Meeting Minutes

Re: Battery Condition Monitoring Workgroup
Meeting in Lisbon, Portugal

Date: March 28, 2001

LIST OF PARTICIPANTS:

Masahiko Amano, Hitachi
Jean-Paul Cloup, PSA Peugeot Citröen
Michael Cox[†], Midtronics
Gary DesGroseilliers, MIT
Thomas Dougherty[†], Johnson Controls
Akihiko Emori, Hitachi
Tadashi Fujiwara, Honda
Takashi Fukunaga, Matsushita Electric
Steven Gladstein, Robert Bosch
Hans-Michael Graf, Siemens Automotive
Takenori Hashimoto, Fuji Heavy Industries
Louis Hruska, PowerSmart
Richard Johnson[†], Bolder Technologies
Anders Kaestel, Volvo
Tsuyoshi Kameda, Yuasa
Thomas Keim, MIT
Jean-Pierre Korb, Renault
Kazuyuki Kubo, Honda
Roger Kuvedu-Libla, Delphi
Malte Kuypers, Delphi
Pierre Malaterre, PSA Peugeot Citröen
John Miller, Ford
Asao Muranaga, Furukawa Electric
Eiji Muto, Honda
Paul Nicastri, Ford
Shinichi Nomoto, Furukawa Electric
Toshio Ohara, Japan Storage Battery
Christophe Picod, Valeo
Kenji Sato, Yazaki
Hans-Peter Schöner, DaimlerChrysler
Takeshi Tachibana, Toyota
Hidefumi Takaya, Toyota
Norman Traub, SAE
Alan Williams, TRW
David Winterbottom, Bolder Technologies
Kazuhiko Yagi, Honda

AGENDA

- Battery Temperature Sensing Methods ➔
- Battery Discharge Performance Parameters ➔
- Agreement Topics and Status ➔
- Future Meetings ➔

BATTERY TEMPERATURE SENSING METHODS

Hans-Peter Schöner gave a presentation on battery temperature sensing methods. A copy of that presentation has been loaded onto the web page and it can be accessed through this link ➔. (To access this web site, the Username is “Ford” and the Password is “Formula1”.)

[†] by teleconference

The main point of Peter's presentation was a proposal to integrate an optional temperature sensor into the battery terminal and to compare different implementations with respect to functionality, reliability and cost. Two basic approaches were considered: 1) temperature-dependent current sources; and 2) thermistors. Peter concluded that the sensitivity of a thermistor is good enough (i.e. ±1.2 K) and that the thermistor is cheaper and more reliable than the current source. He proposed five different thermistor-based configurations:

1. Thermistor at positive pole
2. Thermistor in series to pull-up
3. Symmetrical solution
4. Thermistor at negative pole (3 pins only)
5. Thermistor at positive pole, no pull-up

Following an analysis of each design, Peter concluded that the symmetrical solution shows the best overall performance. This approach would also allow for an extension of the design to include an integrated circuit (IC) which would begin to operate when the voltage across the KTY sensor exceeds a certain limit (>5V). The IC could provide data on battery parameters and save data on battery cycle data or on battery condition or age.

DISCUSSION OF BATTERY TEMPERATURE SENSING METHOD PROPOSAL:

Miller .... concerning the options shown for the configuration of the symmetrical solution with and without temperature sensing (slide 15), option 1 is preferable.

Kuypers............. with regard to the number of pins (3 or 4) and the issue of reliability, what is known about the reliability of the battery itself?

Korb .... if the extra pins are needed, then he recommends the 4-pin solution, two for power and two for sensing.

Keim.................. basically there are two issues: 1) the number of pins; and 2) the use of the extra pins.

Traub .... whichever pin is used for disconnect sensing (probably positive) should not have any secondary function that would compromise reliability.

Nicastri............... believes that one thermistor in series could be used without compromising reliability.

Tachibana.......... concerning the use of a 5k resistor on the positive side, he prefers a lower value for higher reliability.

Traub .... perhaps the resistor could be somewhat smaller but 5k is already very close to the size needed to meet performance requirements.

Keim.................. actually, thinks the size of the resistor might need to be greater than 5k to preserve life, but only operated under fault conditions.

Conclusion....... recommendation for battery terminal standard should include 4 pins, two for power and two for sensing. The application of the sensing pins can be determined later. Action on this item will be taken by the Battery Termination Workgroup.

BATTERY DISCHARGE PERFORMANCE PARAMETERS

At the last meeting Tom Dougherty and Hans-Peter Schöner proposed a set of eight battery discharge performance parameters that could be used to determine the deliverable power and deliverable energy of a lead-acid battery at any time in its use. The proposed parameters are:

1. **Nominal Capacity** –battery's ability to deliver charge at the 20 hour rate. It also sets a data point for *Peukert's Curve.*
2. **Peukert's Slope** – the battery's ability to deliver charge at different rates.
3. **Charged Voltage** – the open circuit voltage of a battery at equilibrium when fully charged and at rest with no loads.
4. **OCV/SOC Slope** – slope of the curve that shows the OCV to the State-of-Charge.
5. **Internal Resistance** – total ohmic resistance of a charged and conditioned battery, measured in milli-ohms.
6. **Ionic/Electronic Ratio** – ratio of the ionic resistive component to the electronic resistive component in a battery, which allows for modeling the temperature dependence of the resistive components.
7. **Kinetics** – voltage drop due to the reaction to form lead sulfate. This nonlinear voltage drop, plus the temperature corrected internal resistance, gives the voltage drop of the battery under load.
8. **Thermal Time Constant** – ability to dissipate heat. The heat capacity divided by heat transfer coefficient.

