

Instruction Manual For Automotive Batteries

■ Battery Main Failure Mode

Failure Type	Battery Part	Factor of Failure	Appearance	Check Method
Over Charge	Battery all cell	1)Alternator charge voltage high 2)Handling negligence (recharging error)	1)Electrolyte Overflow 2)Indicator color:RED - Exhaustion of electrolyte - Etc	1)Indicator color : RED 2)Electrolyte Color : Black,etc
Over Discharge	Battery all cell	1)Electric part trouble 2)User discharge(light) 3)Generater, fan belt 4)Long period stop	1)No Starting 2)Electric equipment ability weak	1)All cell specific gravity : 1.220/25℃ ↓ 2)OCV 12.30V ↓ 3)Generater vs battery voltage difference : 0.2-0.3V ↑
Short	Special cell	Short	1)No Starting 2) Ability loss of electric equipment	1)Specific gravity : low above 0.05 than different cell 2)When discharge, gassing is not in the special cell 3)When charging, gassing is not and S.G is changed in the special cell
Electrolyte leakage	Sealing part case, etc	1)Heat sealing failure 2)Damage	Electrolyte leakage	
Explosion	Exhaust hole	1)Handing negligence - Flammable - Pole short	Battery explosion	

■ Overcharge factor & appearance

1. Overcharge

After the discharge, batteries have to certainly recharge. But, When the battery is overcharged, it is degenerated and then battery capacity grows less and less. Finally, battery life is finished early on. Accordingly, after using battery, it has to be charged carefully.

2. A primary factor of Overcharge

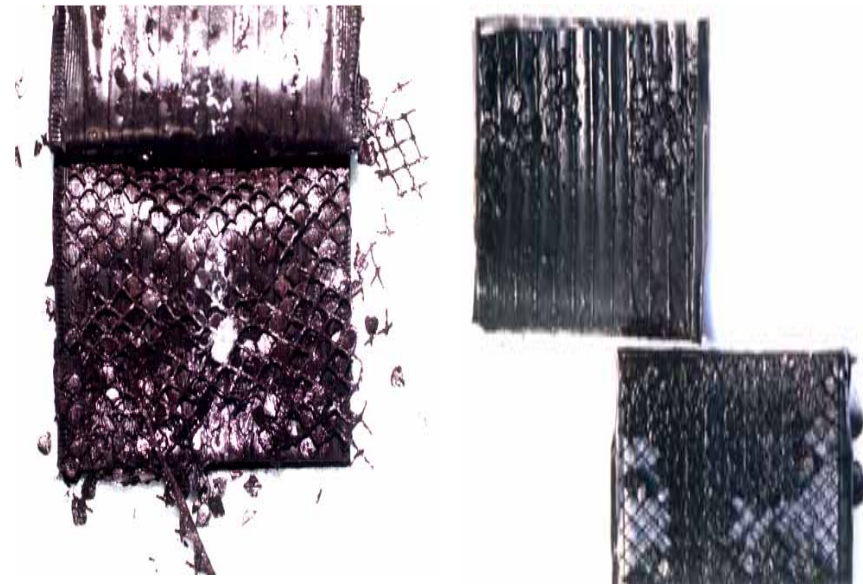
Subject	Detail contents
A defect of automobile's electric part Regulator (AC Alternator, etc)	1) bad charge voltage control → charge current rise – badness of regulator voltage :have to control about temperature change (temperature ↑ → charge voltage ↓)
	2) Regulator badness - increase of charge quantity
	3) Contact badness of AC Alternator & Regulator connector
long continuance time of Idle condition	The inside temperature of a bonnet(vehicle) ↑ → charge efficiency ↑ (long continuance time of Idle condition under high temperature)
recharge	In the case of battery recharge high charge current or excessive charge quantity
partial discharged battery	Under the reduced inner capacity, In use, battery can be change to overcharge even in regularity charge current (electric efficiency of plate ↓ → charge efficiency ↓ : capacity ↓)

3. An appearance of overcharge

[Casting paltes]



