Proposed New Battery Characteristics
- some alternative ideas

In his presentation "*Proposed New Battery Characteristics for System Simulation and Vehicle Modeling Part I - Battery Load Calculations*", Tom Dougherty described 8 performance characteristics.
(file: TJD_MIT FEB_021601c.pdf)

Some alternative methods of measurement of 4 of the characteristics are proposed here with the aim of promoting discussion. The limited evidence shown is not sufficient to claim that these alternatives are definitely superior. If there is no consensus on the relative merits then tests may be needed to establish the advantages and disadvantages of these and other alternatives.

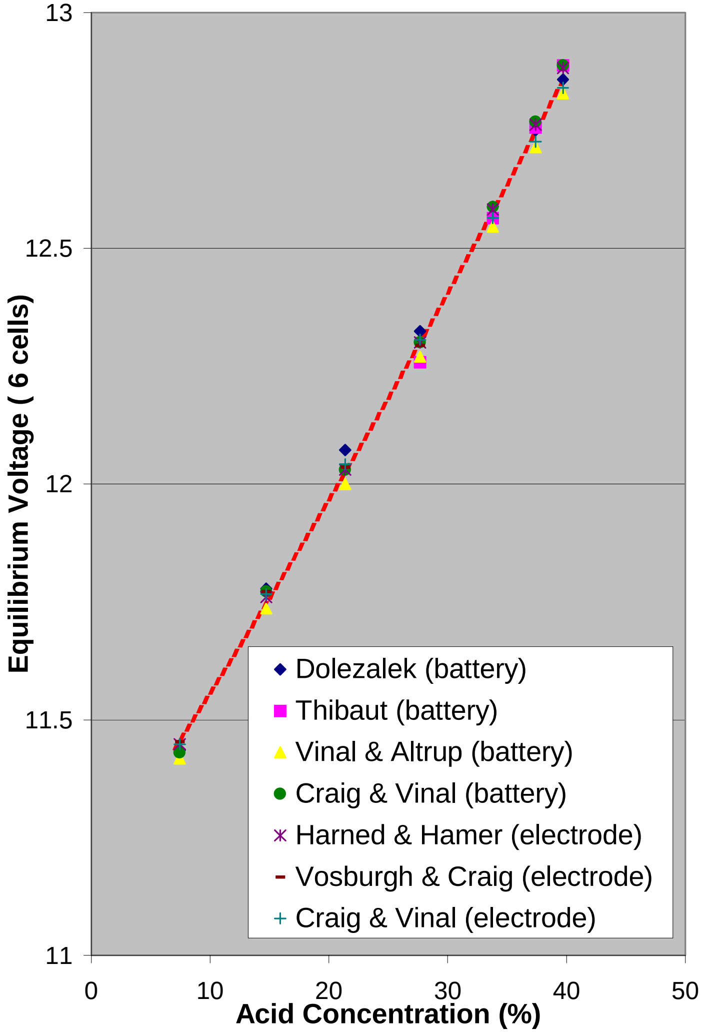
Charged Voltage and OCV/RSOC
- an alternative approach

AN ALTERNATIVE TO TESTING EACH BATTERY TYPE

- Assume that all batteries have the same fully stabilised open circuit voltage at a given acid concentration and temperature.
- Assume that this universal relationship can be represented by a polynomial equation, for example: -
  OVC = 11.140 + 0.0367*conc% + 0.0001419*conc%*conc% + 0.001452*degC
- A battery may be characterised by two parameters
  - the acid concentration at 100% SOC and 25 degC
  - the acid concentration at 0% SOC (10% SOC?) or the slope of acid concentration with SOC

Evidence for “Universal” OCV Relationship

Equilibrium Voltage Measurement from G W Vinal Table 39



- There is no systematic difference between data taken with batteries (pure lead and antimony alloy) and measurements on separate lead dioxide and lead electrodes.

