Service Information

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Coverage ☐ Distributor only ■ Please inform your dealers		Date Issued September 10, 2012	
Please convey this information to your ☐ Director ■ General Manager ■ Warranty Dept. ■ Parts Dept. ■ Training Dept. ■ Field Rep.		Date Revised	
Applicable Model Models with i-stop System	Applicable Countries or Specifications Worldwide		

Subject: Fundamental Knowledge of Battery used for i-stop System

DESCRIPTION

This Service Information addresses, in a FAQ form, Service Points, Characteristics, Constructions and Functions of the battery (Q85/T110) which is used for i-stop system.

[CONTENTS]

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1. FAQ

1) Is the construction of Q85/T110 battery for i-stop system the same as for conventional battery?

- Compared with the conventional battery, required amount of charging and discharging for i-stop system battery is significantly higher because the engine is cranked frequently and electric power is supplied to the vehicle electrical systems only from the battery during the engine is stopped by i-stop system. In addition, after the engine is re-started, the battery must be re-charged quickly.
- For these reasons, compared with the conventional battery, i-stop system battery requires higher durability against frequent charging/discharging and charging acceptability. To achieve these performances, the number of battery plates is increased and the material is changed.
- On the other hand, dendrite short is more likely to occur due to smaller gap between battery plates and occurrence of sulfation generated during battery discharging.

<Reference>

2-1) Difference between conventional battery and i-stop system battery
2-2) Reasons why a specific battery is necessary for i-stop system

2) What is an appropriate inspection procedure to judge whether i-stop system battery is in good condition or not?

- Measure the specific gravity. This is the way to verify enough electric energy is stored in the battery.

Judgment Criteria

Before Charging: The specific gravity should be 1.17 or more for all cells
NOTE: Before measuring, by using a big siphon suck the electrolyte solution from the battery as much as possible and put it back.
After Charging: The specific gravity should be 1.25 or more for all cells

- Battery not meeting the criteria needs replacement.
- If specific gravity is 1.17 or more for all cells, sulfation can be recovered by charging.
- Dendrite short may occur if specific gravity in any cell is lower than 1.17.

<Reference>

3-2) Battery Inspection
3-3) Battery Charge

3) What cautions should be taken when measuring specific gravity?

- When measuring specific gravity, the specific gravity of electrolyte solution must be even in the entire battery. If polarization has occurred, the specific gravity becomes uneven between the cells, therefore stir the electrolyte solution well before measurement. (Before charging)
- In case that the battery was charged with “constant-current” and “high-voltage”, the electrolyte solution is well mixed so you can measure the specific gravity as it is.
- Use a scope type specific gravity meter which is of higher accuracy.

<Reference>

3-2) Battery Inspection

4) Is it possible to verify whether i-stop system battery is in good condition or not by measuring CCA or battery voltage with a battery tester available in the market?

- It is difficult to verify it correctly.
- As mentioned in 1-1), i-stop system battery has higher charging/discharging ability so it may indicate higher CCA even after discharging or when battery deterioration has progressed.
- Because of this, there is a characteristic that the terminal voltage may rise immediately after charging started. So even if the terminal voltage/CCA is indicated higher, it doesn’t always mean the battery is in good condition.

<Reference>
3-2) Battery Inspection
3-3) Battery Charge

5) Is there any special procedure required when charging i-stop system battery?

- According to the Workshop Manual "BATTERY RECHARGING", charge the battery with constant current and high voltage.
- In order to operate i-stop system properly, it is essential to store enough electric energy in the battery. This way of charging can charge the battery fully and it can also remove sulfation which may lead to dendrite short.
- In case of automatic battery charger, the terminal voltage may immediately rise after charging started and charging may be finished before the battery is fully charged.
- The following cautions should be taken when charging with constant current and high voltage because a large amount of gas is generated during charging.
  - ✓ Remove the battery from the vehicle.
  - ✓ Check the battery fluid level and adjust it as necessary.
  - ✓ Remove the battery filler caps.
  - ✓ Keep all flames away from the battery and perform the servicing in a well-ventilated area.

<Reference>
2-1) Difference between conventional battery and i-stop system battery
2-2) Reasons why a specific battery is necessary for i-stop system
2-3) Battery charge control
3-2) Battery Inspection
3-3) Battery Charge

6) How often should i-stop system battery be recharged during the vehicle storage?

- For battery during the vehicle storage, recharge it every 2 months.
- For battery during parts storage, recharge it every 4 months.