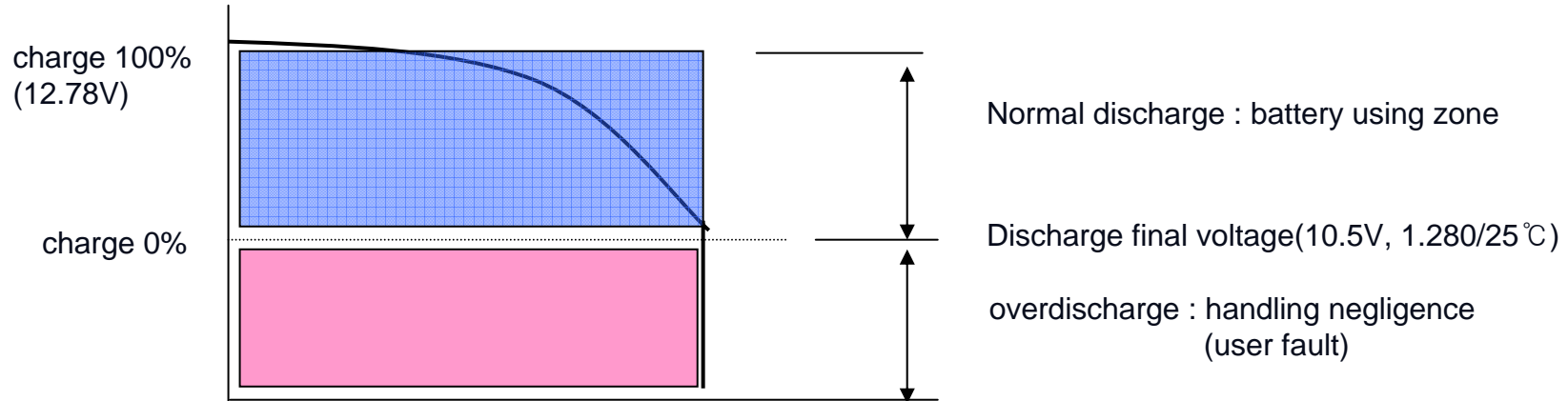
[Expanded plate]



1. Positive plate color change : Light brown → Dark Brown
2. High density of electrolyte
3. Exhaustion of electrolyte.
4. Active material sticking of indicater
5. Shedding of Positive plate active material. : Coherence reduction of active material.
5. Separater damage. : crack.

Overdischarge factor & appearance

1. Overdischarge



-	Normal discharge	Overdischarge
Application Zone	When the battery is used in above final discharge voltage(10.5V) (blue zond of the Picture 1.)	When the battery is used till below final discharge voltage(10.5V) (the red zond of the Picture 1.)
Special Feature	Discharge curve descend down slowly	Discharge curve descend down quickly
Recovery property	In the case battery is recharged, battery is recovered normally.	In the case battery is recharged, battery is not recovered. (gradually life is decreased)

- When normal discharge of blue zone is repeated continually, battery is changed to overdischarge of red zone
- Normal discharge can recover battery capacity and overdischarge can not recover battery capacity

2. A primary factor of Overdischarge

-	Discharge factor	Detail
Vehicle	Low current discharge (Radio,etc)	Charge efficiently of the battery is dropped greatly by the deep discharge → reduction of charge recovery property
	A defect of the electric Circuit	1) Leak current is increase 2) Genelater trouble
	Vehicle charging system trouble	1) Regulator setting voltage 14.4V ↓ 2) Belt tention trouble, 3) Disconnection or ubstable connection)
	Long keeping period	Long keeping period before battery is delivered to customer
	Loose battery connection	Contact resistance increase
Customer	Running stop of long period	Leaving alone long period after running vehicle :discharge rate increase in the summer period (high temperature)
	Load use after parking (Idle condition)	Using of the excess load after parking (Idle condition) : an air conditioner, TV, AV system
	Attachment electric equipment	Many attachment electric equipment(TV, charging, etc)
	Insufficiently charging	Forget fulness after using load ; leaving alone turnning on load(radio, a headlight, door open,etc)
Etc.	Impurities	* Inflowed Impurities into electrolyte: discharge rate crease

3. An appearance of discharge

1) Sulfation of plates(Sulfation)

- ① plate color : light brown → light red
- ② hardening of the plate & deficiency of grid softness → vertical or horizontal cutting state
- ③ active material shedding
- ④ shrinkage of the plate → bending of the plate

2) A change of color in separator: white cristal or color

3) Decrease of the specific gravity in the electrolyte : gradually corrosion from the upper part of the plate → especially, leaving alone long time in discharge state (final voltage or low gravity)



※ Plate Condition

Normal



Partial sulfation



Sulfation



■ Overdischarge Factor

Self Discharge

- Self-discharge is a kind of loss of capacity on open circuit state with no load.

- It is occurred naturally.

