Around the turn of the century, scientists in many countries were trying to find better materials for storage batteries. In America, work was begun with the nickel iron electrochemical couple. In Europe, the nickel cadmium couple was experimented with. The battery that was developed, in principle, today's modern nickel cadmium alkaline battery, did in fact, provide some superior performance.

For example: A nickel cadmium battery will not freeze (-25°F with 1.190 specific gravity electrolyte; -54°F with 1.225 specific gravity electrolyte), charged or discharged. Since the electrolyte concentration is virtually unaffected by the state-of-charge, the freezing point is almost completely independent of the state-of-charge. Furthermore, the nickel cadmium battery makes available a significantly higher percentage of its current at lower temperatures than does a lead acid battery.

A nickel cadmium battery goes for years without watering. A nickel cadmium battery does not deteriorate if left in a discharged condition. Nickel cadmium batteries have been returned to service after 10 to 15 years "on the shelf".

Even under heavy industrial use, the nickel cadmium cell emits only a small amount of gas, and the small amount of deposits that may occur are non-corrosive to any ferrous metal and can be easily wiped away. Nickel cadmium batteries are often installed in cabinets right next to delicate equipment.

Nickel cadmium batteries are chemically and mechanically rugged. They can withstand all the use, abuse, and misuse of normal industrial applications without damage. They are unaffected by vibration and can take an amazing amount of impact shock. Even an extreme overcharge current, certain to damage a lead acid cell, does not destroy their capacity nor impact their efficiency.

While it is the chemical nature of the material used, and the fact that the electrolyte (a solution of potassium hydroxide and distilled water) does not take part in the reaction that is responsible for the performance of the nickel cadmium battery, it is the unique construction that makes it so rugged.

In the pocket plate nickel cadmium battery, the plates are made from thin strips of finely perforated steel. The strips are formed into troughs into which is placed the active material (nickel hydroxide for the positive plate, and cadmium oxide for the negative plate). A similar perforated strip is then placed over the original strip and the sides crimped together, forming an endless perforated pocket with the active material retained inside. These finished pockets are cut to suitable lengths and attached together by interlocking the crimps, the number of pockets so attached being determined by the height of the plate desired. A "U" frame of steel is then placed around the pocket plate and the sides firmly crimped on. The result is a mechanically rugged plate with extremely low electrical resistance.

It is most important that the steel from which the pockets are made is correctly perforated. If the holes are too large, the pocket may fracture. If the holes are too small, the discharge efficiency of the cell will suffer. The manufacture of pocket plate batteries is therefore a very exacting process. A 100 AH cell for engine cranking, for example, has about 7 million perforations, all of which are held within a tolerance of 0.0008 inches.

Positive and negative plates are held together by specially constructed separators and assembled in translucent polypropylene cases.

The sintered plate nickel cadmium battery plates are formed on very thin, perforated, sheet steel. The active material for the positive and negative plates is impregnated into the pores of the sheet steel plate.

The resultant battery has a very high plate surface area per pound of active material ratio. The positive and negative plates are held by means of a thin plastic mesh. There is, however, sufficient electrolyte space surrounding each plate to provide adequate cooling. The battery, therefore, has the highest rapid discharge current capability per AH capacity of any of the stationary industrial batteries.

Thus, the inherent characteristics of the nickel cadmium battery closely approaching those of the sought after "ideal" storage battery, can be summed up as follows: high performance; rugged and immune to damage, both mechanically and electrically; long life and low maintenance.

While the nickel cadmium alkaline storage battery shares some of the general features of the lead acid storage battery, it is considerably different in construction and performance as well as required maintenance. The following questions are those "most asked". These answers serve as a brief summary of the distinguishing characteristics of the nickel cadmium battery.

1. <u>What is alkaline electrolyte</u>?

Instead of sulfuric acid and water, as used in the lead acid battery, the electrolyte in the nickel cadmium battery is a solution of potassium hydroxide (KOH) and water. Usually, specific gravity is set at 1.190 ± 0.020. For very cold ambients, a heavier electrolyte concentration is used. The specific gravity remains essentially constant regardless of the battery's state-of-charge.

2. <u>Can I use an ordinary battery charger with a nickel cadmium battery?</u>

Ordinary battery chargers such as those used to charge lead acid batteries can be used with nickel cadmium batteries. However, the voltage setting must be adjusted to the requirements of the nickel cadmium battery as follows: 1.40 to 1.42 v/c on float; and 1.55 v/c or higher on recharge. Nominal cell voltage is 1.2 v/c for nickel cadmium.

3. How does ambient operating temperature affect nickel cadmium batteries?

All batteries exhibit decreased performance at low temperatures. However, the nickel cadmium battery performs better at low temperature than the lead acid battery. Further, at sub-freezing temperatures, electrolyte in the nickel cadmium battery will not freeze and cause cell cracking and failure, even in a fully discharged cell. The specific gravity of the electrolyte in a lead acid cell drops to near water when discharged and will freeze.

