

Nickel Batteries

Different types						
Type	Positive Electrode	Negative Electrode	Electrolyte	Global reaction during discharge		
<i>Ni-Cd</i>	NiOOH	Cd	KOH	$2 \text{NiOOH} + 2 \text{H}_2\text{O} + \text{Cd} \Rightarrow 2\text{Ni}(\text{OH})_2 + \text{Cd}(\text{OH})_2$		
<i>Ni-Mh (MH : metallic hydride)</i>	NiOOH	M : AB (TiFe), AB ₂ (Ti and Zr alloys, ZnMn ₂ ...), A ₂ B (Mg ₂ Ni), AB ₅ (LaNi ₅ , rare-earth metals/nickel: the most used)	KOH	$\text{NiOOH} + \text{MH}_{\text{ab}} \Rightarrow \text{Ni}(\text{OH})_2 + \text{M}$ M : hydrogen absorbing alloy H _{ab} : hydrogen absorbed		
<i>Ni-Zn</i>	NiOOH	Zn	KOH	$2 \text{NiOOH} + \text{Zn} + 2\text{H}_2\text{O} \Rightarrow \text{Zn}(\text{OH})_2 + 2\text{Ni}(\text{OH})_2$		
<i>Na-NiCl₂ (Zebra)</i>	NiCl ₂	Na	NaAlCl ₄ (melted salt) + β-Al ₂ O ₃ solid	$2 \text{Na} + \text{NiCl}_2 \Rightarrow 2 \text{NaCl} + \text{Ni}$		
Technical data						
Type	Temperature of operation	Energy	Number of deep cycles	Power at steady state/ 30s	Charge/discharge efficiency	Self discharge
<i>Ni-Cd</i>	-40 to +50 °C	20/40 Wh/kg 40/100 Wh/dm ³	300/1500	100/800 W/kg	energy: 60 to 80% faradic : 70% to 90%	5 - 20 % / month
<i>Ni-MH</i>	-20 to 50 °C	45/75 Wh/kg 80/200 Wh/dm ³	300/600	170/1000 W/kg	energy: 65 to 70% faradic : 80% to 85%	15 - 25 % / month
<i>Ni-Zn</i>	-20 to 50 °C	50/60 Wh/kg 80/120 Wh/dm ³	≅ 500	280 W/kg	energy: ≅ 80% faradic : ≅ 90%	< 20 % / month
<i>Na-NiCl₂ (Zebra)</i>	270 to 350 °C	90/120 Wh/kg 85/150 Wh/dm ³	≅ 1300	90-169 W/kg	energy: ≅ 91%	
Maintenance			Environmental impact		Safety	
- Ni-Cd : maintain the electrolyte at the proper level (for vented batteries) with adding water - Ni-MH : strong charge control (pressure & temperature) - Na-NiCl ₂ (Zebra): auxiliaries are needed for batteries thermal management			- NiCd : Cadmium toxic ⇒ forbidden use threat but high recycling level (99%) - NiZn : no heavy metal ⇒ good environmental performances - NiMH : no specific problem. recycled at 90% - Na-NiCl ₂ : good recyclability		- NiMH : possible temperature rise at end of charge - Na-NiCl ₂ : high temperature Sodium is very reactive	
Disadvantages				Advantages		
- NiCd : memory effect - NiZn : small life time of zinc electrode - NiMH : memory effect cost self discharge at room temperature				- NiCd : extended capacity range ; long life time, good reliability, good strength - NiZn : recycling - NiMH : rapid charge environmentally better than NiCd discharge rate up to 4C - Na-NiCl ₂ : high energy density, large number of cycles		

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Applications						Economic data
Type	Application	Voltage	Power	Capacity	Status	
<i>Ni-Cd</i> (pocket plate)	PV systems	Not available.	Not available.	Not available.	production	<p>Current costs :</p> <ul style="list-style-type: none"> - NiCd : 200 to 600 €/kWh targeted cost : 150 €/kWh. - NiZn: 50 to 200 €/kWh - NiMh : 600 to 750 €/kWh - Na-NiCl₂ : \$300/kWh (production started in 1996) targeted cost : <\$150/kWh <p>Manufacturers :</p> <ul style="list-style-type: none"> - NiCd : Saft, Tudor, Energizer, Varta, Panasonic, Sanyo, GP Batteries - NiZn : Evercell Corp., Eagle-Picher, - NiMh : Sanyo, Matsushita, Eveready, Duracell, Varta, Saft - Na-NiCl₂ : Beta R&D <p style="text-align: center;">R&D Perspectives</p> <p><u>NiCd</u> :</p> <ul style="list-style-type: none"> - decrease production costs (materials, ...) - environmental impact of cadmium - solve temperature problems occurring during charging <p><u>NiZn</u> :</p> <ul style="list-style-type: none"> - improve life duration and capacity - demonstration <p><u>NiMH</u> :</p> <ul style="list-style-type: none"> - cost reduction - develop high capacity range batteries - decrease self discharge <p><u>Na-NiCl₂</u> :</p> <ul style="list-style-type: none"> - Production achievement needed to have feedbacks
<i>Ni-Cd</i> (sintered plate)	Space Military	Not available.	Not available.	Not available.	production	
<i>Ni-Cd</i> (sealed)	Portable	Not available.	Not available.	Not available.	production	
<i>Ni-Zn</i>	Electric Vehicles	Not available.	Not available.	Not available.	production	
<i>Ni-MH</i>	Portable	Not available.	Not available.	Not available.	production	
<i>Ni-MH</i>	Electric & hybrid Vehicles	144 V	10 kW	1,8 kWh	production	
<i>Na-NiCl₂</i>	Electric Vehicles	300V to 600V	40kW to 180kW	20 kWh to 120 kWh	development	
<i>Na-NiCl₂</i>	Peak shaving	Not available.	Not available.	100 kWh to 10 MWh	development	