- Fitted Equation: -

Veq = 11.140 + 0.0367*conc% + 0.0001419*conc%*conc%+ 0.001452*degC

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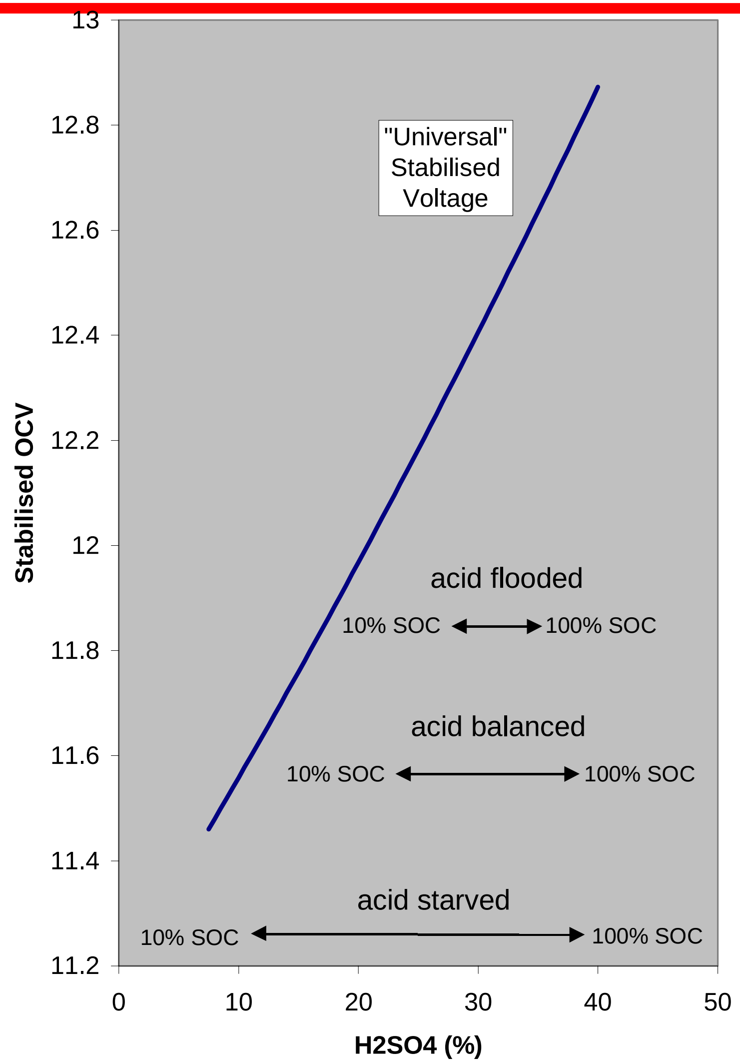
Acid Concentration Ranges



Open Circuit Voltage and Acid Concentration

(equivalent OCV ranges to JCI "RSOC Vs OCV" chart)

- A battery OCV range may be characterised by two parameters - the acid concentrations at
  - 100% SOC and
  - 0% (or 10%) SOC

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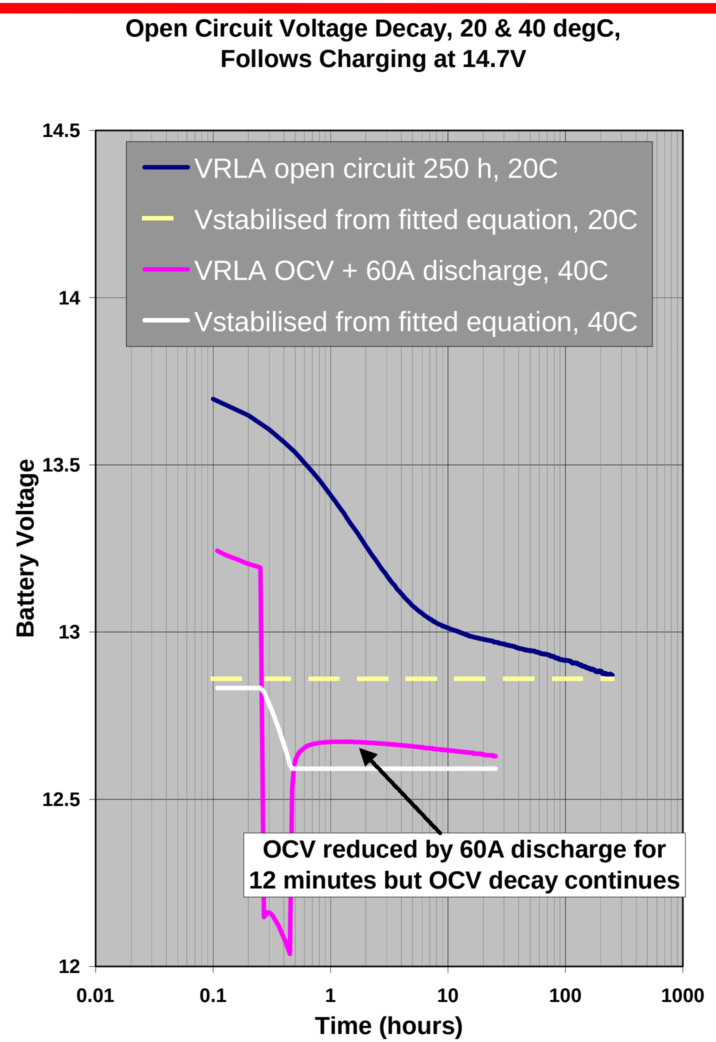
OCV Decay to Stabilised Level