<Reference>
3-1) Battery Maintenance
3-3) Battery Charge

7) Is there any suitable automatic battery charger available in the market, which can be used to charge i-stop system battery?

- If it is possible to adjust/select "charge-current", "charge-voltage" and "charge-time" arbitrarily, you can use the charger.

<Reference>
3-1) Battery Maintenance
3-3) Battery Charge

8) Why is it possible to start engine even if the specific gravity in multiple battery cells drops around 1.0?

- i-stop system battery has higher discharging/charging ability in order to meet the requirement of frequent engine cranking. Even if the specific gravity in some cells is low, electric energy reserved in other cells can compensate and it can crank the engine.
- If the cell with the lowest specific gravity is less than 1.17, battery replacement becomes necessary.

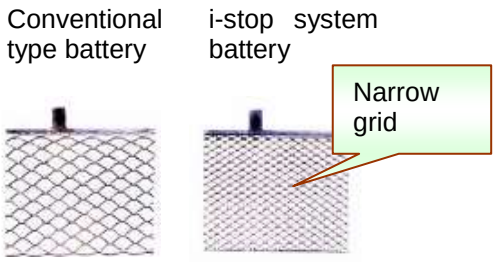
<Reference>
2-1) Difference between conventional battery and i-stop system battery
3-2) Battery Inspection

2. CHARACTERISTICS AND FUNCTIONS OF I-STOP SYSTEM BATTERY

1) Difference between conventional battery and i-stop system battery

Compared to the conventional battery or the charge control battery, i-stop system battery has improved durability/charging acceptability. In order to achieve these performances, it has the following features.

① More durability

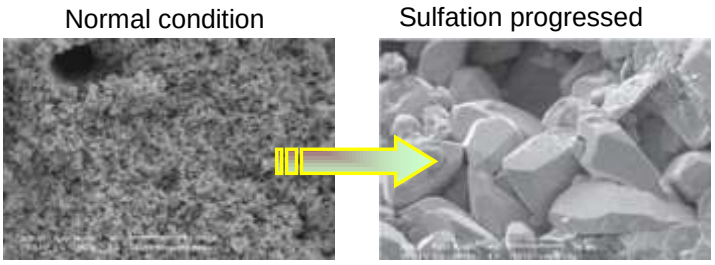


(1) With the use of narrow grid, holding capacity of active material is raised to prevent active material from becoming softened and dropping.

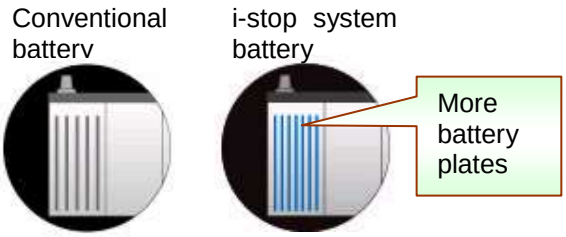
(2) Charging ability is improved by reducing ***sulfation*** due to discharging.

※Sulfation : At this condition, battery cannot be reduced to lead and sulfuric acid even after charging because lead sulfate, which is generated during battery discharging, causes coarsening in the recrystallization process.

Recrystallization progresses gradually. So, by keeping the discharging condition (with more lead sulfate included) for a long time, sulfation occurs, which lowers battery capacity or charging ability.



② More charging ability



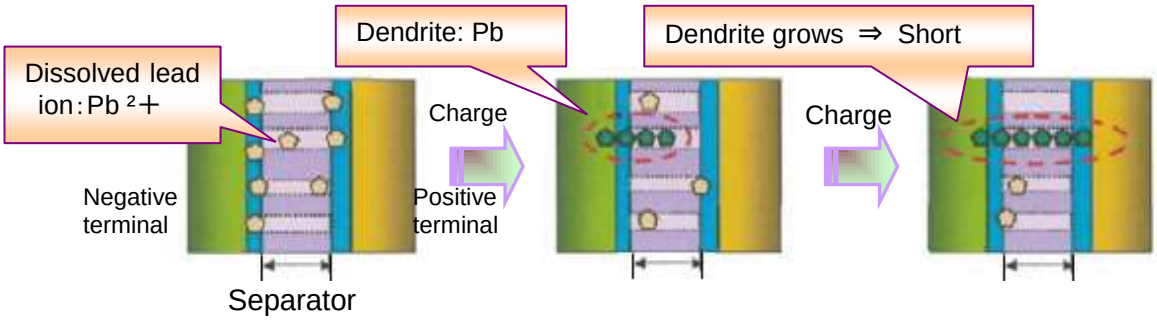
(1) Additive included in lead of battery plate is optimized to increase charging performance.

