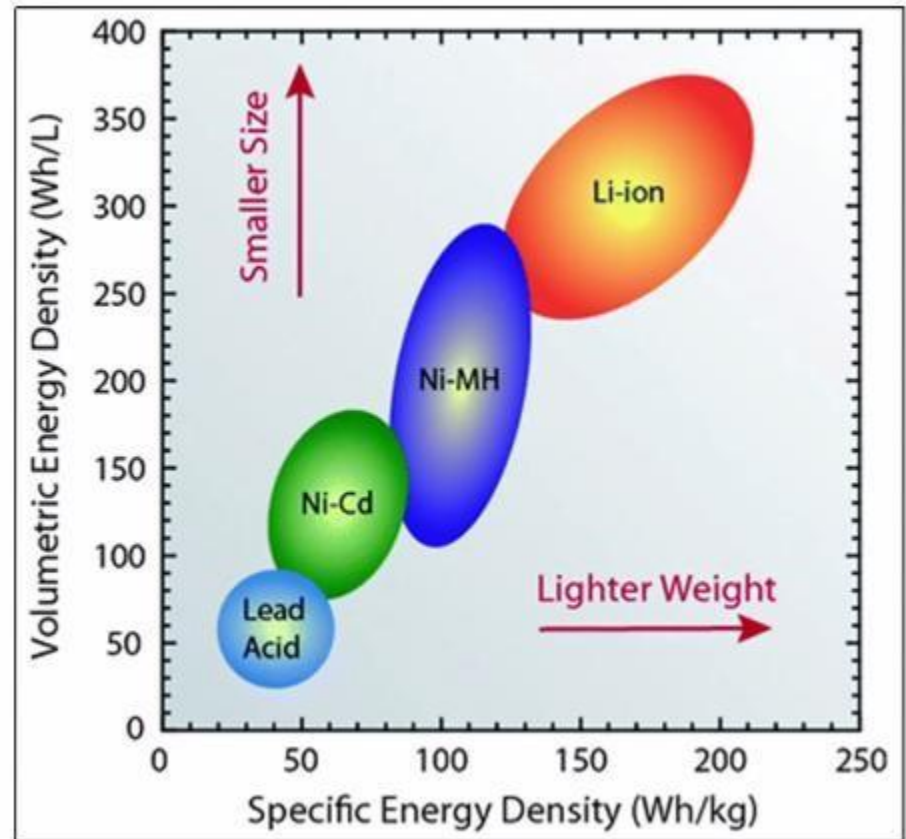


Parameters for selection of battery

- Cell voltage
- Specific energy
- Energy density
- Power density
- Useful capacity

