes.

Metadata (OPTIONAL)

Any additional metadata can be saved as long as it is represented in key value format as specified above. Some suggestions are below:

- ❑ "Procedure Name"
 - ❑ Unique name of the tester protocol used to run the test.
- ❑ "Description"
 - ❑ Non-unique description of the test.
- ❑ "Nominal Capacity"
 - ❑ The nominal capacity for the device being tested.
- ❑ "Project"
 - ❑ The project that the device being tested belongs to.
- ❑ "Server Version"
 - ❑ Version of Tester Server Software.
- ❑ "Client Version"

- ☐ Version of Tester Client Software.
- ☐ "Test Protocol ID"
 - ☐ File name of the test protocol.
- ☐ "Tester Calibration Date"
 - ☐ Date that the tester was last calibrated.
- ☐ "Comment"
 - ☐ Any comment on the test file.

Test Uniqueness

The name of the test file as well as the "Start Time" metadata value, will be used **in combination to determine if this test has been imported into the system before**. If an exact match for the values is not found, a new test is created in Voltaiq containing the data. If an exact match for the values **is** found, a new test record will not be created.

Example Metadata Header

Below is a set of sample header lines:

```
Test Name: Example_Demo-01-041
Start Time: 1347489654000
Channel Number: 42
Tester Serial Number: A10345
Format Version: 2.0
Timezone: America/Los_Angeles
Comment: Comment about this test here.
[DATA START]
```

Data

After the Metadata Header and the "[DATA START]" line, the remainder of the file should contain a data header followed by time-series performance data.

Data Header

The **Data Header** begins on the line directly after the "[DATA START]" line. The data header is two sequential lines that describe the measurement and unit associated with the measurement. The data header and all data lines are delimited by a tab character. The order of the columns is not important, they can come in any order.

The first data header line contains labels for each data column. Some common examples of this might be: "Voltage", "Current", or "Power". The second data header line contains units for each column, from the list of supported units provided by Voltaiq (see Appendix A). If a unit is desired that is not currently supported by Voltaiq, let us know (support@voltaiq.com) and we can prioritize building support for it within our platform.

Data Columns

Data columns are the time series data that will be imported and displayable in the Voltaiq Application.

Data Columns **(REQUIRED)**

The following columns are required, and must be present in each data file in order for any data to be imported into Voltaiq. **If these columns are not present, the data file will not be imported.**

Note: for columns with a Dimension other than "None", a Unit from Appendix A matching the specified dimension must be included on the second data header line.

- ❑ "Test Time"
 - ❑ **Definition:** Time elapsed since the start of the test.
 - ❑ **Data Type:** Float
 - ❑ **Dimension:** Time

- ❑ **Logical requirements and notes:**
 - ❑ Sequential values within the test may not decrease (i.e. values should be in ascending order).
- ❑ “Current”
 - ❑ **Definition:** Instantaneous value of current.
 - ❑ **Data Type:** Float
 - ❑ **Dimension:** Current
 - ❑ **Logical requirements and notes:**
 - ❑ The sign convention is positive for charge current and negative for discharge current.
- ❑ “Voltage”
 - ❑ **Definition:** Instantaneous value of potential.
 - ❑ **Data Type:** Float
 - ❑ **Dimension:** Potential
 - ❑ **Logical requirements and notes:**
 - ❑ N/A

Data Columns (STRONGLY RECOMMENDED)

The following columns are not required, but their presence will help enable the most value from all parts of the Voltaiq product. If not present, these values will be calculated or inferred from the data columns and header fields included in the file. Any column below that is of particular importance in subsequent analysis (e.g. Cycle Number) should be included to ensure proper functionality.

- ❑ “Datapoint Number”
 - ❑ **Definition:** Datapoint number of the test.
 - ❑ **Data Type:** Integer
 - ❑ **Dimension:** None
 - ❑ **Logical requirements and notes:**
 - ❑ Must start with 1 and be monotonically increasing (i.e. 1,2,3...) for an entire test.
- ❑ “Cycle Number”
 - ❑ **Definition:** Cycle number of the test.

- ❑ **Data Type:** long
- ❑ **Dimension:** None
- ❑ **Logical requirements and notes:**
 - ❑ Must start with 1 and be monotonically increasing and gapless (doesn't skip any numbers).
 - ❑ Special Note: if a cycle column is not observed, the default algorithm will look for the first charge datapoint after any discharge datapoint as the boundary for a new cycle
- ❑ "Timestamp"
 - ❑ **Definition:** Absolute (date) time datapoint.
 - ❑ **Data Type:** Integer (epoch) or String (Date and Time)
 - ❑ **Dimension:** Date
 - ❑ **Logical requirements and notes:**
 - ❑ Reminder: Voltaiq "epoch" is specified in milliseconds; e.g. record 1577836800000 for 12 AM Jan 1, 2020 GMT.
 - ❑ If using the "Date and Time" Unit, record with ISO 8601 standard: ("yyyy-MM-ddT'H:mm:ss'Z").
 - ❑ Sequential values may not decrease (i.e. values should be in ascending order).
- ❑ "Step Index"
 - ❑ **Definition:** Program step number associated with each control step.
 - ❑ **Data Type:** Long
 - ❑ **Dimension:** None
 - ❑ **Logical requirements and notes:**
 - ❑ This trace is required for a number of Voltaiq's Advanced Analytic (AA) offerings to work properly.
- ❑ "Step Time"
 - ❑ **Definition:** Elapsed time since the start of the current step.
 - ❑ **Data Type:** Float
 - ❑ **Dimension:** Time
 - ❑ **Logical requirements and notes:**
 - ❑ This value should reset to zero anytime the Step Index changes.
 - ❑ Sequential values within a step may not decrease (i.e. values should be in ascending order).