- The freshly charged battery at 20ºC took 250 hours open circuit to decay to the equilibrium voltage calculated from the fitted equation

- The same freshly charged battery at 40ºC approached the calculated equilibrium voltage much more closely after a 60A discharge for 12 minutes but the OCV continued to decay in the subsequent 24 hours

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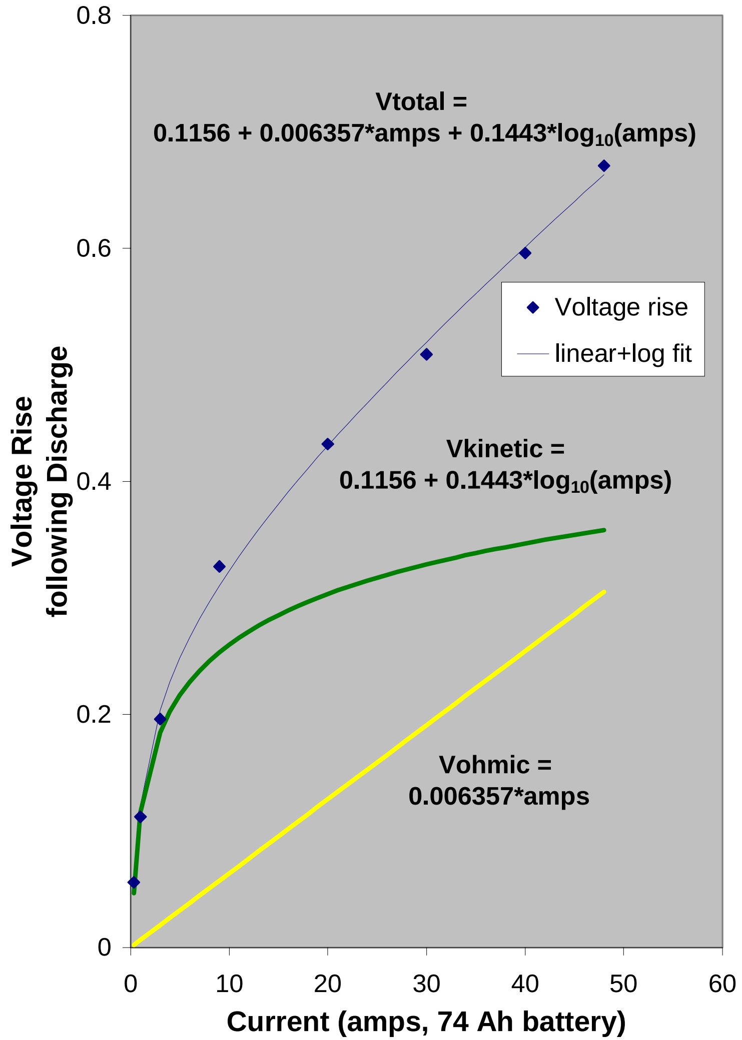
Ohmic and Kinetic Polarisation



- Both ohmic and "kinetic" resistance can be found from a single experiment by fitting an equation with current and log(current) terms.
- The ohmic resistance is the coefficient of the current term (in this case 0.006357 ohms)
- The "Kinetic Resistance" is the coefficient of the log-current term (in this case 0.1443 volts per decade)

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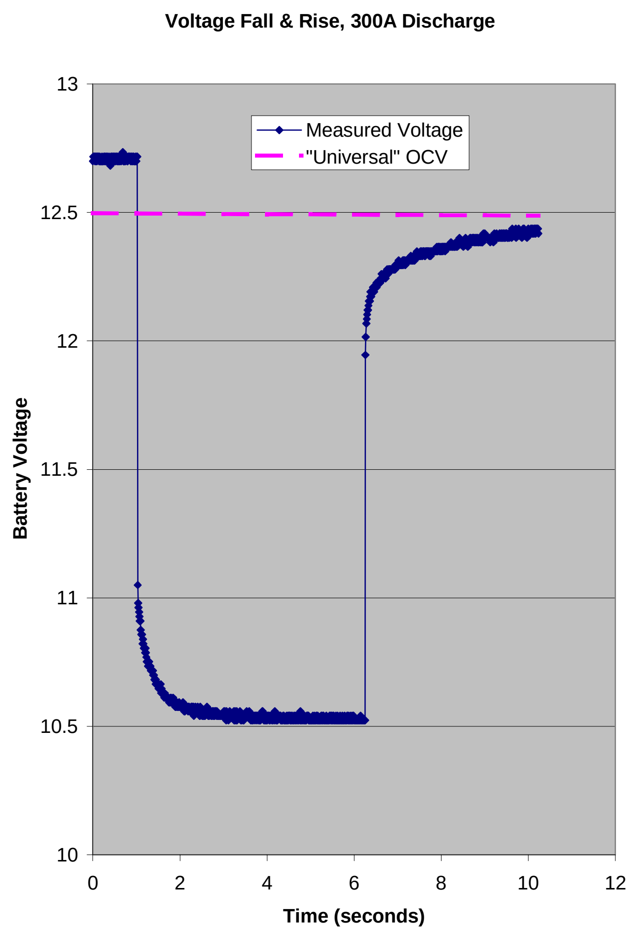
Kinetic Characterisation Test