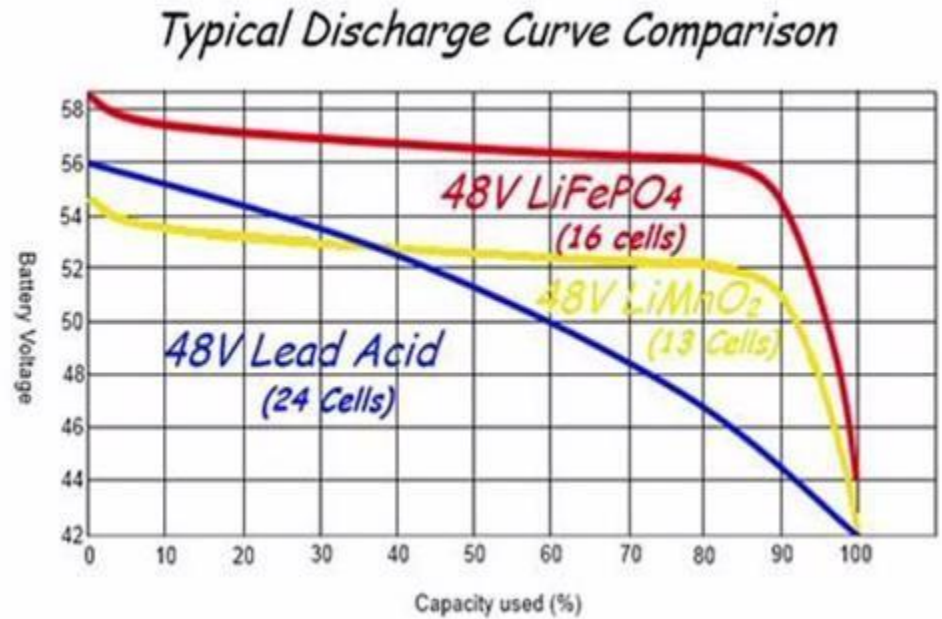
Parameters for
selection of
battery



- Cell discharge
- Temperature range
- Cycle life
- Memory effect
- Coulombic efficiency

Parameters

comparison for various
batteries



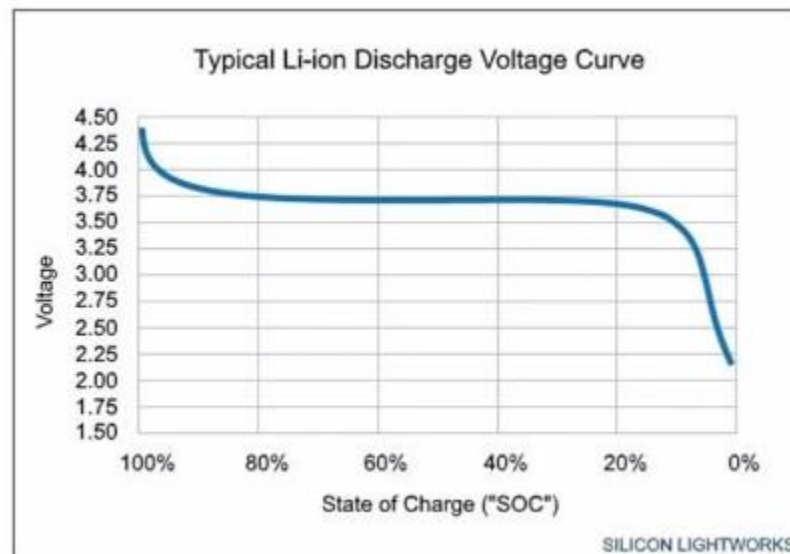
Specifications	Lead Acid	NiCd	NiMH	Li-ion ¹		
				Cobalt	Manganese	Phosphate
Specific energy (Wh/kg)	30–50	45–80	60–120	150–250	100–150	90–120
Internal resistance	Very Low	Very low	Low	Moderate	Low	Very low
Cycle life ² (80% DoD)	200–300	1,000 ³	300–500 ³	500–1,000	500–1,000	1,000–2,000
Charge time ⁴	8–16h	1–2h	2–4h	2–4h	1–2h	1–2h
Overcharge tolerance	High	Moderate	Low	Low. No trickle charge		
Self-discharge/month (room temp)	5%	20% ⁵	30% ⁵	<5% Protection circuit consumes 3%/month		
Cell voltage (nominal)	2V	1.2V ⁶	1.2V ⁶	3.6V ⁷	3.7V ⁷	3.2–3.3V
Charge cutoff voltage (V/cell)	2.40 Float 2.25	Full charge detection by voltage signature		4.20 typical Some go to higher V		3.60
Discharge cutoff voltage (V/cell, 1C)	1.75V	1.00V		2.50–3.00V		2.50V