Usually it is caused by chemical reason.

- Main reasons

- 1) Temperature : temperature (atmosphere and battery) , self-discharge

Self-discharge is slowly increasing until 25 , rapidly accelerated above 25 .

Generally, high temperature is the main factor increasing self-discharge.

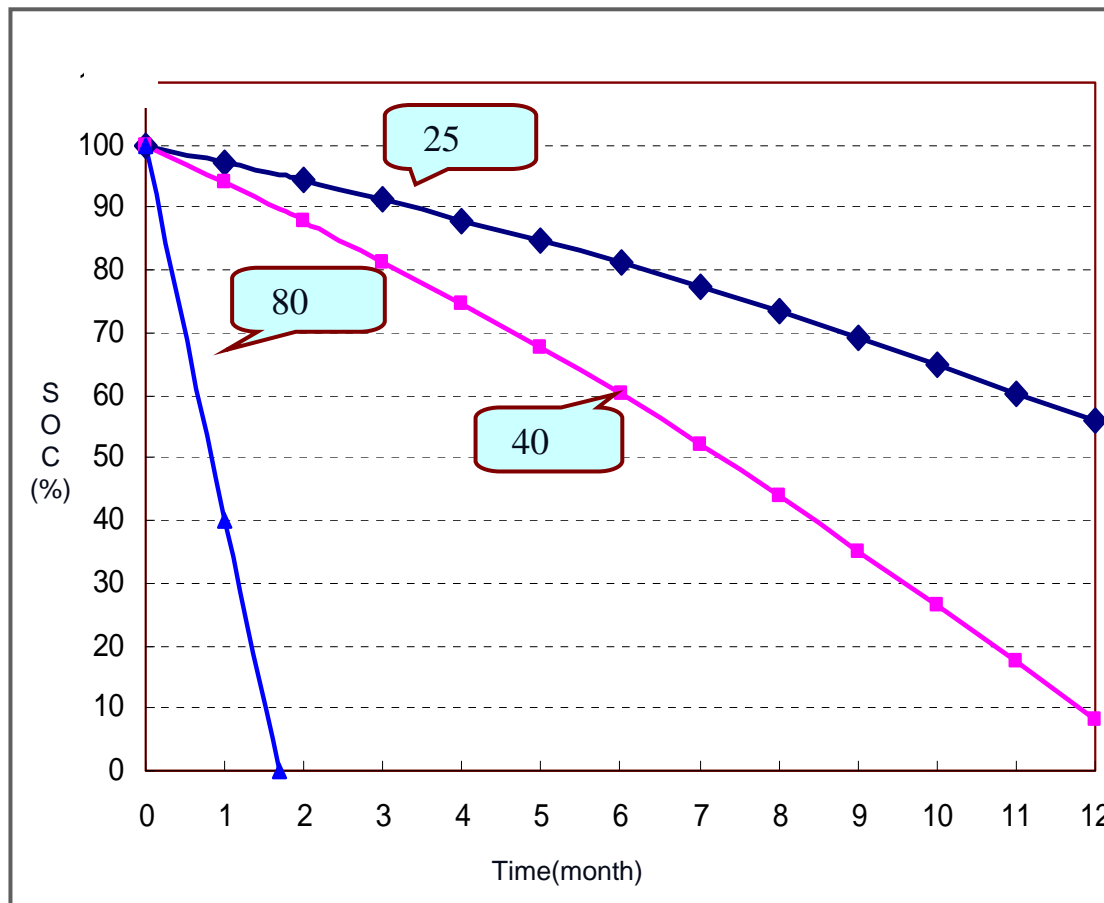
- 2) State of battery : self-discharge reaction is more active just after charging.

- 3) Concentration of electrolyte ; Self-discharge is increasing at too low (S.G 1.250) or too high (S.G 1.300) concentration.