(2) Reaction area is increased by having more battery plates to improve charging performance.

On the other hand, though charging acceptability has increased with more battery plates, ***dendrite short*** is more likely to occur due to smaller gap between battery plates!

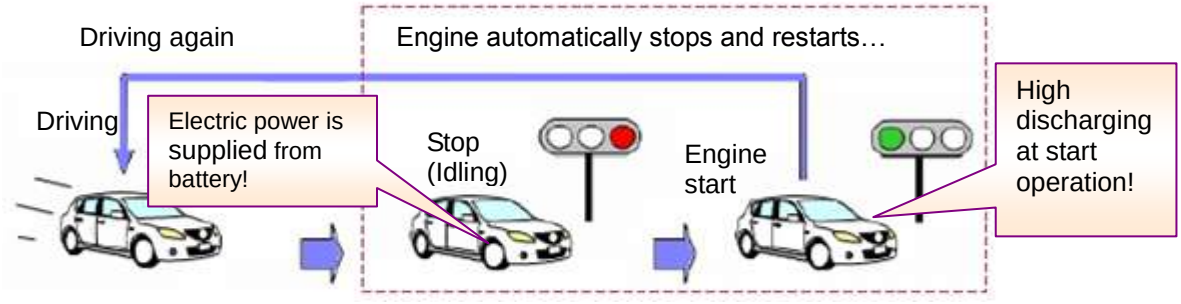
※Dendrite short: If sulfuric acid concentration in the electrolyte solution decreases battery is exhaustively discharged. At that time, lead ion dissolves from lead sulfate. If the battery is charged under such condition, lead ion grows and becomes like a shape of a needle on the (-) battery plate surface, which is called dendrite.

Dendrite keeps on growing inside the separator between battery plates. So, if the exhaustively discharging is repeated, dendrite hits (+) battery plate, causing short circuit. Such condition is called dendrite short. If dendrite short occurs, it causes short circuit between positive and negative terminals. Under such condition, even though the current flows, reduction of lead and sulfuric acid doesn't occur. As a result, specific gravity of electrolyte solution does not increase.



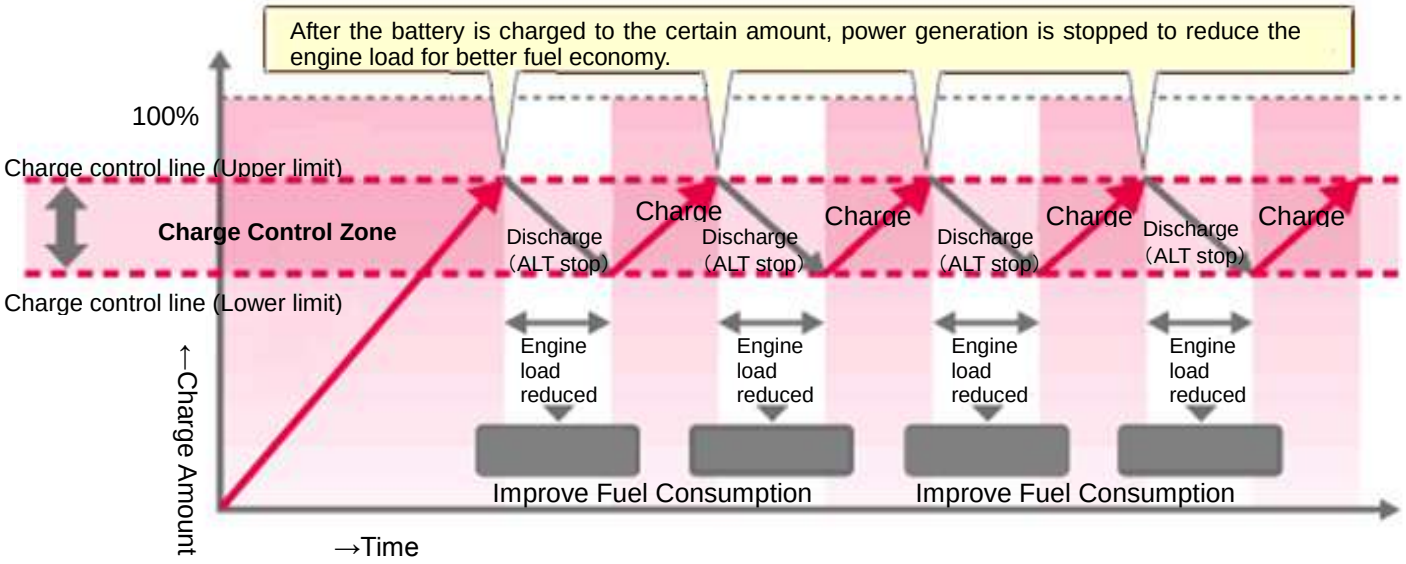
2) Reasons why a specific battery for i-stop system is necessary