At elevated temperatures, nickel cadmium batteries do not experience the severe shortening of service life of lead-acid types. (For more detailed information, see Sections 19 and 20).

4. What are the grayish-white deposits which sometimes appear on cell tops of nickel cadmium batteries after long service?

These deposits are potassium carbonate (KCO_3) which are a result of minute quantities of potassium hydroxide (KOH) electrolyte being expelled from the vents. The KOH combines with the carbon dioxide (CO_2) in the air to form KCO_3.

The deposits are not corrosive and cannot damage the battery. However, because KCO_3 is electrically conductive when damp, it can cause current leakage if allowed to build up. It is good practice to remove the accumulations. Deposits can be washed off with water or brushed off with a non-metal brush.

Note: If this buildup is excessive, it is an indication that the charger voltage is adjusted too high. This will not damage the battery, but will result in increased water consumption.

5. What about nickel cadmium battery gassing?

Like all storage batteries, the gas given off by the nickel cadmium battery during rapid charging is a mixture of hydrogen and oxygen. This gassing is a result of the disassociation of water by the passage of current through the electrolyte.

The gas, if confined to a small space, can be potentially explosive. Normal ventilation is usually adequate for the room in which a nickel cadmium battery is to be installed since slight movement of air around the battery will dissipate the concentration of gas. (See Section 21)

Because the emitted gases from the nickel cadmium battery do not contain fumes which are corrosive to ferrous metals, nickel cadmium batteries can be installed in cabinets with other equipment without fear of corrosion damage.

6. <u>How is state-of-charge determined for a nickel cadmium battery?</u>

Because specific gravity remains essentially constant--from fully charged to completely discharged--use of a hydrometer is not helpful in determining the state-of-charge of a nickel cadmium battery. Instead, the following procedure is recommended:

> Switch the battery charger from "float" to the "recharge" mode. The current as indicated on the charger ammeter will immediately rise, and the battery voltage as shown on the charger voltmeter will start to rise at the same time.
>
> The actual value of the voltage rise is unimportant since it depends on many variables. The length of time it takes for the voltage to rise is the important factor.
>
> If, for example, the voltage rises rapidly (in a few minutes), then holds steady at the new value, the battery was fully charged. At the same time the current will drop to slightly above its original value.
>
> In contrast, if the voltage rises slowly and the output current remains high, the high charge rate should be continued until the voltage remains constant. Such a condition is an indication that the battery was not fully charged. The "float" voltage may need to be increased slightly.

7. Are there any special safety precautions to be observed when maintaining nickel cadmium batteries?

There are no special safety precautions required, only those which apply when servicing any storage battery. But some points to consider are:

* never use a match or other open flame when checking electrolyte levels
* avoid sparks
* do not drop tools on the battery
* never smoke when servicing the battery
* use tools with insulated handles only
* remove rings, wrist watches, and items of clothing with metal parts, when working on the battery
* never use a hydrometer, thermometer, filler syringe, etc. that has been used with a lead acid battery

Alkaline electrolyte is a caustic agent. Should alkaline electrolyte be accidentally splashed on the skin or clothing, apply a mild acid solution such as a mild boric acid or household vinegar. If this is not available, flood the area with water to neutralize. If required, contact a physician and inform him it is an alkaline burn.

8. What are the maintenance procedures for nickel cadmium batteries?

Like all storage batteries, nickel cadmium batteries lose water through natural evaporation and during recharging. This water must be replenished. Maintaining the electrolyte level above the plate tops is vital to the proper performance and long life of the battery since prolonged exposure of charged plates to the air will cause permanent damage.

In normal float operation, the nickel cadmium battery will require water additions no more often than once every 1-1/2 years. Add only distilled or deionized water -- never electrolyte. It is not necessary to add small amounts of water frequently in an attempt to hold the level at the upper limit of the cell. Avoid over filling cells and spilling water around the battery, because excessive water around the battery can result in grounds and faulty equipment operation. Note: Never use acid electrolyte in alkaline batteries or alkaline electrolyte in acid batteries.

9. Are equalizing charges required at regular intervals?

Periodic equalizing charges are not required on nickel cadmium batteries in float service. This is because a fully charged nickel cadmium battery will be kept fully charged at the normal float voltage. However, it must be understood that to fully restore any discharged electrochemical couple, the cell voltage must be increased approximately 10% above its nominal float voltage, and this recharge voltage maintained for an extended period of time. (See Section 26)

10. What about storage or "shelf life"?

Nickel cadmium batteries have an unlimited storage or "shelf life". They may be stored when filled with electrolyte, and do not need to be connected to a temporary trickle charge source while awaiting installation.

A fully charged nickel cadmium battery in storage will gradually lose a portion of its original charge (approximately 1-3% per month). It will not, however, experience any permanent loss of capacity. Thus, after it has been recharged, it will continue to function at top performance.