- 4) Influence of impurities : iron(Fe) accelerate self discharge in the electrolyte

► The Self Discharge characteristics for temperature

Temp.	25	40	80
Self Discharge(%)	about 0.12%/day	about 0.25%/day	about 2.0%/day

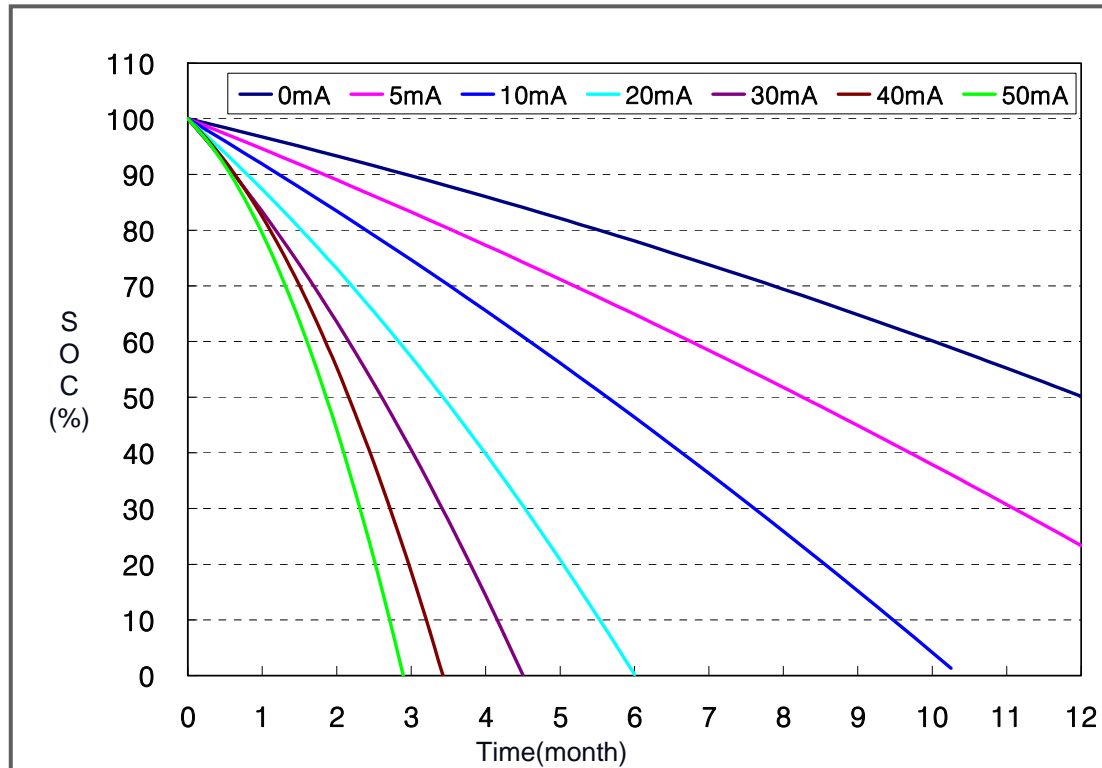


Voltage	S.G	SOC(%)
12.84	1.290	100
12.72	1.270	90
12.60	1.250	80
12.48	1.230	70
12.36	1.210	60
12.24	1.190	50
12.12	1.170	40
12.00	1.150	30
11.88	1.130	20
11.76	1.110	10
11.64	1.090	0

► Leak current discharge (vehicle]

