The BEST diagnosis device for storage batteries
Batteries are generally used in UPS systems, DC power supplies, generators, oil pumps, telephone central office, outside plant areas, etc. And they are still used in processing plants, by utilities, transportation companies, government offices, in telecommunications, and the hospital and so on. The battery is typically the last line of defense against total shutdown during power outages.

Experience has confirmed that storage battery failures cause more down time and service calls on emergency power systems than any other component. How can users be sure that their last line of defense is sufficient?

Until recently, the commonly used method to determine battery and cell health was to perform a load test. Although reliable, this method has proven to be cumbersome, time consuming, expensive, and risky.

B-BEST Inc. has developed an on-line battery discharging device which can detect deterioration battery before cell can cause system failure.

To find the deterioration cells!
To clarify the true end-life time!
To the reduction of the battery maintenance cost!
To maintain the reliability of the storage battery equipment!

An actual test of 60 cells can be finished within 2 hours!
It is a deterioration inspection device with excellent functions for the storage battery system.

**BEST LINE UP**

1) BEST 600nx2 (1v or 2v)  
   \[10 \leq A \leq 600\]
2) BEST 2000mx2 (1v or 2v)  
   \[50 \leq A \leq 2000\]
3) BEST 30mx2 (6v or 12v)  
   \[1 \leq A \leq 50\]
4) BEST 300mx12 (6v or 12v)  
   \[10 \leq A \leq 300\]

**Float voltage measurement**
**Internal resistance measurement**
**The electric discharge measurement for 1 second**
**Specific gravity measurement**
**Remaining capacity measurement**

**BEST600nx2**

**Auto-polarity type**
Easy operation by the key pad!

Electric discharge with large current is possible.
(10 ≤ A ≤ 600)

It can be measured in the practical use.

Various measurement data are graphed easily.

Internal resistance can be calculated by the electric discharge and the recovery voltage.

It is compact and safety.
Size: 180 × 270 × 150 mm
Weight: 5 Kg
Application to various storage batteries

The BEST device can be used for the storage battery of various types.

- Valve-regulated batteries (2V)
- Lead-acid batteries (HS)
- Lead-acid batteries (CS)
- Nickel Cadmium batteries (AH)
- Valve-regulated batteries (6 or 12V)
- Batteries (AHH)
Batteries are generally used to UPS systems, DC power supplies, generators, oil pumps, telephone central office, outside plant areas, etc.

And they are still used in processing plants, by utilities, transportation companies, government offices, in telecommunications, and the military.
## Comparison of inspection device to storage battery

<table>
<thead>
<tr>
<th></th>
<th>Digital voltmeter</th>
<th>Internal resistance meter</th>
<th>Load test device</th>
<th>BEST device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement of float voltage</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Measurement of internal resistance</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Measurement of open circuit voltage</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Identification of failed batteries (※1)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Identification of failed batteries (※2)</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Identification of end life batteries</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

*1 Storage batteries which had problem of terminal posts, internal straps and grids and so on.

*2 Storage batteries which had problem of short-circuit between plates.
The constant current electric discharge is performed for 0.5 seconds, and the discharge voltage and the recovery voltage are measured automatically.  
- The electrical discharge current is easily selected depends on the capacity of a cell.  
- A semiconductor is applied as the electric load.  
- A cell voltage of 121 points for each cell is measured for 1 second automatically.  
- Data is transmitted to the personal computer with the USB conversion cable automatically.  
- The analysis of life expectancy and deterioration is easy with various graph data.
**Analysis of internal resistance**

**Charge**

\[ V_B = E + (I_c \times R) \]

**Discharge**

When the electric discharge is end,

\[ V_{B1} = E - (I_d \times R) \]

Therefore, electromotive power\( (V_{B1}) \) returns to the point of \( V_{B2} \)

\[ V_{B2} = E \]

\[ V_{B2} - V_{B1} = I_d \times R \]

\[ R \approx \frac{(V_{B2} - V_{B1})}{I_d} \]
This is a basic characteristic graph when a cell is discharged with the BEST device.

The discharge voltage of each 50mS with 20 points is showed automatically.
This is an example of the storage battery which exceeds the end-life period. Because an electric characteristic is normal, it is possible to use more continuously.

The replacement costs can be postponed and reduced!

<table>
<thead>
<tr>
<th>Cell No.</th>
<th>Discharge voltage</th>
<th>Recovery voltage</th>
<th>Floating voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-20</td>
<td>2.20</td>
<td>2.10</td>
<td>2.30</td>
</tr>
<tr>
<td>21-30</td>
<td>2.10</td>
<td>2.00</td>
<td>2.20</td>
</tr>
<tr>
<td>31-40</td>
<td>2.00</td>
<td>1.90</td>
<td>2.10</td>
</tr>
<tr>
<td>41-50</td>
<td>1.90</td>
<td>1.80</td>
<td>2.00</td>
</tr>
<tr>
<td>51-60</td>
<td>1.80</td>
<td>1.70</td>
<td>1.90</td>
</tr>
</tbody>
</table>

(V)

Battery discharge voltage and recovery voltage

***** Company
Tokyo Factory
Storage battery type VRLA200x60
Manufacturing years Mar-01
Discharge current 200 A
Inspected day 15-Sep-10

- Float voltage
- Voltage at 500ms
- Voltage at 550mS
- 80% capacity line
- 50% capacity line
- 100% capacity line
Internal resistance of all cells are shown as below. All cells shows the good resistance which are similar as new cells. This battery system is used over 14 years, however the internal resistance still shows the good value.

