PRECAUTIONS FOR DESIGNING DEVICES WITH NI-MH BATTERIES

In order to take full advantage of the properties of Ni-MH batteries and also to prevent problems due to improper use, please note the following points during the use and design of battery operated products.

Underlined sections indicate information that is especially important

1. Charging

1.1 Charging temperature

- Charge batteries within an ambient temperature range of 0°C to 40°C.
- Ambient temperature during charging affects charging efficiency. Since charging efficiency is best within a temperature range of 10°C to 30°C, whenever possible, place the charger (battery pack) in a location that is within this temperature range.
- At temperatures below 0°C the gas absorption reaction is not adequate, causing gas pressure inside the battery to rise, which can activate the safety vent and lead to leakage of alkaline gas and deterioration in battery performance.
- Charging efficiency drops at temperatures above 40°C. This can disrupt full charging and lead to deterioration in performance and battery leakage.

1.2 Parallel charging of batteries

- Sufficient care must be taken during the design of the charger when charging batteries connected in parallel.
  Consult Panasonic when parallel charging is required.

1.3 Reverse charging

- Never attempt reverse charging.
  Charging with polarity reversed can cause a reversal in battery polarity causing gas pressure inside the battery to rise, which can activate the safety vent, lead to alkaline electrolyte leakage, rapid deterioration in battery performance, battery swelling or battery rupture.

1.4 Overcharging

- Avoid overcharging. Repeated overcharging can lead to deterioration in battery performance. ("Overcharging" means charging a battery when it is already fully charged.)

1.5 Rapid charging

- To charge batteries rapidly, use the specified charger (or charging method recommended by Panasonic) and follow the correct procedures.

1.6 Trickle charging (continuous charging)

- Trickle charging cannot be used with Ni-MH batteries. However, after applying a refresh charge using a rapid charge, use a trickle charge of 0.033 CmA to 0.05 CmA.
  Also, to avoid overcharging with trickle charge, which could damage the cell characteristics, a timer measuring the total charge time should be used.
- Note : "CmA"
  During charging and discharging, CmA is a value indicating current and expressed as a multiple of nominal capacity. Substitute "C" with the battery's nominal capacity when calculating. For example, for a 1500mAh battery of 0.033CmA, this value is equal to 1/30 × 1500, or roughly 50mA.

2. Discharging

2.1 Discharge temperature

- Discharge batteries within an ambient temperature range of -10°C to +45°C.
- Discharge current level (i. e. the current at which a battery is discharged) affects discharging efficiency. Discharging efficiency is good within a current range of 0.1 CmA to 2 CmA.
- Discharge capacity drops at temperatures below -10°C or above +45°C. Such decreases in discharge capacity can lead to deterioration in battery performance.

2.2 Overdischarge (deep discharge)

- Since overdischarging (deep discharge) damages the battery characteristics, do not forget to turn off the switch when discharging, and do not leave the battery connected to the equipment for long periods of time. Also, avoid shipping the battery installed in the equipment.

2.3 High-current discharging

- As high-current discharging can lead to heat generation and decreased discharging efficiency, consult Panasonic before attempting continuous discharging or pulse discharging at currents larger than 2 CmA.

3. Storage

3.1 Storage temperature and humidity (short-term)

- Store batteries in a dry location with low humidity, no corrosive gases, and at a temperature range of -20°C to +45°C.
- Storing batteries in a location where humidity is extremely high or where temperatures fall below -20°C or rise above +45°C can lead to the rusting of metallic parts and battery leakage due to expansion or contraction in parts composed of organic materials.

3.2 Long-term storage (1 year, -20°C to +35°C)

- Because long-term storage can accelerate battery self-discharge and lead to the deactivation of reactants, locations where the temperature ranges between +10°C and +30°C are suitable for long-term storage.
- When charging for the first time after long-term storage, deactivation of reactants may lead to increased battery voltage and decreased battery capacity. Restore such batteries to original performance by repeating several cycles of charging and discharging.
- When storing batteries for more than 1 year, charge at least once a year to prevent leakage and deterioration in performance due to self-discharging.

4. Service Life of Batteries

4.1 Cycle life

- Batteries used under proper conditions of charging and discharging can be used 500 cycles or more.
  Significantly reduced service time in spite of proper charging means that the life of the battery has been exceeded.
  Also, at the end of service life, an increase in internal resistance, or an internal short-circuit failure may occur. Chargers and charging circuits should therefore be designed to ensure safety in the event of heat generated upon battery failure at the end of service life.

4.2 Service life with long-term use

- Because batteries are chemical products involving internal chemical reactions, performance deteriorates not only with use but also during prolonged storage.
  Normally, a battery will last 2 years (or 500 cycles) if used under proper conditions and not overcharged or overdischarged. However, failure to satisfy conditions concerning charging, discharging, temperature and other factors during actual use can lead to shortened life (or cycle life) damage to products and deterioration in performance due to leakage and shortened service life.