The presentation also proposed standard methods for measuring each of these parameters. At this meeting, Alan Williams presented alternative methods for measuring four of the parameters: 1) charged voltage; 2) OCV/SOC slope; 3) internal resistance; and 4) kinetics. A copy of Alan's presentation has been loaded onto the web page and it can be accessed through this link ➔. To summarize his conclusions:

- If the variation of stabilized OCV with acid concentration is universal, a battery can be characterized by the acid concentration fully discharged and fully charged without testing each battery type.
- Measurements of the internal resistance and kinetic resistance can be derived from a single experiment by fitting an equation with current and log (current) terms. Also, the kinetic resistance should be measured at part charge (e.g., 90% SOC) to avoid untypical high values due to the *coup-de-fouet* effect at 100% SOC.

Williams' presentation was made for the purpose of promoting a discussion and he does not claim that the alternative methods are definitely superior. If there is no consensus on the relative merits of the alternative approaches, then Williams suggests that testing may be needed to establish the advantages and disadvantages of these and other alternatives.

DISCUSSION OF BATTERY DISCHARGE PERFORMANCE PARAMETERS:

Schöner .... concerning the proposal to characterize a battery's OCV range by the acid concentrations at 100% SOC and 0% (or 10%) SOC, he thinks that the relationships are non-linear in those ranges. Therefore, it would be better to take the measurements at 90% SOC and 40% SOC.

Schöner .... concerning the proposed voltage rise following discharge equation (slide 6), the results at 50A will be even better than the originally proposed methodology. However, at zero current, an accurate measurement cannot be made.

Graf.................... while it will be possible to agree on a set of parameters for battery performance characterization, he recommends that we first consider what battery information is needed and then select parameters to satisfy those requirements.

Schöner............ an alternative approach that has been recommended by Varta would require the battery condition monitoring (BCM) system to know the name of the manufacturer, model of the battery, and date of manufacture. Then all information about various batteries would be stored as "drivers" in the BCM system.

Williams............ since safety critical applications depend on the condition of the battery, he thinks that measurement of standardized parameters is very important.

Hruska.............. standardized parameters will help battery manufacturers and OEMs, but he believes that battery monitoring requires a dynamic approach. Therefore, he does not think that it will be possible to determine performance based on original state information. It would be better to focus the attention of this group on the battery monitoring process.

Williams............ it has been announced that a second set of battery parameters will be proposed to determine charge and life characteristics of the battery. Will these be fixed or variable parameters?

Schöner............ the second set of parameters has not yet been defined. Peter plans to make a presentation on this topic at the September consortium meeting. He will probably be able to give preliminary information to the BCM Workgroup before that time.

Williams............ does the proposed methodology require that a battery introduced into a vehicle be new? What would happen if someone installs a used battery? Is there a learning process to determine battery information?

Nicastri.............. not concerned yet about implementation issues.

Graf.................... if self-learning will do a good enough job, then maybe we don't need all these parameters.

Williams............ suggested that we need to consider the practical implications of implementation so that the right decisions are made now.

Conclusion....... no agreement yet on any particular battery discharge performance parameters or measurement methodology. Additional discussion required at next meeting.

AGREEMENT TOPICS AND STATUS:

The status of topics under discussion by the BCM workgroup is summarized in the table below

Topic	Status
1. BCM Workgroup "Statement-of-Purpose" and "Guidelines for Participants"	Accepted without change
2. Battery discharge performance parameters to be encoded in 5-bits each, referred to as "Word-1"	Under discussion
3. Charging and life information of the battery would be	Under discussion

	encoded in separate set of parameters, “Word-2”	
4.	“Words” will be provided on a label or electronically coded chip.	Under discussion
5.	Battery discharge performance parameters will include:	
	Nominal capacity	Under discussion
	Peukert’s slope	Under discussion
	Charged voltage	Proposed alternatively to charged voltage and OCV/SOC slope would be acid concentration fully discharged and fully charged
	OCV/SOC slope	Proposed alternatively to charged voltage and OCV/SOC slope would be acid concentration fully discharged and fully charged
	Internal resistance	Proposal to determine both internal resistance and kinetic resistance from a single experiment by fitting an equation with current and log (current) terms
	Ionic/electronic ratio	Proposal to determine both internal resistance and kinetic resistance from a single experiment by fitting an equation with current and log (current) terms
	Kinetics	Under discussion
	Thermal time constant	Under discussion
6.	Battery terminal standard should include 4 pins, two for power and two for sensing. The application of the sensing pins (e.g., temperature, disconnect, battery condition monitoring) will be determined later.	Accepted

FUTURE MEETINGS:

The next meeting will be a teleconference on Wednesday, May 2, 2001, from 10:00 a.m. until 12:00 noon (United States Daylight Savings Time). At that time, Dell Crouch of Delphi will make a proposal for the future direction of the BCM Workgroup and we will provide an opportunity for a discussion of his proposal. Depending upon the outcome of that discussion and available time, we will discuss other Agreement Topics, including the proposed battery discharge performance parameters.