Parameters comparison for various batteries

Peak load current Best result	5C ⁸ 0.2C	20C 1C	5C 0.5C	2C <1C	>30C <10C	>30C <10C
Charge temperature	-20 to 50°C (-4 to 122°F)	0 to 45°C (32 to 113°F)		0 to 45°C ⁹ (32 to 113°F)		
Discharge temperature	-20 to 50°C (-4 to 122°F)	-20 to 65°C (-4 to 149°F)		-20 to 60°C (-4 to 140°F)		
Maintenance requirement	3-6 months ¹⁰ (toping chg.)	Full discharge every 90 days when in full use		Maintenance-free		
Safety requirements	Thermally stable	Thermally stable, fuse protection		Protection circuit mandatory ¹¹		
In use since	Late 1800s	1950	1990	1991	1996	1999
Toxicity	Very high	Very high	Low	Low		
Coulombic efficiency¹²	~90%	~70% slow charge ~90% fast charge		99%		
Cost	Low	Moderate		High ¹³		

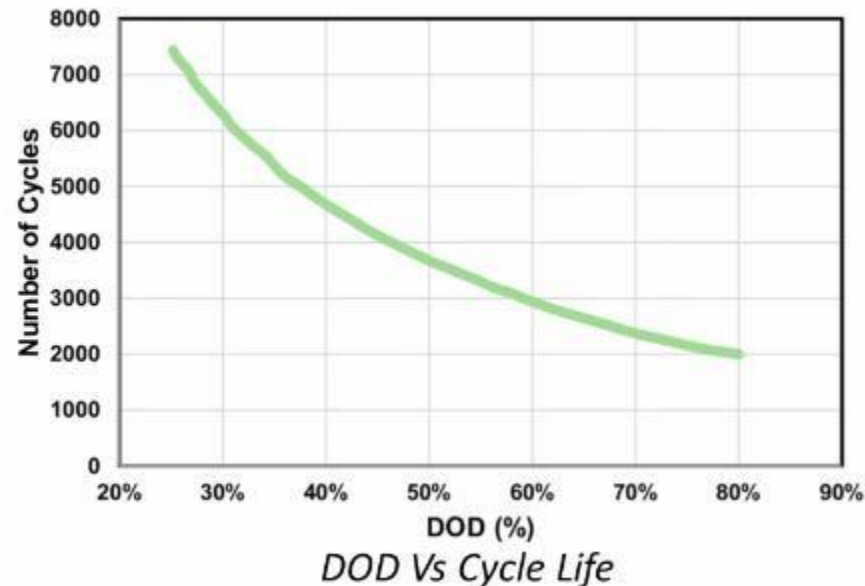
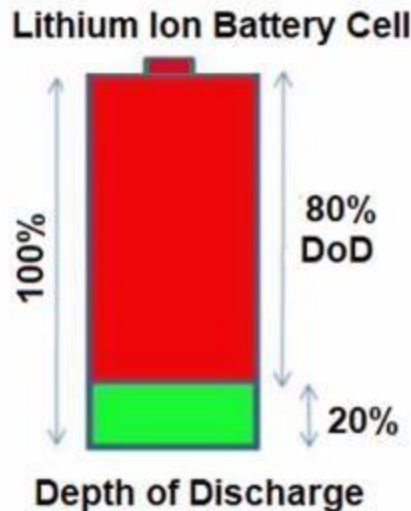
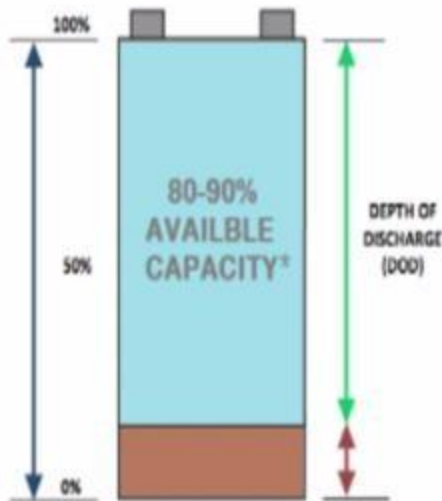
Battery Terminologies

- **State of Charge (SoC)**
 - ✓ Measure to show the energy capacity left in the battery
 - ✓ Defines as the ratio of energy (or) charge presented to the nominal rated capacity in %
 - ✓ 100% shows battery is full