- When a vehicle equipped with i-stop system stops at a red light, engine is stopped for fuel economy improvement. When the vehicle starts to drive again, the engine restarts. So, battery discharging and charging are repeated in a short period of time.
- Also, during i-stop operation, as electric power for air conditioning and audio systems etc. is supplied from the battery only, discharging occurs more than on vehicles without i-stop system.
- If a battery other than the specifically designed for i-stop is used instead, its lifecycle may be reduced or it may disable i-stop function.



3) Battery charge control

- In order to improve fuel economy, the alternator charge amount is monitored on recent vehicles by using a current sensor, being installed close to the battery.
- If the battery is charged to a certain amount, the alternator's power generation is stopped and electrical load is supplied from the battery to the vehicle to reduce the power generation load.
- For vehicles with battery charge control, charge and discharge are repeated within a specified range frequently, which results in high load to the battery. Also, if charging ability isn't good, more power generation time would be required, which applies more load to the engine with fuel consumption increased.



3. SERVICE POINTS

1) Battery Maintenance

① Don't leave the battery for a long time under discharge condition

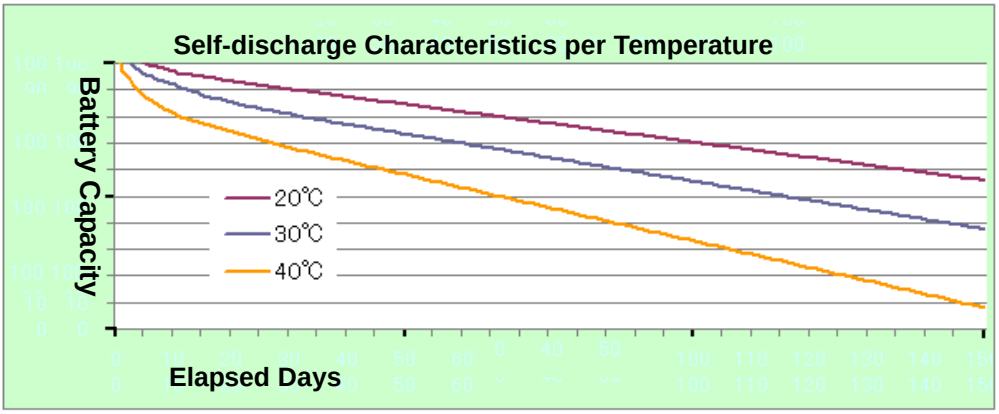
- If the battery is kept under discharge condition for a long time, sulfation occurs due to lead sulfate crystallization.
- As a result, reduction of lead and sulfuric acid will not occur after charging, which will lower charging ability and battery capacity, ending up with the situation that original vehicle specification (ex. fuel economy) cannot be achieved.
- Therefore, battery capacity needs to be maintained, either by starting the engine or connecting the battery to a battery charger regularly.

② Don't exhaustively discharge the battery

- If charge and discharge are repeated with the exhaustively discharged battery, it may cause dendrite short, which most likely causes the battery to be unusable.
- Particularly, for i-stop system battery, the distance between positive and negative plates is smaller than in other batteries due to increased number of plates. This increases the risk of short circuit, as described earlier.
- To prevent exhaustively discharging and keep the battery capacity to a certain level, you need to remove (-) terminal or charge the battery regularly when the vehicle is stockpiled for a long time.

③ **Charge the battery regularly even though there's no electrical load applied.**

- As the battery capacity gradually lowers due to self-discharge even under the condition without electrical load application, battery terminal must be removed during long-term stockpiling to reduce discharging.
- When the battery is kept in the stock as service part, it needs to be charged regularly to restore its capacity.
- In addition, self-discharge amount increases when the temperature rises. Therefore, if you have to keep the vehicle in a place where it is exposed to the direct sunlight or hot temperature, supplemental charging must be performed in a shorter period of time than usual.