5. Design of Products Which Use Batteries

5.1 Connecting batteries and products

- Never solder a lead wire and other connecting materials directly to the battery, as doing so will damage the battery's internal safety vent, separator, and other parts made of organic materials.
  To connect a battery to a product, spot-weld a tab made of nickel or nickel-plated steel to the battery's terminal strip, then solder a lead wire to the tab.
  Perform soldering in as short a time as possible.
- Use caution in applying pressure to the terminals in cases where the battery pack can be separated from the equipment.

5.2 Material for terminals in products using the batteries

- Because small amounts of alkaline electrolyte can leak from the battery seal during extended use or when the safety vent is activated during improper use, a highly alkaline-resistant material should be used for a product's contact terminals in order to avoid problems due to corrosion.

High Alkaline-resistant Metals	Low Alkaline-resistant Metals
Nickel, stainless steel, nickel-plated steel, etc.	Tin, aluminum, zinc, copper, brass, etc.

(Note that stainless steel generally results in higher contact resistance.)

5.3 Temperature related the position of batteries in products

- Excessively high temperatures (i.e. higher than 45°C) can cause alkaline electrolyte to leak from the battery, thus damaging the product and shorten battery life by causing deterioration in the separator or other battery parts. Install batteries far from heat-generating parts of the product. The best battery position is in a battery compartment that is composed of an alkaline-resistant material which isolates the batteries from the product's circuitry. This prevents damage that may be caused by a slight leakage of alkaline electrolyte from the battery.

5.4 Discharge end voltage

- The discharge end voltage is determined by the formula given below. Please set the end voltage of each battery at 1.1 volts or less.

Number of Batteries Arranged Serially	
1 to 6	(Number of batteries × 1.0) V
7 to 12	((Number of batteries - 1) × 1.2) V

5.5 Overdischarge (deep discharge) prevention

- Overdischarging (deep discharging) or reverse charging damages the battery characteristics. In order to prevent damage associated with forgetting to turn off the switch or leaving the battery in the equipment for extended periods, preventative options should be incorporated in the equipment. At the same time, it is recommended that leakage current is minimized. Also, the battery should not be shipped inside the equipment.

6. Prohibited Items Regarding the Battery Handling

- Panasonic assumes no responsibility for problems resulting from batteries handled in the following manner.

6.1 Disassembly

Never disassemble a battery, as the electrolyte inside is strong alkaline and can damage skin and clothes.

6.2 Short-circuiting

Never attempt to short-circuit a battery. Doing so can damage the product and generate heat that can cause burns.

6.3 Throwing batteries into a fire or water

Disposing of a battery in fire can cause the battery to rupture. Also avoid placing batteries in water, as this causes batteries to cease to function.

6.4 Soldering

Never solder anything directly to a battery. This can destroy the safety features of the battery by damaging the safety vent inside the cap.

6.5 Inserting the batteries with their polarities reversed

Never insert a battery with the positive and negative poles reversed. as this can cause the battery to swell or rupture.

6.6 Overcharging at high currents and reverse charging

- Never reverse charge or overcharge with high currents (i.e. higher than rated). Doing so causes rapid gas generation and increased gas pressure, thus causing batteries to swell or rupture.
- Charging with an unspecified charger or specified charger that has been modified can cause batteries to swell or rupture. Be sure to indicate this safety warning clearly in all operating instructions as a handling restriction for ensuring safety.

6.7 Installation in equipment (with an airtight battery compartment)

- Always avoid designing airtight battery compartments. In some cases, gases (oxygen, hydrogen) may be given off, and there is a danger of the batteries bursting or rupturing in the presence of a source of ignition_(sparks generated by a motor switch, etc.).

6.8 Use of batteries for other purposes

- Do not use a battery in an appliance or purpose for which it was not intended. Differences in specifications can damage the battery or appliance.

6.9 Short-circuiting of battery packs

- Special caution is required to prevent short-circuits.
  Care must be taken during the design of the battery pack shape to ensure batteries cannot be inserted in reverse. Also, caution must be given to certain structures or product terminal shapes which can make short-circuiting more likely.

6.10 Using old and new batteries together

- Avoid using old and new batteries together. Also avoid using these batteries with ordinary dry-cell batteries, Ni-Cd batteries or with another manufacturer's batteries.
  Differences in various characteristic values, etc., can cause damage to batteries or the product.

7. Other Precautions

- Batteries should always be charged prior to use. Be sure to charge correctly.

8. Final Point to Bear in Mind

- In order to ensure safe battery use and to prolong the battery performance, please consult Panasonic regarding charge and discharge conditions for use and product design prior to the release of a battery-operated product.