Temp. : 25

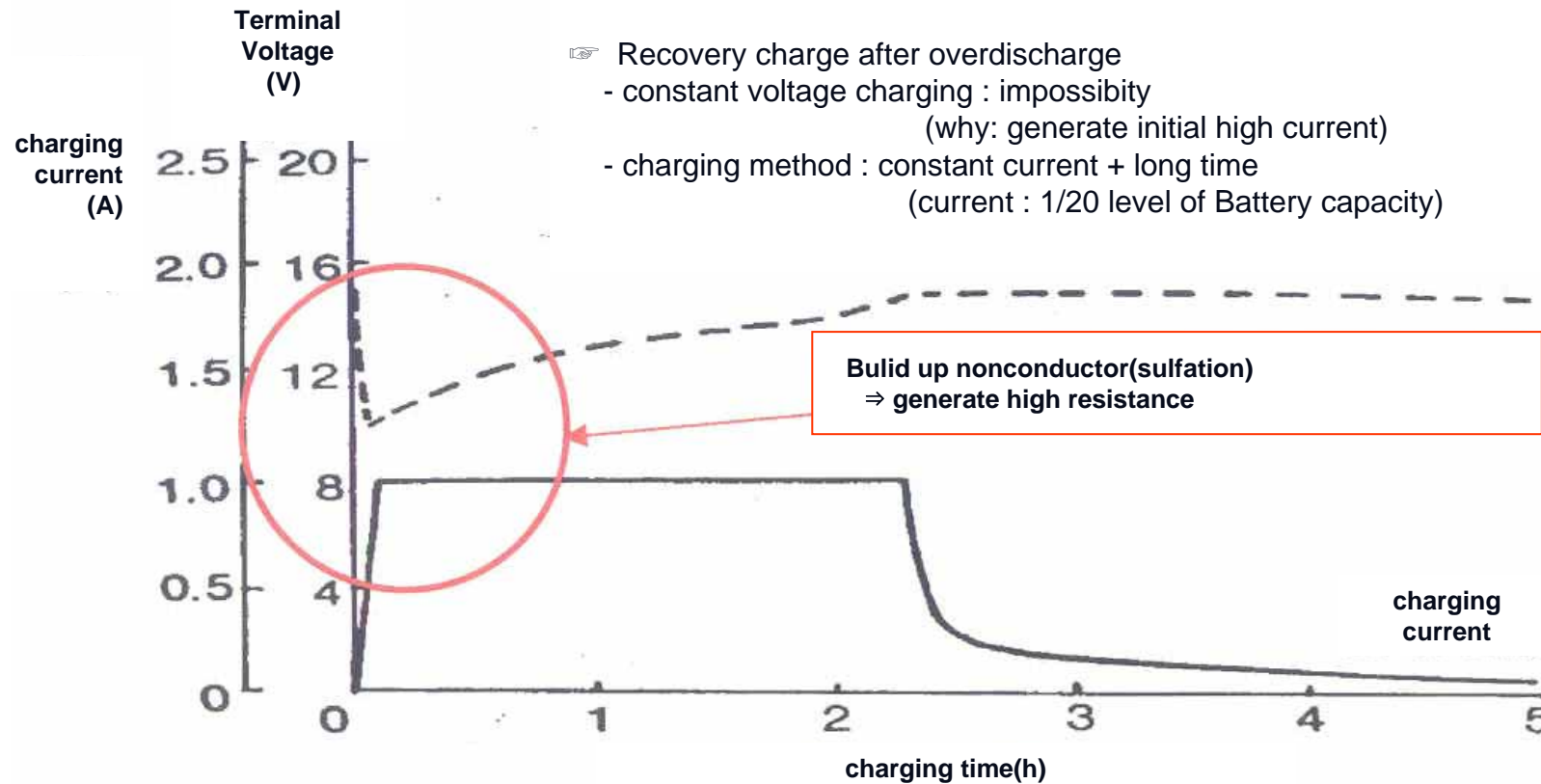
-		0mA	5mA	10mA	20mA	30mA	40mA	50mA
SOC (%)	80%	22week	14week	9week	6week	5week	4week	3week
	60%	40week	27week	18week	11week	9week	7week	6week
	40%	56week	39week	26week	16week	12week	10week	8week
	20%	69week	50week	34week	20week	15week	12week	10week
	0%	82week	60week	40week	23week	17week	13week	11week