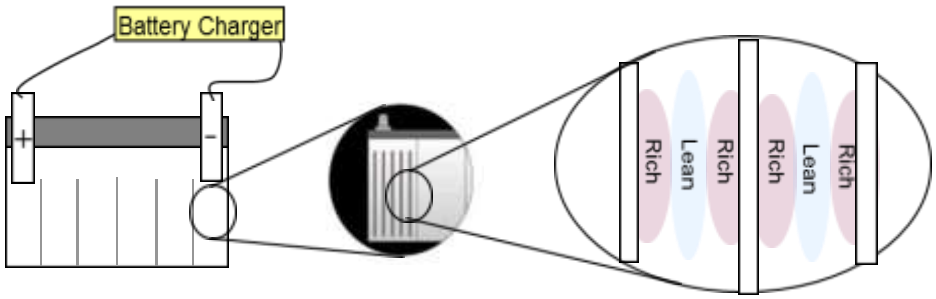
2) Battery Inspection

① **Points to be considered during battery inspection/charge**

- As a characteristic of lead battery, voltage may be different or specific gravity of electrolyte solution may not be increased when the battery, being kept for a while, is compared with the one right after charge.
- That is due to ***polarization*** or ***stratification*** of electrolytic solution. So, if battery inspection and charge is performed without taking these into consideration, it would result in unnecessary battery replacement.

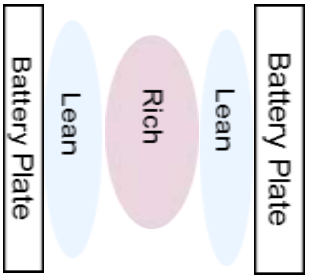
※Polarization:

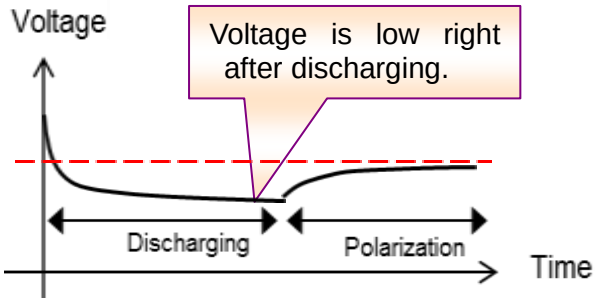
Since chemical reaction starts around the battery plate at charging/discharging, specific gravity of electrolyte solution becomes different depending on the distance from the electric pole causing the difference of voltage relative to specific gravity.



※Discharge polarization

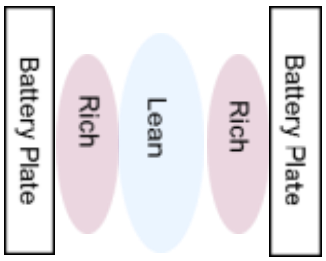
When electric load is applied to the battery, it causes the electrolyte solution becoming lean around the electrode while it becomes rich around the area far from electrode.
In this case, measured voltage right after discharging is lower than the one when the battery is left for a while.

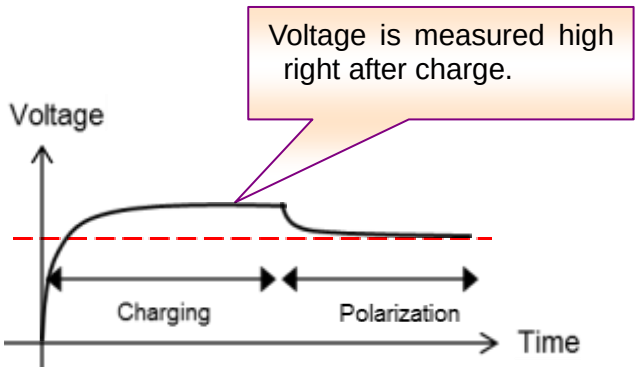




※Charge polarization

When the battery is charged, it causes the electrolyte solution to be rich around the electrode while being lean around the area far from the electrode.
In this case, voltage right after charge is higher than the one when the battery is left for a while.