Data Columns (OPTIONAL)

Any additional data columns are optional and dynamically supported. Data headers for these additional data columns will be supported in the same manner as described above, with the first header line entry corresponding to the data column label and the second header line entry corresponding to the data column unit as defined in Appendix A.

Note: Column names must be unique.

The following data columns are some suggested optional columns. If they are present they will be imported and will be viewable from the platform. If they are not present (or left blank), they will be calculated from the required data columns above.

****WARNING:** these definitions and requirements around resetting values to zero and sign convention must be strictly respected to ensure data integrity for the customers for both time series and calculated cycle aggregation data. If recording these columns, please take special care to ensure that the definitions are adhered to.

- ❑ “Charge Capacity”
 - ❑ **Definition:** Cumulative charge capacity of the current cycle.
 - ❑ **Data Type:** Float
 - ❑ **Dimension:** Capacity
 - ❑ **Logical requirements and notes:**
 - ❑ Values must be greater than or equal to zero.
 - ❑ This value must reset to zero at the beginning of every cycle (including beginning of the test), and should not reset at step changes within a cycle.
 - ❑ Sequential values within a cycle may not decrease (i.e. values should be in ascending order).
- ❑ “Discharge Capacity”
 - ❑ **Definition:** Cumulative discharge capacity of the current cycle.
 - ❑ **Data Type:** Float
 - ❑ **Dimension:** Capacity
 - ❑ **Logical requirements and notes:**
 - ❑ Values must be greater than or equal to zero.

- ☐ This value must reset to zero at the beginning of every cycle (including beginning of the test), and should not reset at other step changes within a cycle.
 - ☐ Sequential values within a cycle may not decrease (i.e. values should be in ascending order).
- ☐ “Charge Energy”
 - ☐ **Definition:** Cumulative charge energy of the current cycle.
 - ☐ **Data Type:** Float
 - ☐ **Dimension:** Energy
 - ☐ **Logical requirements and notes:**
 - ☐ Values must be greater than or equal to zero.
 - ☐ This value must reset to zero at the beginning of every cycle (including beginning of the test), and should not reset at other step changes within a cycle.
 - ☐ Sequential values within a cycle may not decrease (i.e. values should be in ascending order).
- ☐ “Discharge Energy”
 - ☐ **Definition:** Cumulative discharge energy of the current cycle.
 - ☐ **Data Type:** Float
 - ☐ **Dimension:** Energy
 - ☐ **Logical requirements and notes:**
 - ☐ Values must be greater than or equal to zero.
 - ☐ This value must reset to zero at the beginning of every cycle (including beginning of the test), and should not reset at other step changes within a cycle.
 - ☐ Sequential values within a cycle may not decrease (i.e. values should be in ascending order).
- ☐ “Power”
 - ☐ **Definition:** Instantaneous value of power.
 - ☐ **Data Type:** Float
 - ☐ **Dimension:** Power
 - ☐ **Logical requirements and notes:**
 - ☐ The sign of power should align with the defined sign convention of current.

Auxiliary Measurement Equipment Column

Auxiliary Measurement Equipment is a subset of dynamically supported data columns. **It is required that all auxiliary measurement channels contain their own individually named columns.**

All auxiliary values will be treated as double-precision float values.

Data Section

All lines following the Data Header should contain only data. As with the data header, data on these lines should be separated by tab characters.

The number of data columns must be consistent throughout a file and match the number of Data Header columns; i.e. tab separation must still be used, even for blank entries, and no additional data columns, that have not already been assigned to a data header, can appear anywhere in a file.