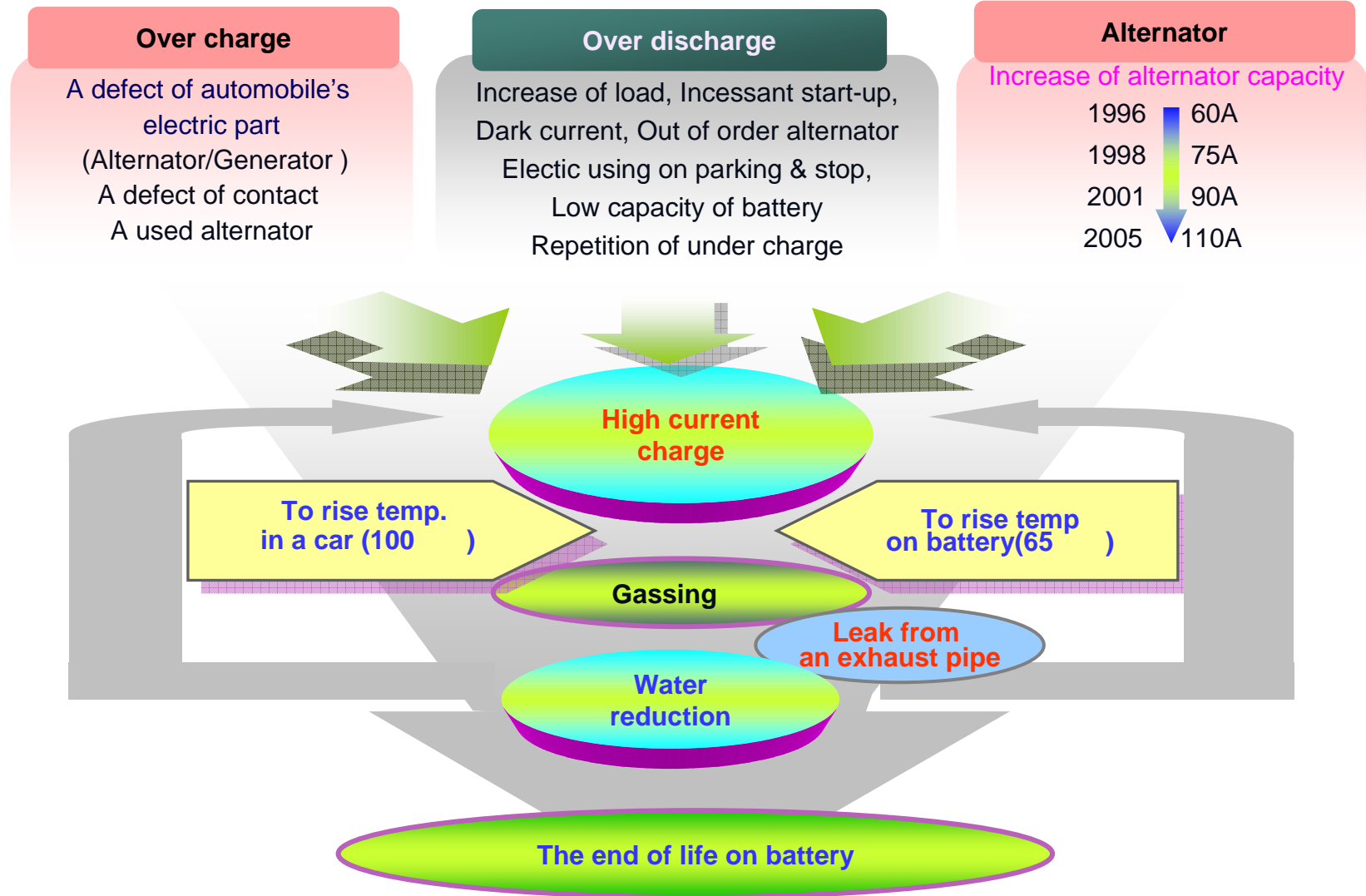
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■ Recovery charge after overdischarge.

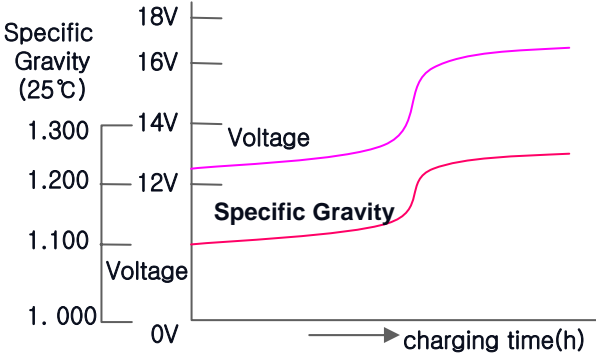
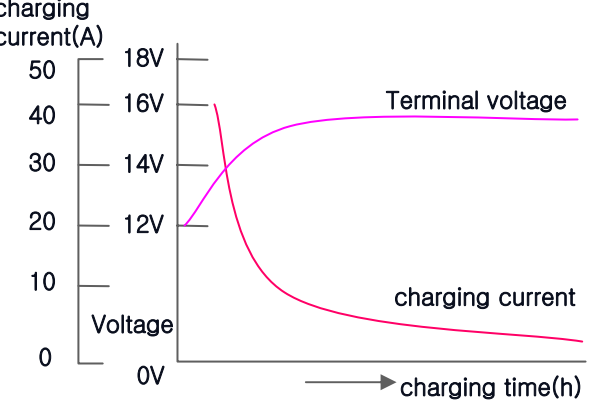
● The characteristics for charge after overdischarge