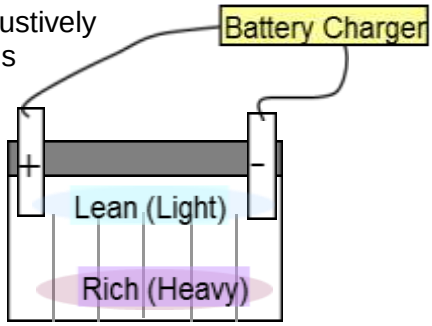




Stratification:

Specific gravity may be different between the top and the bottom of electrolytic solution during charging/discharging. This is called stratification.
At early discharging stage, as discharging on the top of battery plate takes place first, specific gravity becomes different between the top and the bottom.
During charging, highly-concentrated sulfuric acid is released in the electrolyte solution in the process of lead sulfate being reduced into lead and sulfuric acid. Then, the released sulfuric acid sinks to the bottom because of higher weight, which causes the gap of specific gravity between the top and the bottom of the battery.

Particularly, when the battery is charged from the exhaustively discharge condition, the above-stated polarization tends to occur, which makes the heavy electric solution sink and the light one flow.
Also, if the battery is charged by low voltage, gas is hardly generated at the end of charge. Then, the electrolyte solution will not be stirred, to eliminate the stratification condition.
However, battery terminal voltage can be measured correctly because the specific gravity on the bottom is high enough.



② Inspection by voltage/specific gravity measurement

a. Voltage measurement

- Due to charging polarization as mentioned earlier, the battery terminal voltage right after charging indicates higher than the actual battery capacity. Therefore, voltage must be measured by leaving the battery for a reasonable amount of time (6 hours or more) after charging.
- In case of long-term stock battery, the voltage measurement is sufficient to determine the charging condition because rest time is long enough.

b. Specific gravity measurement

By measuring specific gravity, it can be judged if the battery is properly charged with a sufficient amount of electric energy. Follow the procedure below.

Measurement before charging

- To mix the electrolyte solution, using a big siphon suck the electrolyte solution from the battery as much as possible and put it back.
- Using a scope type specific gravity meter which is of higher accuracy, measure specific gravity of all cells.

<Judgment Criteria>

-If the cell with the lowest specific gravity is less than 1.17, replace the battery as it can be determined as a dendrite short.

-If the cell with the lowest specific gravity is 1.17 or more, recharge the battery with a constant current for the required time.

Measurement after charging

- In case that the battery was charged with “constant-current” and “high-voltage”, the electrolyte solution is well mixed so you can measure the specific gravity as it is.
- In case that the battery was charged by method other than with “constant-current” and “high-voltage”, mix the electrolyte solution thoroughly before measurement. Using a big siphon, suck the electrolyte solution from the battery as much as possible and put it back.
- Using a scope type specific gravity meter which is of higher accuracy, measure the electrolyte gravity of all cells.

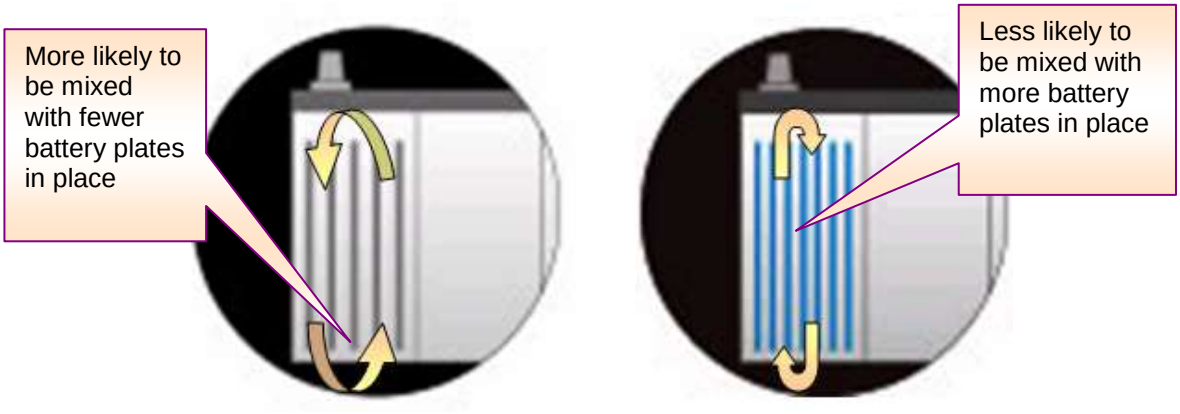
<Judgment Criteria>

-If the cell with the lowest specific gravity is 1.25 or more, the battery is fully charged.