Battery Terminologies

- ✓ 0% SoC shows battery is completely discharged
- **Depth of Discharge (DoD)**
- ✓ Used to measure the amount of energy that can be used from the battery
- ✓ Battery cannot be drain out from 100% to 0%
- ✓ DoD is 80% for Li-ion cells



Battery Terminologies

- ✓ Only 80% of the battery capacity is taken for designing of battery pack

Battery Terminologies

- **C- Rating:**

- ✓ The charge and discharge rate of the battery is governed by C-rates
- ✓ 1C shows a battery is charged/discharged in an hour
- ✓ 10Ah battery with 1C rate shows that is getting charged in 1 hour with 10A current
- ✓ 10Ah with 2C rate=>charged in 30 minutes with 20A
- ✓ 10Ah with 0.5C rate=>charged in 2 hours with 5A

C Rating	Time
30C	2 mins
20C	3 mins
10C	6 mins
5C	12 mins
2C	30 mins
1C	1 hour
0.5C or C/2	2 hours
0.2C or C/5	5 hours
0.1C or C/10	10 hours
0.05C or C/20	20 hours

t = Time

Cr = C Rate

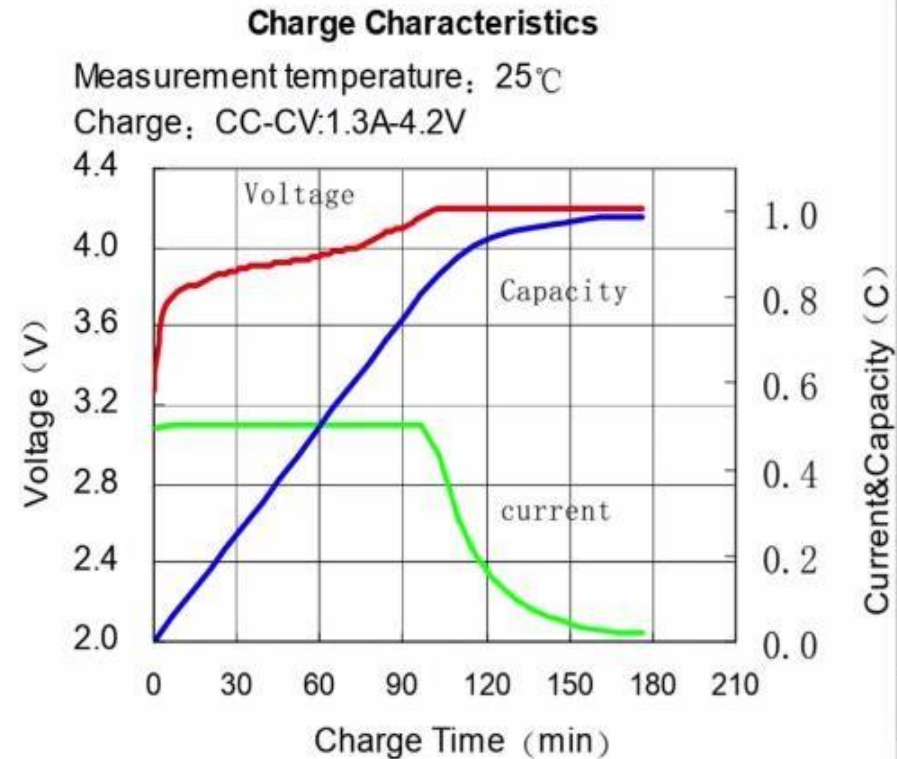
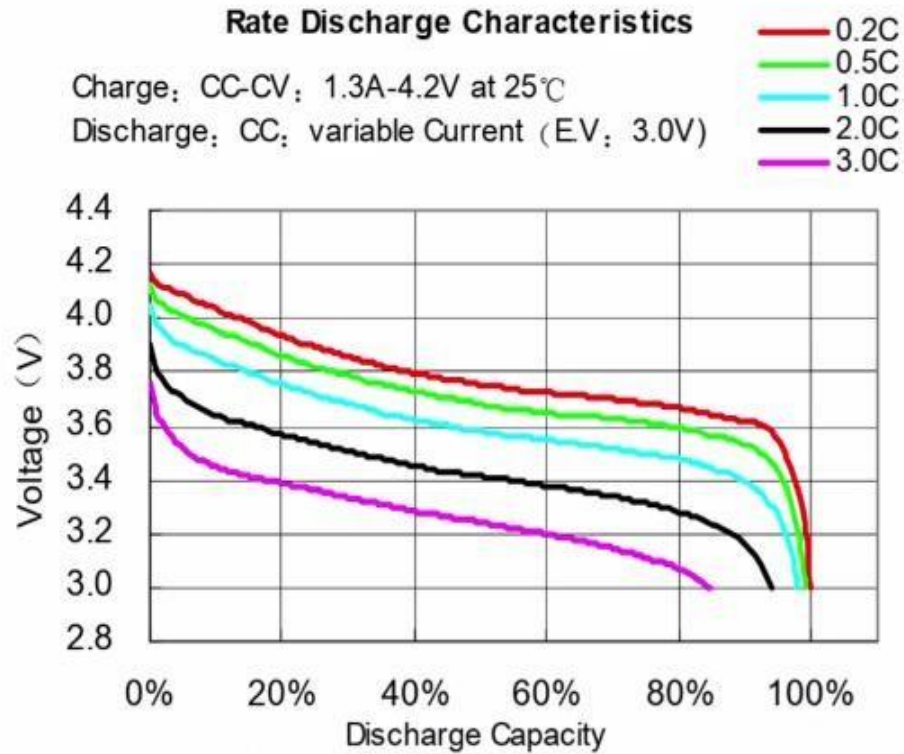
t = 1 / Cr (to view in hours)