- It is preferable to use the voltage rise between the end of discharge and the subsequent settled OCV because: -
  - If the battery was not fully stabilised first, the discharge will reduce the OCV nearer to the stabilised value
  - No current flows between the measurement points so there is no possibility of a small fall in the OCV due to a drop in the SOC in addition to the ohmic and kinetic contributions.

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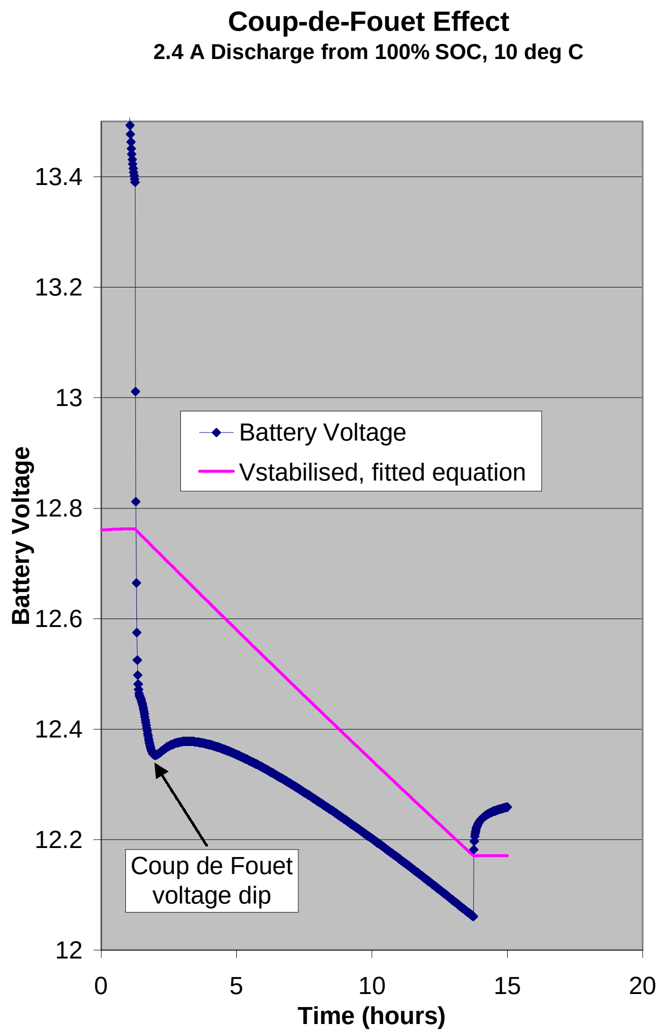
“Coup-de-Fouet” Voltage Dip



- Sometimes, a pronounced voltage dip is seen at the start of a discharge from 100% SOC. Using such an untypical low voltage would cause the “kinetic resistance” to be overestimated.
- Therefore, it is preferable to measure the kinetic resistance in a part-discharged condition (90% SOC?)

Conclusions (1)

- Stabilised OCV and SOC
  - if the variation of stabilised OCV with acid concentration differs from battery to battery, characterisation tests will be needed
  - if the variation of stabilised OCV with acid concentration is universal, a battery can be characterised by the acid concentration fully discharged and fully charged without testing.
  - *How strong is the evidence in support of each alternative?*

Conclusions (2)

- Ohmic & "Kinetic" Resistance
  - Measurements can be made in separate, optimised experiments or derived from a single experiment - *perhaps work needs to be done to clarify the accuracy and robustness of the two approaches*
  - In principle, measuring the voltage rise following a discharge is preferable to measuring the voltage drop but the difference may be insignificant in practice.
  - The "kinetic resistance" should be measured at part charge (90% SOC?) to avoid untypical high values due to the *coup-de-fouet* effect at 100% SOC