■ The end of life Mechanism by high temp & current charge



■ The characteristics for charging method

-	Contents	Reference
Constant Current Charge	<p>► Charge of using constant current</p> <p>① Predetermined Current : 1/8 or 1/16 level of Battery capacity(5HR)</p> <p>② The Voltage Rising Point : The voltage is rapidly rising from coming to 14.4V. The reason is that gassing take wings when charge is almost completed(80%). it remains essentially constant after reach 16.8~17.4V. if battery is charged continually this rate, it will be over-charge and it will be causative of early life's end of battery.</p> <p>③ The Completion Of Charge : When it is fixed terminal voltage and specific gravity 3 times</p>	 <p>The graph plots Voltage and Specific Gravity (at 25°C) against charging time in hours. The voltage curve starts at approximately 12V and rises to about 16.8V. The specific gravity curve starts at 1.100 and rises to approximately 1.280. Both curves show a sharp increase around 80% charge completion.</p>
Constant Voltage Charge	<p>► Charge of using constant voltage</p> <p>① Predetermined Voltage : 14.4 ~ 16.0V regularit</p> <p>② Characteristics of charge : Charging current is decided by a potential difference between battery voltage. An early stage it turn on high current, it will be a gradual lower.</p> <p>③ Merit : Less venting of gases, Less a reduction High rate of charge(until 80% of capacity To minimize the effects of overcharge</p> <p>Demerit : To need a mass charger Difference of Specific gravity between the upper and lower part(low temperature) A long duration until a full charge Uncertainty of completion</p>	 <p>The graph plots Terminal voltage and charging current against charging time in hours. The terminal voltage curve starts at 12V and rises to a steady state of 16V. The charging current curve starts at 40A and gradually decreases to about 2A as the battery approaches full charge.</p>

■ Method of auxiliary charge

Charger (Rectifier)

- 1) Charger must be **controlled charging ampere or voltage** freely.
Charging current can be controlled by 0.1A scale.
- 2) When many batteries must be charged, connect between batteries series or parallel circuit by using connector.
Notice the connecting condition. Loose contact can occur sparking. Sparking is cause of post damage and battery explosion. Connector must be keeping **clean condition**.
- 3) charger must be checked current and voltage periodically.
- 4) H₂ gas is generated during charging. So the charging place **must have good air circulate**.

Notice

- 1) Classify according to degree of discharge.
- 2) Low charging current is better, and current must be lower 5 hour rate current
- 3) The temperature of battery must be **lower than 45** .
If temperature increase over 45 , pause charging several(1~2) hours.
- 4) Check the (+),(-) position.
- 5) **Don't treat or polish with dry clothes within several hour**. Static electricity can lead to explosion. Wear protective device. Keep free from smoking and firing.

6) Calculation of auxiliary charging

charging amount

$$C = C_{20} \times D \times 1.3$$

C : charging amount (AH)

C₂₀ : 20Hr rate capacity

1.3 : 130% (coefficient)

D : discharging amount(%)

Charging time

$$T = C \div A$$

T : charging time(Hr)

C : charging amount[AH]

A : charging current

ex] 56048 : specific gravity 1.210/25 . How to charge ?

Charging amount : 60Ah \times 0.4 \times 1.3 = 31Ah (40% discharged ; see table 1)

charging current : 0.1 C₂₀ is OK = 6A

Charging time : 31Ah \div 6A = 5.2Hr

7) specific gravity must convert temperature effect.