-If the cell with the lowest specific gravity is less than 1.25, replace the battery as battery charge could not be restored.

SUPPLEMENTARY EXPLANATION:

- When you need to determine if the battery is OK or not right after charging, you can determine it by measuring specific gravity. However, there's a possibility of wrong judgment if the specific gravity doesn't go up after charging due to stratification of electrolyte solution.
- To prevent this, measure the specific gravity after high-voltage charging that causes electrolyte solution to be stirred.
- Or if the stratification doesn't disappear soon, the stirring effect can be obtained by sucking all electrolyte solution on the top of battery plate with a siphon etc. before measuring the specific gravity.
- Since i-stop system battery has more battery plates in a cell than other batteries, electrolyte solution is less prone to be mixed. Hence electrolyte solution cannot be mixed well even if it is sucked up and put back to the battery again with a small dropper-type hydrometer.



3) Battery charge

① Points to be considered during battery charging

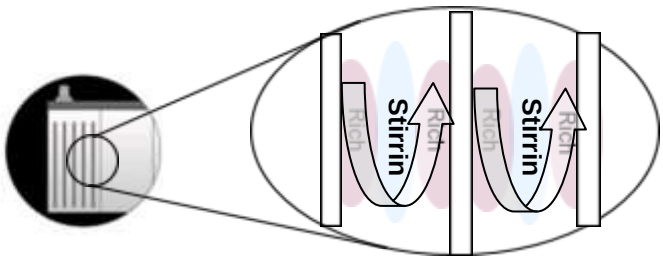
- Due to polarization and stratification of electrolyte solution, only terminal voltage is raised relative to the specific gravity of the entire battery during the late stage of charging. As a result charging current drops, increasing the time required for full battery charging.
- In this type of battery charging, some lead sulfate remains without reduction. If the battery is left in such condition, sulfation occurs, resulting in significant deterioration of battery capability.
- Therefore, you need to generate gas during battery charge while keeping the high current (1/5 of battery capacity) so that the battery can be charged 100% and that the lead sulfate which is likely to be crystalized can be reduced by stirring electrolyte solution and removing stratification.

NOTE:

See the Workshop Manual "BATTERY RECHARGING" and attached video (status of gas generation at charge) about how to charge i-stop system battery with constant-current/constant-voltage battery charger.

② "Constant-current" and "high-voltage" charging

- This is the way to charge battery maintaining a constant current by adjusting the charge voltage. In this way of charging, the electrolyte solution is mixed well during charging so enough electric energy can be stored in the battery as mentioned earlier.



• Although the charge voltage may increase above 17V, the battery will not be damaged unless the charge current is maintained within 10 to 15A.
• Perform “constant-current” charging for the time in the below table according to the specific gravity value which was measured before charging.

Specific Gravity	1.24 or more	1.23	1.22	1.21	1.20	1.19	1.18	1.17
Charge Time (min)	180	200	220	240	270	290	330	360

CAUTIONS:

- The charging time should be less than 6 hours; otherwise it will result in battery over-charging.
- A large amount of gas will be generated during charging so take cautions below.
  - ✓ Remove the battery from the vehicle.
  - ✓ Remove the battery filler caps.
  - ✓ Perform charging in a well-ventilated area.
- Right after charging, the battery terminal voltage may be raised. To prevent giving damage to vehicle electrical systems, leave the battery until the terminal voltage drops below 15V and then install it on the vehicle.

(For Europe only)
The same way of charging can be performed by using a manual type low-voltage battery charger. Follow the procedures below.

1. Adjust the charge current to 10A.
2. After 60 minutes have elapsed since the start of charging, adjust the charge current to 10A again.
3. Then continue the charge for the required time.

Some automatic battery charger can also be used if they are equipped with the following functions.

- Charge-voltage can be adjusted between 17.0 – 17.5V.
- It can charge keeping a constant current.
  A guide of charge-current is 1/5 of the battery capacity (AH).
  Battery for PE: 12.4A (=1/5 X 62AH)
  Battery for SH: 16.0A (=1/5 X 80AH)
- It can set charging time.

※Sample automatic battery charger
Wuerth ACCTIVA PROFESIONAL 35A/70A

The screen shows the charging condition is set as follows:
-Charge voltage: 17V
-Charge time: 6.0H
-Charge current is selected according to AH.

Confirm if settings like this are possible for your automatic battery charger by referring to the instruction manual or consulting the battery charger agent.