Here is an example for entries of 3 sequential columns, with headers “Column1”, “Column2”, and “Column3”, and with an empty datum in the middle column:

```
Column1\tColumn2\tColumn3  
Unit1\Unit2\Unit3  
1.00\t\t1.05"
```

Appendices

Appendix A: Supported Units

<u>Dimension</u>	<u>Unit</u>	<u>Key for Data File</u>
Angle	Degrees	degree
Angle	Radians	radian
Area	Square Centimeters	square-cm
Area	Square Meters	square-m
Area	Square Inches	square-in
Area	Square Millimeters	square-mm
Areal Density	Milligrams per Square Centimeters	milligram-per-square-cm
Areal Density	Grams per Square Centimeters	gram-per-square-cm
Areal Density	Kilograms per Square Meters	kilogram-per-square-m
Boolean	Boolean	boolean
Capacity	Ampere-Hours	amp-hour
Capacity	Milliampere-Hours	milliamp-hour
Capacity	Kiloampere-Hours	kiloamp-hour
Capacity	Coulombs	coulomb
Current	Amperes	amp
Current	Milliamperes	milliamp

Current	Microamperes	microamp
Current	Kiloamperes	kiloamp
Current	Megaamperes	megaamp
Date	Date and Time	datetime
Date	Milliseconds since 1970	epoch
Density	Grams per Cubic Centimeters	gram-per-cubic-cm
Density	Kilograms per Cubic Meters	kilogram-per-cubic-m
dI/dt	Amps per second	amp-per-second
dI/dt	Amps per minute	amp-per-minute
dI/dt	Amps per hour	amp-per-hour
dQ/dV	Ampere-hours per Volt	amp-hour-volt
dQ/dV	Milliampere-hours per Volt	milliamp-hour-volt
dT/dt	Degrees Celsius per Second	celsius-per-second
dT/dt	Degrees Celsius per Minute	celsius-per-minute
dT/dt	Degrees Celsius per Hour	celsius-per-hour
dV/dt	Volts per Second	volt-second
dV/dt	Millivolts per Second	millivolt-second
dV/dt	Volts per Minute	volt-per-minute
dV/dt	Volts per Hour	volt-per-hour
Energy	Watt-Hours	watt-hour
Energy	Milliwatt-Hours	milliwatt-hour
Energy	Kilowatt-Hours	kilowatt-hour

Energy	Megawatt-Hours	megawatt-hour
Energy	Joules	joule
Energy	Millijoules	millijoule
Energy	Kilojoules	kilojoule
Energy	Megajoules	megajoule
Flow	Standard Liters per Minute	slpm
Force	Newtons	newton
Force	Pounds-Force	pound-force
Force	Dynes	dyne
Force	Poundals	poundal
Impedance	Ohms Imaginary	ohm-imaginary
Impedance	Microohms Imaginary	microohm-imaginary
Impedance	Milliohms Imaginary	milliohm-imaginary
Impedance	Megaohms Imaginary	megaohm-imaginary
Impedance	Killiohms Imaginary	killiohm-imaginary
Length	Meters	meter
Length	Centimeters	centimeter
Length	Millimeteres	millimeter
Length	Microns	micron
Length	Nanometers	nanometer
Length	Angstroms	angstrom
Length	Feet	foot

Length	Inches	inch
Mass	Micrograms	microgram
Mass	Milligrams	milligram
Mass	Grams	gram
Mass	Kilograms	kilogram
Mass	Pounds	pound
Mass	Slugs	slug
None	None	none (or empty string)
Percent	Percent	percent
Percent	Decimal Fraction	decimal
pH	pH	ph
Potential	Volts	volt
Potential	Millivolts	millivolt
Potential	Kilovolts	kilovolt
Power	Watts	watt
Power	Milliwatts	milliwatt
Power	Kilowatts	kilowatt
Power	Megawatts	megawatt
Power	Horsepower	horsepower
Pressure	Pascals	pascal
Pressure	Kilopascals	kilopascal
Pressure	Pounds per Square Inch	psi

Pressure	Bars	bar
Pressure	Atmospheres	atmosphere
Resistance	Ohms	ohm
Resistance	Microohms	microohm
Resistance	Milliohms	milliohm
Resistance	Megaohms	megaohm
Resistance	killiohms	killiohm
Specific Energy	Watt-Hours Per Gram	watt-hour-per-gram
Specific Energy	Watt-Hours Per Kilogram	watt-hour-per-kilogram
Temperature	Degrees Celsius	celsius
Temperature	Degrees Fahrenheit	fahrenheit
Temperature	Kelvins	kelvin
Time	Seconds	second
Time	Deciseconds	decisecond
Time	Milliseconds	millisecond
Time	Minutes	minute
Time	Hours	hour
Time	Hours Decimal	hour-dec
Time	Days	day
Volume	Cubic Millimeters	cubic-mm
Volume	Cubic Centimeters	cubic-cm



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Volume	Cubic Meters	cubic-m
Volume	Liters	liter
Volume	Cubic Inches	cubic-in

Appendix B: Example Data with Single Datapoint

Test Name: Voltaiq_House_Sample_01

Start Time: 1347489555000

Channel Number: 42

Tester Serial Number: A10345

Format Version: 2.0

Timezone: America/Los_Angeles

Comment: Comment about this test here.

[DATA START]

Datapoint Number	Cycle Number	Test Time	Timestamp	Step Index	Step Time		
Current	Potential	Charge Capacity	Discharge Capacity	Charge Energy	Discharge Energy		
none	none	secondepoch	none	secondamp	volt	amp-hour	amp-hour
watt-hour	watt-hour						
1	1	60.0324538367	1347471616000	1	59.7825961121	0.0	6.467822
0.0	0.0	0.0	0.0				