2C Rate Example

- 2300mAh Battery
- 2300mAh / 1000 = 2.3A
- 2C x 2.3A = 4.6A available
- 1 / 2C = 0.5 hours
- 60 / 2C = 30 minutes

C-Rate Vs Time

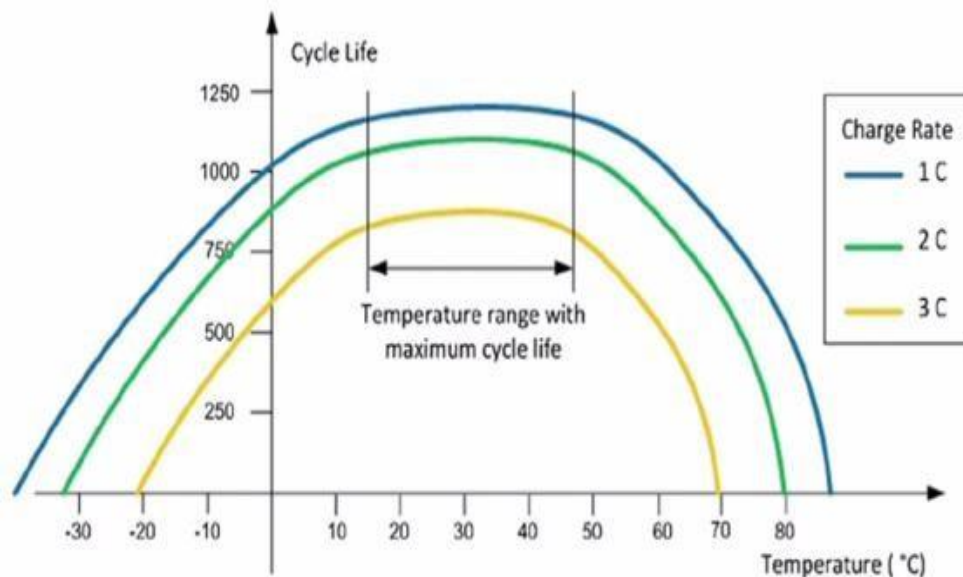
Battery Terminologies



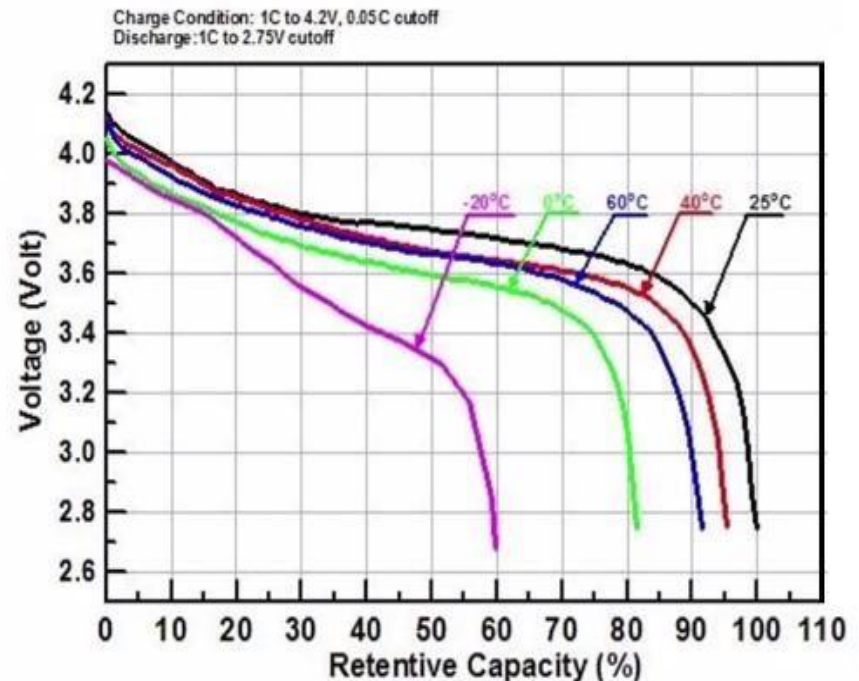
- Discharging and charging characteristics:

Battery Terminologies

- **Temperature range:**
 - ✓ Max. and Min. temperature range at which battery can operate efficiently under natural convection cooling method



Temperature Vs Cycle Life



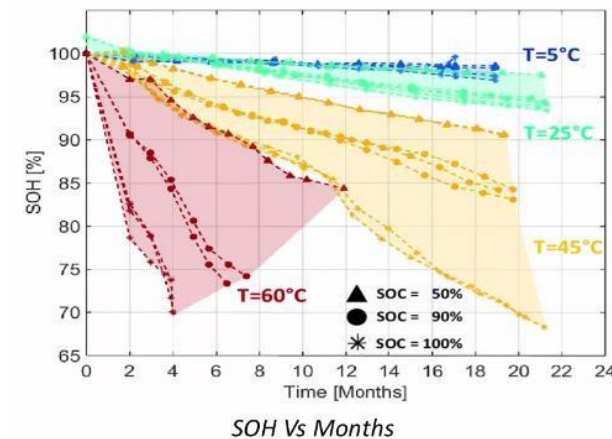
Retentive Capacity Vs Voltage for Various Temperature

Battery Terminologies

- ✓ Below and above the battery temperature range will decrease the life of the battery

Battery Terminologies

- **Calendar life:**
 - ✓ Typically 1% and 2% of capacity loss per year occurs in battery even if it is not used
 - ✓ Depends on
 - Number of cycles
 - Operating conditions
 - Types of load
 - C- rate
- **End of life:**
 - ✓ When the battery operates at lower peak capacity during its lifespan then the battery reaches to its end of life
 - ✓ For Lead-acid battery is 80% ✓ For Li-ion battery is 70%
- **State of Health:**
 - ✓ Measure which shows the max. battery capacity to its rated capacity
 - ✓ Shows the difference between battery being studied and a fresh battery
 - ✓ Depends on
 - DoD



Battery Terminologies

- Calendar Aging
- End of Life