temperature converting equation : $S_{25} = S_t + 0.0007 (t - 25)$

S₂₅ : s.g at 25

S_t : s.g at t

t : electrolyte temperature

s.g of full charged battery: 1.290 \pm 0.01/25

■ Table 1.: electrolyte specific gravity conversion table

-	-15	-10	-5	0	+5	+10	+15	+20	+25	+30	+35	+40	Charing quantity	(V)
11.7%	1.108	1.105	1.101	1.098	1.094	1.090	1.087	1.084	1.080	1.076	1.073	1.069	0%	11.58
13.1%	1.118	1.115	1.111	1.108	1.104	1.100	1.097	1.094	1.090	1.086	1.083	1.079	5%	11.64
14.7%	1.128	1.125	1.121	1.118	1.114	1.110	1.107	1.104	1.100	1.096	1.093	1.089	10%	11.70
16.1%	1.138	1.135	1.131	1.128	1.124	1.120	1.117	1.114	1.110	1.106	1.103	1.099	15%	11.76
17.3%	1.148	1.145	1.141	1.138	1.134	1.130	1.127	1.124	1.120	1.116	1.113	1.109	20%	11.82
18.7%	1.158	1.155	1.151	1.148	1.144	1.140	1.137	1.134	1.130	1.126	1.123	1.119	25%	11.88
20.0%	1.168	1.165	1.161	1.158	1.154	1.150	1.147	1.144	1.140	1.136	1.133	1.129	30%	11.94
21.2%	1.178	1.175	1.171	1.168	1.164	1.160	1.157	1.154	1.150	1.146	1.143	1.139	35%	12.00
22.5%	1.188	1.185	1.181	1.178	1.174	1.170	1.167	1.164	1.160	1.156	1.153	1.149	40%	12.06
23.8%	1.198	1.195	1.191	1.188	1.184	1.180	1.177	1.174	1.170	1.166	1.163	1.159	45%	12.12
25.1%	1.208	1.205	1.201	1.198	1.194	1.190	1.187	1.184	1.180	1.176	1.173	1.169	50%	12.18
26.3%	1.218	1.215	1.211	1.208	1.304	1.200	1.197	1.194	1.190	1.186	1.183	1.179	55%	12.24
27.6%	1.228	1.225	1.221	1.218	1.214	1.210	1.207	1.204	1.200	1.196	1.193	1.189	60%	12.30
28.8%	1.238	1.235	1.231	1.228	1.224	1.220	1.217	1.214	1.210	1.206	1.203	1.199	65%	12.36
30.0%	1.248	1.245	1.241	1.238	1.234	1.230	1.227	1.224	1.220	1.216	1.213	1.209	70%	12.42
31.4%	1.258	1.255	1.251	1.248	1.244	1.240	1.237	1.234	1.230	1.226	1.223	1.219	75%	12.48
32.6%	1.268	1.265	1.261	1.258	1.254	1.250	1.247	1.244	1.240	1.236	1.233	1.229	80%	12.54
33.8%	1.278	1.275	1.271	1.268	1.264	1.260	1.257	1.254	1.250	1.246	1.243	1.239	85%	12.60
35.0%	1.288	1.285	1.281	1.278	1.274	1.270	1.267	1.264	1.260	1.256	1.253	1.249	90%	12.66
36.2%	1.298	1.295	1.291	1.288	1.284	1.280	1.277	1.274	1.270	1.266	1.263	1.259	95%	12.72
37.4%	1.308	1.305	1.301	1.298	1.294	1.290	1.287	1.284	1.280	1.276	1.273	1.269	100%	12.78
38.6%	1.318	1.315	1.311	1.308	1.304	1.300	1.297	1.294	1.290	1.286	1.283	1.279	-	-
39.7%	1.328	1.325	1.321	1.318	1.314	1.310	1.307	1.304	1.300	1.296	1.293	1.289	-	-

■ Table 2. :charging standard classified by discharge state

* Charge standard : In the case of above minimum 24hour After running vehicle

-	Battery voltage/charging state			Auliliary charging method		Remark
	voltage	charge	judgement	Constane voltage	IDLING(vehicle)	
A	12.78V ↑	100%	possibility	<ul style="list-style-type: none"> ⚡ Auxiliary charge advice 	<ul style="list-style-type: none"> ⚡ Auxiliary charge advice ⇒ about 10~30 minite Idling 	<ul style="list-style-type: none"> ▶ In the case of vehicle IDLING, All electric load have to keep turning off
	12.66V	90%				
	12.54V	80%				
	12.42V	70%				
B	12.30V	60%	Auxiliary Charge	<ul style="list-style-type: none"> ⚡ Auxiliary charge (essentiality) ☞ constant voltage charger setting - voltage : 14.4V - current : auto control 	<ul style="list-style-type: none"> ⚡ Auxiliary charge (essentiality) ⇒ Idling above 1hr. 	<ul style="list-style-type: none"> ▶ charge standard calculated by winter
	12.16V	50%				
	12.06V	40%				
C	11.94V	30%	Auxiliary Charge	<ul style="list-style-type: none"> ⚡ Auxiliary charge (essentiality) ⇒ Idling above 2hr ☞ In the case of 11.58V , charging above about 4hr (recovery : above 90%) 		
	11.82V	20%				
	11.70V	10%				
	11.58V	0%				
D	11.57V ↓	Full Dischar	battery exchange	<ul style="list-style-type: none"> ⚡ Impossibility of recovery (excessive sulfation(PbSO₄)) 		
	0V					

-	Handling mothod vs battery voltage				Remark
	12.40V ↑		12.40V ↓		
ALT' current	10A ↓	10A ↑	10A ↓	10A ↑	<ul style="list-style-type: none"> ⚡ AIT' current measurement: after 5minute since starting vehicle 예) Voltage 12,60V,ALT' current 35A →handling 'B'
Handling mothod	A	B	B	C	