**Company**

**Storage battery type**

**Tokyo Factory**

**VRLA200x60**

Manufacturing years: Mar-01

Discharge current: 200 A

**Inspected day**: 15-Sep-10

**Initial resistance value** of VRLA-200AH type
Discharging characteristic of two cells are shown. One is the best cell and the other one is lowest cell (No.33). The lowest cell (No.33) shows the level over 80% capacity line.

---

**Discharging Voltage as a Function of Time**

- **54**
- **33**
- **80% capacity line**
- **50% capacity line**

---

**Table:**

<table>
<thead>
<tr>
<th>Company</th>
<th>Storage battery type</th>
<th>VRLA200x60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokyo Factory</td>
<td>Manufacturing years</td>
<td>Mar–01</td>
</tr>
<tr>
<td></td>
<td>Discharge current</td>
<td>200 A</td>
</tr>
<tr>
<td></td>
<td>Inspected day</td>
<td>15–Sep–10</td>
</tr>
</tbody>
</table>
Relation between capacity of storage battery and internal resistance
The defective cell was found at the first inspection.

Reliability can be improved by taking out the defective cell (No.18) or replacement of it to new one.

<table>
<thead>
<tr>
<th>Company</th>
<th>Storage battery type</th>
<th>Manufacturing years</th>
<th>Discharge current</th>
<th>Inspected day</th>
</tr>
</thead>
<tbody>
<tr>
<td>***** Power Company</td>
<td>CS130AH_60cells</td>
<td>Mar-94</td>
<td>130 A</td>
<td>23-Aug-11</td>
</tr>
</tbody>
</table>

**Battery discharge voltage and recovery voltage**

- **Float voltage**
- **Voltage at 500ms**
- **Voltage at 550mS**
- **80% capacity line**
- **50% capacity line**
- **100% capacity line**

**Cell No.**
All 60 cells are sorted according to deterioration order. These batteries are used over 17 years. Generally the life time of this kind of battery is designed as 14 years. However there is only one sell which is defective. Another cell still have over 80% capacity so that after taking out the No.18 cell from the system, then we can use the battery system in safe.

The cell No.18 shows the abnormal floating voltage and recovery voltage (EMF) which means already self-discharged inside of the cell. It means remaining capacity is also less.
Internal resistance of all cells are shown as below. The cell No.18 shows the high resistance. Another 59 cells still keep good resistance which means good cells even though it is over the life period.
Discharging characteristic of two cells are shown. One is the best cell and the other one is worst cell (No.18). The worst cell (No.18) shows the level under 50% capacity line.

<table>
<thead>
<tr>
<th>Power Company</th>
<th>Storage battery type</th>
<th>CS130AH_60cells</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturing years</td>
<td>Mar–94</td>
</tr>
<tr>
<td></td>
<td>Discharge current</td>
<td>130 A</td>
</tr>
<tr>
<td></td>
<td>Inspected day</td>
<td>23–Aug–11</td>
</tr>
</tbody>
</table>

![Discharge voltage as a function of time graph](image)
This photograph shows the cause of a defective cell of No.42 as shown in (2-1)

The defective welding
Example of initial defective storage battery (2-4)

Corrosion of a minus pole part

Internal structure

Defective part

Normal plus pole part

Defective minus pole part
Example of initial defective storage battery (2-5)

Defective pole

Defective welding

ABNORMAL POLE (Corrosion)

ABNORMAL

NORMAL
There is no characteristic difference among cells for the first five years since they are installed. There, the discharge voltage at 500mS when is measured by BEST tool shows generally over 2.0V. If there is a defective cell in a battery equipment, the discharge voltage will be dropped below 1.95V. In this case, replacement of the defective cell is a good method to keep its reliability of the system.
These photographs shows the method of an actual test.
Total 54 cells are connected in series and used in DC power supply system.
The capacitor of each cell is 200AH.
In our BEST case, an actual test will be finished within a few hours, including making visual reports.
1) Safety to a load equipment

The typical discharge test with BEST device is performed to each cell. Then, the voltage drops in a cell is approximately 0.3V. Because the total voltage to the load is always controlled as 138V, voltage drops of 0.3V does not make any influence to the load equipment.

2) Safety in an actual test

To perform the actual test, the detector leads are connected at first across the terminals of a cell. And next, discharge cables are pressed properly against both terminals of the same cell. BEST device has some protect circuits with buzzer against reverse connection.

3) Safety to a cell

If there is a very high internal resistance, the current will be low and the discharge will be instantaneously terminated.

After over ten thousands of cell tests, there have been no reports indicating that the BEST test discharge has caused a cell to open circuit.